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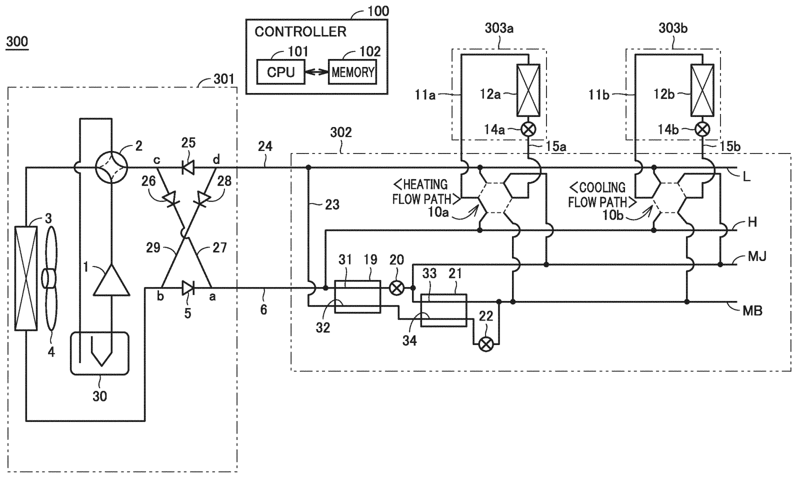
(54) **REFRIGERATION CYCLE DEVICE**

(57) A refrigeration cycle apparatus includes a heat source unit (301), a plurality of indoor units (303a, 303b), and a branch unit (302) configured to transfer refrigerant. The branch unit (302) includes a plurality of six-way valves (10a, 10b) each being provided for a corresponding one of the plurality of indoor units (303a, 303b). Each of the six-way valves includes a housing (41) having a first port to a sixth port, and a valve body (42) disposed inside the housing and provided with a first flow path and a second flow path. In a second switching state, the first port communicates with the second port through the first flow path, and the fourth port communicates with the fifth port through the second flow path. In a first switching state, the second port communicates with the third port through the first flow path, and the fifth port communicates with the sixth port through the second flow path.

FIG.1



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Description

TECHNICAL FIELD

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

BACKGROUND ART

[0002] There is known a refrigeration cycle apparatus in which a plurality of indoor units are connected to an outdoor unit with a branch unit interposed therebetween. In some of these refrigeration cycle apparatuses, each of the plurality of indoor units is capable of selecting cooling/heating independently of the operation states of cooling/heating in other indoor units.

[0003] For example, in a large-scale building, heating is required in an office room, whereas cooling may be required in a room in which heat is generated, such as a computer room or a kitchen. When the above-mentioned refrigeration cycle apparatus is employed in such a case, air conditioning for cooling and heating different rooms can be simultaneously achieved by one refrigeration cycle apparatus. This air conditioning system is generally called a simultaneous cooling and heating-type air conditioning system.

[0004] As an example of such a simultaneous cooling and heating-type air conditioning system, there is known a system in which an outdoor unit and a branch unit are connected by a total of two refrigerant pipes including a first pipe and a second pipe (for example, Japanese Patent Laying-Open No. 2011-112233, PTL 1).

CITATION LIST

PATENT LITERATURE

[0005] PTL 1: Japanese Patent Laying-Open No. 2011-112233

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0006] However, in the configuration as disclosed in Japanese Patent Laying-Open No. 2011-112233 (PTL 1) in which two solenoid valves and two check valves are used as a mechanism for switching between a cooling operation and a heating operation of each indoor unit, there occur problems that the number of components is increased, the cost becomes expensive, and a larger installation space is also required.

[0007] The present disclosure has been made in order to describe embodiments for solving the above-described problems, and relates to a refrigeration cycle apparatus including a branch unit in which a mechanism for switching between a cooling operation and a heating operation of each indoor unit is implemented by a six-way valve.

SOLUTION TO PROBLEM

[0008] The present disclosure relates to a refrigeration cycle apparatus. The refrigeration cycle apparatus includes: a heat source unit including a compressor and an outdoor heat exchanger; a plurality of indoor units; and a branch unit connected between the heat source unit and the plurality of indoor units, the branch unit being configured to transfer refrigerant. The branch unit has a first pipe through which the refrigerant delivered from the heat source unit passes, a second pipe through which the refrigerant returning to the heat source unit passes, a third pipe, a fourth pipe, a first expansion valve provided between the first pipe and the third pipe, a second expansion valve provided between the fourth pipe and the second pipe, and a plurality of six-way valves, each of the plurality of six-way valves being provided for a corresponding one of the plurality of indoor units. Each of the plurality of six-way valves has: a first port connected to the second pipe; a second port connected to one end of a refrigerant flow path of the corresponding one of the plurality of indoor units; a third port connected to the first pipe; a fourth port connected to the fourth pipe; a fifth port connected to the other end of the refrigerant flow path of the corresponding one of the plurality of indoor units; a sixth port connected to the third pipe; a housing having the first port to the sixth port; and a valve body disposed inside the housing, the valve body being provided with a first flow path and a second flow path. The valve body is configured to switch a communication state of each of the plurality of six-way valves between a first switching state and a second switching state. In the second switching state, the first port communicates with the second port through the first flow path, and the fourth port communicates with the fifth port through the second flow path. At this time, the third port and the sixth port are closed. In the first switching state, the second port communicates with the third port through the first flow path, and the fifth port communicates with the sixth port through the second flow path. At this time, the first port and the fourth port are closed.

ADVANTAGEOUS EFFECTS OF INVENTION

[0009] The refrigeration cycle apparatus of the present disclosure makes it possible to implement a refrigeration cycle apparatus in which a cooling/heating switching mechanism of an indoor unit is implemented by a six-way valve to thereby achieve a less expensive and more compact configuration as compared with the configuration employing two solenoid valves and two check valves.

BRIEF DESCRIPTION OF DRAWINGS

[0010]

Fig. 1 is a refrigerant circuit diagram showing a refrigerant circuit configuration of a refrigeration cycle apparatus 300 according to a first embodiment.

Fig. 2 is a diagram representatively showing one indoor unit and one six-way valve (of a rotary type) corresponding thereto.

Fig. 3 is a diagram showing a state of a six-way valve (of a rotary type) when an indoor unit performs a heating operation.

Fig. 4 is a diagram showing a state of the six-way valve (of a rotary type) when the indoor unit performs a cooling operation.

Fig. 5 is a diagram representatively showing one indoor unit and one six-way valve (of a slide type) corresponding thereto.

Fig. 6 is a diagram showing a state of a six-way valve (of a slide type) when the indoor unit performs a heating operation.

Fig. 7 is a diagram showing a state of a six-way valve (of a slide type) when the indoor unit performs a cooling operation.

Fig. 8 is a refrigerant circuit diagram showing a refrigerant circuit configuration of a refrigeration cycle apparatus 500 according to a comparative example.

Fig. 9 is a diagram showing a state in which an indoor unit of a six-way valve (of a rotary type) used in a second embodiment performs a heating operation.

Fig. 10 is a diagram showing a state in which the indoor unit of the six-way valve (of a rotary type) used in the second embodiment performs a cooling operation.

Fig. 11 is a diagram showing a state in which an indoor unit of a six-way valve (of a slide type) used in the second embodiment performs a heating operation.

Fig. 12 is a diagram showing a state in which the indoor unit of the six-way valve (of a slide type) used in the second embodiment performs a cooling operation.

Fig. 13 is a diagram showing a state in which an indoor unit of a six-way valve (of a slide type) used in a third embodiment performs a heating operation.

Fig. 14 is a diagram showing a state at some midpoint of switching an operation of a six-way valve (of a slide type) used in the third embodiment.

Fig. 15 is a diagram showing a state in which the indoor unit of the six-way valve (of a slide type) used in the third embodiment performs a cooling operation.

Fig. 16 is a diagram showing a state at some midpoint of switching an operation of a six-way valve (of a rotary type) used in the third embodiment.

Fig. 17 is a diagram showing configurations of a branch unit, an indoor unit, and a controller for illustrating six-way valve control according to a fourth embodiment.

Fig. 18 is a flowchart for illustrating six-way valve switching control executed by a controller 100.

DESCRIPTION OF EMBODIMENTS

[0011] The following describes embodiments in detail with reference to the accompanying drawings. While a plurality of embodiments will be described below, it has been originally intended at the time of filing of the present application to appropriately combine the configurations described in the embodiments. In the accompanying drawings, the same or corresponding portions are denoted by the same reference characters, and the description thereof will not be repeated.

First Embodiment

<Apparatus Configuration>

[0012] Fig. 1 is a refrigerant circuit diagram showing a refrigerant circuit configuration of a refrigeration cycle apparatus 300 according to the first embodiment. The configuration and the operation of refrigeration cycle apparatus 300 shown in Fig. 1 will be described.

[0013] Refrigeration cycle apparatus 300 is a two pipe-type multi-system air conditioner capable of simultaneously processing a cooling operation and a heating operation selected in each indoor unit by performing a vapor compression-type refrigeration cycle operation.

[0014] Note that, in the accompanying drawings including Fig. 1, the relation between components in terms of size may be different from the actual one. Also, components each having a reference character with a suffix "a" are disposed in an indoor unit 303a and components each having a reference character with a suffix "b" are disposed in an indoor unit 303b.

[0015] Refrigeration cycle apparatus 300 includes a heat source unit 301, a branch unit 302, and indoor units 303a and 303b. Note that one of indoor units 303a and 303b may be representatively referred to as an indoor unit 303 in the following description.

[0016] Heat source unit 301 and branch unit 302 are connected to each other through a high-pressure connection pipe 6 and a low-pressure connection pipe 24. Specifically, an outlet side of a check valve 5 is connected to a high-pressure pipe H of branch unit 302 through high-pressure connection pipe 6. Further, an inlet of check valve 25 is connected to a low-pressure pipe L of branch unit 302 through low-pressure connection pipe 24.

[0017] Four pipes of branch unit 302 are connected to indoor unit 303a via a six-way valve 10a. Four pipes of branch unit 302 are connected to indoor unit 303b via a six-way valve 10b.

[0018] Although the first embodiment is described with reference to an example in which two indoor units are connected to one heat source unit, the present disclosure is not limited thereto, and the number of indoor units and the number of heat source units may be the equal to or greater than or may be equal to or less than those shown in the figure. Examples of the refrigerant used in refrigeration cycle apparatus 300 include HFC (hydrofluorocarbon) refrigerant such as R32 and R410A, natural refrigerant such as hydrocarbon, carbon dioxide, and ammonia, or the like.

<Operation Mode of Heat Source Unit 301>

[0019] The following briefly describes the operation mode executed by refrigeration cycle apparatus 300.

[0020] In refrigeration cycle apparatus 300, the operation mode of heat source unit 301 is determined based on the ratio of the cooling load to the heating load of indoor units 303 connected thereto. Refrigeration cycle apparatus 300 executes the following four operation modes.

(a) An operation mode of heat source unit 301 in a case where no heating load exists and all of indoor units 303 perform a cooling operation (hereinafter referred to as a full-cooling operation mode).

(b) An operation mode of heat source unit 301 in a case where a cooling load is large in a simultaneous cooling and heating operation in which indoor units 303 simultaneously perform both a cooling operation and a heating operation (hereinafter referred to as a cooling-dominated operation mode).

(c) An operation mode of heat source unit 301 in a case where no cooling load exists and all of indoor units 303 perform a heating operation (hereinafter referred to as a full-heating operation mode).

(d) An operation mode of heat source unit 301 in a case where a heating load is large in a simultaneous cooling and heating operation in which indoor units 303 simultaneously perform both a cooling operation and a heating operation (hereinafter referred to as a heating-dominated operation mode).

<Indoor Unit 303>

[0021] Indoor unit 303 is installed in a place where it can blow conditioned air out to an air conditioning target area. Indoor unit 303 is installed in such a place, for example, by embedding it in an indoor ceiling, by suspending it from the indoor ceiling, or by hanging it on a wall surface. Indoor unit 303 is connected to heat source unit 301 through branch unit 302, high-pressure connection pipe 6, and low-pressure connection pipe 24, and constitutes a part of a refrigerant circuit.

[0022] Indoor unit 303a includes an indoor-side refrigerant circuit that constitutes a part of the refrigerant circuit. The indoor-side refrigerant circuit includes an indoor heat exchanger 12a as a use-side heat exchanger and an indoor decompressing mechanism 14a connected in series to indoor heat exchanger 12a. Further, indoor unit 303a is provided with an indoor fan (not shown) with which the conditioned air having exchanged heat with the refrigerant in indoor heat exchanger 12a is supplied to an air conditioning target area such as an indoor space.

[0023] Similarly, indoor unit 303b includes an indoor-side refrigerant circuit that constitutes a part of the refrigerant circuit. The indoor-side refrigerant circuit includes an indoor heat exchanger 12b as a use-side heat exchanger and an indoor decompressing mechanism 14b connected in series to indoor heat exchanger 12b. Further, indoor unit 303b is provided with an indoor fan (not shown) with which the conditioned air having exchanged heat with the refrigerant in indoor heat exchanger 12b is supplied to an air conditioning target area such as an indoor space.

[0024] Each of indoor heat exchangers 12a and 12b can be configured, for example, of a cross-fin type fin-and-tube type heat exchanger formed of a heat transfer tube and a plurality of fins. Further, each of indoor heat exchangers 12a and 12b may be configured of a micro-channel heat exchanger, a shell-and-tube type heat exchanger, a heat-pipe type heat exchanger, or a double-pipe type heat exchanger. When indoor units 303a and 303b each operate in a cooling operation mode, indoor heat exchangers 12a and 12b each function as an evaporator of refrigerant to cool the air in the air conditioning target area. When indoor units 303a and 303b each operate in a heating operation mode, indoor heat exchangers 12a and 12b each function as a condenser of refrigerant to heat the air in the air conditioning target area.

[0025] The indoor fan (not shown) has a function of suctioning indoor air into each of indoor units 303a and 303b to cause the suctioned indoor air to exchange heat with the refrigerant in indoor heat exchangers 12a and 12b, respectively, and then supplying the resultant air as conditioned air to the air conditioning target area. In other words, in each of indoor units 303a and 303b, heat can be exchanged between the indoor air taken in by the indoor fan and the refrigerant flowing through each of indoor heat exchangers 12a and 12b.

[0026] The indoor fan is capable of changing the flow rate of the conditioned air to be supplied to the corresponding indoor heat exchanger, and includes a fan such as a centrifugal fan or a multi-blade fan, and a motor including, for example, a DC fan motor for driving the fan.

<Heat Source Unit 301>

[0027] Heat source unit 301 is installed outdoors, for example, and is connected to indoor unit 303 through high-pressure connection pipe 6, low-pressure connection pipe 24, and branch unit 302, and also constitutes a part of the refrigerant circuit in refrigeration cycle apparatus 300.

[0028] Heat source unit 301 is provided with two connection pipes 27 and 29 that connect high-pressure connection pipe 6 and low-pressure connection pipe 24 in order to fix the flow direction of the refrigerant that flows into and out of branch unit 302.

[0029] Heat source unit 301 includes an outdoor-side refrigerant circuit that constitutes a part of the refrigerant circuit. The outdoor-side refrigerant circuit includes: a compressor 1 that compresses refrigerant; a four-way valve 2 for switching the flow direction of the refrigerant; an outdoor heat exchanger 3 as a heat source-side heat exchanger; four check valves 5, 25, 26, and 28 that each allow the refrigerant to flow only in one direction to control the flow of the refrigerant; and an accumulator 30 in which excessive refrigerant is accumulated. Further, heat source unit 301 is provided with an outdoor fan 4 for supplying air to outdoor heat exchanger 3.

[0030] Compressor 1 suctions the refrigerant and compresses the refrigerant into a high-temperature and high-pressure state. Compressor 1 installed in the air conditioner according to the first embodiment can be changed in operation capacity and is configured, for example, of a positive displacement compressor driven by a motor (not shown) controlled by an inverter. In the first embodiment, only one compressor 1 is presented as an example, but the present disclosure is not limited thereto, and two or more compressors 1 may be connected in parallel depending on the number of connected indoor units.

[0031] Four-way valve 2 serves as a flow-path switching device that switches the flow direction of the refrigerant according to the operation mode of heat source unit 301. In the full-cooling operation mode or the cooling-dominated operation mode, four-way valve 2 connects the discharge side of compressor 1 to the gas side of outdoor heat exchanger 3 and also connects the suction side of compressor 1 to the low-pressure connection pipe 24 side via check valve 25 in order to allow outdoor heat exchanger 3 to function as a condenser for the refrigerant that is to be compressed in compressor 1. In this case, a flow path is formed as indicated by a solid line in four-way valve 2.

[0032] Further, in the full-heating operation mode or the heating-dominated operation mode, four-way valve 2 connects the discharge side of compressor 1 to the high-pressure connection pipe 6 side via check valve 26 and also connects the suction side of compressor 1 to the gas side of outdoor heat exchanger 3 in order to allow outdoor heat exchanger 3 to function as an evaporator for refrigerant. In this case, a flow path is formed as indicated by a dashed line in four-way valve 2.

[0033] Check valve 5 is provided between a connection portion "a" at which high-pressure connection pipe 6 is connected to connection pipe 27 and a connection portion "b" at which high-pressure connection pipe 6 is connected to connection pipe 29, and allows the refrigerant to flow only in a direction from heat source unit 301 toward branch unit 302.

[0034] Check valve 25 is provided between a connection portion "c" at which low-pressure connection pipe 24 is connected to connection pipe 27 and a connection portion "d" at which low-pressure connection pipe 24 is connected to connection pipe 29, and allows the refrigerant to flow only in a direction from branch unit 302 toward heat source unit 301.

[0035] Check valve 26 is provided in connection pipe 27 and allows the refrigerant to flow only in a direction from heat source unit 301 toward branch unit 302.

[0036] Check valve 28 is provided in connection pipe 29 and allows the refrigerant to flow only in a direction from branch unit 302 toward heat source unit 301.

[0037] Four check valves 5, 25, 26, and 28 disposed in this manner allow the refrigerant to flow only in the direction from heat source unit 301 toward branch unit 302 through high-pressure connection pipe 6, and also allow the refrigerant to flow only in the direction from branch unit 302 toward heat source unit 301 through low-pressure connection pipe 24. By the configuration as described above, the flow direction of the refrigerant at the time when four-way valve 2 is switched is determined.

[0038] Outdoor heat exchanger 3 can be configured, for example, of a cross-fin type fin-and-tube type heat exchanger formed of a heat transfer tube and a plurality of fins. Further, outdoor heat exchanger 3 may be configured of a micro-channel heat exchanger, a shell-and-tube type heat exchanger, a heat-pipe type heat exchanger, or a double-pipe type heat exchanger. In the full-cooling operation mode and the cooling-dominated operation mode, outdoor heat exchanger 3 functions as a condenser for refrigerant and the refrigerant dissipates heat. In the full-heating operation mode and the heating-dominated operation mode, outdoor heat exchanger 3 functions as an evaporator for refrigerant and the refrigerant absorbs heat. Outdoor heat exchanger 3 has a gas side connected to four-way valve 2, and a liquid side connected to check valves 5 and 28.

[0039] Outdoor fan 4 has a function of suctioning outdoor air into heat source unit 301 to cause the outdoor air to exchange heat by outdoor heat exchanger 3, and then discharging the resultant air to the outdoors. Heat source unit 301 exchanges heat between outdoor air taken in by outdoor fan 4 and the refrigerant flowing through outdoor heat exchanger 3.

[0040] Outdoor fan 4 is capable of changing the flow rate of the air to be supplied to outdoor heat exchanger 3, and includes a fan such as a propeller fan, and a motor including, for example, a DC fan motor for driving the fan.

[0041] Accumulator 30 is connected to the suction side of compressor 1 in order to accumulate liquid refrigerant to prevent liquid from flowing back to compressor 1 when an abnormality occurs in refrigeration cycle apparatus 300 or in the transient response of the operation state that occurs when the operation control is changed.

[0042] The operations of compressor 1, four-way valve 2, and outdoor fan 4 are controlled by a controller 100 functioning as a normal operation controller that performs a normal operation, including operations in a full-cooling operation mode, a cooling-dominated operation mode, a full-heating operation mode, and a heating-dominated operation mode.

[0043] Controller 100 is configured to include a central processing unit (CPU) 101, a memory 102 (a read only memory (ROM) and a random access memory (RAM)), an input/output buffer (not shown), and the like. CPU 101 deploys a program stored in the ROM into the RAM or the like and executes the program. The programs stored in the ROM describe the processing procedure for controller 100. Controller 100 controls each of devices in refrigeration cycle apparatus 300 according to these programs. Such control is not necessarily processed by software, but can also be processed by dedicated hardware (an electronic circuit).

<Branch Unit 302>

[0044] Branch unit 302 is, for example, installed indoors, connected to heat source unit 301 through low-pressure connection pipe 24 and high-pressure connection pipe 6, connected to indoor unit 303 through pipes 11 and 15, and constitutes a part of the refrigerant circuit in refrigeration cycle apparatus 300. Branch unit 302 is interposed between heat source unit 301 and each indoor unit 303, and has a function of controlling the flow of the refrigerant in accordance with the operation requested for each indoor unit 303.

[0045] Branch unit 302 includes a branch refrigerant circuit that constitutes a part of the refrigerant circuit. The branch refrigerant circuit includes: heat exchange units 19 and 21 for exchanging heat of the refrigerant; expansion valves 20 and 22 for controlling the distribution flow rate of the refrigerant; a low-pressure pipe L; a high-pressure pipe H; a middle pressure junction pipe MJ; a middle pressure branched pipe MB; and six-way valves 10a and 10b.

[0046] The refrigerant supplied from high-pressure connection pipe 6 flows through expansion valves 20 and 22 into the low-pressure connection pipe, and is distributed to high-pressure pipe H and middle pressure branched pipe MB by adjusting the degree of opening of expansion valves 20 and 22.

[0047] Fig. 2 is a diagram representatively showing one indoor unit and one six-way valve (of a rotary type) corresponding thereto. Fig. 3 is a diagram showing the state of the six-way valve (of a rotary type) when the indoor unit performs a heating operation. Fig. 4 is a diagram showing the state of the six-way valve (of a rotary type) when the indoor unit performs a cooling operation.

[0048] In accordance with the operation requested for indoor unit 303a, six-way valve 10a connects a pipe 11a to one of low-pressure pipe L and high-pressure pipe H, and connects a pipe 15a to one of middle pressure junction pipe MJ and middle pressure branched pipe MB.

[0049] In accordance with the operation requested for indoor unit 303b, six-way valve 10b connects pipe 1 1b to one of low-pressure pipe L and high-pressure pipe H, and connects pipe 15b to one of middle pressure junction pipe MJ and middle pressure branched pipe MB.

[0050] In the following description, indoor units 303a and 303b may be collectively referred to as an indoor unit 303, six-way valves 10a and 10b may be collectively referred to as a six-way valve 10, pipes 11a and 11b may be collectively referred to as a pipe 11, and pipes 15a and 15b may be collectively referred to as a pipe 15.

[0051] When the heating operation is requested for the corresponding indoor unit 303, six-way valve 10 is set as shown in Fig. 3. Six-way valve 10 includes a housing 41 and a valve body 42. Valve body 42 is provided with a first flow path C1 and a second flow path C2. By controlling the rotational position of valve body 42 as shown in Fig. 3, a heating flow path is formed in six-way valve 10. In this case, port P2 communicates with port P3 through first flow path C1, port P5 communicates with port P6 through second flow path C2, and ports P1 and P4 are closed by valve body 42. Thus, via six-way valve 10, pipe 11 is connected to high-pressure pipe H and pipe 15 is connected to middle pressure junction pipe MJ. Also, low-pressure pipe L and middle pressure branched pipe MB are blocked at their end portions by six-way valve 10. When a heating flow path is formed in six-way valve 10, flow paths are formed in six-way valve 10 as indicated by solid lines in Fig. 2.

[0052] When the cooling operation is requested for the corresponding indoor unit 303, six-way valve 10 is set as shown in Fig. 4. By controlling the rotational position of valve body 42 as shown in Fig. 4, a cooling flow path is formed in six-way valve 10. In this case, port P2 communicates with port P1 through first flow path C1, port P5 communicates with port P4 through second flow path C2, and ports P3 and P6 are closed by valve body 42. Thus, via six-way valve 10, pipe 11 is connected to low-pressure pipe L and pipe 15 is connected to middle pressure branched pipe MB. Also, high-pressure pipe H and middle pressure junction pipe MJ are blocked at their end portions by six-way valve 10. When a cooling flow path is formed in six-way valve 10, flow paths are formed in six-way valve 10 as indicated by dashed lines in Fig. 2.

[0053] Referring back to Fig. 1, the description will continue. Heat exchange unit 19 includes flow paths 31 and 32, and is configured to exchange heat between the refrigerant flowing through flow path 31 and the refrigerant flowing through flow path 32. Heat exchange unit 21 includes flow paths 33 and 34, and is configured to exchange heat between the refrigerant flowing through flow path 33 and the refrigerant flowing through flow path 34. Part of the refrigerant flowing through high-pressure pipe H passes through flow path 31 and reaches expansion valve 20. Middle pressure junction pipe MJ is connected at the downstream of expansion valve 20. Flow path 33 is connected between middle pressure junction pipe MJ and middle pressure branched pipe MB. Part of the refrigerant branched from middle pressure branched pipe MB passes through expansion valve 22, flow path 34, and flow path 32 in this order and then flows toward low-pressure pipe L.

[0054] Each of expansion valves 20 and 22 can be configured of a flow rate controller whose degree of opening can be variably controlled. Examples of such a flow rate controller can be a precise flow rate controller such as an electronic expansion valve or an inexpensive refrigerant flow rate regulator such as a capillary tube in place of an expansion valve.

<Full-Cooling Operation Mode>

[0055] First, a full-cooling operation mode will be described. The full-cooling operation mode is an operation mode of the refrigeration cycle apparatus executed when all the indoor units to be operated are in the cooling operation state while there is no indoor unit operating in the heating operation state.

[0056] In the full-cooling operation mode, four-way valve 2 is in the state indicated by a solid line, i.e., the state in which the discharge side of compressor 1 is connected to the gas side of outdoor heat exchanger 3 and the suction side of compressor 1 is connected to low-pressure connection pipe 24 via check valve 25. Further, all of indoor units 303 are in the cooling operation mode, in which six-way valves 10a and 10b each are controlled to form a cooling flow path.

[0057] When compressor 1, outdoor fan 4, and an indoor fan 13 are started to operate in the above-described state of the refrigerant circuit, the low-pressure gas refrigerant is suctioned into compressor 1 and compressed into high-temperature and high-pressure gas refrigerant. Then, the high-temperature and high-pressure gas refrigerant is sent to outdoor heat exchanger 3 via four-way valve 2, exchanges heat with the outdoor air supplied by outdoor fan 4, and is condensed into high-pressure liquid refrigerant.

[0058] The high-pressure liquid refrigerant passes via check valve 5, flows through high-pressure connection pipe 6, and is sent to high-pressure pipe H of branch unit 302. Then, the refrigerant flows into flow path 31 on the high-pressure side of heat exchange unit 19. The refrigerant having flowed into flow path 31 releases heat to the refrigerant flowing through flow path 32 on the low-pressure side of heat exchange unit 19. The refrigerant flows out of flow path 31 and then flows into expansion valve 20 whose degree of opening is fully opened. The refrigerant having passed through expansion valve 20 then flows into flow path 33 on the high-pressure side of heat exchange unit 21, and releases heat to the refrigerant flowing through flow path 34 on the low-pressure side of heat exchange unit 21. Then, the refrigerant is divided into refrigerant flowing via expansion valve 22 and refrigerant passing via six-way valves 10a and 10b and flowing through pipes 15a and 15b, respectively.

[0059] The refrigerant having flowed into expansion valve 22 is decompressed into a low-pressure gas-liquid two-phase state, flows into flow path 34 on the low-pressure side of heat exchange unit 21, and is then heated by the refrigerant flowing through flow path 33 on the high-pressure side of heat exchange unit 21. Then, the refrigerant flows out of flow path 34 on the low-pressure side of heat exchange unit 21, flows into flow path 32 on the low-pressure side of heat exchange unit 19, and is then heated by the refrigerant flowing through flow path 31 on the high-pressure side of heat exchange unit 19. The refrigerant thereafter flows through a bypass connection pipe 23 into low-pressure connection pipe 24.

[0060] Expansion valve 22 is controlled by controller 100 to be set at a degree of opening such that the degree of superheat at the downstream of flow path 32 on the low-pressure side of heat exchange unit 19 reaches a reference value. Thereby, the low-pressure gas refrigerant evaporated at the downstream of flow path 32 on the low-pressure side of heat exchange unit 19 has a degree of superheat having a reference value. In this way, expansion valve 22 is controlled such that the refrigerant flows through each of indoor units 303a and 303b at a flow rate corresponding to the cooling load requested in each air-conditioned space.

[0061] On the other hand, the refrigerant flowing from middle pressure branched pipe MB via six-way valve 10 through pipe 15 flows into indoor unit 303. Then, the refrigerant is decompressed by an indoor decompressing mechanism 14 into a low-pressure gas-liquid two-phase state, and then flows into an indoor heat exchanger 12. Then, the refrigerant exchanges heat with the indoor air supplied by the indoor fan and is evaporated into low-pressure gas refrigerant.

[0062] In indoor decompressing mechanism 14, the flow rate of the refrigerant flowing through indoor heat exchanger 12 is controlled, so that the refrigerant flows through indoor heat exchanger 12 at a flow rate corresponding to the cooling load requested in the air-conditioned space in which indoor unit 303 is installed.

[0063] The low-pressure gas refrigerant having cooled the indoor air in indoor heat exchanger 12 flows out of indoor heat exchanger 12, flows through pipe 11, and then flows out of indoor unit 303. The refrigerant then flows into low-pressure connection pipe 24 through first flow path C1 of six-way valve 10, and merges with the refrigerant that has flowed through bypass connection pipe 23 after having passed through expansion valve 22.

[0064] The merged refrigerant flows into heat source unit 301, passes through check valve 25 and further through four-way valve 2 and accumulator 30, and is then suctioned again into compressor 1.

[0065] In the full-cooling operation mode, all of indoor units 303 are in the cooling operation in which no heating load exists and only a cooling load exists. Thus, an evaporation temperature Te is controlled by the operating frequency of compressor 1 to control the cooling capability of indoor unit 303 that is performing the cooling operation at the maximum temperature difference. Further, the air volume of outdoor fan 4 is maximized to thereby maximize the performance of outdoor heat exchanger 3. When a large number of indoor units 303 are connected, in indoor unit 303 in which the temperature difference is not the maximum, the degree of opening of indoor decompressing mechanism 14 is controlled according to the temperature difference to thereby control the cooling capability. The degree of opening of indoor decompressing mechanism 14 in indoor unit 303 that is performing the cooling operation at the maximum temperature difference is controlled to be large to such an extent that liquid does not flow back to compressor 1.

<Cooling-Dominated Operation Mode>

[0066] Next, the cooling-dominated operation mode will be described. The cooling-dominated operation mode is an operation mode of the refrigeration cycle apparatus in the case where the indoor units to be operated include both the indoor units each in the cooling operation state and the indoor units each in the heating operation state, and the cooling air-conditioning load is larger than the heating air-conditioning load.

[0067] In the configuration shown in Fig. 1, indoor unit 303b is in the cooling operation state and indoor unit 303a is in the heating operation state. At this time, the cooling-dominated operation mode is an operation mode in the state in which the cooling operation load is larger than the heating operation load.

[0068] In the cooling-dominated operation mode, four-way valve 2 is controlled to form flow paths indicated by solid lines in four-way valve 2 in the same manner as in the full-cooling operation mode. Further, six-way valves 10a and 10b are controlled such that a heating path is formed in six-way valve 10a and a cooling path is formed in six-way valve 10b, as indicated by solid lines in Fig. 1.

[0069] When compressor 1, outdoor fan 4, and the indoor fan (not shown) are started to operate in the above-described state of the refrigerant circuit, the low-pressure gas refrigerant is suctioned into compressor 1 and compressed into high-temperature and high-pressure gas refrigerant. Then, the high-temperature and high-pressure gas refrigerant is sent to outdoor heat exchanger 3 via four-way valve 2, exchanges heat with the outdoor air supplied by outdoor fan 4, and is condensed into high-pressure liquid refrigerant.

[0070] The high-pressure liquid refrigerant passes via check valve 5 through high-pressure connection pipe 6, flows into branch unit 302, and is then sent to high-pressure pipe H.

[0071] The gas refrigerant having flowed from high-pressure pipe H through first flow path C1 of six-way valve 10a into pipe 11a exchanges heat with the indoor air in indoor heat exchanger 12a of indoor unit 303a and is consequently condensed into high-pressure liquid refrigerant. Then, the high-pressure liquid refrigerant having heated the indoor air is decompressed by indoor decompressing mechanism 14a into intermediate-pressure refrigerant in gas-liquid two phases or in a liquid phase.

[0072] In indoor decompressing mechanism 14a, the flow rate of the refrigerant flowing through indoor heat exchanger 12a is controlled, so that the refrigerant flows through indoor heat exchanger 12a at a flow rate corresponding to the heating load requested in the air-conditioned space in which indoor unit 303a is installed. Then, the refrigerant passes through indoor decompressing mechanism 14a, flows out of indoor unit 303a, and is sent to middle pressure junction pipe MJ through second flow path C2 of six-way valve 10a.

[0073] On the other hand, part of the refrigerant having passed through high-pressure connection pipe 6 flows into flow path 31 on the high-pressure side of heat exchange unit 19, releases heat to the refrigerant flowing through flow path 32 on the low-pressure side of heat exchange unit 19, and is then decompressed by expansion valve 20 into intermediate-pressure refrigerant in gas-liquid two phases or in a liquid phase.

[0074] In this case, expansion valve 20 is controlled by controller 100 to be set at a degree of opening such that the differential pressure between the high pressure and the intermediate pressure reaches a predetermined target value. In order to detect the differential pressure, a pressure sensor may be provided in each of high-pressure pipe H and middle pressure junction pipe MJ so as to detect a pressure difference.

[0075] Since expansion valve 20 controls the flow rate of the refrigerant flowing through expansion valve 20 at the degree of opening at which the differential pressure between the high pressure side and the intermediate pressure side reaches the target value, the differential pressure between the high pressure side and the intermediate pressure side is controlled to be set at the pressure necessary for performing a heating operation. In this way, expansion valve 20 is controlled such that the refrigerant flows through indoor unit 303a at a flow rate corresponding to the heating operation load requested in the air-conditioned space.

[0076] The refrigerant having passed through expansion valve 20 flows out of indoor unit 303a, merges with the refrigerant having passed through second flow path C2 of six-way valve 10a and middle pressure junction pipe MJ, and then flows into flow path 33 on the high-pressure side of heat exchange unit 21.

[0077] The refrigerant flowing through flow path 33 on the high-pressure side of heat exchange unit 21 releases heat to the refrigerant flowing through flow path 34 on the low-pressure side, and is then divided into refrigerant flowing through expansion valve 22 and refrigerant flowing through middle pressure branched pipe MB.

[0078] The refrigerant having flowed into expansion valve 22 is decompressed into a low-pressure gas-liquid two-phase state, and flows into flow path 34 on the low-pressure side of heat exchange unit 21. The refrigerant having flowed into flow path 34 is heated by the refrigerant flowing through flow path 33 on the high-pressure side of heat exchange unit 21. Then, the refrigerant flows into flow path 32 on the low-pressure side of heat exchange unit 19, is heated by the refrigerant flowing through flow path 31 on the high-pressure side in heat exchange unit 19, and then flows into low-pressure connection pipe 24 through bypass connection pipe 23.

[0079] Note that expansion valve 22 is controlled by controller 100 to be set at a degree of opening such that the degree of superheat at the downstream on the low-pressure side of heat exchange unit 19 reaches a target value.

[0080] On the other hand, the refrigerant having flowed into second flow path C2 of six-way valve 10b flows into indoor unit 303b through pipe 15b. The refrigerant having flowed into indoor unit 303b is decompressed by indoor decompressing mechanism 14b into a low-pressure gas-liquid two-phase state and flows into indoor heat exchanger 12b. The refrigerant passing through indoor heat exchanger 12b exchanges heat with the indoor air and evaporates into low-pressure gas refrigerant.

[0081] In indoor decompressing mechanism 14b, the flow rate of the refrigerant flowing through indoor heat exchanger 12b is controlled, so that the refrigerant flows through indoor heat exchanger 12b at a flow rate corresponding to the cooling load requested in the air-conditioned space in which indoor unit 303b is installed. The refrigerant having cooled the indoor air in indoor heat exchanger 12b flows out of indoor unit 303b.

[0082] The refrigerant having flowed out of indoor unit 303b flows through pipe 1 1b and further through first flow path C 1 of six-way valve 10b into low-pressure pipe L. The refrigerant having flowed into low-pressure pipe L merges with the refrigerant having flowed into expansion valve 22 and passed through bypass connection pipe 23, and is then sent to low-pressure connection pipe 24.

[0083] The merged refrigerant then flows into heat source unit 301, passes through check valve 25 and further through four-way valve 2 and accumulator 30, and is then suctioned again into compressor 1.

[0084] In the cooling-dominated operation, a cooling load and a heating load both exist at the same time in indoor units 303, and the cooling load is larger than the heating load. Thus, evaporation temperature Te is controlled by the operating frequency of compressor 1 to control the cooling capability of indoor unit 303 that is performing the cooling operation at the maximum temperature difference. Further, a condensation temperature Tc is controlled by the air volume of outdoor fan 4 to control the heating capability of indoor unit 303 that is performing the heating operation at the maximum temperature difference. When a large number of indoor units 303 are connected, in indoor unit 303 in which the temperature difference is not the maximum, the air conditioning capability is controlled by controlling the degree of opening of indoor decompressing mechanism 14 according to the temperature difference.

[0085] The degree of opening of indoor decompressing mechanism 14 in indoor unit 303 that is performing the cooling operation at the maximum temperature difference is controlled to be large to such an extent that liquid does not flow back to compressor 1. Further, the degree of opening of indoor decompressing mechanism 14 in indoor unit 303 that is performing the heating operation at the maximum temperature difference is controlled to be large such that the performance of indoor heat exchanger 12 is maximized.

[0086] For example, in the operation state in Fig. 1, when the maximum temperature difference is 4 °C in indoor unit 303b among the indoor units that each are performing the cooling operation, compressor 1 controls the cooling capability of indoor unit 303b. When the maximum temperature difference is 2 °C in indoor unit 303a among the indoor units that each are performing the heating operation, outdoor fan 4 controls the heating capability of indoor unit 303a. When the indoor units other than indoor units 303a and 303b are connected to the branch unit, indoor decompressing mechanism 14 controls the cooling capability and the heating capability of each indoor unit in which the temperature difference is not the maximum.

<Full-Heating Operation Mode>

[0087] The full-heating operation mode will be subsequently described. The full-heating operation mode is an operation mode of the refrigeration cycle apparatus in which all of the indoor units to be operated are in the heating operation state and there is no indoor unit operating in the cooling operation state.

[0088] In the full-heating operation mode, four-way valve 2 is in the state indicated by dashed lines, i.e., the state in which the discharge side of compressor 1 is connected to high-pressure connection pipe 6 via check valve 26, and the suction side of compressor 1 is connected to the gas side of outdoor heat exchanger 3. Further, all of indoor units 303 are in the heating operation mode, and six-way valves 10a and 10b each are controlled so as to form a heating flow path.

[0089] When compressor 1, outdoor fan 4, and the indoor fan (not shown) are started to operate in the above-described state of the refrigerant circuit, the low-pressure gas refrigerant is suctioned into compressor 1 and compressed into high-temperature and high-pressure gas refrigerant. Then, the high-temperature and high-pressure gas refrigerant flows into branch unit 302 via four-way valve 2 and check valve 26. The refrigerant having flowed into branch unit 302 flows into indoor unit 303 through high-pressure pipe H and first flow path C1 of six-way valve 10.

[0090] The refrigerant having flowed into indoor unit 303 flows into indoor heat exchanger 12, exchanges heat with the indoor air, and is condensed into high-pressure liquid refrigerant, which then flows out of indoor heat exchanger 12. The refrigerant having heated the indoor air in indoor heat exchanger 12 is decompressed by indoor decompressing mechanism 14 into intermediate-pressure refrigerant in gas-liquid two phases or in a liquid phase.

[0091] The refrigerant having passed through indoor decompressing mechanism 14 flows out of indoor unit 303, and then flows into heat exchange unit 21 through second flow path C2 of six-way valve 10 and middle pressure junction pipe MJ. Note that expansion valve 20 is controlled to be fully closed.

[0092] The refrigerant having flowed into flow path 33 on the high-pressure side of heat exchange unit 21 releases heat to the refrigerant flowing through flow path 34 on the low-pressure side of heat exchange unit 21, flows into expansion valve 22, and is then decompressed into low-pressure gas-liquid two-phase refrigerant.

[0093] In this case, expansion valve 22 is controlled by controller 100 to be set at a degree of opening such that the differential pressure between the high pressure and the intermediate pressure reaches a target value. The differential pressure between the high pressure and the intermediate pressure can be detected by a pressure sensor (not shown). In this way, expansion valve 22 is controlled such that the refrigerant flows through indoor unit 303 at a flow rate corresponding to the heating operation load requested in the air-conditioned space.

[0094] The refrigerant having passed through expansion valve 22 is then heated in flow path 34 on the low-pressure side of heat exchange unit 21 by the refrigerant flowing through flow path 33 on the high-pressure side of heat exchange unit 21, further flows into flow path 32 on the low-pressure side of heat exchange unit 19, and then flows into low-pressure connection pipe 24 through bypass connection pipe 23.

[0095] Then, the refrigerant having flowed into heat source unit 301 and then flowed via check valve 28 into outdoor heat exchanger 3 exchanges heat with the outdoor air supplied by outdoor fan 4 and then evaporates into low-pressure gas refrigerant. The low-pressure gas refrigerant subsequently flows via four-way valve 2 and through accumulator 30 and is suctioned again into compressor 1.

[0096] In the full-heating operation, all of indoor units 303 are in the heating operation in which no cooling load exists and only a heating load exists. Thus, condensation temperature Tc is controlled by the operating frequency of compressor 1 to thereby control the heating capability of indoor unit 303 that is performing the heating operation at the maximum temperature difference. Further, the air volume of outdoor fan 4 is maximized to maximize the performance of outdoor heat exchanger 3. When a large number of indoor units 303 are connected, in indoor unit 303 in which the temperature difference is not the maximum, the degree of opening of indoor decompressing mechanism 14 is controlled according to the temperature difference to thereby control the heating capability. Further, the degree of opening of indoor decompressing mechanism 14 in indoor unit 303 that is performing the heating operation at the maximum temperature difference is controlled to be large such that the performance of indoor heat exchanger 12 is maximized.

<Heating-Dominated Operation Mode>

[0097] Finally, the heating-dominated operation mode will be described. The heating-dominated operation mode is an operation mode of the refrigeration cycle apparatus in the case where the indoor units to be operated include both the indoor units each in the cooling operation state and the indoor units each in the heating operation state, and the heating air-conditioning load is larger than the cooling air-conditioning load.

[0098] In the configuration shown in Fig. 1, indoor unit 303b is in the cooling operation state while indoor unit 303a is in the heating operation state. At this time, the heating-dominated operation mode is an operation mode in the state in which the heating operation load is larger than the cooling operation load.

[0099] In the heating-dominated operation mode, four-way valve 2 is controlled in the same manner as in the full-heating operation mode. Six-way valves 10a and 10b are controlled such that a heating path is formed in six-way valve 10a and a cooling path is formed in six-way valve 10b, as indicated by solid lines in Fig. 1.

[0100] When compressor 1, outdoor fan 4, and the indoor fan (not shown) are started to operate in the above-described state of the refrigerant circuit, the low-pressure gas refrigerant is suctioned into compressor 1 and compressed into high-temperature and high-pressure gas refrigerant.

[0101] The high-pressure liquid refrigerant passes via four-way valve 2 and check valve 26 and through high-pressure connection pipe 6, flows into branch unit 302, and is then sent to high-pressure pipe H.

[0102] The gas refrigerant having flowed from high-pressure pipe H through first flow path C1 of six-way valve 10a into pipe 11a exchanges heat with the indoor air in indoor heat exchanger 12a of indoor unit 303a and is consequently condensed into high-pressure liquid refrigerant. Then, the high-pressure liquid refrigerant having heated the indoor air is decompressed by indoor decompressing mechanism 14a into intermediate-pressure refrigerant in gas-liquid two phases or in a liquid phase.

[0103] The refrigerant having passed through indoor decompressing mechanism 14a flows out of indoor unit 303a, and then flows into flow path 33 on the high-pressure side of heat exchange unit 21 through pipe 15a, second flow path C2 of six-way valve 10a, and middle pressure junction pipe MJ. Note that expansion valve 20 is controlled to be fully closed.

[0104] The refrigerant having flowed into flow path 33 on the high-pressure side of heat exchange unit 21 releases heat to the refrigerant flowing through flow path 34 on the low-pressure side of heat exchange unit 21. The refrigerant having passed through flow path 33 is divided into refrigerant flowing toward expansion valve 22 and refrigerant flowing toward middle pressure branched pipe MB.

[0105] The refrigerant having been divided and flowed into expansion valve 22 is decompressed into a low-pressure gas-liquid two-phase state, and flows into flow path 34 on the low-pressure side of heat exchange unit 21. In this case, expansion valve 22 is controlled by controller 100 to be set at a degree of opening such that the differential pressure between the high pressure and the intermediate pressure reaches a target value.

[0106] The refrigerant having flowed into flow path 34 of heat exchange unit 21 is heated by the refrigerant flowing through flow path 33 on the high-pressure side of heat exchange unit 21, then flows into flow path 32 on the low-pressure side of heat exchange unit 19, and further flows into low-pressure connection pipe 24 through bypass connection pipe 23.

[0107] On the other hand, the refrigerant having been divided and flowed into middle pressure branched pipe MB flows into indoor unit 303b through second flow path C2 of six-way valve 10b and pipe 15b. The refrigerant having flowed into indoor unit 303b is first decompressed by indoor decompressing mechanism 14b into low-pressure gas-liquid two-phase state, and then flows into indoor heat exchanger 12b. The refrigerant having flowed into indoor heat exchanger 12b exchanges heat with the indoor air and evaporates into low-pressure gas refrigerant.

[0108] The low-pressure gas refrigerant having cooled the indoor air in indoor heat exchanger 12b flows out of indoor heat exchanger 12b, and then flows through pipe 11b and out of indoor unit 303b. The refrigerant having flowed out of indoor unit 303b flows through first flow path C1 of six-way valve 10b and low-pressure pipe L, then merges with the refrigerant having flowed through bypass connection pipe 23, and flows into low-pressure connection pipe 24.

[0109] The merged refrigerant flows into heat source unit 301 and flows via check valve 28 into outdoor heat exchanger 3. The refrigerant having flowed into outdoor heat exchanger 3 exchanges heat with the outdoor air supplied by outdoor fan 4, and evaporates into low-pressure gas refrigerant.

[0110] Then, the refrigerant flows through the flow path indicated by the dashed lines in four-way valve 2 and passes through accumulator 30, and is then suctioned again into compressor 1.

[0111] In the heating-dominated operation, the heating load and the cooling load both exist at the same time in indoor units 303, and the heating load is larger than the cooling load. Thus, condensation temperature Tc is controlled by the operating frequency of compressor 1 to control the heating capability of indoor unit 303 that is performing the heating operation at the maximum temperature difference. Further, evaporation temperature Te is controlled by the air volume of outdoor fan 4 to control the cooling capability of indoor unit 303 that is performing the cooling operation at the maximum temperature difference. When a large number of indoor units 303 are connected, in indoor unit 303 in which the temperature difference is not the maximum, the air conditioning capability is controlled by controlling the degree of opening of indoor decompressing mechanism 14 according to the temperature difference.

[0112] The degree of opening of indoor decompressing mechanism 14 in indoor unit 303 that is performing the cooling operation at the maximum temperature difference is controlled to be large to such an extent that liquid does not flow back to compressor 1. Further, the degree of opening of indoor decompressing mechanism 14 in indoor unit 303 that is performing the heating operation at the maximum temperature difference is controlled to be large such that the performance of indoor heat exchanger 12 is maximized.

[0113] For example, when the maximum temperature difference is 8 °C in indoor unit 303a among the indoor units that each are performing the heating operation, compressor 1 controls the heating capability of indoor unit 303a. Further, when the maximum temperature difference is 2 °C in indoor unit 303b among the indoor units that each are performing the cooling operation, outdoor fan 4 controls the cooling capability of indoor unit 303b. When a further indoor unit is connected, indoor decompressing mechanism 14 controls the cooling capability and the heating capability of the indoor unit in which the temperature difference is not the maximum.

[0114] As described above, in refrigeration cycle apparatus 300 according to the first embodiment, the cooling operation and the heating operation of the indoor unit to be operated can be individually switched by the flow path switching function of the six-way valve in any of the full-cooling operation mode, the cooling-dominated operation, the full-heating operation, and the heating-dominated operation.

(Modifications of Six-Way Valve)

[0115] In Figs. 1 to 4, the valve body of the six-way valve has a structure of a rotary-type valve body, but may have a structure of a slide-type valve body.

[0116] Fig. 5 is a diagram representatively showing one indoor unit and one six-way valve (of a slide type) corresponding thereto. Fig. 6 is a diagram showing the state of a six-way valve (of a slide type) when the indoor unit performs a heating operation. Fig. 7 is a diagram showing the state of a six-way valve (of a slide type) when the indoor unit performs a cooling operation.

[0117] In the modification shown in Fig. 5, a slide-type six-way valve 410 is used in place of rotary-type six-way valve 10 in the configuration shown in Fig. 2.

[0118] In accordance with the operation requested for indoor unit 303a, a six-way valve 410a connects pipe 11a to one of low-pressure pipe L and high-pressure pipe H, and connects pipe 15a to one of middle pressure junction pipe MJ and middle pressure branched pipe MB.

[0119] In accordance with the operation requested for indoor unit 303b, a six-way valve 410b connects pipe 1 1b to one of low-pressure pipe L and high-pressure pipe H, and connects pipe 15b to one of middle pressure junction pipe MJ and middle pressure branched pipe MB.

[0120] In the following description, indoor units 303a and 303b may be collectively referred to as an indoor unit 303, six-way valves 10a and 10b may be collectively referred to as a six-way valve 10, pipes 11a and 11b may be collectively referred to as a pipe 11, and pipes 15a and 15b may be collectively referred to as a pipe 15.

[0121] When the heating operation is requested for the corresponding indoor unit 303, six-way valve 410 is set as shown in Fig. 6. Six-way valve 410 includes a housing 411 and a valve body 412. Valve body 412 is provided with a first flow path C1 and a second flow path C2. By controlling the position along which valve body 412 slides as shown in Fig. 6, a heating flow path is formed in six-way valve 410. In this case, port P2 communicates with port P3 through first flow path C1, port P5 communicates with port P6 through second flow path C2, and ports P1 and P4 are closed by valve body 412. Thus, via six-way valve 410, pipe 11 is connected to high-pressure pipe H and pipe 15 is connected to middle pressure junction pipe MJ. Also, low-pressure pipe L and middle pressure branched pipe MB are blocked at their end portions by six-way valve 410. When a heating flow path is formed in six-way valve 410, a flow path is formed in six-way valve 410 as shown in Fig. 5.

[0122] When the cooling operation is requested for the corresponding indoor unit 303, six-way valve 410 is set as shown in Fig. 7. By controlling the position along which valve body 412 slides as shown in Fig. 7, a cooling flow path is formed in six-way valve 410. In this case, port P2 communicates with port P1 through first flow path C1, port P5 communicates with port P4 through second flow path C2, and ports P3 and P6 are closed by valve body 412. Thus, via six-way valve 410, pipe 11 is connected to low-pressure pipe L and pipe 15 is connected to middle pressure branched pipe MB. Also, high-pressure pipe H and middle pressure junction pipe MJ are blocked at their end portions by six-way valve 410.

[0123] Fig. 8 is a refrigerant circuit diagram showing a refrigerant circuit configuration of a refrigeration cycle apparatus 500 according to a comparative example. In refrigeration cycle apparatus 500, a branch unit 502 is disposed in place of branch unit 302 in the configuration of refrigeration cycle apparatus 300 shown in Fig. 1.

[0124] The refrigeration cycle apparatus of the comparative example shown in Fig. 8 is characterized in that low-pressure connection pipe 24 and high-pressure connection pipe 6 are used as a low-pressure pipe and a high-pressure pipe, respectively, by a refrigerant flow path switching mechanism formed using one four-way valve and four check valves both in the first switching state of four-way valve 2 that operates outdoor heat exchanger 3 in heat source unit 301 as a condenser and the second switching state of four-way valve 2 that operates outdoor heat exchanger 3 in heat source unit 301 as an evaporator, and also in that there is an advantage of simplified construction as compared with a system commonly used as a simultaneous cooling and heating-type air conditioning system in which an outdoor unit is connected to a branch unit through three pipes.

[0125] Note that the first switching state of four-way valve 2 corresponds to the full-cooling operation mode and the cooling-dominated operation described above, and the second switching state of four-way valve 2 corresponds to the full-heating operation and the heating-dominated operation described above.

[0126] On the other hand, each indoor unit 303 is connected to branch unit 502 through two refrigerant pipes including pipes 11 and 15.

[0127] Inside branch unit 502, pipe 11 is connected to high-pressure pipe H via a solenoid valve 511 and connected to low-pressure pipe L via a solenoid valve 512. Further, pipe 15 is connected to middle pressure junction pipe MJ via a check valve 514 and connected to middle pressure branched pipe MB via a check valve 515.

[0128] In general, solenoid valve 512 connecting pipe 11 and low-pressure pipe L is provided with a solenoid valve 513 and an orifice 501 in parallel.

[0129] Switching between the cooling operation and the heating operation in each indoor unit is done by switching the opened/closed state of each of the solenoid valve and the check valve inside the branch unit that correspond to the connection ports of each indoor unit.

[0130] During the cooling operation of indoor unit 303, solenoid valve 511 is closed and solenoid valve 512 is opened to thereby connect indoor unit 303 to low-pressure pipe L. At this time, check valve 514 is closed and check valve 515 is opened to allows refrigerant to flow therethrough, and thereby, indoor unit 303 is connected to middle pressure branched pipe MB.

[0131] During the heating operation of indoor unit 303, solenoid valve 511 is opened and solenoid valve 512 is closed to thereby connect indoor unit 303 to high-pressure pipe H. At this time, check valve 514 is opened to allow refrigerant to flow therethrough and check valve 515 is closed, and thereby, indoor unit 303 is connected to middle pressure junction pipe MJ.

[0132] In other words, when the operation of indoor unit 303 is switched from the heating operation to the cooling operation, solenoid valve 511 is switched from the opened state to the closed state and solenoid valve 512 is switched from the closed state to the opened state. In this case, when solenoid valve 512 is opened in the state in which there is a pressure difference between both ends of solenoid valve 512, the high-temperature and high-pressure refrigerant inside indoor unit 303 in the heating operation rapidly flows out toward low-pressure pipe L while it is expanding, so that a large noise of expanding refrigerant is produced.

[0133] Thus, in general, in the state in which solenoid valve 513 smaller in diameter than solenoid valve 512 is provided in parallel with solenoid valve 512, solenoid valve 513 is opened before solenoid valve 512 is opened, and then, the pressure inside the indoor heat exchanger and the pressure inside the low-pressure pipe are gradually equalized, and thereafter, solenoid valve 512 is opened to thereby suppress the noise of expanding refrigerant.

[0134] Further, when the refrigeration cycle apparatus is newly installed, disassembled for relocation, or inspected due to some abnormal conditions in the refrigeration cycle, a vacuum pump may be connected to a service port inside heat source unit 301 to recover air or refrigerant inside the refrigeration cycle apparatus.

[0135] At this time, the solenoid valve is generally closed in the non-conductive state, and if the degree of opening of indoor decompressing mechanism 14 is unknown, indoor decompressing mechanism 14 may also be in a fully closed state. In this case, even when the vacuum pump connected to heat source unit 301 is operated, air or refrigerant blocked inside indoor heat exchanger 12 may not be able to be recovered.

[0136] When the refrigerant is additionally introduced into the refrigeration cycle apparatus in the state in which air or refrigerant inside the refrigeration cycle apparatus is not completely recovered, the required performance may not be able to be exhibited since the composition or the weight of the refrigerant is different from the design values. Further, there may be a risk of causing defects in the apparatus due to entry of impurities such as water or air into the refrigerant.

[0137] Thus, in general, orifice 501 is provided in parallel with solenoid valve 512 so as to continuously ensure communication between the interior of indoor unit 303 and heat source unit 301 through low-pressure pipe L and low-pressure connection pipe 24.

[0138] On the other hand, in the comparative example in Fig. 8, orifice 501 is in communication at all times, and thus, high-temperature and high-pressure refrigerant flows out of high-pressure pipe H through orifice 501 into low-pressure pipe L during the heating operation, which may lead to a disadvantage of deteriorated heating performance.

[0139] By replacing the functions of solenoid valves 511, 512, and 513, orifice 501, and check valves 514 and 515 in the comparative example in Fig. 8 with the function of six-way valve 10 shown in Figs. 2 to 4 or six-way valve 410 shown in Figs. 5 to 7, reduction in number of components, cost reduction, and downsizing can be achieved.

[0140] In particular, in a branch unit having a large number of connection ports such as a branch unit having connection ports to which up to eight or sixteen indoor units are connected, it is effective to replace the functions of the solenoid valve, the check valve, and the orifice with the function of the six-way valve.

[0141] In addition, at the time of switching between the first switching state in which a heating flow path is formed and the second switching state in which a cooling flow path is formed, the six-way valve of a rotary type shown in Figs. 2 to 4 or of a slide type shown in Figs. 5 to 7 gradually opens or closes the refrigerant flow path as the valve body moves, and equalizes the pressure over several seconds, so that the noise of expanding refrigerant can be reduced without having to provide solenoid valves having small diameters in parallel.

[0142] Further, in the case of each of six-way valves 10 and 410, indoor unit 303 communicates with heat source unit 301 through high-pressure pipe H or low-pressure pipe L both in the first switching state and the second switching state, and therefore, no orifice is required and the heating performance is not deteriorated.

[0143] Further, the check valve may cause a risk of a noise produced by vibrations of the valve body resulting from balanced gravity, fluid force, and buoyant force, or a risk of breakage of the check valve resulting from shaving of the inner wall of the check valve. Further, the valve body resin may be shaved or may swell and thereby may be deformed to cause a closing failure in the check valve, which may also cause an operation failure of the system. In the first embodiment, failures resulting from the check valve can be overcome by replacing the function of the check valve with the function of the six-way valve.

[0144] Thus, in the first embodiment, the refrigeration cycle apparatus can be improved in quality and performance.

Second Embodiment

[0145] The second embodiment will be described with reference to Figs. 9 to 12. Fig. 9 is a diagram showing the state in which an indoor unit of a six-way valve (of a rotary type) used in the second embodiment performs a heating operation. Fig. 10 is a diagram showing the state in which the indoor unit of the six-way valve (of a rotary type) used in the second embodiment performs a cooling operation. A six-way valve 450 includes a housing 451 and a valve body 452. Fig. 11 is a diagram showing the state in which an indoor unit of a six-way valve (of a slide type) used in the second embodiment performs a heating operation. Fig. 12 is a diagram showing the state in which the indoor unit of the six-way valve (of a slide type) used in the second embodiment performs a cooling operation. A six-way valve 460 includes a housing 461 and a valve body 462.

[0146] In the first switching state in which a heating flow path is formed and the second switching state in which a cooling flow path is formed, vapor refrigerant flows through first flow path C 1 in communication with pipe 11 during both the cooling operation and the heating operation of indoor unit 303. Both in the first switching state and the second switching state, the liquid refrigerant flows through second flow path C2 in communication with pipe 15 during the cooling operation of indoor unit 303, and the gas-liquid two-phase refrigerant flows through this second flow path C2 during the heating operation of indoor unit 303.

[0147] As compared with the liquid refrigerant or the gas-liquid two-phase refrigerant, the vapor refrigerant is relatively low in density and relatively high in flow velocity. Thus, the flow path is designed to have a relatively large cross-sectional area to thereby reduce the flow velocity of the refrigerant, so that the pressure loss and the performance deterioration in the six-way valve can be reduced.

[0148] In particular, in the case where the installation constraints inside the branch unit impose design constraints upon the outer dimensions of the six-way valve or the valve body thereof, first flow path C1 is designed to be larger in flow path cross-sectional area than second flow path C2, which makes it possible to minimize the performance deterioration resulting from the dimensions of two flow paths inside the six-way valve.

[0149] Further, as shown in Figs. 9 to 12, the minimum dimension among the inner diameters of high-pressure pipe H, low-pressure pipe L, and pipe 11 is designed to be larger than the maximum dimension among the inner diameters of middle pressure junction pipe MJ, middle pressure branched pipe MB, and pipe 15 in accordance with the dimensions of first flow path C 1 and the dimensions of second flow path C2, and thereby, the pipes connected to the six-way valve can be downsized and reduced in cost.

Third Embodiment

[0150] The second embodiment will be described with reference to Figs. 13 to 15. Fig. 13 is a diagram showing the state in which an indoor unit of a six-way valve (of a slide type) used in the third embodiment performs a heating operation. Fig. 14 is a diagram showing the state at some midpoint of switching the operation of the six-way valve (of a slide type) used in the third embodiment. Fig. 15 is a diagram showing the state in which the indoor unit of the six-way valve (of a slide type) used in the third embodiment performs a cooling operation. A six-way valve 470 includes a housing 471 and a valve body 472.

[0151] As shown in Figs. 13 to 15, first flow path C1 inside six-way valve 470 is formed such that first flow path C1 communicates with at least one of high-pressure pipe H and low-pressure pipe L at an arbitrary position of valve body 472 between the first switching state in which a heating flow path is formed in six-way valve 470 and the second switching state in which a cooling flow path is formed in six-way valve 470. Thereby, even if the valve body stops operating at an arbitrary position at some midpoint of switching due to power loss at some midpoint of switching of the six-way valve, due to insufficient differential pressure for switching operation, or due to increased frictional resistance in switching, the interior of the indoor unit communicates with at least one of high-pressure pipe H or low-pressure pipe L, and thereby, the refrigerant inside indoor heat exchanger 12 can be recovered using the vacuum pump connected to the heat source unit.

[0152] Although Figs. 13 to 15 each show an example of a slide-type six-way valve, even in the case of a rotary-type six-way valve, forming a similar first flow path C 1 in its valve body allows the similar effect to be achieved. Fig. 16 is a diagram showing the state at some midpoint of switching an operation of a six-way valve (of a rotary type) used in the third embodiment. As shown in Fig. 16, even in the case of a rotary-type six-way valve, forming a similar first flow path C1 in its valve body allows the interior of indoor heat exchanger 12 to communicate with at least one of high-pressure pipe H or low-pressure pipe L.

Fourth Embodiment

[0153] When a plurality of six-way valves are simultaneously switched in the state in which pipe 11 communicates with both high-pressure pipe H and low-pressure pipe L at a certain valve body position between the first switching state and the second switching state of the six-way valve, high-pressure pipe H and low-pressure pipe L are short-circuited through first flow path C1 inside the six-way valve. Accordingly, in the case of a differential pressure-operated type valve, the differential pressure required for valve switching cannot be maintained, so that the valve body may remain stopped at some midpoint during switching and may not be able to be restored.

[0154] Further, when a plurality of six-way valves are simultaneously switched in the state in which pipe 11 does not communicate with both high-pressure pipe H and low-pressure pipe L at a certain valve body position between the first switching state and the second switching state of the six-way valve, the refrigerant discharged from compressor 1 is less likely to return to the suction side of compressor 1, and thus, the air conditioning system may abnormally stop due to excessive pressure rise, low pressure fall, or the like.

[0155] The fourth embodiment is characterized in that the plurality of six-way valves are switched one by one when these six-way valves are switched in accordance with the state of the cooling/heating operation of the indoor unit. The above-described problems can be prevented by switching the plurality of six-way valves one by one without simultaneously switching these six-way valves.

[0156] For example, after the completion of switching of one six-way valve is detected according to the value of a pressure sensor or a temperature sensor that is separately installed, switching of the next six-way valve is started. Alternatively, after an instruction to switch the six-way valve is given, switching of the next six-way valve is started after an elapse of a pre-estimated required switching time period (for example, 5 seconds) or more.

[0157] Fig. 17 is a diagram showing configurations of a branch unit, an indoor unit, and a controller for illustrating six-way valve control according to the fourth embodiment.

[0158] Indoor unit 303a further includes a controller 110a. Indoor unit 303b further includes a controller 110b. Branch unit 302 further includes sensors 120a and 120b.

[0159] Six-way valves 10a and 10b are controlled by controller 100. Controller 100 controls six-way valves 10a and 10b based on signals from controller 1 10a, sensor 120a, controller 110b and sensor 120b.

[0160] Since other configurations of branch unit 302 and indoor units 303a and 303b are the same as those in Fig. 1, the description thereof will not be repeated.

[0161] Fig. 18 is a flowchart for illustrating six-way valve switching control executed by controller 100. Controller 100 stores a switching permission flag indicating whether or not to permit switching of the six-way valve, and includes a switching waiting counter for counting the number of six-way valves that are waiting for being switched.

[0162] In step S1, controller 100 initializes the switching permission flag to "permitted" and initializes the switching waiting counter to zero.

[0163] Then, controller 100 determines whether or not a switching request signal for requesting switching of the corresponding six-way valve has been received from one of controller 110a of indoor unit 303a and controller 110b of indoor unit 303b. When the switching request signal has been received (YES in S2), controller 100 adds 1 to the count value of the switching waiting counter in step S3, and advances the process to step S4. On the other hand, when the switching request signal has not been received (NO in S2), the process proceeds to step S4 without performing the process in step S3.

[0164] In step S4, controller 100 determines whether or not the count value of the switching waiting counter is "equal to or greater than 1" and whether or not the switching permission flag indicates "permitted". When the count value of the switching waiting counter is "equal to or greater than 1" and the switching permission flag indicates "permitted" (YES in S4), then in step S5, controller 100 transmits a switching signal to the next waiting six-way valve, starts switching of the six-way valve, changes the switching permission flag to "not permitted", and then advances the process to step S6.

[0165] On the other hand, when the switching permission flag indicates "not permitted" (NO in S4), switching of the six-way valve is already being performed, and therefore, completion of the switching needs to be waited. Thus, the process proceeds to step S6 without performing the process in step S5.

[0166] Controller 100 subsequently determines by the processes in steps S6 and S7 whether or not the state of the six-way valve that is being switched has been stabilized. First, in step S6, it is determined whether or not the temperature value or the pressure value measured by a sensor 120 corresponding to the six-way valve that is being switched has reached a value falling within a prescribed range corresponding to completion of the switching. In step S7, it is determined whether or not a prescribed time period has elapsed since the switching signal was transmitted to the six-way valve.

[0167] When one of the conditions in steps S6 and S7 is satisfied, it is determined that switching of the six-way valve has completed. Then, in step S8, controller 100 changes the switching permission flag from "not permitted" to "permitted" and subtracts 1 from the count value of the switching waiting counter.

[0168] Between the processes in steps S5 and S8, the order of executing the process may be changed by replacing step S6 with step S7, or only one of steps S6 and S7 may be performed.

[0169] Subsequent to step S8, in step S9, controller 100 determines whether or not the count value of the switching waiting counter is zero. When the count value is not zero (NO in S9), there still remains a six-way valve to be switched, and thus, the processes in step S2 and subsequent steps are repeated. When the count value is zero (YES in S9), there remains no six-way valve to be switched, and thus, the process in this flowchart ends.

[0170] By the control executed as described above, in the present embodiment, the plurality of six-way valves are switched one by one when these six-way valves are switched. This makes it possible to prevent the plurality of six-way valves from being simultaneously switched and also prevent a problem, for example, that the valve body remains stopped at some midpoint during switching and cannot be restored.

(Summary)

[0171] The following summarizes the present embodiment again with reference to the accompanying drawings.

[0172] The present disclosure relates to a refrigeration cycle apparatus. A refrigeration cycle apparatus 300 shown in Fig. 1 includes: a heat source unit 301 including a compressor 1 and an outdoor heat exchanger 3; a plurality of indoor units 303a and 303b; and a branch unit 302 connected between heat source unit 301 and the plurality of indoor units 303a and 303b, the branch unit 302 being configured to transfer refrigerant. Branch unit 302 has: a first pipe (a high-pressure pipe H) through which the refrigerant delivered from heat source unit 301 passes; a second pipe (a low-pressure pipe L) through which the refrigerant returning to the heat source unit passes; a third pipe (a middle pressure junction pipe MJ); a fourth pipe (middle pressure branched pipe) MB; a first expansion valve 20 provided between the first pipe and the third pipe; a second expansion valve 22 provided between the fourth pipe and the second pipe; and a plurality of six-way valves 10a and 10b, each of the plurality of six-way valves 10a and 10b being provided for a corresponding one of the plurality of indoor units 303a and 303b. As shown in Figs. 2 to 4, each of the plurality of six-way valves 10a and 10b has: a first port P1 connected to the second pipe; a second port P2 connected to one end of the refrigerant flow path of the corresponding one of the plurality of indoor units; a third port P3 connected to the first pipe; a fourth port P4 connected to the fourth pipe; a fifth port P5 connected to the other end of the refrigerant flow path of the corresponding one of the plurality of indoor units; a sixth port P6 connected to the third pipe; a housing 41 having the first port to the sixth port; and a valve body 42 disposed inside the housing, valve body 42 being provided with a first flow path C1 and a second flow path C2. Valve body 42 is configured to switch a communication state of each of the plurality of six-way valves 10a and 10b between a first switching state shown in Fig. 3 and a second switching state shown in Fig. 4. In the second switching state, first port P1 communicates with second port P2 through first flow path C1, and fourth port P4 communicates with fifth port P5 through second flow path C2. At this time, third port P3 and sixth port P6 are closed. In the first switching state, second port P2 communicates with third port P3 through first flow path C1, and fifth port P5 communicates with sixth port P6 through second flow path C2. At this time, first port P1 and fourth port P4 are closed.

[0173] Preferably, as shown in Figs. 9 to 12, a cross-sectional area of first flow path C1 is equal to or greater than a cross-sectional area of second flow path C2.

[0174] Preferably, as shown in Figs. 9 to 12, a minimum dimension of inner diameters of three pipes (a low-pressure pipe L, a pipe 1 1a (or 1 1b), and a high-pressure pipe H) each connected to a corresponding one of first port P1 to third port P3 of each of six-way valves 450a, 450b, 460a, and 460b is equal to or greater than a maximum dimension of inner diameters of three pipes (a middle pressure branched pipe MB, a pipe 15a (or 15b), and a middle pressure junction pipe MJ) each connected to a corresponding one of fourth port P4 to sixth port P6 of each of six-way valves 450a, 450b, 460a, and 460b.

[0175] Preferably, as shown in Figs. 13 to 15, valve body 472 is configured to slide inside housing 471 to switch the communication state of each of six-way valves 470a and 470b between the first switching state and the second switching state. As shown in Fig. 16, valve body 452 is configured to rotate inside housing 451 to switch the communication state of each of six-way valves 450a and 450b between the first switching state and the second switching state. As shown in Figs. 14 and 16, first flow path C1 is formed such that second port P2 communicates with at least one of first port P1 or third port P3 at an arbitrary position between a position in the first switching state and a position in the second switching state.

[0176] Preferably, as shown in Fig. 17, the refrigeration cycle apparatus further includes a controller 100 configured to perform control to switch the plurality of six-way valves. When controller 100 collectively switches communication states of a first six-way valve 10a and a second six-way valve 10b among the plurality of six-way valves, controller 100 is configured to start switching of first six-way valve 10a, and, after completion of the switching of first six-way valve 10a, start switching of second six-way valve 10b, as shown in S5 of Fig. 18.

[0177] More preferably, as shown in Fig. 17, the refrigeration cycle apparatus further includes a sensor 120a configured to detect a switching state of first six-way valve 10a. As shown in S6 in Fig. 18, controller 100 is configured to determine completion of the switching of first six-way valve 10a based on an output from sensor 120a. Sensor 120a may be a pressure sensor or a temperature sensor.

[0178] More preferably, when controller 100 collectively switches the communication states of first six-way valve 10a and second six-way valve 10b among the plurality of six-way valves, controller 100 is configured to start switching of the first six-way valve, and, after an elapse of a predetermined time period or longer, start switching of second six-way valve 10b as shown in S7 in Fig. 18.

[0179] It should be understood that the embodiments disclosed herein are illustrative and non-restrictive in every respect. The scope of the present disclosure is defined by the terms of the claims, rather than the description of the aforementioned embodiments, and is intended to include any modifications within the meaning and scope equivalent to the terms of the claims.

REFERENCE SIGNS LIST

[0180] 1 compressor, 2 four-way valve, 3, 12, 12a, 12b heat exchanger, 4 outdoor fan, 5, 25, 26, 28, 514, 515 check valve, 6 high-pressure connection pipe, 10, 10a, 10b, 410, 410a, 410b, 470 six-way valve, 11, 11a, 11b, 15, 15a, 15b pipe, 13 indoor fan, 14, 14a, 14b indoor decompressing mechanism, 19, 21 heat exchange unit, 20, 22 expansion valve, 23 bypass connection pipe, 24 low-pressure connection pipe, 27, 29 connection pipe, 30 accumulator, 31 to 34, C1, C2 flow path, 41, 411, 451, 461, 471 housing, 42, 412, 452, 462, 472 valve body, 100, 110a, 110b controller, 101 CPU, 102 memory, 120, 120a, 120b sensor, 300, 500 refrigeration cycle apparatus, 301 heat source unit, 302, 502 branch unit, 303, 303a, 303b indoor unit, 501 orifice, 511, 512, 513 solenoid valve, H high-pressure pipe, L low-pressure pipe, MJ middle pressure junction pipe, MB middle pressure branched pipe, P1 to P6 port.

Claims

1. A refrigeration cycle apparatus comprising:

a heat source unit comprising a compressor and an outdoor heat exchanger;
a plurality of indoor units; and
a branch unit connected between the heat source unit and the plurality of indoor units, the branch unit being configured to transfer refrigerant, wherein
the branch unit has

a first pipe through which the refrigerant delivered from the heat source unit passes,
a second pipe through which the refrigerant returning to the heat source unit passes,
a third pipe,
a fourth pipe,
a first expansion valve provided between the first pipe and the third pipe,
a second expansion valve provided between the fourth pipe and the second pipe, and
a plurality of six-way valves, each of the plurality of six-way valves being provided for a corresponding one of the plurality of indoor units,
each of the plurality of six-way valves has

a first port connected to the second

pipe,

a second port connected to one end of a refrigerant flow path of the corresponding one of the plurality of indoor units,

a third port connected to the first pipe,

a fourth port connected to the fourth pipe,

a fifth port connected to the other end of the refrigerant flow path of the corresponding one of the plurality of indoor units,

a sixth port connected to the third pipe,

a housing having the first port to the sixth port, and

a valve body disposed inside the housing, the valve body being provided with a first flow path and a second flow path,

the valve body is configured to switch a communication state of each of the plurality of six-way valves between a first switching state and a second switching state,

in the second switching state, the first port communicates with the second port through the first flow path, and the fourth port communicates with the fifth port through the second flow path, and

in the first switching state, the second port communicates with the third port through the first flow path, and the fifth port communicates with the sixth port through the second flow path.

2. The refrigeration cycle apparatus according to claim 1, wherein a cross-sectional area of the first flow path is equal to or greater than a cross-sectional area of the second flow path.

3. The refrigeration cycle apparatus according to claim 1, wherein a minimum dimension of inner diameters of three pipes each connected to a corresponding one of the first port to the third port of each of the plurality of six-way valves is equal to or greater than a maximum dimension of inner diameters of three pipes each connected to a corresponding one of the fourth port to the sixth port of each of the plurality of six-way valves.

4. The refrigeration cycle apparatus according to claim 1, wherein

the valve body is configured to rotate or slide inside the housing to switch the communication state of each of the plurality of six-way valves between the first switching state and the second switching state, and

the first flow path is formed such that the second port communicates with at least one of the first port or the third port at an arbitrary position between a position in the first switching state and a position in the second switching state.

5. The refrigeration cycle apparatus according to claim 1, further comprising a controller configured to perform control to switch the plurality of six-way valves, wherein

when the controller switches communication states of a first six-way valve and a second six-way valve among the plurality of six-way valves, the controller is configured to start switching of the first six-way valve, and, after completion of the switching of the first six-way valve, start switching of the second six-way valve.

6. The refrigeration cycle apparatus according to claim 5, further comprising a sensor configured to detect a switching state of the first six-way valve, wherein the controller is configured to determine completion of the switching of the first six-way valve based on an output from the sensor.

7. The refrigeration cycle apparatus according to claim 5, wherein, when the controller collectively switches the communication states of the first six-way valve and the second six-way valve, the controller is configured to start switching of the first six-way valve, and, after an elapse of a predetermined time period or longer, start switching of the second six-way valve.

FIG.1

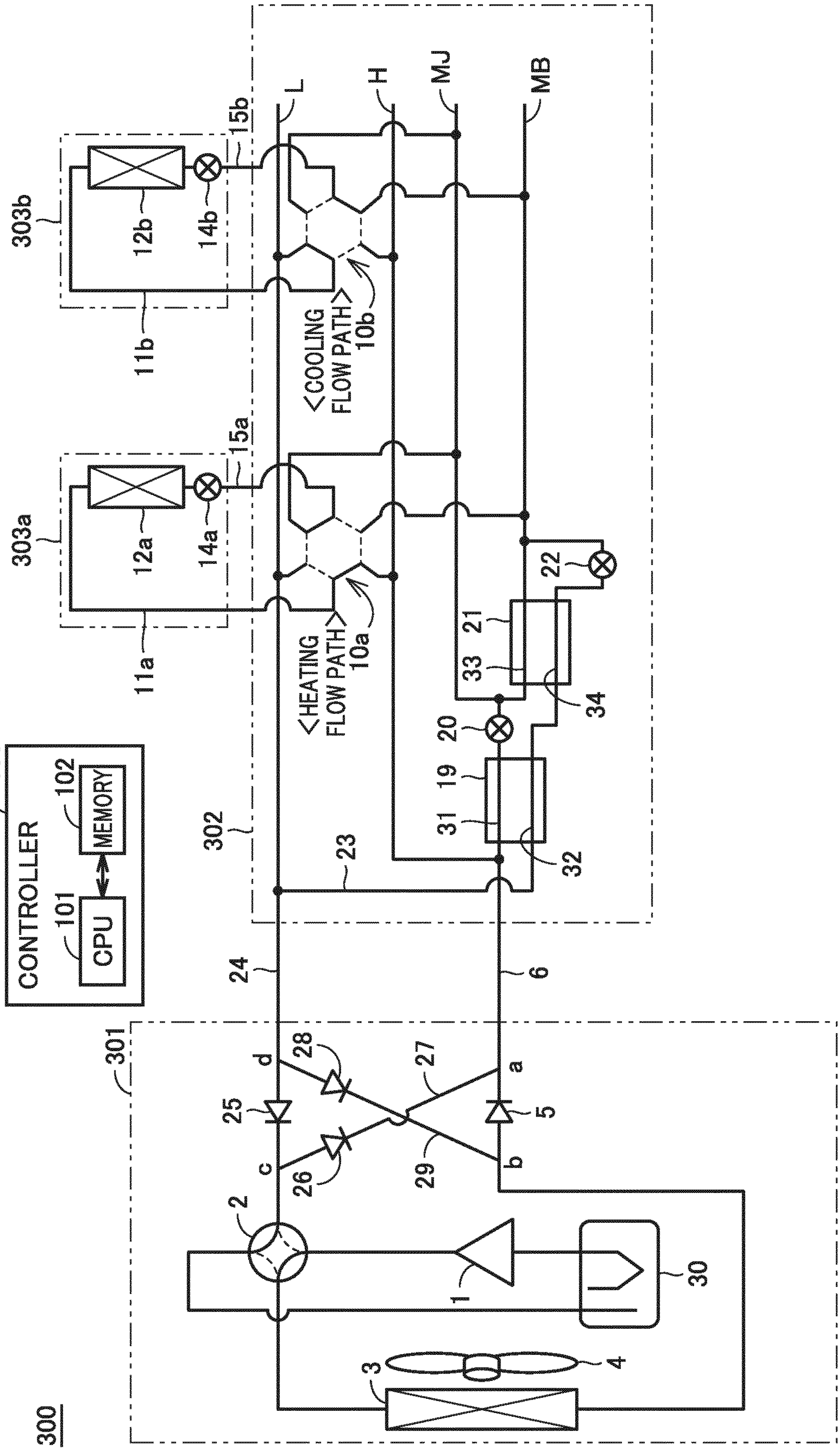

300
301
302
303a
303b
CONTROLLER
CPU
MEMORY
100
101
102
<HEATING FLOW PATH>
<COOLING FLOW PATH>
10a
10b
11a
11b
12a
12b
14a
14b
15a
15b
L
H
MJ
MB
1
2
3
4
5
6
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
a
b
c
d

FIG.2

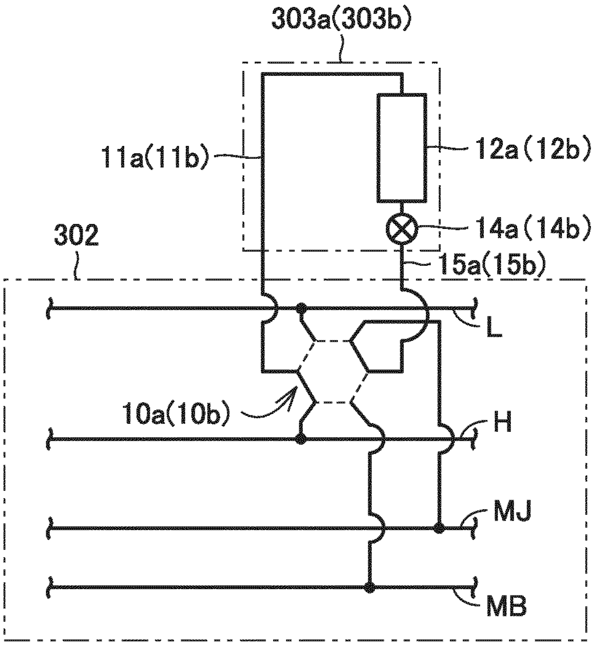


FIG.3

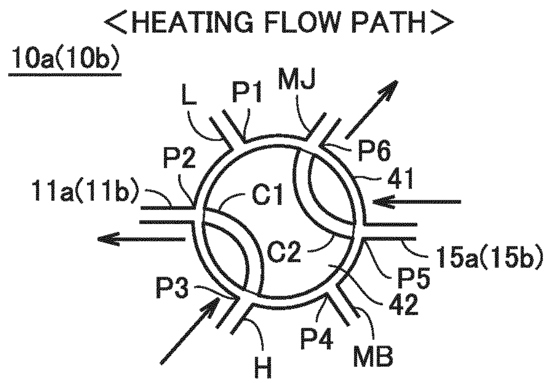


FIG.4

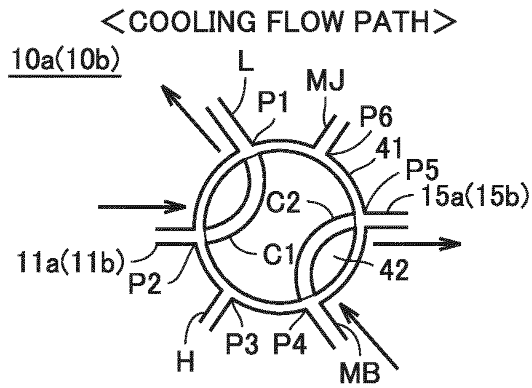


FIG.5

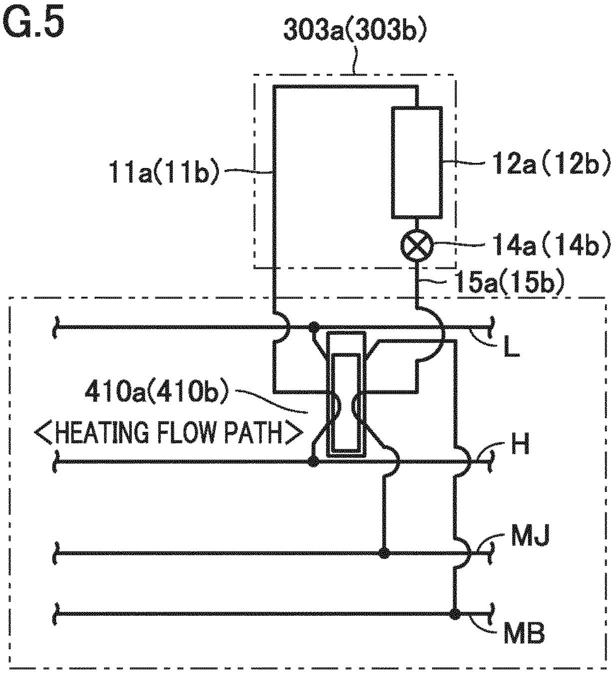


FIG.6

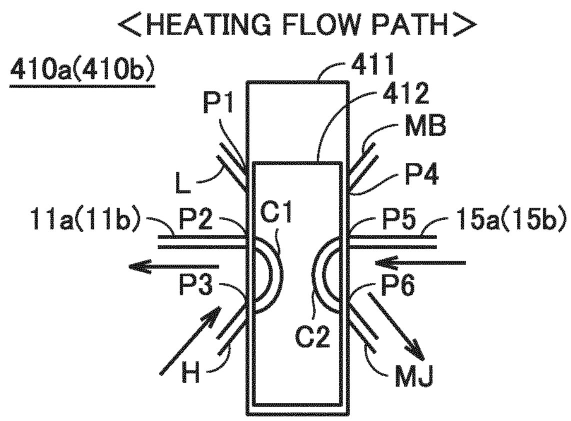


FIG.7

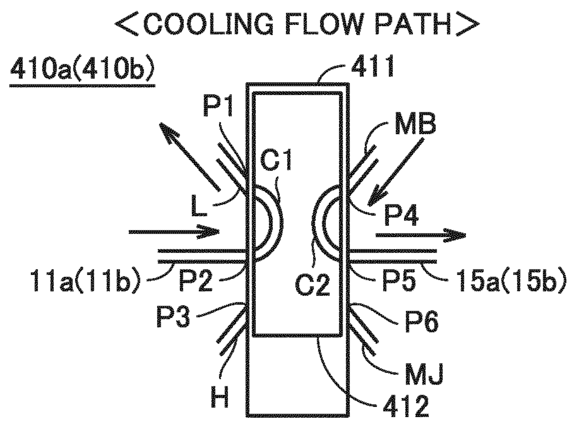
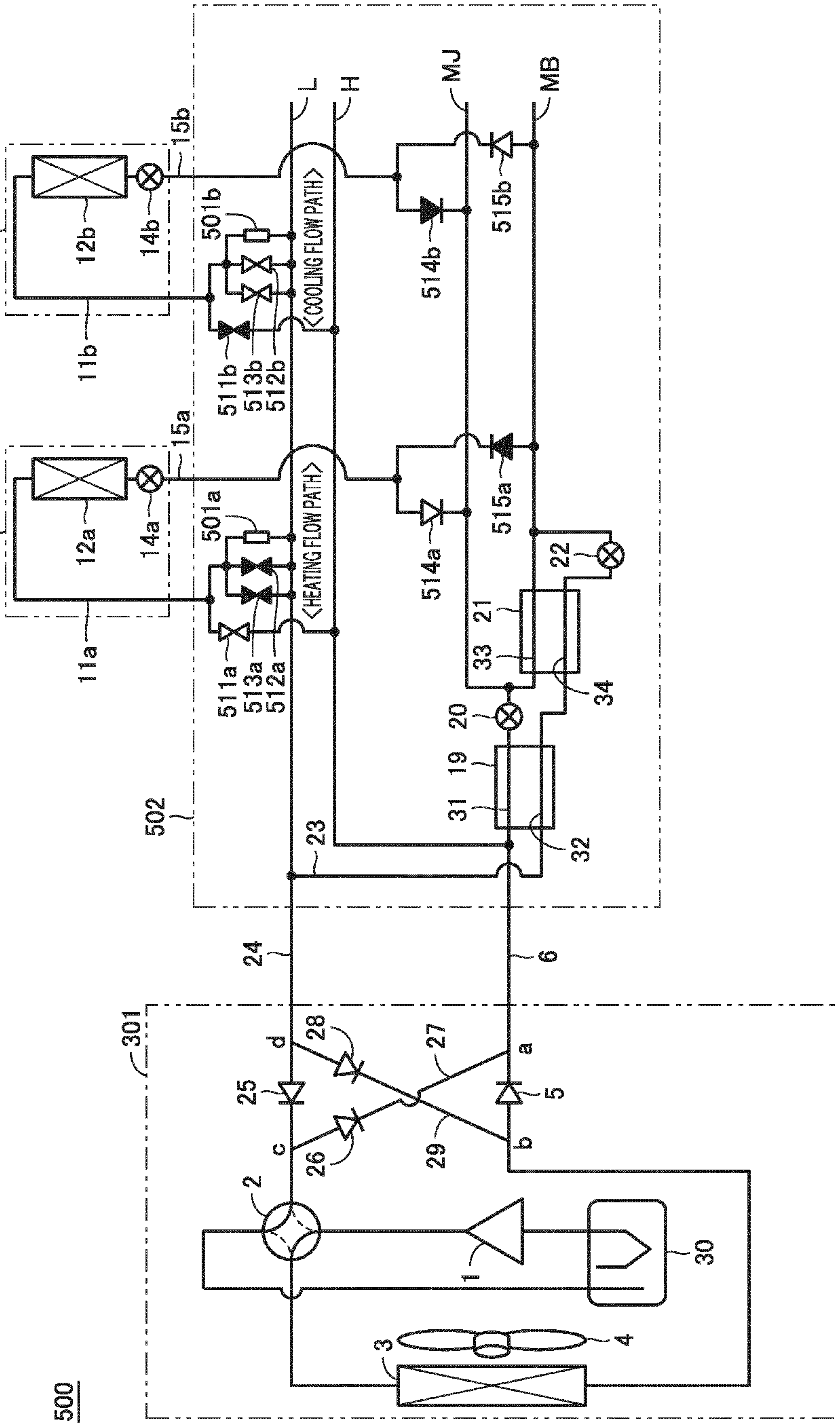


FIG.8


500
301
502
303a
303b
1
2
3
4
5
6
11a
11b
12a
12b
14a
14b
15a
15b
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
501a
501b
511a
511b
512a
512b
513a
513b
514a
514b
515a
515b
a
b
c
d
L
H
MJ
MB
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<COOLING FLOW PATH>

FIG.9

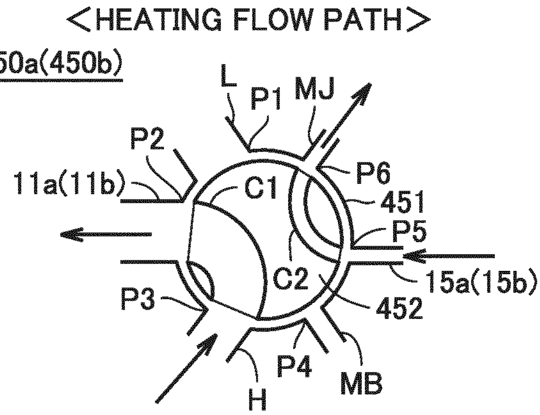


FIG.10

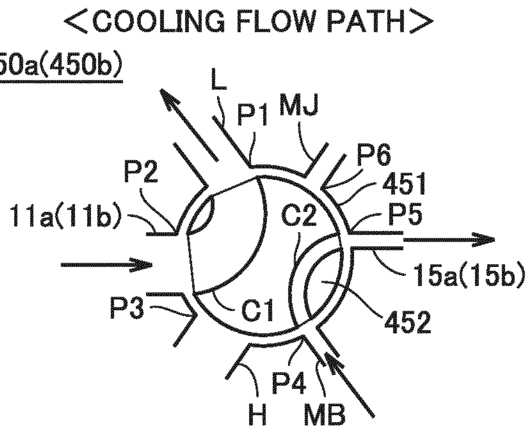


FIG.11

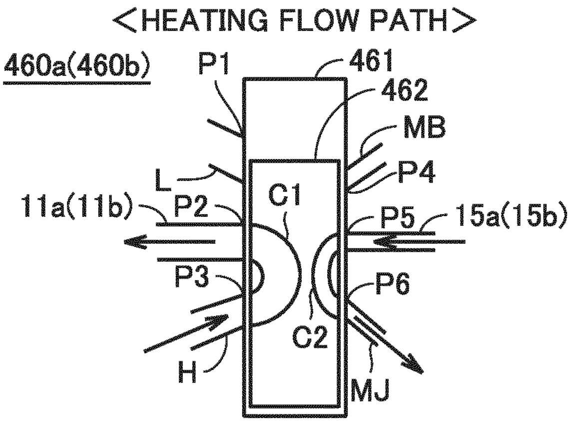


FIG.12

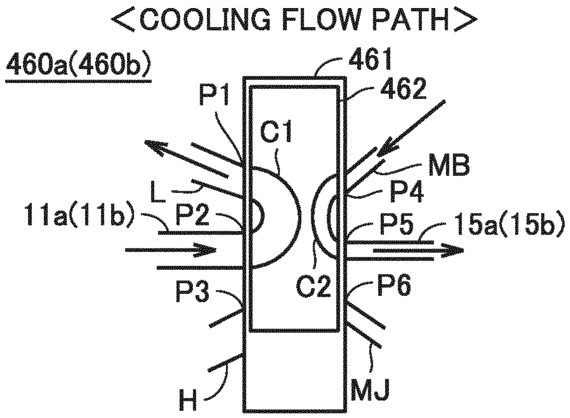


FIG.13

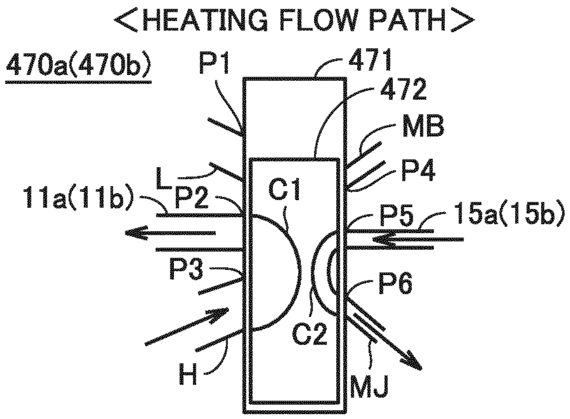


FIG.14

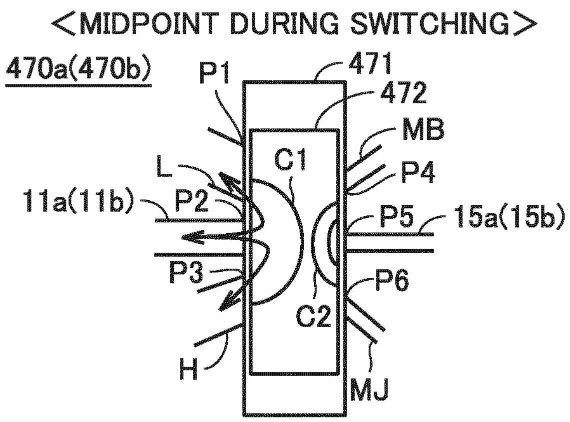
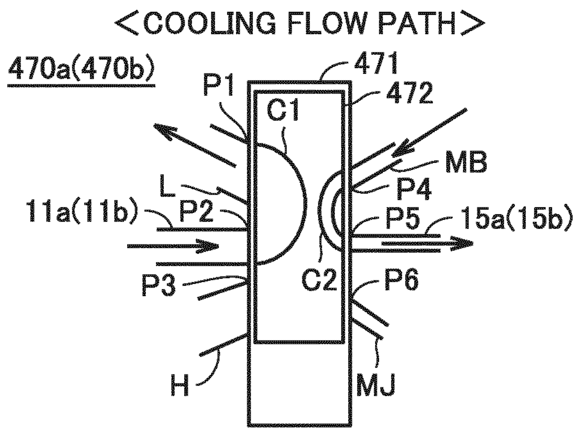


FIG.15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470a(470b)
471
472
P1
C1
MB
P4
L
11a(11b)
P2
P5
15a(15b)
P3
C2
P6
H
MJ

FIG.16

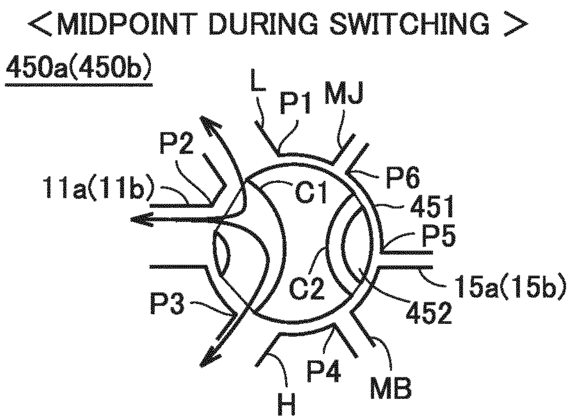
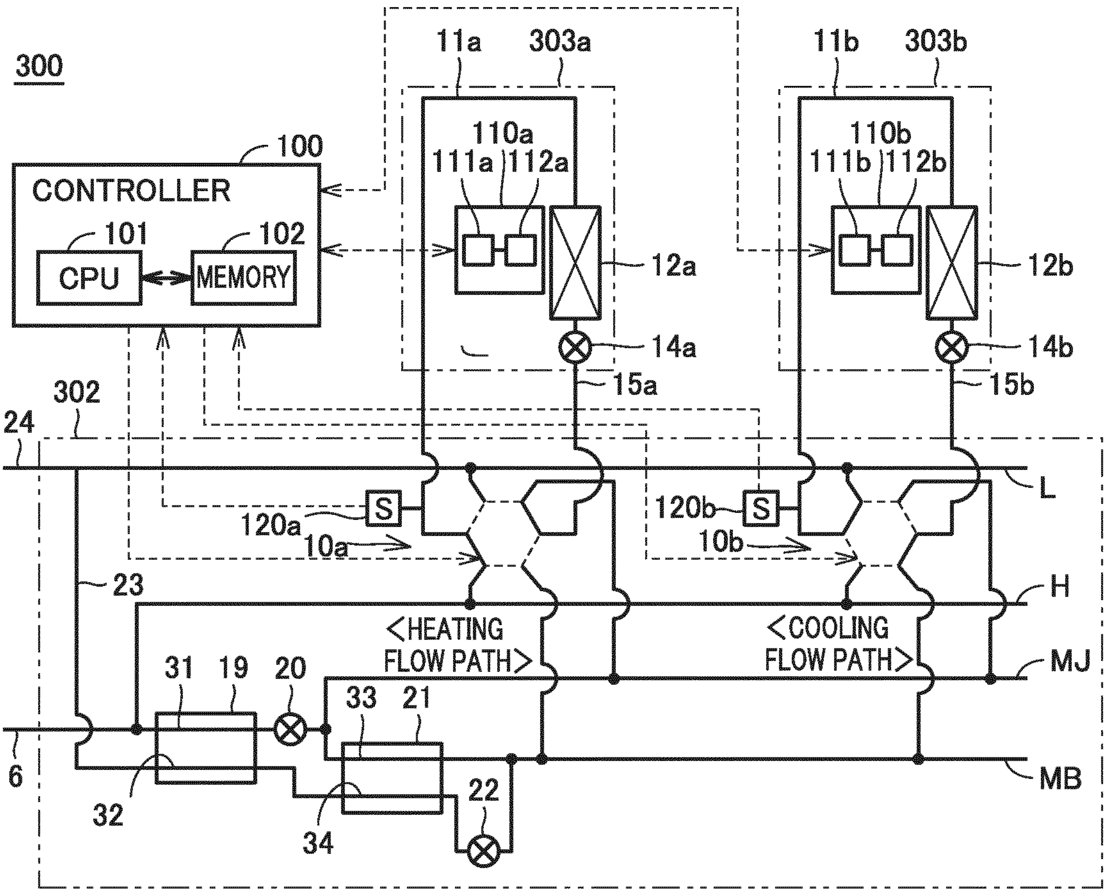

<MIDPOINT DURING SWITCHING >
450a(450b)
L
P1
MJ
P2
P6
11a(11b)
C1
451
P5
C2
15a(15b)
P3
452
P4
MB
H

FIG.17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CONTROLLER
100
101
102
CPU
MEMORY
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303a
110a
111a
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12a
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303b
110b
111b
112b
12b
14b
15b
302
24
120a
S
10a
120b
S
10b
L
H
MJ
MB
23
<HEATING FLOW PATH>
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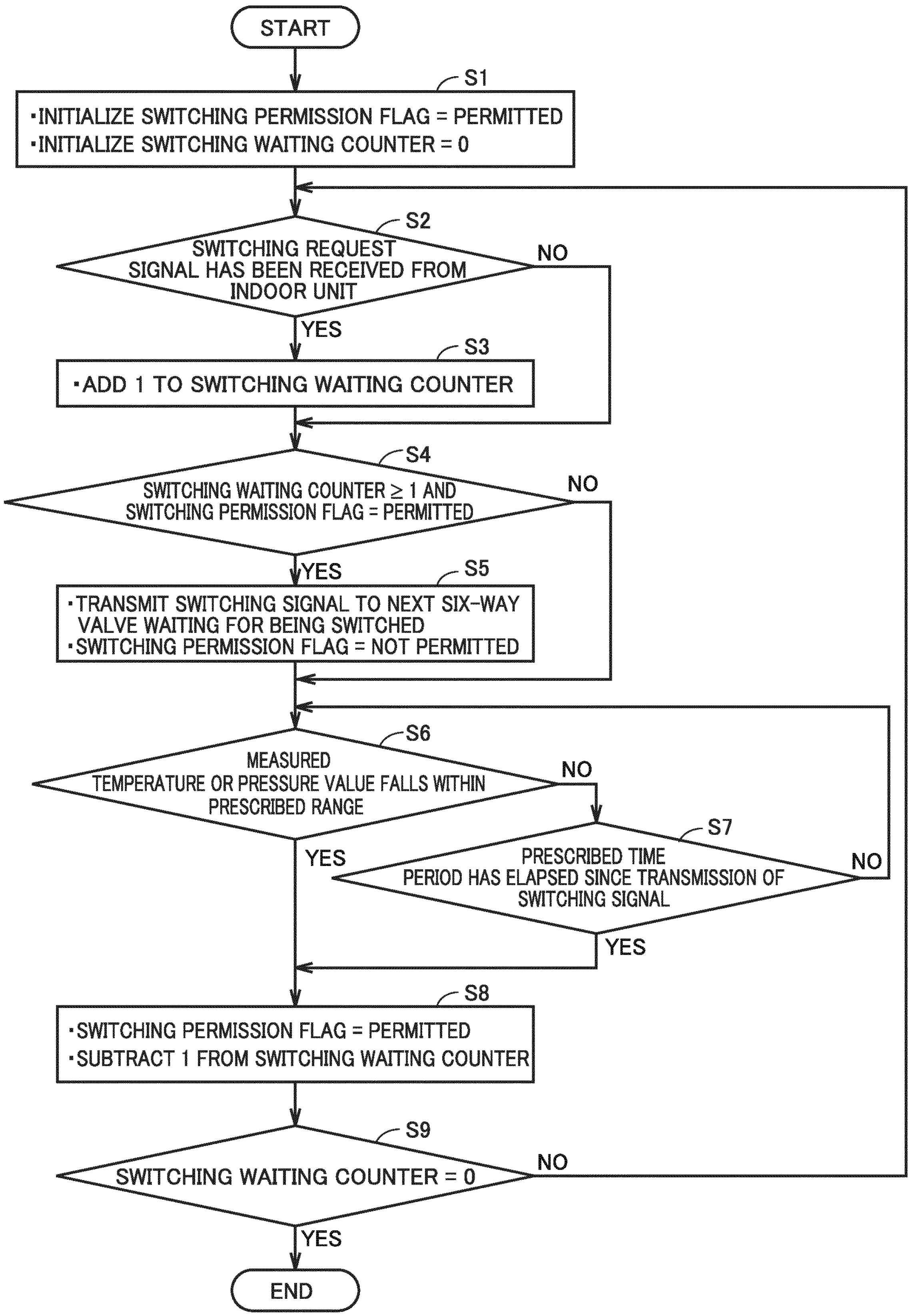
31
19
20
33
21
22
6
32
34

FIG.18


START
S1
・INITIALIZE SWITCHING PERMISSION FLAG = PERMITTED
・INITIALIZE SWITCHING WAITING COUNTER = 0
S2
SWITCHING REQUEST SIGNAL HAS BEEN RECEIVED FROM INDOOR UNIT
NO
YES
S3
・ADD 1 TO SWITCHING WAITING COUNTER
S4
SWITCHING WAITING COUNTER ≥ 1 AND SWITCHING PERMISSION FLAG = PERMITTED
NO
YES
S5
・TRANSMIT SWITCHING SIGNAL TO NEXT SIX-WAY VALVE WAITING FOR BEING SWITCHED
・SWITCHING PERMISSION FLAG = NOT PERMITTED
S6
MEASURED TEMPERATURE OR PRESSURE VALUE FALLS WITHIN PRESCRIBED RANGE
NO
YES
S7
PRESCRIBED TIME PERIOD HAS ELAPSED SINCE TRANSMISSION OF SWITCHING SIGNAL
NO
YES
S8
・SWITCHING PERMISSION FLAG = PERMITTED
・SUBTRACT 1 FROM SWITCHING WAITING COUNTER
S9
SWITCHING WAITING COUNTER = 0
NO
YES
END

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2021/028744

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl. F25B41/26(2021.01)i
FI: F25B41/26B

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)
Int.Cl. F25B41/26

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	1971-2021
Registered utility model specifications of Japan	1996-2021
Published registered utility model applications of Japan	1994-2021

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.
A	WO 2017/145219 A1 (MITSUBISHI ELECTRIC CORP.) 31 August 2017 (2017-08-31), entire text, all drawings	1-7
A	WO 2019/215916 A1 (MITSUBISHI ELECTRIC CORP.) 14 November 2019 (2019-11-14), entire text, all drawings	1-7
A	WO 2021/106084 A1 (MITSUBISHI ELECTRIC CORP.) 03 June 2021 (2021-06-03), entire text, all drawings	1-7
A	JP 2020-148254 A (FUJIKOKI CORPORATION) 17 September 2020 (2020-09-17), entire text, all drawings	1-7
A	JP 2011-112233 A (MITSUBISHI ELECTRIC CORP.) 09 June 2011 (2011-06-09), entire text, all drawings	1-7

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"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

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Date of the actual completion of the international search	Date of mailing of the international search report
31 August 2021	07 September 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.

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2021/028744

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REFERENCES CITED IN THE DESCRIPTION

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