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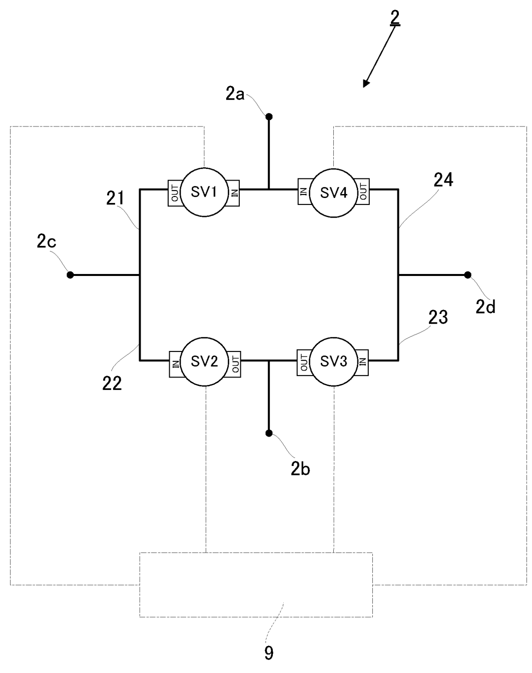
(54) REFRIGERATION CYCLE DEVICE

(57) A channel switching device (2) included in a refrigeration cycle device includes a first communication channel (21) that connects between an inflow port (2a) and a first inflow/outflow port (2c), a second communication channel (22) that connects between the first inflow/outflow port (2c) and an outflow port (2b), a third communication channel (23) that connects between the outflow port (2b) and the second inflow/outflow port (2d), a fourth communication channel (24) that connects between the second inflow/outflow channel (2d) and inflow port (2a), and first to fourth electromagnetic on-off valves (SV1 to SV4) disposed in the first to fourth communication channels (21 to 24) respectively to open/close the first to fourth communication channels (21 to 24) respectively.

FIG.2



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Description

Technical Field

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

Background Art

[0002] A refrigeration cycle device includes a compressor that compresses gaseous refrigerant to increase temperature, a condenser that gives off heat from the gaseous refrigerant having increased pressure and temperature to condense the gaseous refrigerant into a liquid, an expansion valve that decompresses and expands the liquefied refrigerant to partially evaporate the liquefied refrigerant, and an evaporator that evaporates and vaporizes the remaining liquid refrigerant to take heat off from the surroundings. The refrigerant vaporized in the evaporator is circulated to the compressor. In this way, the refrigerant circulates in the refrigeration cycle device through the compressor, the condenser, the expansion valve, and the evaporator. The refrigerant releases heat to the surroundings of the condenser as the refrigerant flows through the condenser. The refrigerant absorbs heat from the surroundings of the evaporator as the refrigerant passes through the evaporator. Both of the condenser and the evaporator are heat exchangers that transfers heat between the refrigerant and the surroundings and have basic mechanical components in common.

[0003] The refrigeration cycle device can be used as a heat source of a refrigerator or freezer but also as a heat source of an air-conditioning device. In the refrigeration cycle device used as a heat source of a refrigerator or the like, the evaporator is always disposed in an inside of the refrigerator or the like and the condenser is always in an outside of the refrigerator or the like.

[0004] In a case of use of the air-conditioning device as a cooling device, the heat exchanger disposed inside a room is to function as the evaporator and the heat exchanger disposed outside the room to function as the condenser. In a case of use of the air-conditioning device as a heating device, the heat exchanger disposed inside the room is to function as the condenser and the heat exchanger disposed outside the room is to function as the evaporator. Thus the refrigeration cycle device used as a heat source of the air-conditioning device needs to include a channel switching device that changes a direction of a flow of refrigerant between a cooling operation period and a heating operation period. In the refrigeration cycle device used as a heat source of the air-conditioning device, the heat exchanger disposed inside the room is called a use-side heat exchanger and the heat exchanger disposed outside the room is called a heat-source-side heat exchanger.

[0005] A four-way valve has been often used as a channel switching device in the refrigeration cycle device used as a heat source of the air-conditioning device. For example, Patent Literature 1 describes a vehicular air-conditioning device having a four-way valve as a channel switching device.

[0006] A specific structure of the four-way valve is described in Patent Literature 2. The four-way valve in Patent Literature 2 includes a valve housing having openings of first to fourth ports and a valve body that is disposed inside the valve housing and rotates around an axis perpendicular to a plane where the first to fourth ports are arranged. In this four-way valve, rotation of the valve body allows switching between a state where the first port is in communication with the second port and the third port is in communication with the fourth port and a state where the first port is in communication with the fourth port and the second port is in communication with the third port.

Citation List

Patent Literature

[0007]

Patent Literature 1: Unexamined Japanese Patent Application Publication No. 2002-316531

Patent Literature 2: Unexamined Japanese Patent Application Publication No. 2002-22041

Summary of Invention

Technical Problem

[0008] Vehicular air-conditioning devices have often used fluorocarbon refrigerants called R407C. However, since the R407C has a high global warming potential (GWP), its replacement with a low GWP alternative is desired from a perspective of the prevention of global warning. Then carbon dioxide, having noninflammability and a low GWP property, is a promising candidate as alternative refrigerant for a vehicular air-conditioning device. Use of carbon dioxide as refrigerant of the vehicular air-conditioning device is also described in Patent Literature 1.

[0009] A design pressure in a case of use of carbon dioxide as the refrigerant of the refrigeration cycle device is 14.0 Mpa, and the design pressure is considerably high compared with the R407C's design pressure of 2.94 Mpa. Thus when carbon dioxide is used as refrigerant, the pressure resistance of the refrigeration cycle device is to be enhanced. This means that the pressure resistance of the channel switching device is also to be enhanced.

[0010] However, the four-way valve having a complex structure poses a problem that attempts to enhance the pressure resistance of the four-way valve used as the channel switching device may result in increase of the overall dimension and the mass of the four-way valve. As a result, the overall dimension and the mass of the whole refrigeration cycle device increase. Especially, since the vehicular air-conditioning device has demanding requirements to be smaller and lighter, making the channel switching device smaller and lighter is highly desirable.

[0011] Some four-way valves cannot shut off inflow of the refrigerant into the compressor in a shutdown period of the refrigeration cycle device, and thus a phenomenon called refrigerant stagnation in which refrigerant stagnates in the compressor occurs. Occurrence of the refrigerant stagnation causes dissolution of the refrigerant into the lubricant oil in the compressor and reduces viscosity of the lubricant oil, which may causes lubrication failure. Upon restart of the compressor after occurrence of the refrigerant stagnation, the refrigerant dissolved in lubricant oil is gasified at once to make the lubricant oil be in a foamy state, which may cause failure to supply enough oil.

[0012] In view of the above circumstances, an objective of the present disclosure is to provide a refrigeration cycle device capable of using high pressure refrigerant, capable of being produced lighter and smaller in size, and capable of reducing refrigerant stagnation.

Solution to Problem

[0013] A refrigeration cycle device according to the present disclosure includes a channel switching device, a compressor, a use-side heat exchanger, a heat-source-side heat exchanger, an expansion valve, a first annular channel, and a second annular channel. The channel switching device includes an inflow port for inflow of refrigerant, an outflow port for outflow of the refrigerant, first and second inflow/outflow ports for inflow or outflow of the refrigerant, a first communication channel that connects between the inflow port and the first inflow/outflow port, a second communication channel that connects between the first inflow/outflow port and the outflow port, a third communication channel that connects between the outflow port and the second inflow/outflow port, a fourth communication channel that connects between the second inflow/outflow port and the inflow port, and first to fourth two-way valves that are disposed in the first to fourth communication channels respectively and open/close the first to fourth communication channels respectively. The compressor is disposed between the outflow port and the inflow port of the channel switching device. The use-side heat exchanger is connected to the first inflow/outflow port of the channel switching device. The heat-source-side heat exchanger is connected to the second inflow/outflow port of the channel switching device. The expansion valve is disposed between the use-side heat exchanger and the heat-source-side heat exchanger. The first annular channel starts from the outflow port of the channel switching device through the compressor back to the inflow port of the channel switching device. The second annular channel starts from the first inflow/outflow port of the channel switching device through the use-side heat exchanger, the expansion valve, and the heat-source-side heat exchanger in order, back to the second inflow/outflow port of the channel switching device.

Advantageous Effects of Invention

[0014] In the refrigeration cycle device according to the present disclosure, four two-way valves are used as the channel switching device in place of a conventional four-way valve. Since the two-way valve has a simple structure compared with the four-way valve, the pressure resistance can be enhanced with relative ease. Thus the overall dimension and the mass can be small with the pressure resistance enhanced. Simultaneous closure of the first to fourth communication channels can isolate the compressor from the second annular channel in a shutdown period of the refrigeration cycle device, which can prevent the refrigerant stagnation

Brief Description of Drawings

[0015]

FIG. 1 is a diagram illustrating a configuration of a refrigeration cycle device according to Embodiment 1 of the present disclosure;

FIG. 2 is a diagram illustrating a configuration of a channel switching device included in the refrigeration cycle device illustrated in FIG. 1;

FIG. 3A is a cross-sectional view of an electromagnetic on-off valve included in the channel switching device illustrated in FIG. 2 in a closed state, illustrating a configuration and an effect of the electromagnetic on-off valve;

FIG. 3B is a cross-sectional view of the electromagnetic on-off valve included in the channel switching device illustrated in FIG. 2 in an open state, illustrating a configuration and an effect of the electromagnetic on-off valve;

FIG. 4 is a diagram illustrating an effect of the refrigeration cycle device illustrated in FIG. 1, in operation of the refrigeration cycle device in a cooling mode;

FIG. 5 is a diagram illustrating an effect of the refrigeration cycle device illustrated in FIG. 1, in operation of the refrigeration cycle device in a heating mode;

FIG. 6 is a diagram illustrating a configuration of a channel switching device included in a refrigeration cycle device according to Embodiment 2;

FIG. 7 is a diagram illustrating a configuration of a refrigeration cycle device according to Modified Example 1;

FIG. 8 is a diagram illustrating a configuration of a refrigeration cycle device according to Modified Example 2;

FIG. 9 is a diagram illustrating a configuration of a refrigeration cycle device according to Modified Example 3; and

FIG. 10 is a diagram illustrating a configuration of a refrigeration cycle device according to Modified Example 4.

Description of Embodiments

[0016] The configuration and effect of a refrigeration cycle device according to embodiments of the present disclosure is hereinafter described in detail with reference to the drawings. The same or similar part are designated by the same reference numerals through the drawings.

Embodiment 1

[0017] FIG. 1 is a drawing illustrating a configuration of a refrigeration cycle device 1 according to Embodiment 1 of the present disclosure. The refrigeration cycle device 1 is a device that is mounted on an unillustrated vehicle and adjusts temperature of air in a compartment of the vehicle, that is, performs cooling and heating of the compartment. The refrigeration cycle device 1 uses carbon dioxide as refrigerant.

[0018] As illustrated in FIG. 1, the refrigeration cycle device 1 includes a channel switching device 2 that changes a direction of flow of the refrigerant. The channel switching device 2 includes an inflow port 2a for inflow of the refrigerant, an outflow port 2b for outflow of the refrigerant, and first and second inflow/outflow ports 2c and 2d for inflow or outflow of the refrigerant. Detailed configuration of the channel switching device 2 is described later.

[0019] A compressor 3 is disposed between the inflow port 2a and the outflow port 2b of the channel switching device 2. A pipe line 4a is disposed between the outflow port 2b and the compressor 3. The refrigerant flowing out from the outflow port 2b thus flows through the pipe line 4a into the compressor 3. A pipe line 4b is disposed between the compressor 3 and the inflow port 2a. The refrigerant compressed in the interior of the compressor 3 and having elevated temperature and pressure thus flows through the pipe line 4b into the inflow port 2a. In this way, the refrigerant circulates between the channel switching device 2 and the compressor 3. The pipe line 4a and the pipe line 4b serve to form a first annular channel 4 starting from the outflow port 2b of the channel switching device 2 through the compressor 3 back to the inflow port 2a of the channel switching device 2.

[0020] As illustrated in FIG. 1, the refrigeration cycle device 1 includes a use-side heat exchanger 5, a heat-source-side heat exchanger 6, and an expansion valve 7. The use-side heat exchanger 5 is connected through the pipe line 8a to a first inflow/outflow port 2c of the channel switching device 2. The heat-source-side heat exchanger 6 is connected through a pipe line 8d to a second inflow/outflow port 2d of the channel switching device 2. The expansion valve 7 is disposed between the use-side heat exchanger 5 and the heat-source-side heat exchanger 6. The expansion valve 7 is connected through a pipe line 8b to the use-side heat exchanger 5 and through a pipe line 8c to the heat-source-side heat exchanger 6. In this way, the pipe lines 8a, 8b, 8c, and 8d serve to form a second annular channel 8 starting from the first inflow/outflow port 2c of the channel switching device 2, through the use-side heat exchanger 5, the expansion valve 7, and the heat-source-side heat exchanger 6 in this order, back to the second inflow/outflow port 2d of the channel switching device 2. A direction of flow of the refrigerant in the second annular channel 8 is changed by the channel switching device 2. Such an effect by the channel switching device 2 is described in detail later.

[0021] The use-side heat exchanger 5 is a heat exchanger that is disposed in a target compartment to be air-conditioned and cools or heats air in the compartment. The use-side heat exchanger 5 includes an unillustrated fan. The heat-source-side heat exchanger 6 is a heat exchanger that is disposed outside the target compartment to be air-conditioned and releases heat carried by the refrigerant to the atmosphere or releases heat carried by the atmosphere to the refrigerant. The heat-source-side heat exchanger 6 also includes an unillustrated fan.

[0022] The expansion valve 7 decompresses and expands the liquefied refrigerant discharged from the use-side heat exchanger 5 or the heat-source-side heat exchanger 6 to partially evaporate the liquefied refrigerant.

[0023] As illustrated in FIG. 1, the refrigeration cycle device 1 includes a control device 9. The control device 9 is a computer that controls the entire refrigeration cycle device 1. The channel switching device 2, the compressor 3, the use-side heat exchanger 5, the heat-source-side heat exchanger 6, and the expansion valve 7 are controlled by the control device 9.

[0024] FIG. 2 is a drawing illustrating a configuration of the channel switching device 2 included in the refrigeration cycle device 1. As illustrated in FIG. 2, the channel switching device 2 includes a first communication channel 21 that connects between the inflow port 2a and the first inflow/outflow port 2c, a second communication channel 22 that connects between the first inflow/outflow port 2c and the outflow port 2b, a third communication channel 23 that connects between the outflow port 2b and the second inflow/outflow port 2d, and a fourth communication channel 24 that connects between the second inflow/outflow port 2d and the inflow port 2a. The first to fourth communication channels 21 to 24 include the first to fourth electromagnetic on-off valves SV1 to SV4, respectively. The first to fourth electromagnetic on-off valves SV1 to SV4 are two-way valves that are controlled by the control device 9 to open/close the first to fourth communication channels 21 to 24, respectively. In FIG. 2, IN represents inlets of the first to fourth electromagnetic on-off valves SV1 to SV4 and OUT represents outlets of the first to fourth electromagnetic on-off valves SV1 to SV4. As described later, when the first to fourth electromagnetic on-off valves SV1 to SV4 open, the refrigerant flows from the inlet IN toward the outlet OUT.

[0025] FIG. 3A and FIG. 3B illustrate the configuration and effect of the first to fourth electromagnetic on-off valves SV1 to SV4. FIG. 3A is a cross-sectional view of the first to fourth electromagnetic on-off valves SV1 to SV4 in a closed state, FIG. 3B is a cross-sectional view of the first to fourth electromagnetic on-off valves SV1 to SV4 in an open state. As illustrated in FIG. 3A and 3B, the first to fourth electromagnetic on-off valves SV1 to SV4 include a casing 31 in which an inlet IN and an outlet OUT are formed. Inside the casing 31, a valve body 32 and a spring 33 are disposed. The spring 33 is an elastic member that biases the valve body 32 in a direction toward a valve seat 34.

[0026] In a state illustrated in FIG. 3A, the valve body 32 is pressed by the spring 33 to abut the valve seat 34. Since this closes the channel from the casing 31 toward the outlet OUT, the refrigerant passing through the inlet IN into the casing 31 do not flow to the outlet OUT. In a state illustrated in FIG. 3A, a fluid pressure of the refrigerant inside the casing 31 acts in a direction to force the valve body 32 to abut the valve seat 34.

[0027] As illustrated in FIG. 3A and FIG. 3B, a rod 35 made of a magnetic material is fixed on a back side of the valve body 32, that is, a side opposite to the side of the valve body 32 abutting the side of the valve seat 34. A solenoid coil 36 is fixed to the casing 31. The rod 35 extends through in the center of the solenoid coil 36. Thus when the solenoid coil 36 is energized by control of the control device 9, as illustrated in FIG. 3B, the rod 35 is attracted by the solenoid coil 36 to move upward as in FIG. 3B. As a result, the valve body 32 moves away from the valve seat 34. As a result, the refrigerant flowing through the inlet IN into the casing 31 flows out through the outlet OUT.

[0028] As illustrated in FIG. 1, the inflow port 2a of the channel switching device 2 is connected to an outlet of the compressor 3 and the outflow port 2b is connected to an inlet of the compressor 3. Thus while the compressor 3 operates, that is, the refrigeration cycle device 1 operates, a fluid pressure of the refrigerant at the inflow port 2a of the channel switching device 2 is always higher than that of the refrigerant at the outflow port 2b. As illustrated in FIG. 2, in the first to fourth electromagnetic on-off valves SV1 to SV4, the inlet IN is located on a side nearer to the inflow port 2a and the outlet OUT is located on a side nearer to the outflow port 2b. Thus the fluid pressure of the refrigerant acting on the valve body 32 when the first to fourth electromagnetic on-off valves SV1 to SV4 close acts in a direction to force the valve body 32 against the valve seat 34. That is, the fluid pressure of the refrigerant acting on the valve body 32 acts in a direction to maintain the closed state. In this way, since the closed state of the first to fourth electromagnetic on-off valves SV1 to SV4 is maintained by the fluid pressure of the refrigerant, inadvertent opening of the first to fourth electromagnetic on-off valves SV1 to SV4 is suppressed.

[0029] As described above, the channel switching device 2 is controlled by the control device 9 and the first to fourth electromagnetic on-off valves SV1 to SV4 are controlled by the control device 9 to open/close. The control device 9 can cause the open/close states of the first to fourth electromagnetic on-off valves SV1 to SV4 to be states corresponding to a cooling operation mode, a heating operation mode, a pressure equalizing mode, an oil return mode, and a stop mode. Change of the above modes can be done by a manual operation to the control device 9.

Cooling operation mode

[0030] When the refrigeration cycle device 1 operates in the cooling operation mode, that is, the refrigeration cycle device 1 serves as a cooling device, the second electromagnetic on-off valve SV2 and the fourth electromagnetic on-off valve SV4 open and the first electromagnetic on-off valve SV1 and the third electromagnetic on-off valve SV3 close. Then, as illustrated in FIG. 4, a channel for flow of the refrigerant between the inflow port 2a and the second inflow/outflow port 2d is formed in the channel switching device 2. A channel for flow of the refrigerant between the outflow port 2b and the first inflow/outflow port 2c is formed. Thus the refrigerant discharged from the compressor 3 flows through the pipe line 4b, the channel switching device 2, and the pipe line 8d in this order, into the heat-source-side heat exchanger 6. Then the refrigerant flows from the heat-source-side heat exchanger 6 through the pipe line 8c, the expansion valve 7, and the pipe line 8b in this order, into the use-side heat exchanger 5. The refrigerant flowing into the use-side heat exchanger 5 flows through the pipe line 8a to the channel switching device 2. The refrigerant flowing into the channel switching device 2 flows through the pipe line 4a back to the compressor 3. In this way, the refrigerant circulates in the second annular channel 8 in a counterclockwise direction, that is, a direction indicated by an arrow of FIG. 4.

[0031] As described before, in the cooling mode, the heat-source-side heat exchanger 6 functions as a condenser since the refrigerant circulates in the second annular channel 8 counterclockwise. The use-side heat exchanger 5 functions as an evaporator. Thus in the heat-source-side heat exchanger 6, heat carried by the refrigerant is released to the atmosphere. In the use-side heat exchanger 5, heat carried by air in the compartment where the use-side heat exchanger 5 is disposed is absorbed in the refrigerant. As a result, air in the compartment where the use-side heat exchanger 5 is disposed is cooled.

Heating operation mode

[0032] When the refrigeration cycle device 1 operates in the heating operation mode, that is, the refrigeration cycle device 1 serves as a heating device, the first electromagnetic on-off valve SV1 and the third electromagnetic on-off valve SV3 open and the second electromagnetic on-off valve SV2 and the fourth electromagnetic on-off valve SV4 close. Then, as illustrated in FIG. 5, a channel for flow of the refrigerant between the inflow port 2a and the first inflow/outflow port 2c is formed in the channel switching device 2. A channel for flow of the refrigerant between the outflow port 2b and the second inflow/outflow port 2d is formed. Thus the refrigerant discharged from the compressor 3 flows through the pipe line 4b, the channel switching device 2, the pipe line 8a in this order, into the use-side heat exchanger 5. The refrigerant flows from the use-side heat exchanger 5 through the pipe line 8b, the expansion valve 7, and the pipe line 8c in this order, into the heat-source-side heat exchanger 6. The refrigerant flowing into the heat-source-side heat exchanger 6 flows through the pipe line 8d to the channel switching device 2. The refrigerant flowing into the channel switching device 2 flows through the pipe line 4a back to the compressor 3. In this way, the refrigerant circulates in the second annular channel 8 in a clockwise direction, that is, a direction indicated by an arrow of FIG. 5.

[0033] As described before, in the heating operation mode, the use-side heat exchanger 5 functions as a condenser since the refrigerant circulates in the second annular channel 8 clockwise. The heat-source-side heat exchanger 6 functions as an evaporator. Thus in the use-side heat exchanger 5, heat carried by the refrigerant is released to air in the compartment where the use-side heat exchanger 5 is disposed. In the heat-source-side heat exchanger 6, heat carried by the atmosphere is absorbed in the refrigerant. As a result, the air in the compartment where the use-side heat exchanger 5 is disposed is heated.

Pressure equalizing mode

[0034] In the cooling operation mode, the refrigerant in the heat-source-side heat exchanger 6 is in a high-pressure state compared with the refrigerant in the use-side heat exchanger 5. By contrast, in the heating operation mode, the refrigerant in the heat-source-side heat exchanger 6 is in a low-pressure state compared with the refrigerant in the use-side heat exchanger 5. Thus switching directly from the cooling operation mode to the heating operation mode or directly from the heating operation mode to the cooling operation mode leads to inflow of the high-pressure refrigerant into the compressor 3, which applies overload to the compressor 3. To avoid such a phenomenon, the operation mode of the refrigeration cycle device 1 is switched between the cooling operation mode and the heating operation mode through the pressure equalizing mode described below.

[0035] In the pressure equalizing mode, the first to fourth electromagnetic on-off valves SV1 to SV4 are controlled by the control device 9 for all of the valves to open. Upon opening of all of the first to fourth electromagnetic on-off valves SV1 to SV4, the pressures of the refrigerant in the first annular channel 4 and the second annular channel 8 are equalized. Then the cooling operation mode or the heating operation mode is selected, and each of the first to fourth electromagnetic on-off valves SV1 to SV4 open or close before operation of the compressor 3. This avoids inflow of high-pressure refrigerant into the compressor 3. Thus overload is not thus applied to the compressor 3.

Oil return mode

[0036] Upon operation of the refrigeration cycle device 1, the lubricant oil of the compressor 3 is partially mixed with the refrigerant and the mixture flows into the first annular channel 4 and the second annular channel 8. This may cause lubrication failure in the compressor 3. To avoid such a phenomenon, in the refrigeration cycle device 1, the lubrication oil flowing out into the first annular channel 4 and the second annular channel 8 can be returned to the compressor 3 as necessary by slection of the oil return mode described below.

[0037] In the oil return mode, the first electromagnetic on-off valve SV1 is controlled by the control device 9 to close, and the second to fourth electromagnetic valves SV2 to SV4 are controlled by the control device 9 to open. In a state where the compressor 3 is stopped, the lubrication oil flowing out into the first annular channel 4 and the second annular channel 8 is returned to the compressor 3 upon selection of the oil return mode.

Stop mode

[0038] In a state where the refrigeration cycle device 1 stops, a stop mode can be selected. Upon selection of the stop mode, the first to fourth electromagnetic on-off valves SV1 to SV4 are controlled by the control device 9 for all of the valves to close. Upon closing of all of the first to fourth electromagnetic on-off valves SV1 to SV4, the compressor 3 is separated from the second annular channel 8. That is, a flow of the refrigerant between the compressor 3 and the second annular channel 8 is shut off. As a result, no inflow of the refrigerant into the compressor 3 avoids stagnation of the refrigerant in the compressor 3. Thus occurrence of the refrigerant stagnation in the compressor 3 can be prevented.

Embodiment 2

[0039] Embodiment 1 described above illustrates an example in which the first to fourth electromagnetic on-off valves SV1 to SV4 are disposed one in each of the first to fourth communication channels 21 to 24 of the channel switching device 2. However, the channel switching device 2 is not limited to the arrangement in which the first to fourth electromagnetic on-off valves SV1 to SV4 are disposed one in each of the first to fourth communication channels 21 to 24. The channel switching device 2 may be an arrangement of a plurality of first to fourth electromagnetic on-off valves SV1 to SV4 disposed in parallel in each of the first to fourth communication channels 21 to 24. For example, as illustrated in

FIG. 6, two first electromagnetic on-off valves SV1a and SV1b may be disposed in the first communication channel 21, two second electromagnetic on-off valves SV2a and SV2b may be disposed in the second communication channel 22, two third electromagnetic on-off valves SV3a and SV3b may be disposed in the third communication channel 23, and two fourth electromagnetic on-off valves SV4a and SV4b may be disposed in the fourth communication channel 24. In this way, arrangement in which the plurality of first to fourth electromagnetic on-off valves SV1 to SV4is disposed in parallel in each of the first to fourth communication channels 21 to 24 can improve efficiency of the refrigeration cycle device 1 since channel resistances in the first to fourth communication channels 21 to 24 decrease.

Modified Example 1

[0040] The refrigeration cycle device 1 according to Embodiments 1 and 2 may include a sensor that determines a direction of flow of the refrigerant in the second annular channel 8. For example, as illustrated in FIG. 7, the refrigeration cycle device 1 may include a pressure sensor P1 in a pipe line between the inflow port 2a and the compressor 3, that is, the pipe line 4a; a pressure sensor P2 in a pipe line between the first inflow/outflow port 2c and the use-side heat exchanger 5, that is, the pipe line 8a; a pressure sensor P3 in a pipe line between the outflow port 2b and the compressor 3, that is, the pipe line 4a; and a pressure sensor P4 in a pipe line between the second inflow/outflow port 2d and the heat-source-side heat exchanger 6, that is, the pipe line 8d. The pressure sensors P1, P2, P3, and P4 are sensors that detect magnitude of pressures of the refrigerant flowing in each pipe line.

[0041] In the refrigeration cycle device 1 illustrated in FIG. 7, when values p1 to p4 of pressures measured by the pressure sensors P1 to P4 satisfy the relationship $p1 \geq p4 > p2 \geq p3$, it can be determined that the refrigerant circulates in the second annular channel 8 counterclockwise in FIG. 7. That is, it can be determined that the refrigeration cycle device 1 is operated in the cooling operation cycle.

[0042] In the refrigeration cycle device 1 illustrated in FIG. 7, when the values p1 to p4 of the pressures measured by the pressure sensors P1 to P4 satisfy the relationship $p1 \geq p2 > p4 \geq p3$, it can be determined that the refrigerant circulates in the second annular channel 8 clockwise in FIG. 7. That is, it can be determined that the refrigeration cycle device 1 is operated in the heating operation cycle.

Modified Example 2

[0043] The sensor that determines a direction of flow of the refrigerant in the second annular channel 8 is not limited to a set of four pressure sensors P1 to P4 illustrated in FIG. 7. As illustrated in FIG. 8, the refrigeration cycle device 1 may include two pressure sensors P2 and P4.

[0044] In the refrigeration cycle device 1 illustrated in FIG. 8, when the values p2 and p4 of pressures measured by the pressure sensors P2 and P4 satisfy the relationship $p4 > p2$, it can be determined that the refrigerant circulates in the second annular channel 8 counterclockwise in FIG. 8. That is, it can be determined that the refrigeration cycle device 1 is operated in the cooling operation cycle.

[0045] In the refrigeration cycle device 1 illustrated in FIG. 8, when the values p2 and p4 of pressures measured by the pressure sensors P2 and P4 satisfy the relationship $p2 > p4$, it can be determined that the refrigerant circulates in the second annular channel 8 clockwise in FIG. 8. That is, it can be determined that the refrigeration cycle device 1 is operated in the heating operation cycle.

Modified Example 3

[0046] The sensors that determine a direction of flow of the refrigerant in the second annular channel 8 is not limited to the pressure sensors P1 to P4. As illustrated in FIG. 9, the refrigeration cycle device 1 may include a temperature sensor T1 in a pipe line between the first inflow/outflow port 2c and the use-side heat exchanger 5, that is, the pipe line 8a; and a temperature sensor T2 in a pipe line between the second inflow/outflow port 2d and the heat-source-side heat exchanger 6, that is, the pipe line 8d. The temperature sensors T1 and T2 are sensors that each measure a temperature of the refrigerant flowing in each pipe line.

[0047] In the refrigeration cycle device 1 illustrated in FIG. 9, the temperatures t1 and t2 measured by the temperature sensors T1 and T2 satisfy the relationship $t2 > t1$, it can be determined that the refrigerant circulates in the second annular channel 8 counterclockwise in FIG. 9. That is, it can be determined that the refrigeration cycle device 1 is operated in the cooling operation cycle.

[0048] In the refrigeration cycle device 1 illustrated in FIG. 9, when the temperatures t1 and t2 measured by the temperature sensors T1 and T2 satisfy the relationship $t1 > t2$, it can be determined that the refrigerant circulates in the second annular channel 8 clockwise in FIG. 9. That is, it can be determined that the refrigeration cycle device 1 is operated in the heating operation cycle.

Modified Embodiment 4

[0049] The sensor that determines a direction of flow of the refrigerant in the second annular channel 8 is not limited to the pressure sensors P1 to P4 or the temperature sensors T1 and T2. In addition to these sensors, the refrigeration cycle device 1 may include flow rate sensors F1 and F2 that directly measure a flow rate and a direction of flow of the refrigerant flowing in the second annular channel 8. That is, as illustrated in FIG. 10, the refrigeration cycle device 1 may include the flow rate sensor F1 in a pipe line between the first inflow/outflow port 2c and the use-side heat exchanger 5, that is, pipe line 8a; and the flow sensor F2 in a pipe line between the second inflow/outflow port 2d and the heat-source-side heat exchanger 6, that pipe line 8d.

[0050] Although he refrigeration cycle device 1 includes both of the flow rate sensor F1 and the flow rate sensor F2 in the above example, either one of the flow rate sensors F1 and F2 can be omitted. With the refrigeration cycle device 1 having either one of the flow rate sensors F1 and F2, the direction of flow of the refrigerant in the second annular channel 8 can be determined.

[0051] As described above, the refrigeration cycle device 1 according to Embodiments 1 and 2 includes the first to fourth electromagnetic on-off valves SV1 to SV4 in the channel switching device 2 in place of a conventional four-way valve. Since the first to fourth electromagnetic on-off valves SV1 to SV4 are two-way valves having a simpler structure than the four-way valves, the pressure resistance can be easily enhanced. Thus even in use of the refrigerant that is circulated in high pressure, making the channel switching device 2 smaller and lighter can be easily achieved. As a result, making the refrigeration cycle device 1 smaller and lighter can be easily achieved.

[0052] Since the first to fourth electromagnetic on-off valves SV1 to SV4 included in the channel switching device 2 can be opened and closed independently of one another, the stop mode, a transforming mode, and the oil return mode can be selected in the channel switching device 2, in addition to the heating operation mode and the cooling operation mode. Thus occurrence of the refrigerant stagnation or lubrication failure can be suppressed in the compressor 3.

[0053] The refrigeration cycle device 1 according to each of the aforementioned modified examples may include the pressure sensors P1 to P4, the temperature sensors T1 and T2, or the flow rate sensors F1 and F2 in the second annular channel 8 to confirm the direction of flow of the refrigerant in the second annular channel 8. Thus easy control can be achieved.

[0054] The technical scope of the present disclosure is not limited by the aforementioned embodiments. The present disclosure can be implemented freely by applications, alternations, or modification within the technical idea defined by the claims.

[0055] Specifically, the technical scope of the present disclosure is not limited to the refrigeration cycle device in which carbon dioxide is used as refrigerant.

[0056] Although a vehicular air-conditioning device is exemplified in the description of the background, application of the refrigeration cycle device according to the present disclosure is not limited to the vehicular air-conditioning device.

[0057] The foregoing describes some example embodiments for explanatory purposes. Although the foregoing discussion has presented specific embodiments, persons skilled in the art will recognize that changes may be made in form and detail without departing from the broader spirit and scope of the invention. Accordingly, the specification and drawings are to be regarded in an illustrative rather than a restrictive sense. This detailed description, therefore, is not to be taken in a limiting sense, and the scope of the invention is defined only by the included claims, along with the full range of equivalents to which such claims are entitled.

[0058] This application claims the benefit of Japanese Patent Application No. 2018-240670, filed on December 25, 2018, the entire disclosure of which is incorporated by reference herein.

Industrial Applicability

[0059] The present disclosure can be preferably used as a refrigeration cycle device.

Reference Signs List

[0060]

- 1 Refrigeration cycle device
- 2 Channel switching device
- 2a Inflow port
- 2b Outflow port
- 2c First inflow/outflow port
- 2d Second inflow/outflow port
- 3 Compressor
- 4 First annular channel
- 4a, 4b Pipe line
- 5 Use-side heat exchanger
- 6 heat-source-side heat exchanger
- 7 Expansion valve
- 8 Second annular channel
- 8a, 8b, 8c, 8d Pipe line
- 9 Control device
- 21 First communication channel
- 22 Second communication channel
- 23 Third communication channel
- 24 Fourth communication channel
- 31 Casing
- 32 Valve body
- 33 Spring
- 34 Valve seat
- 35 Rod
- 36 Solenoid coil
- SV1, SV1a, SV1b First electromagnetic on-off valve
- SV2, SV2a, SV2b Second electromagnetic on-off valve
- SV3, SV3a, SV3b Third electromagnetic on-off valve
- SV4, SV4a, SV4b Fourth electromagnetic on-off valve
- IN Input port
- OUT Output port
- P1, P2, P3, P4 Pressure sensor
- T1, T2 Temperature sensor
- F1, F2 Flow rate sensor

Claims

1. A refrigeration cycle device comprising:

   a channel switching device including

   an inflow port for inflow of refrigerant,
   an outflow port for outflow of the refrigerant,
   first and second inflow/outflow ports for inflow or outflow of the refrigerant,
   a first communication channel that connects between the inflow port and the first inflow/outflow port,
   a second communication channel that connects between the first inflow/outflow port and the outflow port,
   a third communication channel that connects between the outflow port and the second inflow/outflow port,
   a fourth communication channel that connects between the second inflow/outflow port and the inflow port, and
   first to fourth two-way valves that are disposed in the first to fourth communication channels respectively and open/close the first to fourth communication channels respectively;

   a compressor disposed between the outflow port and the inflow port of the channel switching device;
   a use-side heat exchanger connected to the first inflow/outflow port of the channel switching device;
   a heat-source-side heat exchanger connected to the second inflow/outflow port of the channel switching device;
   an expansion valve disposed between the use-side heat exchanger and the heat-source-side heat exchanger;
   a first annular channel that starts from the outflow port of the channel switching device through the compressor back to the inflow port of the channel switching device; and
   a second annular channel that starts from the first inflow/outflow port of the channel switching device through the use-side heat exchanger, the expansion valve, and the heat-source-side heat exchanger in order, back to the second inflow/outflow port of the channel switching device.

2. The refrigeration cycle device according to claim 1, wherein a plurality of the first two-way valves, a plurality of the second two-way valves, a plurality of the third two-way valves, and a plurality of the fourth two-way valves are disposed in parallel in the first to fourth communication channels, respectively.

3. The refrigeration cycle device according to claim 1, further comprising, in a pipe line connected to the channel switching device, a sensor to determine a direction of flow of the refrigerant in the second annular channel.

4. The refrigeration cycle device according to claim 3, wherein the sensor is a pressure sensor disposed in each of a pipe line between the inflow port and the compressor, a pipe line between the first inflow/outflow port and the use-side heat exchanger, a pipe line between the second inflow/outflow port and the heat-source-side heat exchanger, and a pipe line between the outflow port and the compressor to detect a magnitude of pressure of the refrigerant flowing in each of the pipe lines.

5. The refrigeration cycle device according to claim 3, wherein the sensor is a pressure sensor disposed in each of a pipe line between the first inflow/outflow port and the use-side heat exchanger and a pipe line between the second inflow/outflow port and the heat-source-side heat exchanger to detect a magnitude of pressure of the refrigerant flowing in each of the pipe lines.

6. The refrigeration cycle device according to claim 3, wherein the sensor is a temperature sensor disposed in each of a pipe line between the first inflow/outflow port and the use-side heat exchanger and a pipe line between the second inflow/outflow port and the heat-source-side heat exchanger to detect a level of temperature of the refrigerant flowing in each of the pipe lines.

7. The refrigeration cycle device according to claim 3, wherein the sensor is a flow rate sensor disposed in a pipe line between the first inflow/outflow port and the use-side heat exchanger or a pipe line between the second inflow/outflow port and the heat-source-side heat exchanger to detect a direction of flow of the refrigerant in the pipe line.

FIG.1

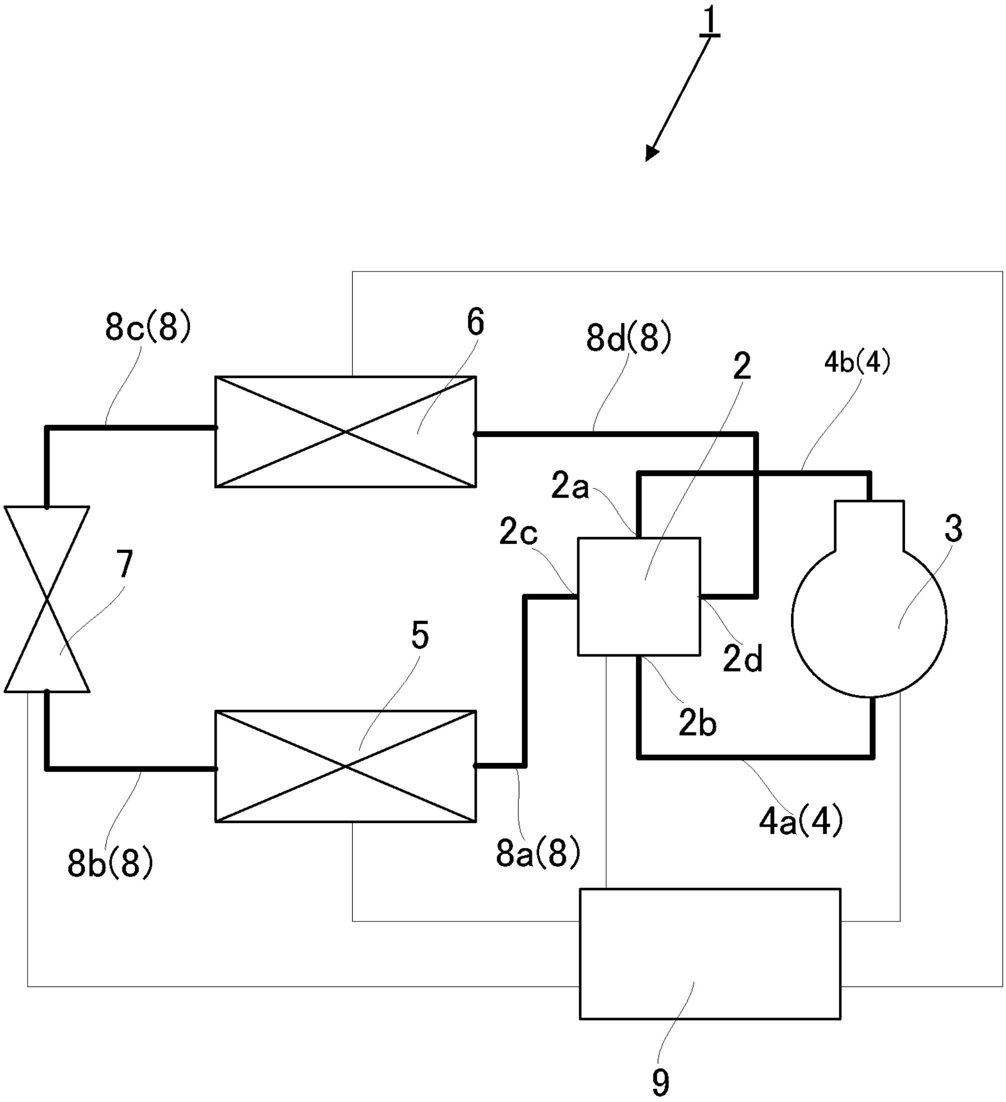
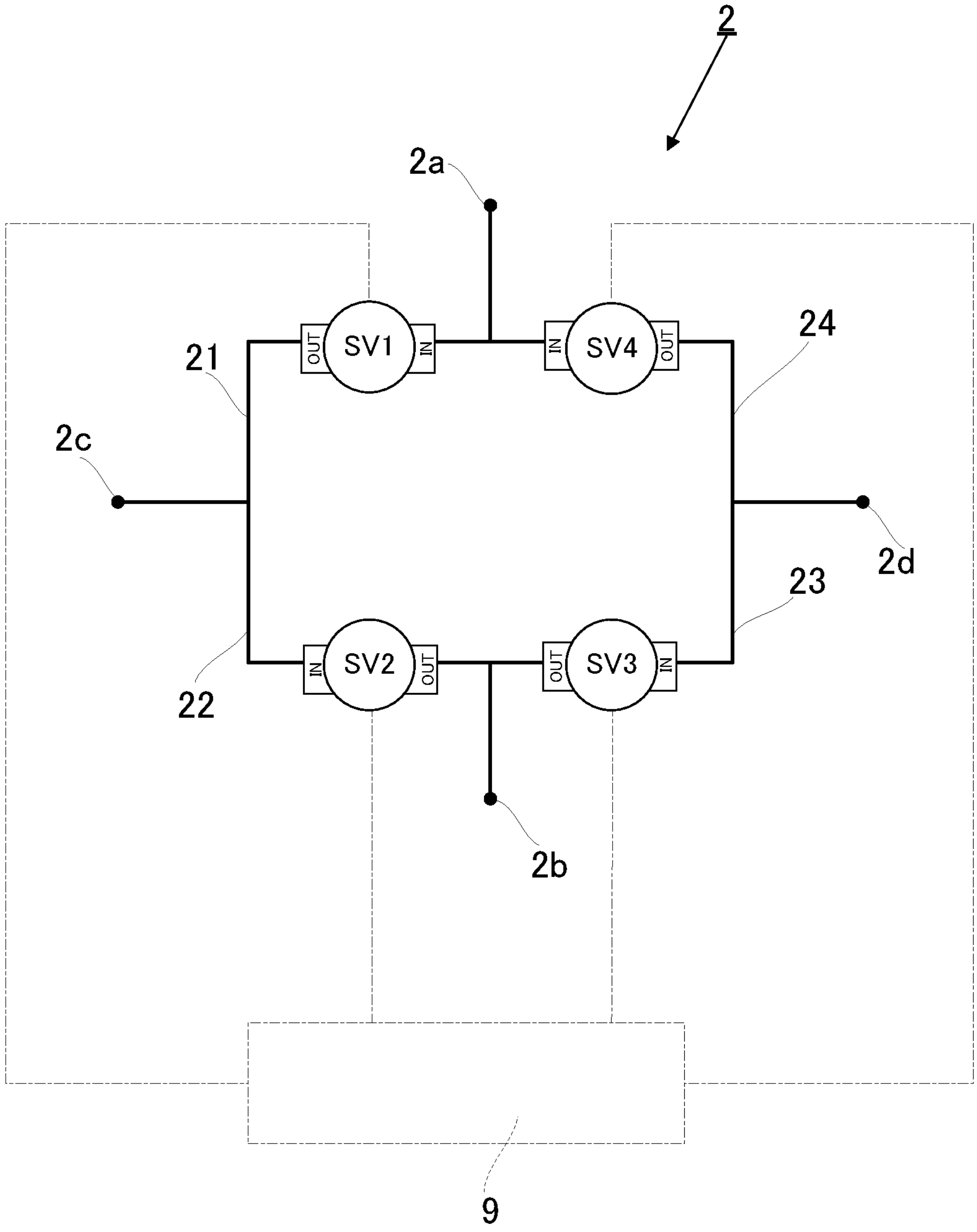


FIG.2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2a
SV1
SV4
OUT
IN
IN
OUT
21
24
2c
2d
23
22
SV2
SV3
IN
OUT
OUT
IN
2b
9

FIG.3A

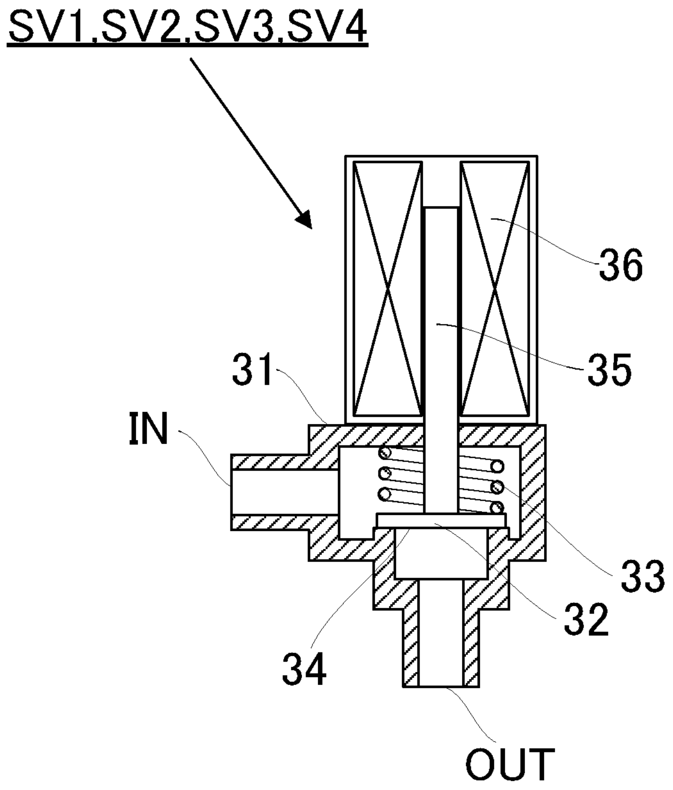


FIG.3B

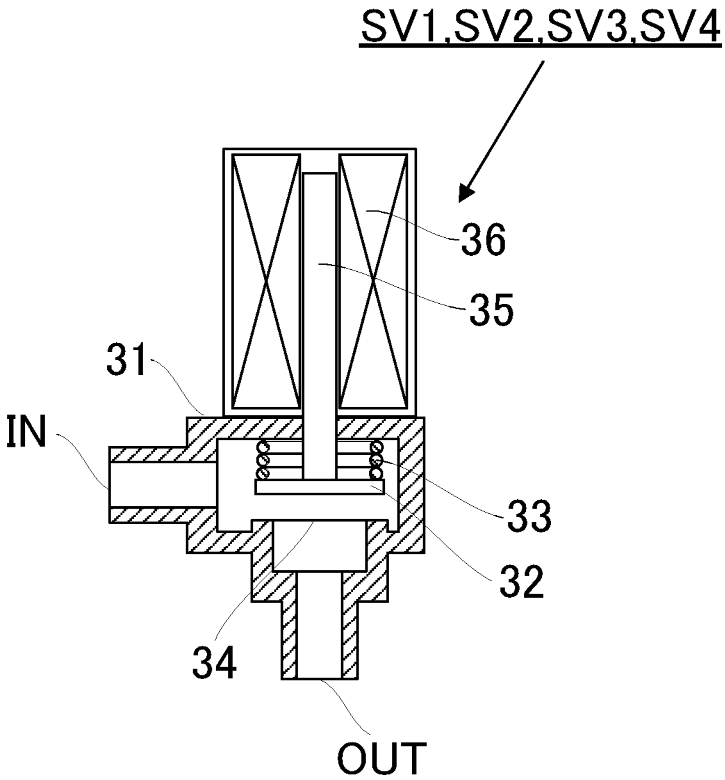


FIG.4

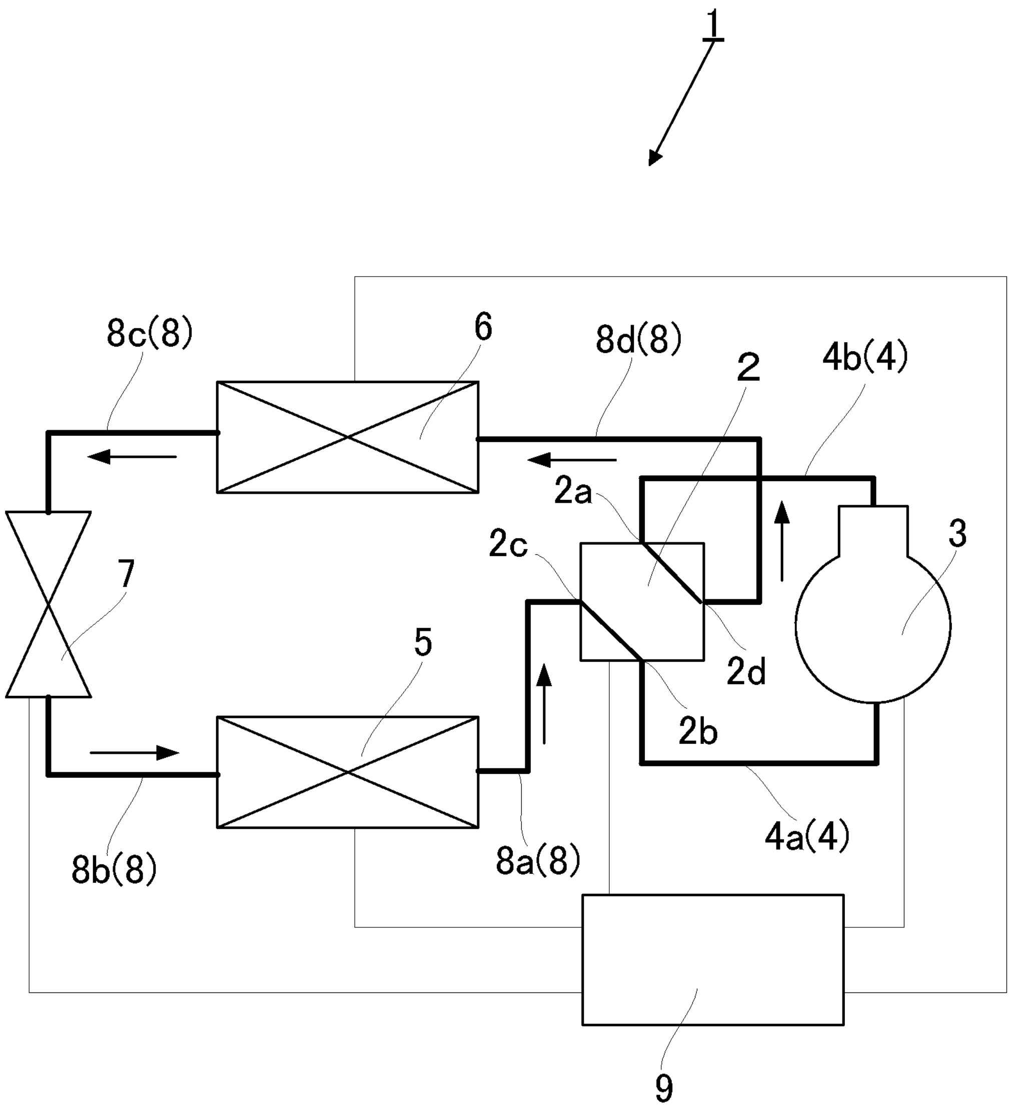


FIG.5

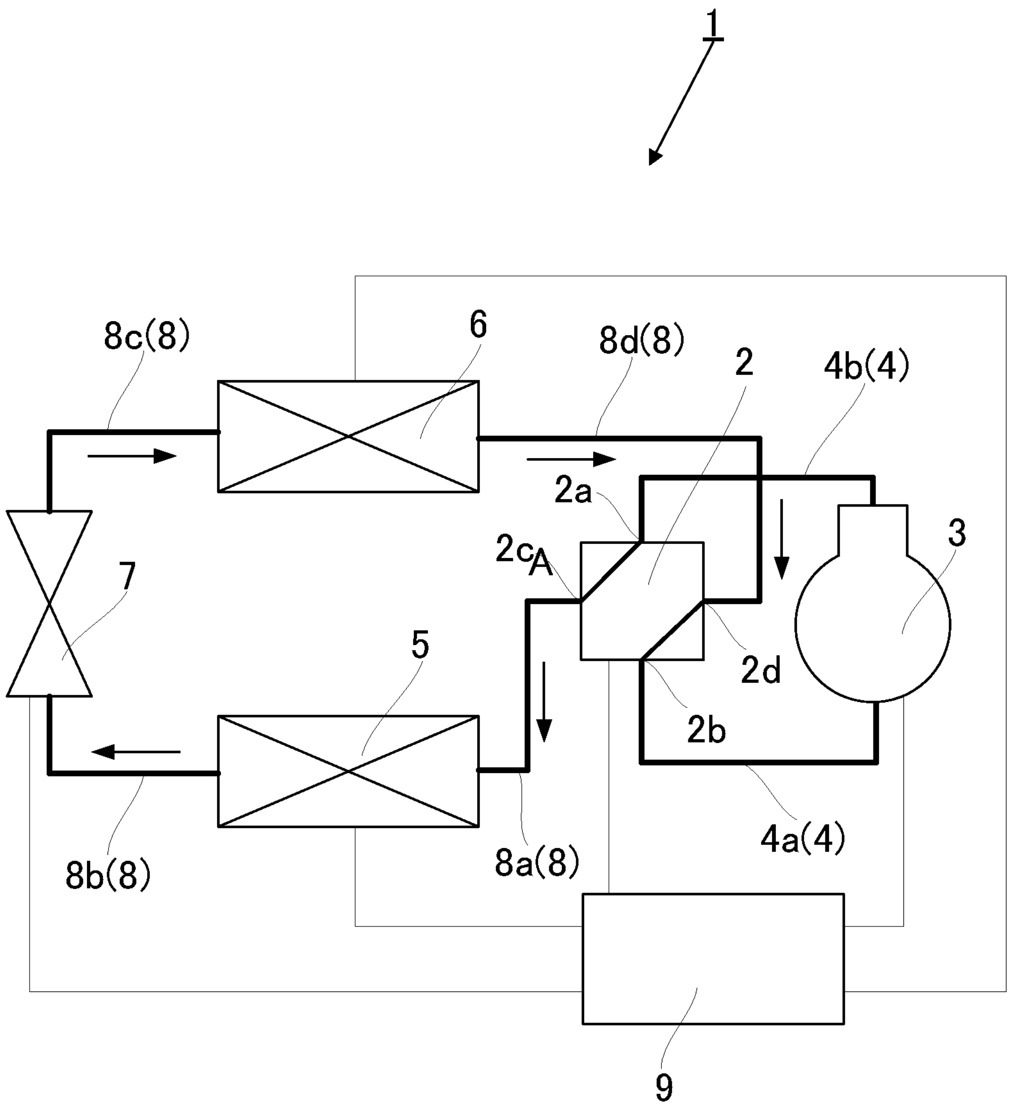
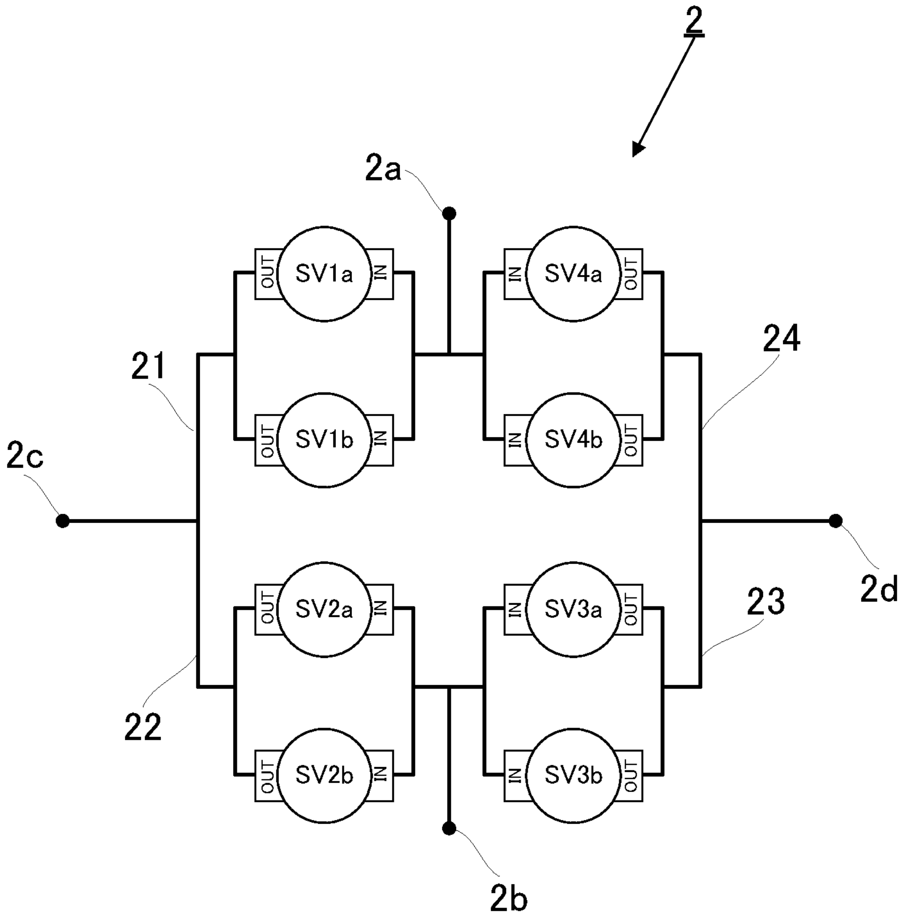


FIG.6


2
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SV1a
OUT
IN
SV4a
IN
OUT
21
24
SV1b
OUT
IN
SV4b
IN
OUT
2c
SV2a
OUT
IN
SV3a
IN
OUT
23
2d
22
SV2b
OUT
IN
SV3b
IN
OUT
2b

FIG.7

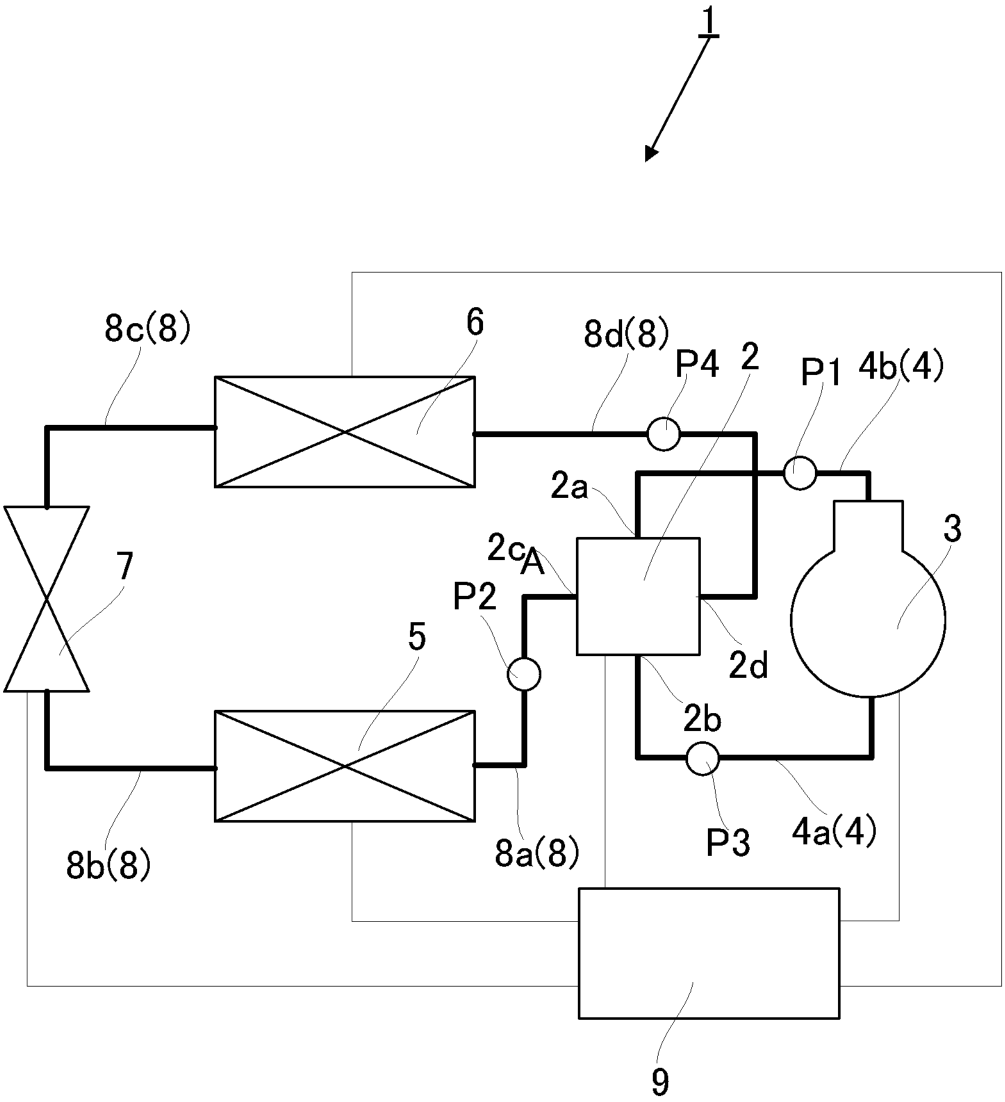


FIG.8

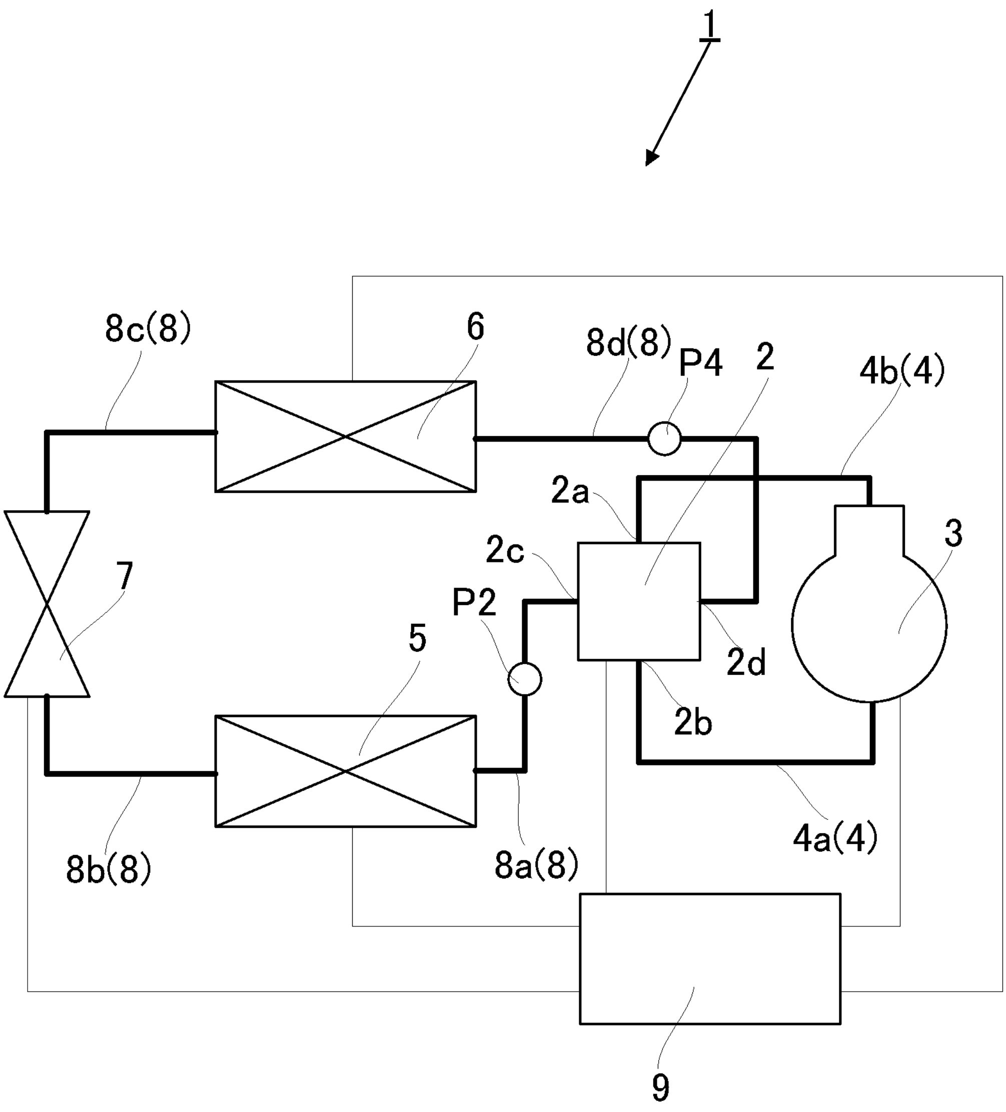


FIG.9

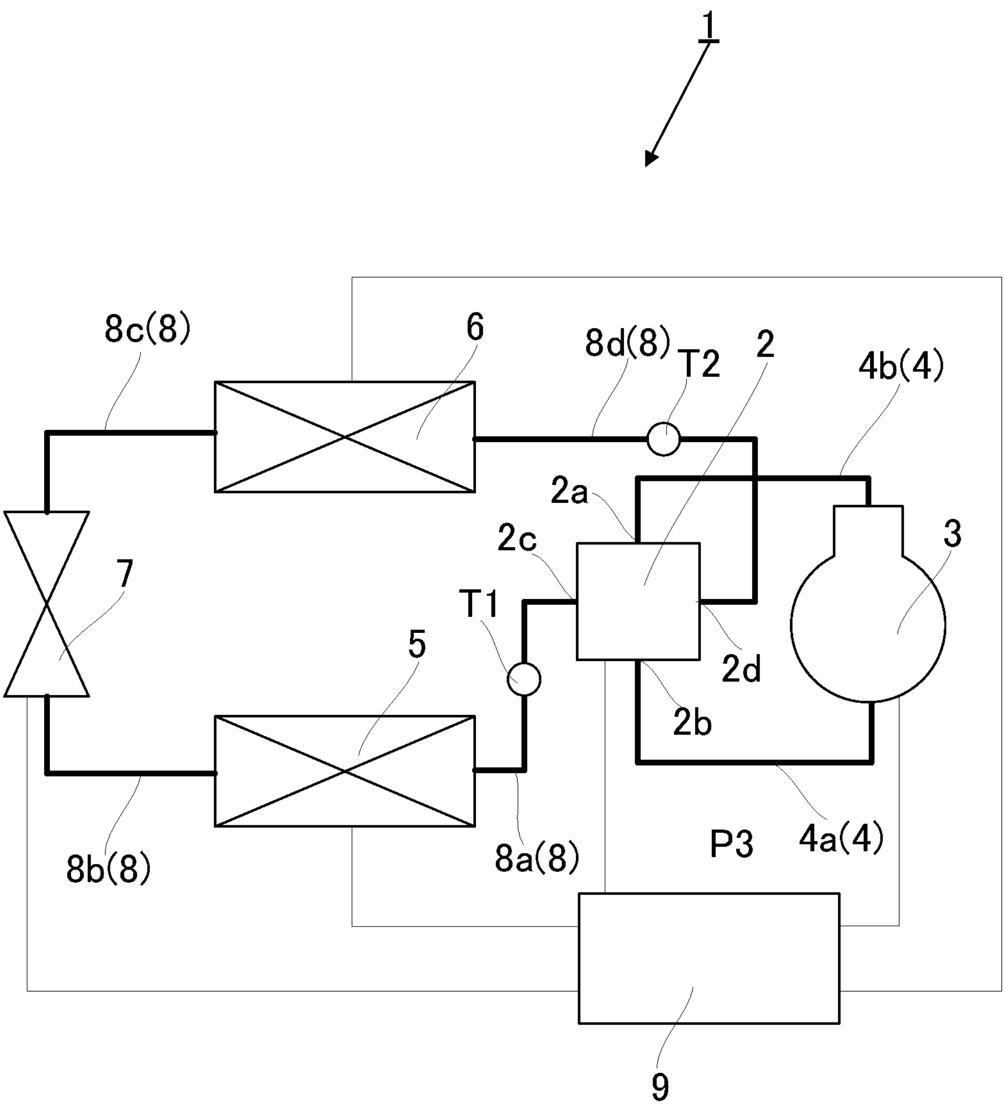
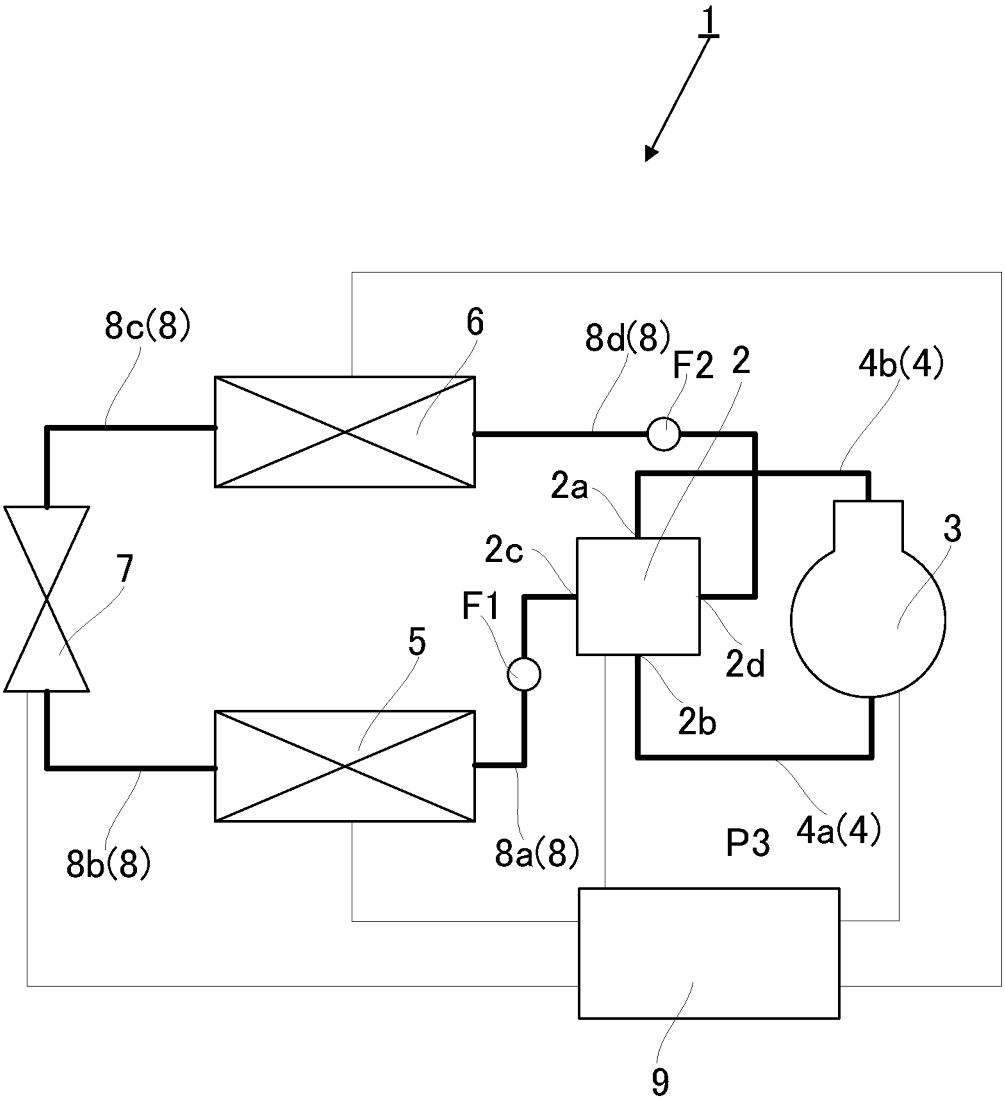


FIG.10



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2019/020680

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl. F25B41/04(2006.01)i, F25B13/00(2006.01)i, F25B49/02(2006.01)i

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. F25B41/04, F25B13/00, F25B49/02

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	1971-2019
Registered utility model specifications of Japan	1996-2019
Published registered utility model applications of Japan	1994-2019

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.
X Y A	JP 2011-80654 A (FUJIKOKI CORPORATION) 21 April 2011, fig. 1-4 (Family: none)	1 3-7 2
X Y A	JP 2005-16890 A (DAIKIN INDUSTRIES, LTD.) 20 January 2005, fig. 1 (Family: none)	1 3-7 2

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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
01.07.2019	09.07.2019

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

International application No.
PCT/JP2019/020680

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	JP 2008-249268 A (MITSUBISHI ELECTRIC CORPORATION) 16 October 2008, fig. 1, 2 (Family: none)	1 3-7 2
Y	JP 6-50642 A (DAIKIN INDUSTRIES, LTD.) 25 February 1994, paragraphs [0027]-[0053], fig. 1-8 (Family: none)	3-7

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

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- JP 2002316531 A **[0007]**
- JP 2002022041 A **[0007]**
- JP 2018240670 A **[0058]**