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

(11) EP 3 306 230 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
11.04.2018 Bulletin 2018/15

(51) Int Cl.:
F25B 30/02 *(2006.01)*

(21) Application number: **17194420.0**

(22) Date of filing: **02.10.2017**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD

(30) Priority: **05.10.2016 JP 2016197358**

(71) Applicant: **MITSUBISHI HEAVY INDUSTRIES THERMAL SYSTEMS, LTD.**
Tokyo 108-8215 (JP)

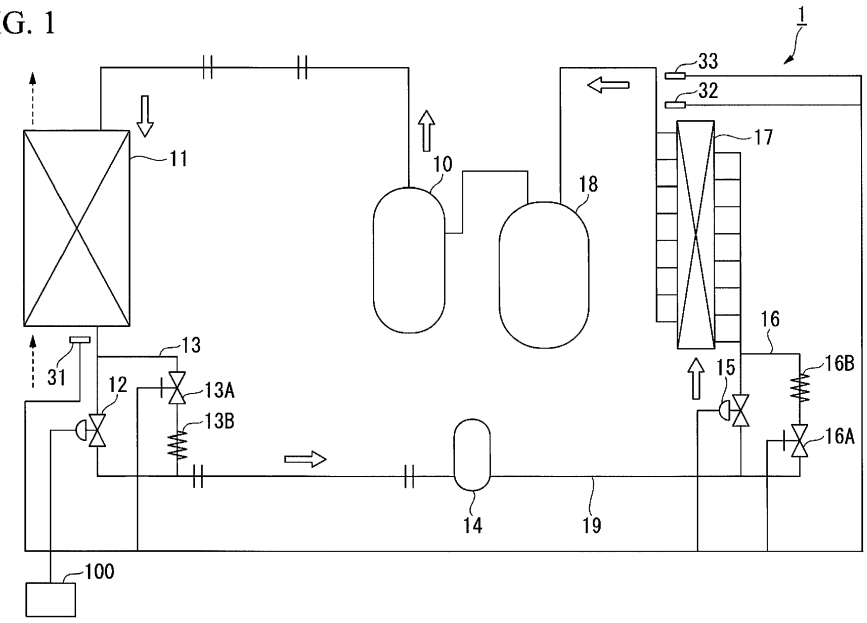
(72) Inventors:
- **MAENO, Masashi**
  TOKYO, 108-8215 (JP)
- **YOSHIDA, Shigeru**
  TOKYO, 108-8215 (JP)
- **NAKANO, Gaku**
  TOKYO, 108-8215 (JP)

(74) Representative: **Intès, Didier Gérard André et al**
Cabinet Beau de Loménie
158 rue de l'Université
75340 Paris Cedex 07 (FR)

(54) REFRIGERANT CIRCUIT SYSTEM AND CONTROL METHOD

(57) There is provided a refrigerant circuit system (1) capable of being effectively operated even if there is a change in a utilization-side inlet temperature of a heat pump or the like. The refrigerant circuit system (1) includes a compressor (10), a utilization-side heat exchanger (11), a receiver (14), a first expansion valve (12) configured to depressurize a refrigerant introduced from the utilization-side heat exchanger (11), a receiver, a second expansion valve (15) configured to depressurize the refrigerant flowing out from the receiver, a heat source-side heat exchanger (17), a first bypass circuit (13) configured to bypass the flow of the refrigerant passing through the first expansion valve (12), a second bypass circuit (16) configured to bypass the flow of the refrigerant passing through the second expansion valve (15), and a control device (100) configured to control opening and closing of the first bypass circuit (13) and opening and closing of the second bypass circuit (16).

FIG. 1



EP 3 306 230 A1

Description

CROSS-REFERENCE TO RELATED APPLICATION

[0001] Priority is claimed on Japanese Patent Application No. 2016-197358, filed October 5, 2016, the content of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] The present invention relates to a refrigerant circuit system and a control method.

Description of Related Art

[0003] A water heater using a heat pump has a once-through system which supplies hot water obtained by heating low temperature feed water to a target temperature and a circulation system which heats circulated feed water to a target temperature and then supplies the heated water. In the once-through system, the feed water having an arbitrary temperature (for example, 5°C) varying according to an external air temperature or the like is heated to a set temperature (for example, 80°C). Meanwhile, in the circulation system, warm water having a predetermined temperature (for example, 75°C) is heated to the set temperature (for example, 80°C). The following refrigerant circuit provided in the water heater corresponding to both of the once-through system and the circulation system can be considered. That is, the refrigerant circuit includes a condenser, a receiver, an evaporator, a compressor and the like which increases the temperature of the feed water and further includes expansion valves which are located on a downstream side of the condenser and an upstream side of the evaporator with the receiver interposed therebetween. In this refrigerant circuit, since there is a change (for example, 5°C and 75°C) in a utilization-side inlet temperature of the condenser, it is necessary to use a heat exchanger having a capacity capable of responding to the change in the utilization-side inlet temperature in the condenser.

[0004] Further, Patent Document 1 discloses a refrigeration cycle apparatus which is capable of switching between a two-stage compression operation and a single-stage compression operation according to a load.

[Citation List]

[Patent Documents]

[0005] [Patent Document 1] Japanese Unexamined Patent Application, First Publication No. 2007-10282

[0006] However, when the utilization-side inlet temperature is low (for example, 5°C), a pressure difference between a front and a rear of the expansion valve on the downstream side of the condenser is increased. In this case, since the pressure difference is large, the flow rate of a refrigerant can be secured by a small-diameter expansion valve. Meanwhile, when the utilization-side inlet temperature is high (for example, 75°C), the pressure difference between the front and the rear of the expansion valve on the downstream side of the condenser is reduced. Therefore, a large-diameter expansion valve is required to secure the required flow rate of the refrigerant. In order to respond to a magnitude of the pressure difference, for example, it is conceivable that a large-diameter flow rate control valve may be used in the expansion valve on the downstream side of the condenser, but when the pressure difference is large, a flow rate adjustment at a low opening degree is required. However, there is a problem that the control of the large-diameter flow rate control valve in a low opening degree range has a large amount of change per pulse and thus stable control is difficult. In addition, there is also a problem that cost is increased when the large-diameter flow rate control valve is used.

SUMMARY OF THE INVENTION

[0007] Accordingly, it is an object of the present invention to provide a refrigerant circuit system and a control method which are capable of solving the above-described problems.

[0008] A first aspect of the present invention is a refrigerant circuit system including one or a plurality of compressors configured to compress a refrigerant, a utilization-side heat exchanger configured to condense the refrigerant compressed by the compressor, a first expansion valve configured to depressurize the refrigerant introduced from the utilization-side heat exchanger, a receiver configured to store some of the refrigerant depressurized by the first expansion valve, a second expansion valve configured to depressurize the refrigerant flowing out from the receiver, a heat source-side heat exchanger configured to evaporate the refrigerant depressurized by the second expansion valve, a first bypass circuit configured to bypass the flow of the refrigerant passing through the first expansion valve, and a control device configured to control opening and closing of the first bypass circuit.

[0009] A second aspect of the present invention is a refrigerant circuit system including one or a plurality of compressors configured to compress a refrigerant, a utilization-side heat exchanger configured to condense the refrigerant compressed by the compressor, a first expansion valve configured to depressurize the refrigerant introduced from the utilization-side heat exchanger, a receiver configured to store some of the refrigerant depressurized by the first expansion valve, a second expansion valve configured to depressurize the refrigerant flowing out from the receiver, a heat source-side heat exchanger configured to evaporate the refrigerant depressurized by the second expansion valve, a second bypass circuit configured to bypass the flow of the refrigerant passing through the second expansion valve, and a control device

configured to control opening and closing of the second bypass circuit.

[0010] A third aspect of the present invention is a refrigerant circuit system including one or a plurality of compressors configured to compress a refrigerant, a utilization-side heat exchanger configured to condense the refrigerant compressed by the compressor, a first expansion valve configured to depressurize the refrigerant introduced from the utilization-side heat exchanger, a receiver configured to store some of the refrigerant depressurized by the first expansion valve, a second expansion valve configured to depressurize the refrigerant flowing out from the receiver, a heat source-side heat exchanger configured to evaporate the refrigerant depressurized by the second expansion valve, a first bypass circuit configured to bypass the flow of the refrigerant passing through the first expansion valve, a second bypass circuit configured to bypass the flow of the refrigerant passing through the second expansion valve, and a control device configured to control opening and closing of the first bypass circuit and opening and closing of the second bypass circuit.

[0011] The control device in a fourth aspect of the present invention may control the opening and closing of the first bypass circuit on the basis of an outlet side temperature of the utilization-side heat exchanger or an outlet side supercooling degree of the utilization-side heat exchanger and an opening degree of the first expansion valve.

[0012] The control device in a fifth aspect of the present invention may control the opening and closing of the second bypass circuit on the basis of the outlet side superheat degree of the heat source-side heat exchanger or a suction side superheat degree of the compressor and an opening degree of the second expansion valve.

[0013] A sixth aspect of the present invention is a refrigerant circuit system described in one of the above aspects wherein the compressors include a high stage-side compressor and a low stage-side compressor, and which further includes an injection circuit configured to supply the refrigerant flowing out from the receiver to a high stage-side compressor, a third expansion valve provided at a middle portion of the injection circuit, and a third bypass circuit configured to bypass the flow of the refrigerant passing through the injection circuit in the refrigerant circuit system, and wherein the control device also controls the opening and closing of the third bypass circuit.

[0014] A seventh aspect of the present invention is a control method in a refrigerant circuit system which includes one or a plurality of compressors configured to compress a refrigerant, a utilization-side heat exchanger configured to condense the refrigerant compressed by the compressor, a first expansion valve configured to depressurize the refrigerant introduced from the utilization-side heat exchanger, a receiver configured to store some of the refrigerant depressurized by the first expansion valve, a second expansion valve configured to depressurize the refrigerant flowing out from the receiver, a heat source-side heat exchanger configured to evaporate the refrigerant depressurized by the second expansion valve, and a first bypass circuit configured to bypass the flow of the refrigerant passing through the first expansion valve, wherein opening and closing of the first bypass circuit is controlled on the basis of the outlet side temperature of the utilization-side heat exchanger or an outlet side supercooling degree of the utilization-side heat exchanger and an opening degree of the first expansion valve.

[0015] An eighth aspect of the present invention is a control method in a refrigerant circuit system which includes one or a plurality of compressors configured to compress a refrigerant, a utilization-side heat exchanger configured to condense the refrigerant compressed by the compressor, a first expansion valve configured to depressurize the refrigerant introduced from the utilization-side heat exchanger, a receiver configured to store some of the refrigerant depressurized by the first expansion valve, a second expansion valve configured to depressurize the refrigerant flowing out from the receiver, a heat source-side heat exchanger configured to evaporate the refrigerant depressurized by the second expansion valve, and a second bypass circuit configured to bypass the flow of the refrigerant passing through the second expansion valve, wherein opening and closing of the second bypass circuit is controlled on the basis of the outlet side superheat degree of the heat source-side heat exchanger or the suction side superheat degree of the compressor and the opening degree of the second expansion valve.

[0016] According to the present invention, an efficient operation can be allowed using a flow rate control valve having a predetermined diameter in the expansion valve even if the utilization-side inlet temperature is changed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017]

FIG. 1 is a first diagram showing an example of a refrigerant circuit system in a first embodiment of the present invention.

FIG. 2 is a P-h diagram of the refrigerant circuit system in the first embodiment of the present invention.

FIG. 3 is a flowchart of a control device in the first embodiment of the present invention.

FIG. 4 is a second diagram showing an example of the refrigerant circuit system in the first embodiment of the present invention.

FIG. 5 is a third diagram showing an example of the refrigerant circuit system in the first embodiment of the present invention.

FIG. 6 is a view showing an example of a refrigerant circuit system in a second embodiment of the present invention.

FIG. 7 is a P-h diagram of the refrigerant circuit sys-

tem in the second embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

<First embodiment>

[0018] Hereinafter, a refrigerant circuit system according to a first embodiment of the present invention will be described with reference to FIGS. 1 to 5.

[0019] FIG. 1 is a first diagram showing an example of a refrigerant circuit system in a first embodiment of the present invention.

[0020] A refrigerant circuit system 1 is a refrigerant circuit used for a water heater. The refrigerant circuit system 1 heats feed water supplied from an outside to a predetermined temperature (for example, 80°C) and supplies the hot water to a user. The embodiment provides the refrigerant circuit system 1 which is capable of efficiently supplying the hot water when the temperature of the feed water supplied from the outside is changed (for example, 5°C and 75°C).

[0021] As shown in FIG. 1, the refrigerant circuit system 1 includes a compressor 10, a utilization-side heat exchanger (condenser) 11, a first expansion valve 12, a first bypass circuit 13, a receiver 14, a second expansion valve 15, a second bypass circuit 16, a heat source-side heat exchanger (evaporator) 17, an accumulator 18, a pipe 19 which connects the above-described elements, and a control device 100. A first two-way valve 13A and a first capillary tube 13B are provided in first bypass circuit 13. A second two-way valve 16A and a second capillary tube 16B are provided in the second bypass circuit 16.

[0022] Further, the specific constitution of the refrigerant circuit system 1 shown in FIG. 1 schematically shows a basic constitution of the refrigerant circuit system 1 and may further include other elements.

[0023] The compressor 10 compresses a refrigerant and discharges a high-pressure refrigerant. The high-pressure refrigerant is supplied to the utilization-side heat exchanger 11. The utilization-side heat exchanger 11 serves as a condenser. The high-pressure refrigerant supplied to the utilization-side heat exchanger 11 exchanges heat with the feed water used by the user, radiates heat and is condensed and liquefied. Meanwhile, the feed water supplied to the utilization-side heat exchanger 11 absorbs heat from the high-pressure refrigerant, is heated to a predetermined set temperature (utilization-side outlet temperature) and is provided to the user. Further, in the drawing, a dotted arrow indicates the flow direction of the feed water, and a solid arrow indicates the flow direction of the refrigerant.

[0024] The high-pressure refrigerant after the heat exchange is depressurized and expanded in the first expansion valve 12 and is supplied to the receiver 14. The receiver 14 is a pressure container which temporarily stores some of the supplied refrigerant. In the receiver 14, a two-phase refrigerant in which a gas and a liquid are mixed is present. The refrigerant flowing out from the receiver 14 is further depressurized and expanded in the second expansion valve 15 and becomes a low-pressure refrigerant. The low-pressure refrigerant is supplied to the heat source-side heat exchanger 17. The heat source-side heat exchanger 17 serves as an evaporator. The low-pressure refrigerant supplied to the heat source-side heat exchanger 17 absorbs heat from a heat source such as external air so that a temperature thereof is increased, and thus the low pressure refrigerant is evaporated. The low-pressure refrigerant is supplied to the accumulator 18. The low-pressure refrigerant is separated into gas and liquid by the accumulator 18, and only the gas refrigerant is suctioned into the compressor 10. The refrigerant is again made into a high pressure refrigerant by the compressor 10 and circulates through the above-described route.

[0025] Here, the first expansion valve 12 and the second expansion valve 15 are flow rate control valves, and an opening degree thereof is adjusted by the control device 100. For example, the opening degree of the first expansion valve 12 is controlled with the goal of an outlet side temperature of the utilization-side heat exchanger 11 becoming higher than a utilization-side inlet temperature by a predetermined temperature (for example, 2°C). The utilization-side inlet temperature is the temperature of the feed water flowing into the utilization-side heat exchanger 11. In the embodiment, the temperature of the feed water is, for example, 5 °C or 75°C (5°C in the case of a once-through system and 75°C in the case of a circulation system). For example, if the outlet side temperature of the utilization-side heat exchanger 11 is higher than a target temperature (for example, the target temperature is 77°C) when the utilization-side inlet temperature is 75°C, the control device 100 increases the opening degree of the first expansion valve 12 and performs control so that the outlet side temperature becomes the target temperature. Here, the first bypass circuit 13 is a circuit which bypasses the flow of the refrigerant passing through the first expansion valve 12. When the pressure difference between the front and the rear of the first expansion valve 12 is small, an amount of the refrigerant flowing through the refrigerant circuit may be reduced, and thus the control device 100 opens the first bypass circuit 13 and secures the flow rate of the refrigerant. Specifically, the control device 100 performs the control to open the first two-way valve 13A. When the first two-way valve 13A is controlled to be in an open state, the refrigerant flowing out from the utilization-side heat exchanger 11 passes through the first expansion valve 12 and the first bypass circuit 13 and is supplied to the receiver 14. Further, for example, when the first expansion valve 12 is fully opened and the first two-way valve 13A is controlled to be in the open state, the first capillary tube 13B is provided to adjust resistance such that the refrigerant does not flow into only the first bypass circuit 13 side.

[0026] Further, for example, the opening degree of the

second expansion valve 15 is controlled with the goal of the outlet side temperature of the heat source-side heat exchanger 17 becoming a predetermined superheat degree (for example, 3K). For example, when the superheat degree on an outlet side of the heat source-side heat exchanger 17 is 10K, the control device 100 performs control to increase the opening degree of the second expansion valve 15. Here, the second bypass circuit 16 is a circuit which bypasses the flow of the refrigerant passing through the second expansion valve 15. When the pressure difference between the front and the rear of the second expansion valve 15 is small, the amount of the refrigerant flowing through the refrigerant circuit may be reduced, and thus the control device 100 opens the second bypass circuit 16 and secures the flow rate of the refrigerant flowing through the refrigerant circuit. Specifically, the control device 100 performs control so that the second two-way valve 16A is in the open state. In this case, the refrigerant flowing out from the receiver 14 passes through both the second expansion valve 15 and the second bypass circuit 16 and is supplied to the heat source-side heat exchanger 17. Further, for example, when the second expansion valve 15 is fully opened and the second two-way valve 16A is controlled to be in the open state, the second capillary tube 16B is provided to adjust the resistance such that the refrigerant does not flow into only the second bypass circuit 16 side.

[0027] Further, a temperature sensor 31 is provided on an outlet side of the utilization-side heat exchanger 11, and a temperature sensor 32 and a pressure sensor 33 are provided on the outlet side of the heat source-side heat exchanger 17. The control device 100 obtains the outlet side temperature of the utilization-side heat exchanger 11 which is measured by the temperature sensor 31, the outlet side temperature of the heat source-side heat exchanger 17 which is measured by the temperature sensor 32 and an outlet side pressure of the heat source-side heat exchanger 17 which is measured by the pressure sensor 33. Further, the control device 100 controls the valve opening degrees of the first expansion valve 12 and the second expansion valve 15. In addition, the control device 100 controls opening and closing of the first two-way valve 13A on the basis of the valve opening degree of the first expansion valve 12 and the temperature measured by the temperature sensor 31. Also, the control device 100 controls the opening and closing of the second two-way valve 16A on the basis of the valve opening degree of the second expansion valve 15, the temperature measured by the temperature sensor 32 and the pressure measured by the pressure sensor 33. Further, the control device 100 is a computer device such as a microcomputer.

[0028] When both of the utilization-side outlet temperature and the utilization-side inlet temperature are constant, it is possible to design each of the first expansion valve 12 and the second expansion valve 15 having a capacity according to the operation. However, when the utilization-side outlet temperature is constant (for example, 80°C.) and the utilization-side inlet temperature varies (5°C and 75°C) as in the embodiment, a change occurs also in a pressure range (control region) which is controlled by the first expansion valve 12 and the second expansion valve 15. Next, a variation of the pressure range which is controlled by the first expansion valve 12 and the second expansion valve 15 will be described with reference to FIG. 2.

[0029] FIG. 2 is a P-h diagram of the refrigerant circuit system in the first embodiment of the present invention.

[0030] FIG. 2 is a relationship diagram of the pressure and the enthalpy which indicates a refrigeration cycle of the refrigerant circuit system 1 according to the embodiment. In FIG. 2, each symbol indicates the following state. That is, A1 indicates the state of the high temperature and high pressure refrigerant discharged from the compressor 10, A2 indicates the state of the refrigerant on the outlet side of the utilization-side heat exchanger 11 when the utilization-side inlet temperature is high (for example, 75°C), A3 indicates the state of the refrigerant on the outlet side of the first expansion valve 12 when the utilization-side inlet temperature is high, A4 indicates the state of the refrigerant on the outlet side of the second expansion valve 15 when the utilization-side inlet temperature is high, A5 indicates the state of the refrigerant on the outlet side of the utilization-side heat exchanger 11 when the utilization-side inlet temperature is low (for example, 5°C), A6 indicates the state of the refrigerant on the outlet side of the first expansion valve 12 when the utilization-side inlet temperature is low, A7 indicates the state of the refrigerant on the outlet side of the second expansion valve 15 when the utilization-side inlet temperature is low, and A8 indicates the state of the refrigerant on the outlet side of the heat source-side heat exchanger 17.

[0031] The change in the control region of the first expansion valve 12 and the second expansion valve 15 corresponding to a change in the utilization-side inlet temperature are as follows.

(When utilization-side inlet temperature is high)

[0032] The high temperature and high pressure refrigerant (state A1) discharged from the compressor 10 slightly radiates heat to the feed water in the utilization-side heat exchanger 11, is condensed and liquefied and becomes a high pressure liquid refrigerant (state A2). Then, the refrigerant (state A3) having passed through the first expansion valve 12 and slightly depressurized (PH2) reaches the second expansion valve 15 via the receiver 14. Additionally, the refrigerant is further depressurized (PL2) by the second expansion valve 15 (state A4), flows into the heat source-side heat exchanger 17, absorbs heat from the external air to be evaporated and becomes a low pressure gas refrigerant (state A8). The low pressure gas refrigerant flows into the accumulator 18, only the gas refrigerant is suctioned into the compressor 10, and the same cycle is repeated again.

[0033] In the refrigeration cycle, the pressure difference between the front and the rear of the first expansion valve 12 is a low differential pressure (PH2). On the other hand, the pressure difference between the front and the rear of the second expansion valve 15 is a high differential pressure (PL2). That is, the control region due to the second expansion valve 15 has the high differential pressure, and the control region due to the first expansion valve 12 has a low differential pressure.

(When utilization-side inlet temperature is low)

[0034] The high temperature and high pressure refrigerant (state A1) discharged from the compressor 10 radiates a large amount of heat to the feed water in the utilization-side heat exchanger 11, is condensed and liquefied and becomes a high pressure liquid refrigerant (state A5). Then, the refrigerant (state A6) greatly depressurized (PH1) by passing through the first expansion valve 12 reaches the second expansion valve 15 via the receiver 14. Additionally, the refrigerant is slightly depressurized (PL1) (state A7) by the second expansion valve 15 and flows into the heat source-side heat exchanger 17. Next, the refrigerant is evaporated by the heat source-side heat exchanger 17 and becomes a low pressure gas refrigerant (state A8). The low pressure gas refrigerant flows into the accumulator 18, only the gas refrigerant is suctioned into the compressor 10, and the same cycle is repeated again.

[0035] In the refrigeration cycle, the pressure difference between the front and the rear of the first expansion valve 12 is a high differential pressure (PH1). On the other hand, the pressure difference between the front and the rear of the second expansion valve 15 is a low differential pressure (PL1). That is, the control region due to the first expansion valve 12 has a high differential pressure, and the control region due to the second expansion valve 15 has a low differential pressure.

[0036] As described above, the pressure difference which should be controlled by the first expansion valve 12 is largely different between the case (PH2) in which the utilization-side inlet temperature is high and the case (PH1) in which the utilization-side inlet temperature is low. Similarly, the pressure difference which should be controlled by the second expansion valve 15 is largely different between the case (PL2) in which the utilization-side inlet temperature is high and the case (PL1) in which the utilization-side inlet temperature is low.

[0037] If it is matched with the operation in the case in which the utilization-side inlet temperature is low (the control region has the high differential pressure), the flow rate of the refrigerant can be secured even if the flow rate control valve having a small diameter is used in the first expansion valve 12. However, when considering the operation in the case in which the utilization-side inlet temperature is high (the control range has the low differential pressure), the flow rate of the refrigerant cannot be secured unless the flow rate control valve having a relatively large diameter is used in the first expansion valve 12.

[0038] Similarly, in the second expansion valve 15, if it is matched with the operation in the case in which the utilization-side inlet temperature is high (the control region has the high differential pressure), the flow rate of the refrigerant can be secured even if the flow rate control valve having the small diameter is used in the second expansion valve 15. However, when the utilization-side inlet temperature is low (the control range has the low differential pressure), the flow rate of the refrigerant cannot be secured unless the flow rate control valve having the relatively large diameter should be used in the second expansion valve 15. When the flow rate of the refrigerant cannot be secured, a problem that the superheat degree of the refrigerant due to the evaporator is increased and the coefficient of performance (COP) is lowered occurs.

[0039] In order to secure the flow rate of the refrigerant, the problem may be solved by using the flow rate control valve having the large diameter as both of the first expansion valve 12 and the second expansion valve 15. However, in the case of the flow rate control valve having the large diameter, there is a problem that the flow rate change per pulse at low opening is large and fine control is difficult. Further, when the flow rate control valve having the large diameter is used, there is also a problem that cost is increased. Therefore, in the embodiment, the diameter of the flow rate control valve used in the first expansion valve 12 and the second expansion valve 15 is selected assuming the case of a normal differential pressure, and the bypass circuit (the first bypass circuit 13, the second bypass circuit 16) having a throttle function which can be opened and closed is provided in parallel with the first expansion valve 12 and the second expansion valve 15. Additionally, when the front and the rear of the flow rate control valve have the low differential pressure according to operating conditions, the flow rate of the refrigerant is secured by opening the bypass circuit and flowing the refrigerant to both of the flow rate control valve and the bypass circuit. That is, the necessary flow rate of the refrigerant is secured by reducing the flow rate of the refrigerant flowing through the flow rate control valve side and flowing the remaining refrigerant to the bypass circuit side. Meanwhile, when the front and the rear of the flow rate control valve has the high differential pressure, the bypass circuit is closed so that the refrigerant flows through only the flow rate control valve, and thus the fine flow rate control is performed by the flow rate control valve.

[0040] Specifically, in a state transition of the refrigerant shown in FIG. 2, when the utilization-side inlet temperature is high, the control device 100 determines whether the flow rate of the refrigerant is insufficient and performs control to open the first bypass circuit 13 (the first two-way valve 13A) when the flow rate of the refrigerant is insufficient. Also, when the utilization-side inlet temperature is low, the control device 100 performs control to open the second bypass circuit 16 (the second two-way valve 16A) if the refrigerant flow rate is insuffi-

cient.

[0041] Next, the opening and closing control of the first bypass circuit 13 and the second bypass circuit 16 by the control device 100 will be described in detail using the constitution of FIG. 1 as an example.

[0042] FIG. 3 is a flowchart of the control device in the first embodiment of the present invention.

[0043] As a premise, the control device 100 acquires information on the temperature measured by the temperature sensor 31 and the temperature sensor 32 at predetermined time intervals and records the acquired information on the temperature in a built-in memory part (not shown). Further, the control device 100 acquires information on the pressure measured by the pressure sensor 33 at predetermined time intervals and records the acquired information on the pressure in the memory part. Furthermore, the control device 100 controls the number of rotations (frequency) of the compressor 10 and the opening degree of each of the first expansion valve 12 and the second expansion valve 15, and these values during the operation are recorded in the memory part. Hereinafter, the case in which the opening and closing of the first expansion valve 12 is controlled on the basis of the valve opening degree of the first expansion valve 12 and the outlet side temperature of the utilization-side heat exchanger 11 which is measured by the temperature sensor 31 will be described as an example.

[0044] First, the control device 100 reads the valve opening degree of the first expansion valve 12 from the memory part. Next, the control device 100 determines whether the read valve opening degree is within a predetermined range (Step S11). The predetermined range is, for example, 20% to 80%. When the valve opening degree is within the predetermined range (Step S11; Yes), the control device 100 continues the normal operation (Step S17). When the normal operation is continued, the control device 100 continues the adjustment of the valve opening degree so that the outlet side temperature of the utilization-side heat exchanger 11 is higher than the utilization-side inlet temperature by a predetermined temperature (for example, 2°C). Further, regarding the control of the valve opening degree of the first expansion valve 12, a pressure sensor is provided on the outlet side of the utilization-side heat exchanger 11, and the control device 100 may find a saturation temperature at the pressure indicated by a measurement result of the pressure sensor and may control the valve opening degree so that a supercooling degree which is a value obtained by subtracting the temperature measured by the temperature sensor 31 from the saturation temperature becomes a predetermined target value.

[0045] Further, when the valve opening degree is not within the predetermined range (Step S11; No), the control device 100 determines whether the valve opening degree of the first expansion valve 12 is less than a lower limit (Step S12). The lower limit of the valve opening degree is, for example, 20%. When the valve opening degree is less than the lower limit (Step S12; Yes), the control device 100 determines whether a control value (the outlet side temperature or the outlet side supercooling degree of the utilization-side heat exchanger 11) has reached the target value (Step S13). When the target value has been achieved (Step S13: Yes), the control device 100 continues the normal operation (Step S17). When the target value has not been achieved (Step S13; No), the control device 100 controls the first bypass circuit 13 to be closed (Step S14) because it is considered that the flow rate of the refrigerant is excessive and thus the target value cannot be achieved. Specifically, the control device 100 closes the first two-way valve 13A. The control device 100 controls the first bypass circuit 13 to be closed and then continues normal operation (Step S17).

[0046] On the other hand, when the valve opening degree of the first expansion valve 12 is not less than the lower limit (Step S12; No), that is, when the valve opening degree of the first expansion valve 12 is higher than an upper limit (80%), the control device 100 determines whether the control value (the outlet side temperature or the outlet side supercooling degree of the utilization-side heat exchanger 11) has reached the target value (Step S15). When the target value has been achieved (Step S15; Yes), the control device 100 continues the normal operation (Step S17). When the target value has not been achieved (Step S15; No), the control device 100 controls the first bypass circuit 13 to be opened (Step S16) because it is considered that the target value cannot be achieved due to an insufficient flow rate of the refrigerant despite the valve opening degree of the first expansion valve 12 being sufficient. Specifically, the control device 100 opens the first two-way valve 13A. The control device 100 opens the first bypass circuit 13 and then continues the normal operation (Step S17).

[0047] Next, the control device 100 determines whether the operation is to be continued (Step S18). For example, when an instruction to stop the operation is input, the control device 100 determines to stop the operation. Further, when an operation instruction is input, the control device 100 determines to continue the operation. When it is determined that the operation is to be continued (Step S18; Yes), the processing from Step S11 is repeated. When it is determined that the operation is to be stopped (Step S18; No), the processing flow ends.

[0048] Next, the opening and closing control of the second two-way valve 16A will be described. First, in the determination of Step S13 and Step S15, the control device 100 compares the outlet side superheat degree of the heat source-side heat exchanger 17 or the suction side superheat degree of the compressor 10 with the target values thereof and determines whether the target value is achieved or not yet achieved. For example, in the case of the superheat degree on the outlet side of the heat source-side heat exchanger 17, the control device 100 finds a saturation temperature at the pressure measured by the pressure sensor 33 and calculates the superheat degree by subtracting the saturation temperature from the temperature measured by the temperature

sensor 32. Further, in the memory part of the control device 100, a conversion table of the pressure and the saturation temperature is recorded, and the control device 100 calculates the saturation temperature from the pressure measured by the pressure sensor 33 and the conversion table.

[0049] In addition, regarding the control of the bypass circuit in the Step S14 and the Step S16, the control device 100 opens the second bypass circuit 16 by opening the second two-way valve 16A. Further, the control device 100 closes the second bypass circuit 16 by closing the second two-way valve 16A. Also, in the operation of Step S17, the control device 100 controls the opening degree of the second expansion valve 15 so that the outlet side superheat degree of the heat source-side heat exchanger 17 or the suction side superheat degree of the compressor 10 becomes the target value thereof.

[0050] According to the embodiment, even if the pressure difference in the first expansion valve 12 and the second expansion valve 15 is the low differential pressure, the flow rate of the refrigerant is ensured, and thus COP reduction in the refrigerant circuit system 1 and an increase in cost due to use of the large-diameter flow rate control valve can be prevented. For example, when the utilization-side inlet temperature is low (e.g., 5°C), an excessive increase in the outlet side superheat degree of the heat source-side heat exchanger (evaporator) 17 which causes a low COP can be prevented by opening the second bypass circuit.

<Another embodiment 1>

[0051] FIG. 4 is a second diagram showing an example of the refrigerant circuit system in the first embodiment of the present invention.

[0052] As shown in FIG. 4, the second bypass circuit 16 may not be provided in the refrigerant circuit system 1 of FIG. 1, and only the first bypass circuit 13 may be provided. For example, when the operation can be performed while the utilization-side inlet temperature is relatively high and the pressure difference on the side of the second expansion valve 15 is maintained in a high differential pressure state, a refrigerant circuit system 1A as shown in FIG. 4 can be used in the water heater. In the case of the refrigerant circuit system 1A, the control device 100 performs only the opening and closing control of the first two-way valve 13A according to the control method of the flowchart described in FIG. 3. By opening the first two-way valve 13A (opening the first bypass circuit 13), the flow rate of the refrigerant can be ensured and the refrigerant circuit system 1A can be efficiently operated even if the first expansion valve 12 side has the low differential pressure.

<Another embodiment 2>

[0053] FIG. 5 is a third diagram showing an example of the refrigerant circuit system in the first embodiment of the present invention.

[0054] As shown in FIG. 5, the first bypass circuit 13 may not be provided in the refrigerant circuit system 1 of FIG. 1, and only the second bypass circuit 16 may be provided. For example, when the operation can be performed while the utilization-side inlet temperature is relatively low and the pressure difference on the side of the first expansion valve 12 is maintained in a high differential pressure state, a refrigerant circuit system 1B as shown in FIG. 5 can be used in the water heater. In the case of the refrigerant circuit system 1B, the control device 100 performs only the opening and closing control of the second two-way valve 16A according to the control method of the flowchart described in FIG. 3. By opening the second two-way valve 16A (opening the second bypass circuit 16), the flow rate of the refrigerant can be ensured and the refrigerant circuit system 1B can be efficiently operated even if the second expansion valve 15 side has the low differential pressure.

<Second embodiment>

[0055] Hereinafter, a refrigerant circuit system according to a second embodiment of the present invention will be described with reference to FIGS. 6 and 7.

[0056] FIG. 6 is a view showing an example of a refrigerant circuit system in a second embodiment of the present invention.

[0057] As shown in FIG. 6, a refrigerant circuit system 1C includes a high stage-side compressor 10A, a low stage-side compressor 10B, a utilization-side heat exchanger (condenser) 11, a first expansion valve 12, a first bypass circuit 13, a receiver 14, a second expansion valve 15, a second bypass circuit 16, a heat source-side heat exchanger (evaporator) 17, an accumulator 18, a pipe 19 which connects the elements, an intermediate heat exchanger 20, a third expansion valve 21, a third bypass circuit 22, an injection circuit 23, and a control device 100. A first two-way valve 13A and a first capillary tube 13B are provided in the first bypass circuit 13. A second two-way valve 16A and a second capillary tube 16B are provided in the second bypass circuit 16. A third two-way valve 22A and a third capillary tube 22B are provided in the third bypass circuit 22. Also, the third expansion valve is provided in the middle of the injection circuit 23.. Hereinafter, a constitution which is different from that of the first embodiment will be described, and a description of the constitution which is the same as that of the first embodiment will be omitted.

[0058] The high stage-side compressor 10A and the low stage-side compressor 10B are connected in series. A suction side of the low stage-side compressor 10B is connected to the accumulator 18. Further, an outlet side of the low stage-side compressor 10B is connected to a suction side of the high stage-side compressor 10A. The low stage-side compressor 10B suctions and compresses a low pressure refrigerant and discharges an intermediate pressure refrigerant to the high stage-side com-

pressor 10A side. The injection circuit 23 which diverges some of the refrigerant from a main flow circuit connected to the second expansion valve 15 and the heat source-side heat exchanger 17 and then supplies the diverged refrigerant to the suction side of the high stage-side compressor 10A is provided on a downstream side of the receiver 14. Further, the intermediate heat exchanger 20 which exchanges heat between the refrigerant flowing through the injection circuit 23 and depressurized in the third expansion valve 21 and the refrigerant flowing through the main flow circuit is provided in the injection circuit 23. The diverged refrigerant is depressurized by the third expansion valve 21, then exits from an outlet of the intermediate heat exchanger 20 on the high stage-side compressor side, is returned to the high stage-side compressor 10A and is then recompressed. The injection circuit 23 can improve the COP of the refrigeration cycle as is well known. Meanwhile, the refrigerant flowing in the main flow circuit exchanges heat with an intermediate pressure refrigerant in the intermediate heat exchanger 20, is supercooled, is then depressurized and expanded by the second expansion valve 15 and flows into the heat source-side heat exchanger 17. Here, the third bypass circuit 22 is a circuit for bypassing the flow of the refrigerant passing through the third expansion valve 21. The third bypass circuit 22 of the embodiment is controlled to be in an open state when a pressure difference between a front and a rear of the third expansion valve 21 is a low differential pressure and the flow rate of the refrigerant returned to the high stage-side compressor 10A through the injection circuit 23 cannot be secured. Other constitutions are the same as those in the first embodiment.

[0059] FIG. 7 is a P-h diagram of the refrigerant circuit system in the second embodiment of the present invention.

[0060] FIG. 7 is a relationship diagram of the pressure and the enthalpy which indicates a refrigeration cycle of a refrigerant circuit system 1C according to the embodiment. In FIG. 7, each symbol indicates the following state. That is, A1 indicates the state of the refrigerant discharged from the high stage-side compressor 10A, A2 indicates the state of the refrigerant on the outlet side of the utilization-side heat exchanger 11 when the utilization-side inlet temperature is high (e.g., 75°C), A3 indicates the state of the refrigerant on the outlet side of the first expansion valve 12 when the utilization-side inlet temperature is high, A4 indicates the state of the refrigerant on the inlet side of the second expansion valve 15 when the utilization-side inlet temperature is high, A5 indicates the state of the refrigerant on the outlet side of the second expansion valve 15 when the utilization-side inlet temperature is high, A6 indicates the state of the refrigerant on the outlet side of the heat source-side heat exchanger 17, A7 indicates the state of the refrigerant discharged from the low stage-side compressor 10B, A8 indicates the state of the refrigerant on the outlet side of the third expansion valve 21 when the utilization-side inlet temperature is high, and A9 indicates the state of the refrigerant on the suction side of the high stage-side compressor 10A.

[0061] Further, B2 indicates the state of the refrigerant on the outlet side of the utilization-side heat exchanger 11 when the utilization-side inlet temperature is low (e.g., 5°C), B3 indicates the state of the refrigerant on the outlet side of the first expansion valve 12 when the utilization-side inlet temperature is low, B4 indicates the state of the refrigerant on the inlet side of the second expansion valve 15 when the utilization-side inlet temperature is low, B5 indicates the state of the refrigerant on the outlet side of the second expansion valve 15 when the utilization-side inlet temperature is low, and B8 indicates the state of the refrigerant on the outlet side of the third expansion valve 21 when the utilization-side inlet temperature is low.

[0062] The change in the control region of the first expansion valve 12, the second expansion valve 15 and the third expansion valve 21 corresponding to a change in the utilization-side inlet temperature are as follows.

(When utilization-side inlet temperature is high)

[0063] The high temperature and high pressure refrigerant (state A1) discharged from the high stage-side compressor 10A radiates heat in the utilization-side heat exchanger 11, is condensed and liquefied and becomes a high pressure liquid refrigerant (state A2). Then, the refrigerant (state A3) having passed through the first expansion valve 12, slightly depressurized (PH4) and flowing in the main flow circuit is cooled (stage A4) in the intermediate heat exchanger 20 and reaches the second expansion valve 15. Additionally, the refrigerant is further depressurized (PL4) (state A5) by the second expansion valve 15, flows into the heat source-side heat exchanger 17, absorbs heat from the external air to be evaporated and becomes a low pressure gas refrigerant (state A6). The low pressure gas refrigerant is boosted to an intermediate pressure by the low stage-side compressor 10B (state A7) and is supplied to the suction side of the high stage-side compressor 10A. Meanwhile, the refrigerant diverged to the injection circuit 23 is depressurized (PM4) to the intermediate pressure (state A8) by the third expansion valve 21, absorbs heat through the intermediate heat exchanger 20 and is supplied to the suction side of the high stage-side compressor 10A. Here, the intermediate pressure refrigerant whose temperature is lowered (state A9) by mixing the refrigerant supplied through the injection circuit 23 and the refrigerant compressed by the low stage-side compressor 10B is supplied to the high stage-side compressor 10A. The high stage-side compressor 10A compresses the intermediate pressure refrigerant and discharges the high temperature and high pressure refrigerant (state A1). The same cycle is repeated thereafter.

[0064] In the example of FIG. 7, the pressure difference between the front and the rear of the first expansion valve 12 is a low differential pressure (PH4). The pressure difference between the front and the rear of the second

expansion valve 15 is a high differential pressure (PL4). Also, the pressure difference between the front and the rear of the third expansion valve 21 is a high differential pressure (PM4).

(When utilization-side inlet temperature is low)

[0065] The high temperature and high pressure refrigerant (state A1) discharged from the high stage-side compressor 10A radiates a large amount of heat in the utilization-side heat exchanger 11, is condensed and liquefied and becomes a high pressure liquid refrigerant (state B2). Then, the refrigerant (state B3) largely depressurized (PH3) by the first expansion valve 12 and flowing in the main flow circuit is cooled (stage B4) in the intermediate heat exchanger 20 and reaches the second expansion valve 15. Additionally, the refrigerant is depressurized (PL3) (state B5) by the second expansion valve 15, flows into the heat source-side heat exchanger 17, absorbs heat from the external air to be evaporated and becomes a low pressure gas refrigerant (state A6). The low pressure gas refrigerant is compressed to an intermediate pressure by the low stage-side compressor 10B (state A7) and is supplied to the suction side of the high stage-side compressor 10A. Meanwhile, the refrigerant diverged to the injection circuit 23 is depressurized (PM3) to the intermediate pressure (state B8) by the third expansion valve 21, absorbs heat through the intermediate heat exchanger 20 and is supplied to the suction side of the high stage-side compressor 10A. Here, the intermediate pressure refrigerant whose temperature is lowered (state A9) by mixing the refrigerant supplied through the injection circuit 23 and the refrigerant compressed by the low stage-side compressor 10B is supplied to the high stage-side compressor 10A. The high stage-side compressor 10A compresses the intermediate pressure refrigerant and discharges the high temperature and high pressure refrigerant (state A1). The same cycle is repeated thereafter.

[0066] In the example of FIG. 7, the pressure difference between the front and the rear of the first expansion valve 12 is a high differential pressure (PH3). Meanwhile, the pressure difference between the front and the rear of the second expansion valve 15 is a low differential pressure (PL3). Also, the pressure difference between the front and the rear of the third expansion valve 21 is a low differential pressure (PM3).

[0067] As in the first embodiment, in the operation state in which the pressure difference between the front and the rear of each of the expansion valves (the first expansion valve 12, the second expansion valve 15 and the third expansion valve 21) is the low differential pressure, the necessary flow rate of the refrigerant may not pass through. Therefore, the control device 100 opens the third bypass circuit 22, for example, in the case of the third expansion valve 21 and controls the necessary amount of refrigerant to flow through the injection circuit 23.

[0068] Next, a control method of the first bypass circuit 13, the second bypass circuit 16 and the third bypass circuit 22 in the second embodiment will be described.

[0069] The control of the first bypass circuit 13 is the same as in the first embodiment. The control device 100 controls the opening and closing of the first two-way valve 13A on the basis of the valve opening degree of the first expansion valve 12 and the outlet side temperature or supercooling degree of the utilization-side heat exchanger 11.

[0070] The control of the second bypass circuit 16 is the same as in the first embodiment. The control device 100 controls the opening and closing of the second two-way valve 16A on the basis of the valve opening degree of the second expansion valve 15 and the outlet side superheat degree of the heat source-side heat exchanger 17 or the suction side superheat degree of the low stage-side compressor 10B.

[0071] The control of the third bypass circuit 22 is also the same. The control device 100 controls the opening and closing of the third two-way valve 22A, for example, on the basis of the valve opening degree of the third expansion valve 21 and the outlet side temperature of the intermediate heat exchanger 20 measured by a temperature sensor 34. Details of the control are as described in the flowchart of FIG. 3. Therefore, even if the flow rate of the refrigerant passing through the third expansion valve 21 is small, the refrigerant flowing into the injection circuit 23 is also supplied from the third bypass circuit 22, and thus the flow rate of the intermediate pressure refrigerant supplied from the injection circuit 23 to the high stage-side compressor 10A can be secured.

[0072] According to the embodiment, even if the pressure difference between the front and the rear of each of the first expansion valve 12, the second expansion valve 15 and the third expansion valve 21 is the low differential pressure, the flow rate of the refrigerant is ensured, and thus the COP reduction in the refrigerant circuit system 1C and an increase in cost due to the use of the large-diameter flow rate control valve in each of the expansion valves can be prevented. Also, in the refrigerant circuit system 1C shown in FIG. 6, the case in which the first bypass circuit 13, the second bypass circuit 16 and the third bypass circuit 22 are provided has been described. However, only one or two of the three bypass circuits may be provided according to the width of the control range of the first expansion valve 12, the second expansion valve 15 and the third expansion valve 21.

[0073] In addition, it is possible to substitute well-known elements with the elements in the above-described embodiment within a scope not deviating from the gist of the present invention. Further, the technical scope of the present invention is not limited to the above-described embodiments, and various modifications can be made without departing from the spirit of the present invention.

[0074] For example, in the embodiments, the two-way valve and the capillary tube are combined as an example of the constitution of the first bypass circuit 13, the second

bypass circuit 16 and the third bypass circuit 22. However, this combination may be replaced with a single flow rate control valve, and in the first bypass circuit 13 or the like, the flow rate of the refrigerant may be secured by adjusting the valve opening degree of the flow rate control valve used as a replacement.

EXPLANATION OF REFERENCES

[0075]

1, 1A, 1B, 1C Refrigerant circuit system
10 Compressor
10A High stage-side compressor
10B Low stage-side compressor
11 Utilization-side heat exchanger
12 First expansion valve
13 First bypass circuit
13A First two-way valve
13B First capillary tube
14 Receiver
15 Second expansion valve
16 Second bypass circuit
16A Second two-way valve
16B Second capillary tube
17 Heat source-side heat exchanger
18 Accumulator
19 Pipe
20 Intermediate heat exchanger
21 Third expansion valve
22 Third bypass circuit
22A Third two-way valve
22B Third capillary tube
23 Injection circuit
31, 32, 34 Temperature sensor
33 Pressure sensor
100 Control device

Claims

1. A refrigerant circuit system (1A) comprising:

one or a plurality of compressors (10) configured to compress a refrigerant,
a utilization-side heat exchanger (11) configured to condense the refrigerant compressed by the compressor,
a first expansion valve (12) configured to depressurize the refrigerant introduced from the utilization-side heat exchanger,
a receiver (14) configured to store some of the refrigerant depressurized by the first expansion valve,
a second expansion valve (15) configured to depressurize the refrigerant flowing out from the receiver,
a heat source-side heat exchanger (17) configured to evaporate the refrigerant depressurized by the second expansion valve,
a first bypass circuit (13) configured to bypass a flow of the refrigerant passing through the first expansion valve (12), and
a control device (100) configured to control opening and closing of the first bypass circuit (13).

2. A refrigerant circuit system (1B) comprising:

one or a plurality of compressors (10) configured to compress a refrigerant,
a utilization-side heat exchanger (11) configured to condense the refrigerant compressed by the compressor,
a first expansion valve (12) configured to depressurize the refrigerant introduced from the utilization-side heat exchanger,
a receiver (14) configured to store some of the refrigerant depressurized by the first expansion valve,
a second expansion valve (15) configured to depressurize the refrigerant flowing out from the receiver,
a heat source-side heat exchanger (17) configured to evaporate the refrigerant depressurized by the second expansion valve,
a second bypass circuit (16) configured to bypass a flow of the refrigerant passing through the second expansion valve (15), and
a control device (100) configured to control opening and closing of the second bypass circuit (16).

3. A refrigerant circuit system (1) comprising:

one or a plurality of compressors (10) configured to compress a refrigerant,
a utilization-side heat exchanger (11) configured to condense the refrigerant compressed by the compressor,
a first expansion valve (12) configured to depressurize the refrigerant introduced from the utilization-side heat exchanger,
a receiver (14) configured to store some of the refrigerant depressurized by the first expansion valve,
a second expansion valve (15) configured to depressurize the refrigerant flowing out from the receiver,
a heat source-side heat exchanger (17) configured to evaporate the refrigerant depressurized by the second expansion valve,
a first bypass circuit (13) configured to bypass a flow of the refrigerant passing through the first expansion valve (12),
a second bypass circuit (16) configured to by-

pass a flow of the refrigerant passing through the second expansion valve (15), and
a control device (100) configured to control opening and closing of the first bypass circuit (13) and opening and closing of the second bypass circuit (16).

4. The refrigerant circuit system (1A, 1) according to claim 1 or 3, wherein the control device (100) controls the opening and closing of the first bypass circuit (13) on the basis of an outlet side temperature of the utilization-side heat exchanger (11) or an outlet side supercooling degree of the utilization-side heat exchanger (11) and an opening degree of the first expansion valve (12).

5. The refrigerant circuit system (1B, 1) according to claim 2 or 3, wherein the control device (100) controls the opening and closing of the second bypass circuit (16) on the basis of an outlet side superheat degree of the heat source-side heat exchanger (11) or a suction side superheat degree of the compressor (10) and an opening degree of the second expansion valve (15).

6. The refrigerant circuit system (1C) according to any one of claims 1 to 5, wherein the compressors include a high stage-side compressor (10A) and a low stage-side compressor (10B), and the refrigerant circuit system further comprises an injection circuit (23) configured to supply the refrigerant flowing out from the receiver (14) to the high stage-side compressor (10A), a third expansion valve (21) provided at a middle portion of the injection circuit (23), and a third bypass circuit (22) configured to bypass the flow of the refrigerant passing through the injection circuit (23), and
wherein the control device (100) also controls the opening and closing of the third bypass circuit (22).

7. A control method in a refrigerant circuit system (1A) which comprises one or a plurality of compressors (10) configured to compress a refrigerant, a utilization-side heat exchanger (11) configured to condense the refrigerant compressed by the compressor, a first expansion valve (12) configured to depressurize the refrigerant introduced from the utilization-side heat exchanger, a receiver (14) configured to store some of the refrigerant depressurized by the first expansion valve, a second expansion valve (15) configured to depressurize the refrigerant flowing out from the receiver, a heat source-side heat exchanger (17) configured to evaporate the refrigerant depressurized by the second expansion valve, and a first bypass circuit (13) configured to bypass a flow of the refrigerant passing through the first expansion valve (12),
wherein opening and closing of the first bypass circuit (13) is controlled on the basis of an outlet side temperature of the utilization-side heat exchanger (11) or an outlet side supercooling degree of the utilization-side heat exchanger (11) and an opening degree of the first expansion valve (12).

8. A control method in a refrigerant circuit system (1B) which comprises one or a plurality of compressors (10) configured to compress a refrigerant, a utilization-side heat exchanger (11) configured to condense the refrigerant compressed by the compressor, a first expansion valve (12) configured to depressurize the refrigerant introduced from the utilization-side heat exchanger, a receiver (14) configured to store some of the refrigerant depressurized by the first expansion valve, a second expansion valve (15) configured to depressurize the refrigerant flowing out from the receiver, a heat source-side heat exchanger (17) configured to evaporate the refrigerant depressurized by the second expansion valve, and a second bypass circuit (16) configured to bypass a flow of the refrigerant passing through the second expansion valve (15),
wherein opening and closing of the second bypass circuit (16) is controlled on the basis of an outlet side superheat degree of the heat source-side heat exchanger (17) or a suction side superheat degree of the compressor (10) and an opening degree of the second expansion valve (15).

FIG. 1

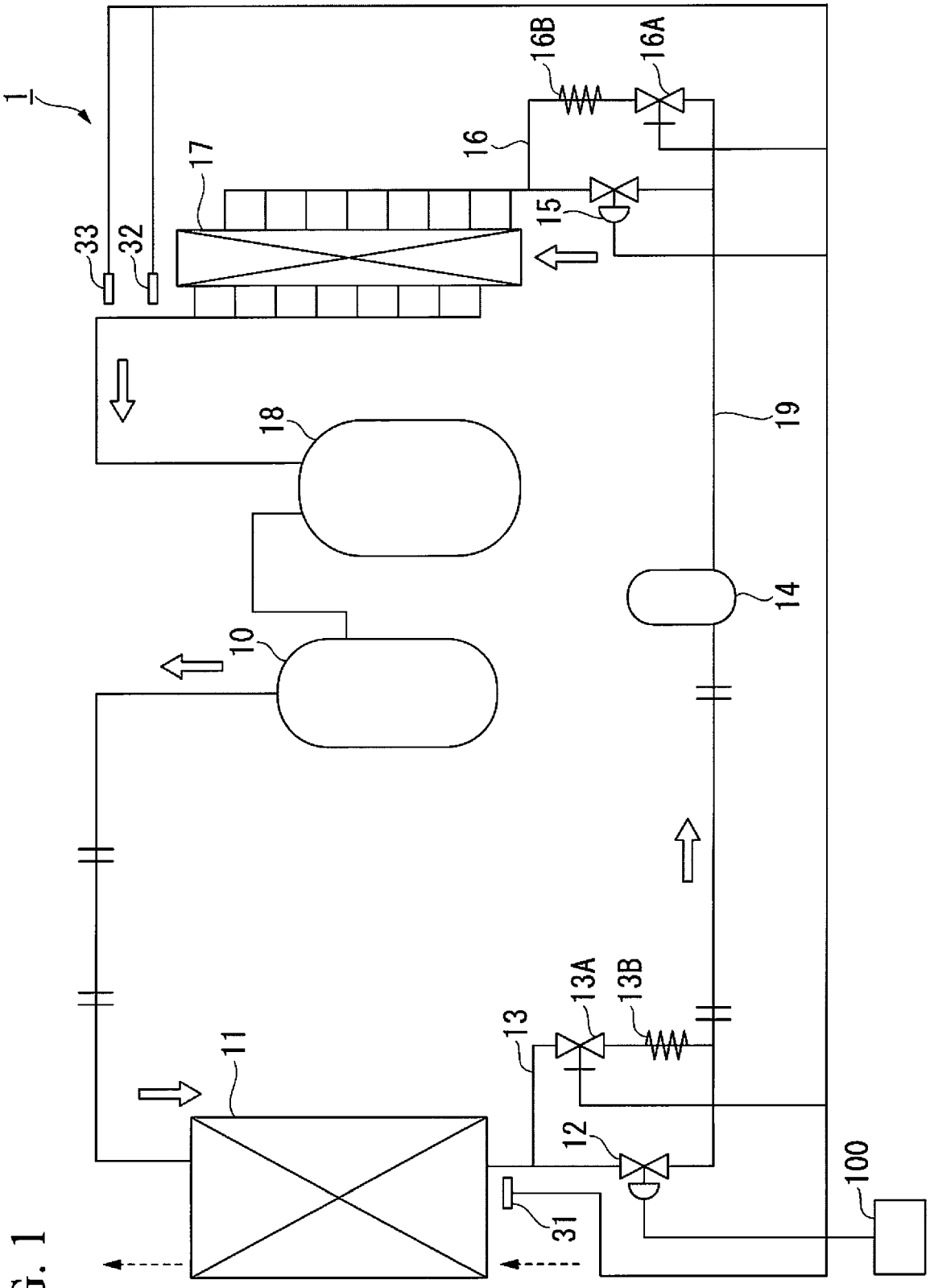


FIG. 2

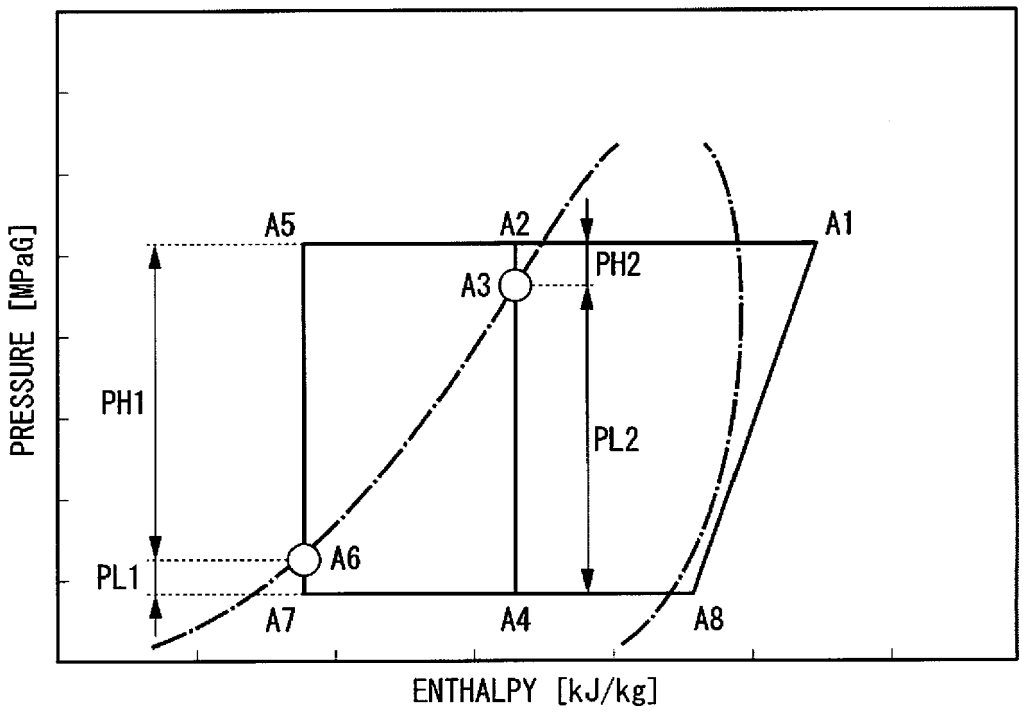

PRESSURE [MPaG]
ENTHALPY [kJ/kg]
A1
A2
A3
A4
A5
A6
A7
A8
PH1
PH2
PL1
PL2

FIG. 3

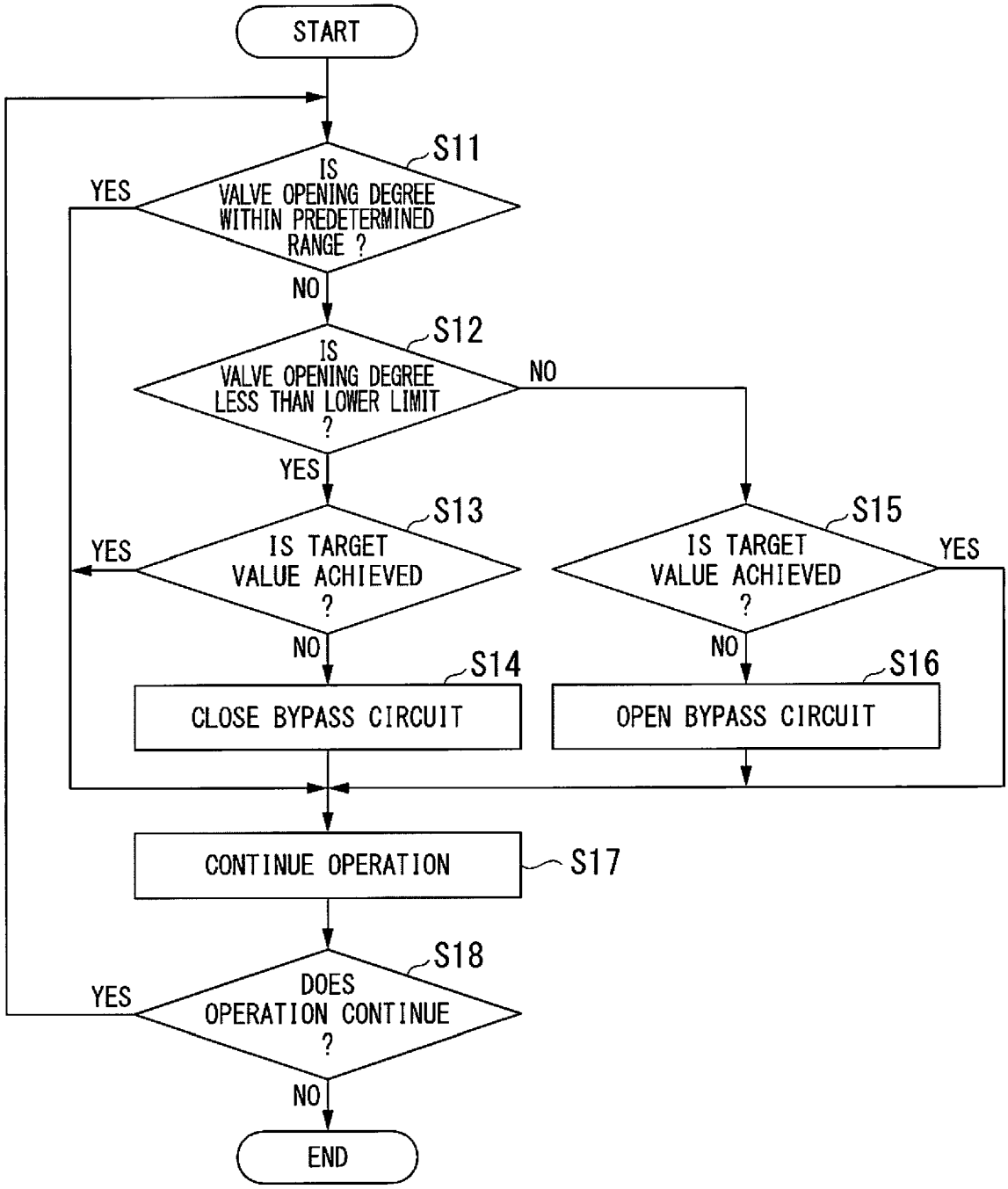

START
S11
IS VALVE OPENING DEGREE WITHIN PREDETERMINED RANGE ?
YES
NO
S12
IS VALVE OPENING DEGREE LESS THAN LOWER LIMIT ?
NO
YES
S13
IS TARGET VALUE ACHIEVED ?
YES
NO
S14
CLOSE BYPASS CIRCUIT
S15
IS TARGET VALUE ACHIEVED ?
YES
NO
S16
OPEN BYPASS CIRCUIT
CONTINUE OPERATION
S17
S18
DOES OPERATION CONTINUE ?
YES
NO
END

FIG. 4

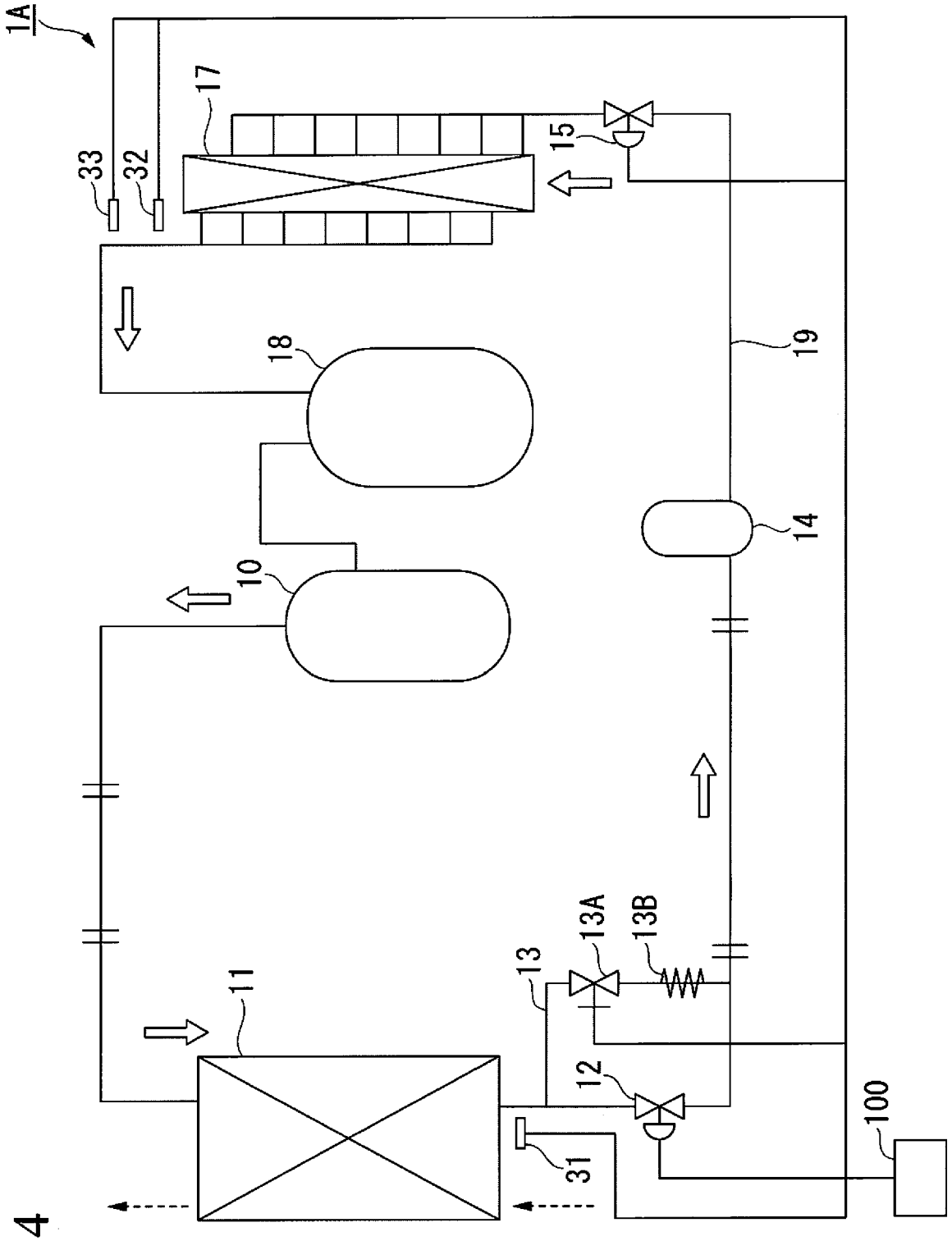


FIG. 5

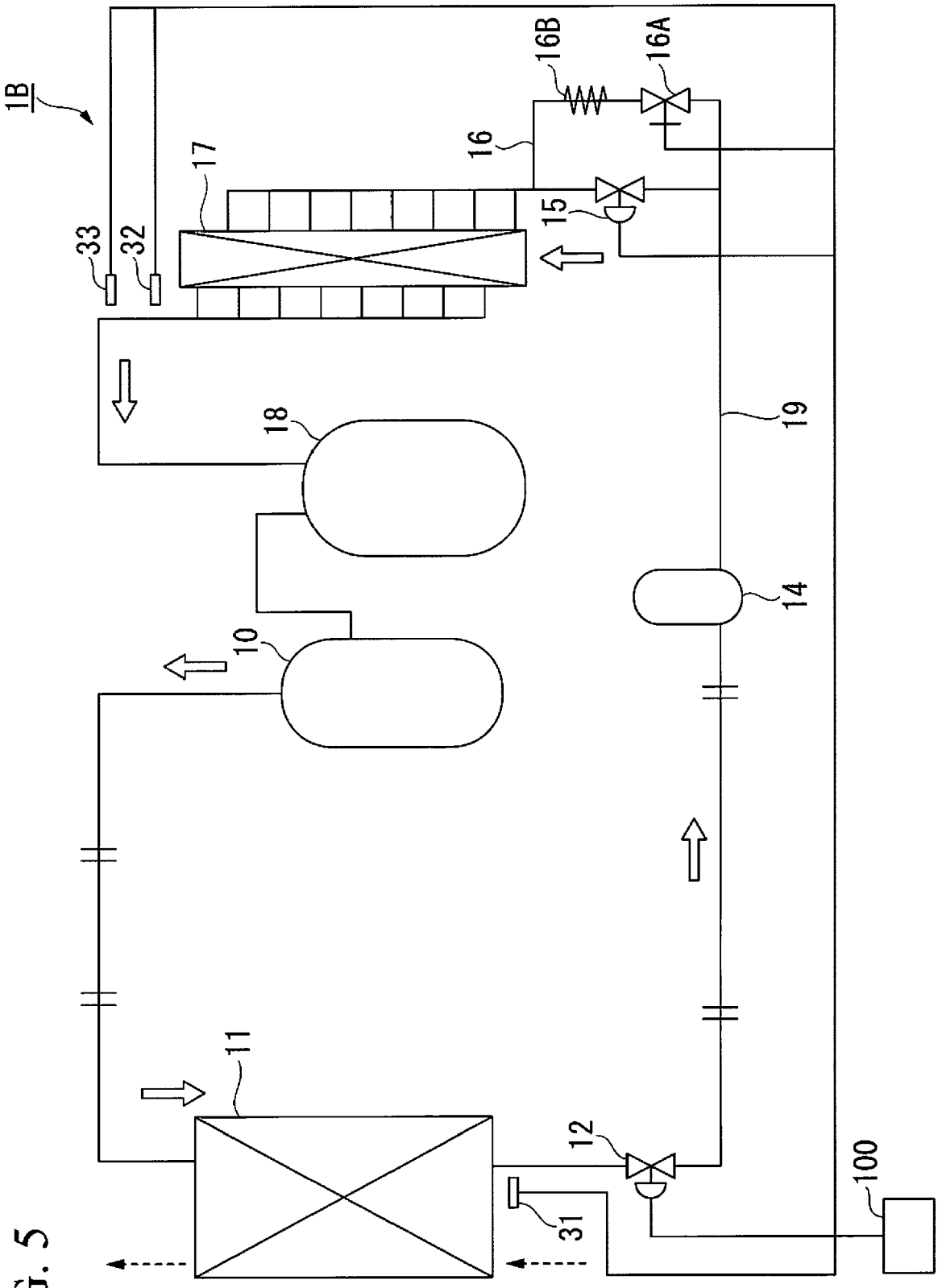


FIG. 6

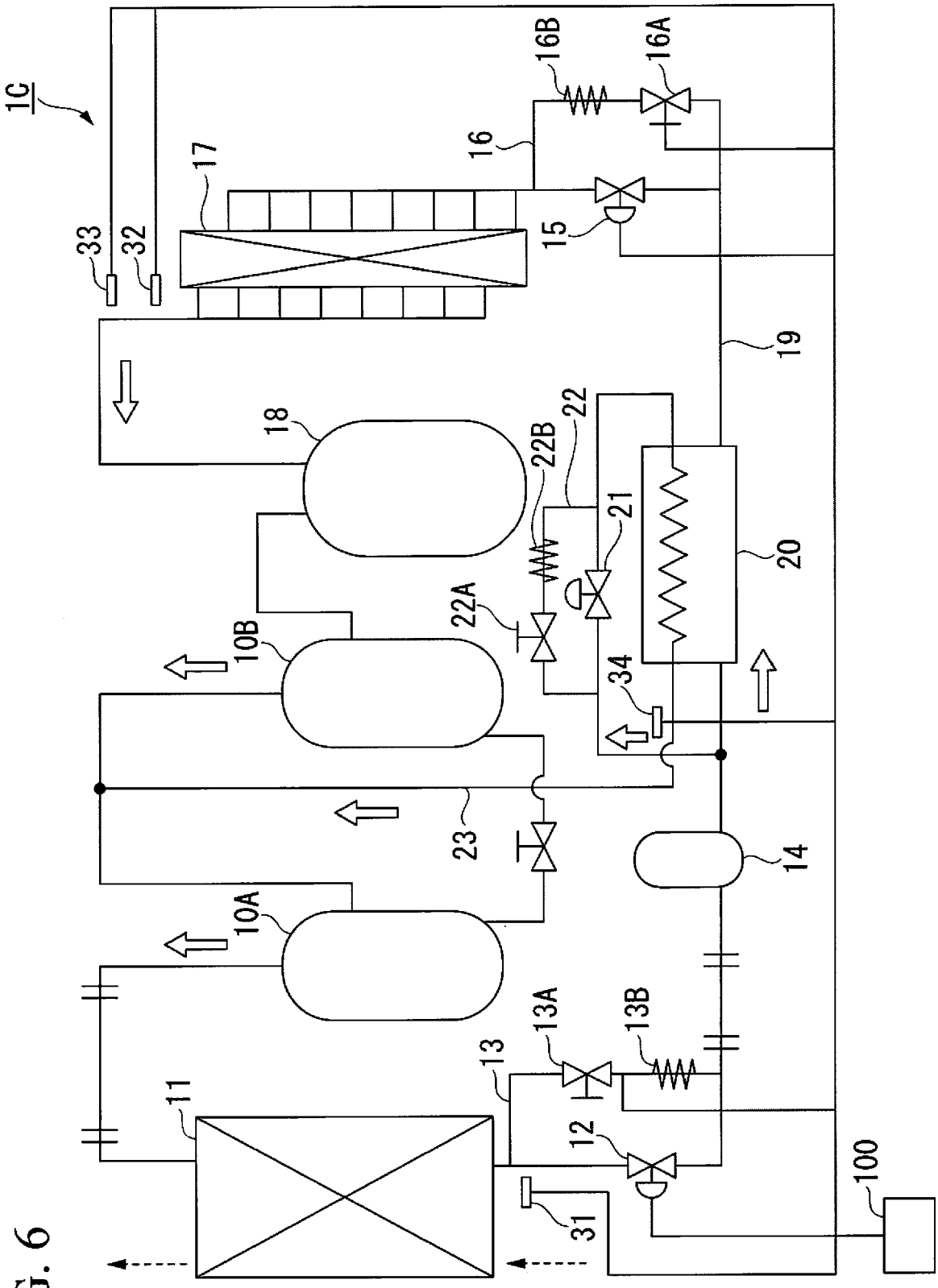
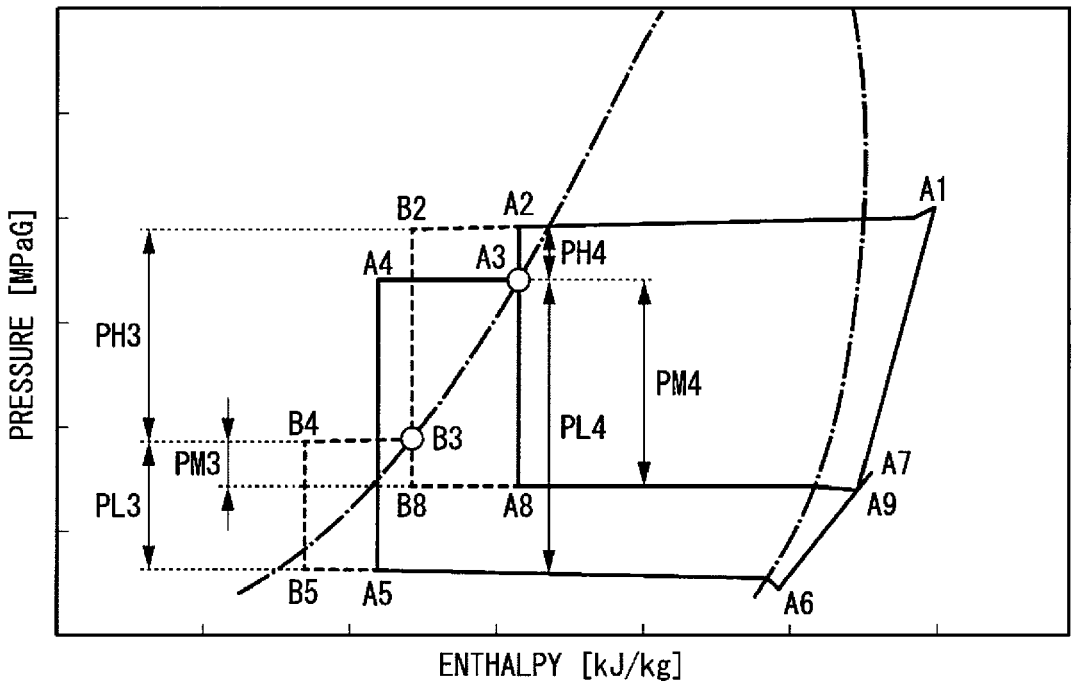

1C
16B
16A
16
17
15
33
32
19
18
22
22B
21
20
22A
10B
34
23
14
10A
13A
13B
13
11
12
100
31

FIG. 7


PRESSURE [MPaG]
ENTHALPY [kJ/kg]
A1
A2
A3
A4
A5
A6
A7
A8
A9
B2
B3
B4
B5
B8
PH3
PH4
PL3
PL4
PM3
PM4

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 17 19 4420

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	JP 2007 155230 A (HITACHI APPLIANCES INC) 21 June 2007 (2007-06-21) * paragraphs [0001], [0016] - [0029]; figures 1,6 *	2 1,3-8	INV. F25B30/02
Y	EP 2 722 616 A1 (MITSUBISHI ELECTRIC CORP [JP]) 23 April 2014 (2014-04-23) * paragraphs [0012] - [0027], [0047] - [0111]; figure 1 *	1,3-8	
Y	WO 2013/061365 A1 (MITSUBISHI ELECTRIC CORP [JP]; SHIMAZU YUSUKE [JP]) 2 May 2013 (2013-05-02) * paragraphs [0017] - [0075]; figures 1,4,5 *	1,3-8	
A	EP 2 224 187 A2 (MITSUBISHI ELECTRIC CORP [JP]) 1 September 2010 (2010-09-01) * paragraphs [0019] - [0036]; figure 1 *	1-8	
			TECHNICAL FIELDS SEARCHED (IPC) F25B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	20 November 2017	Weisser, Meinrad

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 17 19 4420

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

20-11-2017

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 2007155230 A	21-06-2007	NONE	
EP 2722616 A1	23-04-2014	CN 104204691 A	10-12-2014
		EP 2722616 A1	23-04-2014
		JP 5665981 B2	04-02-2015
		JP WO2012172599 A1	23-02-2015
		US 2014083126 A1	27-03-2014
		WO 2012172599 A1	20-12-2012
WO 2013061365 A1	02-05-2013	NONE	
EP 2224187 A2	01-09-2010	EP 1647783 A2	19-04-2006
		EP 2119982 A2	18-11-2009
		EP 2119983 A2	18-11-2009
		EP 2119984 A2	18-11-2009
		EP 2224187 A2	01-09-2010
		JP 4459776 B2	28-04-2010
		JP 2006112753 A	27-04-2006
		US RE43805 E	20-11-2012
		US RE43998 E	19-02-2013
		US 2006080989 A1	20-04-2006

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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

Patent documents cited in the description

- JP 2016197358 A **[0001]**
- JP 2007010282 A **[0005]**