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

(11) **EP 4 317 845 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
13.05.2026 Bulletin 2026/20

(21) Application number: **22781287.2**

(22) Date of filing: **31.03.2022**

(51) International Patent Classification (IPC):
F25B 7/00 *(2006.01)* ***F25B 1/00*** *(2006.01)*

(52) Cooperative Patent Classification (CPC):
F25B 13/00; F25B 7/00; F25B 2313/004; F25B 2313/0233; F25B 2313/02732; F25B 2400/121

(86) International application number:
PCT/JP2022/016797

(87) International publication number:
WO 2022/211077 (06.10.2022 Gazette 2022/40)

(54) **REFRIGERATION CYCLE DEVICE**

KÄLTEKREISLAUFVORRICHTUNG

DISPOSITIF DE CYCLE FRIGORIFIQUE

(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

(30) Priority: **31.03.2021 JP 2021061280**

(43) Date of publication of application:
07.02.2024 Bulletin 2024/06

(73) Proprietor: **DAIKIN INDUSTRIES, LTD.**
Osaka 530-0001 (JP)

(72) Inventors:
- **YOSHIMI, Atsushi**
  Osaka-Shi, Osaka 530-0001 (JP)
- **YAMADA, Takuro**
  Osaka-Shi, Osaka 530-0001 (JP)
- **KUMAKURA, Eiji**
  Osaka-Shi, Osaka 530-0001 (JP)
- **IWATA, Ikuhiro**
  Osaka-Shi, Osaka 530-0001 (JP)
- **KAJI, Ryuhei**
  Osaka-Shi, Osaka 530-0001 (JP)
- **MIYAZAKI, Takeru**
  Osaka-Shi, Osaka 530-0001 (JP)
- **UEDA, Hiroki**
  Osaka-Shi, Osaka 530-0001 (JP)
- **TANAKA, Masaki**
  Osaka-Shi, Osaka 530-0001 (JP)
- **NAKAYAMA, Masaki**
  Osaka-Shi, Osaka 530-0001 (JP)

(74) Representative: **Hoffmann Eitle**
Patent- und Rechtsanwälte PartmbB
Arabellastraße 30
81925 München (DE)

(56) References cited:
EP-A1- 2 679 934
WO-A1-2012/161325
WO-A1-2017/221382
CN-A- 108 759 144
JP-A- 2000 320 914
JP-A- 2021 011 985

EP 4 317 845 B1

Description

TECHNICAL FIELD

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

BACKGROUND ART

[0002] To date, refrigeration cycle apparatuses have been proposed that use refrigerants with low global warming potential (GWP), taking into account the global environment.

[0003] For example, in a refrigeration cycle apparatus described in JP 2015-197254, it is proposed to fill a refrigerant circuit with a working fluid having a GWP equal to or less than a predetermined value. CN 108 759 144 A discloses a cascading ultralow-temperature air source heat pump unit comprising a water-side heat exchanger, a first refrigerant circuit and a second refrigerant circuit and a cascade heat exchanger. The first refrigerant circuit comprises a low-temperature compressor, a low-temperature four-way reversing valve, an air-side heat exchanger, the water-side heat exchanger and the cascade heat exchanger. The second refrigerant circuit comprises a high-temperature compressor, the water-side heat exchanger and the cascade heat exchanger. The heat pump is configured such that the first refrigerant circuit and the second refrigerant circuit can be operated in a two-stage heating mode, and such that the first refrigerant circuit can be operated in a single-stage heating mode or in a single-stage cooling mode.

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0004] The refrigerants with low GWP described above include a low-pressure refrigerant used at a relatively low refrigerant pressure. Such a low-pressure refrigerant has low heat transfer capacity, and a sufficient amount of circulation of the refrigerant is difficult to secure during a heating operation, with the tendency that the heating operation is difficult to perform or the COP (Coefficient Of Performance) is low during the heating operation.

[0005] To address this, a two-stage refrigeration cycle in which a carbon dioxide refrigerant serving as a high-pressure refrigerant with low GWP is used as a heat-source-side refrigerant and a low-pressure refrigerant is used as a use-side refrigerant may be used to secure heating operation capacity. However, even in this case, the critical pressure of the carbon dioxide refrigerant on the heat-source side is exceeded during a cooling operation, and the COP is low during the cooling operation.

[0006] Accordingly, it is desirable to provide a refrigeration cycle apparatus capable of efficiently performing a cooling operation and a heating operation using a high-pressure refrigerant and a low-pressure refrigerant.

SOLUTION TO PROBLEM

[0007] The claimed invention is defined by the independent claims 1 and 4. Optional features are described in the dependent claims.

[0008] In a first aspect of the claimed invention, a two-stage refrigeration cycle is performed during the heating operation, the two-stage refrigeration cycle including a use-side refrigeration cycle using a first refrigerant that is a low-pressure refrigerant having 1 MPa or less at 30°C and a heat-source-side refrigeration cycle using a second refrigerant that is a high-pressure refrigerant having 1.5 MPa or more at 30°C. Thus, it is easy to secure heating capacity while achieving a high COP. In this refrigeration cycle apparatus, furthermore, a single-stage refrigeration cycle using the first refrigerant, which is a low-pressure refrigerant having 1 MPa or less at 30°C, is performed during the cooling operation. Thus, it is possible to perform the two-stage refrigeration cycle using the second refrigerant in the heat-source-side refrigeration cycle, without causing a reduction in COP due to the second refrigerant exceeding a critical pressure. Accordingly, the cooling operation and the heating operation can be efficiently performed using a high-pressure refrigerant and a low-pressure refrigerant.

[0009] In the use heat exchanger, the first refrigerant evaporates during the cooling operation. In the first outdoor heat exchanger, the first refrigerant radiates heat during the cooling operation. In the first outdoor heat exchanger, the first refrigerant may condense during the cooling operation. The first outdoor heat exchanger is not limited. For example, the refrigerant flowing through the first outdoor heat exchanger may exchange heat with air.

[0010] In this refrigeration cycle apparatus, the cooling operation can be efficiently performed by using an outdoor heat source.

[0011] In the second outdoor heat exchanger, the second refrigerant evaporates during the heating operation. The second outdoor heat exchanger is not limited. For example, the refrigerant flowing through the second outdoor heat exchanger may exchange heat with air. In this refrigeration cycle apparatus, the heating operation can be efficiently performed by using an outdoor heat source.

[0012] A refrigeration cycle apparatus according to a second aspect is the refrigeration cycle apparatus according to the first aspect, including a cascade heat exchanger. The cascade heat exchanger includes a first cascade flow path and a second cascade flow path. The first cascade flow path is a flow path through which the first refrigerant flows during the heating operation. The second cascade flow path is a flow path that is independent of the first cascade flow path, and is a flow path through which the second refrigerant flows during the heating operation. The cascade heat exchanger is configured to exchange heat between the first refrigerant and the second refrigerant.

[0013] In this refrigeration cycle apparatus, the efficiency of heat exchange between the refrigerant flowing through the heat-source-side refrigeration cycle and the refrigerant flowing through the use-side refrigeration cycle can be increased.

[0014] A refrigeration cycle apparatus according to a third aspect is the refrigeration cycle apparatus according to the second aspect, further including that during the heating operation, the first refrigerant evaporates when passing through the first cascade flow path, and the second refrigerant radiates heat when passing through the second cascade flow path.

[0015] In the use heat exchanger, the first refrigerant may condense during the heating operation.

[0016] The use heat exchanger is preferably a heat exchanger that processes a heat load. The refrigerant flowing through the use heat exchanger may exchange heat with air, or may exchange heat with a fluid such as brine or water.

[0017] In this refrigeration cycle apparatus, the heating operation can be efficiently performed.

[0018] In a refrigeration cycle apparatus according to a fourth aspect of the claimed invention, a two-stage refrigeration cycle is performed during the heating operation, the two-stage refrigeration cycle including a use-side refrigeration cycle using a first refrigerant that is a low-pressure refrigerant having 1 MPa or less at 30°C and a heat-source-side refrigeration cycle using a second refrigerant that is a high-pressure refrigerant having 1.5 MPa or more at 30°C. Thus, it is easy to secure heating capacity while achieving a high COP. In this refrigeration cycle apparatus, furthermore, a two-stage refrigeration cycle is performed during the cooling operation, the two-stage refrigeration cycle including a use-side refrigeration cycle using the second refrigerant, which is a high-pressure refrigerant having 1.5 MPa or more at 30°C, and a heat-source-side refrigeration cycle using the first refrigerant, which is a low-pressure refrigerant having 1 MPa or less at 30°C. Thus, it is possible to perform the two-stage refrigeration cycle using the second refrigerant in the heat-source-side refrigeration cycle, without causing a reduction in COP due to the second refrigerant exceeding a critical pressure. Accordingly, the cooling operation and the heating operation can be efficiently performed using a high-pressure refrigerant and a low-pressure refrigerant.

[0019] In the first outdoor heat exchanger, the first refrigerant radiates heat during the cooling operation. In the first outdoor heat exchanger, the first refrigerant may condense during the cooling operation. The first outdoor heat exchanger is not limited. For example, the refrigerant flowing through the first outdoor heat exchanger may exchange heat with air. In this refrigeration cycle apparatus, the cooling operation can be efficiently performed by using an outdoor heat source.

[0020] In the second outdoor heat exchanger, the second refrigerant evaporates during the heating operation. The second outdoor heat exchanger is not limited. For example, the refrigerant flowing through the second outdoor heat exchanger may exchange heat with air. In this refrigeration cycle apparatus, the heating operation can be efficiently performed by using an outdoor heat source.

[0021] A refrigeration cycle apparatus according to a fifth aspect is the refrigeration cycle apparatus according to the fourth aspect, including a cascade heat exchanger. The cascade heat exchanger includes a first cascade flow path and a second cascade flow path that is a flow path independent of the first cascade flow path. The first cascade flow path is a flow path through which the first refrigerant flows. The second cascade flow path is a flow path through which the second refrigerant flows. The cascade heat exchanger is configured to exchange heat between the first refrigerant and the second refrigerant.

[0022] In this refrigeration cycle apparatus, the efficiency of heat exchange between the refrigerant flowing through the heat-source-side refrigeration cycle and the refrigerant flowing through the use-side refrigeration cycle can be increased.

[0023] A refrigeration cycle apparatus according to an sixth aspect is the refrigeration cycle apparatus according to the fifth aspect, further including a use heat exchanger. The use heat exchanger includes a first use flow path and a second use flow path that is a flow path independent of the first use flow path. The first use flow path is a flow path through which the first refrigerant flows. The second use flow path is a flow path through which the second refrigerant flows.

[0024] The use heat exchanger is preferably a heat exchanger that processes a heat load. The refrigerant flowing through the use heat exchanger may exchange heat with air, or may exchange heat with a fluid such as brine or water.

[0025] In this refrigeration cycle apparatus, the use heat exchanger can perform heat load processing by using the first refrigerant and heat load processing by using the second refrigerant.

[0026] A refrigeration cycle apparatus according to a seventh aspect is the refrigeration cycle apparatus according to the sixth aspect, in which during the heating operation, the first refrigerant evaporates when passing through the first cascade flow path, the second refrigerant radiates heat when passing through the second cascade flow path, and the first refrigerant radiates heat when passing through the first use flow path.

[0027] The first refrigerant may condense when passing through the first use flow path during the heating operation.

[0028] In this refrigeration cycle apparatus, the heating operation can be efficiently performed.

[0029] A refrigeration cycle apparatus according to a eighth aspect is the refrigeration cycle apparatus according to the sixth or seventh aspect, in which during the cooling operation, the first refrigerant evaporates when passing through the first cascade flow path, the second refrigerant radiates heat when passing through the second cascade flow path, and the second refrigerant evaporates when passing through the second use flow path.

[0030] In this refrigeration cycle apparatus, the cooling operation can be efficiently performed.

[0031] A refrigeration cycle apparatus pertaining to a ninth aspect is the refrigeration cycle apparatus pertaining to any of the sixth to eighth aspects, in which during the cooling operation, the first refrigerant evaporates when passing through the first use flow path, and the second refrigerant evaporates when passing through the second use flow path.

[0032] In this refrigeration cycle apparatus, the first refrigerant and the second refrigerant can be simultaneously evaporated in the use heat exchanger during the cooling operation.

[0033] A refrigeration cycle apparatus pertaining to a tenth aspect is the refrigeration cycle apparatus pertaining to any of the sixth to ninth aspects, in which during the heating operation, the first refrigerant radiates heat when passing through the first use flow path, and the second refrigerant radiates heat when passing through the second use flow path.

[0034] The first refrigerant may condense when passing through the first use flow path during the heating operation.

[0035] In this refrigeration cycle apparatus, the first refrigerant and the second refrigerant can simultaneously radiate heat in the use heat exchanger during the heating operation.

[0036] A refrigeration cycle apparatus according to a eleventh aspect is the refrigeration cycle apparatus according to any one of the first to tenth aspects, in which the first refrigerant includes at least one of R1234yf or R1234ze.

[0037] The first refrigerant may include only R1234yf or may include only R1234ze.

[0038] In this refrigeration cycle apparatus, an operation can be performed by using a refrigerant having a sufficiently low global warming potential (GWP).

[0039] A refrigeration cycle apparatus according to a twelfth aspect is the refrigeration cycle apparatus according to any one of the first to eleventh aspects, in which the second refrigerant includes carbon dioxide.

[0040] The second refrigerant may include only carbon dioxide.

[0041] In this refrigeration cycle apparatus, an operation can be performed by using a refrigerant having a sufficiently low ozone depletion potential (ODP) and a sufficiently low global warming potential (GWP).

Brief Description of Drawings

[0042]

[Fig. 1] Fig. 1 is an overall configuration diagram of a refrigeration cycle apparatus according to a first embodiment of the present invention.

[Fig. 2] Fig. 2 is a functional block configuration diagram of the refrigeration cycle apparatus according to the first embodiment.

[Fig. 3] Fig. 3 is a diagram illustrating how a refrigerant flows during a cooling operation according to the first embodiment.

[Fig. 4] Fig. 4 is a diagram illustrating how a refrigerant flows during a heating operation according to the first embodiment.

[Fig. 5] Fig. 5 is an overall configuration diagram of a refrigeration cycle apparatus according to a second embodiment.

[Fig. 6] Fig. 6 is a functional block configuration diagram of the refrigeration cycle apparatus according to the second embodiment.

[Fig. 7] Fig. 7 is a diagram illustrating how a refrigerant flows during a cooling operation according to the second embodiment.

[Fig. 8] Fig. 8 is a diagram illustrating how a refrigerant flows during a heating operation according to the second embodiment.

[Fig. 9] Fig. 9 is an overall configuration diagram of a refrigeration cycle apparatus according to a third embodiment.

[Fig. 10] Fig. 10 is a functional block configuration diagram of the refrigeration cycle apparatus according to the third embodiment.

[Fig. 11] Fig. 11 is a diagram illustrating how a refrigerant flows during a cooling operation according to the third embodiment.

[Fig. 12] Fig. 12 is a diagram illustrating how a refrigerant flows during a heating operation according to the third embodiment.

[Fig. 13] Fig. 13 is an overall configuration diagram of a refrigeration cycle apparatus according to a fourth embodiment.

[Fig. 14] Fig. 14 is a functional block configuration diagram of the refrigeration cycle apparatus according to the fourth embodiment.

[Fig. 15] Fig. 15 is a diagram illustrating how a refrigerant flows during a first cooling operation according to the fourth embodiment.

[Fig. 16] Fig. 16 is a diagram illustrating how a refrigerant flows during a second cooling operation according to the fourth embodiment.

[Fig. 17] Fig. 17 is a diagram illustrating how a refrigerant flows during a third cooling operation which is not in accordance with the present invention.

[Fig. 18] Fig. 18 is a diagram illustrating how a refrigerant flows during a first heating operation which is not in accordance with the present invention.

[Fig. 19] Fig. 19 is a diagram illustrating how a refrigerant flows during a second heating operation according to the fourth embodiment.

[Fig. 20] Fig. 20 is a diagram illustrating how a refrigerant flows during a third heating operation which is not in accordance with the present invention.

Description of Embodiments

(1) First Embodiment

[0043] Fig. 1 is a schematic configuration diagram of a refrigeration cycle apparatus 1 according to a first embodiment. Fig. 2 is a functional block configuration diagram of the refrigeration cycle apparatus 1 according to the first embodiment.

[0044] The refrigeration cycle apparatus 1 is an apparatus used to process a heat load through a vapor-compression refrigeration cycle operation. The refrigeration cycle apparatus 1 includes a heat-load circuit 90, a first refrigerant circuit 10, a second refrigerant circuit 20, an outdoor fan 9, and a controller 7.

[0045] The heat load to be processed by the refrigeration cycle apparatus 1 is not limited, and a fluid such as air, water, or brine may be subjected to heat exchange. In the refrigeration cycle apparatus 1 according to the present embodiment, water flowing through the heat-load circuit 90 is supplied to a heat-load heat exchanger 91, and the heat load in the heat-load heat exchanger 91 is processed. The heat-load circuit 90 is a circuit in which water serving as a heat medium circulates, and includes the heat-load heat exchanger 91, a pump 92, and a use heat exchanger 13 shared with the first refrigerant circuit 10. The pump 92 is driven and controlled by the controller 7, which will be described below, to circulate the water through the heat-load circuit 90. In the heat-load circuit 90, the water flows through a heat-load flow path 13c included in the use heat exchanger 13. As described below, the use heat exchanger 13 includes a first use flow path 13a through which a first refrigerant flowing through the first refrigerant circuit 10 passes. The water flowing through the heat-load flow path 13c of the use heat exchanger 13 exchanges heat with the first refrigerant flowing through the first use flow path 13a. As a result, the water is cooled during a cooling operation and is heated during a heating operation.

[0046] The first refrigerant circuit 10 includes a first compressor 11, a first switching mechanism 12, the use heat exchanger 13 shared with the heat-load circuit 90, a first use expansion valve 15, a second use expansion valve 16, a heat-source heat exchanger 17 shared with the second refrigerant circuit 20, and a first outdoor heat exchanger 18. The first refrigerant circuit 10 is filled with the first refrigerant, which is a low-pressure refrigerant, as a refrigerant. The first refrigerant is a refrigerant having 1 MPa or less at 30°C, and is a refrigerant including, for example, at least one of R1234yf or R1234ze. The first refrigerant may include only R1234yf or may include only R1234ze.

[0047] The first compressor 11 is a positive-displacement compressor to be driven by a compressor motor. The compressor motor is driven by electric power supplied via an inverter device. The first compressor 11 has an operating capacity that is changeable by varying a drive frequency that is the number of rotations of the compressor motor. A discharge side of the first compressor 11 is connected to the first switching mechanism 12. A suction side of the first compressor 11 is connected to a gas-refrigerant-side outlet of a first heat-source flow path 17a of the heat-source heat exchanger 17.

[0048] The first switching mechanism 12 includes a switching valve 12a and a switching valve 12b. The switching valve 12a and the switching valve 12b are connected in parallel to each other on the discharge side of the first compressor 11. The switching valve 12a is a three-way valve that switches between a state in which the discharge side of the first compressor 11 is connected to the first use flow path 13a of the use heat exchanger 13 and a state in which the suction side of the first compressor 11 is connected to the first use flow path 13a of the use heat exchanger 13. The switching valve 12b is a three-way valve that switches between a state in which the discharge side of the first compressor 11 is connected to the first outdoor heat exchanger 18 and a state in which the suction side of the first compressor 11 is connected to the first outdoor heat exchanger 18.

[0049] A gas refrigerant side of the first use flow path 13a of the use heat exchanger 13 through which the first refrigerant flowing through the first refrigerant circuit 10 passes is connected to the switching valve 12a. A liquid refrigerant side of the first use flow path 13a is connected to a first branch point A included in the first refrigerant circuit 10. The first refrigerant evaporates when flowing through the first use flow path 13a of the use heat exchanger 13 to cool the water flowing through the heat-load circuit 90. The first refrigerant condenses when flowing through the first use flow path 13a of the use heat exchanger 13 to heat the water flowing through the heat-load circuit 90.

[0050] At the first branch point A, a flow path extending from the liquid refrigerant side of the first use flow path 13a, a flow path extending to the side of the first use expansion valve 15 opposite to the heat-source heat exchanger 17 side, and a flow path extending to the side of the second use expansion valve 16 opposite to the first outdoor heat exchanger 18 side are connected.

[0051] The first use expansion valve 15 includes an electronic expansion valve that is adjustable in valve opening degree. In the first refrigerant circuit 10, the first use expansion valve 15 is disposed between the first branch point A and an inlet on a liquid refrigerant side of the first heat-source flow path 17a of the heat-source heat exchanger 17.

[0052] The second use expansion valve 16 includes an electronic expansion valve that is adjustable in valve opening degree. In the first refrigerant circuit 10, the second use expansion valve 16 is disposed between the first branch point A and an outlet on a liquid refrigerant side of the first outdoor heat exchanger 18.

[0053] The heat-source heat exchanger 17 is a cascade heat exchanger that includes the first heat-source flow path 17a through which the first refrigerant flowing through the first refrigerant circuit 10 passes, and a second heat-source flow path 17b through which a second refrigerant flowing through the second refrigerant circuit 20 passes, and that exchanges heat between the first refrigerant and the second refrigerant. In the heat-source heat exchanger 17, the first heat-source flow path 17a and the second heat-source flow path 17b are independent of each other, and the first refrigerant and the second refrigerant do not mix with each other. The gas-refrigerant-side outlet of the first heat-source flow path 17a of the heat-source heat exchanger 17 is connected to the suction side of the first compressor 11. The inlet on the liquid refrigerant side of the first heat-source flow path 17a of the heat-source heat exchanger 17 is connected to the first use expansion valve 15.

[0054] The first outdoor heat exchanger 18 includes a plurality of heat transfer tubes and a plurality of fins joined to the plurality of heat transfer tubes. In the present embodiment, the first outdoor heat exchanger 18 is arranged outdoors. The first refrigerant flowing through the first outdoor heat exchanger 18 exchanges heat with air sent to the first outdoor heat exchanger 18, thereby allowing the first outdoor heat exchanger 18 to function as a condenser of the first refrigerant.

[0055] The outdoor fan 9 generates an air flow of outdoor air passing through both the first outdoor heat exchanger 18 and a second outdoor heat exchanger 23.

[0056] The second refrigerant circuit 20 includes a second compressor 21, the heat-source heat exchanger 17 shared with the first refrigerant circuit 10, a first heat-source expansion valve 26, and the second outdoor heat exchanger 23. The second refrigerant circuit 20 is filled with the second refrigerant, which is a high-pressure refrigerant, as a refrigerant. The second refrigerant is a refrigerant having 1.5 MPa or more at 30°C. The second refrigerant may include carbon dioxide, or may include only carbon dioxide.

[0057] The second compressor 21 is a positive-displacement compressor to be driven by a compressor motor. The compressor motor is driven by electric power supplied via an inverter device. The second compressor 21 has an operating capacity that is changeable by varying a drive frequency that is the number of rotations of the compressor motor. A discharge side of the second compressor 21 is connected to an inlet on a gas refrigerant side of the second heat-source flow path 17b of the heat-source heat exchanger 17. A suction side of the second compressor 21 is connected to the second outdoor heat exchanger 23.

[0058] The inlet on the gas refrigerant side of the second heat-source flow path 17b of the heat-source heat exchanger 17 is connected to the discharge side of the second compressor 21. An outlet on a liquid refrigerant side of the second heat-source flow path 17b of the heat-source heat exchanger 17 is connected to the first heat-source expansion valve 26.

[0059] The first heat-source expansion valve 26 is disposed in a flow path between the liquid refrigerant side of the second heat-source flow path 17b of the heat-source heat exchanger 17 and a liquid refrigerant side of the second outdoor heat exchanger 23.

[0060] The second outdoor heat exchanger 23 includes a plurality of heat transfer tubes and a plurality of fins joined to the plurality of heat transfer tubes. In the present embodiment, the second outdoor heat exchanger 23 is arranged outdoors alongside the first outdoor heat exchanger 18. The second refrigerant flowing through the second outdoor heat exchanger 23 exchanges heat with air sent to the second outdoor heat exchanger 23, thereby allowing the second outdoor heat exchanger 23 to function as an evaporator of the second refrigerant.

[0061] The controller 7 controls the operation of the devices included in the heat-load circuit 90, the first refrigerant circuit 10, and the second refrigerant circuit 20. Specifically, the controller 7 includes a processor serving as a CPU provided for performing control, a memory, and the like.

[0062] In the refrigeration cycle apparatus 1 described above, the controller 7 controls the devices to execute a refrigeration cycle, thereby performing a cooling operation for processing a cooling load in the heat-load heat exchanger 91 and a heating operation for processing a heating load in the heat-load heat exchanger 91.

(1-1) Cooling Operation

[0063] During the cooling operation, as illustrated in Fig. 3, the first refrigerant circuit 10 performs a single-stage refrigeration cycle such that the use heat exchanger 13 functions as an evaporator of the first refrigerant and the first outdoor heat exchanger 18 functions as a condenser of the first refrigerant, and the second refrigerant circuit 20 does not perform a refrigeration cycle. Specifically, the switching valves 12a and 12b of the first switching mechanism 12 are switched to a connection state indicated by solid lines in Fig. 3, the pump 92, the first compressor 11, and the outdoor fan 9 are driven, the first use expansion valve 15 is fully closed, and the valve opening degree of the second use expansion valve 16 is controlled such that the degree of superheating of the first refrigerant to be sucked into the first compressor 11 satisfies a predetermined condition.

[0064] Accordingly, the first refrigerant discharged from the first compressor 11 is sent to the first outdoor heat exchanger 18 via the switching valve 12b of the first switching mechanism 12. The first refrigerant sent to the first outdoor heat exchanger 18 is condensed by heat exchange with the outdoor air supplied by the outdoor fan 9. The first refrigerant having passed through the first outdoor heat exchanger 18 is decompressed in the second use expansion valve 16, passes through the first branch point A, and is sent to the first use flow path 13a of the use heat exchanger 13. The first refrigerant flowing through the first use flow path 13a of the use heat exchanger 13 is evaporated by heat exchange with the water flowing through the heat-load flow path 13c of the use heat exchanger 13 included in the heat-load circuit 90. The water cooled by this heat exchange is sent to the heat-load heat exchanger 91 in the heat-load circuit 90 to process the cooling load. The first refrigerant evaporated in the first use flow path 13a of the use heat exchanger 13 is sucked into the first compressor 11 via the switching valve 12a of the first switching mechanism 12.

(1-2) Heating Operation

[0065] During the heating operation, as illustrated in Fig. 4, the first refrigerant circuit 10 performs a refrigeration cycle such that the use heat exchanger 13 functions as a condenser of the first refrigerant and the heat-source heat exchanger 17 functions as an evaporator of the first refrigerant, and the second refrigerant circuit 20 performs a refrigeration cycle such that the heat-source heat exchanger 17 functions as a radiator of the second refrigerant and the second outdoor heat exchanger 23 functions as an evaporator of the second refrigerant. As a result, a two-stage refrigeration cycle is performed by the second refrigerant circuit 20 and the first refrigerant circuit 10 during the heating operation. Specifically, the switching valves 12a and 12b of the first switching mechanism 12 are switched to a connection state indicated by broken lines in Fig. 4, the pump 92, the first compressor 11, the second compressor 21, and the outdoor fan 9 are driven, the second use expansion valve 16 is fully closed, the valve opening degree of the first use expansion valve 15 is controlled such that the degree of superheating of the first refrigerant to be sucked into the first compressor 11 satisfies a predetermined condition, and the valve opening degree of the first heat-source expansion valve 26 is controlled such that the degree of superheating of the second refrigerant to be sucked into the second compressor 21 satisfies a predetermined condition.

[0066] Accordingly, the second refrigerant discharged from the second compressor 21 is sent to the heat-source heat exchanger 17. When flowing through the second heat-source flow path 17b, the second refrigerant radiates heat by heat exchange with the first refrigerant flowing through the first heat-source flow path 17a. The second refrigerant, which has radiated heat in the heat-source heat exchanger 17, is decompressed in the first heat-source expansion valve 26. Then, the second refrigerant is evaporated by heat exchange with the outdoor air supplied by the outdoor fan 9 in the second outdoor heat exchanger 23, and is sucked into the second compressor 21. The first refrigerant discharged from the first compressor 11 is sent to the first use flow path 13a of the use heat exchanger 13 via the switching valve 12a of the first switching mechanism 12. The first refrigerant flowing through the first use flow path 13a of the use heat exchanger 13 is condensed by heat exchange with the water flowing through the heat-load flow path 13c of the use heat exchanger 13 included in the heat-load circuit 90. The water heated by this heat exchange is sent to the heat-load heat exchanger 91 in the heat-load circuit 90 to process the heating load. The first refrigerant condensed in the first use flow path 13a of the use heat exchanger 13 passes through the first branch point A and is then decompressed in the first use expansion valve 15. The first refrigerant decompressed by the first use expansion valve 15 is evaporated, when passing through the first heat-source flow path 17a of the heat-source heat exchanger 17, by heat exchange with the second refrigerant flowing through the second heat-source flow path 17b. The first refrigerant evaporated in the first heat-source flow path 17a of the heat-source heat exchanger 17 is sucked into the first compressor 11.

(1-3) Features of First Embodiment

[0067] In the refrigeration cycle apparatus 1 according to the first embodiment, the first refrigerant circuit 10 uses the first refrigerant having a sufficiently low global warming potential (GWP). Further, the second refrigerant circuit 20 uses the second refrigerant having a sufficiently low ozone depletion potential (ODP) and a sufficiently low global warming potential (GWP). Thus, global environmental deterioration can be reduced.

[0068] In addition, even when the first refrigerant circuit 10 uses the first refrigerant having a sufficiently low global warming potential (GWP), the two-stage refrigeration cycle in which the second refrigerant circuit 20 is used for the heat-source-side cycle and the first refrigerant circuit 10 is used for the use-side cycle is performed as the heating operation. This makes it easier to secure heating operation capacity than a single-stage refrigeration cycle in which the first refrigerant, which is a low-pressure refrigerant, is used.

[0069] During the cooling operation, the second refrigerant circuit 20 does not perform a refrigeration cycle, and the first refrigerant circuit 10 performs the single-stage refrigeration cycle although the second refrigerant circuit 20 uses carbon dioxide as the second refrigerant. This makes it possible to perform the cooling operation without causing a reduction in COP, as in the case of performing a single-stage refrigeration cycle using a carbon dioxide refrigerant, which is a high-pressure refrigerant, or as in the case of performing a two-stage refrigeration cycle in which carbon dioxide, which is a high-pressure refrigerant, is used in the heat-source-side cycle, the reduction in COP being due to the pressure of the carbon dioxide refrigerant exceeding the critical pressure. It is also possible to reduce the compression strength standards required for the components of the second refrigerant circuit 20 in which carbon dioxide, which is a high-pressure refrigerant, is used.

(2) Second Embodiment

[0070] Fig. 5 is a schematic configuration diagram of a refrigeration cycle apparatus 1a according to a second embodiment. Fig. 6 is a functional block configuration diagram of the refrigeration cycle apparatus 1a according to the second embodiment.

[0071] The refrigeration cycle apparatus 1a is an apparatus used to process a heat load through a vapor-compression refrigeration cycle operation. The refrigeration cycle apparatus 1a includes a heat-load circuit 90, a first refrigerant circuit 10, a second refrigerant circuit 20, an outdoor fan 9, and a controller 7.

[0072] The heat load to be processed by the refrigeration cycle apparatus 1a and the heat-load circuit 90 are similar to those according to the first embodiment.

[0073] A use heat exchanger 13 includes a heat-load flow path 13c through which the water flowing through the heat-load circuit 90 passes, a first use flow path 13a through which the first refrigerant flowing through the first refrigerant circuit 10 passes, and a second use flow path 13b through which the second refrigerant flowing through the second refrigerant circuit 20 passes. The water flowing through the heat-load flow path 13c of the use heat exchanger 13 exchanges heat with the first refrigerant flowing through the first use flow path 13a or the second refrigerant flowing through the second use flow path 13b. As a result, the water is cooled during a cooling operation and is heated during a heating operation.

[0074] The first refrigerant circuit 10 includes a first compressor 11, a first switching mechanism 12x, the use heat exchanger 13 shared with the heat-load circuit 90 and the second refrigerant circuit 20, a second use expansion valve 16, a third use expansion valve 14, a heat-source heat exchanger 17 shared with the second refrigerant circuit 20, and a first outdoor heat exchanger 18. The first refrigerant circuit 10 is filled with the first refrigerant, which is a low-pressure refrigerant, as a refrigerant. The first refrigerant is a refrigerant having 1 MPa or less at 30°C, and is a refrigerant including, for example, at least one of R1234yf or R1234ze. The first refrigerant may include only R1234yf or may include only R1234ze.

[0075] The specific configuration of the first compressor 11 is similar to that according to the first embodiment. A discharge side of the first compressor 11 is connected to the first switching mechanism 12x. A suction side of the first compressor 11 is connected to a gas-refrigerant-side outlet of a first heat-source flow path 17a of the heat-source heat exchanger 17.

[0076] The first switching mechanism 12x is a four-way switching valve that switches between a state in which the suction side of the first compressor 11 is connected to the first outdoor heat exchanger 18 while the discharge side of the first compressor 11 is connected to the first use flow path 13a of the use heat exchanger 13, and a state in which the suction side of the first compressor 11 is connected to the first use flow path 13a of the use heat exchanger 13 while the discharge side of the first compressor 11 is connected to the first outdoor heat exchanger 18.

[0077] A gas refrigerant side of the first use flow path 13a of the use heat exchanger 13 through which the first refrigerant flowing through the first refrigerant circuit 10 passes is connected to the first switching mechanism 12x. A liquid refrigerant side of the first use flow path 13a is connected to a flow path extending from the third use expansion valve 14. The first refrigerant condenses when flowing through the first use flow path 13a of the use heat exchanger 13 to heat the water flowing through the heat-load circuit 90.

[0078] The third use expansion valve 14 includes an electronic expansion valve that is adjustable in valve opening degree. The third use expansion valve 14 is disposed between the use heat exchanger 13 and a first branch point A in the first refrigerant circuit 10.

[0079] At the first branch point A, a flow path extending from the third use expansion valve 14, a flow path extending from a liquid refrigerant side of the first heat-source flow path 17a in the heat-source heat exchanger 17, and a flow path extending to the side of the second use expansion valve 16 opposite to the first outdoor heat exchanger 18 side are connected.

[0080] The second use expansion valve 16 is similar to that according to the first embodiment.

[0081] The heat-source heat exchanger 17 is similar to that according to the first embodiment. The gas-refrigerant-side outlet of the first heat-source flow path 17a of the heat-source heat exchanger 17 is connected to the suction side of the first compressor 11. An inlet on the liquid refrigerant side of the first heat-source flow path 17a of the heat-source heat exchanger 17 is connected to the first branch point A.

[0082] The first outdoor heat exchanger 18 is similar to that according to the first embodiment.

[0083] The outdoor fan 9 generates an air flow of outdoor air passing through both the first outdoor heat exchanger 18 and a second outdoor heat exchanger 23.

[0084] The second refrigerant circuit 20 includes a second compressor 21, the use heat exchanger 13 shared with the heat-load circuit 90 and the first refrigerant circuit 10, the heat-source heat exchanger 17 shared with the first refrigerant circuit 10, a first heat-source expansion valve 26, a second heat-source expansion valve 24, and the second outdoor heat exchanger 23. The second refrigerant circuit 20 is filled with the second refrigerant, which is a high-pressure refrigerant, as a refrigerant. The second refrigerant is a refrigerant having 1.5 MPa or more at 30°C. The second refrigerant may include carbon dioxide, or may include only carbon dioxide.

[0085] The specific configuration of the second compressor 21 is similar to that according to the first embodiment. A discharge side of the second compressor 21 is connected to an inlet on a gas refrigerant side of the second heat-source flow path 17b of the heat-source heat exchanger 17. A suction side of the second compressor 21 is connected to a flow path extending from a third branch point C in the second refrigerant circuit 20.

[0086] At the third branch point C, a flow path extending from the suction side of the second compressor 21, a flow path extending from an outlet on a gas refrigerant side of the second outdoor heat exchanger 23, and a flow path extending from the outlet on the gas refrigerant side of the second use flow path 13b of the use heat exchanger 13 are connected.

[0087] The inlet on the gas refrigerant side of the second heat-source flow path 17b of the heat-source heat exchanger 17 is connected to the discharge side of the second compressor 21. An outlet on a liquid refrigerant side of the second heat-source flow path 17b of the heat-source heat exchanger 17 is connected to a flow path extending from a second branch point B in the second refrigerant circuit 20. The second refrigerant radiates heat when flowing through the second heat-source flow path 17b of the heat-source heat exchanger 17 to evaporate the first refrigerant flowing through the first heat-source flow path 17a.

[0088] At the second branch point B, a flow path extending from the outlet on the liquid refrigerant side of the second heat-source flow path 17b of the heat-source heat exchanger 17, a flow path extending from the first heat-source expansion valve 26, and a flow path extending from the second heat-source expansion valve 24 are connected.

[0089] The first heat-source expansion valve 26 is disposed in a flow path between the second branch point B and an inlet on a liquid refrigerant side of the second outdoor heat exchanger 23.

[0090] The second outdoor heat exchanger 23 is similar to that according to the first embodiment.

[0091] The second heat-source expansion valve 24 is disposed in a flow path between the second branch point B and an inlet on a liquid refrigerant side of the second use flow path 13b of the use heat exchanger 13.

[0092] The second use flow path 13b of the use heat exchanger 13 through which the second refrigerant flowing through the second refrigerant circuit 20 passes is disposed in a flow path between the second heat-source expansion valve 24 and the third branch point C. The second refrigerant evaporates when flowing through the second use flow path 13b of the use heat exchanger 13 to cool the water flowing through the heat-load circuit 90.

[0093] The controller 7 controls the operation of the devices included in the heat-load circuit 90, the first refrigerant circuit 10, and the second refrigerant circuit 20. Specifically, the controller 7 includes a processor serving as a CPU provided for performing control, a memory, and the like.

[0094] In the refrigeration cycle apparatus 1a described above, the controller 7 controls the devices to execute a refrigeration cycle, thereby performing a cooling operation for processing a cooling load in the heat-load heat exchanger 91 and a heating operation for processing a heating load in the heat-load heat exchanger 91.

(2-1) Cooling Operation

[0095] During the cooling operation, as illustrated in Fig. 7, while the first refrigerant circuit 10 performs a refrigeration cycle such that the first outdoor heat exchanger 18 functions as a condenser of the first refrigerant and the heat-source heat exchanger 17 functions as an evaporator of the first refrigerant, the second refrigerant circuit 20 performs a refrigeration cycle such that the heat-source heat exchanger 17 functions as a radiator of the second refrigerant and the use heat exchanger 13 functions as an evaporator of the second refrigerant. As a result, a two-stage refrigeration cycle is performed. Specifically, the first switching mechanism 12x is switched to a connection state indicated by solid lines in Fig. 7, the pump 92, the first compressor 11, the second compressor 21, and the outdoor fan 9 are driven, the third use expansion valve 14 is fully closed, the first heat-source expansion valve 26 is fully closed, the valve opening degree of the second use expansion valve 16 is controlled such that the degree of superheating of the first refrigerant to be sucked into the first compressor 11 satisfies a predetermined condition, and the valve opening degree of the second heat-source expansion valve 24 is controlled such that the degree of superheating of the second refrigerant to be sucked into the second compressor 21 satisfies a predetermined condition.

[0096] Accordingly, the first refrigerant discharged from the first compressor 11 is sent to the first outdoor heat exchanger 18 via the first switching mechanism 12x. The first refrigerant sent to the first outdoor heat exchanger 18 is condensed by heat exchange with the outdoor air supplied by the outdoor fan 9. The first refrigerant having passed through the first outdoor heat exchanger 18 is decompressed in the second use expansion valve 16, passes through the first branch point A, and is sent to the first heat-source flow path 17a of the heat-source heat exchanger 17. The first refrigerant flowing through the first heat-source flow path 17a of the heat-source heat exchanger 17 is evaporated by heat exchange with the second refrigerant flowing through the second heat-source flow path 17b of the heat-source heat exchanger 17. The first refrigerant evaporated in the first heat-source flow path 17a of the heat-source heat exchanger 17 is sucked into the first compressor 11.

[0097] The second refrigerant discharged from the second compressor 21 is sent to the second heat-source flow path 17b of the heat-source heat exchanger 17. The second refrigerant flowing through the second heat-source flow path 17b of the heat-source heat exchanger 17 radiates heat by heat exchange with the first refrigerant flowing through the first heat-source flow path 17a of the heat-source heat exchanger 17. The second refrigerant having passed through the second heat-source flow path 17b of the heat-source heat exchanger 17 is decompressed in the second heat-source expansion valve 24 via the second branch point B, and flows into the use heat exchanger 13. The second refrigerant flowing through the second use flow path 13b of the use heat exchanger 13 is evaporated by heat exchange with the water flowing through the heat-load flow path 13c of the use heat exchanger 13 included in the heat-load circuit 90. The water cooled by this heat exchange is sent to the heat-load heat exchanger 91 in the heat-load circuit 90 to process the cooling load. The second refrigerant having passed through the second use flow path 13b of the use heat exchanger 13 is sucked into the second compressor 21.

(2-2) Heating Operation

[0098] During the heating operation, as illustrated in Fig. 8, the first refrigerant circuit 10 performs a refrigeration cycle such that the use heat exchanger 13 functions as a condenser of the first refrigerant and the heat-source heat exchanger 17 functions as an evaporator of the first refrigerant, and the second refrigerant circuit 20 performs a refrigeration cycle such that the heat-source heat exchanger 17 functions as a radiator of the second refrigerant and the second outdoor heat exchanger 23 functions as an evaporator of the second refrigerant. As a result, a two-stage refrigeration cycle is performed by the second refrigerant circuit 20 and the first refrigerant circuit 10 during the heating operation. Specifically, the first switching mechanism 12x is switched to a connection state indicated by broken lines in Fig. 8, the pump 92, the first compressor 11, the second compressor 21, and the outdoor fan 9 are driven, the second use expansion valve 16 is fully closed, the second heat-source expansion valve 24 is fully closed, the valve opening degree of the third use expansion valve 14 is controlled such that the degree of superheating of the first refrigerant to be sucked into the first compressor 11 satisfies a predetermined condition, and the valve opening degree of the first heat-source expansion valve 26 is controlled such that the degree of superheating of the second refrigerant to be sucked into the second compressor 21 satisfies a predetermined condition.

[0099] Accordingly, the second refrigerant discharged from the second compressor 21 is sent to the heat-source heat exchanger 17. When flowing through the second heat-source flow path 17b, the second refrigerant radiates heat by heat exchange with the first refrigerant flowing through the first heat-source flow path 17a. The second refrigerant, which has radiated heat in the heat-source heat exchanger 17, passes through the second branch point B and is then decompressed in the first heat-source expansion valve 26. Then, the second refrigerant is evaporated by heat exchange with the outdoor air supplied by the outdoor fan 9 in the second outdoor heat exchanger 23, and is sucked into the second compressor 21. The first refrigerant discharged from the first compressor 11 is sent to the first use flow path 13a of the use heat exchanger 13 via the first switching mechanism 12x. The first refrigerant flowing through the first use flow path 13a of the use heat exchanger 13 is condensed by heat exchange with the water flowing through the heat-load flow path 13c of the use heat exchanger 13 included in the heat-load circuit 90. The water heated by this heat exchange is sent to the heat-load heat exchanger 91 in the heat-load circuit 90 to process the heating load. The first refrigerant condensed in the first use flow path 13a of the use heat exchanger 13 is decompressed in the third use expansion valve 14. The first refrigerant decompressed in the third use expansion valve 14 passes through the first branch point A. After that, when passing through the first heat-source flow path 17a of the heat-source heat exchanger 17, the first refrigerant is evaporated by heat exchange with the second refrigerant flowing through the second heat-source flow path 17b. The first refrigerant evaporated in the first heat-source flow path 17a of the heat-source heat exchanger 17 is sucked into the first compressor 11.

(2-3) Features of Second Embodiment

[0100] In the refrigeration cycle apparatus 1a according to the present embodiment, as in the refrigeration cycle apparatus 1 according to the first embodiment, global environmental deterioration can be reduced. In addition, the two-stage refrigeration cycle is performed during the heating operation, thereby making it easy to secure the capacity. The two-stage refrigeration cycle is also performed during the cooling operation. However, the carbon dioxide refrigerant serving as the second refrigerant does not radiate heat in the second outdoor heat exchanger 23, nor is the carbon dioxide refrigerant serving as the second refrigerant evaporated in the heat-source heat exchanger 17 to condense the first refrigerant. Instead of this, in the heat-source heat exchanger 17, the carbon dioxide refrigerant serving as the second refrigerant radiates heat to evaporate the first refrigerant. As a result, the second refrigerant is evaporated in the use heat exchanger 13 to process the cooling load. This makes it possible to perform the cooling operation without causing a reduction in COP due to the pressure of the carbon dioxide refrigerant exceeding the critical pressure when the cooling operation is performed using the carbon dioxide refrigerant in the heat-source-side cycle of the two-stage refrigeration cycle. It is also possible to reduce the compression strength standards required for the components of the second refrigerant circuit 20 in which carbon dioxide, which is a high-pressure refrigerant, is used.

(3) Third Embodiment

[0101] Fig. 9 is a schematic configuration diagram of a refrigeration cycle apparatus 1b according to a third embodiment. Fig. 10 is a functional block configuration diagram of the refrigeration cycle apparatus 1b according to the third embodiment.

[0102] The refrigeration cycle apparatus 1b is an apparatus used to process a heat load through a vapor-compression refrigeration cycle operation. The refrigeration cycle apparatus 1b includes a heat-load circuit 90, a first refrigerant circuit 10, a second refrigerant circuit 20, an outdoor fan 9, and a controller 7.

[0103] The heat load to be processed by the refrigeration cycle apparatus 1b and the heat-load circuit 90 are similar to those according to the first embodiment.

[0104] A use heat exchanger 13 includes a heat-load flow path 13c through which the water flowing through the heat-load circuit 90 passes, a first use flow path 13a through which the first refrigerant flowing through the first refrigerant circuit 10 passes, and a second use flow path 13b through which the second refrigerant flowing through the second refrigerant circuit 20 passes. The water flowing through the heat-load flow path 13c of the use heat exchanger 13 exchanges heat with the first refrigerant flowing through the first use flow path 13a or the second refrigerant flowing through the second use flow path 13b. As a result, the water is cooled during a cooling operation and is heated during a heating operation.

[0105] The first refrigerant circuit 10 includes a first compressor 11, a first switching mechanism 12, the use heat exchanger 13 shared with the heat-load circuit 90 and the second refrigerant circuit 20, a first use expansion valve 15, a second use expansion valve 16, a third use expansion valve 14, a heat-source heat exchanger 17 shared with the second refrigerant circuit 20, and a first outdoor heat exchanger 18. The first refrigerant circuit 10 is filled with the first refrigerant, which is a low-pressure refrigerant, as a refrigerant. The first refrigerant is a refrigerant having 1 MPa or less at 30°C, and is a refrigerant including, for example, at least one of R1234yf or R1234ze. The first refrigerant may include only R1234yf or may include only R1234ze.

[0106] The specific configuration of the first compressor 11 is similar to that according to the first embodiment. A discharge side of the first compressor 11 is connected to the first switching mechanism 12. A suction side of the first compressor 11 is connected to a gas-refrigerant-side outlet of a first heat-source flow path 17a of the heat-source heat exchanger 17.

[0107] The first switching mechanism 12 includes a switching valve 12a and a switching valve 12b. The switching valve 12a and the switching valve 12b are connected in parallel to each other on the discharge side of the first compressor 11. The switching valve 12a is a three-way valve that switches between a state in which the discharge side of the first compressor 11 is connected to the first use flow path 13a of the use heat exchanger 13 and a state in which the suction side of the first compressor 11 is connected to the first use flow path 13a of the use heat exchanger 13. The switching valve 12b is a three-way valve that switches between a state in which the discharge side of the first compressor 11 is connected to the first outdoor heat exchanger 18 and a state in which the suction side of the first compressor 11 is connected to the first outdoor heat exchanger 18.

[0108] A gas refrigerant side of the first use flow path 13a of the use heat exchanger 13 through which the first refrigerant flowing through the first refrigerant circuit 10 passes is connected to the switching valve 12a of the first switching mechanism 12. A liquid refrigerant side of the first use flow path 13a is connected to a flow path extending from the third use expansion valve 14. The first refrigerant condenses when flowing through the first use flow path 13a of the use heat exchanger 13 to heat the water flowing through the heat-load circuit 90.

[0109] The third use expansion valve 14 includes an electronic expansion valve that is adjustable in valve opening degree. The third use expansion valve 14 is disposed between the use heat exchanger 13 and a first branch point A in the first refrigerant circuit 10.

[0110] At the first branch point A, a flow path extending from the third use expansion valve 14, a flow path extending from the first use expansion valve 15, and a flow path extending to the side of the second use expansion valve 16 opposite to the first outdoor heat exchanger 18 side are connected.

[0111] The first use expansion valve 15 is similar to that according to the first embodiment. The second use expansion valve 16 is similar to that according to the first embodiment.

[0112] The heat-source heat exchanger 17 is similar to that according to the first embodiment. The gas-refrigerant-side outlet of the first heat-source flow path 17a of the heat-source heat exchanger 17 is connected to the suction side of the first compressor 11. An inlet on a liquid refrigerant side of the first heat-source flow path 17a of the heat-source heat exchanger 17 is connected to a flow path extending from the first use expansion valve 15.

[0113] The first outdoor heat exchanger 18 is similar to that according to the first embodiment.

[0114] The outdoor fan 9 generates an air flow of outdoor air passing through both the first outdoor heat exchanger 18 and a second outdoor heat exchanger 23.

[0115] The second refrigerant circuit 20 includes a second compressor 21, the use heat exchanger 13 shared with the heat-load circuit 90 and the first refrigerant circuit 10, the heat-source heat exchanger 17 shared with the first refrigerant circuit 10, a first heat-source expansion valve 26, a second heat-source expansion valve 24, and the second outdoor heat exchanger 23. The second refrigerant circuit 20 is filled with the second refrigerant, which is a high-pressure refrigerant, as a refrigerant. The second refrigerant is a refrigerant having 1.5 MPa or more at 30°C. The second refrigerant may include carbon dioxide, or may include only carbon dioxide.

[0116] The specific configuration of the second compressor 21 is similar to that according to the first embodiment. A discharge side of the second compressor 21 is connected to an inlet on a gas refrigerant side of the second heat-source flow path 17b of the heat-source heat exchanger 17. A suction side of the second compressor 21 is connected to a flow path extending from a third branch point C in the second refrigerant circuit 20.

[0117] At the third branch point C, a flow path extending from the suction side of the second compressor 21, a flow path extending from an outlet on a gas refrigerant side of the second outdoor heat exchanger 23, and a flow path extending from the outlet on the gas refrigerant side of the second use flow path 13b of the use heat exchanger 13 are connected.

[0118] The inlet on the gas refrigerant side of the second heat-source flow path 17b of the heat-source heat exchanger 17 is connected to the discharge side of the second compressor 21. An outlet on a liquid refrigerant side of the second heat-source flow path 17b of the heat-source heat exchanger 17 is connected to a flow path extending from a second branch point B in the second refrigerant circuit 20. The second refrigerant radiates heat when flowing through the second heat-source flow path 17b of the heat-source heat exchanger 17 to evaporate the first refrigerant flowing through the first heat-source flow path 17a.

[0119] At the second branch point B, a flow path extending from the outlet on the liquid refrigerant side of the second heat-source flow path 17b of the heat-source heat exchanger 17, a flow path extending from the first heat-source expansion valve 26, and a flow path extending from the second heat-source expansion valve 24 are connected.

[0120] The first heat-source expansion valve 26 is disposed in a flow path between the second branch point B and an inlet on a liquid refrigerant side of the second outdoor heat exchanger 23.

[0121] The second outdoor heat exchanger 23 is similar to that according to the first embodiment.

[0122] The second heat-source expansion valve 24 is disposed in a flow path between the second branch point B and an inlet on a liquid refrigerant side of the second use flow path 13b of the use heat exchanger 13.

[0123] The second use flow path 13b of the use heat exchanger 13 through which the second refrigerant flowing through the second refrigerant circuit 20 passes is disposed in a flow path between the second heat-source expansion valve 24 and the third branch point C. The second refrigerant evaporates when flowing through the second use flow path 13b of the use heat exchanger 13 to cool the water flowing through the heat-load circuit 90.

[0124] The controller 7 controls the operation of the devices included in the heat-load circuit 90, the first refrigerant circuit 10, and the second refrigerant circuit 20. Specifically, the controller 7 includes a processor serving as a CPU provided for performing control, a memory, and the like.

[0125] In the refrigeration cycle apparatus 1b described above, the controller 7 controls the devices to execute a refrigeration cycle, thereby performing a cooling operation for processing a cooling load in the heat-load heat exchanger 91 and a heating operation for processing a heating load in the heat-load heat exchanger 91.

(3-1) Cooling Operation

[0126] During the cooling operation, as illustrated in Fig. 11, while the first refrigerant circuit 10 performs a refrigeration cycle such that the first outdoor heat exchanger 18 functions as a condenser of the first refrigerant and the heat-source heat exchanger 17 functions as an evaporator of the first refrigerant, the second refrigerant circuit 20 performs a refrigeration cycle such that the heat-source heat exchanger 17 functions as a radiator of the second refrigerant and the use heat exchanger 13 functions as an evaporator of the second refrigerant. As a result, a two-stage refrigeration cycle is performed. Specifically, the switching valves 12a and 12b of the first switching mechanism 12 are switched to a connection state indicated by solid lines in Fig. 11, the pump 92, the first compressor 11, the second compressor 21, and the outdoor fan 9 are driven, the third use expansion valve 14 is fully closed, the first heat-source expansion valve 26 is fully closed, one of the first use expansion valve 15 and the second use expansion valve 16 is controlled to be fully opened while the valve opening degree of the other use expansion valve is controlled such that the degree of superheating of the first refrigerant to be sucked into the first compressor 11 satisfies a predetermined condition, and the valve opening degree of the second heat-source expansion valve 24 is controlled such that the degree of superheating of the second refrigerant to be sucked into the second compressor 21 satisfies a predetermined condition.

[0127] Accordingly, the first refrigerant discharged from the first compressor 11 is sent to the first outdoor heat exchanger 18 via the switching valve 12b of the first switching mechanism 12. The first refrigerant sent to the first outdoor heat exchanger 18 is condensed by heat exchange with the outdoor air supplied by the outdoor fan 9. The first refrigerant having passed through the first outdoor heat exchanger 18 is decompressed in the second use expansion valve 16 and passes through the first branch point A, or is decompressed in the first use expansion valve 15 after passing through the first branch point A. Then, the first refrigerant is sent to the first heat-source flow path 17a of the heat-source heat exchanger 17. The first refrigerant flowing through the first heat-source flow path 17a of the heat-source heat exchanger 17 is evaporated by heat exchange with the second refrigerant flowing through the second heat-source flow path 17b of the heat-source heat exchanger 17. The first refrigerant evaporated in the first heat-source flow path 17a of the heat-source heat exchanger 17 is sucked into the first compressor 11.

[0128] The second refrigerant discharged from the second compressor 21 is sent to the second heat-source flow path 17b of the heat-source heat exchanger 17. The second refrigerant flowing through the second heat-source flow path 17b of the heat-source heat exchanger 17 radiates heat by heat exchange with the first refrigerant flowing through the first heat-source flow path 17a of the heat-source heat exchanger 17. The second refrigerant having passed through the second heat-source flow path 17b of the heat-source heat exchanger 17 is decompressed in the second heat-source expansion valve 24 via the second branch point B, and flows into the use heat exchanger 13. The second refrigerant flowing through the second use flow path 13b of the use heat exchanger 13 is evaporated by heat exchange with the water flowing through the heat-load flow path 13c of the use heat exchanger 13 included in the heat-load circuit 90. The water cooled by this heat exchange is sent to the heat-load heat exchanger 91 in the heat-load circuit 90 to process the cooling load. The second refrigerant having passed through the second use flow path 13b of the use heat exchanger 13 is sucked into the second compressor 21.

(3-2) Heating Operation

[0129] During the heating operation, as illustrated in Fig. 12, the first refrigerant circuit 10 performs a refrigeration cycle such that the use heat exchanger 13 functions as a condenser of the first refrigerant and the heat-source heat exchanger 17 functions as an evaporator of the first refrigerant, and the second refrigerant circuit 20 performs a refrigeration cycle such that the heat-source heat exchanger 17 functions as a radiator of the second refrigerant and the second outdoor heat exchanger 23 functions as an evaporator of the second refrigerant. As a result, a two-stage refrigeration cycle is performed by the second refrigerant circuit 20 and the first refrigerant circuit 10 during the heating operation. Specifically, the switching valves 12a and 12b of the first switching mechanism 12 are switched to a connection state indicated by broken lines in Fig. 12, the pump 92, the first compressor 11, the second compressor 21, and the outdoor fan 9 are driven, the second use expansion valve 16 is fully closed, the second heat-source expansion valve 24 is fully closed, the valve opening degree of the third use expansion valve 14 or the first use expansion valve 15 is controlled such that the degree of superheating of the first refrigerant to be sucked into the first compressor 11 satisfies a predetermined condition, and the valve opening degree of the first heat-source expansion valve 26 is controlled such that the degree of superheating of the second refrigerant to be sucked into the second compressor 21 satisfies a predetermined condition.

[0130] Accordingly, the second refrigerant discharged from the second compressor 21 is sent to the heat-source heat exchanger 17. When flowing through the second heat-source flow path 17b, the second refrigerant radiates heat by heat exchange with the first refrigerant flowing through the first heat-source flow path 17a. The second refrigerant, which has radiated heat in the heat-source heat exchanger 17, passes through the second branch point B and is then decompressed in the first heat-source expansion valve 26. Then, the second refrigerant is evaporated by heat exchange with the outdoor air supplied by the outdoor fan 9 in the second outdoor heat exchanger 23, and is sucked into the second compressor 21. The first refrigerant discharged from the first compressor 11 is sent to the first use flow path 13a of the use heat exchanger 13 via the switching valve 12a of the first switching mechanism 12. The first refrigerant flowing through the first use flow path 13a of the use heat exchanger 13 is condensed by heat exchange with the water flowing through the heat-load flow path 13c of the use heat exchanger 13 included in the heat-load circuit 90. The water heated by this heat exchange is sent to the heat-load heat exchanger 91 in the heat-load circuit 90 to process the heating load. The first refrigerant condensed in the first use flow path 13a of the use heat exchanger 13 passes through the first branch point A after being decompressed in the third use expansion valve 14, or passes through the first branch point A and is then decompressed in the first use expansion valve 15. The first refrigerant having passed through the first branch point A is evaporated, when passing through the first heat-source flow path 17a of the heat-source heat exchanger 17, by heat exchange with the second refrigerant flowing through the second heat-source flow path 17b. The first refrigerant evaporated in the first heat-source flow path 17a of the heat-source heat exchanger 17 is sucked into the first compressor 11.

(3-3) Features of Third Embodiment

[0131] Like the refrigeration cycle apparatus 1 according to the first embodiment, the refrigeration cycle apparatus 1b according to the present embodiment can reduce global environmental deterioration and can easily secure heating operation capacity. The two-stage refrigeration cycle is also performed during the cooling operation. However, the carbon dioxide refrigerant serving as the second refrigerant does not radiate heat in the second outdoor heat exchanger 23, nor is the carbon dioxide refrigerant serving as the second refrigerant evaporated in the heat-source heat exchanger 17 to condense the first refrigerant. Instead of this, in the heat-source heat exchanger 17, the carbon dioxide refrigerant serving as the second refrigerant radiates heat to evaporate the first refrigerant. As a result, the second refrigerant is evaporated in the use heat exchanger 13 to process the cooling load. This makes it possible to perform the cooling operation without causing a reduction in COP due to the pressure of the carbon dioxide refrigerant exceeding the critical pressure when the cooling operation is performed using the carbon dioxide refrigerant in the heat-source-side cycle of the two-stage refrigeration cycle. It is also possible to reduce the compression strength standards required for the components of the second refrigerant circuit 20 in which carbon dioxide, which is a high-pressure refrigerant, is used.

(4) Fourth Embodiment

[0132] Fig. 13 is a schematic configuration diagram of a refrigeration cycle apparatus 1c according to a fourth embodiment. Fig. 14 is a functional block configuration diagram of the refrigeration cycle apparatus 1c according to the fourth embodiment.

[0133] The refrigeration cycle apparatus 1c is an apparatus used to process a heat load through a vapor-compression refrigeration cycle operation. The refrigeration cycle apparatus 1c includes a heat-load circuit 90, a first refrigerant circuit 10, a second refrigerant circuit 20, an outdoor fan 9, and a controller 7.

[0134] The heat load to be processed by the refrigeration cycle apparatus 1c and the heat-load circuit 90 are similar to those according to the first embodiment.

[0135] A use heat exchanger 13 includes a heat-load flow path 13c through which the water flowing through the heat-load circuit 90 passes, a first use flow path 13a through which the first refrigerant flowing through the first refrigerant circuit 10 passes, and a second use flow path 13b through which the second refrigerant flowing through the second refrigerant circuit 20 passes. The water flowing through the heat-load flow path 13c of the use heat exchanger 13 exchanges heat with the first refrigerant flowing through the first use flow path 13a and/or the second refrigerant flowing through the second use flow path 13b. As a result, the water is cooled during a cooling operation and is heated during a heating operation.

[0136] The first refrigerant circuit 10 includes a first compressor 11, a first switching mechanism 12, the use heat exchanger 13 shared with the heat-load circuit 90 and the second refrigerant circuit 20, a first use expansion valve 15, a second use expansion valve 16, a third use expansion valve 14, a heat-source heat exchanger 17 shared with the second refrigerant circuit 20, and a first outdoor heat exchanger 18. The first refrigerant circuit 10 is filled with the first refrigerant, which is a low-pressure refrigerant, as a refrigerant. The first refrigerant is a refrigerant having 1 MPa or less at 30°C, and is a refrigerant including, for example, at least one of R1234yf or R1234ze. The first refrigerant may include only R1234yf or may include only R1234ze.

[0137] The specific configuration of the first compressor 11 is similar to that according to the first embodiment. A discharge side and a suction side of the first compressor 11 are connected to different connection points of the first switching mechanism 12.

[0138] The first switching mechanism 12 includes a switching valve 12a, a switching valve 12b, and a switching valve 12c. The switching valve 12a, the switching valve 12b, and the switching valve 12c are connected in parallel to each other on the discharge side of the first compressor 11. The switching valve 12a is a three-way valve that switches between a state in which the discharge side of the first compressor 11 is connected to the first use flow path 13a of the use heat exchanger 13 and a state in which the suction side of the first compressor 11 is connected to the first use flow path 13a of the use heat exchanger 13. The switching valve 12b is a three-way valve that switches between a state in which the discharge side of the first compressor 11 is connected to the first outdoor heat exchanger 18 and a state in which the suction side of the first compressor 11 is connected to the first outdoor heat exchanger 18. The switching valve 12c is a three-way valve that switches between a state in which the discharge side of the first compressor 11 is connected to a first heat-source flow path 17a of the heat-source heat exchanger 17 and a state in which the suction side of the first compressor 11 is connected to the first heat-source flow path 17a of the heat-source heat exchanger 17.

[0139] A gas refrigerant side of the first use flow path 13a of the use heat exchanger 13 through which the first refrigerant flowing through the first refrigerant circuit 10 passes is connected to the switching valve 12a of the first switching mechanism 12. A liquid refrigerant side of the first use flow path 13a is connected to a flow path extending from the third use expansion valve 14. The first refrigerant evaporates when flowing through the first use flow path 13a of the use heat exchanger 13 to cool the water flowing through the heat-load circuit 90. The first refrigerant condenses when flowing through the first use flow path 13a of the use heat exchanger 13 to heat the water flowing through the heat-load circuit 90.

[0140] The third use expansion valve 14 includes an electronic expansion valve that is adjustable in valve opening degree. The third use expansion valve 14 is disposed between the use heat exchanger 13 and a first branch point A in the first refrigerant circuit 10.

[0141] At the first branch point A, a flow path extending from the third use expansion valve 14, a flow path extending from the first use expansion valve 15, and a flow path extending to the side of the second use expansion valve 16 opposite to the first outdoor heat exchanger 18 side are connected.

[0142] The first use expansion valve 15 is similar to that according to the first embodiment.

[0143] The second use expansion valve 16 is similar to that according to the first embodiment.

[0144] The heat-source heat exchanger 17 is similar to that according to the first embodiment. An outlet on a gas refrigerant side of the first heat-source flow path 17a of the heat-source heat exchanger 17 is connected to the switching valve 12c of the first switching mechanism 12. An inlet on a liquid refrigerant side of the first heat-source flow path 17a of the heat-source heat exchanger 17 is connected to a flow path extending from the first use expansion valve 15.

[0145] The first outdoor heat exchanger 18 is similar to that according to the first embodiment.

[0146] The outdoor fan 9 generates an air flow of outdoor air passing through both the first outdoor heat exchanger 18 and a second outdoor heat exchanger 23.

[0147] The second refrigerant circuit 20 includes a second compressor 21, a second switching mechanism 22, the use heat exchanger 13 shared with the heat-load circuit 90 and the first refrigerant circuit 10, the heat-source heat exchanger 17 shared with the first refrigerant circuit 10, a first heat-source expansion valve 26, a second heat-source expansion valve 24, a third heat-source expansion valve 25, and the second outdoor heat exchanger 23. The second refrigerant circuit 20 is filled with the second refrigerant, which is a high-pressure refrigerant, as a refrigerant. The second refrigerant is a refrigerant having 1.5 MPa or more at 30°C. The second refrigerant may include carbon dioxide, or may include only carbon dioxide.

[0148] The specific configuration of the second compressor 21 is similar to that according to the first embodiment. A discharge side and a suction side of the second compressor 21 are connected to different connection points of the second switching mechanism 22.

[0149] The second switching mechanism 22 includes a switching valve 22a, a switching valve 22b, and a switching valve 22c. The switching valve 22a, the switching valve 22b, and the switching valve 22c are connected in parallel to each other on the discharge side of the second compressor 21. The switching valve 22a is a three-way valve that switches between a state in which the discharge side of the second compressor 21 is connected to the second use flow path 13b of the use heat exchanger 13 and a state in which the suction side of the second compressor 21 is connected to the second use flow path 13b of the use heat exchanger 13. The switching valve 22b is a three-way valve that switches between a state in which the discharge side of the second compressor 21 is connected to the second outdoor heat exchanger 23 and a state in which the suction side of the second compressor 21 is connected to the second outdoor heat exchanger 23. The switching valve 22c is a three-way valve that switches between a state in which the discharge side of the second compressor 21 is connected to a second heat-source flow path 17b of the heat-source heat exchanger 17 and a state in which the suction side of the second compressor 21 is connected to the second heat-source flow path 17b of the heat-source heat exchanger 17.

[0150] An inlet on a gas refrigerant side of the second heat-source flow path 17b of the heat-source heat exchanger 17 is connected to the switching valve 22c of the second switching mechanism 22. An outlet on a liquid refrigerant side of the second heat-source flow path 17b of the heat-source heat exchanger 17 is connected to a flow path extending from the third heat-source expansion valve 25. The second refrigerant radiates heat when flowing through the second heat-source flow path 17b of the heat-source heat exchanger 17 to evaporate the first refrigerant flowing through the first heat-source flow path 17a.

[0151] At a second branch point B, a flow path extending from the third heat-source expansion valve 25, a flow path extending from the first heat-source expansion valve 26, and a flow path extending from the second heat-source expansion valve 24 are connected.

[0152] The first heat-source expansion valve 26 is disposed in a flow path between the second branch point B and an inlet on a liquid refrigerant side of the second outdoor heat exchanger 23.

[0153] The second outdoor heat exchanger 23 is similar to that according to the first embodiment.

[0154] The second heat-source expansion valve 24 is disposed in a flow path between the second branch point B and an inlet on a liquid refrigerant side of the second use flow path 13b of the use heat exchanger 13.

[0155] The second use flow path 13b of the use heat exchanger 13 through which the second refrigerant flowing through the second refrigerant circuit 20 passes is disposed in a flow path between the second heat-source expansion valves 24 and the switching valve 22a of the second switching mechanism 22. The second refrigerant evaporates when flowing through the second use flow path 13b of the use heat exchanger 13 to cool the water flowing through the heat-load circuit 90. The second refrigerant radiates heat when flowing through the second use flow path 13b of the use heat exchanger 13 to heat the water flowing through the heat-load circuit 90.

[0156] The controller 7 controls the operation of the devices included in the heat-load circuit 90, the first refrigerant circuit 10, and the second refrigerant circuit 20. Specifically, the controller 7 includes a processor serving as a CPU provided for performing control, a memory, and the like.

[0157] In the refrigeration cycle apparatus 1c described above, the controller 7 controls the devices to execute a refrigeration cycle, thereby performing a cooling operation for processing a cooling load in the heat-load heat exchanger 91 and a heating operation for processing a heating load in the heat-load heat exchanger 91.

(4-1) Cooling Operation

[0158] During the cooling operation, a first cooling operation, a second cooling operation, and a third cooling operation are selectively performed.

[0159] In the first cooling operation, as illustrated in Fig. 15, the first refrigerant circuit 10 performs a refrigeration cycle such that the first outdoor heat exchanger 18 functions as a condenser of the first refrigerant and the use heat exchanger 13 functions as an evaporator of the first refrigerant, and the second refrigerant circuit 20 causes the second compressor 21 to stop operation. As a result, a single-stage refrigeration cycle is performed. Specifically, the switching valves 12a, 12b, and 12c of the first switching mechanism 12 are switched to a connection state indicated by solid lines in Fig. 15, the pump 92, the first compressor 11, and the outdoor fan 9 are driven, the second use expansion valve 16 is fully opened, the first use expansion valve 15 is controlled to be fully closed, and the valve opening degree of the third use expansion valve 14 is controlled such that the degree of superheating of the first refrigerant to be sucked into the first compressor 11 satisfies a predetermined condition.

[0160] Accordingly, the first refrigerant discharged from the first compressor 11 is sent to the first outdoor heat exchanger 18 via the switching valve 12b of the first switching mechanism 12. The first refrigerant sent to the first outdoor heat exchanger 18 is condensed by heat exchange with the outdoor air supplied by the outdoor fan 9. The first refrigerant having passed through the first outdoor heat exchanger 18 passes through the second use expansion valve 16 and the first branch point A, is decompressed in the third use expansion valve 14, and then flows into the use heat exchanger 13. The first refrigerant flowing through the first use flow path 13a of the use heat exchanger 13 is evaporated by heat exchange with the water flowing through the heat-load flow path 13c of the use heat exchanger 13 included in the heat-load circuit 90. The water cooled by this heat exchange is sent to the heat-load heat exchanger 91 in the heat-load circuit 90 to process the cooling load. The first refrigerant evaporated in the first use flow path 13a is sucked into the first compressor 11 via the switching valve 12a of the first switching mechanism 12.

[0161] The second cooling operation is performed when the single-stage refrigeration cycle performed by the first refrigerant circuit 10 causes insufficient capacity because the required temperature of the heat medium flowing through the heat-load circuit 90 drops to a predetermined value or less to increase the cooling load. The second cooling operation is performed, in particular, in a refrigeration cycle apparatus in which the heat medium flowing through the heat-load circuit 90 is antifreeze, when the temperature required in the heat-load circuit 90 is low. In the second cooling operation, as illustrated in Fig. 16, the first refrigerant circuit 10 performs a refrigeration cycle such that the first outdoor heat exchanger 18 functions as a condenser of the first refrigerant and the heat-source heat exchanger 17 functions as an evaporator of the first refrigerant, and the second refrigerant circuit 20 performs a refrigeration cycle such that the heat-source heat exchanger 17 functions as a radiator of the second refrigerant and the use heat exchanger 13 functions as an evaporator of the second refrigerant. As a result, a two-stage refrigeration cycle is performed. Specifically, the switching valves 12a, 12b, and 12c of the first switching mechanism 12 are switched to a connection state indicated by solid lines in Fig. 16, the switching valves 22a, 22b, and 22c of the second switching mechanism 22 are switched to a connection state indicated by solid lines in Fig. 16, and the pump 92, the first compressor 11, the second compressor 21, and the outdoor fan 9 are driven. Then, the second use expansion valve 16 is controlled to be fully opened, the third use expansion valve 14 is controlled to be fully closed, and the valve opening degree of the first use expansion valve 15 is controlled such that the degree of superheating of the first refrigerant to be sucked into the first compressor 11 satisfies a predetermined condition. Further, the first heat-source expansion valve 26 is controlled to be fully closed, the third heat-source expansion valve 25 is controlled to be fully opened, and the valve opening degree of the second heat-source expansion valve 24 is controlled such that the degree of superheating of the second refrigerant to be sucked into the second compressor 21 satisfies a predetermined condition.

[0162] Accordingly, the first refrigerant discharged from the first compressor 11 is sent to the first outdoor heat exchanger 18 via the switching valve 12b of the first switching mechanism 12. The first refrigerant sent to the first outdoor heat exchanger 18 is condensed by heat exchange with the outdoor air supplied by the outdoor fan 9. The first refrigerant having passed through the first outdoor heat exchanger 18 passes through the second use expansion valve 16, is decompressed in the first use expansion valve 15, and then flows into the heat-source heat exchanger 17. The first refrigerant flowing through the first heat-source flow path 17a of the heat-source heat exchanger 17 is evaporated by heat exchange with the second refrigerant flowing through the second heat-source flow path 17b. The first refrigerant evaporated in the heat-source heat exchanger 17 is sucked into the first compressor 11 via the switching valve 12c of the first switching mechanism 12. The second refrigerant discharged from the second compressor 21 is sent to the heat-source heat exchanger 17 via the switching valve 22c of the second switching mechanism 22. The second refrigerant flowing through the second heat-source flow path 17b of the heat-source heat exchanger 17 radiates heat by heat exchange with the first refrigerant flowing through the first heat-source flow path 17a. The second refrigerant having passed through the heat-source heat exchanger 17 passes through the third heat-source expansion valve 25, is decompressed in the second heat-source expansion valve 24, and then flows into the use heat exchanger 13. The second refrigerant flowing through the second use flow path 13b of the use heat exchanger 13 is evaporated by heat exchange with the antifreeze flowing through the heat-load flow path 13c of the use heat exchanger 13 included in the heat-load circuit 90. The antifreeze cooled by this heat exchange is sent to the heat-load heat exchanger 91 in the heat-load circuit 90 to process the cooling load. The second refrigerant evaporated in the use heat exchanger 13 is sucked into the second compressor 21 via the switching valve 22a of the second switching mechanism 22.

[0163] The third cooling operation is an operation performed when more emphasis is placed on the exercise of the capacity than the increase of the operation efficiency in a case where the temperature of the heat medium flowing through the heat-load circuit 90 is higher than a predetermined value and the cooling load is large. In the third cooling operation, parallel refrigeration cycles are performed by the first refrigerant circuit 10 and the second refrigerant circuit 20 to exercise the capacity more than when the single-stage refrigeration cycle using the first refrigerant or the two-stage refrigeration cycle in which the first refrigerant is used in the heat-source-side refrigeration cycle in the higher stage and the second refrigerant is used in the use-side refrigeration cycle in the lower stage is performed. In the third cooling operation, as illustrated in Fig. 17, which is not in accordance with the present invention, the first refrigerant circuit 10 performs a refrigeration cycle such that the first outdoor heat exchanger 18 functions as a condenser of the first refrigerant and the use heat exchanger 13 functions as an evaporator of the first refrigerant, and the second refrigerant circuit 20 performs a refrigeration cycle such that the second outdoor heat exchanger 23 functions as a radiator of the second refrigerant and the use heat exchanger 13 functions as an evaporator of the second refrigerant. As a result, parallel refrigeration cycles are performed. Specifically, the switching valves 12a, 12b, and 12c of the first switching mechanism 12 are switched to a connection state indicated by solid lines in Fig. 17, the switching valves 22a, 22b, and 22c of the second switching mechanism 22 are switched to a connection state indicated by solid lines in Fig. 17, and the pump 92, the first compressor 11, the second compressor 21, and the outdoor fan 9 are driven. Then, the second use expansion valve 16 is controlled to be fully opened, the first use expansion valve 15 is controlled to be fully closed, and the valve opening degree of the third use expansion valve 14 is controlled such that the degree of superheating of the first refrigerant to be sucked into the first compressor 11 satisfies a predetermined condition. Further, the first heat-source expansion valve 26 is controlled to be fully opened, the third heat-source expansion valve 25 is controlled to be fully closed, and the valve opening degree of the second heat-source expansion valve 24 is controlled such that the degree of superheating of the second refrigerant to be sucked into the second compressor 21 satisfies a predetermined condition.

[0164] Accordingly, the first refrigerant discharged from the first compressor 11 is sent to the first outdoor heat exchanger 18 via the switching valve 12b of the first switching mechanism 12. The first refrigerant sent to the first outdoor heat exchanger 18 is condensed by heat exchange with the outdoor air supplied by the outdoor fan 9. The first refrigerant having passed through the first outdoor heat exchanger 18 passes through the second use expansion valve 16, is decompressed in the third use expansion valve 14, and then flows into the use heat exchanger 13. The first refrigerant flowing through the first use flow path 13a of the use heat exchanger 13 is evaporated by heat exchange with the water flowing through the heat-load flow path 13c of the use heat exchanger 13 included in the heat-load circuit 90. The first refrigerant evaporated in the use heat exchanger 13 is sucked into the first compressor 11 via the switching valve 12a of the first switching mechanism 12. The second refrigerant discharged from the second compressor 21 is sent to the second outdoor heat exchanger 23 via the switching valve 22b of the second switching mechanism 22. The second refrigerant sent to the second outdoor heat exchanger 23 radiates heat by heat exchange with the outdoor air supplied by the outdoor fan 9. The second refrigerant having passed through the second outdoor heat exchanger 23 passes through the first heat-source expansion valve 26, is decompressed in the second heat-source expansion valve 24, and then flows into the use heat exchanger 13. The second refrigerant flowing through the second use flow path 13b of the use heat exchanger 13 is evaporated by heat exchange with the water flowing through the heat-load flow path 13c of the use heat exchanger 13 included in the heat-load circuit 90. The water cooled by exchanging heat with the two refrigerants, namely, the first refrigerant and the second refrigerant, in the way described above is sent to the heat-load heat exchanger 91 in the heat-load circuit 90 to process the cooling load. The second refrigerant evaporated in the use heat exchanger 13 is sucked into the second compressor 21 via the switching valve 22a of the second switching mechanism 22.

(4-2) Heating Operation

[0165] During the heating operation, a first heating operation, a second heating operation, and a third heating operation are selectively performed.

[0166] The first heating operation is performed when the outside air temperature is equal to or higher than a predetermined value.

[0167] In the first heating operation, as illustrated in Fig. 18, which is not in accordance with the present invention, the first refrigerant circuit 10 causes the use heat exchanger 13 to function as a condenser of the first refrigerant, and causes the first outdoor heat exchanger 18 to function as an evaporator of the first refrigerant, and the second refrigerant circuit 20 causes the second compressor 21 to stop operation. As a result, a single-stage refrigeration cycle is performed. Specifically, the switching valves 12a and 12b of the first switching mechanism 12 are switched to a connection state indicated by broken lines in Fig. 18 and the switching valve 12c are switched to a connection state indicated by solid line in Fig. 18, the pump 92, the first compressor 11, and the outdoor fan 9 are driven, the third use expansion valve 14 is fully opened, the first use expansion valve 15 is controlled to be fully closed, and the valve opening degree of the second use expansion valve 16 is controlled such that the degree of superheating of the first refrigerant to be sucked into the first compressor 11 satisfies a predetermined condition.

[0168] Accordingly, the first refrigerant discharged from the first compressor 11 is sent to the first use flow path 13a of the use heat exchanger 13 via the switching valve 12a of the first switching mechanism 12. The first refrigerant flowing through the first use flow path 13a of the use heat exchanger 13 is condensed by heat exchange with the water flowing through the heat-load flow path 13c of the use heat exchanger 13 included in the heat-load circuit 90. The water heated by this heat exchange is sent to the heat-load heat exchanger 91 in the heat-load circuit 90 to process the heating load. The first refrigerant condensed in the first use flow path 13a of the use heat exchanger 13 passes through the third use expansion valve 14 and the first branch point A, is decompressed in the second use expansion valve 16, and then flows into the first outdoor heat exchanger 18. The first refrigerant sent to the first outdoor heat exchanger 18 is evaporated by heat exchange with the outdoor air supplied by the outdoor fan 9. The first refrigerant evaporated in the first outdoor heat exchanger 18 is sucked into the first compressor 11 via the switching valve 12b of the first switching mechanism 12.

[0169] The second heating operation is an operation performed when the outside air temperature drops to a predetermined value or lower and the capacity is difficult to secure with the single-stage refrigeration cycle using the first refrigerant in the first refrigerant circuit 10. In the second heating operation, as illustrated in Fig. 19, the first refrigerant circuit 10 performs a refrigeration cycle such that the use heat exchanger 13 functions as a condenser of the first refrigerant and the heat-source heat exchanger 17 functions as an evaporator of the first refrigerant, and the second refrigerant circuit 20 performs a refrigeration cycle such that the heat-source heat exchanger 17 functions as a radiator of the second refrigerant and the second outdoor heat exchanger 23 functions as an evaporator of the second refrigerant. As a result, a two-stage refrigeration cycle is performed. Specifically, the switching valves 12a, 12b, and 12c of the first switching mechanism 12 are switched to a connection state indicated by broken lines in Fig. 19, the switching valves 22a, 22b, and 22c of the second switching mechanism 22 are switched to a connection state indicated by solid lines in Fig. 19, and the pump 92, the first compressor 11, the second compressor 21, and the outdoor fan 9 are driven. Then, the second use expansion valve 16 is controlled to be fully closed, the third use expansion valve 14 is controlled to be fully opened, and the valve opening degree of the first use expansion valve 15 is controlled such that the degree of superheating of the first refrigerant to be sucked into the first compressor 11 satisfies a predetermined condition. Further, the second heat-source expansion valve 24 is controlled to be fully closed, the third heat-source expansion valve 25 is controlled to be fully opened, and the valve opening degree of the first heat-source expansion valve 26 is controlled such that the degree of superheating of the second refrigerant to be sucked into the second compressor 21 satisfies a predetermined condition.

[0170] Accordingly, the first refrigerant discharged from the first compressor 11 is sent to the use heat exchanger 13 via the switching valve 12a of the first switching mechanism 12. The first refrigerant flowing through the first use flow path 13a of the use heat exchanger 13 is condensed by heat exchange with the water flowing through the heat-load flow path 13c of the use heat exchanger 13 included in the heat-load circuit 90. The water heated by this heat exchange is sent to the heat-load heat exchanger 91 in the heat-load circuit 90 to process the heating load. The first refrigerant having passed through the use heat exchanger 13 passes through the third use expansion valve 14, is decompressed in the first use expansion valve 15, and then flows into the heat-source heat exchanger 17. The first refrigerant flowing through the first heat-source flow path 17a of the heat-source heat exchanger 17 is evaporated by heat exchange with the second refrigerant flowing through the second heat-source flow path 17b. The first refrigerant evaporated in the heat-source heat exchanger 17 is sucked into the first compressor 11 via the switching valve 12c of the first switching mechanism 12. The second refrigerant discharged from the second compressor 21 is sent to the heat-source heat exchanger 17 via the switching valve 22c of the second switching mechanism 22. The second refrigerant flowing through the second heat-source flow path 17b of the heat-source heat exchanger 17 radiates heat by heat exchange with the first refrigerant flowing through the first heat-source flow path 17a. The second refrigerant having passed through the heat-source heat exchanger 17 passes through the third heat-source expansion valve 25, is decompressed in the first heat-source expansion valve 26, and then flows into the second outdoor heat exchanger 23. The second refrigerant sent to the second outdoor heat exchanger 23 is evaporated by heat exchange with the outdoor air supplied by the outdoor fan 9. The second refrigerant evaporated in the second outdoor heat exchanger 23 is sucked into the second compressor 21 via the switching valve 22b of the second switching mechanism 22.

[0171] The third heating operation is an operation performed when more emphasis is placed on the exercise of the capacity than the increase of the operation efficiency in a case where the temperature of the heat medium flowing through the heat-load circuit 90 is lower than a predetermined value and the heating load is large. In the third heating operation, parallel refrigeration cycles are performed by the first refrigerant circuit 10 and the second refrigerant circuit 20 to exercise the capacity more than the single-stage refrigeration cycle using the first refrigerant and more than the two-stage refrigeration cycle in which the first refrigerant is used in the heat-source-side refrigeration cycle in the higher stage and the second refrigerant is used in the use-side refrigeration cycle in the lower stage. In the third heating operation, as illustrated in Fig. 20, which is not in accordance with the present invention, the first refrigerant circuit 10 performs a refrigeration cycle such that the use heat exchanger 13 functions as a condenser of the first refrigerant and the first outdoor heat exchanger 18 functions as an evaporator of the first refrigerant, and the second refrigerant circuit 20 performs a refrigeration cycle such that the use heat exchanger 13 functions as a radiator of the second refrigerant and the second outdoor heat exchanger 23 functions as an evaporator of the second refrigerant. As a result, parallel refrigeration cycles are performed. Specifically, the switching valves 12a, 12b, and 12c of the first switching mechanism 12 are switched to a connection state indicated by broken lines in Fig. 20, the switching valves 22a and 22c of the second switching mechanism 22 are switched to a connection state indicated by broken lines in Fig. 20, the switching valve 22b of the second switching mechanism 22 is switched to a connection state indicated by a solid line in Fig. 20, and the pump 92, the first compressor 11, the second compressor 21, and the outdoor fan 9 are driven. Then, the third use expansion valve 14 is controlled to be fully opened, the first use expansion valve 15 is controlled to be fully closed, and the valve opening degree of the second use expansion valve 16 is controlled such that the degree of superheating of the first refrigerant to be sucked into the first compressor 11 satisfies a predetermined condition. Further, the second heat-source expansion valve 24 is controlled to be fully opened, the third heat-source expansion valve 25 is controlled to be fully closed, and the valve opening degree of the first heat-source expansion valve 26 is controlled such that the degree of superheating of the second refrigerant to be sucked into the second compressor 21 satisfies a predetermined condition.

[0172] Accordingly, the first refrigerant discharged from the first compressor 11 is sent to the use heat exchanger 13 via the switching valve 12a of the first switching mechanism 12, and the first refrigerant flowing through the first use flow path 13a of the use heat exchanger 13 is condensed by heat exchange with the water flowing through the heat-load flow path 13c of the use heat exchanger 13 included in the heat-load circuit 90. The first refrigerant having passed through the use heat exchanger 13 passes through the third use expansion valve 14, is decompressed in the second use expansion valve 16, and then flows into the first outdoor heat exchanger 18. The first refrigerant sent to the first outdoor heat exchanger 18 is evaporated by heat exchange with the outdoor air supplied by the outdoor fan 9. The first refrigerant evaporated in the first outdoor heat exchanger 18 is sucked into the first compressor 11 via the switching valve 12b of the first switching mechanism 12. The second refrigerant discharged from the second compressor 21 is sent to the use heat exchanger 13 via the switching valve 22a of the second switching mechanism 22. The second refrigerant flowing through the second use flow path 13b of the use heat exchanger 13 radiates heat by heat exchange with the water flowing through the heat-load flow path 13c of the use heat exchanger 13 included in the heat-load circuit 90. The water heated by exchanging heat with the two refrigerants, namely, the first refrigerant and the second refrigerant, in the way described above is sent to the heat-load heat exchanger 91 in the heat-load circuit 90 to process the heating load. The second refrigerant having passed through the use heat exchanger 13 passes through the second heat-source expansion valve 24, is decompressed in the first heat-source expansion valve 26, and then flows into the second outdoor heat exchanger 23. The second refrigerant sent to the second outdoor heat exchanger 23 is evaporated by heat exchange with the outdoor air supplied by the outdoor fan 9. The second refrigerant evaporated in the second outdoor heat exchanger 23 is sucked into the second compressor 21 via the switching valve 22b of the second switching mechanism 22.

(4-3) Features of Fourth Embodiment

[0173] Like the refrigeration cycle apparatus 1 according to the first embodiment, the refrigeration cycle apparatus 1c according to the present embodiment can reduce global environmental deterioration, and can easily secure heating operation capacity. Further, in addition to the single-stage refrigeration cycle and the two-stage refrigeration cycle, the parallel refrigeration cycles can be performed in both of the cooling operation and the heating operation. Thus, the capacity can be secured according to the situation.

<Supplementary Note>

[0174] While embodiments of the present invention have been described, it will be understood that various changes may be made in form and details without departing from the scope of the present invention as defined in the claims.

REFERENCE SIGNS LIST

[0175]

1, 1a, 1b, 1c	refrigeration cycle apparatus
12	first switching mechanism
12x	first switching mechanism
13	use heat exchanger
13a	first use flow path
13b	second use flow path
13c	heat-load flow path
14	third use expansion valve
15	first use expansion valve
16	second use expansion valve
17	heat-source heat exchanger (cascade heat exchanger)
17a	first heat-source flow path (first cascade flow path)
17b	second heat-source flow path (second cascade flow path)
18	first outdoor heat exchanger
20	second refrigerant circuit
21	second compressor
23	second outdoor heat exchanger
24	second heat-source expansion valve
25	third heat-source expansion valve

26	first heat-source expansion valve
90	heat-load circuit
91	heat-load heat exchanger
92	pump

Claims

1. A refrigeration cycle apparatus (1) comprising

a first refrigerant circuit (10) comprising a first refrigerant and having a use heat exchanger (13), a switching mechanism (12), a first compressor (11), a heat-source heat exchanger (17), and a first outdoor heat exchanger (18), and
a second refrigerant circuit (20) comprising a second refrigerant and having the heat-source heat exchanger (17), a second compressor (21), and a second outdoor heat exchanger (23),
wherein the switching mechanism (12) is configured to enable
the refrigeration cycle apparatus (1) to perform:

a heating operation by performing a two-stage refrigeration cycle, wherein the first refrigerant circuit (10) performs a refrigeration cycle such that the use heat exchanger (13) functions as a condenser of the first refrigerant and the heat source heat exchanger (17) functions as an evaporator of the first refrigerant and the first outdoor heat exchanger (18) is not in use, and the second refrigerant circuit (20) performs a refrigeration cycle such that the heat-source heat exchanger (17) functions as a radiator of the second refrigerant and the second outdoor heat exchanger (23) functions as an evaporator of the second refrigerant, and
a cooling operation by performing a single-stage refrigeration cycle, wherein the first refrigerant circuit (10) performs a refrigeration cycle such that the use heat exchanger (13) functions as an evaporator of the first refrigerant and the first outdoor heat exchanger (18) functions as a condenser of the first refrigerant and the heat-source heat exchanger (17) is not in use; and the second refrigerant circuit (20) does not perform a refrigeration cycle; and

the first refrigerant has 1 MPa or less at 30°C and the second refrigerant has 1.5 MPa or more at 30°C.

2. The refrigeration cycle apparatus according to claim 1, wherein the heat-source heat exchanger (17) is a cascade heat exchanger (17) including a first cascade flow path (17a) through which the first refrigerant flows during the heating operation and a second cascade flow path (17b) that is independent of the first cascade flow path and through which the second refrigerant flows during the heating operation, the cascade heat exchanger (17) being configured to exchange heat between the first refrigerant and the second refrigerant.

3. The refrigeration cycle apparatus according to claim 2, wherein
during the heating operation, the first refrigerant evaporates when passing through the first cascade flow path (17a), and the second refrigerant radiates heat when passing through the second cascade flow path (17b).

4. A refrigeration cycle apparatus (1a, 1b, 1c) comprising a first refrigerant circuit (10) comprising

a first refrigerant and having a use heat exchanger (13), a switching mechanism (12), a first compressor (11), a heat-source heat exchanger (17), and a first outdoor heat exchanger (18), and
a second refrigerant circuit (20) comprising a second refrigerant and having the heat-source heat exchanger (17), the use heat exchanger (13), a second compressor (21), and a second outdoor heat exchanger (23),
wherein
the refrigeration cycle apparatus is configured to perform:

a heating operation by performing a two-stage refrigeration cycle, wherein the first refrigerant circuit (10) performs a refrigeration cycle such that the use heat exchanger (13) functions as a condenser of the first refrigerant and the heat source heat exchanger (17) functions as an evaporator of the first refrigerant and the first outdoor heat exchanger (18) is not in use, and the second refrigerant circuit (20) performs a refrigeration cycle such that the heat-source heat exchanger (17) functions as a radiator of the second refrigerant and the second outdoor heat exchanger (23) functions as an evaporator of the second refrigerant, and
a cooling operation by performing a two-stage refrigeration cycle, wherein the first refrigerant circuit (10) performs a refrigeration cycle such that the first outdoor heat exchanger (18) functions as a condenser of the first refrigerant and the heat-source heat exchanger (17) functions as an evaporator of the first refrigerant, and the second re-

frigerant circuit (20) performs a refrigeration cycle such that the heat-source heat exchanger (17) functions as a radiator of the second refrigerant and the use heat exchanger (13) functions as an evaporator of the second refrigerant and the second outdoor heat exchanger (23) is not in use; and

the first refrigerant has 1 MPa or less at 30°C and the second refrigerant has 1.5 MPa or more at 30°C.

5. The refrigeration cycle apparatus according to claim 4, wherein the heat-source heat exchanger (17) is a cascade heat exchanger (17) including a first cascade flow path (17a) through which the first refrigerant flows and a second cascade flow path (17b) that is independent of the first cascade flow path and through which the second refrigerant flows, the cascade heat exchanger (17) being configured to exchange heat between the first refrigerant and the second refrigerant.

6. The refrigeration cycle apparatus according to claim 5, wherein the use heat exchanger (13) includes a first use flow path (13a) through which the first refrigerant flows and a second use flow path (13b) that is independent of the first use flow path and through which the second refrigerant flows.

7. The refrigeration cycle apparatus according to claim 6, wherein
during the heating operation, the first refrigerant evaporates when passing through the first cascade flow path (17a), the second refrigerant radiates heat when passing through the second cascade flow path (17b), and the first refrigerant radiates heat when passing through the first use flow path (13a).

8. The refrigeration cycle apparatus according to claim 6 or 7, wherein
during the cooling operation, the first refrigerant evaporates when passing through the first cascade flow path (17a), the second refrigerant radiates heat when passing through the second cascade flow path (17b), and the second refrigerant evaporates when passing through the second use flow path (13b).

9. The refrigeration cycle apparatus according to any one of claims 6 to 8, wherein
during the cooling operation, the first refrigerant evaporates when passing through the first use flow path (13a), and the second refrigerant evaporates when passing through the second use flow path (13b).

10. The refrigeration cycle apparatus according to any one of claims 6 to 9, wherein
during the heating operation, the first refrigerant radiates heat when passing through the first use flow path (13a), and the second refrigerant radiates heat when passing through the second use flow path (13b).

11. The refrigeration cycle apparatus according to any one of claims 1 to 10, wherein
the first refrigerant includes at least one of R1234yf or R1234ze.

12. The refrigeration cycle apparatus according to any one of claims 1 to 11, wherein
the second refrigerant includes carbon dioxide.

Patentansprüche

1. Kältekreislaufvorrichtung (1) umfassend einen ersten Kältemittelkreislauf (10), der

ein erstes Kältemittel umfasst und einen nutzungsseitigen Wärmetauscher (13), einen Schaltmechanismus (12), einen ersten Verdichter (11), einen wärmequellenseitigen Wärmetauscher (17) und einen ersten Außenwärmetauscher (18) aufweist, und einen zweiten Kältemittelkreislauf (20), der
ein zweites Kältemittel umfasst und den wärmequellenseitigen Wärmetauscher (17), einen zweiten Verdichter (21) und einen zweiten Außenwärmetauscher (23) aufweist,
wobei der Schaltmechanismus (12) dazu ausgebildet ist, der Kältekreislaufvorrichtung (1) zu ermöglichen, Folgendes durchzuführen

einen Heizbetrieb durch Durchführen eines zweistufigen Kältekreislaufs, wobei der erste Kältemittelkreislauf (10) einen Kältekreislauf so durchführt, dass der nutzungsseitige Wärmetauscher (13) als Kondensator des ersten Kältemittels funktioniert und der wärmequellenseitige Wärmetauscher (17) als Verdampfer des ersten Kältemittels funktioniert und der erste Außenwärmetauscher (18) nicht in Gebrauch ist, und der zweite Kältemittelkreislauf (20) einen Kältekreislauf so durchführt, dass der wärmequellenseitige Wärmetauscher (17) als Kühler des zweiten Kältemittels funktioniert und der zweite Außenwärmetauscher (23) als Verdampfer des zweiten Kältemittels funktioniert, und
einen Kühlbetrieb durch Durchführen eines einstufigen Kältekreislaufs, wobei der erste Kältemittelkreislauf (10) einen Kältekreislauf so durchführt, dass der nutzungsseitige

Wärmetauscher (13) als Verdampfer des ersten Kältemittels funktioniert und der erste Außenwärmetauscher (18) als Kondensator des ersten Kältemittels funktioniert und der wärmequellenseitige Wärmetauscher (17) nicht in Gebrauch ist; und der zweite Kältemittelkreislauf (20) keinen Kältekreislauf durchführt; und

das erste Kältemittel bei 30 °C 1 MPa oder weniger aufweist und
das zweite Kältemittel bei 30 °C 1,5 MPa oder mehr aufweist.

2. Kältekreislaufvorrichtung nach Anspruch 1, wobei der wärmequellenseitige Wärmetauscher (17) ein Kaskadenwärmetauscher (17) ist, der einen ersten Kaskaden-Durchflussweg (17a) einschließt, durch den das erste Kältemittel während des Heizbetriebs strömt, und einen zweiten Kaskaden-Durchflussweg (17b), der unabhängig von dem ersten Kaskaden-Durchflussweg ist und durch den das zweite Kältemittel während des Heizbetriebs strömt, wobei der Kaskadenwärmetauscher (17) dazu ausgebildet ist, Wärme zwischen dem ersten Kältemittel und dem zweiten Kältemittel auszutauschen.

3. Kältekreislaufvorrichtung nach Anspruch 2, wobei während des Heizbetriebs das erste Kältemittel beim Durchströmen des ersten Kaskaden-Durchflusswegs (17a) verdampft, und das zweite Kältemittel beim Durchströmen des zweiten Kaskaden-Durchflusswegs (17b) Wärme abstrahlt.

4. Kältekreislaufvorrichtung (1a, 1b, 1c) umfassend einen ersten Kältemittelkreislauf (10), der

ein erstes Kältemittel umfasst und einen nutzungsseitigen Wärmetauscher (13), einen Schaltmechanismus (12), einen ersten Verdichter (11), einen wärmequellenseitigen Wärmetauscher (17) und einen ersten Außenwärmetauscher (18) aufweist, und
einen zweiten Kältemittelkreislauf (20), der
ein zweites Kältemittel umfasst und den wärmequellenseitigen Wärmetauscher (17), den nutzungsseitigen Wärmetauscher (13), einen zweiten Verdichter (21) und einen zweiten Außenwärmetauscher (23) aufweist,
wobei
die Kältekreislaufvorrichtung ausgebildet ist, Folgendes durchzuführen:

einen Heizbetrieb durch Durchführen eines zweistufigen Kältekreislaufs, wobei der erste Kältemittelkreislauf (10) einen Kältekreislauf so durchführt, dass der nutzungsseitige Wärmetauscher (13) als Kondensator des ersten Kältemittels funktioniert und der wärmequellenseitige Wärmetauscher (17) als Verdampfer des ersten Kältemittels funktioniert und der erste Außenwärmetauscher (18) nicht in Gebrauch ist, und der zweite Kältemittelkreislauf (20) einen Kältekreislauf so durchführt, dass der wärmequellenseitige Wärmetauscher (17) als Kühler des zweiten Kältemittels funktioniert und der zweite Außenwärmetauscher (23) als Verdampfer des zweiten Kältemittels funktioniert, und
einen Kühlbetrieb durch Durchführen eines zweistufigen Kältekreislaufs, wobei der erste Kältemittelkreislauf (10) einen Kältekreislauf so durchführt, dass der erste Außenwärmetauscher (18) als Kondensator des ersten Kältemittels funktioniert und der wärmequellenseitige Wärmetauscher (17) als Verdampfer des ersten Kältemittels funktioniert, und der zweite Kältemittelkreislauf (20) einen Kältekreislauf so durchführt, dass der wärmequellenseitige Wärmetauscher (17) als Kühler des zweiten Kältemittels funktioniert und der nutzungsseitige Wärmetauscher (13) als Verdampfer des zweiten Kältemittels funktioniert und der zweite Außenwärmetauscher (23) nicht in Gebrauch ist; und

das erste Kältemittel bei 30 °C 1 MPa oder weniger aufweist und
das zweite Kältemittel bei 30 °C 1,5 MPa oder mehr aufweist.

5. Kältekreislaufvorrichtung nach Anspruch 4, wobei der wärmequellenseitige Wärmetauscher (17) ein Kaskadenwärmetauscher (17) ist, der einen ersten Kaskaden-Durchflussweg (17a) einschließt, durch den das erste Kältemittel strömt, und einen zweiten Kaskaden-Durchflussweg (17b), der unabhängig von dem ersten Kaskaden-Durchflussweg ist und durch den das zweite Kältemittel strömt, wobei der Kaskadenwärmetauscher (17) dazu ausgebildet ist, Wärme zwischen dem ersten Kältemittel und dem zweiten Kältemittel auszutauschen.

6. Kältekreislaufvorrichtung nach Anspruch 5, wobei der nutzungsseitige Wärmetauscher (13) einen ersten nutzungsseitigen Durchflussweg (13a), durch den das erste Kältemittel strömt, und einen zweiten nutzungsseitigen Durchflussweg (13b), der unabhängig von dem ersten nutzungsseitigen Durchflussweg ist und durch den das zweite Kältemittel strömt, einschließt.

7. Kältekreislaufvorrichtung nach Anspruch 6, wobei während des Heizbetriebs das erste Kältemittel beim

Durchströmen des ersten Kaskaden-Durchflusswegs (17a) verdampft, das zweite Kältemittel beim Durchströmen des zweiten Kaskaden-Durchflusswegs (17b) Wärme abstrahlt und das erste Kältemittel beim Durchströmen des ersten nutzungsseitigen Durchflusswegs (13a) Wärme abstrahlt.

8. Kältekreislaufvorrichtung nach Anspruch 6 oder 7, wobei
während des Kühlbetriebs das erste Kältemittel beim Durchströmen des ersten Kaskaden-Durchflusswegs (17a) verdampft, das zweite Kältemittel beim Durchströmen des zweiten Kaskaden-Durchflusswegs (17b) Wärme abstrahlt und das zweite Kältemittel beim Durchströmen des zweiten nutzungsseitigen Durchflusswegs (13b) verdampft.

9. Kältekreislaufvorrichtung nach einem der Ansprüche 6 bis 8, wobei
während des Kühlbetriebs das erste Kältemittel beim Durchströmen des ersten nutzungsseitigen Durchflusswegs (13a) verdampft und das zweite Kältemittel beim Durchströmen des zweiten nutzungsseitigen Durchflusswegs (13b) verdampft.

10. Kältekreislaufvorrichtung nach einem der Ansprüche 6 bis 9, wobei
während des Heizbetriebs das erste Kältemittel beim Durchströmen des ersten nutzungsseitigen Durchflusswegs (13a) Wärme abstrahlt und das zweite Kältemittel beim Durchströmen des zweiten nutzungsseitigen Durchflusswegs (13b) Wärme abstrahlt.

11. Kältekreislaufvorrichtung nach einem der Ansprüche 1 bis 10, wobei das erste Kältemittel mindestens eines von R1234yf oder R1234ze einschließt.

12. Kältekreislaufvorrichtung nach einem der Ansprüche 1 bis 11, wobei das zweite Kältemittel Kohlendioxid einschließt.

Revendications

1. Appareil de cycle frigorifique (1) comprenant

un premier circuit de fluide frigorigène (10) comprenant
un premier fluide frigorigène et présentant un échangeur de chaleur côté utilisation (13), un mécanisme de commutation (12), un premier compresseur (11), un échangeur de chaleur côté source de chaleur (17), et un premier échangeur de chaleur extérieur (18), et
un deuxième circuit de fluide frigorigène (20) comprenant
un deuxième fluide frigorigène et présentant l'échangeur de chaleur côté source de chaleur (17), un deuxième compresseur (21), et un deuxième échangeur de chaleur extérieur (23),
dans lequel le mécanisme de commutation (12) est configuré pour permettre à l'appareil de cycle frigorifique (1) d'effectuer

un fonctionnement de chauffage en effectuant un cycle frigorifique à deux étages, dans lequel le premier circuit de fluide frigorigène (10) effectue un cycle frigorifique de sorte que l'échangeur de chaleur côté utilisation (13) fonctionne comme un condenseur du premier fluide frigorigène et l'échangeur de chaleur côté source de chaleur (17) fonctionne comme un évaporateur du premier fluide frigorigène et le premier échangeur de chaleur extérieur (18) n'est pas utilisé, et le deuxième circuit de fluide frigorigène (20) effectue un cycle frigorifique de sorte que l'échangeur de chaleur côté source de chaleur (17) fonctionne comme un radiateur du deuxième fluide frigorigène et le deuxième échangeur de chaleur extérieur (23) fonctionne comme un évaporateur du deuxième fluide frigorigène, et
un fonctionnement de refroidissement en effectuant un cycle frigorifique à un étage, dans lequel le premier circuit de fluide frigorigène (10) effectue un cycle frigorifique de sorte que l'échangeur de chaleur côté utilisation (13) fonctionne comme un évaporateur du premier fluide frigorigène et le premier échangeur de chaleur extérieur (18) fonctionne comme un condenseur du premier fluide frigorigène et l'échangeur de chaleur côté source de chaleur (17) n'est pas utilisé ; et le deuxième circuit de fluide frigorigène (20) n'effectue pas un cycle frigorifique ; et

le premier fluide frigorigène présente 1 MPa ou moins à 30 °C et
le deuxième fluide frigorigène présente 1,5 MPa ou plus à 30 °C.

2. Appareil de cycle frigorifique selon la revendication 1, dans lequel l'échangeur de chaleur côté source de chaleur (17) est un échangeur de chaleur en cascade (17) incluant un premier canal d'écoulement en cascade (17a) à travers lequel le premier fluide frigorigène s'écoule pendant le fonctionnement de chauffage et un deuxième canal d'écoulement en cascade (17b) qui est indépendant du premier canal d'écoulement en cascade et à travers lequel le deuxième fluide frigorigène s'écoule pendant le fonctionnement de chauffage, l'échangeur de chaleur en cascade (17) étant configuré pour échanger de la chaleur entre le premier fluide frigorigène et le deuxième fluide frigorigène.

3. Appareil de cycle frigorifique selon la revendication 2, dans lequel
pendant le fonctionnement de chauffage, le premier fluide frigorigène s'évapore lors du passage dans le premier canal d'écoulement en cascade (17a), et le deuxième fluide frigorigène émet de la chaleur lors du passage dans le deuxième canal d'écoulement en cascade (17b).

4. Appareil de cycle frigorifique (1a, 1b, 1c) comprenant un premier circuit de fluide frigorigène (10) comprenant

un premier fluide frigorigène et présentant un échangeur de chaleur côté utilisation (13), un mécanisme de commutation (12), un premier compresseur (11), un échangeur de chaleur côté source de chaleur (17), et un premier échangeur de chaleur extérieur (18), et
un deuxième circuit de fluide frigorigène (20) comprenant,
un deuxième fluide frigorigène et présentant l'échangeur de chaleur côté source de chaleur (17), l'échangeur de chaleur côté utilisation (13), un deuxième compresseur (21), et un deuxième échangeur de chaleur extérieur (23),
dans lequel
l'appareil de cycle frigorifique est configuré pour effectuer :

un fonctionnement de chauffage en effectuant un cycle frigorifique à deux étages, dans lequel le premier circuit de fluide frigorigène (10) effectue un cycle frigorifique de sorte que l'échangeur de chaleur côté utilisation (13) fonctionne comme un condenseur du premier fluide frigorigène et l'échangeur de chaleur côté source de chaleur (17) fonctionne comme un évaporateur du premier fluide frigorigène et le premier échangeur de chaleur extérieur (18) n'est pas utilisé, et le deuxième circuit de fluide frigorigène (20) effectue un cycle frigorifique de sorte que l'échangeur de chaleur côté source de chaleur (17) fonctionne comme un radiateur du deuxième fluide frigorigène et le deuxième échangeur de chaleur extérieur (23) fonctionne comme un évaporateur du deuxième fluide frigorigène, et
un fonctionnement de refroidissement en effectuant un cycle frigorifique à deux étages, dans lequel le premier circuit de fluide frigorigène (10) effectue un cycle frigorifique de sorte que le premier échangeur de chaleur extérieur (18) fonctionne comme un condenseur du premier fluide frigorigène et l'échangeur de chaleur côté source de chaleur (17) fonctionne comme un évaporateur du premier fluide frigorigène, et le deuxième circuit de fluide frigorigène (20) effectue un cycle frigorifique de sorte que l'échangeur de chaleur côté source de chaleur (17) fonctionne comme un radiateur du deuxième fluide frigorigène et l'échangeur de chaleur côté utilisation (13) fonctionne comme un évaporateur du deuxième fluide frigorigène et le deuxième échangeur de chaleur extérieur (23) n'est pas utilisé ; et
le premier fluide frigorigène présente 1 MPa ou moins à 30 °C et,

le deuxième fluide frigorigène présente 1,5 MPa ou plus à 30 °C.

5. Appareil de cycle frigorifique selon la revendication 4, dans lequel l'échangeur de chaleur côté source de chaleur (17) est un échangeur de chaleur en cascade (17) incluant un premier canal d'écoulement en cascade (17a) à travers lequel le premier fluide frigorigène s'écoule et un deuxième canal d'écoulement en cascade (17b) qui est indépendant du premier canal d'écoulement en cascade et à travers lequel le deuxième fluide frigorigène s'écoule, l'échangeur de chaleur en cascade (17) étant configuré pour échanger de la chaleur entre le premier fluide frigorigène et le deuxième fluide frigorigène.

6. Appareil de cycle frigorifique selon la revendication 5, dans lequel l'échangeur de chaleur côté utilisation (13) inclut un premier canal d'écoulement côté utilisation (13a) à travers lequel le premier fluide frigorigène s'écoule et un deuxième canal d'écoulement côté utilisation (13b) qui est indépendant du premier canal d'écoulement côté utilisation et à travers lequel le deuxième fluide frigorigène s'écoule.

7. Appareil de cycle frigorifique selon la revendication 6, dans lequel
pendant le fonctionnement de chauffage, le premier fluide frigorigène s'évapore lors du passage dans le premier canal d'écoulement en cascade (17a), le deuxième fluide frigorigène émet de la chaleur lors du passage dans le deuxième canal d'écoulement en cascade (17b), et le premier fluide frigorigène émet de la chaleur lors du passage dans le premier canal d'écoulement côté utilisation (13a).

8. Appareil de cycle frigorifique selon la revendication 6 ou la revendication 7, dans lequel
pendant le fonctionnement de refroidissement, le premier fluide frigorigène s'évapore lors du passage dans le premier canal d'écoulement en cascade (17a), le deuxième fluide frigorigène émet de la chaleur lors du passage dans le deuxième canal d'écoulement en cascade (17b), et le deuxième fluide frigorigène s'évapore lors du passage dans le deuxième canal d'écoulement côté utilisation (13b).

9. Appareil de cycle frigorifique selon l'une quelconque des revendications 6 à 8, dans lequel
pendant le fonctionnement de refroidissement, le premier fluide frigorigène s'évapore lors du passage dans le premier canal d'écoulement côté utilisation (13a), et le deuxième fluide frigorigène s'évapore lors du passage dans le deuxième canal d'écoulement côté utilisation (13b).

10. Appareil de cycle frigorifique selon l'une quelconque des revendications 6 à 9, dans lequel
pendant le fonctionnement de chauffage, le premier fluide frigorigène émet de la chaleur lors du passage dans le premier canal d'écoulement côté utilisation (13a), et le deuxième fluide frigorigène émet de la chaleur lors du passage dans le deuxième canal d'écoulement côté utilisation (13b).

11. Appareil de cycle frigorifique selon l'une quelconque des revendications 1 à 10,
dans lequel le premier fluide frigorigène inclut au moins un de R1234yf ou R1234ze.

12. Appareil de cycle frigorifique selon l'une quelconque des revendications 1 à 11, dans lequel
le deuxième fluide frigorigène inclut du dioxyde de carbone.

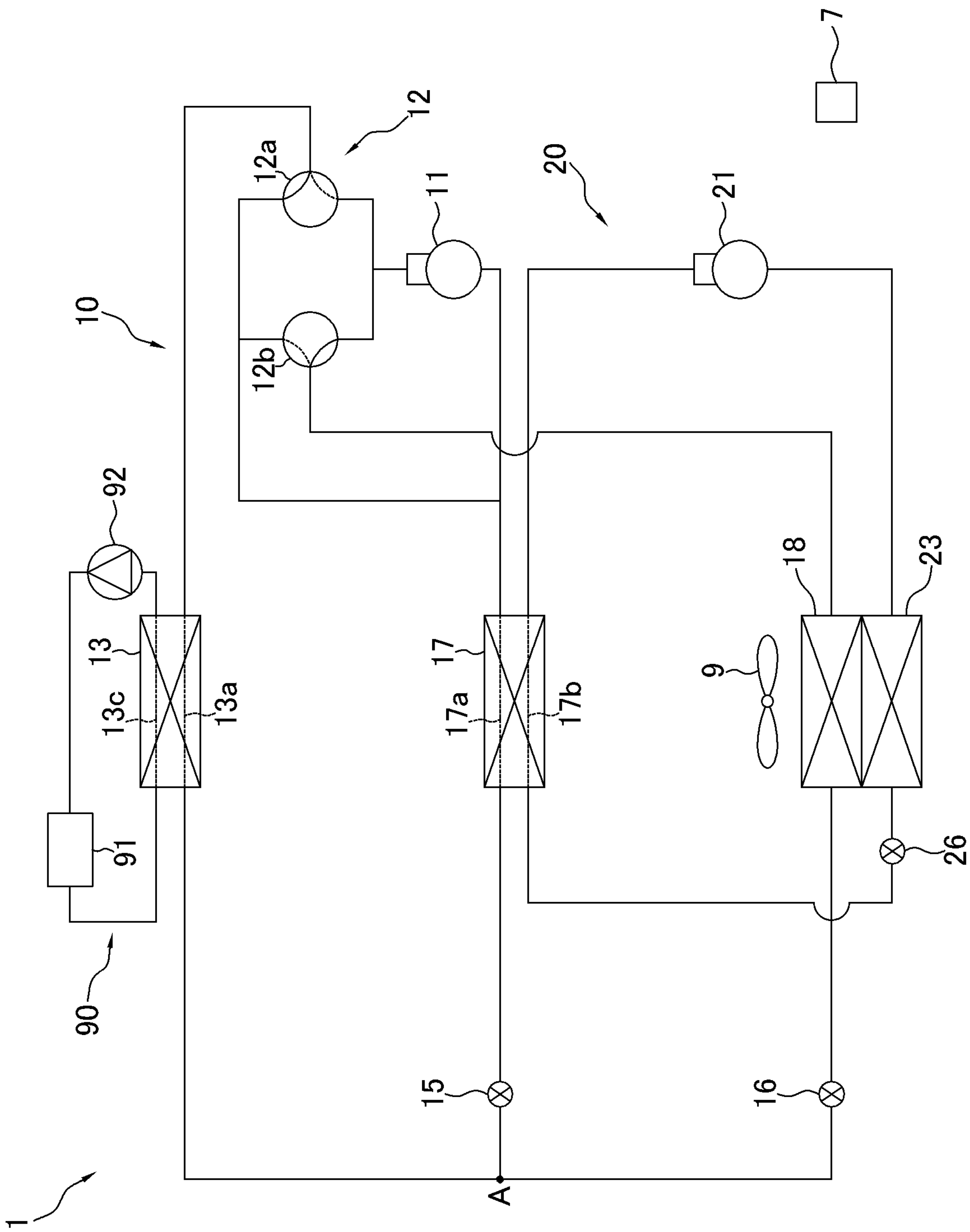

1
10
12
12a
12b
11
20
21
7
92
13
13c
13a
17
17a
17b
9
18
23
91
26
90
15
16
A

FIG. 1

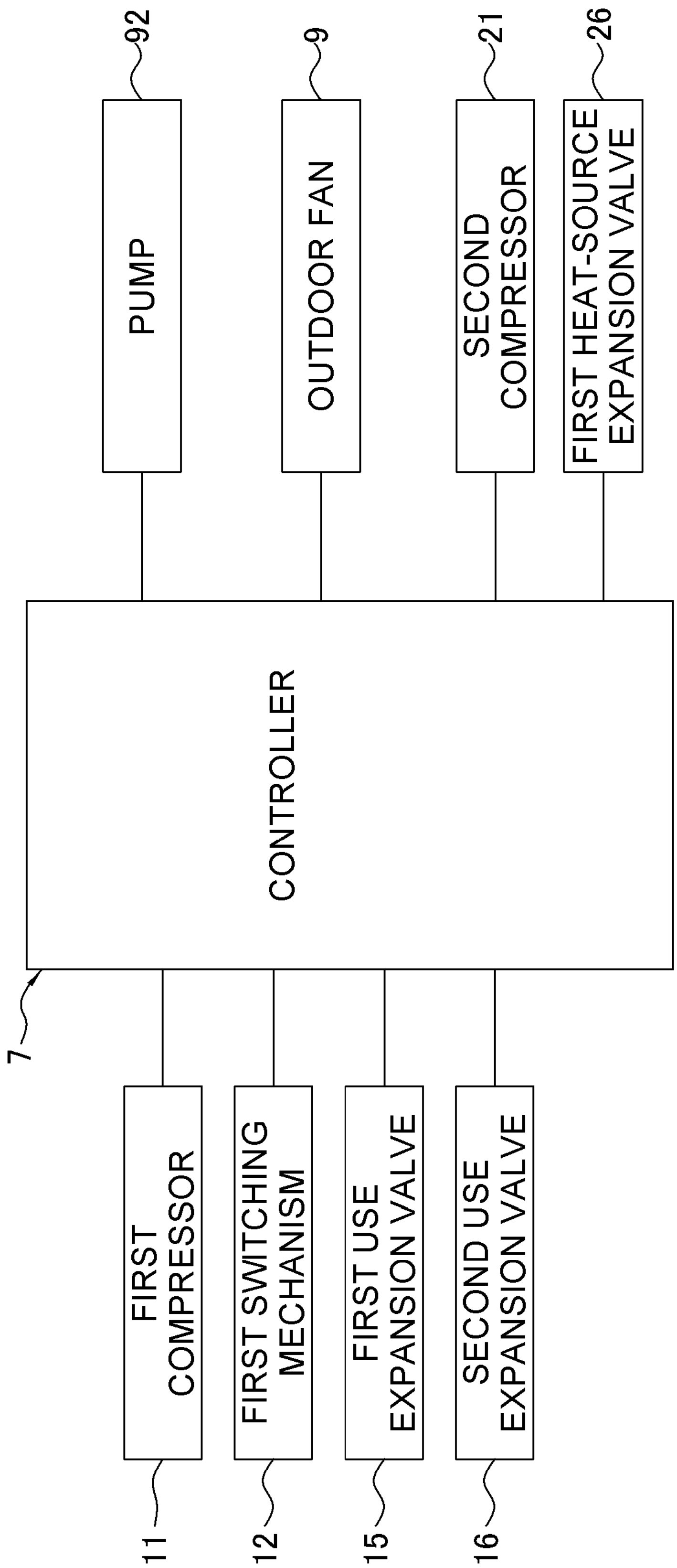

PUMP
92
OUTDOOR FAN
9
SECOND COMPRESSOR
21
FIRST HEAT-SOURCE EXPANSION VALVE
26
CONTROLLER
7
FIRST COMPRESSOR
11
FIRST SWITCHING MECHANISM
12
FIRST USE EXPANSION VALVE
15
SECOND USE EXPANSION VALVE
16

FIG. 2

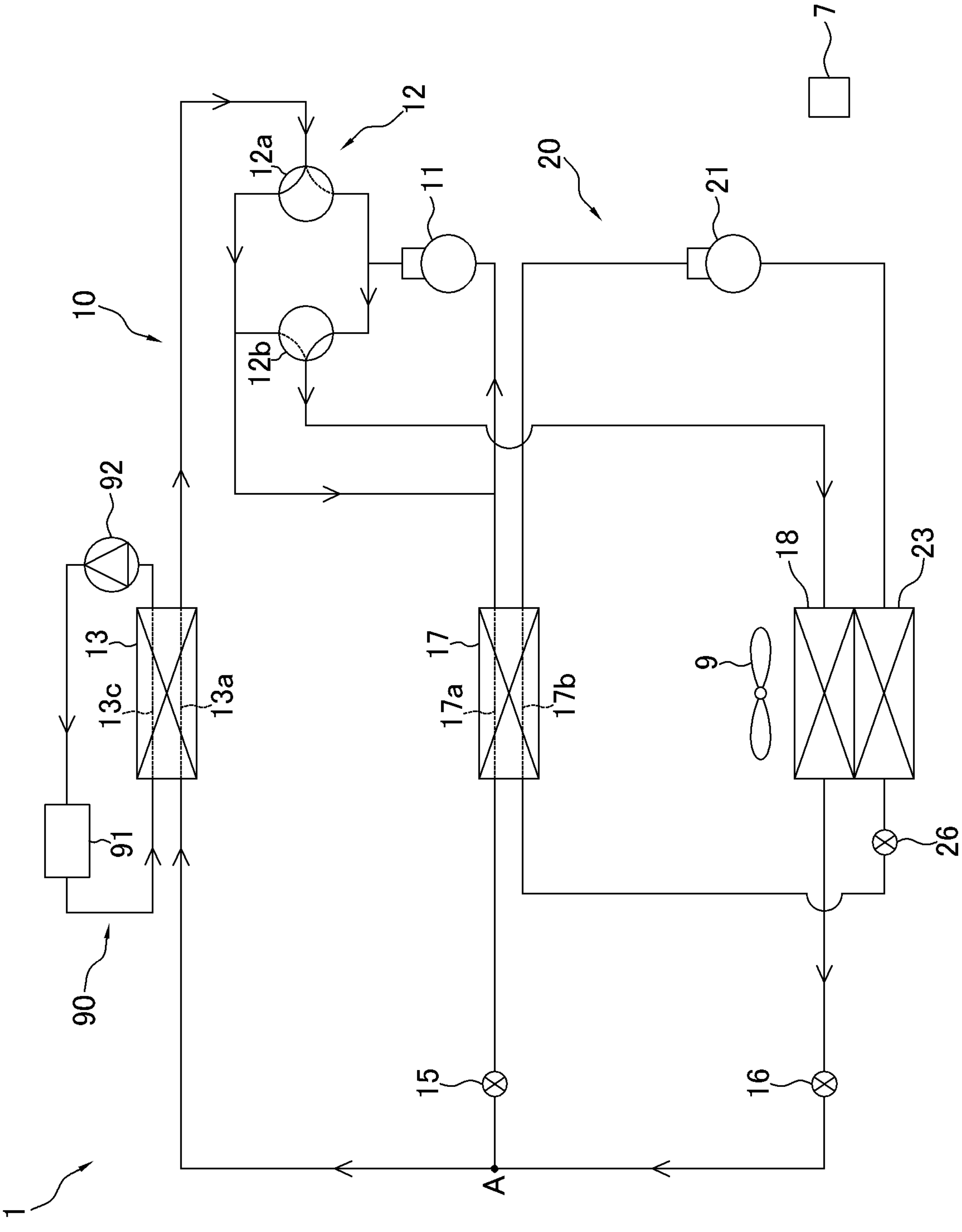

1
10
12
12a
12b
11
20
21
7
92
13
13c
13a
91
90
17
17a
17b
9
18
23
26
15
16
A

FIG. 3

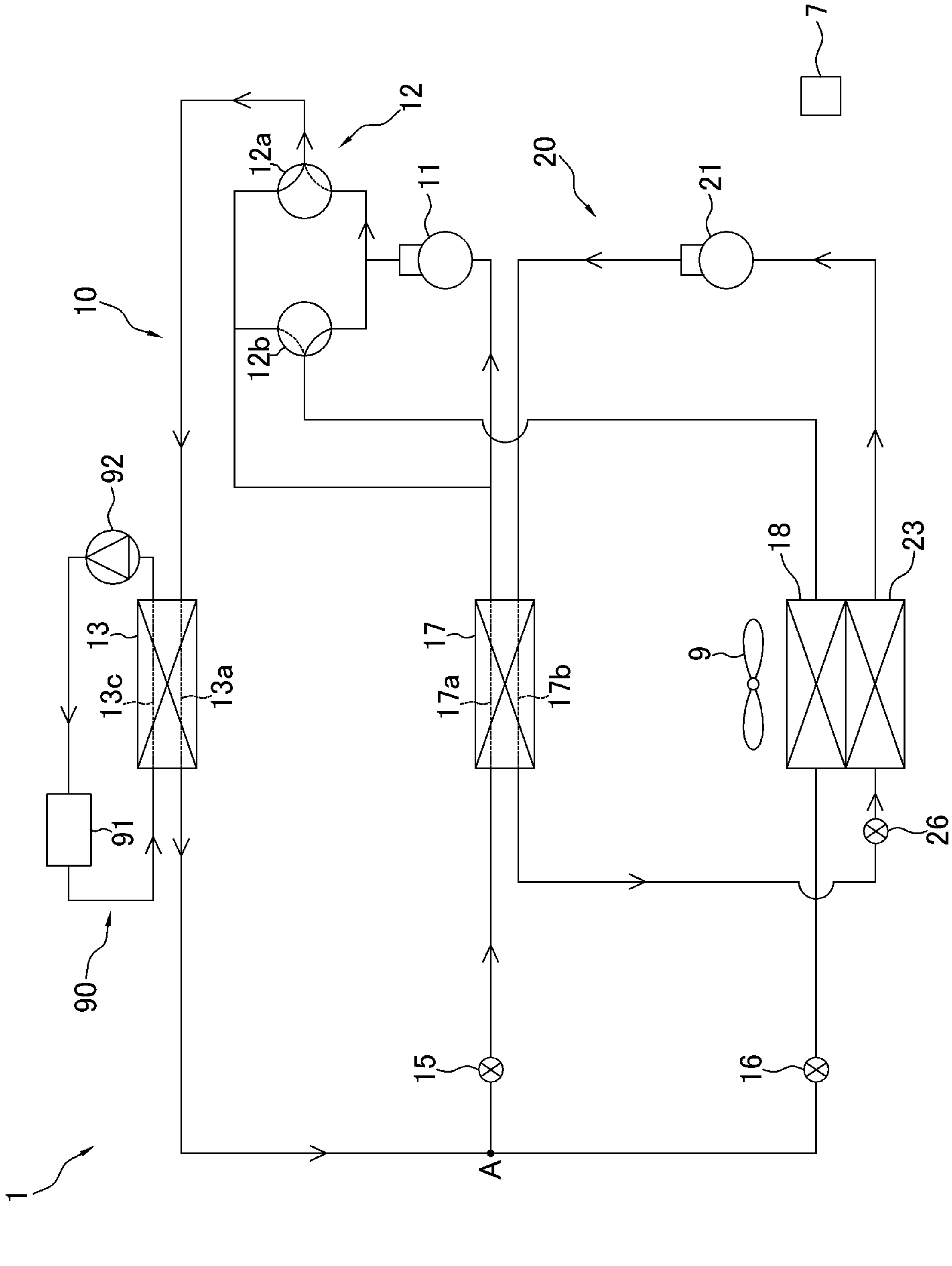

1
10
12
12a
12b
11
20
21
7
92
13
13c
13a
17
17a
17b
9
18
23
26
91
90
15
16
A

FIG. 4

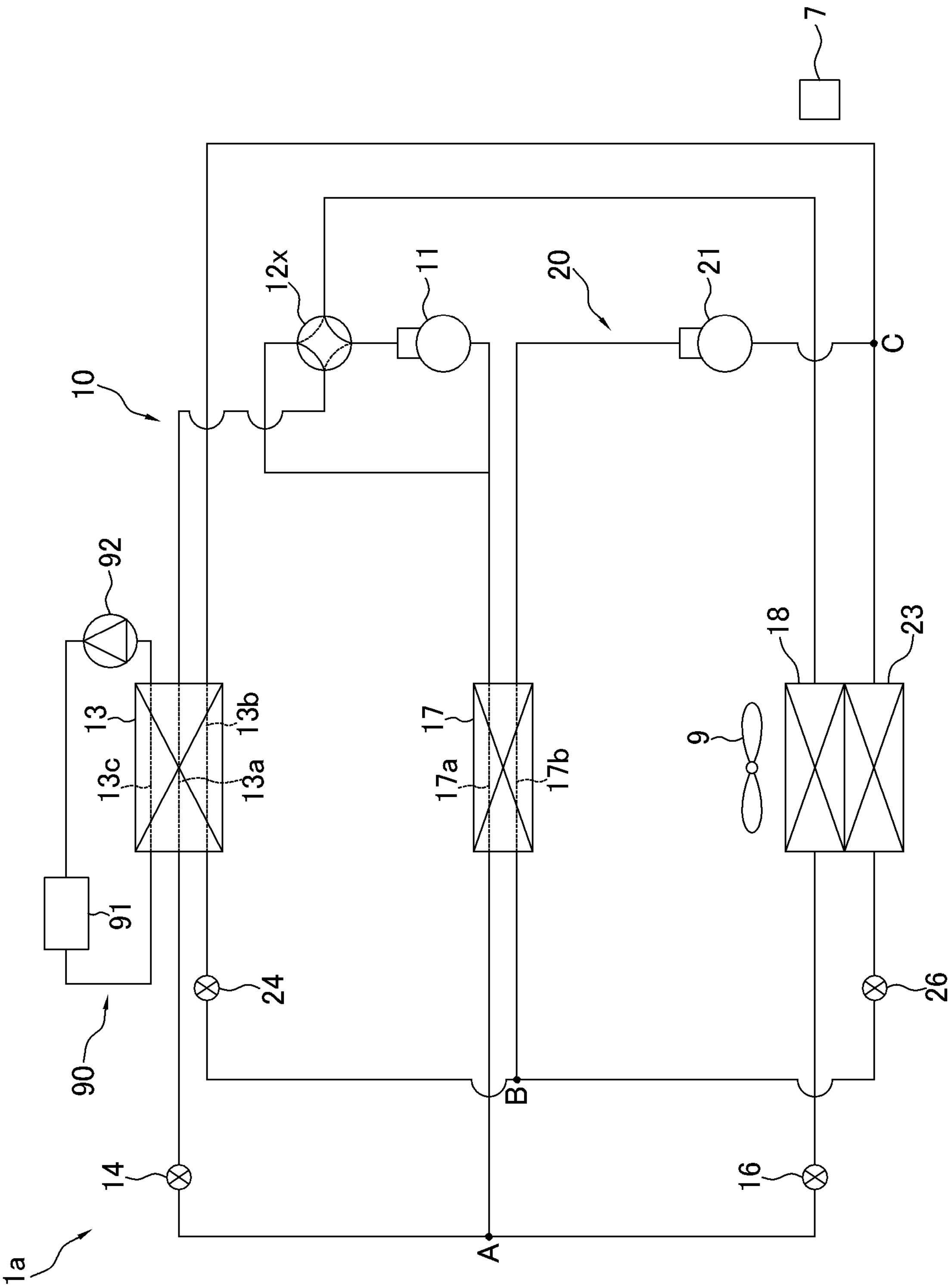

7
10
12x
11
20
21
C
92
13
13b
13c
13a
17
17a
17b
18
23
9
91
24
26
90
B
14
16
1a
A

FIG. 5

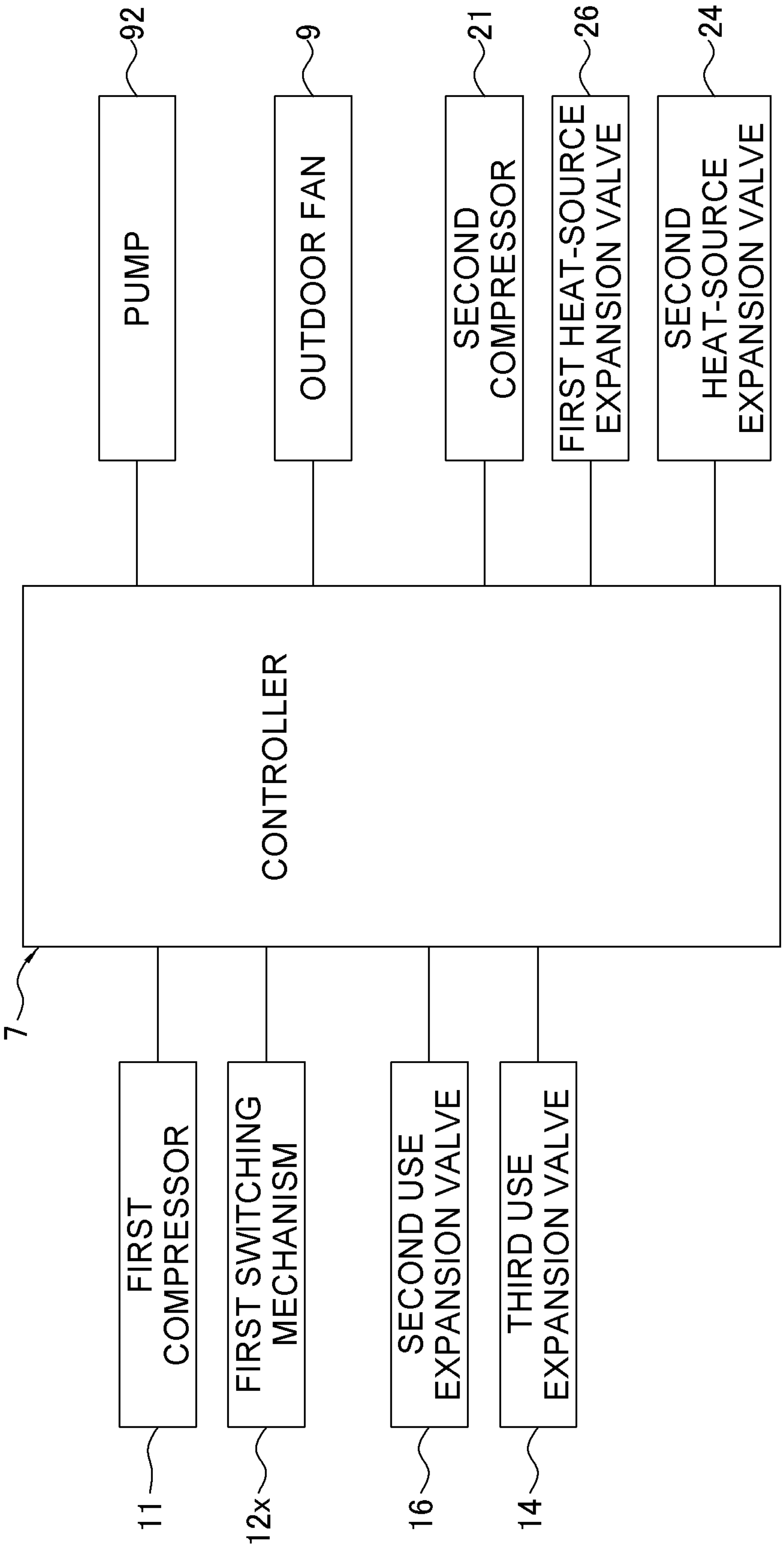

PUMP
92
OUTDOOR FAN
9
SECOND COMPRESSOR
21
FIRST HEAT-SOURCE EXPANSION VALVE
26
SECOND HEAT-SOURCE EXPANSION VALVE
24
CONTROLLER
7
FIRST COMPRESSOR
11
FIRST SWITCHING MECHANISM
12x
SECOND USE EXPANSION VALVE
16
THIRD USE EXPANSION VALVE
14

FIG. 6

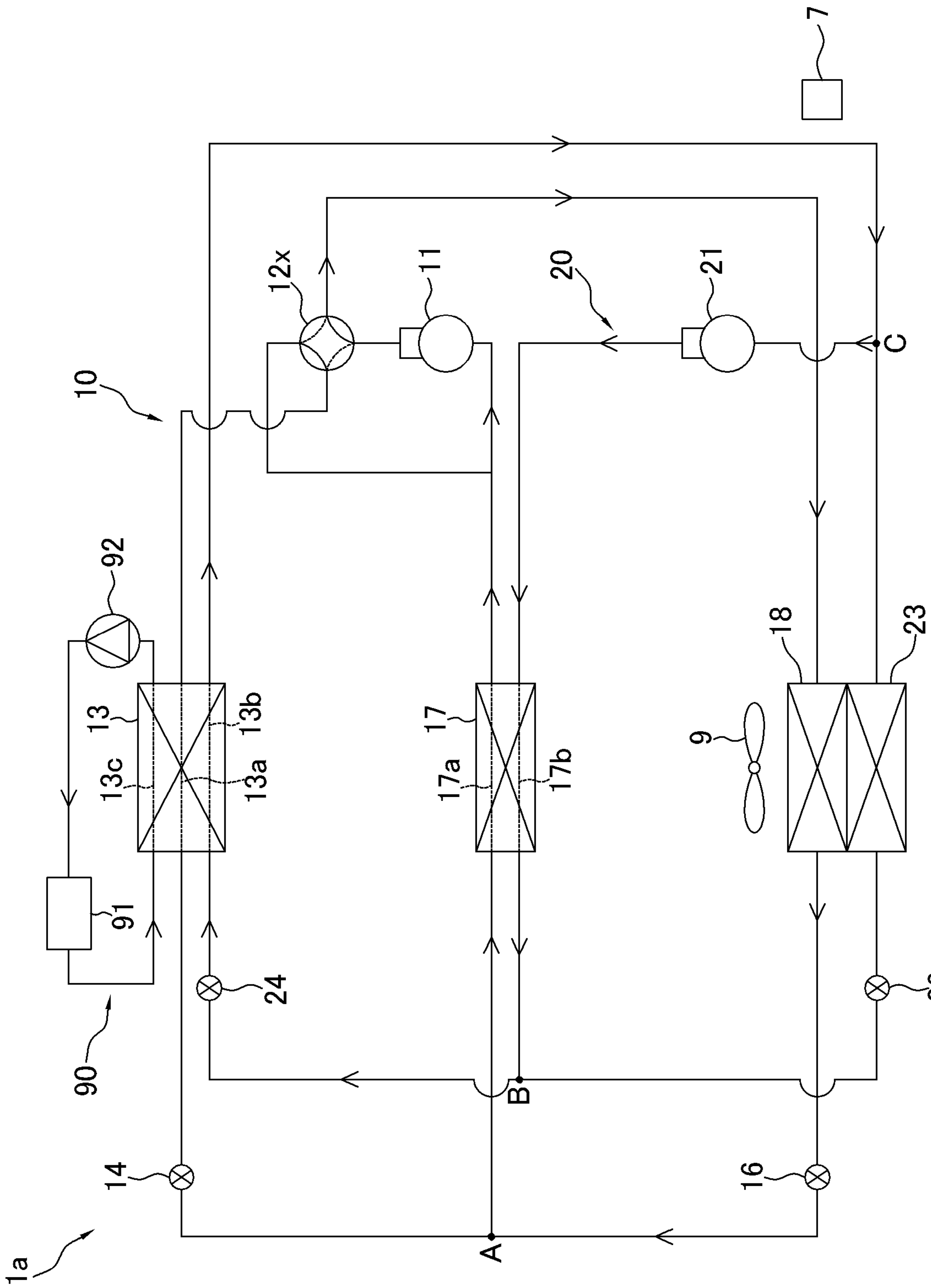

1a
10
12x
11
20
21
7
C
92
13
13b
13c
13a
17
17a
17b
9
18
23
91
24
26
90
14
16
A
B

FIG. 7

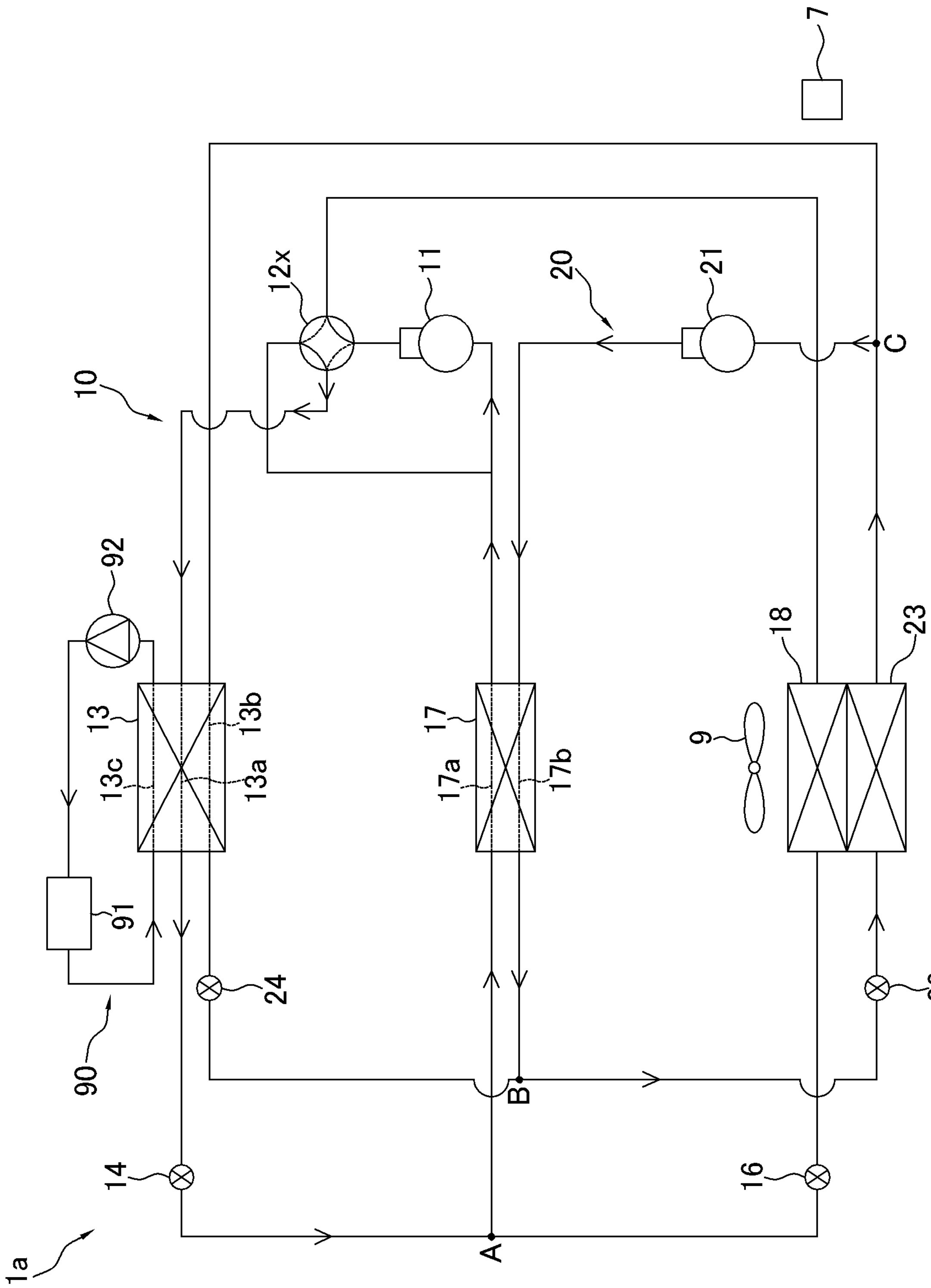

7
10
12x
11
20
21
C
92
13
13b
13c
13a
17
17a
17b
18
23
9
91
24
26
90
B
14
16
A
1a

FIG. 8

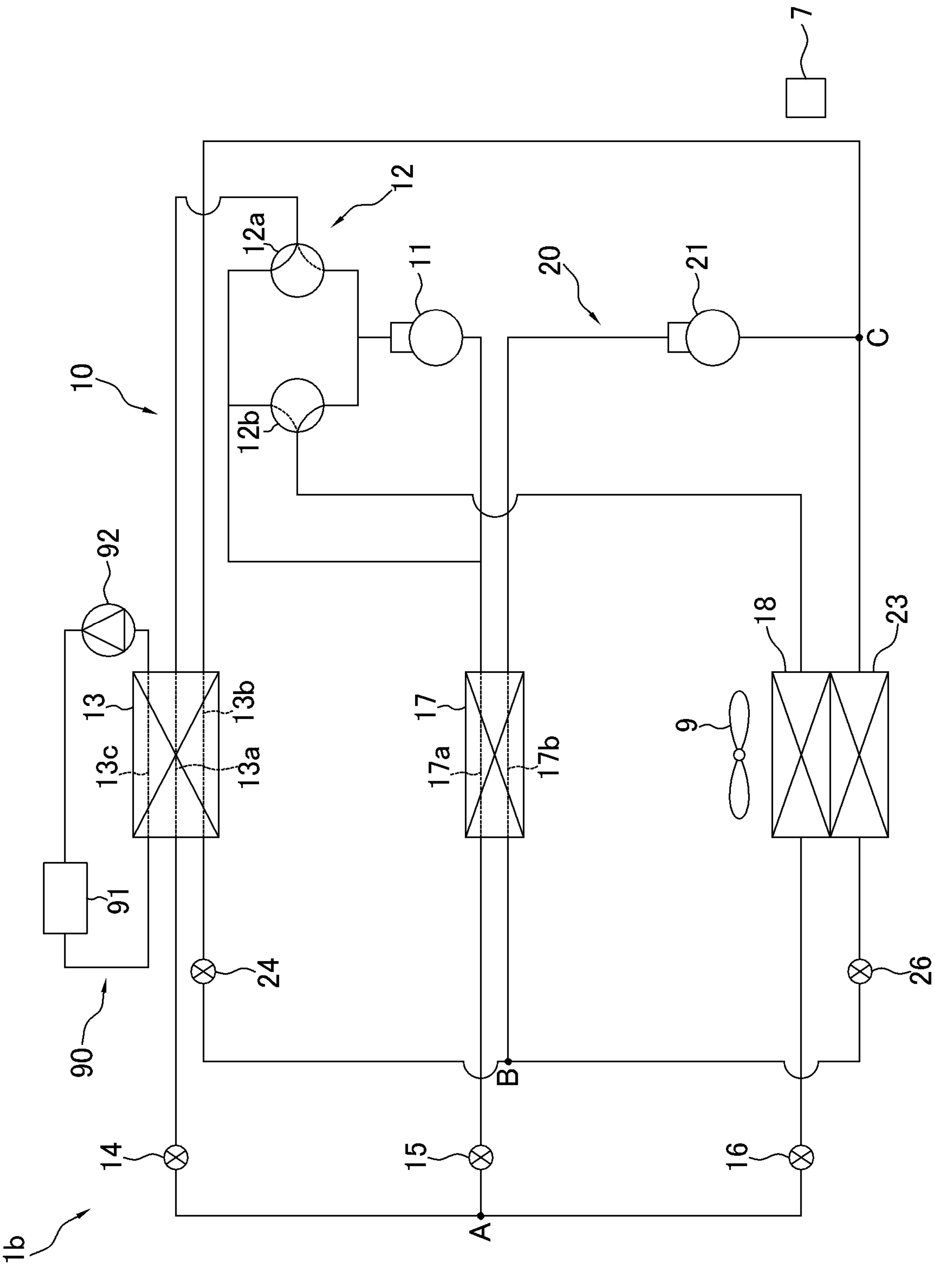

1b
10
12
12a
12b
11
20
21
C
7
92
13
13a
13b
13c
17
17a
17b
18
23
9
91
90
24
26
B
14
15
16
A

FIG. 9

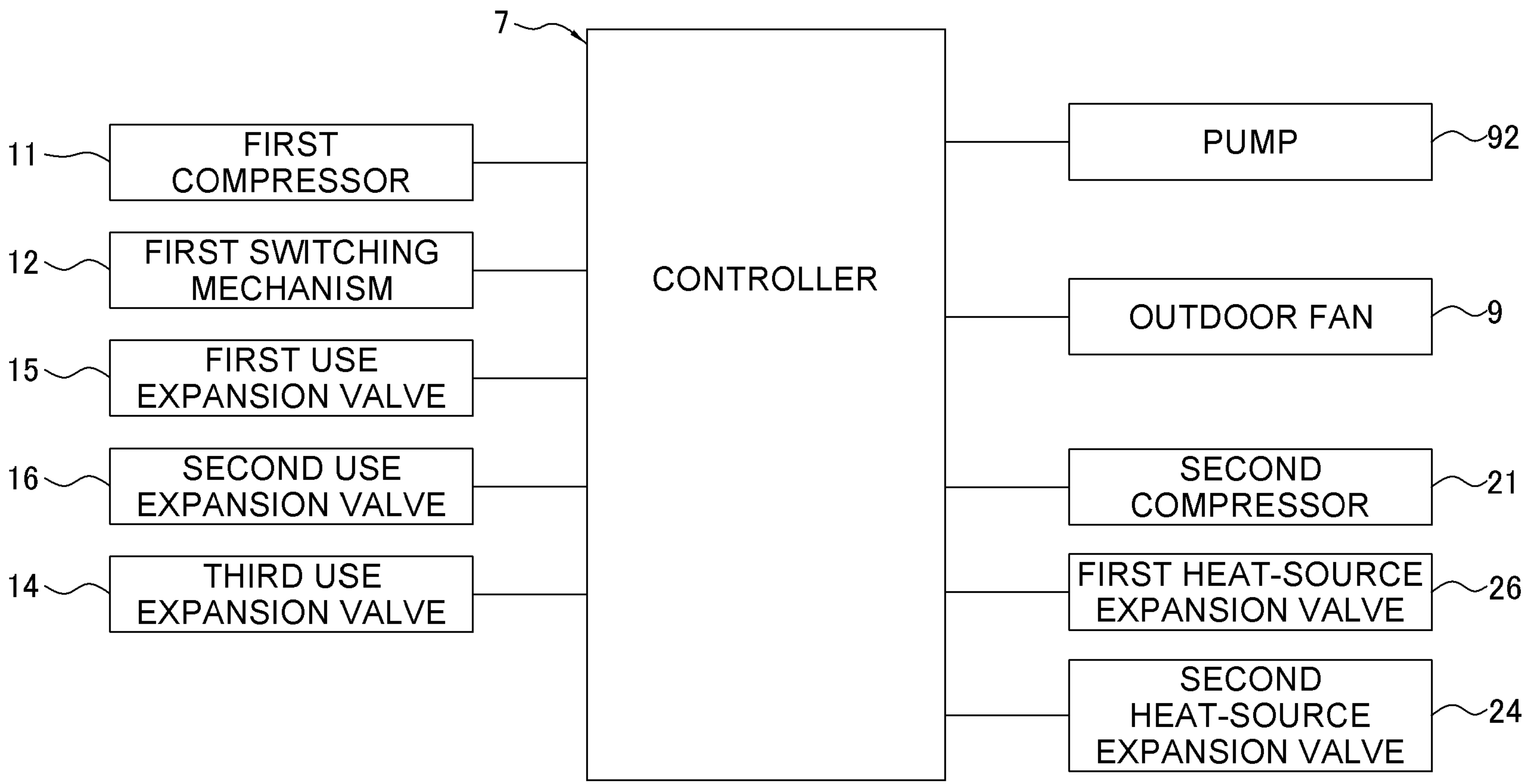

7
CONTROLLER
11
FIRST COMPRESSOR
12
FIRST SWITCHING MECHANISM
15
FIRST USE EXPANSION VALVE
16
SECOND USE EXPANSION VALVE
14
THIRD USE EXPANSION VALVE
PUMP
92
OUTDOOR FAN
9
SECOND COMPRESSOR
21
FIRST HEAT-SOURCE EXPANSION VALVE
26
SECOND HEAT-SOURCE EXPANSION VALVE
24

FIG. 10

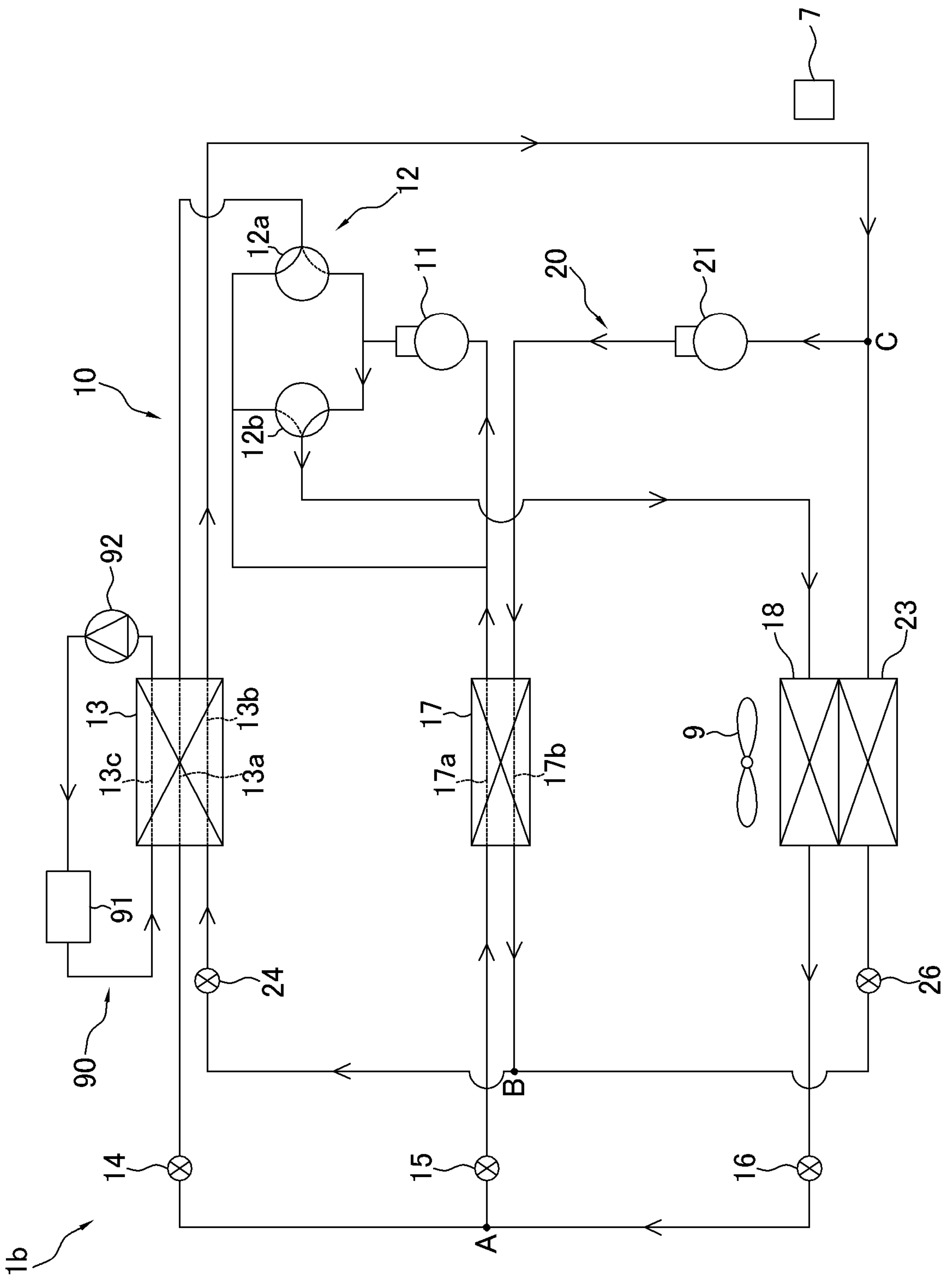

7
12
12a
11
20
21
10
12b
C
92
18
23
13
13b
17
9
13c
13a
17a
17b
91
24
26
90
B
14
15
16
1b
A

FIG. 11

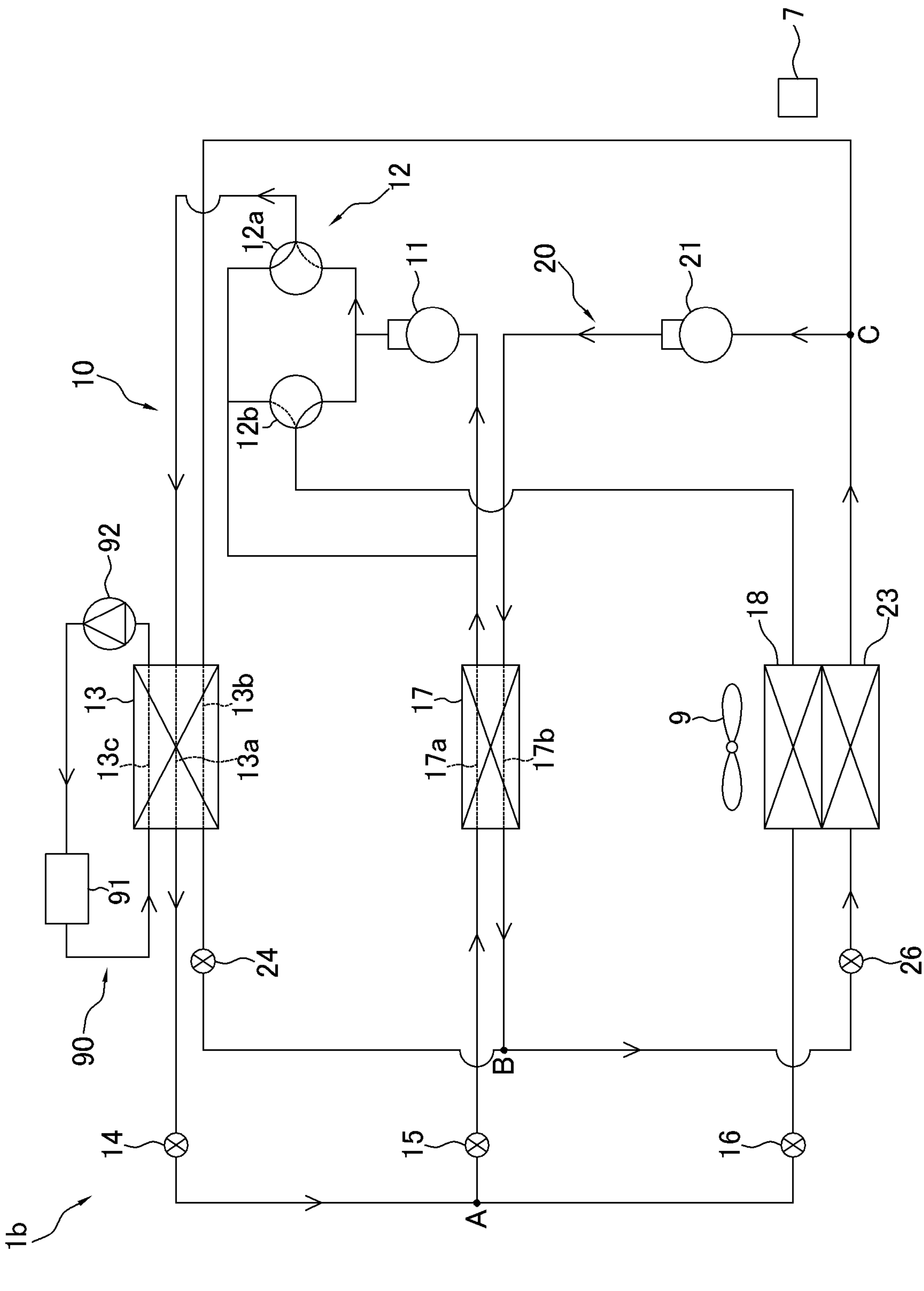

1b
10
12
12a
12b
11
20
21
7
C
92
13
13a
13b
13c
17
17a
17b
9
18
23
91
90
24
26
14
15
16
A
B

FIG. 12

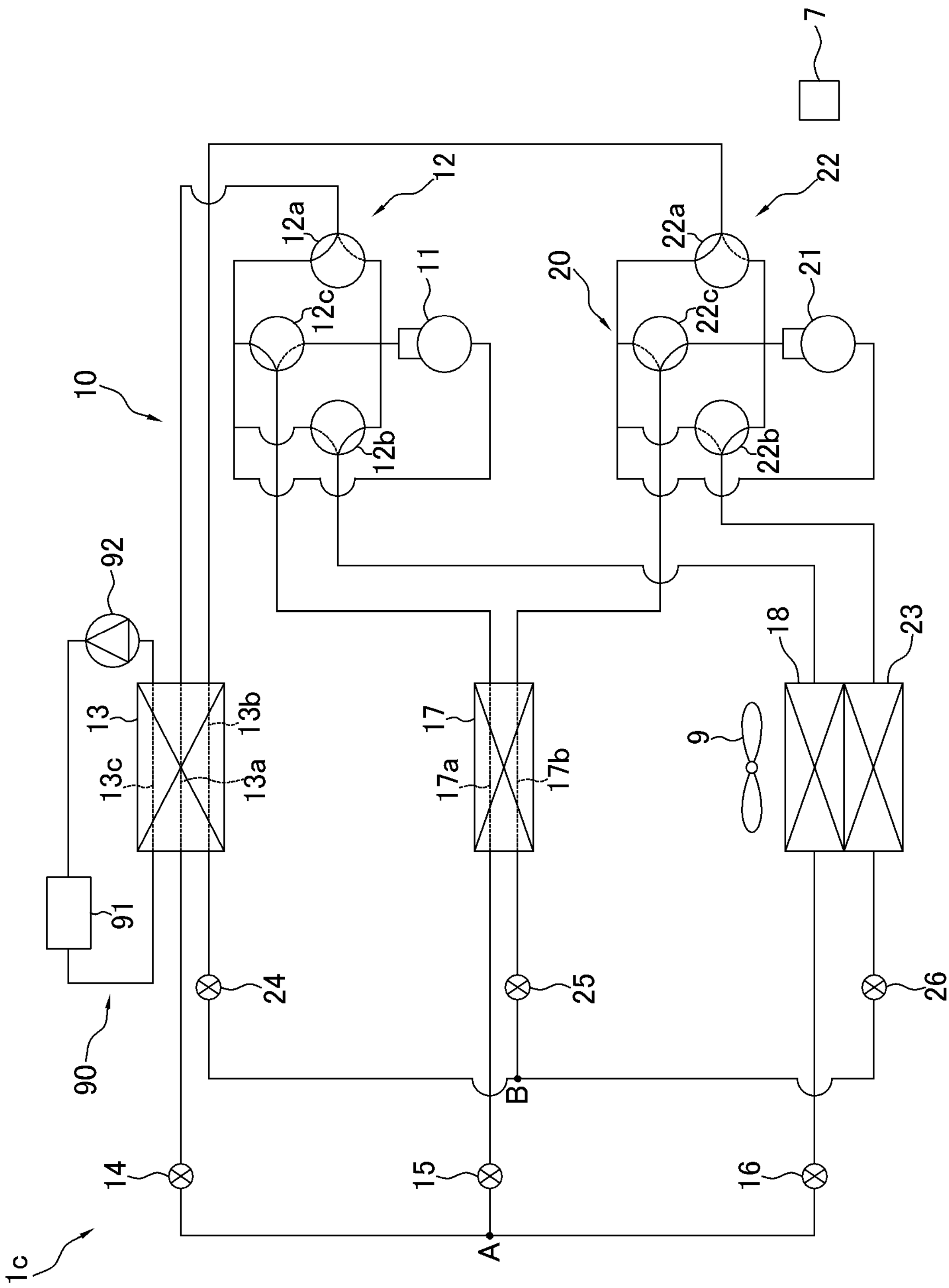

1c
10
12
12a
12b
12c
11
20
22
22a
22b
22c
21
7
92
13
13a
13b
13c
90
91
17
17a
17b
18
23
9
14
15
16
24
25
26
A
B

FIG. 13

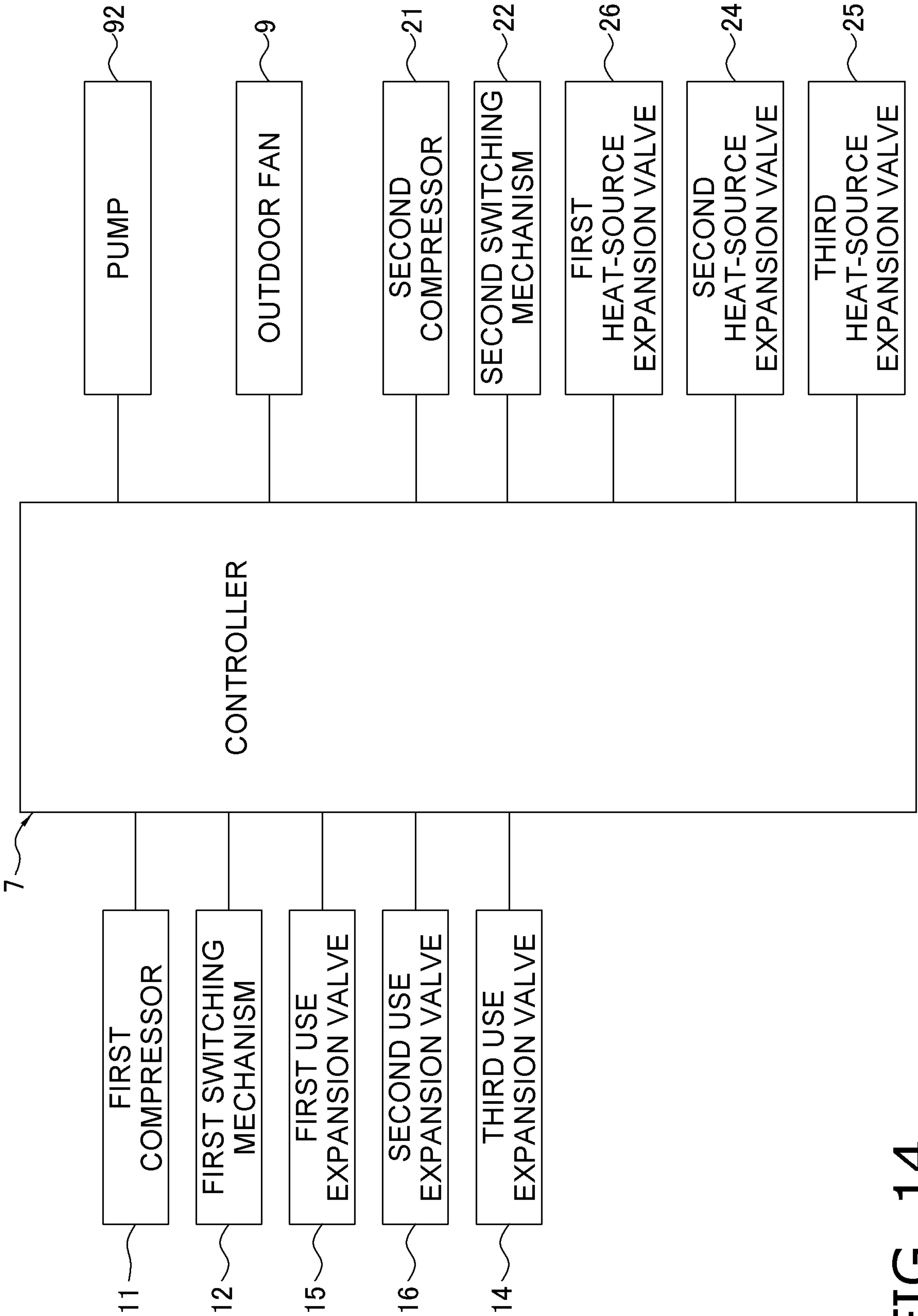

PUMP
92
OUTDOOR FAN
9
SECOND COMPRESSOR
21
SECOND SWITCHING MECHANISM
22
FIRST HEAT-SOURCE EXPANSION VALVE
26
SECOND HEAT-SOURCE EXPANSION VALVE
24
THIRD HEAT-SOURCE EXPANSION VALVE
25
CONTROLLER
7
FIRST COMPRESSOR
11
FIRST SWITCHING MECHANISM
12
FIRST USE EXPANSION VALVE
15
SECOND USE EXPANSION VALVE
16
THIRD USE EXPANSION VALVE
14

FIG. 14

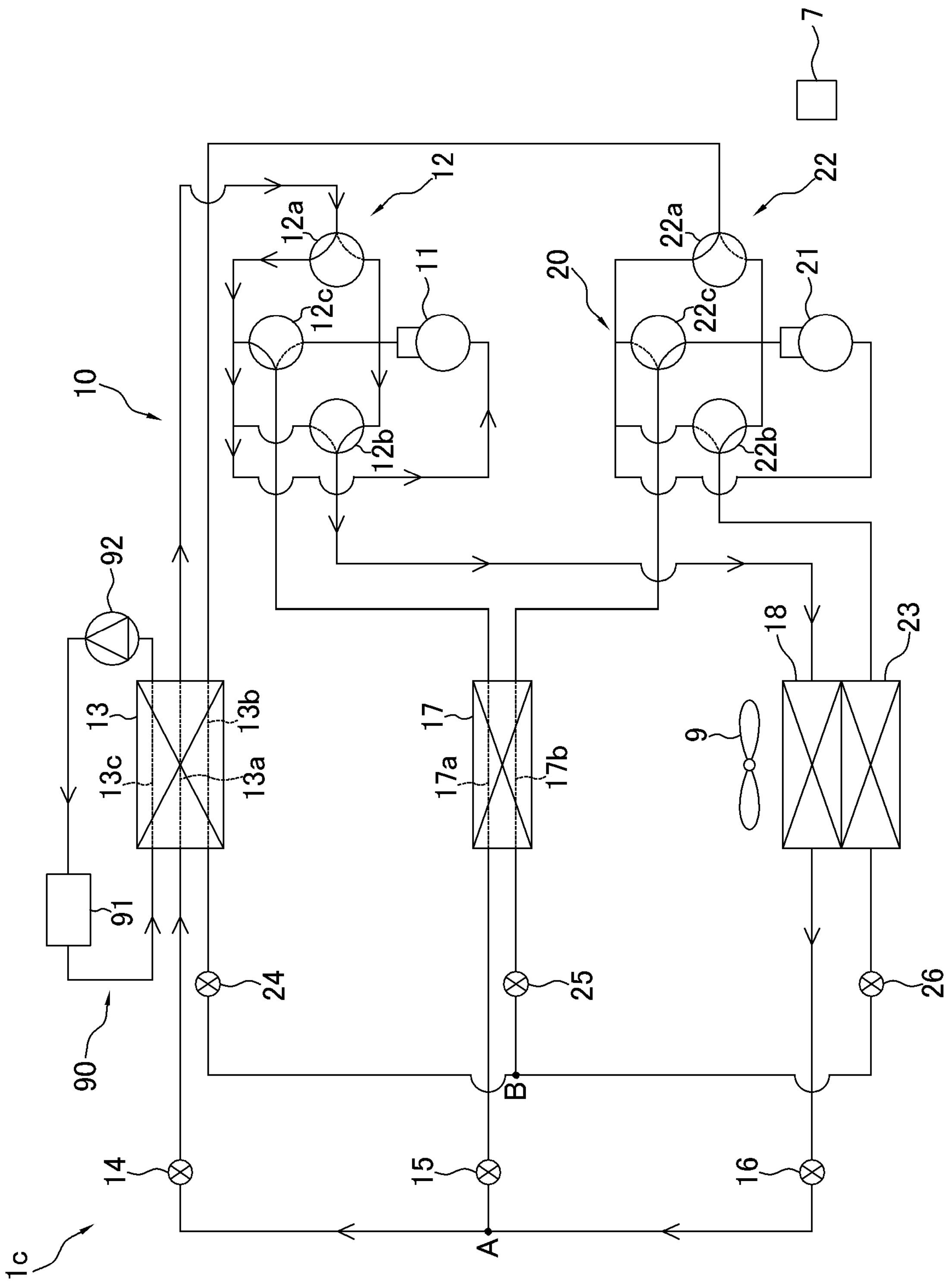
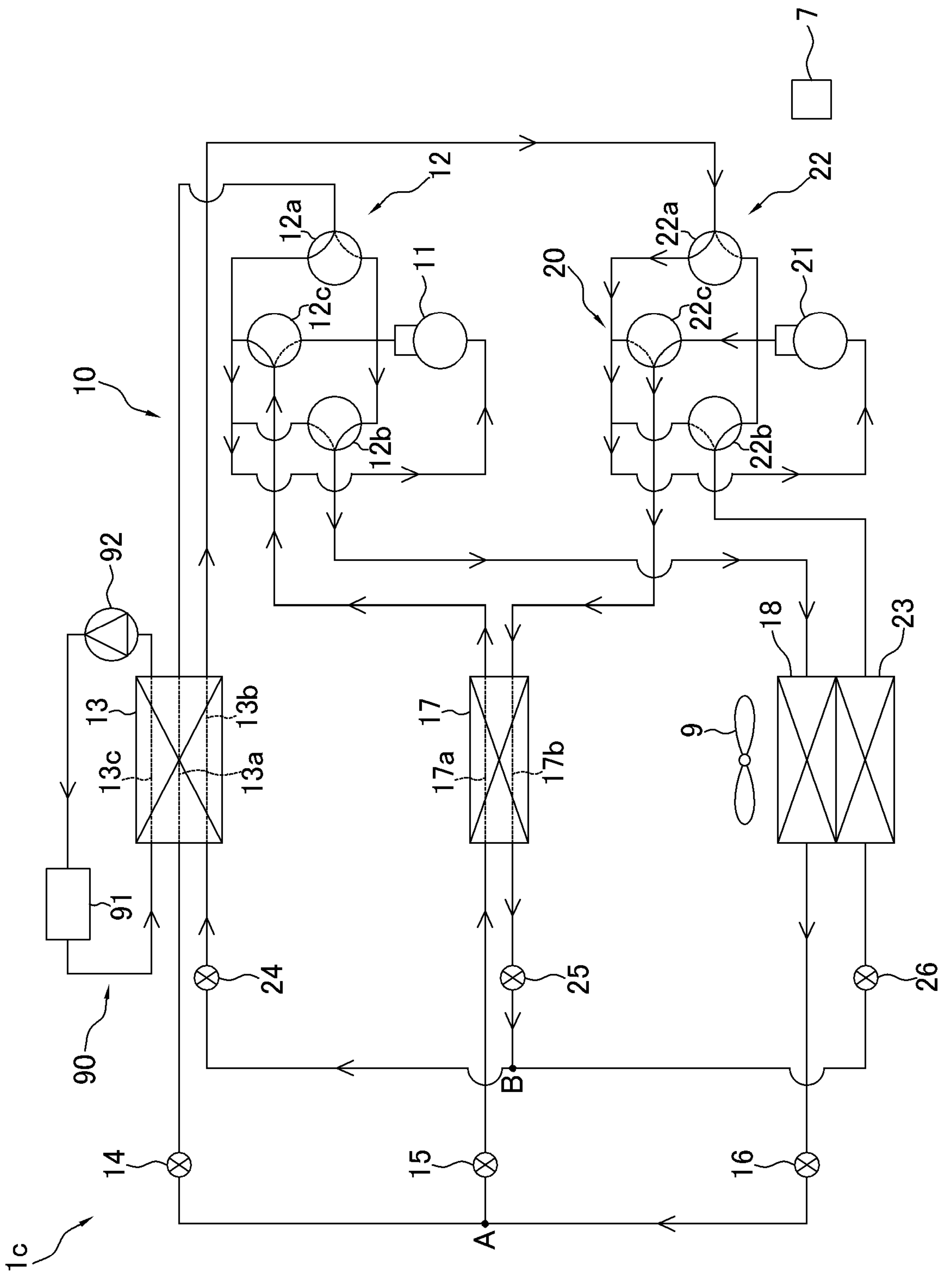

7
12
22
12a
22a
11
21
20
12c
22c
10
12b
22b
92
18
23
13
13b
13c
13a
17
17a
17b
9
91
24
25
26
90
B
14
15
16
A
1c

FIG. 15



7
12
22
12a
22a
11
12c
20
22c
21
10
12b
22b
92
18
23
13
13b
17
9
13c
13a
17a
17b
91
24
25
26
90
B
14
15
16
A
1c

FIG. 16

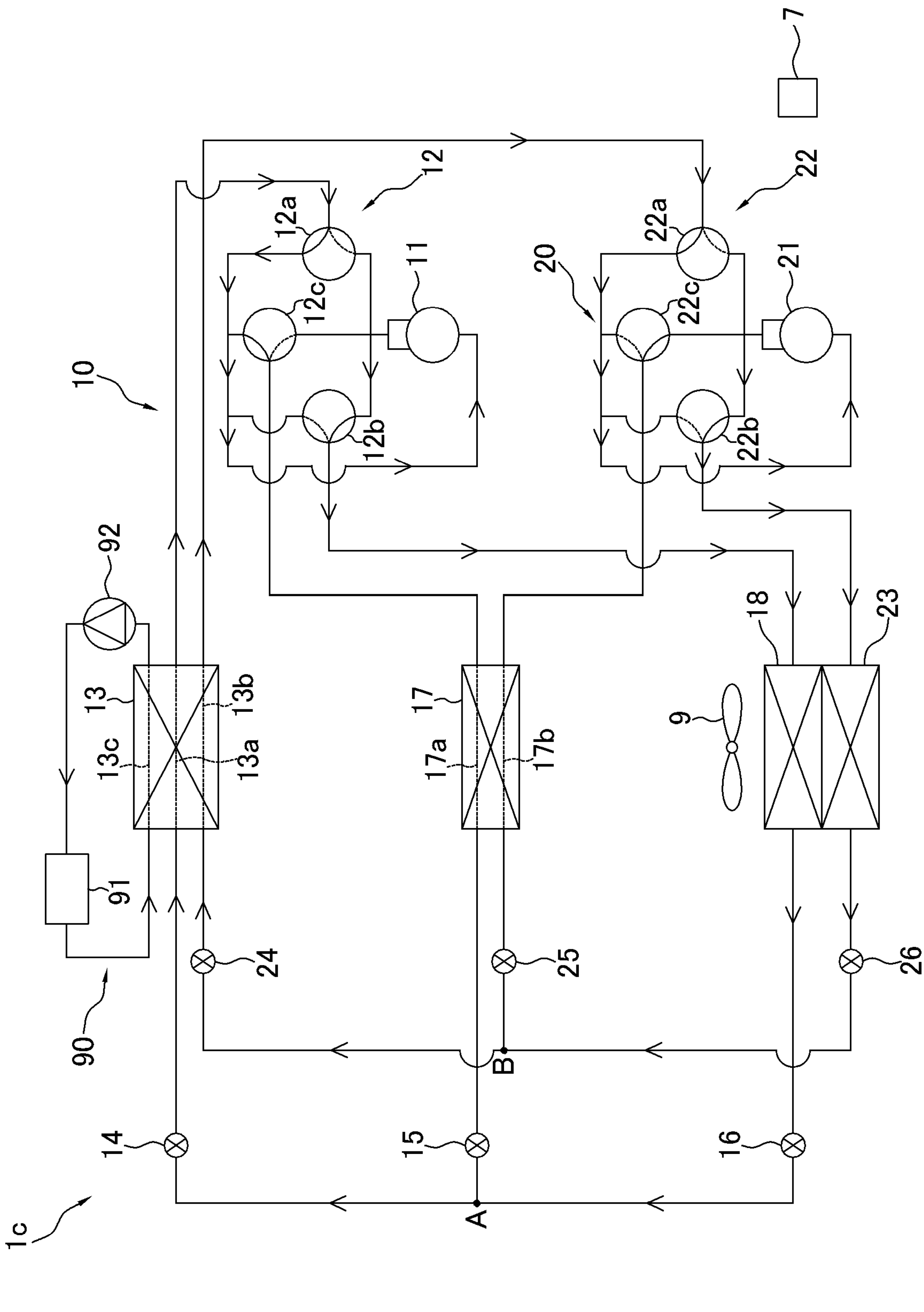
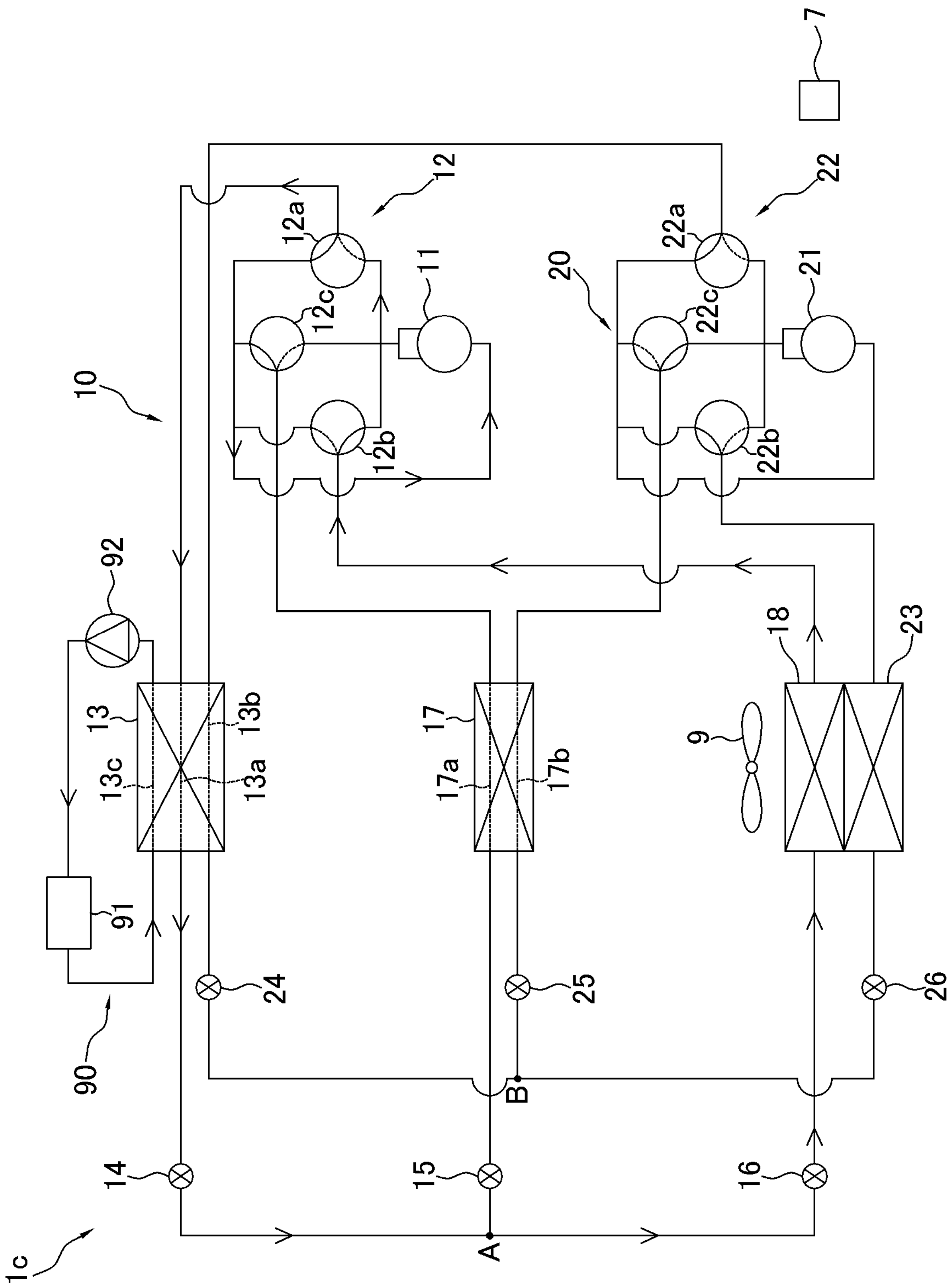

1c
10
12
12a
12b
12c
11
7
22
22a
22b
22c
20
21
92
13
13a
13b
13c
17
17a
17b
18
23
9
91
90
24
25
26
14
15
16
A
B

FIG. 17



7
12
12a
22
22a
10
11
12c
20
21
22c
12b
22b
92
18
23
13
13b
13c
13a
17
17a
17b
9
91
24
25
26
90
B
14
15
16
1c
A

FIG. 18

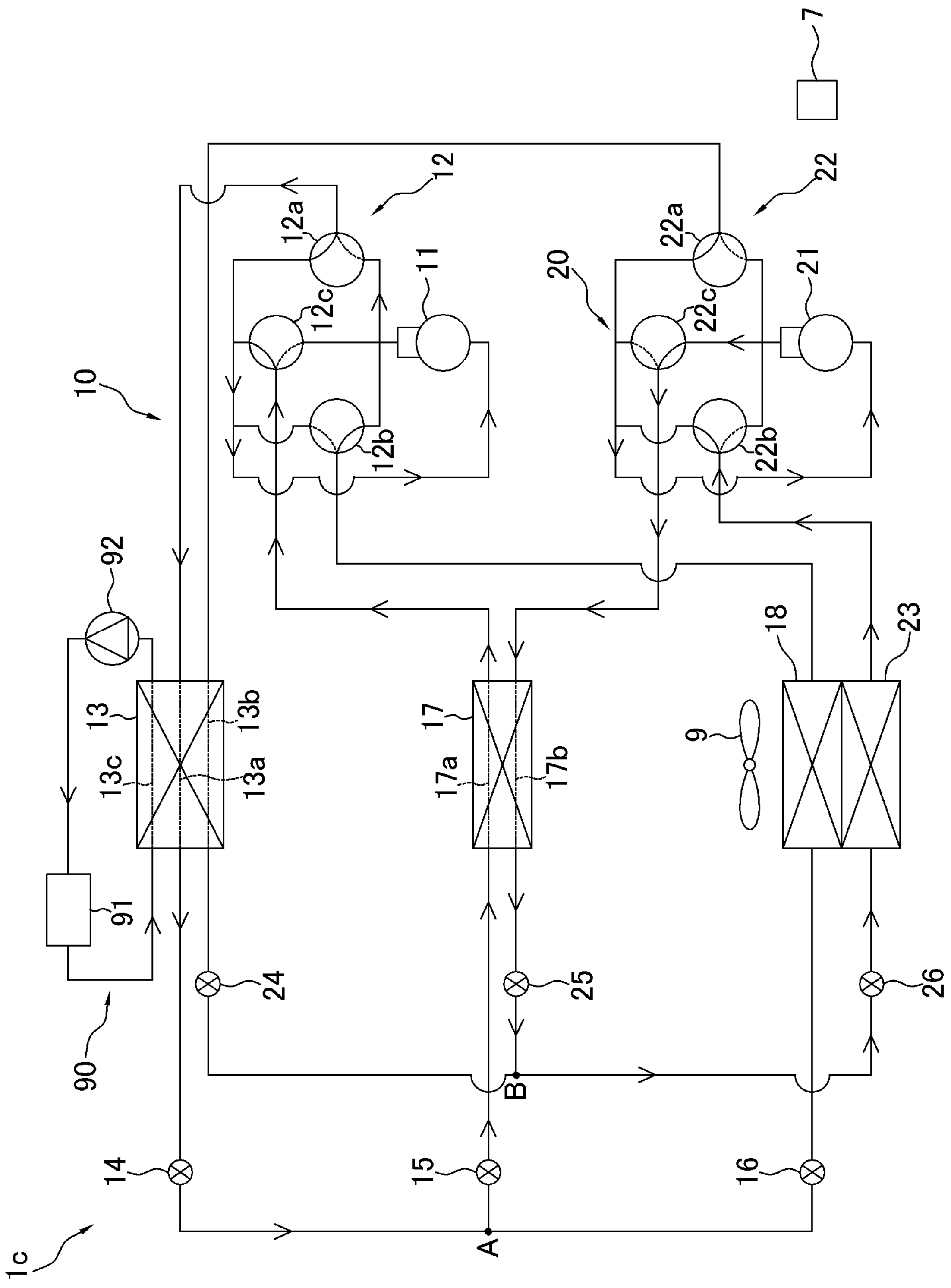
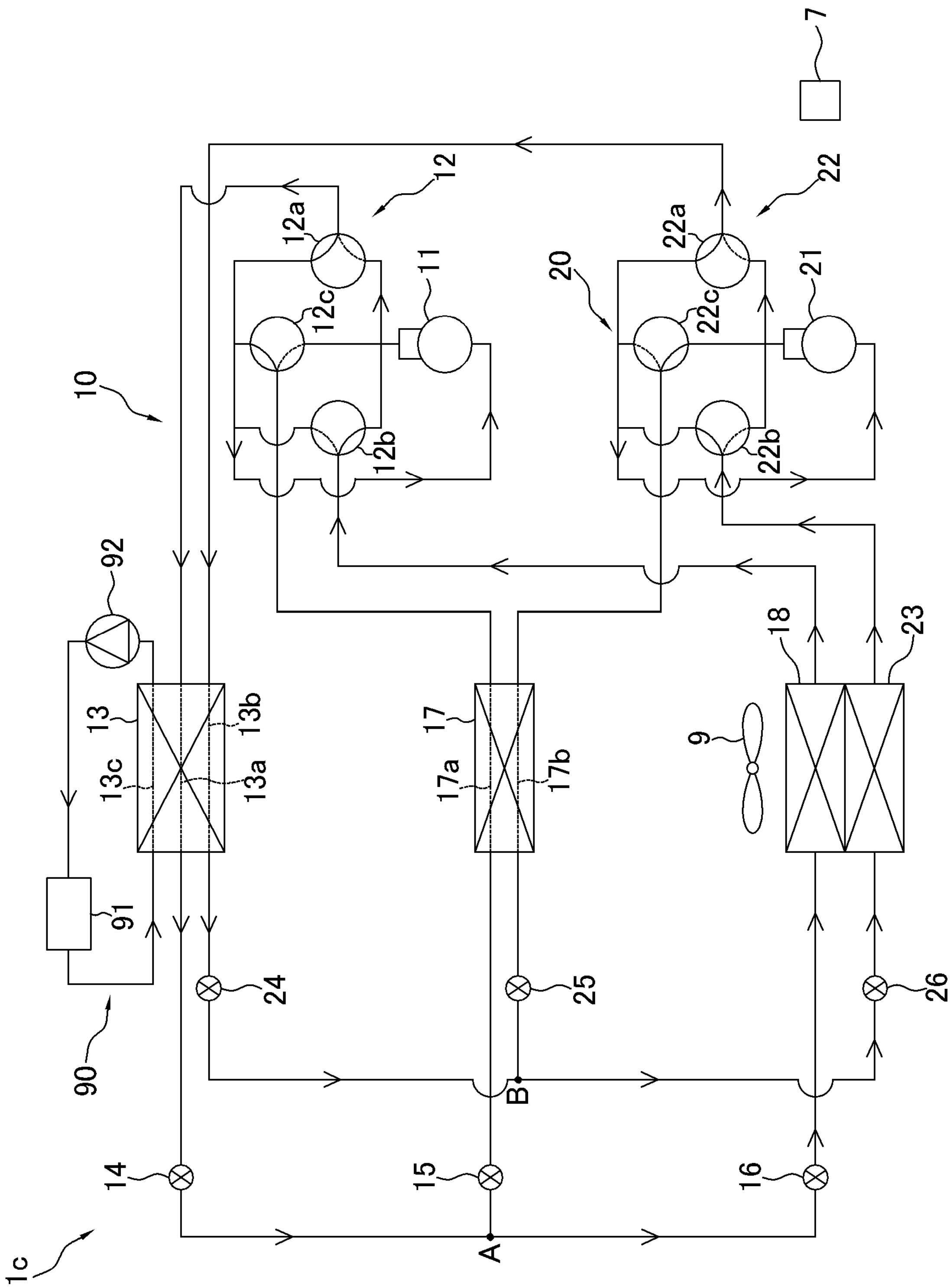

1c
10
12
12a
12b
12c
11
20
22
22a
22b
22c
21
7
92
91
90
13
13a
13b
13c
14
15
16
17
17a
17b
18
23
9
24
25
26
A
B

FIG. 19



1c
10
12
12a
12b
12c
11
20
22
22a
22b
22c
21
7
92
91
90
13
13a
13b
13c
14
15
16
17
17a
17b
18
23
9
24
25
26
A
B

FIG. 20

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2015197254 A **[0003]**
- CN 108759144 A **[0003]**