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

(11) EP 4 246 056 A1

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

(43) Date of publication:
20.09.2023 Bulletin 2023/38

(21) Application number: **20961514.5**

(22) Date of filing: **10.11.2020**

(51) International Patent Classification (IPC):
F25B 13/00 *(2006.01)* ***F25B 29/00*** *(2006.01)*
F25B 41/26 *(2021.01)*

(52) Cooperative Patent Classification (CPC):
F25B 13/00; F25B 29/00; F25B 41/26

(86) International application number:
PCT/JP2020/041931

(87) International publication number:
WO 2022/101986 (19.05.2022 Gazette 2022/20)

(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

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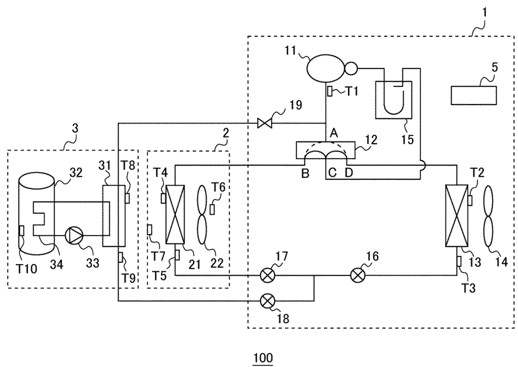
(54) REFRIGERATION CYCLE DEVICE

(57) A refrigeration cycle apparatus includes a heat source unit including a compressor, a flow switching valve, a first heat exchanger, and an expansion valve, an air-conditioning unit including a second heat exchanger and configured to perform air-conditioning, and a hot water supply unit including a third heat exchanger and configured to supply hot water. The flow switching valve includes a first port connected to a discharge port of the compressor, a second port connected to the second heat exchanger, a third port connected to a suction port of the compressor, and a fourth port connected to the first heat exchanger. The flow switching valve is set to one of a first state in which the second port communicates with the third port, the third port communicates with the fourth port, and the first port does not communicate with any ports, a second state in which the first port communicates with the fourth port, and the second port communicates with the third port, and a third state in which the first port communicates with the second port, and the third port communicates with the fourth port.

FIG. 1



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Description

Technical Field

[0001] The present disclosure relates to a refrigeration cycle apparatus that supplies hot water and performs air-conditioning.

Background Art

[0002] In the related art, refrigeration cycle apparatuses capable of supplying hot water and performing air-conditioning at the same time are known. For example, in Patent Literature 1, a refrigeration cycle apparatus that controls refrigerant flows by using two solenoid valves and a four-way valve provided on the discharge side of a compressor to perform a hot water supply cooling operation, a cooling operation, a heating operation, or a hot water supply operation is proposed.

Citation List

Patent Literature

[0003] Patent Literature 1: Japanese Patent No. 6141425

Summary of Invention

Technical Problem

[0004] The refrigeration cycle apparatus of Patent Literature 1 achieves switching of operation among the hot water supply cooling operation, cooling operation, heating operation, and the hot water supply operation with a complicated valve configuration. In this case, because a plurality of valves is required, there are problems, such as an increase in cost of the apparatus as well as an increase in complication of control.

[0005] The present disclosure has been made to solve the problems described above, and has an object to provide a refrigeration cycle apparatus capable of performing hot water supply, cooling, and heating with improved controllability with a less number of components.

Solution to Problem

[0006] A refrigeration cycle apparatus according to an embodiment of the present disclosure includes a heat source unit including a compressor, a flow switching valve, a first heat exchanger, and an expansion valve, an air-conditioning unit including a second heat exchanger and configured to perform air-conditioning, and a hot water supply unit including a third heat exchanger and configured to supply hot water. The flow switching valve includes a first port connected to a discharge port of the compressor, a second port connected to the second heat exchanger, a third port connected to a suction port of the compressor, and a fourth port connected to the first heat exchanger. The flow switching valve is set to one of a first state in which the second port communicates with the third port, the third port communicates with the fourth port, and the first port does not communicate with any ports, a second state in which the first port communicates with the fourth port, and the second port communicates with the third port, and a third state in which the first port communicates with the second port, and the third port communicates with the fourth port.

Advantageous Effects of Invention

[0007] Because the refrigeration cycle apparatus according to an embodiment of the present disclosure is provided with the flow switching valve that has the first port connected to a discharge port of the compressor and is capable of achieving the first state in which the first port does not communicate with any ports, the number of components can be reduced and the controllability can be improved.

Brief Description of Drawings

[0008]

[Fig. 1] Fig. 1 is a schematic configuration diagram of a refrigeration cycle apparatus according to Embodiment 1.
[Fig. 2] Fig. 2 is a control block diagram of the refrigeration cycle apparatus according to Embodiment 1.
[Fig. 3] Fig. 3 is a diagram illustrating behavior of a cooling operation of the refrigeration cycle apparatus according to Embodiment 1.
[Fig. 4] Fig. 4 is a diagram illustrating behavior of a heating operation of the refrigeration cycle apparatus according to Embodiment 1.
[Fig. 5] Fig. 5 is a diagram illustrating behavior of a hot water supply operation of the refrigeration cycle apparatus according to Embodiment 1.
[Fig. 6] Fig. 6 is a diagram illustrating behavior of a first hot water supply cooling operation of the refrigeration cycle apparatus according to Embodiment 1.
[Fig. 7] Fig. 7 is a diagram illustrating behavior of a second hot water supply cooling operation of the refrigeration cycle apparatus according to Embodiment 1.
[Fig. 8] Fig. 8 is a diagram illustrating behavior of a third hot water supply cooling operation of the refrigeration cycle apparatus according to Embodiment 1.
[Fig. 9] Fig. 9 is a diagram illustrating behavior of a first hot water supply heating operation of the refrigeration cycle apparatus according to Embodiment 1.
[Fig. 10] Fig. 10 is a table illustrating a list of controls in each operation of the refrigeration cycle apparatus according to Embodiment 1.

Description of Embodiments

[0009] An embodiment of the present disclosure will be described below with reference to the drawings. Note that, in the drawings, the same or corresponding components are denoted by the same reference symbol, and their descriptions will be omitted or simplified, as appropriate. In addition, the shape, size, and arrangement of each of the components illustrated in the drawings can be changed, as appropriate, within the scope of the present disclosure.

Embodiment 1

(Configuration of Refrigeration Cycle Apparatus)

[0010] Fig. 1 is a schematic configuration diagram of a refrigeration cycle apparatus 100 according to Embodiment 1. As shown in Fig. 1, the refrigeration cycle apparatus 100 of Embodiment 1 includes a heat source unit 1, an air-conditioning unit 2, and a hot water supply unit 3. In the refrigeration cycle apparatus 100 of Embodiment 1, a cooling operation or a heating operation, which is performed by the air-conditioning unit 2, and a hot water supply operation, which is performed by the hot water supply unit 3, can be conducted individually or simultaneously. The heat source unit 1, the air-conditioning unit 2, and the hot water supply unit 3 are connected with each other via a pipe and wiring, such as a power supply line or a signal line.

[0011] The heat source unit 1 is configured to supply heating energy and cooling energy to the air-conditioning unit 2 and the hot water supply unit 3. The heat source unit 1 includes a compressor 11, a flow switching valve 12, a first heat exchanger 13, a first fan 14, an accumulator 15, a first expansion valve 16, a second expansion valve 17, a third expansion valve 18, an on-off valve 19, and a controller 5.

[0012] The air-conditioning unit 2 is configured to cool and heat an air-conditioned space such as a living room. The air-conditioning unit 2 is, for example, an indoor unit. The air-conditioning unit 2 includes a second heat exchanger 21 and a second fan 22.

[0013] The hot water supply unit 3 is configured to heat water and supply hot water. The hot water supply unit 3 includes a third heat exchanger 31, a hot water storage tank 32, a pump 33, and a fourth heat exchanger 34.

[0014] The refrigeration cycle apparatus 100 includes an air-conditioning refrigerant circuit, a hot water supply refrigerant circuit, and a heat medium circuit. The air-conditioning refrigerant circuit is formed by connecting the compressor 11, the flow switching valve 12, the first heat exchanger 13, the first expansion valve 16, the second expansion valve 17, the second heat exchanger 21, and the accumulator 15 by pipes. The hot water supply refrigerant circuit is formed by a pipe branched from the pipe between the compressor 11 and the flow switching valve 12, the on-off valve 19, the third heat exchanger 31, and the third expansion valve 18, which are connected by pipes, and a pipe connected to the pipe between the first expansion valve 16 and the second expansion valve 17. The heat medium circuit is formed by connecting the pump 33, the third heat exchanger 31, and the fourth heat exchanger 34 by pipes.

[0015] The refrigerant circulating in the air-conditioning refrigerant circuit and the hot water supply refrigerant circuit is, for example, a natural refrigerant, such as carbon dioxide, hydrocarbon, or helium, a chlorine-free refrigerant, such as HFC41 0A or HFC407C, or a chlorofluorocarbon-based refrigerant, such as R22 or R134a. The heat medium circulating in the heat medium circuit is water or brine in which antifreeze is mixed.

[0016] The compressor 11 is a fluid machine that sucks and compresses refrigerant in a low-pressure gas state and discharges the refrigerant in a high-pressure gas state. As the compressor 11, an inverter-driven compressor capable of adjusting an operation frequency is used. The operation frequency of the compressor 11 is controlled by the controller 5. A discharge side pipe connected to the discharge port of the compressor 11 is branched on the way, and the one end thereof is connected to the third heat exchanger 31 via the on-off valve 19 and the other end thereof is connected to the flow switching valve 12. In addition, the discharge port of the compressor 11 is provided with a discharge temperature sensor T1 detecting a discharge temperature of the refrigerant.

[0017] The flow switching valve 12 is a four-way valve, and has a first port A, a second port B, a third port C, and a fourth port D. The first port A is connected to the discharge port of the compressor 11. The second port B is connected to the second heat exchanger 21. The third port C is connected to the suction port of the compressor 11 via the accumulator 15. The fourth port D is connected to the first heat exchanger 13. The flow switching valve 12 can be set to a first state, a second state, or a third state. In the first state, the second port B communicates with the third port C, the third port C communicates with the fourth port D, and the first port A does not communicate with any ports and is closed. In the second state, the first port A communicates with the fourth port D, and the second port B communicates with the third port C. In the third state, the first port A communicates with the second port B, and the third port C communicates with the fourth port D. The flow switching valve 12 is switched from one state to another by the controller 5.

[0018] The first heat exchanger 13 is configured to exchange heat between the refrigerant flowing therein and air sent by the first fan 14. The first heat exchanger 13 is, for example, a fin tube type heat exchanger. The first heat exchanger 13 is provided between the first expansion valve 16 and the flow switching valve 12. The first heat exchanger 13 functions as a condenser in the cooling operation and as an evaporator in the heating operation and the hot water supply operation. The first heat exchanger 13 is provided with a first refrigerant temperature sensor T2 detecting the temperature of the refrigerant flowing in the first heat exchanger 13. In addition, an outlet of the first heat exchanger 13, the outlet from which the refrigerant is discharged in the cooling operation, is provided with a first outlet temperature sensor T3 detecting the temperature of the refrigerant flowing out from the first heat exchanger 13.

[0019] The first fan 14 is configured to suck air from the outside of the air-conditioned space, pass the air through the first heat exchanger 13, and blow out the air to the outside of the air-conditioned space. The first fan 14 is, for example, a propeller fan, a sirocco fan, or a cross flow fan, which is driven by a motor. The air volume of the first fan 14 is controlled by the controller 5.

[0020] The accumulator 15 is configured to divide the refrigerant flowed therein into the refrigerant in a gas state and the refrigerant in a liquid state, and allow only the refrigerant in a gas state to enter the compressor 11. The accumulator 15 can store excess refrigerant during operation as well as can prevent the refrigerant in a liquid state from entering the compressor 11 during state change of the refrigerant. The accumulator 15 is provided between the suction port of the compressor 11 and the flow switching valve 12. Note that the accumulator 15 is not a required component for the refrigeration cycle apparatus 100 and may be omitted. When the accumulator 15 is omitted, the suction port of the compressor 11 is directly connected to the third port C.

[0021] The first expansion valve 16, the second expansion valve 17, and the third expansion valve 18 are electronic expansion valves configured to decompress refrigerant. The first expansion valve 16 is provided on an outlet side of the first heat exchanger 13 in the cooling operation. The second expansion valve 17 is provided on an outlet side of the second heat exchanger 21 in the heating operation. The third expansion valve 18 is provided on a pipe that is branched from the pipe connecting the first expansion valve 16 and the second expansion valve 17, and that is connected to the third heat exchanger 31. The opening degrees of the first expansion valve 16, the second expansion valve 17, and the third expansion valve 18 are controlled by the controller 5.

[0022] The on-off valve 19 is a solenoid valve. The opening and closing of the on-off valve 19 are controlled by the controller 5. The on-off valve 19 is provided on a pipe that is branched from the pipe connecting the discharge port of the compressor 11 and the first port A of the flow switching valve 12, and that is connected to the third heat exchanger 31. When the on-off valve 19 is opened, the refrigerant flows in a hot water supply refrigerant circuit. When the on-off valve 19 is closed, the refrigerant does not flow in the hot water supply side refrigerant circuit.

[0023] The second heat exchanger 21 is configured to exchange heat between the refrigerant flowing therein and air sent by the second fan 22. The second heat exchanger 21 is, for example, a fin tube type heat exchanger. The second heat exchanger 21 is provided between the second expansion valve 17 and the flow switching valve 12. The second heat exchanger 21 functions as a condenser in the heating operation and as an evaporator in the cooling operation. The second heat exchanger 21 is provided with a second refrigerant temperature sensor T4 detecting the temperature of the refrigerant flowing in the second heat exchanger 21. In addition, an outlet of the second heat exchanger 21, the outlet from which the refrigerant is discharged in the heating operation, is provided with a second outlet temperature sensor T5 detecting the temperature of the refrigerant flowing out from the second heat exchanger 21.

[0024] The second fan 22 is configured to suck air from the outside of the air-conditioned space, pass the air through the second heat exchanger 21, and blow out the air to the outside of the air-conditioned space. The second fan 22 is, for example, a propeller fan, a sirocco fan, or a cross flow fan, which is driven by a motor. The air volume of the second fan 22 is controlled by the controller 5. An air outlet from which air is blown out by the second fan 22 is provided with a blowing temperature sensor T6 detecting the temperature of the blown out air. An air inlet from which air is sucked by the second fan 22 is provided with an indoor temperature sensor T7 detecting the temperature of the sucked indoor air.

[0025] The third heat exchanger 31 is configured to exchange heat between the refrigerant flowing therein and the heat medium sent by the pump 33. The third heat exchanger 31 is, for example, a plate type heat exchanger. The third heat exchanger 31 is provided between the on-off valve 19 and the third expansion valve 18. The third heat exchanger 31 is provided with a third refrigerant temperature sensor T8 detecting the temperature of the refrigerant flowing in the third heat exchanger 31. In addition, an outlet of the third heat exchanger 31, the outlet from which the refrigerant is discharged, is provided with a third outlet temperature sensor T9 detecting the temperature of the refrigerant flowing out from the third heat exchanger 31.

[0026] The hot water storage tank 32 is a cylindrical tank made of a metal, such as stainless, or a resin or another material. The inside of the hot water storage tank 32 is provided with a hot water supply temperature sensor T10 detecting the temperature of the hot water in the hot water storage tank 32.

[0027] The pump 33 causes the heat medium to circulate in the heat medium circuit. The pump 33 is provided with an inverter circuit (not shown). The rotation speed of the pump 33 is controlled by the controller 5.

[0028] The fourth heat exchanger 34 is installed inside the hot water storage tank 32. The fourth heat exchanger 34 is configured to exchange heat between the water in the hot water storage tank 32 and the heat medium circulating in the heat medium circuit. Through the heat exchange, the water in the hot water storage tank 32 is heated, and thus hot water is generated. The fourth heat exchanger 34 is, for example, a coil type heat exchanger.

[0029] The controller 5 is a microcomputer including a processor, a memory, such as a ROM or RAM, an I/O port, and other devices. The controller 5 is configured to control operations of the heat source unit 1, the air-conditioning unit 2, and the hot water supply unit 3. Note that, in Embodiment 1, although the heat source unit 1 includes the controller 5, the arrangement of the controller 5 is not limited thereto. For example, the controller 5 may be provided in the air-conditioning unit 2 or the hot water supply unit 3. The heat source unit 1, the air-conditioning unit 2, and the hot water supply unit 3 may be provided with respective controllers 5, and the controllers 5 may be configured to communicate with each other. In addition, the controller 5 may be provided in a management device that manages the refrigeration cycle apparatus 100.

[0030] Fig. 2 is a control block diagram of the refrigeration cycle apparatus 100 according to Embodiment 1. The controller 5 is configured to control the entire operation of the refrigeration cycle apparatus 100 based on setting information, which is entered via a remote controller or a similar device, and detection results of the temperature sensors T1 to T10. The setting information to be entered via a remote controller or a similar device includes, for example, setting for operation to be performed, a cooling set temperature, a heating set temperature, air volume setting, and a hot water supply set temperature. The controller 5 is configured to control the operation frequency of the compressor 11, the state of the flow switching valve 12, the opening degrees of the first to third expansion valves 16 to 18, the opening and closing of the on-off valve 19, the air volumes of the first fan 14 and the second fan 22, and the rotation speed of the pump 33.

(Operation of Refrigeration Cycle Apparatus)

[0031] The controller 5 is configured to perform the cooling operation, the heating operation, the hot water supply operation, the hot water supply cooling operation, and the hot water supply heating operation. The cooling operation is an operation in which hot water supply is not performed by the hot water supply unit 3 and only cooling is performed by the air-conditioning unit 2. The heating operation is an operation in which hot water supply is not performed by the hot water supply unit 3 and only heating is performed by the air-conditioning unit 2. The hot water supply operation is an operation in which only hot water supply is performed by the hot water supply unit 3 and cooling or heating is not performed by the air-conditioning unit 2. The hot water supply cooling operation is an operation in which hot water supply by the hot water supply unit 3 and cooling by the air-conditioning unit 2 are performed concurrently. The hot water supply heating operation is an operation in which hot water supply by the hot water supply unit 3 and heating by the air-conditioning unit 2 are performed concurrently.

[0032] In addition, the controller 5 is configured to perform, as the hot water supply cooling operation, a first hot water supply cooling operation in which a hot water supply load is large and a cooling load is large, a second hot water supply cooling operation in which a hot water supply load is large and a cooling load is small, a third hot water supply cooling operation in which a hot water supply load is small and a cooling load is large, and a fourth hot water supply cooling operation in which a hot water supply load is small and a cooling load is small. Furthermore, the controller 5 is configured to perform, as the hot water supply heating operation, a first hot water supply heating operation in which a hot water supply load is large and a heating load is large, a second hot water supply heating operation in which a hot water supply load is large and a heating load is small, a third hot water supply heating operation in which a hot water supply load is small and a heating load is large, and a fourth hot water supply heating operation in which a hot water supply load is small and a heating load is small.

[0033] Here, "a large hot water supply load" means a case where a value ΔTw, which is obtained by subtracting a hot water supply temperature detected by the hot water supply temperature sensor T10 from the hot water supply set temperature, is equal to or larger than a predetermined threshold α, and "a small hot water supply load" means a case where the value ΔTw is less than the threshold α. In addition, "a large cooling load" means a case where a value ΔTc, which is obtained by subtracting the cooling set temperature from an indoor temperature detected by the indoor temperature sensor T7, is equal to or larger than a predetermined value β, and "a small cooling load" means a case where the value ΔTc is less than the threshold β. Furthermore, "a large heating load" means a case where a value ΔTh, which is obtained by subtracting an indoor temperature detected by the indoor temperature sensor T7 from the heating set temperature, is equal to or larger than a predetermined value β, and "a small heating load" means a case where the value ΔTh is less than the threshold β. The thresholds α and β are 5 degrees C, for example.

[0034] The cooling operation, the heating operation, the hot water supply operation, the first to fourth hot water supply cooling operations, and the first to fourth hot water supply heating operations are switched by controlling the state of the flow switching valve 12, the opening degrees of the first to third expansion valves 16 to 18, and the opening and closing of the on-off valve 19 by the controller 5. Refrigerant flows and control of each unit in each operation will be described below.

(Cooling Operation)

[0035] Fig. 3 is a diagram illustrating behavior of the cooling operation of the refrigeration cycle apparatus 100 according to Embodiment 1. Arrows in Fig. 3 indicate directions of refrigerant flow. In the cooling operation, the controller 5 sets the flow switching valve 12 to the second state, in which the first port A communicates with the fourth port D and the second port B communicates with the third port C, and closes the third expansion valve 18 and the on-off valve 19. In addition, the controller 5 controls the opening degree of the first expansion valve 16 and the opening degree of the second expansion valve 17 according to an operation state. Furthermore, the controller 5 controls the frequency of the compressor 11 according to the cooling load in the air-conditioned space. For example, when the cooling load is large, the controller 5 increases the frequency of the compressor 11. When the cooling load is small, the controller 5 reduces the frequency of the compressor 11.

[0036] As shown in Fig. 3, in the cooling operation, the refrigerant that has been compressed by the compressor 11 and thus enters a high-temperature, high-pressure gas state flows into the first heat exchanger 13 via the first port A and the fourth port D of the flow switching valve 12. The refrigerant changes its phase from high-temperature, high-pressure gas to liquid in the first heat exchanger 13 while the refrigerant heats the air passing through the first heat exchanger 13. Then, the refrigerant is decompressed by the first expansion valve 16 and the second expansion valve 17, and enters a two-phase state in which low-temperature, low-pressure liquid and gas are mixed. The refrigerant in the two-phase state flows into the second heat exchanger 21.

[0037] The controller 5 controls the opening degree of the first expansion valve 16 so that the degree of subcooling of the first heat exchanger 13 reaches a target degree of subcooling. The degree of subcooling of the first heat exchanger 13 is obtained from the difference between the condensation temperature detected by the first refrigerant temperature sensor T2 and the outlet temperature detected by the first outlet temperature sensor T3. In addition, the controller 5 controls the opening degree of the second expansion valve 17 so that the discharge temperature detected by the discharge temperature sensor T1 reaches a target discharge temperature. The target degree of subcooling and the target discharge temperature are set in advance based on installation conditions and specifications of the refrigeration cycle apparatus 100 and the cooling set temperature, and are stored in the controller 5.

[0038] The refrigerant flowed into the second heat exchanger 21 changes its phase from liquid to gas while the refrigerant cools the air passing through the second heat exchanger 21. When the cooled air is blown to the air-conditioned space, the air-conditioned space is cooled. Then, the refrigerant flows into the accumulator 15 via the second port B and the third port C of the flow switching valve 12. The refrigerant is then sucked into the compressor 11 and enters a high-temperature, high-pressure gas state again.

(Heating Operation)

[0039] Fig. 4 is a diagram illustrating behavior of the heating operation of the refrigeration cycle apparatus 100 according to Embodiment 1. Arrows in Fig. 4 indicate directions of refrigerant flow. In the heating operation, the controller 5 sets the flow switching valve 12 to the third state, in which the first port A communicates with the second port B and the third port C communicates with the fourth port D, and closes the third expansion valve 18 and the on-off valve 19. In addition, the controller 5 controls the opening degree of the first expansion valve 16 and the opening degree of the second expansion valve 17 according to an operation state. Furthermore, the controller 5 controls the frequency of the compressor 11 according to the heating load in the air-conditioned space. For example, when the heating load is large, the controller 5 increases the frequency of the compressor 11. When the heating load is small, the controller 5 reduces the frequency of the compressor 11.

[0040] As shown in Fig. 4, in the heating operation, the refrigerant that has been compressed by the compressor 11 and thus enters a high-temperature, high-pressure gas state flows into the second heat exchanger 21 via the first port A and the second port B of the flow switching valve 12. The refrigerant changes its phase from high-temperature, high-pressure gas to liquid in the second heat exchanger 21 while the refrigerant heats the air passing through the second heat exchanger 21. When the heated air is blown to the air-conditioned space, the air-conditioned space is heated. Then, the refrigerant is decompressed by the second expansion valve 17 and the first expansion valve 16, and enters a two-phase state in which low-temperature, low-pressure liquid and gas are mixed. The refrigerant in the two-phase state flows into the first heat exchanger 13.

[0041] The controller 5 controls the opening degree of the second expansion valve 17 so that the degree of subcooling of the second heat exchanger 21 reaches a target degree of subcooling. The degree of subcooling of the second heat exchanger 21 is obtained from the difference between the condensation temperature detected by the second refrigerant temperature sensor T4 and the outlet temperature detected by the second outlet temperature sensor T5. In addition, the controller 5 controls the opening degree of the first expansion valve 16 so that the discharge temperature detected by the discharge temperature sensor T1 reaches a target discharge temperature. The target degree of subcooling and the target discharge temperature are set in advance based on installation conditions and specifications of the refrigeration cycle apparatus 100 and the heating set temperature, and are stored in the controller 5.

[0042] The refrigerant flowed into the first heat exchanger 13 changes its phase from liquid to gas while the refrigerant cools the air passing through the first heat exchanger 13. Then, the refrigerant flows into the accumulator 15 via the fourth port D and the third port C of the flow switching valve 12. The refrigerant is then sucked into the compressor 11 and enters a high-temperature, high-pressure gas state again.

(Hot Water Supply Operation)

[0043] Fig. 5 is a diagram illustrating behavior of the hot water supply operation of the refrigeration cycle apparatus 100 according to Embodiment 1. Arrows in Fig. 5 indicate directions of refrigerant flow. In the hot water supply operation, the controller 5 sets the flow switching valve 12 to the first state, in which the second port B communicates with the third port C and the third port C communicates with the fourth port D, closes the second expansion valve 17, and opens the on-off valve 19. In addition, the controller 5 controls the opening degree of the first expansion valve 16 and the opening degree of the third expansion valve 18 according to an operation state. Furthermore, the controller 5 controls the frequency of the compressor 11 according to the hot water supply load. For example, when the hot water supply load is large, the controller 5 increases the frequency of the compressor 11. When the hot water supply load is small, the controller 5 reduces the frequency of the compressor 11.

[0044] As shown in Fig. 5, in the hot water supply operation, the refrigerant that has been compressed by the compressor 11 and thus enters a high-temperature, high-pressure gas state flows into the third heat exchanger 31 via the on-off valve 19. The refrigerant changes its phase from high-temperature, high-pressure gas to liquid in the third heat exchanger 31 while the refrigerant heats the heat medium flowing in the heat medium circuit. When the heat medium heated by the third heat exchanger 31 enters the fourth heat exchanger 34, the water in the hot water storage tank 32 is heated. As a result, hot water can be supplied. The refrigerant flowed out from the third heat exchanger 31 is decompressed by the third expansion valve 18 and the first expansion valve 16, and enters a two-phase state in which low-temperature, low-pressure liquid and gas are mixed. The refrigerant in the two-phase state flows into the first heat exchanger 13.

[0045] The controller 5 controls the opening degree of the third expansion valve 18 so that the degree of subcooling of the third heat exchanger 31 reaches a target degree of subcooling. The degree of subcooling of the third heat exchanger 31 is obtained from the difference between the condensation temperature detected by the third refrigerant temperature sensor T8 and the outlet temperature detected by the third outlet temperature sensor T9. In addition, the controller 5 controls the opening degree of the first expansion valve 16 so that the discharge temperature detected by the discharge temperature sensor T1 reaches a target discharge temperature. The target degree of subcooling and the target discharge temperature are set in advance based on installation conditions and specifications of the refrigeration cycle apparatus 100 and the hot water supply set temperature, and are stored in the controller 5.

[0046] The refrigerant flowed into the first heat exchanger 13 changes its phase from liquid to gas while the refrigerant cools the air passing through the first heat exchanger 13. Then, the refrigerant flows into the accumulator 15 via the fourth port D and the third port C of the flow switching valve 12. The refrigerant is then sucked into the compressor 11 and enters a high-temperature, high-pressure gas state again.

(First Hot Water Supply Cooling Operation)

[0047] Fig. 6 is a diagram illustrating behavior of the first hot water supply cooling operation of the refrigeration cycle apparatus 100 according to Embodiment 1. Arrows in Fig. 6 indicate directions of refrigerant flow. The first hot water supply cooling operation is a hot water supply cooling operation in which hot water supply and cooling are performed at the same, and is performed when the hot water supply load is large and the cooling load is large. In the first hot water supply cooling operation, the controller 5 sets the flow switching valve 12 to the first state, in which the second port B communicates with the third port C and the third port C communicates with the fourth port D, closes the first expansion valve 16, and opens the on-off valve 19. In addition, the controller 5 controls the opening degree of the second expansion valve 17 and the opening degree of the third expansion valve 18 according to an operation state. Furthermore, the controller 5 sets the frequency of the compressor 11 high.

[0048] As shown in Fig. 6, in the first hot water supply cooling operation, the refrigerant that has been compressed by the compressor 11 and thus enters a high-temperature, high-pressure gas state flows into the third heat exchanger 31 via the on-off valve 19. The refrigerant changes its phase from high-temperature, high-pressure gas to liquid in the third heat exchanger 31 while the refrigerant heats the heat medium flowing in the heat medium circuit. When the heat medium heated by the third heat exchanger 31 enters the fourth heat exchanger 34, the water in the hot water storage tank 32 is heated. As a result, hot water can be supplied. The refrigerant flowed out from the third heat exchanger 31 is decompressed by the third expansion valve 18 and the second expansion valve 17, and enters a two-phase state in which low-temperature, low-pressure liquid and gas are mixed. The refrigerant in the two-phase state flows into the second heat exchanger 21.

[0049] The controller 5 controls the opening degree of the second expansion valve 17 so that the discharge temperature detected by the discharge temperature sensor T1 reaches a target discharge temperature. In addition, the controller 5 controls the opening degree of the third expansion valve 18 so that the degree of subcooling of the third heat exchanger 31 reaches a target degree of subcooling.

[0050] The refrigerant flowed into the second heat exchanger 21 changes its phase from liquid to gas while the refrigerant cools the air passing through the second heat exchanger 21. When the cooled air is blown to the air-conditioned space, the air-conditioned space is cooled. Then, the refrigerant flows into the accumulator

15 via the second port B and the third port C of the flow switching valve 12. The refrigerant is then sucked into the compressor 11 and enters a high-temperature, high-pressure gas state again.

(Second Hot Water Supply Cooling Operation)

[0051] Fig. 7 is a diagram illustrating behavior of the second hot water supply cooling operation of the refrigeration cycle apparatus 100 according to Embodiment 1. Arrows in Fig. 7 indicate directions of refrigerant flow. The second hot water supply cooling operation is a hot water supply cooling operation in which hot water supply and cooling are performed at the same, and is performed when the hot water supply load is large and the cooling load is small. In the second hot water supply cooling operation, the controller 5 sets the flow switching valve 12 to the first state, in which the second port B communicates with the third port C and the third port C communicates with the fourth port D, and opens the on-off valve 19. In addition, the controller 5 controls the opening degree of the first expansion valve 16, the opening degree of the second expansion valve 17, and the opening degree of the third expansion valve 18 according to an operation state. Furthermore, the controller 5 sets the frequency of the compressor 11 high.

[0052] As shown in Fig. 7, in the second hot water supply cooling operation, the refrigerant that has been compressed by the compressor 11 and thus enters a high-temperature, high-pressure gas state flows into the third heat exchanger 31 via the on-off valve 19. The refrigerant changes its phase from high-temperature, high-pressure gas to liquid in the third heat exchanger 31 while the refrigerant heats the heat medium flowing in the heat medium circuit. When the heat medium heated by the third heat exchanger 31 enters the fourth heat exchanger 34, the water in the hot water storage tank 32 is heated. As a result, hot water can be supplied.

[0053] The refrigerant flowed out from the third heat exchanger 31 is decompressed by the third expansion valve 18, and is divided to flow into the second expansion valve 17 and the first expansion valve 16. The controller 5 controls the opening degree of the third expansion valve 18 so that the degree of subcooling of the third heat exchanger 31 reaches a target degree of subcooling. In addition, the controller 5 controls the opening degree of the first expansion valve 16 so that the discharge temperature detected by the discharge temperature sensor T1 reaches a target discharge temperature. Furthermore, the controller 5 controls the opening degree of the second expansion valve 17 so that the blowing temperature detected by the blowing temperature sensor T6 reaches the cooling set temperature.

[0054] The refrigerant flowed into the second expansion valve 17 is decompressed, and enters a two-phase state in which low-temperature, low-pressure liquid and gas are mixed. The refrigerant in the two-phase state flows into the second heat exchanger 21. In the second heat exchanger 21, the refrigerant changes its phase from liquid to gas while the refrigerant cools the air passing through the second heat exchanger 21. When the cooled air is blown to the air-conditioned space, the air-conditioned space is cooled. Then, the refrigerant flows into the second port B of the flow switching valve 12.

[0055] Meanwhile, the refrigerant flowed into the first expansion valve 16 is decompressed, and enters a two-phase state in which low-temperature, low-pressure liquid and gas are mixed. The refrigerant in the two-phase state flows into the first heat exchanger 13. In the first heat exchanger 13, the refrigerant changes its phase from liquid to gas while the refrigerant cools the air passing through the first heat exchanger 13. Then, the refrigerant flows into the fourth port D of the flow switching valve 12.

[0056] The refrigerant flowed through the second port B and the fourth port D of the flow switching valve 12 flows into the accumulator 15 from the third port C. Then, the refrigerant is sucked into the compressor 11, and enters a high-temperature, high-pressure gas state again. As described above, in the second hot water supply cooling operation, because the refrigerant is caused to flow also through the first heat exchanger 13 and the first heat exchanger 13 functions as an evaporator, a large hot water supply load can be handled even when the cooling load is small.

(Third Hot Water Supply Cooling Operation)

[0057] Fig. 8 is a diagram illustrating behavior of the third hot water supply cooling operation of the refrigeration cycle apparatus 100 according to Embodiment 1. Arrows in Fig. 8 indicate directions of refrigerant flow. The third hot water supply cooling operation is a hot water supply cooling operation in which hot water supply and cooling are performed at the same, and is performed when the hot water supply load is small and the cooling load is large. In the third hot water supply cooling operation, the controller 5 sets the flow switching valve 12 to the second state, in which the first port A communicates with the fourth port D and the second port B communicates with the third port C, and opens the on-off valve 19. In addition, the controller 5 controls the opening degree of the first expansion valve 16, the opening degree of the second expansion valve 17, and the opening degree of the third expansion valve 18 according to an operation state. Furthermore, the controller 5 sets the frequency of the compressor 11 high.

[0058] As shown in Fig. 8, in the third hot water supply cooling operation, the refrigerant that has been compressed by the compressor 11 and thus enters a high-temperature, high-pressure gas state is divided to flow into the on-off valve 19 and the first port A of the flow switching valve 12. The refrigerant flowed into the on-off valve 19 changes its phase from high-temperature, high-pressure gas to liquid in the third heat exchanger 31 while the refrigerant heats the heat medium flowing in the heat medium circuit. When the heat medium heated by the third heat exchanger 31 enters the fourth heat exchanger 34, the water in the hot water storage tank 32 is heated. As a result, hot water can be supplied. The refrigerant flowed out from the third heat exchanger 31 is decompressed by the third expansion valve 18, and flows into the second expansion valve 17.

[0059] Meanwhile, the refrigerant flowed into the first port A of the flow switching valve 12 flows into the first heat exchanger 13 via the fourth port D. The refrigerant changes its phase from high-temperature, high-pressure gas to liquid in the first heat exchanger 13 while the refrigerant heats the air passing through the first heat exchanger 13. Then, the refrigerant is decompressed by the first expansion valve 16, and flows into the second expansion valve 17.

[0060] The controller 5 controls the opening degree of the first expansion valve 16 so that the degree of subcooling of the first heat exchanger 13 reaches a target degree of subcooling. In addition, the controller 5 controls the opening degree of the second expansion valve 17 so that the discharge temperature detected by the discharge temperature sensor T1 reaches a target discharge temperature. Furthermore, the controller 5 controls the opening degree of the third expansion valve 18 so that the hot water supply temperature detected by the hot water supply temperature sensor T10 reaches the hot water supply set temperature.

[0061] The refrigerant flowed into the second expansion valve 17 enters a two-phase state in which low-temperature, low-pressure liquid and gas are mixed. The refrigerant in the two-phase state flows into the second heat exchanger 21. In the second heat exchanger 21, the refrigerant changes its phase from liquid to gas while the refrigerant cools the air passing through the second heat exchanger 21. When the cooled air is blown to the air-conditioned space, the air-conditioned space is cooled. Then, the refrigerant flows into the accumulator 15 via the second port B and the third port C of the flow switching valve 12. The refrigerant is then sucked into the compressor 11, and enters a high-temperature, high-pressure gas state again. As described above, in the third hot water supply cooling operation, because the refrigerant is caused to flow also through the first heat exchanger 13 and the first heat exchanger 13 functions as a condenser, a large air conditioning load can be handled even when the hot water supply load is small.

(Fourth Hot Water Supply Cooling Operation)

[0062] The fourth hot water supply cooling operation is a hot water supply cooling operation in which hot water supply and cooling are performed at the same time, and is performed when the hot water supply load is small and the cooling load is small. In the fourth hot water supply cooling operation, the controls of the flow switching valve 12, the first expansion valve 16, the second expansion valve 17, the third expansion valve 18, and the on-off valve 19 are the same as those of the first hot water supply cooling operation. In addition, the refrigerant flows in the fourth hot water supply cooling operation are the same as those of the first hot water supply cooling operation shown in Fig. 6. Note, however, that the operation frequency of the compressor 11 in the fourth hot water supply cooling operation is set to lower than that in the first hot water supply cooling operation.

(First Hot Water Supply Heating Operation)

[0063] Fig. 9 is a diagram illustrating behavior of the first hot water supply heating operation of the refrigeration cycle apparatus 100 according to Embodiment 1. The first hot water supply heating operation is a hot water supply heating operation in which hot water supply and heating are performed at the same time, and is performed when the hot water supply load is large and the heating load is large. In the first hot water supply heating operation, the controller 5 set the flow switching valve 12 to the third state, in which the first port A communicates with the second port B and the third port C communicates with the fourth port D, and opens the on-off valve 19. In addition, the controller 5 controls the opening degree of the first expansion valve 16, the opening degree of the second expansion valve 17, and the opening degree of the third expansion valve 18 according to an operation state. Furthermore, the controller 5 sets the frequency of the compressor 11 high.

[0064] As shown in Fig. 9, in the first hot water supply heating operation, the refrigerant that has been compressed by the compressor 11 and thus enters a high-temperature, high-pressure gas state is divided to flow into the on-off valve 19 and the first port A of the flow switching valve 12. The refrigerant flowed into the on-off valve 19 changes its phase from high-temperature, high-pressure gas to liquid in the third heat exchanger 31 while the refrigerant heats the heat medium flowing in the heat medium circuit. When the heat medium heated by the third heat exchanger 31 enters the fourth heat exchanger 34, the water in the hot water storage tank 32 is heated. As a result, hot water can be supplied. The refrigerant flowed out from the third heat exchanger 31 is decompressed by the third expansion valve 18, and flows into the first expansion valve 16.

[0065] Meanwhile, the refrigerant flowed into the first port A flows into the second heat exchanger 21 via the second port B. The refrigerant changes its phase from high-temperature, high-pressure gas to liquid in the second heat exchanger 21 while the refrigerant heats the air passing through the second heat exchanger 21. When the heated air is blown to the air-conditioned space, the air-conditioned space is heated. Then, the refrigerant is decompressed by the second expansion valve 17, and flows into the first expansion valve 16.

[0066] The controller 5 controls the opening degree of the first expansion valve 16 so that the discharge temperature detected by the discharge temperature sensor

T1 reaches a target discharge temperature. In addition, the controller 5 controls the opening degree of the second expansion valve 17 so that the degree of subcooling of the second heat exchanger 21 reaches a target degree of subcooling. Furthermore, the controller 5 controls the opening degree of the third expansion valve 18 so that the degree of subcooling of the third heat exchanger 31 reaches a target degree of subcooling.

[0067] The refrigerant flowed into the first expansion valve 16 is decompressed, and enters a two-phase state in which low-temperature, low-pressure liquid and gas are mixed. The refrigerant in the two-phase state flows into the first heat exchanger 13. The refrigerant flowed into the first heat exchanger 13 changes its phase from liquid to gas while the refrigerant cools the air passing through the first heat exchanger 13. Then, the refrigerant flows into the accumulator 15 via the fourth port D and the third port C of the flow switching valve 12. The refrigerant is then sucked into the compressor 11, and enters a high-temperature, high-pressure gas state again.

(Second Hot Water Supply Heating Operation)

[0068] The second hot water supply heating operation is a hot water supply heating operation in which hot water supply and heating are performed at the same time, and is performed when the hot water supply load is large and the heating load is small. In the second hot water supply heating operation, the controller 5 sets the flow switching valve 12 to the third state, in which the first port A communicates with the second port B and the third port C communicates with the fourth port D, and opens the on-off valve 19. In addition, the controller 5 controls the opening degree of the first expansion valve 16, the opening degree of the second expansion valve 17, and the opening degree of the third expansion valve 18 according to an operation state. Furthermore, the controller 5 sets the frequency of the compressor 11 high.

[0069] The refrigerant flows in the second hot water supply heating operation are the same as those of the first hot water supply heating operation shown in Fig. 9. In addition, the controls of the first expansion valve 16 and the third expansion valve 18 are the same as those of the first hot water supply heating operation. Note, however, that because the cooling load is small in the second hot water supply heating operation, the controller 5 controls the opening degree of the second expansion valve 17 so that the blowing temperature detected by the blowing temperature sensor T6 reaches the cooling set temperature.

(Third Hot Water Supply Heating Operation)

[0070] The third hot water supply heating operation is a hot water supply heating operation in which hot water supply and heating are performed at the same time, and is performed when the hot water supply load is small and the heating load is large. In the third hot water supply heating operation, the controller 5 sets the flow switching valve 12 to the third state, in which the first port A communicates with the second port B and the third port C communicates with the fourth port D, and opens the on-off valve 19. In addition, the controller 5 controls the opening degree of the first expansion valve 16, the opening degree of the second expansion valve 17, and the opening degree of the third expansion valve 18 according to an operation state. Furthermore, the controller 5 sets the frequency of the compressor 11 high.

[0071] The refrigerant flows in the third hot water supply heating operation are the same as those of the first hot water supply heating operation shown in Fig. 9. In addition, the controls of the opening degrees of the first expansion valve 16 and the second expansion valve 17 are the same as those of the first hot water supply heating operation. Note, however, that because the hot water supply load is small in the third hot water supply heating operation, the controller 5 controls the opening degree of the third expansion valve 18 so that the hot water supply temperature detected by the hot water supply temperature sensor T10 reaches the hot water supply set temperature.

(Fourth Hot Water Supply Heating Operation)

[0072] The fourth hot water supply heating operation is a hot water supply heating operation in which hot water supply and heating are performed at the same time, and is performed when the hot water supply load is small and the heating load is small. In the fourth hot water supply heating operation, the controller 5 sets the flow switching valve 12 to the third state, in which the first port A communicates with the second port B and the third port C communicates with the fourth port D, and opens the on-off valve 19. In addition, the controller 5 controls the opening degree of the first expansion valve 16, the opening degree of the second expansion valve 17, and the opening degree of the third expansion valve 18 according to an operation state. Furthermore, the controller 5 sets the frequency of the compressor 11 lower than that of the first hot water supply heating operation.

[0073] The refrigerant flows in the fourth hot water supply heating operation are the same as those of the first hot water supply heating operation shown in Fig. 9. The control of the opening degree of the first expansion valve 16 is the same as that of the first hot water supply heating operation. Note, however, that, in the third hot water supply heating operation, the controller 5 controls the opening degree of the second expansion valve 17 so that the blowing temperature detected by the blowing temperature sensor T6 reaches the cooling set temperature. In addition, the controller 5 controls the opening degree of the third expansion valve 18 so that the hot water supply temperature detected by the hot water supply temperature sensor T10 reaches the hot water supply set temperature.

[0074] Fig. 10 is a table illustrating a list of controls in each operation of the refrigeration cycle apparatus 100 according to Embodiment 1. Note that the controls of the first expansion valve 16 to the third expansion valve 18 in each operation are not limited to the examples shown in Fig. 10. For example, although the third expansion valve 18 is closed in the cooling operation and the heating operation, as shown in Fig. 10, the third expansion valve 18 may be opened. In addition, although the third expansion valve 18 is controlled according to an operation state in the first hot water supply cooling operation, the third expansion valve 18 may be fully opened regardless of operation state. In this case, the controller 5 controls the opening degree of the second expansion valve 17 based on the discharge temperature of the compressor 11 or the degree of subcooling of the third heat exchanger 31.

[0075] As described above, in Embodiment 1, hot water supply, cooling and heating can be performed by switching the directions of refrigerant flow by the flow switching valve 12, which can be set to the state (first state) in which the first port A connected to the discharge port of the compressor 11 is closed. For this reason, the number of components, such as valves and pipes, can be reduced as well as the controllability can be improved, compared with a case where operations are switched by a complicated valve configuration.

[0076] In addition, in Embodiment 1, when the hot water supply load and the cooling load are equal, that is, in the first hot water supply cooling operation and in a fourth hot water supply cooling operation, the first expansion valve 16 is closed so that the refrigerant does not enter the first heat exchanger 13. Meanwhile, when the hot water supply load and the cooling load are not equal, that is, in the second hot water supply cooling operation and in a third hot water supply cooling operation, the first expansion valve 16 is opened so that the refrigerant enters the first heat exchanger 13. With such a configuration, hot water supply and cooling can be achieved efficiently even when the hot water supply load and the cooling load are not equal.

[0077] Although Embodiment 1 is described as above, the present disclosure is not limited to Embodiment 1. Various modifications are possible without departing from the scope of the present disclosure. For example, a method of obtaining hot water by the hot water supply unit 3 is not limited to a heat exchange method using a heat medium as described in Embodiment 1. For example, a heating method may be used in which water in the hot water storage tank 32 is caused to directly flow in a pipe to exchange heat as a heat medium in the third heat exchanger 31 and is caused to return to the hot water storage tank 32 again. In addition, the hot water supply unit 3 may be provided with a heat medium temperature sensor detecting the temperature of the heat medium flowing in the heat medium circuit, in place of or in addition to the hot water supply temperature sensor T10.

[0078] Furthermore, each of the temperature sensors T1 to T10 used in control is not an essential component for the refrigeration cycle apparatus 100 and can be omitted. For example, in place of the temperature sensor detecting the temperature of refrigerant, a pressure sensor detecting the pressure of refrigerant may be used to obtain the temperature of the refrigerant from the detected pressure. In addition, the controller 5 may obtain the indoor temperature and the hot water supply temperature by communicating with external devices provided separately from the refrigeration cycle apparatus 100.

Reference Signs List

[0079] 1: heat source unit, 2: air-conditioning unit, 3: hot water supply unit, 5: controller, 11: compressor, 12: flow switching valve, 13: first heat exchanger, 14: first fan, 15: accumulator, 16: first expansion valve, 17: second expansion valve, 18: third expansion valve, 19: on-off valve, 21: second heat exchanger, 22: second fan, 31: third heat exchanger, 32: hot water storage tank, 33: pump, 34: fourth heat exchanger, 100: refrigeration cycle apparatus, A: first port, B: second port, C: third port, D: fourth port, T1: discharge temperature sensor, T2: first refrigerant temperature sensor, T3: first outlet temperature sensor, T4: second refrigerant temperature sensor, T5: second outlet temperature sensor, T6: blowing temperature sensor, T7: indoor temperature sensor, T8: third refrigerant temperature sensor, T9: third outlet temperature sensor, T10: hot water supply temperature sensor

Claims

1. A refrigeration cycle apparatus comprising:

a heat source unit including a compressor, a flow switching valve, a first heat exchanger, and an expansion valve;
an air-conditioning unit including a second heat exchanger and configured to perform air-conditioning; and
a hot water supply unit including a third heat exchanger and configured to supply hot water;
wherein the flow switching valve includes
a first port connected to a discharge port of the compressor,
a second port connected to the second heat exchanger,
a third port connected to a suction port of the compressor, and
a fourth port connected to the first heat exchanger, and
wherein the flow switching valve is set to one of
a first state in which the second port communicates with the third port, the third port communicates with the fourth port, and the first port does not communicate with any ports,
a second state in which the first port communicates with the fourth port, and the second port communicates with the third port, and

a third state in which the first port communicates with the second port, and the third port communicates with the fourth port.

2. The refrigeration cycle apparatus of claim 1, further comprising:

a controller configured to control operations of the heat source unit, the air-conditioning unit, and the hot water supply unit,
wherein the controller is configured to perform a hot water supply operation in which hot water supply is performed by the hot water supply unit, a cooling operation in which cooling is performed by the air-conditioning unit, and a heating operation in which heating is performed by the air-conditioning unit, and
wherein the controller is configured to set the flow switching valve to the first state in the hot water supply operation,
the second state in the cooling operation, and the third state in the heating operation.

3. The refrigeration cycle apparatus of claim 2, further comprising:

an on-off valve provided on a pipe that is branched from a pipe connecting the discharge port of the compressor and the first port of the flow switching valve, and that is connected to the third heat exchanger,
wherein the controller is configured to
open the on-off valve in the hot water supply operation, and
close the on-off valve in the cooling operation and the heating operation.

4. The refrigeration cycle apparatus of claim 2 or 3,

wherein the controller is configured to
perform a hot water supply cooling operation in which hot water supply by the hot water supply unit and cooling by the air-conditioning unit are performed concurrently, and
switch the flow switching valve to the first state or the second state in the hot water supply cooling operation according to a hot water supply load and a cooling load.

5. The refrigeration cycle apparatus of any one of claims 2 to 4,

wherein the controller is configured to
perform a hot water supply heating operation in which hot water supply by the hot water supply unit and heating by the air-conditioning unit are performed concurrently, and
set the flow switching valve to the third state in the hot water supply heating operation.

6. The refrigeration cycle apparatus of any one of claims 2 to 5,

wherein the expansion valve includes
a first expansion valve provided on an outlet side of the first heat exchanger in the cooling operation,
a second expansion valve provided on an outlet side of the second heat exchanger in the heating operation, and
a third expansion valve provided on a pipe that is branched from a pipe connecting the first expansion valve and the second expansion valve, and that is connected to the third heat exchanger, and
wherein the controller is configured to
close the third expansion valve in the cooling operation and the heating operation, and
close the second expansion valve in the hot water supply operation.

7. The refrigeration cycle apparatus of claim 6 as dependent on claim 4,

wherein, in the hot water supply cooling operation, the controller is configured to
close the first expansion valve when the hot water supply load and the cooling load are equal, and
open the first expansion valve when the hot water supply load and the cooling load are not equal.

FIG. 1

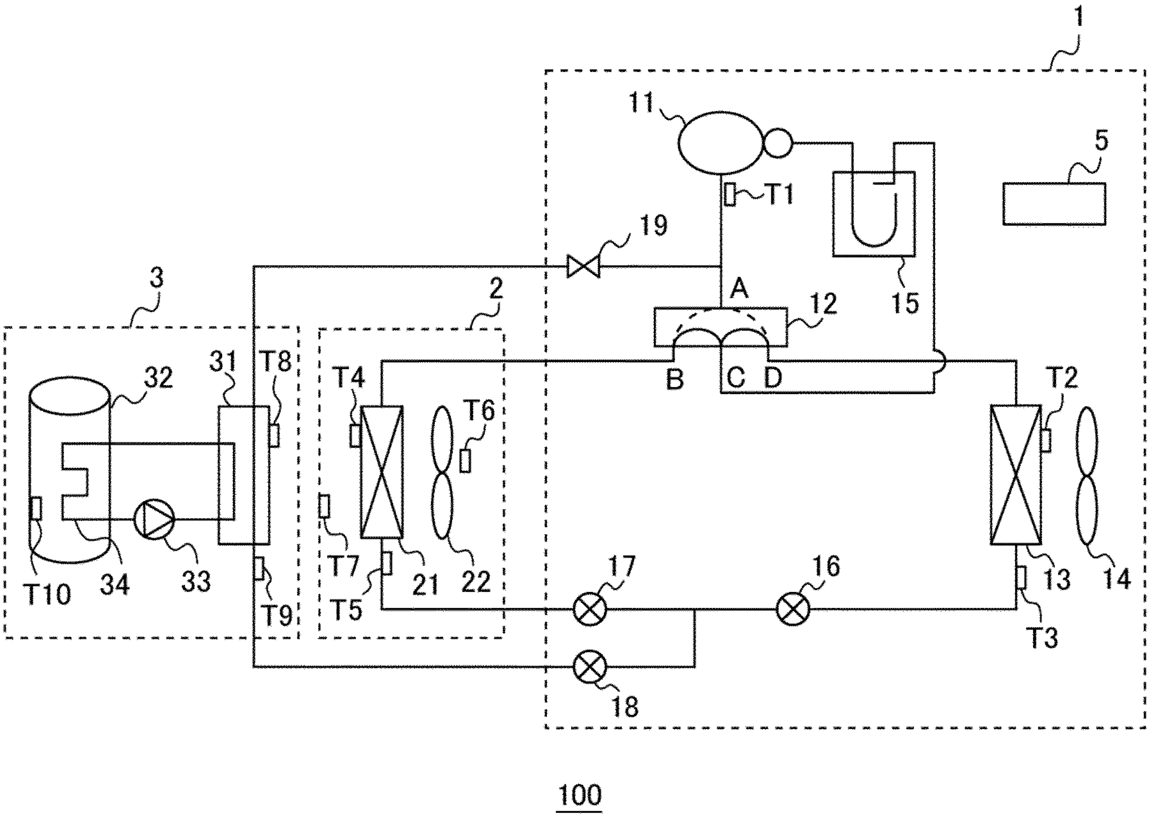
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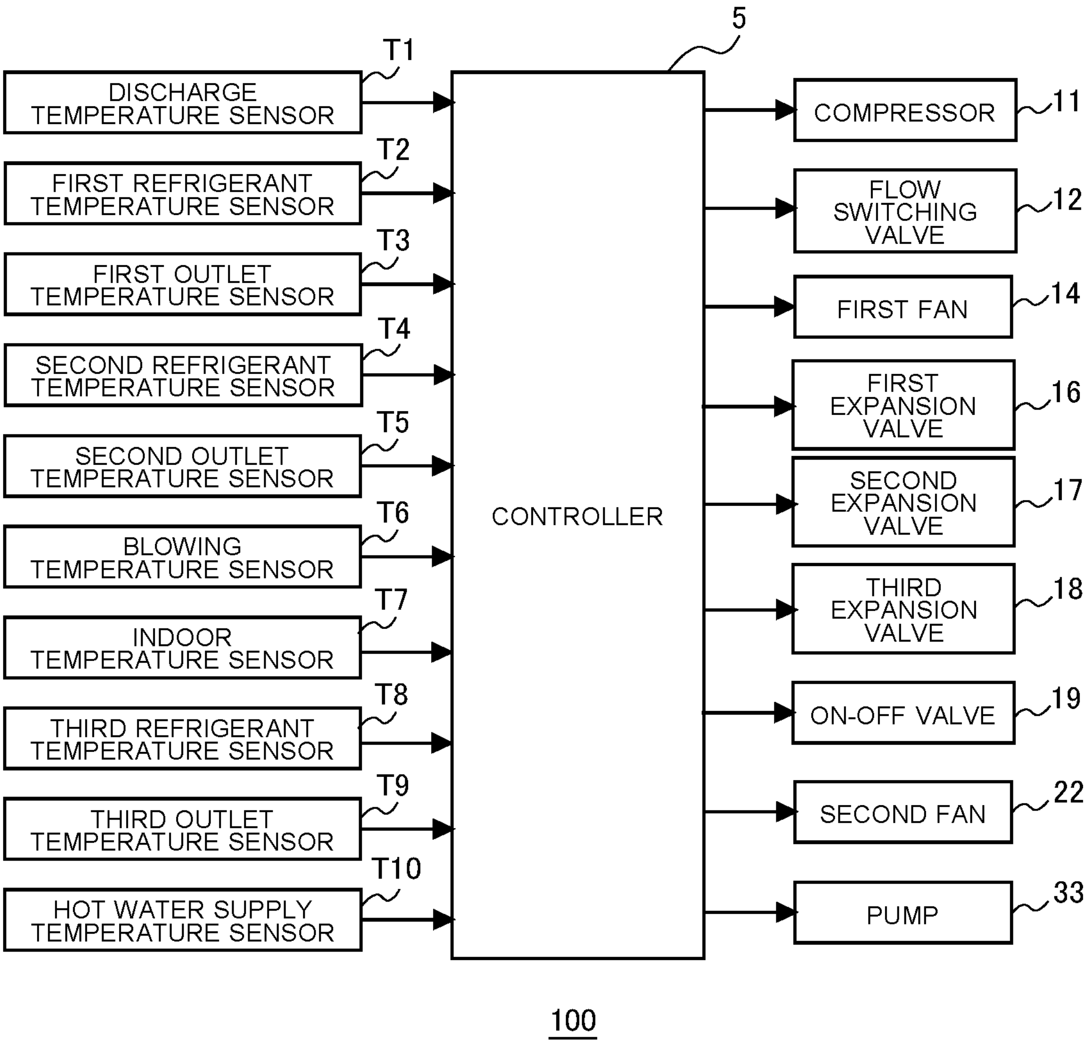
FIG. 2



DISCHARGE TEMPERATURE SENSOR
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FIRST REFRIGERANT TEMPERATURE SENSOR
T2
FIRST OUTLET TEMPERATURE SENSOR
T3
SECOND REFRIGERANT TEMPERATURE SENSOR
T4
SECOND OUTLET TEMPERATURE SENSOR
T5
BLOWING TEMPERATURE SENSOR
T6
INDOOR TEMPERATURE SENSOR
T7
THIRD REFRIGERANT TEMPERATURE SENSOR
T8
THIRD OUTLET TEMPERATURE SENSOR
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HOT WATER SUPPLY TEMPERATURE SENSOR
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COMPRESSOR
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FLOW SWITCHING VALVE
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FIRST EXPANSION VALVE
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SECOND EXPANSION VALVE
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ON-OFF VALVE
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FIG. 3

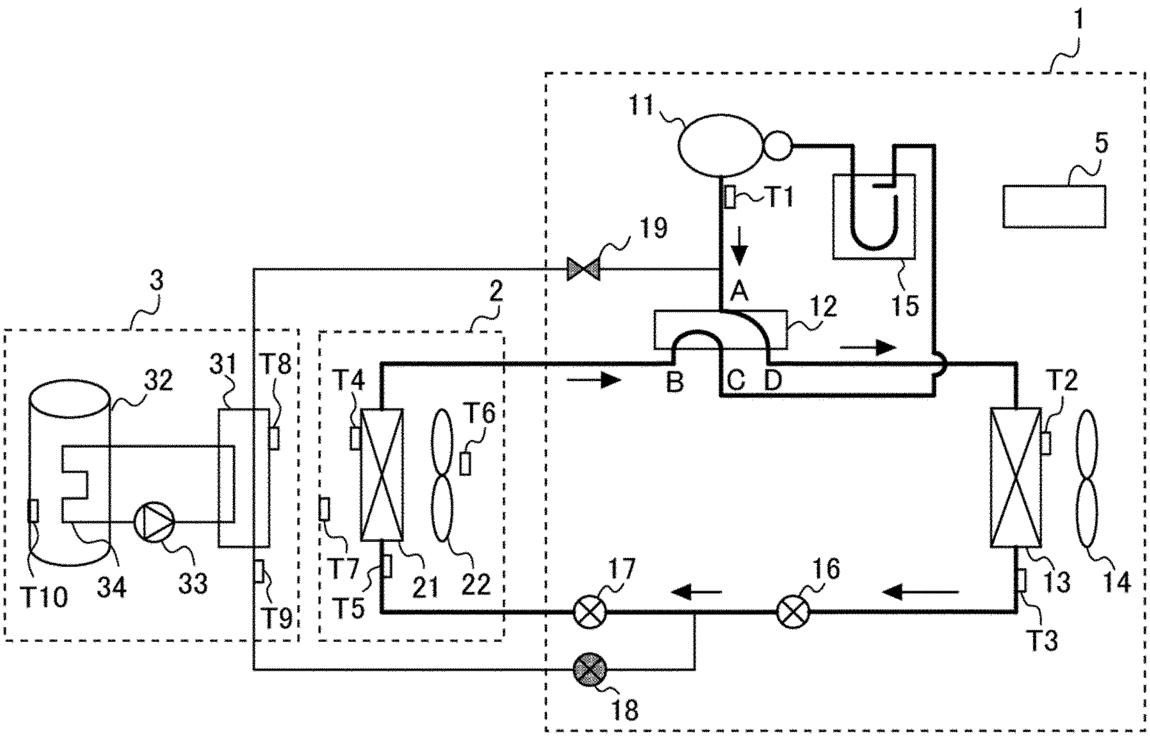
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FIG. 4

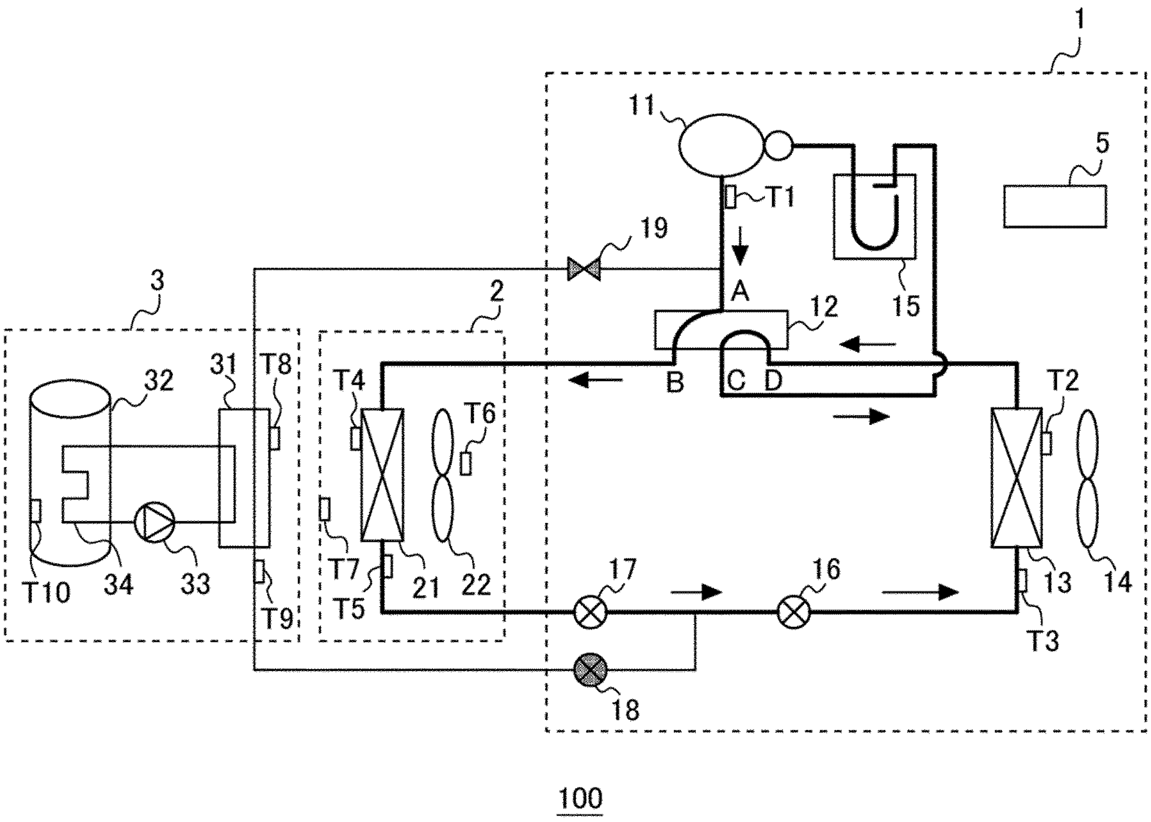
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FIG. 5

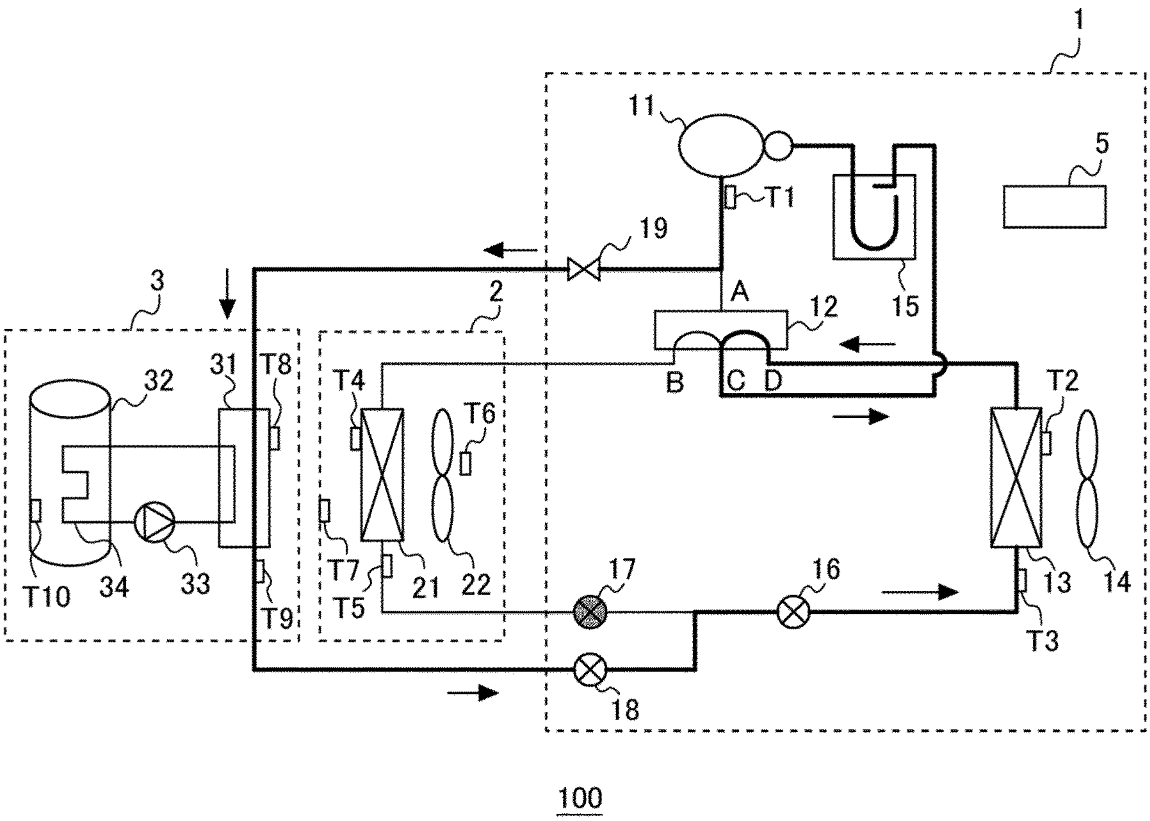
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FIG. 6

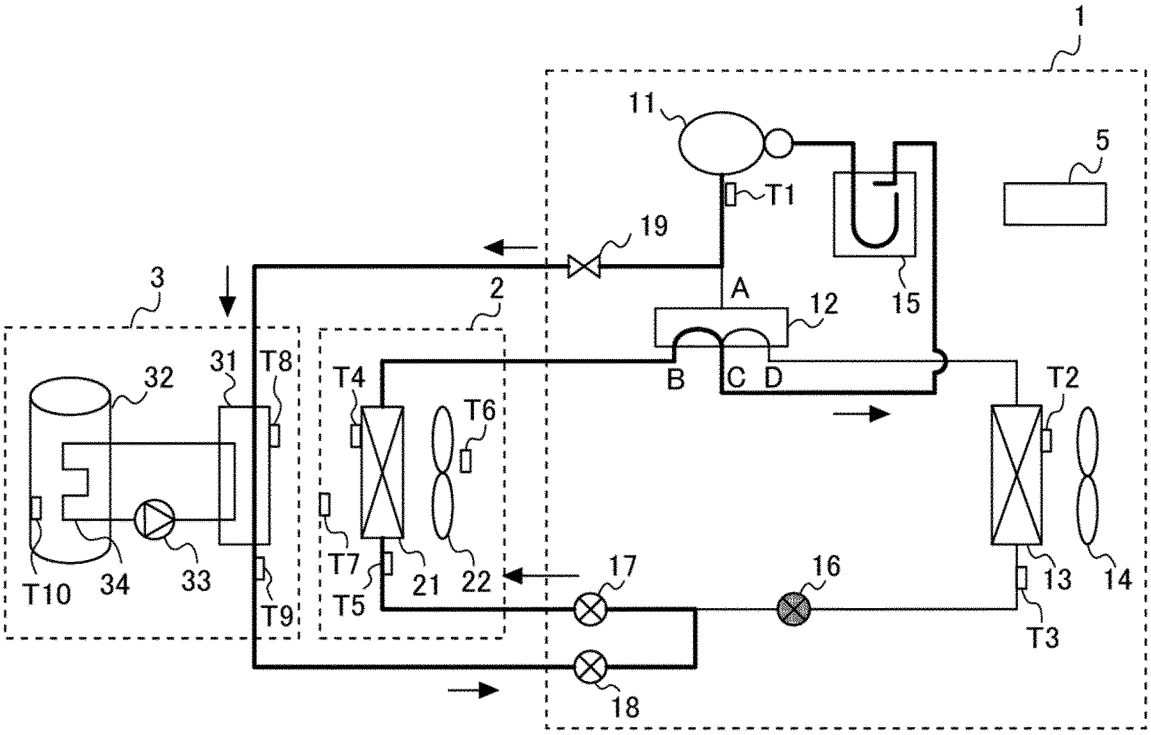
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FIG. 7

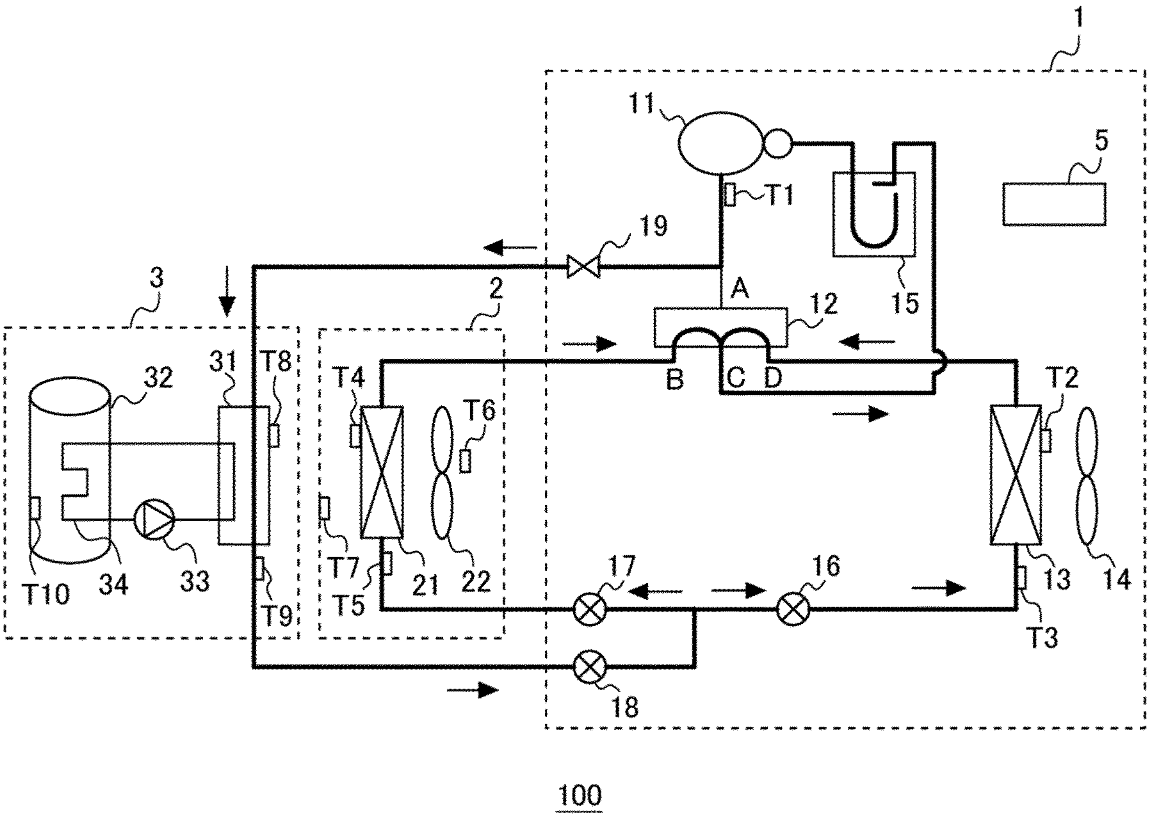
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FIG. 8

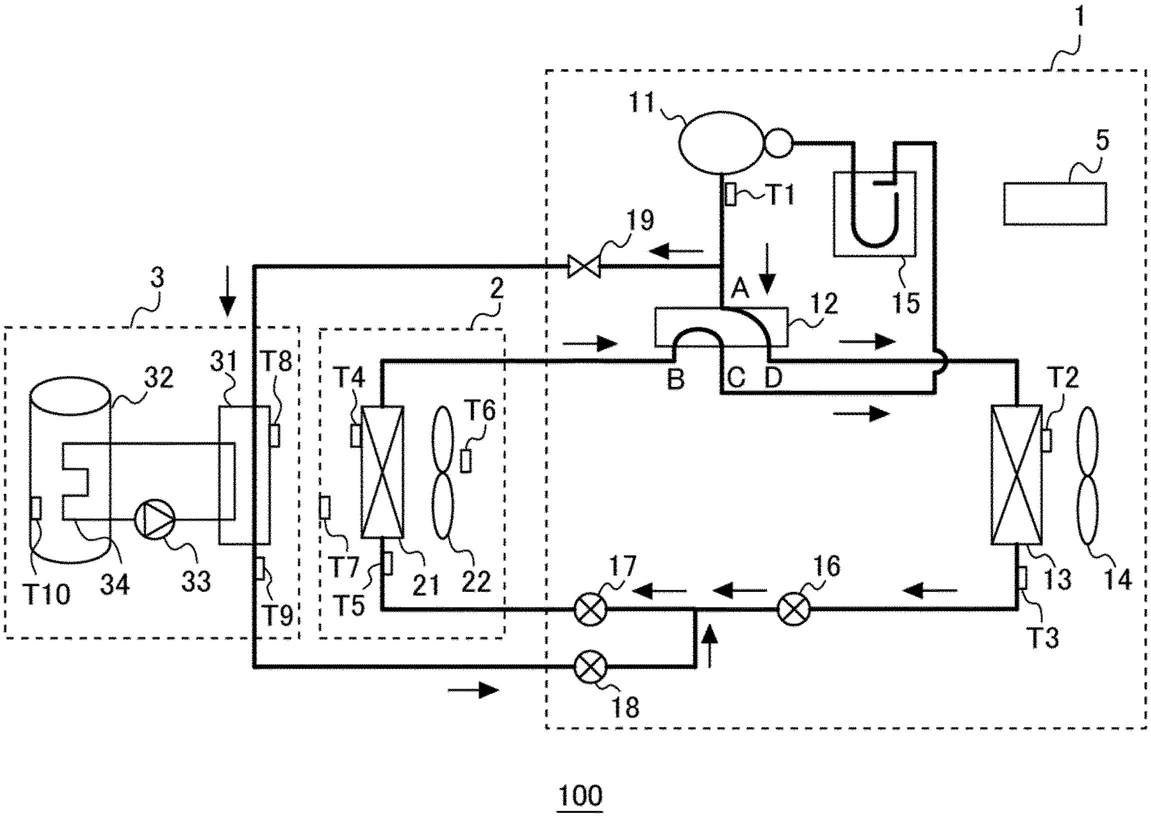
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FIG. 9

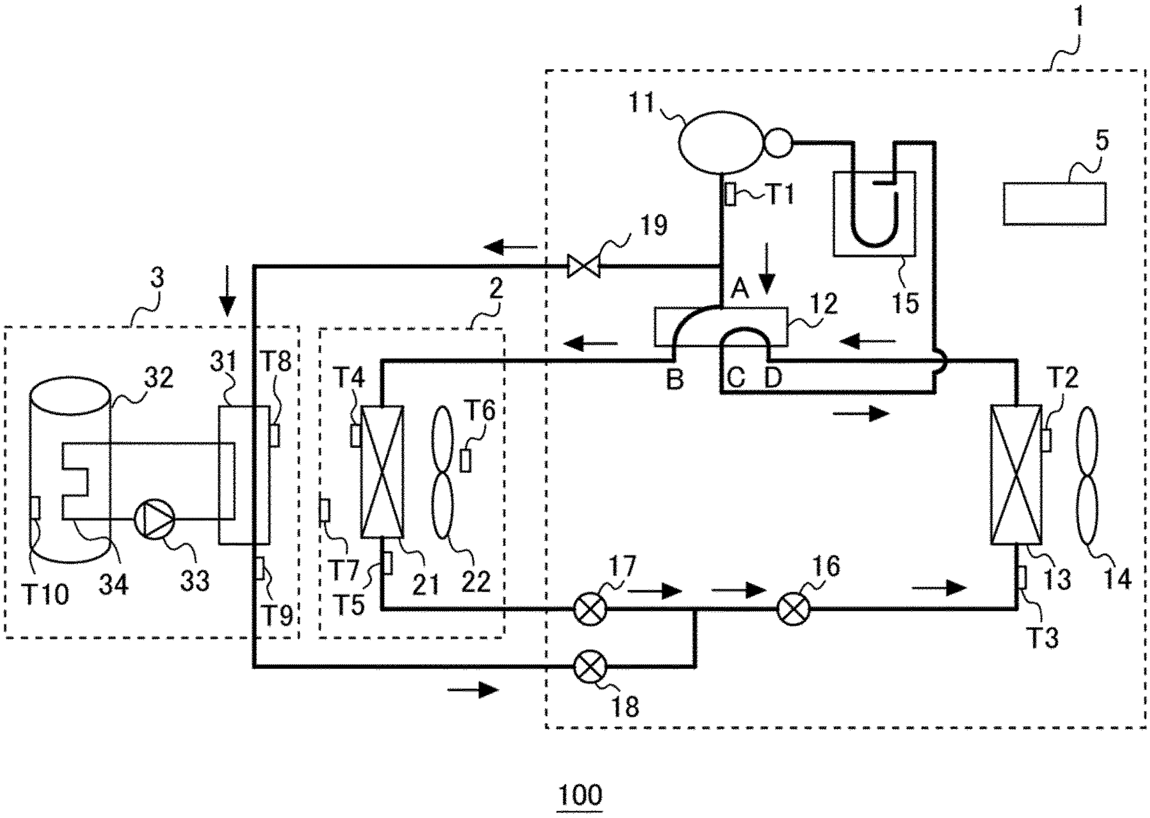
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FIG. 10

OPERATION	HOT WATER SUPPLY LOAD	COOLING/ HEATING LOAD	ON-OFF VALVE 19	FLOW SWITCHING VALVE 12	FIRST EXPANSION VALVE 16	SECOND EXPANSION VALVE 17	THIRD EXPANSION VALVE 18	OPERATION FREQUENCY OF COMPRESSOR 11
COOLING OPERATION	NONE	LARGE	CLOSE	SECOND STATE	DEGREE OF SUBCOOLING	DISCHARGE TEMPERATURE	CLOSE	HIGH
	NONE	SMALL	CLOSE	SECOND STATE	DEGREE OF SUBCOOLING	DISCHARGE TEMPERATURE	CLOSE	MIDDLE TO LOW
HEATING OPERATION	NONE	LARGE	CLOSE	THIRD STATE	DISCHARGE TEMPERATURE	DEGREE OF SUBCOOLING	CLOSE	HIGH
	NONE	SMALL	CLOSE	THIRD STATE	DISCHARGE TEMPERATURE	DEGREE OF SUBCOOLING	CLOSE	MIDDLE TO LOW
HOT WATER SUPPLY OPERATION	LARGE	NONE	OPEN	FIRST STATE	DISCHARGE TEMPERATURE	CLOSE	DEGREE OF SUBCOOLING	HIGH
	SMALL	NONE	OPEN	FIRST STATE	DISCHARGE TEMPERATURE	CLOSE	DEGREE OF SUBCOOLING	MIDDLE TO LOW
FIRST HOT WATER SUPPLY COOLING OPERATION	LARGE	LARGE	OPEN	FIRST STATE	CLOSE	DISCHARGE TEMPERATURE	DEGREE OF SUBCOOLING	HIGH
SECOND HOT WATER SUPPLY COOLING OPERATION	LARGE	SMALL	OPEN	FIRST STATE	DISCHARGE TEMPERATURE	BLOWING TEMPERATURE	DEGREE OF SUBCOOLING	HIGH
THIRD HOT WATER SUPPLY COOLING OPERATION	SMALL	LARGE	OPEN	SECOND STATE	DEGREE OF SUBCOOLING	DISCHARGE TEMPERATURE	HOT WATER SUPPLY TEMPERATURE	HIGH
FOURTH HOT WATER SUPPLY COOLING OPERATION	SMALL	SMALL	OPEN	FIRST STATE	CLOSE	DISCHARGE TEMPERATURE	DEGREE OF SUBCOOLING	MIDDLE TO LOW
FIRST HOT WATER SUPPLY HEATING OPERATION	LARGE	LARGE	OPEN	THIRD STATE	DISCHARGE TEMPERATURE	DEGREE OF SUBCOOLING	DEGREE OF SUBCOOLING	HIGH
SECOND HOT WATER SUPPLY HEATING OPERATION	LARGE	SMALL	OPEN	THIRD STATE	DISCHARGE TEMPERATURE	BLOWING TEMPERATURE	DEGREE OF SUBCOOLING	HIGH
THIRD HOT WATER SUPPLY HEATING OPERATION	SMALL	LARGE	OPEN	THIRD STATE	DISCHARGE TEMPERATURE	DEGREE OF SUBCOOLING	HOT WATER SUPPLY TEMPERATURE	HIGH
FOURTH HOT WATER SUPPLY HEATING OPERATION	SMALL	SMALL	OPEN	THIRD STATE	DISCHARGE TEMPERATURE	BLOWING TEMPERATURE	HOT WATER SUPPLY TEMPERATURE	MIDDLE TO LOW

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2020/041931

A. CLASSIFICATION OF SUBJECT MATTER
F25B 13/00(2006.01)i; F25B 29/00(2006.01)i; F25B 41/26(2021.01)i
FI: F25B29/00 361A; F25B41/04 C; F25B13/00 S
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)
F25B13/00; F25B29/00; F25B41/04

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	1971-2020
Registered utility model specifications of Japan	1996-2020
Published registered utility model applications of Japan	1994-2020

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 6141425 B2 (MITSUBISHI ELECTRIC CORP.) 12 May 2017 (2017-05-12) paragraphs [0013]-[0051], fig. 1	1-7
Y	JP 2017-101844 A (SAMSUNG ELECTRONICS CO., LTD.) 08 June 2017 (2017-06-08) paragraphs [0029]-[0033], fig. 1-2	1-7
A	JP 2017-89940 A (RYOMEI KOGYO KK) 25 May 2017 (2017-05-25) paragraphs [0018]-[0075], fig. 1	1-7
A	JP 2006-313058 A (SAMSUNG ELECTRONICS CO., LTD.) 16 November 2006 (2006-11-16) paragraphs [0026], [0030], fig. 1-3	1-7
A	JP 2014-112031 A (DAIKIN INDUSTRIES, LTD.) 19 June 2014 (2014-06-19) paragraphs [0083]-[0091], fig. 15-17	1-7

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

* Special categories of cited documents:
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"E" earlier application or patent but published on or after the international filing date
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
01 December 2020 (01.12.2020)	12 January 2021 (12.01.2021)

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

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2020/041931

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
JP 6141425 B2	12 May 2017	US 2016/0116191 A1 paragraphs [0025]-[0082], fig. 1	
JP 2017-101844 A	08 Jun. 2017	(Family: none)	
JP 2017-89940 A	25 May 2017	(Family: none)	
JP 2006-313058 A	16 Nov. 2006	US 2006/0248905 A1 paragraph [0047], fig. 1-3	
JP 2014-112031 A	19 Jun. 2014	(Family: none)	

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 6141425 B **[0003]**