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

(11) **EP 4 317 846 A1**

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

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

(21) Application number: **22781288.0**

(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 1/00; F25B 7/00; F25B 13/00; F25B 29/00

(86) International application number:
PCT/JP2022/016798

(87) International publication number:
WO 2022/211078 (06.10.2022 Gazette 2022/40)

(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
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(30) Priority: **31.03.2021 JP 2021061280**
31.03.2021 JP 2021061278
30.09.2021 JP 2021161994

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(54) REFRIGERATION CYCLE DEVICE

(57) A refrigeration cycle apparatus including a first refrigerant circuit and a second refrigerant circuit so as to improve the efficiency of operations is provided. A first refrigerant circuit (10) using a first refrigerant having a pressure of 1.2 MPa or less at 30°C and a second refrigerant circuit (20) using a second refrigerant having a pressure of 1.5 MPa or more at 30°C are provided, and a dual cycle operation in which the first refrigerant circuit (10) and the second refrigerant circuit (20) are simultaneously operated to exchange heat between the first refrigerant and the second refrigerant and a single cycle operation in which the first refrigerant circuit (10) is operated without operating the second refrigerant circuit (20) to perform a cooling operation or heating operation are enabled in a switchable manner.

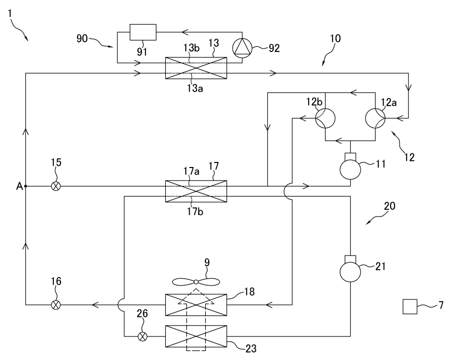

FIG. 3

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Description

TECHNICAL FIELD

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

BACKGROUND ART

[0002] There are conventional dual refrigeration cycle apparatuses in which heat is exchanged between refrigerants flowing through two refrigerant circuits while each of the refrigerant circuits is operated.

[0003] For example, Patent Literature 1 (Japanese Unexamined Patent Publication No. 2014-9829) proposes a refrigeration cycle apparatus that includes a heat-source side refrigerant circuit and a utilization-side refrigerant circuit that are thermally connected to each other via a cascade heat exchanger and efficiently performs a dual refrigeration cycle in a case where both a heat-source side compressor of the heat-source side refrigerant circuit and a utilization-side compressor of the utilization-side refrigerant circuit are driven.

SUMMARY OF THE INVENTION

<Technical Problem>

[0004] In the refrigeration cycle apparatus including a first refrigerant circuit and a second refrigerant circuit, it is desired to improve the efficiency of operations of the refrigeration cycle apparatus by a different method.

<Solution to Problem>

[0005] A refrigeration cycle apparatus according to a first aspect includes a first refrigerant circuit using a first refrigerant and a second refrigerant circuit using a second refrigerant. The first refrigerant has a pressure of 1.2 MPa or less at 30°C. The second refrigerant has a pressure 1.5 MPa or more at 30°C. The refrigeration cycle apparatus enables a dual cycle operation and a single cycle operation in a switchable manner. In the dual cycle operation, the first refrigerant circuit and the second refrigerant circuit are simultaneously operated to exchange heat between the first refrigerant and the second refrigerant. In the single cycle operation, the first refrigerant circuit is operated without operating the second refrigerant circuit to perform a cooling operation or heating operation.

[0006] The refrigeration cycle apparatus may perform only any one of the cooling operation and the heating operation as the single cycle operation or may selectively perform both the cooling operation and the heating operation as the single cycle operation.

[0007] Further, the first refrigerant circuit and the second refrigerant circuit may be refrigerant circuits independent of each other, and the first refrigerant and the second refrigerant may not be mixed with each other.

[0008] Further, when the refrigeration cycle apparatus performs the dual refrigeration cycle, the second refrigerant circuit side may be used as a heat source side, and the first refrigerant circuit side may be used as a utilization side. Specifically, the first refrigerant circuit may process the thermal load.

[0009] Further, on the utilization side, the thermal load of the air may be processed, or the thermal load of fluid such as water or brine may be processed.

[0010] The refrigeration cycle apparatus performs the dual refrigeration cycle including the refrigeration cycle in the first refrigerant circuit using the first refrigerant which is a low-pressure refrigerant having a pressure of 1.2 MPa or less at 30°C and the refrigeration cycle in the second refrigerant circuit using the second refrigerant which is a high-pressure refrigerant having a pressure of 1.5 MPa or more at 30°C, and thus the capacity may be easily ensured while the desirable operating efficiency is obtained. Further, in the refrigeration cycle apparatus, for example, when the heating load is small during the heating operation, the dual refrigeration cycle is not performed, but the heating operation is performed by operating the first refrigerant circuit without operating the second refrigerant circuit so that it is possible to avoid the occurrence of loss due to the heat exchange between the first refrigerant and the second refrigerant at the time of the low load and to prevent a reduction in the operating efficiency.

[0011] In a refrigeration cycle apparatus according to a second aspect, which is the refrigeration cycle apparatus according to the first aspect, during the dual cycle operation, the second refrigerant flowing through the second refrigerant circuit heats the first refrigerant flowing through the first refrigerant circuit to perform the heating operation.

[0012] Further, when the heating load is higher than a predetermined heating load, the heating operation is preferably performed by the dual cycle operation.

[0013] In the refrigeration cycle apparatus, the dual refrigeration cycle is performed during the heating operation so that the operating efficiency may be improved.

[0014] In a refrigeration cycle apparatus according to a third aspect, which is the refrigeration cycle apparatus according to the first aspect or the second aspect, the single cycle operation is performed when a predetermined low-load condition is satisfied.

[0015] Furthermore, when the heating load satisfies a predetermined low-load condition, the heating operation is preferably performed by the single cycle operation.

[0016] In the refrigeration cycle apparatus, it is possible to prevent a reduction in the operating efficiency of the heating operation at the time of the low load.

[0017] A refrigeration cycle apparatus according to a fourth aspect, which is the refrigeration cycle apparatus according to any one of the first aspect to the third aspect, includes a cascade heat exchanger. The cascade heat exchanger includes a first cascade channel through which the first refrigerant flows, and a second cascade channel which is independent of the first cascade channel and through which the second refrigerant flows. The cascade heat exchanger exchanges heat between the first refrigerant and the second refrigerant during the dual cycle operation.

[0018] In the refrigeration cycle apparatus, the load may be processed by using the heat obtained by the first refrigerant circuit side from the second refrigerant circuit side during the dual refrigeration cycle operation.

[0019] In a refrigeration cycle apparatus according to a fifth aspect, which is the refrigeration cycle apparatus according to the fourth aspect, the first refrigerant circuit includes a first compressor, a first heat exchanger, a first expansion valve, and the first cascade channel.

[0020] In the refrigeration cycle apparatus, the first compressor is operated so that the refrigeration cycle using the first refrigerant may be performed in the first refrigerant circuit.

[0021] In a refrigeration cycle apparatus according to a sixth aspect, which is the refrigeration cycle apparatus according to the fifth aspect, the second refrigerant circuit includes a second compressor, the second cascade channel, a second expansion valve, and a second heat exchanger.

[0022] In the refrigeration cycle apparatus, the first compressor and the second compressor are operated so that the dual refrigeration cycle may be performed.

[0023] In a refrigeration cycle apparatus according to a seventh aspect, which is the refrigeration cycle apparatus according to the sixth aspect, during the dual cycle operation, the first cascade channel functions as an evaporator of the first refrigerant, the first heat exchanger functions as a radiator of the first refrigerant, the second cascade channel functions as a radiator of the second refrigerant, and the second heat exchanger functions as an evaporator of the second refrigerant.

[0024] In the refrigeration cycle apparatus, the dual refrigeration cycle is performed so that the operating efficiency of the heating operation may be improved.

[0025] In a refrigeration cycle apparatus according to an eighth aspect, which is the refrigeration cycle apparatus according to the seventh aspect, the first refrigerant circuit further includes a third heat exchanger. The refrigeration cycle apparatus enables the cooling operation in which the third heat exchanger functions as a radiator of the first refrigerant and the first heat exchanger functions as an evaporator of the first refrigerant.

[0026] In the refrigeration cycle apparatus, the cooling operation may be performed by the single cycle.

[0027] In a refrigeration cycle apparatus according to a ninth aspect, which is the refrigeration cycle apparatus according to the seventh aspect, the first refrigerant circuit further includes a third heat exchanger. The refrigeration cycle apparatus enables the heating operation in which the third heat exchanger functions as an evaporator of the first refrigerant and the first heat exchanger functions as a radiator of the first refrigerant.

[0028] In the refrigeration cycle apparatus, the heating operation may be performed by the single cycle.

[0029] In a refrigeration cycle apparatus according to a tenth aspect, which is the refrigeration cycle apparatus according to the seventh aspect, the first refrigerant circuit further includes a third heat exchanger and a switching unit that switches a channel of the first refrigerant. In the refrigeration cycle apparatus, the switching unit is switched to enable the cooling operation in which the third heat exchanger functions as a radiator of the first refrigerant and the first heat exchanger functions as an evaporator of the first refrigerant and the heating operation in which the third heat exchanger functions as an evaporator of the first refrigerant and the first heat exchanger functions as a radiator of the first refrigerant.

[0030] In the refrigeration cycle apparatus, the heating operation by the single refrigeration cycle and the heating operation by the dual refrigeration cycle may be performed in a switchable manner.

[0031] A refrigeration cycle apparatus according to an eleventh aspect, which is the refrigeration cycle apparatus according to any one of the eighth aspect to the tenth aspect, further includes a first blowing unit. The second heat exchanger exchanges heat between air flowing outside and the second refrigerant flowing inside. The third heat exchanger exchanges heat between air flowing outside and the first refrigerant flowing inside. The first blowing unit forms an air flow passing through the second heat exchanger and an air flow passing through the third heat exchanger.

[0032] In the refrigeration cycle apparatus, heat may be exchanged between the second heat exchanger and the third heat exchanger by using the air flow formed by the first blowing unit.

[0033] In a refrigeration cycle apparatus according to a twelfth aspect, which is the refrigeration cycle apparatus according to the eleventh aspect, the second heat exchanger is located at a position other than leeward of the third heat exchanger in the air flow.

[0034] The second heat exchanger may be located on the windward side of the third heat exchanger. Further, the second heat exchanger may be arranged side by side with the third heat exchanger in a direction intersecting with the direction of the air flow by the first blowing unit. The second heat exchanger and the third heat exchanger may be arranged side by side in the circumferential direction so as not to overlap with each other in the direction of the air flow on the windward side of the air flow with respect to the first blowing unit when the first blowing unit forms an upward air flow.

[0035] In the refrigeration cycle apparatus, the second refrigerant in the second heat exchanger may be prevented from being heated by the air having passed through the third heat exchanger.

[0036] In a refrigeration cycle apparatus according to a thirteenth aspect, which is the refrigeration cycle apparatus according to either the eleventh aspect or the twelfth aspect, the second heat exchanger and the third heat exchanger are located away from each other in a direction of the air flow.

[0037] In the refrigeration cycle apparatus, the second refrigerant in the second heat exchanger may be prevented from being heated by the heat of the third heat exchanger itself.

[0038] In a refrigeration cycle apparatus according to a fourteenth aspect, which is the refrigeration cycle apparatus according to any one of the sixth aspect to the thirteenth aspect, the second refrigerant circuit further includes a fourth heat exchanger provided between a discharge side of the second compressor and the second cascade channel.

[0039] In the refrigeration cycle apparatus, the heat of the refrigerant flowing through the fourth heat exchanger may be used to process the heating load on the utilization side.

[0040] A refrigeration cycle apparatus according to a fifteenth aspect, which is the refrigeration cycle apparatus according to the fourteenth aspect, further includes a second blowing unit. The first heat exchanger exchanges heat between air flowing outside and the first refrigerant flowing inside. The fourth heat exchanger exchanges heat between air flowing outside and the second refrigerant flowing inside. The second blowing unit forms an air flow passing through both the first heat exchanger and the fourth heat exchanger.

[0041] In the refrigeration cycle apparatus, the heating load may be processed by using the heat of the refrigerant in the first heat exchanger and the fourth heat exchanger by the air flow formed by the second blowing unit.

[0042] In a refrigeration cycle apparatus according to a sixteenth aspect, which is the refrigeration cycle apparatus according to any one of the first aspect to the fifteenth aspect, the first refrigerant includes at least any of R1234yf, R1234ze, and R290.

[0043] Further, the first refrigerant may include only R1234yf, may include only R1234ze, or may include only R290.

[0044] In the refrigeration cycle apparatus, operations may be performed by using the refrigerant having a sufficiently low global warming potential (GWP).

[0045] In a refrigeration cycle apparatus according to a seventeenth aspect, which is the refrigeration cycle apparatus according to any one of the first aspect to the sixteenth aspect, the second refrigerant includes carbon dioxide.

[0046] Further, the second refrigerant may include only carbon dioxide, or may be a mixed refrigerant of carbon dioxide and another refrigerant.

[0047] In the refrigeration cycle apparatus, operations may be performed by using the refrigerant having a sufficiently low ozone depletion potential (ODP) and a sufficiently low global warming potential (GWP). Further, during the cooling operation, the single refrigeration cycle using the first refrigerant circuit is performed while avoiding performing the dual refrigeration cycle using the second refrigerant circuit, through which the refrigerant including carbon dioxide flows, as the refrigerant circuit on the heat-source side in the dual refrigeration cycle, and thus it is possible to avoid a reduction in the COP due to the supercritical state of the carbon dioxide refrigerant.

BRIEF DESCRIPTION OF THE DRAWINGS

[0048]

Fig. 1 is an overall configuration diagram of a refrigeration cycle apparatus according to a first embodiment.

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

Fig. 3 is a diagram illustrating a flow state of a refrigerant during a cooling operation according to the first embodiment.

Fig. 4 is a diagram illustrating a flow state of the refrigerant during a high-load heating operation according to the first embodiment.

Fig. 5 is a diagram illustrating a flow state of the refrigerant during a low-load heating operation according to the first embodiment.

Fig. 6 is an overall configuration diagram of the refrigeration cycle apparatus according to a second embodiment.

Fig. 7 is an overall configuration diagram of a refrigeration cycle apparatus according to a third embodiment.

Fig. 8 is a schematic configuration diagram of a first outdoor heat exchanger and a second outdoor heat exchanger of a refrigeration cycle apparatus according to a fourth embodiment.

Fig. 9 is a schematic configuration diagram of the first outdoor heat exchanger and the second outdoor heat exchanger of a refrigeration cycle apparatus according to a fifth embodiment.

Fig. 10 is a schematic configuration diagram of the first outdoor heat exchanger and the second outdoor heat exchanger of a refrigeration cycle apparatus according to a sixth embodiment.

Fig. 11 is a schematic configuration diagram of the first outdoor heat exchanger and the second outdoor heat exchanger of a refrigeration cycle apparatus according to a seventh embodiment.

DESCRIPTION OF EMBODIMENTS

(1) First Embodiment

[0049] Fig. 1 is a schematic configuration diagram of a refrigeration cycle apparatus 1 according to the first embodiment. Fig. 2 is a functional block configuration diagram of the refrigeration cycle apparatus 1 according to the first embodiment.

[0050] The refrigeration cycle apparatus 1 is an apparatus used to perform vapor compression refrigeration cycle operations to process thermal loads. The refrigeration cycle apparatus 1 includes a thermal load circuit 90, a first refrigerant circuit 10, a second refrigerant circuit 20, an outdoor fan 9, and a controller 7.

[0051] The thermal loads processed by the refrigeration cycle apparatus 1 are not limited, and heat may be exchanged for fluids such as air, water, or brine, and in the refrigeration cycle apparatus 1 according to the present embodiment, the water flowing through the thermal load circuit 90 is supplied to a thermal-load heat exchanger 91, and the thermal load in the thermal-load heat exchanger 91 is processed. The thermal load circuit 90 is a circuit in which water as a heat medium circulates and includes the thermal-load heat exchanger 91, a pump 92, and a utilization heat exchanger 13 (corresponding to a first heat exchanger) shared with the first refrigerant circuit 10. The pump 92 is driven and controlled by the controller 7, described below, to circulate the water through the thermal load circuit 90. In the thermal load circuit 90, the water flows through a thermal load channel 13b included in the utilization heat exchanger 13. As described below, the utilization heat exchanger 13 includes a utilization channel 13a that passes a first refrigerant flowing through the first refrigerant circuit 10. The water flowing through the thermal load channel 13b of the utilization heat exchanger 13 exchanges heat with the first refrigerant flowing through the utilization channel 13a to be cooled during a cooling operation and to be heated during a heating operation.

[0052] The first refrigerant circuit 10 includes a first compressor 11, a first switching mechanism 12, the utilization heat exchanger 13 (corresponding to a first heat exchanger) shared with the thermal load circuit 90, a first utilization expansion valve 15 (corresponding to a first expansion valve), a second utilization expansion valve 16, a cascade 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 a pressure of 1.2 MPa or less at 30°C, for example, a refrigerant including at least any of R1234yf, R1234ze, and R290, and may include only R1234yf, may include only R1234ze, or may include only R290.

[0053] The first compressor 11 is a volumetric compressor driven by a compressor motor. The compressor motor is driven by the electric power supplied via an inverter device. The operating capacity of the first compressor 11 may be changed by varying the drive frequency that is the number of rotations of the compressor motor. The 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 cascade channel 17a of the cascade heat exchanger 17.

[0054] 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 the state where the discharge side of the first compressor 11 is connected to the utilization channel 13a of the utilization heat exchanger 13 and the state where the suction side of the first compressor 11 is connected to the utilization channel 13a of the utilization heat exchanger 13. The switching valve 12b is a three-way valve that switches between the state where the discharge side of the first compressor 11 is connected to the first outdoor heat exchanger 18 and the state where the suction side of the first compressor 11 is connected to the first outdoor heat exchanger 18.

[0055] A gas-refrigerant side of the utilization channel 13a, which passes the first refrigerant flowing through the first refrigerant circuit 10, in the utilization heat exchanger 13 is connected to the switching valve 12a. Furthermore, a liquid-refrigerant side of the utilization channel 13a is connected to a first branch point A included in the first refrigerant circuit 10. The first refrigerant evaporates when flowing through the utilization channel 13a of the utilization heat exchanger 13 to cool the water flowing through the thermal load circuit 90 and condenses when flowing through the utilization channel 13a of the utilization heat exchanger 13 to heat the water flowing through the thermal load circuit 90.

[0056] At the first branch point A, a channel extending from the liquid-refrigerant side of the utilization channel 13a, a channel extending from the first utilization expansion valve 15 to the opposite side of the cascade heat exchanger 17, and a channel extending from the second utilization expansion valve 16 to the opposite side of the first outdoor heat exchanger 18 are connected to each other.

[0057] The first utilization expansion valve 15 includes an electronic expansion valve whose valve opening degree is adjustable. In the first refrigerant circuit 10, the first utilization expansion valve 15 is provided between the first branch point A and an inlet on the liquid-refrigerant side of the first cascade channel 17a of the cascade heat exchanger 17.

[0058] The second utilization expansion valve 16 includes an electronic expansion valve whose valve opening degree is adjustable. In the first refrigerant circuit 10, the second utilization expansion valve 16 is provided between the first branch point A and an outlet on the liquid-refrigerant side of the first outdoor heat exchanger 18.

[0059] The cascade heat exchanger 17 is a heat exchanger that includes the first cascade channel 17a, which passes the first refrigerant flowing through the first refrigerant circuit 10, and a second cascade channel 17b, which passes the second refrigerant flowing through the second refrigerant circuit 20, and exchanges heat between the first refrigerant and the second refrigerant. In the cascade heat exchanger 17, the first cascade channel 17a and the second cascade channel 17b are independent of each other so that the first refrigerant and the second refrigerant do not mix with each other. The outlet on the gas-refrigerant side of the first cascade channel 17a of the cascade heat exchanger 17 is connected to the suction side of the first compressor 11. The inlet on the liquid-refrigerant side of the first cascade channel 17a of the cascade heat exchanger 17 is connected to the first utilization expansion valve 15.

[0060] 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. According to the present embodiment, the first outdoor heat exchanger 18 is provided outdoors. The first refrigerant flowing through the first outdoor heat exchanger 18 exchanges heat with the air sent to the first outdoor heat exchanger 18 so as to function as a condenser or an evaporator of the first refrigerant.

[0061] The outdoor fan 9 generates the air flow of the outdoor air passing through both the first outdoor heat exchanger 18 and a second outdoor heat exchanger 23.

[0062] The second refrigerant circuit 20 includes a second compressor 21, the cascade heat exchanger 17 shared with the first refrigerant circuit 10, a heat-source expansion valve 26, and the second outdoor heat exchanger 23 (corresponding to a second heat exchanger). 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 a pressure of 1.5 MPa or more at 30°C, for example, a mixed refrigerant including carbon dioxide, or may include only carbon dioxide. The mixed refrigerant including carbon dioxide may be, for example, a mixed refrigerant of carbon dioxide and R1234ze or a mixed refrigerant of carbon dioxide and R1234yf.

[0063] The second compressor 21 is a volumetric compressor driven by a compressor motor. The compressor motor is driven by the electric power supplied via an inverter device. The operating capacity of the second compressor 21 may be changed by varying the drive frequency that is the number of rotations of the compressor motor. The discharge side of the second compressor 21 is connected to the inlet on the gas-refrigerant side of the second cascade channel 17b of the cascade heat exchanger 17. The suction side of the second compressor 21 is connected to the second outdoor heat exchanger 23.

[0064] The inlet on the gas-refrigerant side of the second cascade channel 17b of the cascade heat exchanger 17 is connected to the discharge side of the second compressor 21. The outlet on the liquid-refrigerant side of the second cascade channel 17b of the cascade heat exchanger 17 is connected to the heat-source expansion valve 26.

[0065] The heat-source expansion valve 26 is provided in a channel between the liquid-refrigerant side of the second cascade channel 17b of the cascade heat exchanger 17 and the liquid-refrigerant side of the second outdoor heat exchanger 23.

[0066] 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. According to the present embodiment, the second outdoor heat exchanger 23 is arranged side by side with the first outdoor heat exchanger 18 outdoors. Specifically, the second outdoor heat exchanger 23 is located away from the first outdoor heat exchanger 18 to the windward side in the direction of the air flow formed by the outdoor fan 9. As described above, as the second outdoor heat exchanger 23 and the first outdoor heat exchanger 18 are located away from each other, transfer of the heat from the first outdoor heat exchanger 18 to the second outdoor heat exchanger 23 is prevented. Further, as the second outdoor heat exchanger 23 is not located on the leeward side of the first outdoor heat exchanger 18, the air heated by the first outdoor heat exchanger 18 may be prevented from being sent to the second outdoor heat exchanger 23. Thus, it is possible to prevent the carbon dioxide refrigerant in the second outdoor heat exchanger 23 from being heated by the heat of the first outdoor heat exchanger 18. The second refrigerant flowing through the second outdoor heat exchanger 23 exchanges heat with the air sent to the second outdoor heat exchanger 23 so as to function as an evaporator of the second refrigerant.

[0067] The controller 7 controls the operation of each device included in the thermal load circuit 90, the first refrigerant circuit 10, and the second refrigerant circuit 20. Specifically, the controller 7 includes a processor such as a CPU provided for performing control, memories such as a ROM and a RAM, and the like.

[0068] In the above-described refrigeration cycle apparatus 1, the controller 7 controls each device so as to perform the refrigeration cycle and thus performs a cooling operation to process the cooling load in the thermal-load heat exchanger 91 and a heating operation to process the heating load in the thermal-load heat exchanger 91. The heating operation includes a low-load heating operation performed when the heating load is low and a high-load heating operation performed when the heating load is high.

(1-1) Cooling Operation

[0069] During the cooling operation, as illustrated in Fig. 3, the first refrigerant circuit 10 performs the single refrigeration cycle such that the utilization 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 the refrigeration cycle. Specifically, the switching valves 12a, 12b of the first switching mechanism 12 are switched to the connection states indicated in solid lines in Fig. 3, the pump 92, the first compressor 11, and the outdoor fan 9 are driven, the first utilization expansion valve 15 is fully closed, and the valve opening degree of the second utilization expansion valve 16 is controlled such that the degree of superheating of the first refrigerant suctioned by the first compressor 11 satisfies a predetermined condition. Here, the number of rotations of the first compressor 11 is controlled so that the cooling load of the thermal-load heat exchanger 91 in the thermal load circuit 90 may be processed. Furthermore, during the cooling operation, the second compressor 21 is stopped so that the operation of the second refrigerant circuit 20 is stopped.

[0070] Thus, 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 utilization expansion valve 16, passes through the first branch point A, and is sent to the utilization channel 13a of the utilization heat exchanger 13. The first refrigerant flowing through the utilization channel 13a of the utilization heat exchanger 13 evaporates by heat exchange with the water flowing through the thermal load channel 13b of the utilization heat exchanger 13 included in the thermal load circuit 90. The water cooled by this heat exchange is sent to the thermal-load heat exchanger 91 in the thermal load circuit 90 to process the cooling load. The first refrigerant evaporated in the utilization channel 13a of the utilization heat exchanger 13 is suctioned into the first compressor 11 via the switching valve 12a of the first switching mechanism 12.

(1-2) High-load Heating Operation

[0071] The high-load heating operation is performed when a high-load condition is satisfied, which is that the heating load to be processed in the thermal-load heat exchanger 91 of the thermal load circuit 90 is high in a case where the heating operation is performed. The high-load condition is not limited, but may be that a low-load condition described below is not satisfied.

[0072] During the high-load heating operation, as illustrated in Fig. 4, the first refrigerant circuit 10 performs the refrigeration cycle such that the utilization heat exchanger 13 functions as a condenser of the first refrigerant and the cascade heat exchanger 17 functions as an evaporator of the first refrigerant, and the second refrigerant circuit 20 performs the refrigeration cycle such that the cascade 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. Thus, during the high-load heating operation, the second refrigerant circuit 20 and the first refrigerant circuit 10 perform the dual refrigeration cycle. Specifically, the switching valves 12a, 12b of the first switching mechanism 12 are switched to the connection states indicated in the 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 utilization expansion valve 16 is fully closed, the valve opening degree of the first utilization expansion valve 15 is controlled such that the degree of superheating of the first refrigerant suctioned by the first compressor 11 satisfies a predetermined condition, and the valve opening degree of the heat-source expansion valve 26 is controlled such that the degree of superheating of the second refrigerant suctioned by the second compressor 21 satisfies a predetermined condition. Further, the number of rotations of the first compressor 11 is controlled such that the cooling load of the thermal-load heat exchanger 91 in the thermal load circuit 90 may be processed. Further, the number of rotations of the second compressor 21 is controlled such that, for example, the degree of superheating of the first refrigerant, which passes through the first cascade channel 17a in the cascade heat exchanger 17 and is suctioned into the first compressor 11, becomes a predetermined value or the second refrigerant flowing through the second cascade channel 17b in the cascade heat exchanger 17 has a predetermined pressure.

[0073] Accordingly, the second refrigerant discharged from the second compressor 21 is sent to the cascade heat exchanger 17 and, when flowing through the second cascade channel 17b, the second refrigerant radiates heat by heat exchange with the first refrigerant flowing through the first cascade channel 17a. The second refrigerant, which has radiated heat in the cascade heat exchanger 17, is decompressed in the heat-source expansion valve 26, then evaporates by heat exchange with the outdoor air supplied by the outdoor fan 9 in the second outdoor heat exchanger 23, and is suctioned into the second compressor 21. The first refrigerant discharged from the first compressor 11 is sent to the utilization channel 13a of the utilization heat exchanger 13 via the switching valve 12a of the first switching mechanism 12. The first refrigerant flowing through the utilization channel 13a of the utilization heat exchanger 13 is condensed by heat exchange with the water flowing through the thermal load channel 13b of the utilization heat exchanger 13 included in the thermal load circuit 90. The water heated by this heat exchange is sent to the thermal-load heat exchanger 91 in the thermal load circuit 90 to process the heating load. The first refrigerant condensed in the utilization channel 13a of the utilization heat exchanger 13 is decompressed in the first utilization expansion valve 15 after passing through the first branch point A. The refrigerant decompressed by the first utilization expansion valve 15 evaporates by heat exchange with the second refrigerant flowing through the second cascade channel 17b when passing through the first cascade channel 17a of the cascade heat exchanger 17. The first refrigerant evaporated in the first cascade channel 17a of the cascade heat exchanger 17 is suctioned into the first compressor 11.

(1-3) Low-load Heating Operation

[0074] The low-load heating operation is performed when a low-load condition is satisfied, which is that the heating load to be processed in the thermal-load heat exchanger 91 of the thermal load circuit 90 is small in a case where the heating operation is performed.

[0075] The low load condition is not limited, but may be, for example, a condition that the heating load in the thermal-load heat exchanger 91 of the thermal load circuit 90 is a load that may be processed even when the compression ratio of the first compressor 11 is equal to or less than a predetermined compression ratio. The predetermined compression ratio here may be, for example, a compression ratio of the first compressor 11 at which the degree of reduction in the operating efficiency of the refrigeration cycle apparatus 1 due to the heat exchange loss in the cascade heat exchanger 17 when the heating operation of the dual refrigeration cycle is performed in the refrigeration cycle apparatus 1 is larger than the degree of reduction in the operating efficiency of the refrigeration cycle apparatus 1 when the heating load process by the heating operation of the dual refrigeration cycle in which both the first refrigerant circuit 10 and the second refrigerant circuit 20 are operated is changed to the heating load process by the heating operation of the single refrigeration cycle in which only the first refrigerant circuit 10 is operated. Furthermore, the predetermined compression ratio here may be, for example, the compression ratio of the first compressor 11 at which the coefficient of performance (COP) when the heating load is processed by the single refrigeration cycle in which only the first refrigerant circuit 10 is operated is larger than the coefficient of performance (COP) when the heating load is processed by the dual refrigeration cycle in which both the first refrigerant circuit 10 and the second refrigerant circuit 20 are operated in the refrigeration cycle apparatus 1.

[0076] Furthermore, the low load condition is not limited to the conditions based on the predetermined compression ratio, and may be, for example, that the temperature of the fluid required in the thermal-load heat exchanger 91 of the thermal load circuit 90 is equal to or more than a predetermined value or that the difference between the outside air temperature and the temperature of the fluid required in the thermal-load heat exchanger 91 of the thermal load circuit 90 is equal to or more than a predetermined value, or these predetermined values may be previously set based on the above-described predetermined compression ratio. The threshold value used for the determination of the low load condition may be previously set and held in a memory, or the like, of the controller 7.

[0077] During the low-load heating operation, as illustrated in Fig. 5, the first refrigerant circuit 10 performs the refrigeration cycle such that the utilization heat exchanger 13 functions as a condenser of the first refrigerant, the first refrigerant is not sent to the cascade heat exchanger 17, and the first outdoor heat exchanger 18 functions as an evaporator of the first refrigerant, and the operation of the second refrigerant circuit 20 is stopped. Thus, during the low-load heating operation, the first refrigerant circuit 10 performs the single refrigeration cycle. Specifically, the switching valves 12a, 12b of the first switching mechanism 12 are switched to the connection states indicated in the broken lines in Fig. 5, the pump 92, the first compressor 11, and the outdoor fan 9 are driven, the first utilization expansion valve 15 is fully closed, and the valve opening degree of the second utilization expansion valve 16 is controlled such that the degree of superheating of the first refrigerant suctioned by the first compressor 11 satisfies a predetermined condition. The number of rotations of the first compressor 11 is controlled such that the heating load of the thermal-load heat exchanger 91 in the thermal load circuit 90 may be processed. Furthermore, during the low-load heating operation, the second compressor 21 is stopped so that the operation of the second refrigerant circuit 20 is stopped.

[0078] Thus, the first refrigerant discharged from the first compressor 11 is sent to the utilization channel 13a of the utilization heat exchanger 13 via the switching valve 12a of the first switching mechanism 12. The first refrigerant flowing through the utilization channel 13a of the utilization heat exchanger 13 is condensed by heat exchange with the water flowing through the thermal load channel 13b of the utilization heat exchanger 13 included in the thermal load circuit 90. The water heated by this heat exchange is sent to the thermal-load heat exchanger 91 in the thermal load circuit 90 to process the heating load. After passing through the first branch point A, the first refrigerant condensed in the utilization channel 13a of the utilization heat exchanger 13 does not flow into the first utilization expansion valve 15 in the fully closed state, but is decompressed in the second utilization expansion valve 16 whose opening degree is controlled. When passing through the first outdoor heat exchanger 18, the refrigerant decompressed by the second utilization expansion valve 16 evaporates by heat exchange with the air in the air flow formed by the outdoor fan 9. The first refrigerant evaporated in the first outdoor heat exchanger 18 is suctioned into the first compressor 11.

(1-4) Features of First Embodiment

[0079] 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). Furthermore, 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). This may prevent deteriorations of the global environment.

[0080] Further, even though the first refrigerant circuit 10 uses the first refrigerant having a sufficiently low global warming potential (GWP), the high-load heating operation is performed when the heating load is high so that the heating load is processed. Specifically, during the high-load heating operation, the dual refrigeration cycle is performed, in which the second refrigerant circuit 20 serves as a heat-source side cycle and the first refrigerant circuit 10 serves as a utilization side cycle, and thus the capability during the heating operation may be easily ensured as compared with the case where the single refrigeration cycle is performed, in which the first refrigerant, which is a low-pressure refrigerant, is used.

[0081] Furthermore, in the refrigeration cycle apparatus 1 according to the present embodiment, the first refrigerant circuit 10 uses the first refrigerant having a pressure of 1.2 MPa or less at 30°C instead of the second refrigerant having a pressure of 1.5 MPa or more at 30°C. Therefore, the density of the first refrigerant suctioned by the first compressor 11 of the first refrigerant circuit 10 may be increased, and the efficiency of the first compressor 11 may be enhanced. Further, the capacity of the first compressor 11 may be reduced.

[0082] Furthermore, in the refrigeration cycle apparatus 1 according to the present embodiment, the first refrigerant circuit 10 includes the first outdoor heat exchanger 18 that is connected in parallel to the cascade heat exchanger 17. Therefore, even when the second refrigerant circuit 20 is in the operation stop state and thus heat is not exchanged between the first refrigerant and the second refrigerant in the cascade heat exchanger 17, the first refrigerant may exchange heat with air in the first outdoor heat exchanger 18. Thus, the first refrigerant circuit 10 may perform the refrigeration cycle even when the second refrigerant circuit 20 is in the operation stop state. Specifically, in the refrigeration cycle apparatus 1 according to the present embodiment, even when the second refrigerant circuit 20 is in the operation stop state, the first refrigerant circuit 10 may be operated to perform the low-load heating operation by the single refrigeration cycle.

[0083] Further, when the heating load is small, the low-load heating operation, which is a single refrigeration cycle using only the first refrigerant circuit 10, is performed instead of the dual refrigeration cycle. Accordingly, it is possible to process the heating load while suppressing the compression ratio in the first compressor 11 so as to be small and also to prevent the loss at the time of heat exchange between the first refrigerant and the second refrigerant in the cascade heat exchanger 17 and thus suppress a reduction in the operating efficiency of the refrigeration cycle apparatus 1 so as to be small.

[0084] Further, although the second refrigerant circuit 20 uses carbon dioxide as the second refrigerant, the second refrigerant circuit 20 does not perform the refrigeration cycle during the cooling operation, and the first refrigerant circuit 10 performs the single refrigeration cycle. Thus, the cooling operation may be performed while avoiding a reduction in the operating efficiency due to the pressure of the carbon dioxide refrigerant exceeding the critical pressure as in the case of performing the single refrigeration cycle using the carbon dioxide refrigerant, which is a high-pressure refrigerant, or the case of performing the dual refrigeration cycle using carbon dioxide, which is a high-pressure refrigerant, in the heat-source side cycle. Further, the second refrigerant circuit 20 is used only as the refrigeration cycle on the heat source side in the dual refrigeration cycle during the high-load heating operation. For this reason, it is possible to manufacture the apparatus at low costs by setting low pressure capacity criteria required for components of the second refrigerant circuit 20 using carbon dioxide that is a high-pressure refrigerant.

[0085] Furthermore, in the refrigeration cycle apparatus 1 according to the present embodiment, the second outdoor heat exchanger 23, in which the carbon dioxide refrigerant is present, is located on the windward side of the first outdoor heat exchanger 18 in the direction of the air flow of the outdoor fan 9. Therefore, it is possible to prevent the air heated by heat exchange with the first refrigerant flowing through the first outdoor heat exchanger 18 from being sent to the second outdoor heat exchanger 23. This prevents an increase in the pressure of the carbon dioxide refrigerant in the second outdoor heat exchanger 23 due to the heated air sent to the second outdoor heat exchanger 23 in a state where the operation of the second refrigerant circuit 20 is stopped as in the low-load heating operation. In particular, in a case where the second refrigerant circuit 20 is configured by using components having low pressure capacity criteria, an increase in the pressure of the carbon dioxide refrigerant in the second outdoor heat exchanger 23 tends to become a significant issue, but even in the second refrigerant circuit 20 having such a low pressure capacity, the issue is prevented as the heated air is not sent to the second outdoor heat exchanger 23 in the refrigeration cycle apparatus 1 according to the present embodiment.

[0086] Further, in the refrigeration cycle apparatus 1 according to the present embodiment, the second outdoor heat exchanger 23 and the first outdoor heat exchanger 18 use the common outdoor fan 9 so that the fan may be shared. In this manner, even when the outdoor fan 9 is shared, the second outdoor heat exchanger 23 and the first outdoor heat exchanger 18 are located away from each other in the refrigeration cycle apparatus 1 according to the present embodiment. Therefore, an increase in the pressure of the carbon dioxide refrigerant in the second outdoor heat exchanger 23 is prevented as the heat of the first outdoor heat exchanger 18 is prevented from being transferred to the second outdoor heat exchanger 23 even in a state where the operation of the second refrigerant circuit 20 is stopped as in the low-load heating operation.

(2) Second Embodiment

[0087] In the example described above, the refrigeration cycle apparatus 1 according to the first embodiment includes the thermal load circuit 90 and the utilization heat exchanger 13 includes the utilization channel 13a and the thermal load channel 13b.

[0088] Conversely, the refrigeration cycle apparatus 1 may not include the thermal load circuit 90, and the loads processed by the refrigeration cycle apparatus 1 may be air loads.

[0089] Fig. 6 is a schematic configuration diagram of a refrigeration cycle apparatus 1a according to a second embodiment.

[0090] The refrigeration cycle apparatus 1a according to the second embodiment includes, for example, a thermal load fan 92a that forms an air flow, instead of the pump 92 of the thermal load circuit 90 according to the above embodiment. The thermal load fan 92a is driven and controlled by the controller 7 when the first refrigerant circuit 10 is driven.

[0091] The utilization heat exchanger 13 in the refrigeration cycle apparatus 1a according to the second embodiment is used for cooling or heating the air in a space such as a room of a building. Specifically, in the utilization heat exchanger 13, the air in an air-conditioning target space is sent by the thermal load fan 92a so that heat is exchanged between the first refrigerant and the air.

[0092] The above-described configuration may also achieve the same effects as those of the first embodiment.

(3) Third Embodiment

[0093] In the example described according to the above second embodiment, the refrigeration cycle apparatus 1a includes the thermal load fan 92a and processes the thermal load in the air-conditioning target space.

[0094] Conversely, the refrigeration cycle apparatus may be, for example, a refrigeration cycle apparatus 1b dedicated to heating in which a first utilization heat exchanger 131 and a second utilization heat exchanger 132 are used to process the heating load in the air-conditioning target space.

[0095] Fig. 7 is a schematic configuration diagram of the refrigeration cycle apparatus 1b according to a third embodiment.

[0096] In the refrigeration cycle apparatus 1b according to the third embodiment, the first utilization heat exchanger 131 of the first refrigerant circuit 10 is an air heat exchanger that exchanges heat between the first refrigerant flowing inside and the air flowing outside, and the first switching mechanism 12 is not provided. Therefore, the first utilization heat exchanger 131 functions as a radiator of the first refrigerant discharged from the first compressor 11.

[0097] In the refrigeration cycle apparatus 1b according to the third embodiment, the second refrigerant circuit 20 includes the second utilization heat exchanger 132 between the second compressor 21 and the second cascade channel 17b of the cascade heat exchanger 17. The second utilization heat exchanger 132 is an air heat exchanger that exchanges heat between the second refrigerant flowing inside and the air flowing outside and is located away from the first utilization heat exchanger 131 on the windward side of the first utilization heat exchanger 131 in the direction of the air flow by the thermal load fan 92a. The second utilization heat exchanger 132 functions as a radiator of the second refrigerant discharged from the second compressor 21.

[0098] In the refrigeration cycle apparatus 1b described above, the single refrigeration cycle operation using only the first refrigerant circuit 10 is performed as a low-load heating operation. During the low-load heating operation, the first utilization expansion valve 15 is controlled to be fully closed. Furthermore, during the low-load heating operation, the refrigerant discharged from the first compressor 11 is controlled so as to condense in the first utilization heat exchanger 131, get decompressed in the second utilization expansion valve 16, evaporate in the first outdoor heat exchanger 18, and return to the first compressor 11.

[0099] Furthermore, the refrigeration cycle apparatus 1b performs the dual refrigeration cycle using the first refrigerant circuit 10 and the second refrigerant circuit 20 during the high-load heating operation. During the high-load heating operation, the second utilization expansion valve 16 is controlled so as to be fully closed in the first refrigerant circuit 10. Further, during the high-load heating operation, the first refrigerant discharged from the first compressor 11 is controlled so as to condense in the first utilization heat exchanger 131, get decompressed by the first utilization expansion valve 15, evaporate when flowing through the first cascade channel 17a of the cascade heat exchanger 17, and return to the first compressor 11. Further, during the high-load heating operation, in the second refrigerant circuit 20, the second refrigerant discharged from the second compressor 21 is controlled so as to radiate heat when passing through the second utilization heat exchanger 132, further radiate heat by heat exchange with the first refrigerant flowing through the first cascade channel 17a when flowing through the second cascade channel 17b of the cascade heat exchanger 17, gets decompressed in the heat-source expansion valve 26, evaporate in the second outdoor heat exchanger 23, and return to the second compressor 21.

[0100] In the refrigeration cycle apparatus 1b according to the third embodiment, as in the above first embodiment, the operation is performed in a switchable manner in accordance with the magnitude of the heating load so that a reduction in the operating efficiency may be suppressed while the heating load is processed. Furthermore, in the refrigeration cycle apparatus 1b, not only the first utilization heat exchanger 131 of the first refrigerant circuit 10 but also the second utilization heat exchanger 132 of the second refrigerant circuit 20 are provided, and the heat exchanger functioning as a radiator in each cycle is provided so that the heating capacity may be enhanced. Here, the second utilization heat exchanger 132 is located on the windward side of the first utilization heat exchanger 131 in the direction of the air flow generated by the thermal load fan 92a. Thus, even when the single refrigeration cycle is performed only by the first refrigerant circuit 10 in a state where the second refrigerant circuit 20 is stopped, the air heated when passing through the first utilization heat exchanger 131 is not sent to the second utilization heat exchanger 132. Further, the first utilization heat exchanger 131 and the second utilization heat exchanger 132 are located away from each other. Therefore, when the second refrigerant circuit 20 is stopped, the carbon dioxide refrigerant inside the second utilization heat exchanger 132 is prevented from being heated, and an excessive increase in the pressure inside the second refrigerant circuit 20 is prevented. As a result, the second refrigerant circuit 20 may be designed to have a low pressure capacity.

(4) Fourth Embodiment

[0101] In the example of the refrigeration cycle apparatus described according to each of the above embodiments, the first outdoor heat exchanger 18 and the second outdoor heat exchanger 23 are located away from each other.

[0102] Conversely, in the refrigeration cycle apparatus, the first outdoor heat exchanger 18 and the second outdoor heat exchanger 23 may be configured as an integrated heat exchanger of the first outdoor heat exchanger 18 and the second outdoor heat exchanger 23, as illustrated in Fig. 8, for example. Examples of the integrated heat exchanger include a heat exchanger including a plurality of first heat transfer tubes forming the first outdoor heat exchanger 18 through which the first refrigerant flows, a plurality of second heat transfer tubes forming the second outdoor heat exchanger 23 through which the second refrigerant flows, and a plurality of heat transfer fins fixed to both the first heat transfer tubes and the second heat transfer tubes. In the case of this configuration, the manufacturing of the apparatus may be facilitated.

(5) Fifth Embodiment

[0103] In the example of the refrigeration cycle apparatus described according to each of the above embodiments, the heat exchange area is optional when viewed in the direction of the air flow between the first outdoor heat exchanger 18 and the second outdoor heat exchanger 23.

[0104] Conversely, in the refrigeration cycle apparatus, for example, as illustrated in Fig. 9, the first outdoor heat exchanger 18 and the second outdoor heat exchanger 23 may be configured such that the first outdoor heat exchanger 18 and the second outdoor heat exchanger 23 have an overlapping portion when viewed in the direction of the air flow by the outdoor fan 9 and the heat exchange area of the first outdoor heat exchanger 18 is smaller than the heat exchange area of the second outdoor heat exchanger 23 when viewed in the direction of the air flow.

[0105] This may suppress the air flow resistance of the air in the first outdoor heat exchanger 18, and therefore it is easy to cause a larger amount of air to pass through the second outdoor heat exchanger 23. This makes it easy to ensure the evaporation capacity of the second refrigerant in the second outdoor heat exchanger 23 during the high-load heating operation and makes it easy to process the high heating load. Furthermore, in particular, it is effective as the refrigeration cycle apparatus for which a higher heating capacity is required than a cooling capacity.

[0106] Furthermore, as described in the fourth embodiment, when the first outdoor heat exchanger 18 and the second outdoor heat exchanger 23 are configured as an integrated heat exchanger, in particular, the amount of air passing through the second outdoor heat exchanger 23 tends to decrease as the air flow resistance of the first outdoor heat exchanger 18 increases. In this case, in particular, the effect of reducing the heat exchange area of the first outdoor heat exchanger 18 as described above may be remarkably achieved.

(6) Sixth Embodiment

[0107] In the example of the refrigeration cycle apparatus according to each of the above embodiments, the first outdoor heat exchanger 18 and the second outdoor heat exchanger 23 are provided so as to overlap with each other when viewed in the direction of the air flow of the outdoor fan 9.

[0108] Conversely, in the refrigeration cycle apparatus, for example, as illustrated in Fig. 10, the first outdoor heat exchanger 18 and the second outdoor heat exchanger 23 may be located on the windward side of the outdoor fan 9 in the air flow formed by the outdoor fan 9 and at different positions around the rotation axis when viewed in the direction of the rotation axis of the outdoor fan 9. Here, in Fig. 10, the direction of the rotation axis of the outdoor fan 9 is a direction perpendicular to the sheet surface. Furthermore, for example, the arrangement of the first outdoor heat exchanger 18 and the second outdoor heat exchanger 23 may be adopted in a top-blown refrigeration cycle apparatus in which the outdoor fan 9 takes in the air from below and blows the air upward.

[0109] In this case, too, the air having passed through the first outdoor heat exchanger 18 is not sent to the second outdoor heat exchanger 23, so the carbon dioxide refrigerant in the second outdoor heat exchanger 23 is prevented from being heated when the second refrigerant circuit 20 is stopped.

(7) Seventh Embodiment

[0110] In the example of the refrigeration cycle apparatus according to each of the above embodiments, the first outdoor heat exchanger 18 and the second outdoor heat exchanger 23 are provided so as to overlap with each other when viewed in the direction of the air flow of the outdoor fan 9.

[0111] Conversely, in a refrigeration cycle apparatus, for example, as illustrated in Fig. 11, the first outdoor heat exchanger 18 and the second outdoor heat exchanger

23 may be provided so as not to overlap with each other when viewed in the direction of the air flow.

[0112] In this case, for example, the second outdoor heat exchanger 23 may be provided above the first outdoor heat exchanger 18.

(Note)

[0113] Although the embodiments of the present disclosure have been described above, it is understood that various modifications may be made to forms and details without departing from the spirit and scope of the present disclosure described in the scope of claims.

REFERENCE SIGNS LIST

[0114]

1, 1a, 1b	Refrigeration cycle apparatus
9	Outdoor fan (first blowing unit)
10	First refrigerant circuit
11	First compressor
12	First switching mechanism (switching unit)
13	Utilization heat exchanger (first heat exchanger)
13a	Utilization channel
13b	Thermal load channel
15	First utilization expansion valve (first expansion valve)
16	Second utilization expansion valve
17	Cascade heat exchanger
17a	First cascade channel
17b	Second cascade channel
18	First outdoor heat exchanger (third heat exchanger)
20	Second refrigerant circuit
21	Second compressor
23	Second outdoor heat exchanger (second heat exchanger)
26	Heat-source expansion valve (second expansion valve)
90	Thermal load circuit
91	Thermal-load heat exchanger
92	Pump
92a	Thermal load fan (second blowing unit)
131	First utilization heat exchanger (first heat exchanger)
132	Second utilization heat exchanger (fourth heat exchanger)

CITATION LIST

PATENT LITERATURE

[0115] Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2014-9829

Claims

1. A refrigeration cycle apparatus (1, 1a, 1b) comprising:

   a first refrigerant circuit (10) using a first refrigerant having a pressure of 1.2 MPa or less at 30°C; and
   a second refrigerant circuit (20) using a second refrigerant having a pressure of 1.5 MPa or more at 30°C, wherein
   the refrigeration cycle apparatus enables, in a switchable manner,

      a dual cycle operation in which the first refrigerant circuit and the second refrigerant circuit are simultaneously operated to exchange heat between the first refrigerant and the second refrigerant, and
      a single cycle operation in which the first refrigerant circuit is operated without operating the second refrigerant circuit to perform a cooling operation or heating operation.

2. The refrigeration cycle apparatus according to claim 1, wherein, during the dual cycle operation, the second refrigerant flowing through the second refrigerant circuit heats the first refrigerant flowing through the first refrigerant circuit to perform the heating operation.

3. The refrigeration cycle apparatus according to claim 1 or 2, wherein the single cycle operation is performed when a predetermined low-load condition is satisfied.

4. The refrigeration cycle apparatus according to any one of claims 1 to 3, comprising

   a cascade heat exchanger (17) that exchanges heat between the first refrigerant and the second refrigerant during the dual cycle operation wherein
   the cascade heat exchanger includes a first cascade channel (17a) through which the first refrigerant flows, and a second cascade channel (17b) which is independent of the first cascade channel and through which the second refrigerant flows.

5. The refrigeration cycle apparatus according to claim 4, wherein the first refrigerant circuit includes a first compressor (11), a first heat exchanger (13, 131), a first expansion valve (15), and the first cascade channel (17a).

6. The refrigeration cycle apparatus according to claim

5, wherein the second refrigerant circuit includes a second compressor (21), the second cascade channel (17b), a second expansion valve (26), and a second heat exchanger (23).

7. The refrigeration cycle apparatus according to claim 6, wherein, during the dual cycle operation, the first cascade channel functions as an evaporator of the first refrigerant, the first heat exchanger functions as a radiator of the first refrigerant, the second cascade channel functions as a radiator of the second refrigerant, and the second heat exchanger functions as an evaporator of the second refrigerant.

8. The refrigeration cycle apparatus according to claim 7, wherein

the first refrigerant circuit further includes a third heat exchanger (18), and
the cooling operation is enabled in which the third heat exchanger functions as a radiator of the first refrigerant and the first heat exchanger functions as an evaporator of the first refrigerant.

9. The refrigeration cycle apparatus according to claim 7, wherein

the first refrigerant circuit further includes a third heat exchanger (18), and
the heating operation is enabled, in which the third heat exchanger functions as an evaporator of the first refrigerant and the first heat exchanger functions as a radiator of the first refrigerant.

10. The refrigeration cycle apparatus according to claim 7, wherein

the first refrigerant circuit further includes a third heat exchanger (18) and a switching unit (12) that switches a channel of the first refrigerant, and
the switching unit is switched to enable the cooling operation in which the third heat exchanger functions as a radiator of the first refrigerant and the first heat exchanger functions as an evaporator of the first refrigerant and the heating operation in which the third heat exchanger functions as an evaporator of the first refrigerant and the first heat exchanger functions as a radiator of the first refrigerant.

11. The refrigeration cycle apparatus according to any one of claims 8 to 10, wherein

the second heat exchanger exchanges heat between air flowing outside and the second refrigerant flowing inside,
the third heat exchanger exchanges heat between air flowing outside and the first refrigerant flowing inside, and
the refrigeration cycle apparatus further comprises a first blowing unit (9) that forms an air flow passing through the second heat exchanger and an air flow passing through the third heat exchanger.

12. The refrigeration cycle apparatus according to claim 11, wherein the second heat exchanger is located at a position other than leeward of the third heat exchanger in the air flow.

13. The refrigeration cycle apparatus according to claim 11 or 12, wherein the second heat exchanger and the third heat exchanger are located away from each other in a direction of the air flow.

14. The refrigeration cycle apparatus according to any one of claims 6 to 13, wherein the second refrigerant circuit further includes a fourth heat exchanger (132) provided between a discharge side of the second compressor and the second cascade channel.

15. The refrigeration cycle apparatus according to claim 14, wherein

the first heat exchanger exchanges heat between air flowing outside and the first refrigerant flowing inside,
the fourth heat exchanger exchanges heat between air flowing outside and the second refrigerant flowing inside, and
the refrigeration cycle apparatus further comprises a second blowing unit (92a) that forms an air flow passing through both the first heat exchanger and the fourth heat exchanger.

16. The refrigeration cycle apparatus according to any one of claims 1 to 15, wherein the first refrigerant includes at least any of R1234yf, R1234ze, and R290.

17. The refrigeration cycle apparatus according to any one of claims 1 to 16, wherein the second refrigerant includes carbon dioxide.

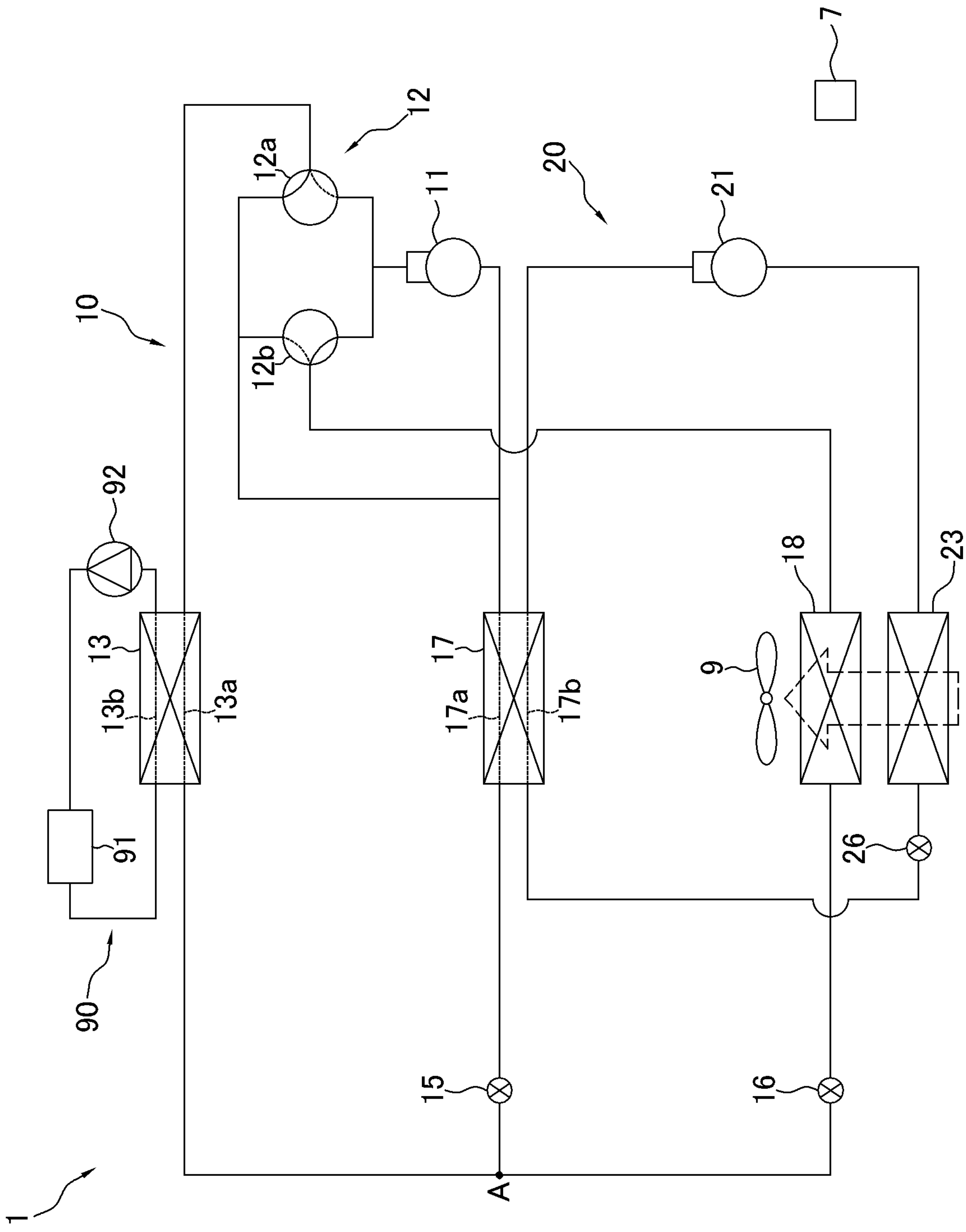
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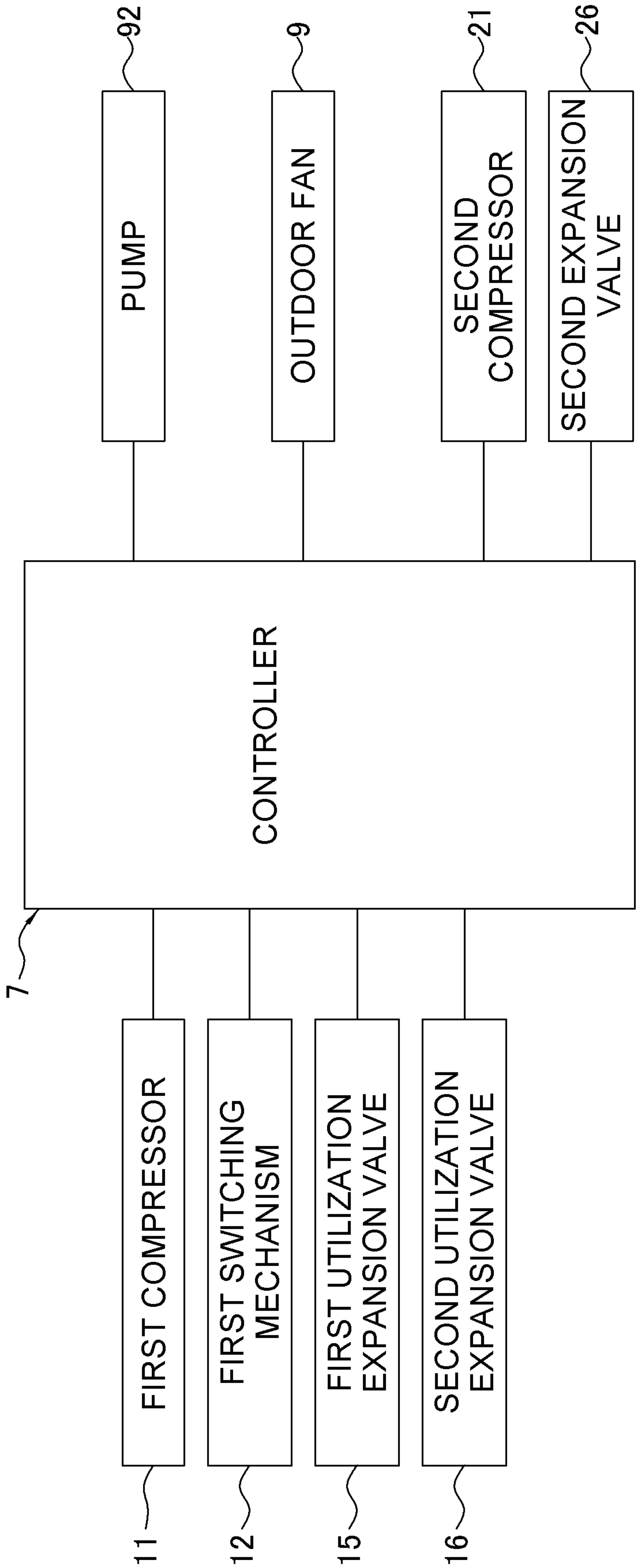
FIG. 1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CONTROLLER
FIRST COMPRESSOR
FIRST SWITCHING MECHANISM
FIRST UTILIZATION EXPANSION VALVE
SECOND UTILIZATION EXPANSION VALVE
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FIG. 2

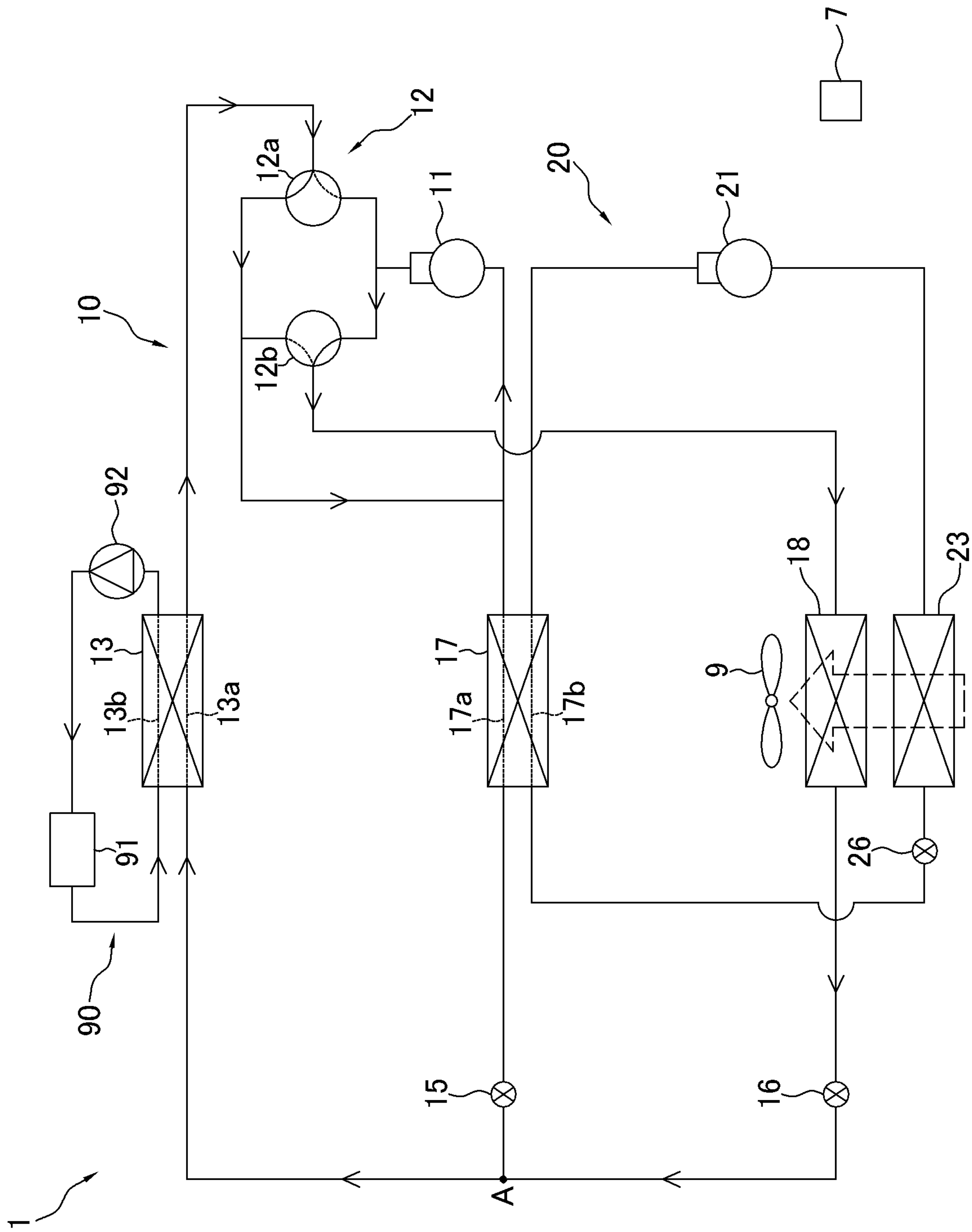
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FIG. 3

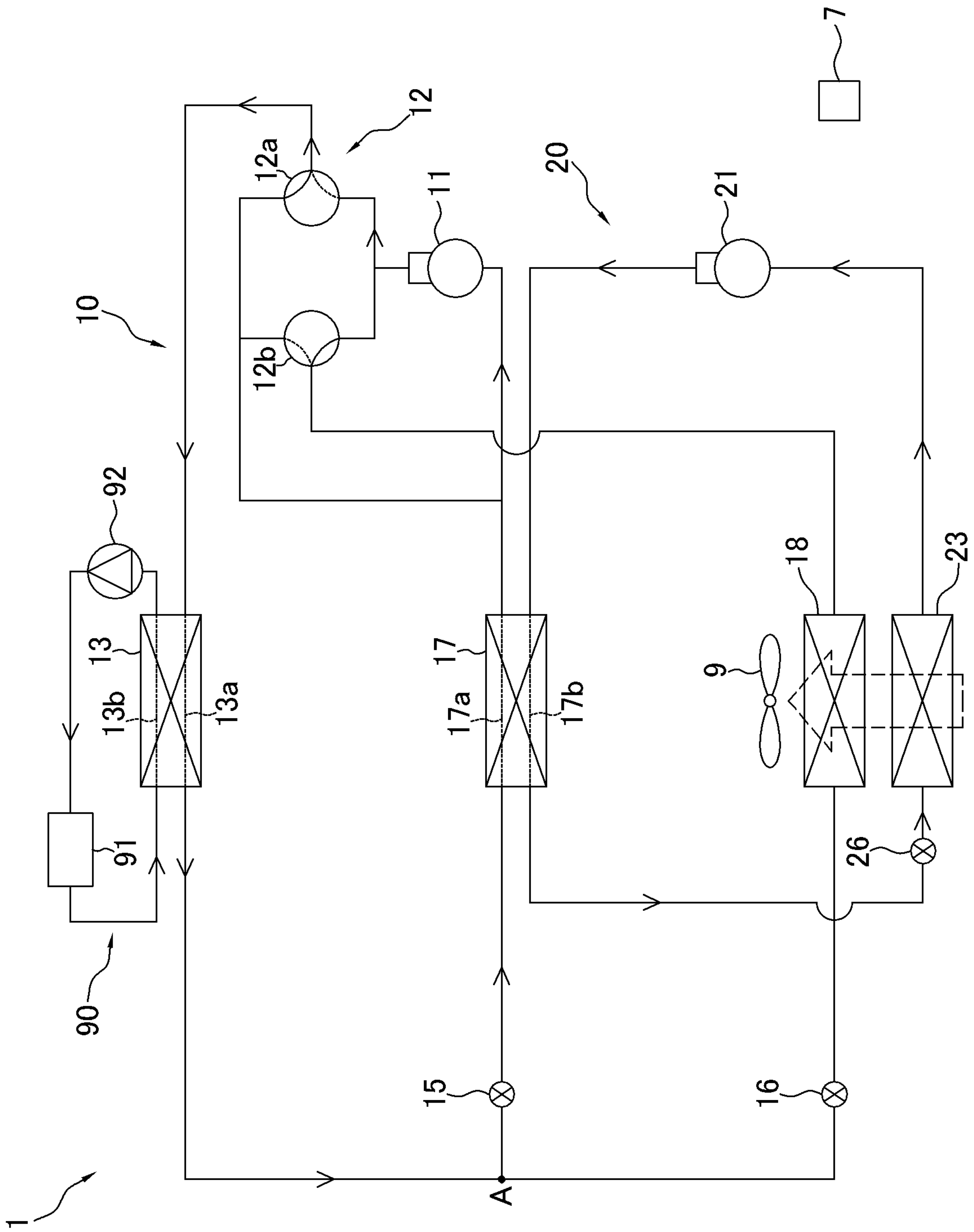
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FIG. 4

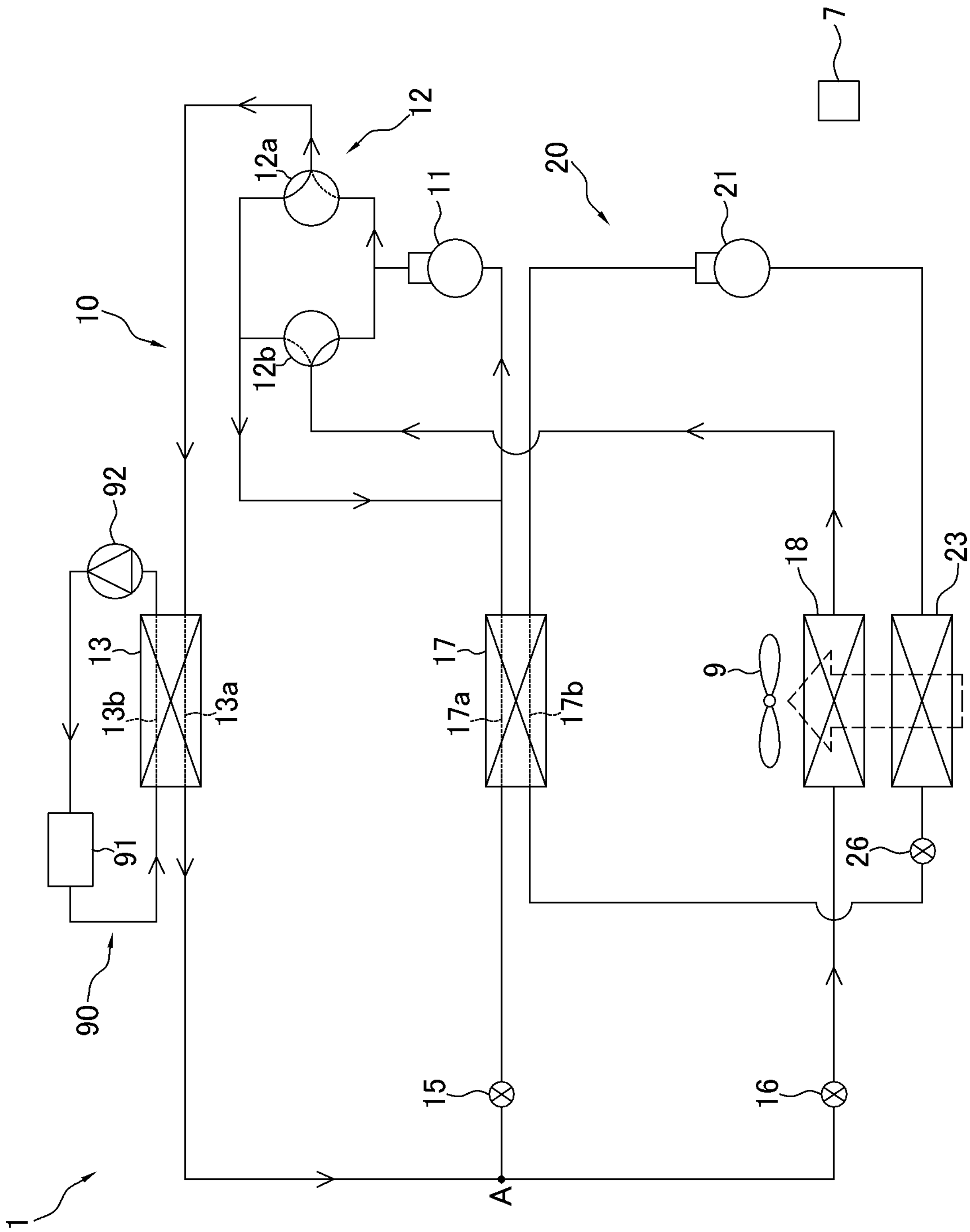
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FIG. 5

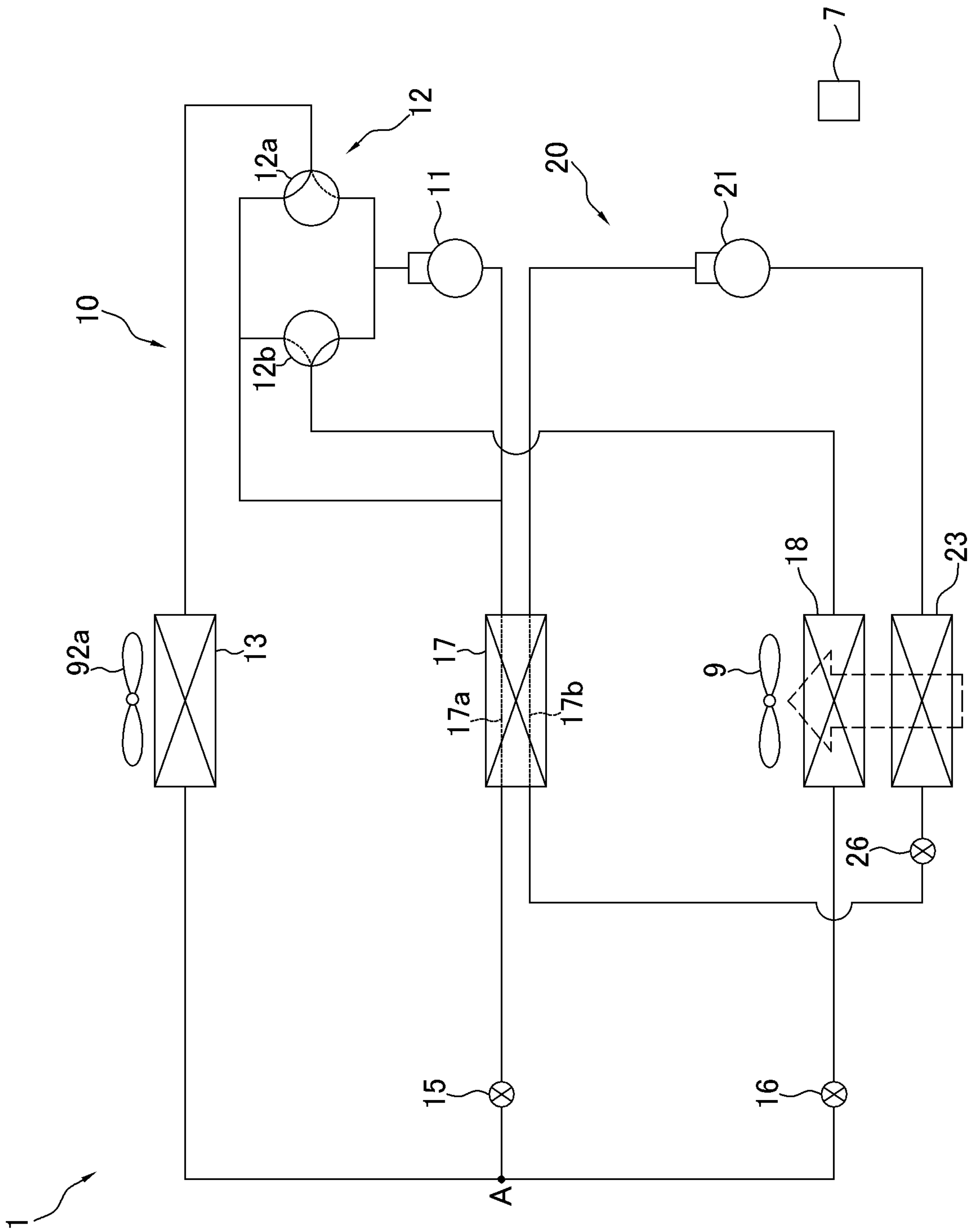

FIG. 6

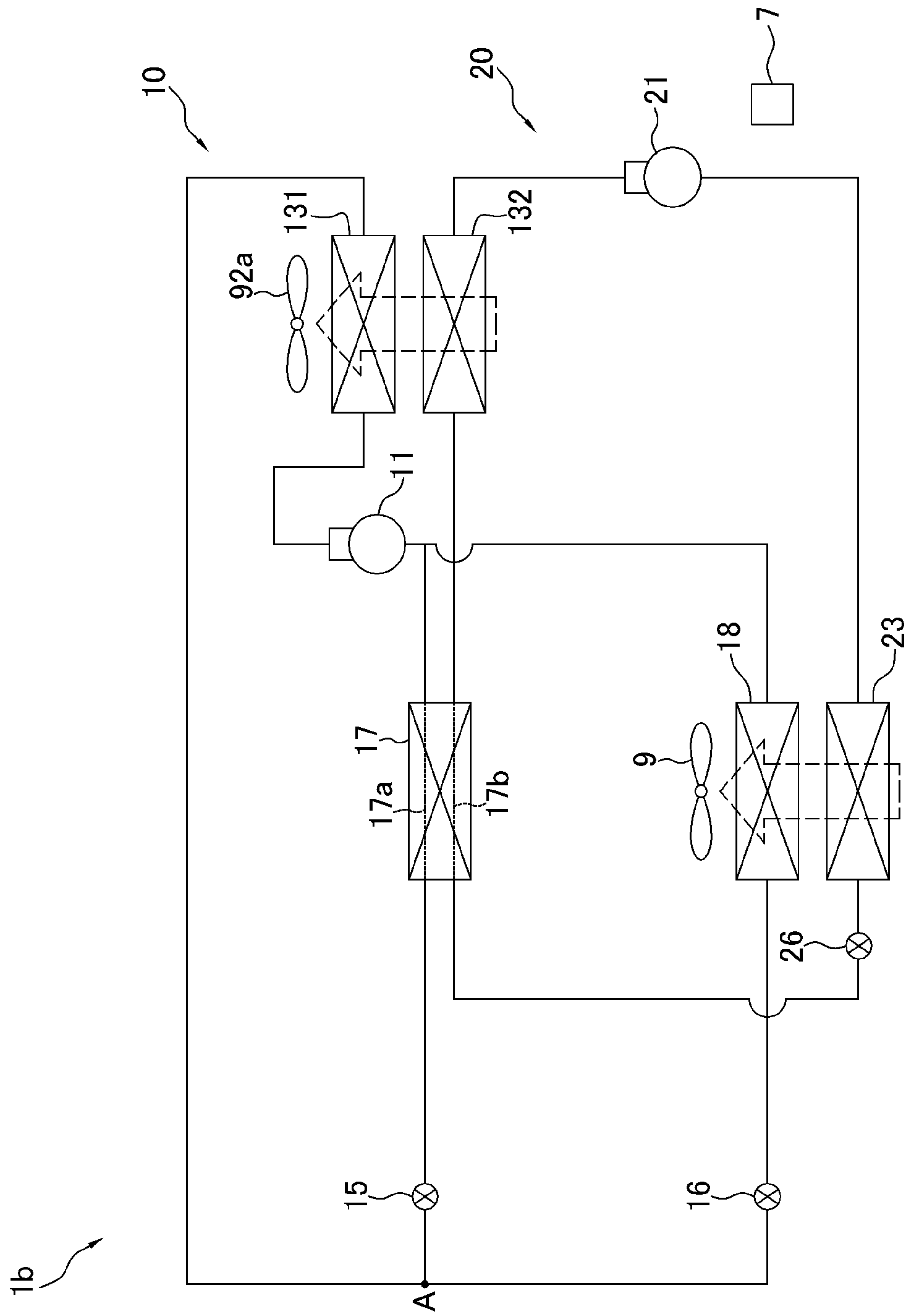

FIG. 7

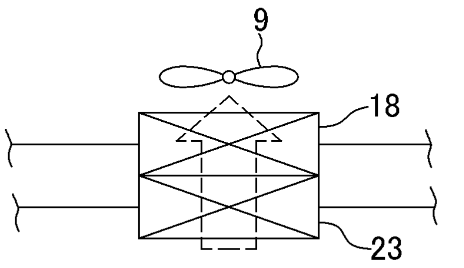

FIG. 8

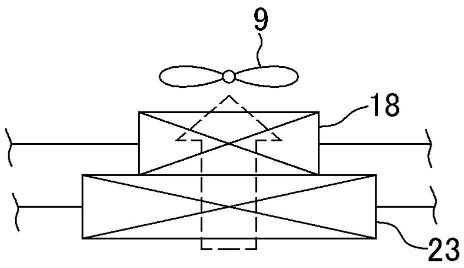

FIG. 9

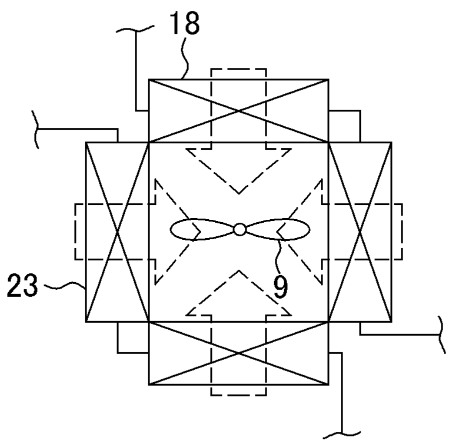

FIG. 10

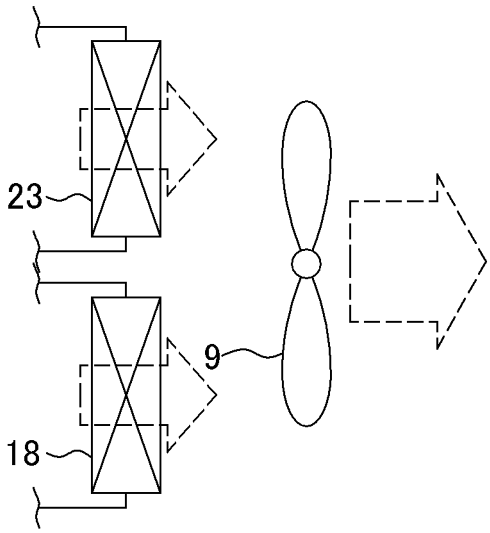

FIG. 11

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2022/016798

A. CLASSIFICATION OF SUBJECT MATTER

F25B 7/00(2006.01)i; ***F25B 1/00***(2006.01)i
FI: F25B7/00 D; F25B1/00 396D; F25B1/00 396Z; F25B1/00 396U; F25B1/00 397E; F25B7/00 A

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F25B7/00; F25B1/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2022
Registered utility model specifications of Japan 1996-2022
Published registered utility model applications of Japan 1994-2022

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2000-320914 A (DAIKIN IND LTD) 24 November 2000 (2000-11-24) paragraphs [0028]-[0054], fig. 1-6	1-7, 14, 16-17
A		8-13, 15
Y	JP 2021-11985 A (FUJI ELECTRIC CO LTD) 04 February 2021 (2021-02-04) paragraph [0022]	1-7, 14, 16-17
A		8-13, 15
Y	WO 2017/221382 A1 (MITSUBISHI ELECTRIC CORP) 28 December 2017 (2017-12-28) paragraphs [0036]-[0037]	1-7, 14, 16-17
A		8-13, 15

☐ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30 May 2022	**07 June 2022**

Name and mailing address of the ISA/JP	Authorized officer
Japan Patent Office (ISA/JP) **3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915** **Japan**	Telephone No.

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2022/016798

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 2000-320914 A	24 November 2000	(Family: none)	
JP 2021-11985 A	04 February 2021	(Family: none)	
WO 2017/221382 A1	28 December 2017	GB 2565472 A paragraphs [0036]-[0037]	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2014009829 A **[0003] [0115]**