



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

(43) Date of publication:
26.09.2018 Bulletin 2018/39

(51) Int Cl.:
F25B 1/00 (2006.01) **F25B 1/10** (2006.01)
F25B 31/00 (2006.01)

(21) Application number: **17741416.6**

(86) International application number:
PCT/JP2017/001519

(22) Date of filing: **18.01.2017**

(87) International publication number:
WO 2017/126539 (27.07.2017 Gazette 2017/30)

(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

(72) Inventors:
• **OMURA, Minemasa**
Tokyo 108-8215 (JP)
• **MURAKAMI, Kenichi**
Tokyo 108-8215 (JP)
• **TAKEDA, Takeshi**
Tokyo 108-8215 (JP)
• **MIZUNO, Hisao**
Tokyo 108-8215 (JP)
• **KAWANISHI, Akio**
Tokyo 108-8215 (JP)

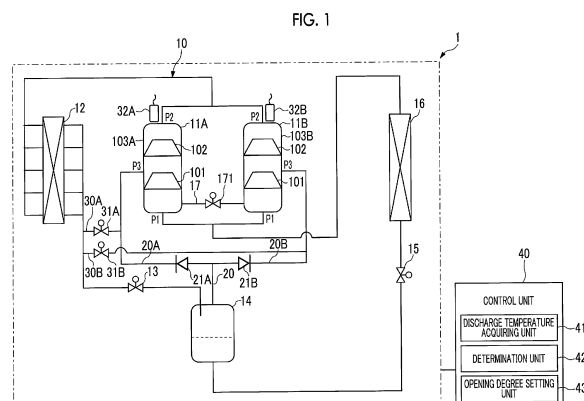
(30) Priority: **20.01.2016 JP 2016008819**

(74) Representative: **Cabinet Beau de Loménie**
158, rue de l'Université
75340 Paris Cedex 07 (FR)

(71) Applicant: **Mitsubishi Heavy Industries Thermal Systems, Ltd.**
Minato-ku, Tokyo 108-8215 (JP)

(54) **REFRIGERATION CYCLE PROVIDED WITH PLURALITY OF MULTISTAGE COMPRESSORS CONNECTED IN PARALLEL**

(57) In a configuration provided with a plurality of multistage compressors connected in parallel and an injection circuit for feeding a refrigerant gas of an intermediate pressure into the individual housings of the multistage compressors, the lubricating oil in each of the housings is averaged while an adequate injection amount is secured. A refrigeration cycle 1 is provided with: an oil equalization path 17 linking housings 103A, 103B of a plurality of multistage compressors 11A, 11B to each other; a plurality of gas injection circuits 20A, 20B for feeding a gas refrigerant in a gas-liquid separator 14 into the housing of the corresponding multistage compressor; a plurality of bypass channels 30A, 30B for feeding the refrigerant extracted from between a cooler 12 and a first expansion valve 13 into the housing of the corresponding multistage compressor; bypass flow rate adjustment valves 31A, 31B capable of varying the flow rate of at least one of the bypass paths 20A, 20B of the plurality of multistage compressors; check valves 21A, 21B; and a control unit 40.



Description

Technical Field

[0001] The present invention relates to a refrigeration cycle that is provided with a plurality of multistage compressors connected in parallel and a circuit supplying intermediate-pressure refrigerant gas into a housing of each of the multistage compressors.

Background Art

[0002] A refrigeration cycle, which is provided with a gas injection circuit that supplies intermediate-pressure refrigerant gas into a housing of a two-stage compressor including two compression mechanisms, has been known.

[0003] With two-stage compression and intermediate-pressure refrigerant injection, it is possible to secure a compressing efficiency and to suppress the temperature of a refrigerant discharged from a compressor in comparison with a case of achieving the same refrigeration ability with one-stage compression.

[0004] In addition, a refrigeration cycle, which is provided with a plurality of two-stage compressors connected in parallel for the purpose of comprehensively changing the refrigeration ability, has also been known (PTL 1).

[0005] Meanwhile, if an operation is continued for a long period of time, lubricating oil in housings is unevenly distributed to a portion of compressors in accordance with operation conditions since the amount of lubricating oil discharged from a compressor housing and the amount of returning lubricating oil are different between a plurality of compressors connected in parallel, the lubricating oil being included in refrigerant gas.

[0006] Therefore, the housings of the plurality of compressors are connected to each other with a pipe and an oil equalization operation of applying a pressure difference between the housings such that the lubricating oil moves between the housings of the plurality of compressors in accordance with the pressure difference is performed at an appropriate time.

[0007] In PTL 1, gas injection circuits are used in order to apply a pressure difference needed for oil equalization. In PTL 1, a flow regulation valve is provided for each of the gas injection circuits that respectively supply intermediate-pressure refrigerant gas into a plurality of compressor housings and a pressure difference is applied between the housings by controlling the opening degrees of the flow regulation valves in order to equalize the lubricating oil in the housings.

Citation List

Patent Literature

[0008] [PTL 1] Japanese Patent No. 5193011

Summary of Invention

Technical Problem

[0009] It is conceivable to apply a pressure difference between respective housings of a plurality of compressors by increasing the rotation speed of a portion of the compressors and increasing the pressure loss of a refrigerant sucked into or discharged from the compressors in order to achieve oil equalization.

[0010] However, it is possible to apply a pressure difference between the housings by changing the pressures in the housings in the above-described manner only in the case of a configuration provided with one-stage compression compressors connected in parallel, in which only low-pressure refrigerant gas is supplied into the housings.

[0011] In a case where low-pressure refrigerant gas and intermediate-pressure gas from a gas injection circuit are supplied into each housing at the same flow rate, the pressure in each housing is not changed much even when the rotation speed of a portion of the compressors is increased and thus it is difficult to achieve a pressure difference between the housings needed to move lubricating oil.

[0012] Therefore, it is conceivable to increase and decrease the amount of intermediate-pressure refrigerant gas supplied into a compressor housing by controlling the opening degree of a flow regulation valve provided for each gas injection circuit as in PTL 1. However, when the amount of supplied intermediate-pressure refrigerant gas is decreased, it may not be possible to secure a necessary injection amount (flow rate).

[0013] Accordingly, an object of the present invention is to equalize lubricating oil in each housing while securing a necessary injection amount in a refrigeration cycle provided with a plurality of multistage compressors connected in parallel and a gas injection circuit supplying intermediate-pressure refrigerant gas into the housing of each of the multistage compressors.

Solution to Problem

[0014] A refrigeration cycle according to the present invention includes a plurality of multistage compressors each of which includes a housing that accommodates a multistage compression mechanism including a low-stage compression mechanism and a high-stage compression mechanism and which are connected in parallel. A refrigerant circuit is configured by sequentially connecting the plurality of multistage compressors, a cooler, a first pressure-reducing unit, a gas-liquid separator, a second pressure-reducing unit, and an evaporator, and the refrigeration cycle includes an oil equalization path that connects the housings of the plurality of multistage compressors to each other, a plurality of gas injection circuits through which a gas refrigerant in the gas-liquid separator is supplied to between the low-stage compression

mechanism and the high-stage compression mechanism of the housing of the corresponding multistage compressor, a plurality of bypass paths through which a refrigerant extracted from between the cooler and the first pressure-reducing unit is supplied to between the low-stage compression mechanism and the high-stage compression mechanism of the housing of the corresponding multistage compressor, a bypass valve that is capable of changing a flow rate of the refrigerant that flows in at least one of the bypass paths of the plurality of multistage compressors, a check valve that is provided in the gas injection circuit and that prevents a backward flow of the gas refrigerant flowing toward the inside of the housing, and a control unit configured to control an opening degree of the bypass valve.

[0015] The "cooler" in the present invention is for decreasing the temperature of the refrigerant and includes a condenser or a gas cooler.

[0016] In the refrigeration cycle according to the present invention, the refrigerant extracted from between the cooler and the first pressure-reducing unit preferably flows into the gas injection circuits through the bypass paths.

[0017] Meanwhile, in the refrigeration cycle according to the present invention, the bypass paths may be configured to be directly connected to the insides of the housings of the multistage compressors, respectively.

[0018] In the refrigeration cycle according to the present invention, the control unit may be configured to control the opening degree of the bypass valve at least at the time of an oil equalization operation in which lubricating oil moves between the housings of the plurality of multistage compressors through the oil equalization path.

[0019] The refrigeration cycle according to the present invention preferably further includes a discharge temperature sensor that measures a discharge temperature, which is a temperature of a refrigerant discharged from the multistage compressor, and the control unit is preferably configured to control the opening degree of the bypass valve by using the discharge temperature.

[0020] In addition, the refrigeration cycle according to the present invention may further include a pressure sensor that measures the pressure of an injection gas refrigerant and/or a bypass refrigerant flowing into the housings of the multistage compressors, and the control unit may be configured to control the opening degree of the bypass valve based on the pressure of the refrigerant measured by the pressure sensor.

[0021] In the refrigeration cycle according to the present invention, the bypass valve is preferably a flow regulation valve that is capable of adjusting the flow rate and is preferably provided for each of the plurality of bypass paths.

[0022] Meanwhile, in the refrigeration cycle according to the present invention, the bypass valve may be configured to be provided for at least one of the plurality of the bypass paths.

[0023] In the refrigeration cycle according to the present invention, CO₂ is preferably used as a refrigerant circulating in the refrigerant circuit.

5 Advantageous Effects of Invention

[0024] A refrigerant that is extracted from between the cooler and the first pressure-reducing unit to the bypass paths is in a liquid state or a liquid-phase-dominant state and the pressure thereof is higher than that of the gas refrigerant extracted from the inside of the gas-liquid separator. Therefore, a pressure difference between the housings, which is needed to move the lubricating oil in the housings through the oil equalization path, can be realized by controlling the opening degree of the bypass valve such that the flow rates in the plurality of bypass paths become different from each other. According to the present invention, it is not necessary to decrease the flow rate of the gas refrigerant with respect to a portion of the plurality of gas injection circuits, through which the gas refrigerant extracted from the inside of the gas-liquid separator is supplied to the housings, in order to achieve a pressure difference between the housings.

[0025] In addition to a low-temperature gas refrigerant extracted from the inside of the gas-liquid separator to the gas injection circuits, a low-temperature refrigerant extracted from between the cooler and the first pressure-reducing unit to the bypass paths is supplied into the housings of the multistage compressors according to the present invention in surplus.

[0026] Therefore, even at a time other than the time of the oil equalization operation, the bypass paths can be used at the time of operation conditions under which the temperature and the pressure in the housings and the temperature of the refrigerant discharged from the compressors may exceed an upper limit if injection is performed by using only the gas injection circuits.

[0027] That is, it is possible to prevent the temperature of the refrigerant discharged from the compressors from being excessive or to prevent the temperatures or the internal pressures of the housings from being excessive while securing a necessary injection amount as a whole including injection of a low-temperature refrigerant through the bypass paths.

[0028] Since the refrigerant, of which the density is higher than that of the gas refrigerant flowing in the gas injection circuits, flows in the bypass paths according to the present invention, as the bypass valve, a valve having a bore diameter smaller than that of a flow regulation valve, which is provided in the gas injection circuits in a case of increasing and decreasing the flow rates of the gas injection circuits, can be used. Therefore, it is possible to suppress the cost of the valve.

55 Brief Description of Drawings

[0029]

Fig. 1 is a schematic view illustrating a refrigeration cycle according to a first embodiment of the present invention.

Fig. 2 is a schematic view illustrating a refrigeration cycle according to a second embodiment of the present invention.

Fig. 3 is a schematic view illustrating a refrigeration cycle according to a modification example of the present invention.

Fig. 4 is a schematic view illustrating a refrigeration cycle according to another modification example of the present invention.

Fig. 5 is a schematic view illustrating a refrigeration cycle according to a comparative example of the embodiments of the present invention.

Description of Embodiments

[0030] Hereinafter, embodiments of the present invention will be described with reference to drawings.

(First Embodiment)

[0031] A refrigeration cycle 1 illustrated in Fig. 1 is provided with a refrigerant circuit 10 which is provided with two two-stage compressors 11A and 11B (hereinafter, compressors) connected in parallel, an oil equalization path 17 that connects the two-stage compressors 11A and 11B to each other, two gas injection circuits 20A and 20B and two bypass paths 30A and 30B which are provided corresponding to the two compressors 11A and 11B, and a control unit 40 that controls the operation of the entire refrigeration cycle 1.

[0032] Reference symbols each of which has "A" added to the end thereof like 11A, 20A, and 30A correspond to each other. Similarly, reference symbols each of which has "B" added to the end thereof like 11B, 20B, and 30B correspond to each other.

[0033] The refrigeration cycle 1 according to the present embodiment can be used for, for example, a refrigeration device, an air conditioner, and a water heater.

[0034] The control unit 40 changes the refrigeration ability by operating only one of the compressors 11A and 11B or two of the compressors 11A and 11B in accordance with a thermal load.

[0035] The refrigerant circuit 10 is configured by sequentially connecting the compressors 11A and 11B, a cooler 12, a first expansion valve (first pressure-reducing unit) 13, a gas-liquid separator 14, a second expansion valve (second pressure-reducing unit) 15, and an evaporator 16.

[0036] As a refrigerant circulating in the refrigerant circuit 10, in the present embodiment, CO₂, which is a natural refrigerant, is used.

[0037] However, other refrigerants such as ammonia, propane, hydrochlorofluorocarbons (HCFC), hydrofluorocarbons (HFC), and the like can also be used.

[0038] The compressor 11A is provided with a low-

stage compression mechanism 101, a high-stage compression mechanism 102, an electric motor (not shown) that drives the compression mechanisms 101 and 102, and a housing 103A that accommodates the compression mechanisms 101 and 102 and the electric motor in an air-tightly sealed state. The compressors 11A and 11B are configured such that a compression capability can be changed in accordance with a rotation speed under the control of the control unit 40.

[0039] As the low-stage compression mechanism 101, a rotary piston type compression mechanism is adopted in the present embodiment.

[0040] As the high-stage compression mechanism 102, a scroll type compression mechanism is adopted in the present embodiment.

[0041] The above configuration is merely an example and the compression mechanisms 101 and 102 can be appropriately configured.

[0042] A low-pressure refrigerant that is sucked into the low-stage compression mechanism 101 in the housing 103A through a suction port P1 is compressed by the low-stage compression mechanism 101 until an intermediate pressure is reached and is discharged to a space in the housing 103A which is positioned above the low-stage compression mechanism 101. A refrigerant that is discharged to the inside of the housing 103A from the low-stage compression mechanism 101 and a refrigerant that is supplied into the housing 103A from the gas injection circuit 20A are sucked by the high-stage compression mechanism 102. Then, a high-pressure gas refrigerant compressed by the high-stage compression mechanism 102 is discharged toward the refrigerant circuit 10 from a discharge port P2.

[0043] Here, the "intermediate pressure" refers to a pressure between the pressure of a refrigerant that is sucked into the low-stage compression mechanism 101 via the second expansion valve 15 and the evaporator 16 and the pressure of a refrigerant that is discharged from the high-stage compression mechanism 102. With the "intermediate pressure" as a standard, a relatively low pressure will be referred to as a "low pressure" and a relatively high pressure will be referred to as a "high pressure".

[0044] As with the compressor 11A, the compressor 11B is also provided with the low-stage compression mechanism 101, the high-stage compression mechanism 102, the electric motor (not shown) that drives the compression mechanisms 101 and 102, and a housing 103B that accommodates the compression mechanisms 101 and 102 and the electric motor in an air-tightly sealed state.

[0045] In a bottom portion in each of the housings 103A and 103B of the compressors 11A and 11B, lubricating oil to be supplied to the compression mechanisms 101 and 102 or a sliding portion such as a bearing or the like of the electric motor is stored. In order to secure a reliability by sufficiently supplying the lubricating oil to the sliding portion, it is necessary that a predetermined

amount of lubricating oil is present in the housings 103A and 103B.

[0046] The lubricating oil in the housings 103A and 103B is discharged from the insides of the housings 103A and 103B in a state of being mixed into refrigerants in the housings 103A and 103B and returns to the insides of the housings 103A and 103B after circulating in the refrigerant circuit 10.

[0047] In order to secure a sufficient reliability, an oil returning mechanism that separates the lubricating oil from a refrigerant discharged from the high-stage compression mechanism 102 and returns the lubricating oil to the housings 103A and 103B is provided as necessary.

[0048] Even in a case where the same amounts of lubricating oil are present in the housings 103A and 103B of the compressors 11A and 11B at a time when the operation of the compressors 11A and 11B is started, the amounts of lubricating oil in the housings 103A and 103B of the compressors 11A and 11B become uneven as the operation continues.

[0049] The unevenness is caused by a difference in discharging amount attributable to an individual difference between the compressors 11A and 11B or a difference in resistance of the oil returning mechanism.

[0050] In order to move the lubricating oil between the housing 103A of the compressor 11A and the housing 103B of the compressor 11B and to secure a necessary amount of lubricating oil in each of the housings 103A and 103B, the housings 103A and the 103B are connected to each other by the oil equalization path 17.

[0051] The oil equalization path 17 connects the inside of the housing 103A of the compressor 11A and the inside of the housing 103B of the compressor 11B to each other near the bottom portions of the housings 103A and the 103B.

[0052] The oil equalization path 17 is provided with an oil equalization valve 171 that opens and closes the oil equalization path 17.

[0053] The oil equalization valve 171 is opened at the time of an oil equalization operation of the refrigeration cycle 1 which is performed at an appropriate time. At the time of an operation other than the oil equalization operation, the oil equalization valve 171 is closed.

[0054] In order to acquire a pressure difference that is needed to move the lubricating oil between the housings 103A and 103B of the compressors 11A and 11B through the oil equalization path 17 at the time of the oil equalization operation, in the present embodiment, it is possible to introduce a pressure into the housings 103A and 103B through each of the bypass paths 30A and 30B which will be described later.

[0055] Meanwhile, in the present embodiment, the first expansion valve 13, the gas-liquid separator 14, and the second expansion valve 15 are disposed between the cooler 12 and the evaporator 16. High-temperature high-pressure gas refrigerants discharged from the compressors 11A and 11B are liquefied through heat dissipation in the cooler 12. A liquid refrigerant flowing out from the

cooler 12 is brought into a gas-liquid two-phase state through pressure reduction in the first expansion valve 13 and is subject to gas-liquid separation in the gas-liquid separator 14. A gas refrigerant in the gas-liquid separator 14 is supplied to between the low-stage compression mechanism 101 and the high-stage compression mechanism 102 of each of the housings 103A and 103B of the compressors 11A and 11B through the gas injection circuits 20A and 20B.

[0056] In the present embodiment, an intermediate-pressure gas refrigerant branches into the gas injection circuit 20A and the gas injection circuit 20B after being extracted from the inside of the gas-liquid separator 14 through a pipe 20 shared by the gas injection circuits 20A and 20B.

[0057] In the refrigeration cycle 1, a low-temperature intermediate-pressure gas refrigerant is supplied to between the low-stage compression mechanism 101 and the high-stage compression mechanism 102 through the gas injection circuits 20A and 20B for the purpose of suppressing the temperature of refrigerants discharged from the compressors 11A and 11B, improving a compressing efficiency, and reducing the internal pressures of the housings 103A and 103B.

[0058] An injection gas refrigerant extracted from the gas-liquid separator 14 to the gas injection circuits 20A and 20B is not subject to pressure reduction caused by the second expansion valve 15 and heat absorption caused by the evaporator 16.

[0059] The pressure of the injection gas refrigerant corresponds to the intermediate pressure. Since the temperature of the injection gas refrigerant is lower than the temperatures of refrigerants in the housings 103A and 103B, when the injection gas refrigerant gas is sucked and compressed by the high-stage compression mechanism 102 along with the refrigerants in the housings 103A and 103B, the temperature of a refrigerant discharged from the high-stage compression mechanism 102 is suppressed.

[0060] Particularly, injection of an intermediate-pressure low-temperature refrigerant is effective in a case where CO₂, which results in a high possibility of an increase in maximum temperature and maximum pressure of a refrigerant in the refrigeration cycle 1, is used as a refrigerant.

[0061] In consideration of a temperature at which electric motor coils in the housings 103A and 103B can be used, quality maintenance of the lubricating oil, the efficiency of the refrigeration cycle, and the like, it is necessary to suppress the temperature and the pressure in the housings 103A and 103B and the temperature of a discharged refrigerant to be equal to or lower than allowable limits by means of injection of an intermediate-pressure low-temperature refrigerant. Therefore, it is necessary to secure an injection amount (injection flow rate) of a predetermined level or more.

[0062] Next, the bypass paths 30A and 30B, which are the main features of the present embodiment, will be de-

scribed.

[0063] The bypass paths 30A and 30B connect the cooler 12, the first expansion valve 13, and the corresponding gas injection circuits 20A and 20B to each other.

[0064] Since the bypass paths 30A and 30B are provided, a refrigerant passing through the cooler 12 flows into the gas injection circuits 20A and 20B without passing through (while bypassing) the first expansion valve 13 and the gas-liquid separator 14 and is supplied to between the low-stage compression mechanism 101 and the high-stage compression mechanism 102 in each of the housings 103A and 103B through the gas injection circuits 20A and 20B.

[0065] The bypass paths 30A and 30B are provided in the refrigeration cycle 1 for the purpose of achieving a pressure difference between the housings 103A and 103B which is needed for oil equalization while satisfying the temperature of a discharged refrigerant, the internal pressures of the housings 103A and 103B, and a cycle efficiency by securing a necessary injection amount.

[0066] The temperature of a bypass refrigerant that is extracted from between the cooler 12 and the first expansion valve 13 to the bypass paths 30A and 30B is low since the bypass refrigerant passes through the cooler 12. In addition, since the bypass refrigerant does not pass through the first expansion valve 13, the bypass refrigerant is in a liquid state or a liquid-phase-dominant state and the pressure thereof is higher than that of a gas refrigerant extracted from the inside of the gas-liquid separator 14 to the gas injection circuits 20A and 20B. It is possible to achieve a pressure difference for causing the lubricating oil to move between the housings 103A and 103B with the temperature of the discharged refrigerant and the internal pressures of the housings 103A and 103B being suppressed to be equal to or lower than allowable values by supplying the bypass refrigerant into the housings 103A and 103B.

[0067] The amount of low-temperature refrigerants supplied into the housings 103A and 103B through the bypass paths 30A and 30B is smaller than that of gas that is discharged into the housings 103A and 103B by the low-stage compression mechanisms 101 and the low-temperature refrigerants are evaporated when being mixed with the discharged gas and are sucked into the high-stage compression mechanism 102.

[0068] Since the bypass refrigerant, of which the pressure is higher than that of the gas refrigerant extracted from the gas-liquid separator 14, flows thereinto, the gas injection circuit 20A is provided with a check valve 21A and the gas injection circuit 20B is provided with a check valve 21B. Since the check valves 21A and 21B are provided, it is possible to prevent a backward flow of refrigerants that respectively flow in the gas injection circuits 20A and 20B toward the housings 103A and 103B.

[0069] The bypass path 30A is provided with a bypass flow regulation valve (bypass valve) 31A that can perform flow rate adjustment and the bypass path 30B is provided

with a bypass flow regulation valve (bypass valve) 31B that can perform flow rate adjustment.

[0070] It is possible to apply a pressure difference between the housings 103A and 103B by manipulating the opening degree of each of the bypass flow regulation valves 31A and 31B with the control unit 40 at the time of the oil equalization operation such that the pressure in each of the housings 103A and 103B of the compressors 11A and 11B is changed.

[0071] Hereinafter, the operation and effect of the bypass paths 30A and 30B in the present embodiment will be described via comparison with a case (comparative example) where the flow rate of a gas refrigerant extracted from the inside of the gas-liquid separator 14 to the gas injection circuits 20A and 20B is adjusted.

[0072] The comparative example is a refrigeration cycle illustrated in Fig. 5.

[0073] In the refrigeration cycle illustrated in Fig. 5, the gas injection circuit 20A is provided with a flow regulation valve 91A and the gas injection circuit 20B is provided with a flow regulation valve 91B.

[0074] It will be assumed that a pressure difference needed for the oil equalization is applied between the housings 103A and 103B by controlling the opening degree of each of the flow regulation valves 91A and 91B at the time of the oil equalization operation by means of a control unit 90.

[0075] The pressure in each of the housings 103A and 103B is changed based on the flow rates of gas refrigerants flowing in the gas injection circuits 20A and 20B, which correspond to the opening degrees of the flow regulation valves 91A and 91B.

[0076] For example, when a flow rate is decreased by the flow regulation valve 91A, the pressure in the housing 103A of the compressor 11A becomes relatively small and the flow rate is increased by the flow regulation valve 91B, the pressure in the housing 103B of the compressor 11B becomes relatively large. In this case, the lubricating oil moves through the oil equalization path 17 in accordance with a pressure difference between the housings 103A and 103B of the compressors 11A and 11B.

[0077] In the comparative example, in order to realize a pressure difference between the housings 103A and 103B which is needed for the oil equalization, it is necessary to make the flow rates of injection refrigerants supplied to the housings 103A and 103B of the compressors 11A and 11B different from each other. Therefore, it is necessary to decrease the flow rate of a gas refrigerant flowing in one of the plurality of gas injection circuits 20A and 20B and there is a possibility that it is not possible to secure a necessary injection amount with respect to the compressor 11A in which the flow rate is decreased.

[0078] Unlike the above-described comparative example, in the present embodiment (Fig. 1), there is no difference between the flow rates of gas refrigerants extracted from the inside of the gas-liquid separator 14 to the gas injection circuits 20A and 20B and a pressure difference is applied between the housings 103A and

103B by means of a difference between the flow rates in the bypass paths 30A and 30B which are adjusted by the bypass flow regulation valves 31A and 31B.

[0079] The flow rate of a refrigerant extracted to the bypass paths 30A and 30B only have to reach a limit necessary for moving the lubricating oil between the housings 103A and 103B.

[0080] As described above, since a refrigerant that is extracted from between the cooler 12 and the first expansion valve 13 to the bypass paths 30A and 30B is in a liquid state or a liquid-phase-dominant state and the pressure thereof is higher than that of a gas refrigerant extracted from the inside of the gas-liquid separator 14 as described above, a pressure difference between the housings 103A and 103B, which is needed to move the lubricating oil in the oil equalization path 17, can be secured by extracting a slight amount of the refrigerant to the bypass paths 30A and 30B, the pressure difference being maximized when one of the bypass flow regulation valves 31A and 31B is fully opened and the other of the bypass flow regulation valves 31A and 31B is fully closed.

[0081] In addition, since a refrigerant flowing in the bypass paths 30A and 30B is in a liquid state or a liquid-phase-dominant state and the density thereof is higher than that of a gas refrigerant, as the bypass flow regulation valves 31A and 31B of the bypass paths 30A and 30B, a valve having a bore diameter smaller than that of the flow regulation valves 91A and 91B (Fig. 5) of the gas injection circuits 20A and 20B can be used. Therefore, in the present embodiment, it is possible to suppress the cost of a flow regulation valve in comparison with the comparative example.

[0082] Control performed by the control unit 40 at the time of the oil equalization operation will be described.

[0083] When the refrigeration cycle 1 is continuously operated for a long period of time and an appropriate timing, at which the amount of lubricating oil in the housing 103A of the compressor 11A and the amount of lubricating oil in the housing 103B of the compressor 11B may be uneven, is reached, the control unit 40 causes the refrigeration cycle 1 to perform the oil equalization operation.

[0084] The control unit 40 according to the present embodiment causes the refrigeration cycle 1 to perform the oil equalization operation by adding up the amounts of lubricating oil flowing out from the insides of the housings 103A and 103B in accordance with operation conditions and estimating how the amounts of lubricating oil in the housings 103A and 103B are uneven. Specifically, the oil equalization valve 171 is opened and the opening degrees of the bypass flow regulation valves 31A and 31B are set. The added up amount of lubricating oil flowing out is reset each time the oil equalization operation is performed.

[0085] The oil equalization operation may be performed each time a predetermined operation continuation time elapses.

[0086] A pressure difference corresponding to a direc-

tion in which the lubricating oil moves from the inside of the housing 103A of the compressor 11A to the inside of the housing 103B of the compressor 11B and a pressure difference corresponding to a direction in which the lubricating oil moves from the inside of the housing 103B of the compressor 11B to the inside of the housing 103A of the compressor 11A, which is opposite to the above-described pressure difference, are applied to the housings 103A and 103B of the compressors 11A and 11B. In this case, it is possible to equalize the amounts of lubricating oil in the housings 103A and 103B even if it is unclear which of the housings 103A and 103B of the compressors 11A and 11B has a larger amount of lubricating oil therein and it is unclear which of the housings 103A and 103B has a smaller amount of lubricating oil therein.

[0087] Therefore, first, the control unit 40 sets the opening degrees of the bypass flow regulation valves 31A and 31B such that the opening degree of the bypass flow regulation valve 31A becomes larger than the opening degree of the bypass flow regulation valve 31B in order that "the pressure in the housing 103A of the compressor 11A > the pressure in the housing 103B of the compressor 11B" is satisfied. Thereafter, the opening degrees of the bypass flow regulation valves 31A and 31B are set such that the opening degree of the bypass flow regulation valve 31B becomes larger than the opening degree of the bypass flow regulation valve 31A in order that "the pressure in the housing 103A of the compressor 11A < the pressure in the housing 103B of the compressor 11B" is satisfied.

[0088] In this case, the amounts of lubricating oil in the housings 103A and 103B of the compressors 11A and 11B are equalized regardless of how the amounts of lubricating oil in the housings 103A and 103B are uneven before the oil equalization operation.

[0089] Note that, in the present embodiment, it is also allowable to contribute to realization of a pressure difference between the housings 103A and 103B by increasing the rotation speed of any of the compressors 11A and 11B and increasing the pressure loss of a refrigerant sucked and discharged.

[0090] Meanwhile, when the bypass flow regulation valve 31A or the bypass flow regulation valve 31B is open, since the corresponding bypass paths 30A and 30B are open, a low-temperature refrigerant extracted from between the cooler 12 and the first expansion valve 13 is supplied into the housings 103A and 103B through the bypass paths 30A and 30B which are open. A low-temperature gas refrigerant is supplied into the housings 103A and 103B through the gas injection circuits 20A and 20B and in addition to the low-temperature gas refrigerant, a low-temperature refrigerant is supplied in surplus into the housings 103A and 103B through the bypass paths 30A and 30B which are open.

[0091] Therefore, the bypass paths 30A and 30B can be used at the time of operation conditions under which the temperature and the pressure in the housings 103A

and 103B and the temperature of a refrigerant discharged from the compressors 11A and 11B may exceed an upper limit if gas injection is performed by using only the gas injection circuits 20A and 20B.

[0092] The control unit 40 in the present embodiment controls the opening degrees of the bypass flow regulation valves 31A and 31B to perform injection of a low-temperature refrigerant through the bypass paths 30A and 30B even at a time other than the time of the oil equalization operation.

[0093] When controlling the opening degrees of the bypass flow regulation valves 31A and 31B, the control unit 40 uses the temperature of refrigerants discharged from the compressors 11A and 11B as an index.

[0094] For this reason, the refrigerant circuit 10 is provided with a temperature sensor (discharge temperature sensor) 32A that measures the temperature of a refrigerant discharged from the compressor 11A and a temperature sensor (discharge temperature sensor) 32B that measures the temperature of a refrigerant discharged from the compressor 11B.

[0095] Hereinafter, the temperatures of refrigerants discharged from the compressors 11A and 11B will be referred to as "discharge temperatures".

[0096] As illustrated in Fig. 1, the control unit 40 is provided with a discharge temperature acquiring unit 41 that acquires discharge temperatures from the temperature sensors 32A and 32B, a determination unit 42 that determines whether the discharge temperatures measured by the temperature sensors 32A and 32B exceed predetermined threshold values or not, and an opening degree setting unit 43 that sets the opening degrees of the bypass flow regulation valves 31A and 31B in accordance with the result of the determination performed by the determination unit 42.

[0097] The flow of control performed by the control unit 40 will be described.

[0098] The discharge temperature acquiring unit 41 of the control unit 40 acquires discharge temperatures measured by the temperature sensors 32A and 32B.

[0099] Next, the determination unit 42 of the control unit 40 determines whether the acquired discharge temperatures of the compressors 11A and 11B respectively exceed the predetermined threshold values.

[0100] Then, in a case where a discharge temperature exceeds the threshold value, the opening degree setting unit 43 of the control unit 40 causes a bypass flow regulation valve (one or both of 31A and 31B) of a bypass path connected to a housing (one or both of 103A and 103B) of a compressor corresponding to the discharge temperature exceeding the threshold value to be opened to a predetermined opening degree.

[0101] For example, in a case where the discharge temperature of the compressor 11A exceeds the threshold value, the opening degree setting unit 43 causes the bypass flow regulation valve 31A to be opened such that a low-temperature refrigerant is supplied into the housing 103A of the compressor 11A. Since the refrigerant is

compressed by the high-stage compression mechanism 102 along with a refrigerant in the housing 103A, the discharge temperature of the compressor 11A is suppressed.

[0102] In addition, in a case where the discharge temperature of the compressor 11B exceeds the threshold value, the opening degree setting unit 43 causes the bypass flow regulation valve 31B to be opened such that a low-temperature refrigerant is supplied into the housing 103B of the compressor 11B and thus the discharge temperature of the compressor 11B is suppressed.

[0103] It is preferable that larger opening degrees of the bypass flow regulation valves 31A and 31B are set as a deviation between a threshold temperature and the discharge temperatures becomes larger. In this case, it is possible to quickly suppress the discharge temperatures to be equal to or lower than the threshold values.

[0104] In a case where the discharge temperatures are equal to or lower than the threshold values, it is not necessary to open the bypass flow regulation valves 31A and 31B to suppress the discharge temperatures.

[0105] It is possible to suppress the temperatures and internal pressures of the housings 103A and 103B to be equal or lower than allowable values as with the discharge temperatures by controlling the opening degrees of the bypass flow regulation valves 31A and 31B by using the discharge temperatures as described above.

[0106] It is also possible to control the bypass flow regulation valves 31A and 31B by using a detected value such as the temperatures or the internal pressures or the like of the housings 103A and 103B instead of the discharge temperatures or at a predetermined opening degree that is determined corresponding to the operation conditions.

[0107] As described above, in the present embodiment, a refrigerant of which the pressure is higher than that of a gas refrigerant, which is extracted from the inside of the gas-liquid separator 14 and is supplied into the housings 103A and 103B, is supplied into the housings 103A and 103B through the bypass paths 30A and 30B and the flow rates of refrigerants flowing in the bypass paths 30A and 30B are made different from each other with the opening degrees of the bypass flow regulation valves 31A and 31B being controlled.

[0108] According to this configuration, at the time of the oil equalization operation, it is possible to achieve oil equalization by applying a pressure difference between the housings 103A and 103B of the compressor 11A and the compressor 11B.

[0109] In addition, even at a time other than the time of the oil equalization operation, it is possible to prevent the temperatures of refrigerants discharged from the compressors 11A and 11B from being excessive or to prevent the temperatures or internal pressures of the housings 103A and 103B from being excessive while securing a necessary refrigerant injection amount as a whole obtained by combining injection of a low-temperature refrigerant through the bypass paths 30A and 30B

and injection of a gas refrigerant through the gas injection circuits 20A and 20B.

[0110] In the present embodiment, it is possible to adjust the flow rates of refrigerants flowing in the bypass paths 30A and 30B in accordance with the discharge temperatures of the compressors 11A and 11B by using the bypass flow regulation valves 31A and 31B. Therefore, for example, it is possible to appropriately control the discharge temperatures as in a case of controlling the bypass flow regulation valves 31A and 31B such that the opening degrees become larger as a deviation between the threshold values and the discharge temperatures becomes larger in order to quickly suppress the discharge temperature deviating from the threshold value to be equal to or lower than the threshold value.

[0111] Furthermore, in the present embodiment, pipes for injection are integrated into one pipe at a position downstream of flowing-in positions of the bypass paths 30A and 30B to the gas injection circuits 20A and 20B and one injection port P3 for receiving an injection refrigerant may be provided for each of the housings 103A and 103B. Therefore, it is possible to suppress the weight or the cost in comparison with a case where the gas injection circuit 20A and the bypass path 30A (or gas injection circuit 20B and bypass path 30B) are individually configured.

[0112] Instead of the bypass flow regulation valves 31A and 31B, on-off valves also can be used. For example, it is possible to realize the same function as the flow regulation valves by intermittently turning on and off the on-off valves respectively disposed in the bypass paths 30A and 30B and changing the proportion of a turned-on time per unit time or by providing a plurality of on-off valves in parallel in each of the bypass paths 30A and 30B and changing the ratio between the number of on-off valves turned on and the number of on-off valves turned off.

(Second Embodiment)

[0113] Next, a second embodiment of the present invention will be described with reference to Fig. 2.

[0114] In the second embodiment, a more basic circuit for supplying a refrigerant of which the temperature is lower than that of an injection gas refrigerant to the housings 103A and 103B of the compressors 11A and 11B is illustrated.

[0115] In a refrigeration cycle 2 illustrated in Fig. 2, the bypass paths 30A and 30B are not connected to the gas injection circuits 20A and 20B and are directly connected to the insides of the housings 103A and 103B.

[0116] Since the check valves 21A and 21B are provided in the gas injection circuits 20A and 20B, a backward flow of refrigerants in the gas injection circuits 20A and 20B is prevented. Even in the case of a configuration illustrated in Fig. 2, it is possible to achieve a pressure difference between the housings 103A and 103B which is needed for oil equalization by making the flow rates of refrigerants flowing in the bypass paths 30A and 30B

different from each other by controlling the opening degrees of the bypass flow regulation valves 31A and 31B with the control unit 40.

[0117] In addition, even under severe operation conditions against allowable values of the discharge temperatures, it is possible to secure an injection amount needed for preventing overheating with injection refrigerants supplied into the housings 103A and 103B through the bypass paths 30A and 30B.

[0118] A refrigeration cycle 3 illustrated in Fig. 3 is provided with a pressure sensor 33A that measures the pressure of an injection refrigerant flowing into the injection port P3 of the housing 103A of the compressor 11A and a pressure sensor 33B that measures the pressure of an injection refrigerant flowing into the injection port P3 of the housing 103B of the compressor 11B.

[0119] Based on the pressures measured by the pressure sensors 33A and 33B, the control unit 40 can control the opening degrees of the bypass flow regulation valves 31A and 31B such that a necessary and sufficient difference is generated between the flow rates of refrigerants flowing in the bypass paths 30A and 30B. In this case, it is possible to reliably achieve a pressure difference between the housings 103A and 103B which is needed for oil equalization.

[0120] In addition, in order to more appropriately control the discharge temperatures or the like of the compressors 11A and 11B, the control unit 40 can control the opening degrees of the corresponding bypass flow regulation valves 31A and 31B by using pressures measured by the pressure sensors 33A and 33B in addition to discharge temperatures measured by the temperature sensors 32A and 32B.

[0121] In the refrigeration cycle 2 illustrated in Fig. 2, the pressure sensors 33A and 33B may be provided in the vicinity of injection ports P3' into which injection refrigerants from the bypass paths 30A and 30B flow. Even in this case, it is possible to control the opening degrees of the bypass flow regulation valves 31A and 31B with the control unit 40 by using pressures measured by the pressure sensors 33A and 33B.

[0122] In addition to the above, the configurations described in the above embodiment can be selectively adopted or appropriately changed to other configurations without departing from the gist of the present invention.

[0123] Instead of the bypass flow regulation valves 31A and 31B of the refrigeration cycle 1 in Fig. 1, on-off valves can be used. For example, it is possible to apply a pressure difference which is needed for movement of lubricating oil between the housings 103A and 103B of the compressors 11A and 11B by opening an on-off valve corresponding to the bypass path 30A and closing an on-off valve corresponding to the bypass path 30B with the control unit 40.

[0124] In addition, it is possible to prevent discharge temperatures or the like from exceeding limits thereof by opening an on-off valve of a bypass path corresponding to a compressor of which the discharge temperature ex-

ceeds a threshold value in a case where discharge temperatures from the compressors 11A and 11B exceed threshold values.

[0125] The refrigeration cycle in the present invention is adequate for an object thereof as long as at least oil equalization between the housings 103A and 103B of the compressors can be achieved with an injection amount being secured. A limit on the discharge temperature may not be necessary in the case of a compressor operated at a constant speed and in view point of a pressing amount.

[0126] Therefore, in a refrigeration cycle of the present invention, a bypass valve can be provided only for a bypass path that needs a change in refrigerant flow rate from among the bypass paths 30A and 30B corresponding to the housings of the plurality of compressors and a bypass valve may not be provided for each of the bypass paths 30A and 30B.

[0127] For example, as in the case of a refrigeration cycle 4 illustrated in Fig. 4, it is possible to make the flow rates of refrigerants flowing in the bypass paths 30A and 30B different from each other by making the bore diameters of the bypass paths 30A and 30B different from each other and to provide an on-off valve 35 only for one bypass path 30A with a large flow rate.

[0128] In the above-described configuration, it is possible to apply a pressure difference for oil equalization between the housings 103A and 103B by opening the on-off valve 35 or closing the on-off valve 35.

[0129] Although each of the above-described refrigeration cycles 1, 2, and 3 is configured to include two compressors 11A and 11B connected in parallel, each of the above-described refrigeration cycles may be configured to include three or more compressors connected in parallel. Even in this case, housings of the plurality of compressors are connected to each other through an oil equalization path. In addition, the opening degree of a bypass valve of a bypass path provided for each compressor is controlled. For example, when a bypass valve corresponding to one of the three compressors is opened to a predetermined opening degree and bypass valves corresponding to the remaining two compressors are closed, lubricating oil can move from a housing in which the pressure is relatively high to a housing in which the pressure is relatively low.

Reference Signs List

[0130]

- 1, 2, 3, 4 refrigeration cycle
- 10 refrigerant circuit
- 11A, 11B compressor (multistage compressor)
- 12 cooler
- 13 first expansion valve (first pressure-reducing unit)
- 14 gas-liquid separator
- 15 expansion valve (second pressure-reducing unit)
- 16 evaporator

- 17 oil equalization path
- 20A, 20B gas injection circuit
- 21A, 21B check valve
- 30A, 30B bypass path
- 31A, 31B bypass flow regulation valve (bypass valve)
- 32A, 32B temperature sensor (discharge temperature sensor)
- 33A, 33B pressure sensor
- 35 on-off valve
- 40 control unit
- 41 discharge temperature acquiring unit
- 42 determination unit
- 43 opening degree setting unit
- 90 control unit
- 91A, 91B flow regulation valve
- 101 low-stage compression mechanism
- 102 high-stage compression mechanism
- 103A, 103B housing
- 171 oil equalization valve
- P1 suction port
- P2 discharge port
- P3 injection port

Claims

1. A refrigeration cycle including a plurality of multistage compressors each of which includes a housing that accommodates a multistage compression mechanism including a low-stage compression mechanism and a high-stage compression mechanism and which are connected in parallel, in which a refrigerant circuit is configured by sequentially connecting the plurality of multistage compressors, a cooler, a first pressure-reducing unit, a gas-liquid separator, a second pressure-reducing unit, and an evaporator, the refrigeration cycle comprising:

an oil equalization path that connects the housings of the plurality of multistage compressors to each other;

a plurality of gas injection circuits through which a gas refrigerant in the gas-liquid separator is supplied to between the low-stage compression mechanism and the high-stage compression mechanism of the housing of the corresponding multistage compressor;

a plurality of bypass paths through which a refrigerant extracted from between the cooler and the first pressure-reducing unit is supplied to between the low-stage compression mechanism and the high-stage compression mechanism of the housing of the corresponding multistage compressor;

a bypass valve that is capable of changing a flow rate of the refrigerant that flows in at least one of the bypass paths of the plurality of multistage

- compressors;
 a check valve that is provided in the gas injection circuit and that prevents a backward flow of the gas refrigerant flowing toward the inside of the housing; and
 a control unit configured to control an opening degree of the bypass valve.
2. The refrigeration cycle according to Claim 1, wherein the refrigerant extracted from between the cooler and the first pressure-reducing unit flows into the gas injection circuits through the plurality of bypass paths. 10
3. The refrigeration cycle according to Claim 1 or 2, wherein the control unit is configured to control the opening degree of the bypass valve at least at the time of an oil equalization operation in which lubricating oil moves between the housings of the plurality of multistage compressors through the oil equalization path. 15 20
4. The refrigeration cycle according to any one of Claims 1 to 3, further comprising: 25
- a discharge temperature sensor that measures a discharge temperature, which is a temperature of a refrigerant discharged from the multistage compressor, wherein the control unit is configured to control the opening degree of the bypass valve by using the discharge temperature. 30
5. The refrigeration cycle according to any one of Claims 1 to 4, wherein the bypass valve is a flow regulation valve that is capable of adjusting the flow rate of the refrigerant and is provided for each of the plurality of bypass paths. 35 40
6. The refrigeration cycle according to any one of Claims 1 to 5, wherein CO₂ is used as a refrigerant circulating in the refrigerant circuit. 45
7. The refrigeration cycle according to Claim 1, further comprising:
- a pressure sensor that measures the pressure of the gas refrigerant and/or the refrigerant flowing into the housings of the plurality of multistage compressors, wherein the control unit is configured to control the opening degree of the bypass valve based on the pressure of the refrigerant measured by the pressure sensor. 50 55
8. The refrigeration cycle according to Claim 1,

wherein the plurality of bypass paths are directly connected to the insides of the housings of the plurality of multistage compressors, respectively.

- 5 9. The refrigeration cycle according to Claim 1, wherein the bypass valve is provided for at least one of the plurality of the bypass paths.

FIG. 1

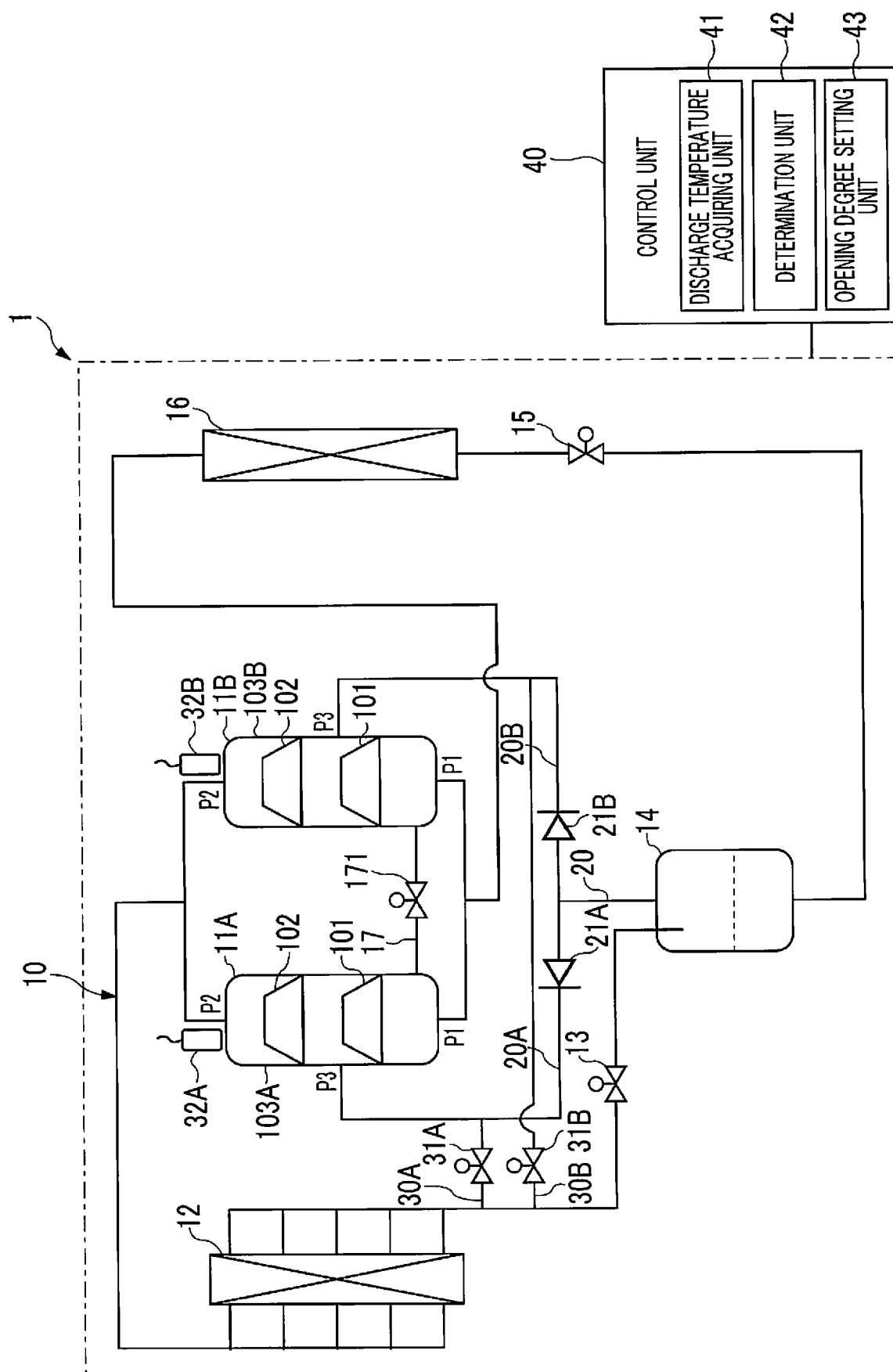


FIG. 2

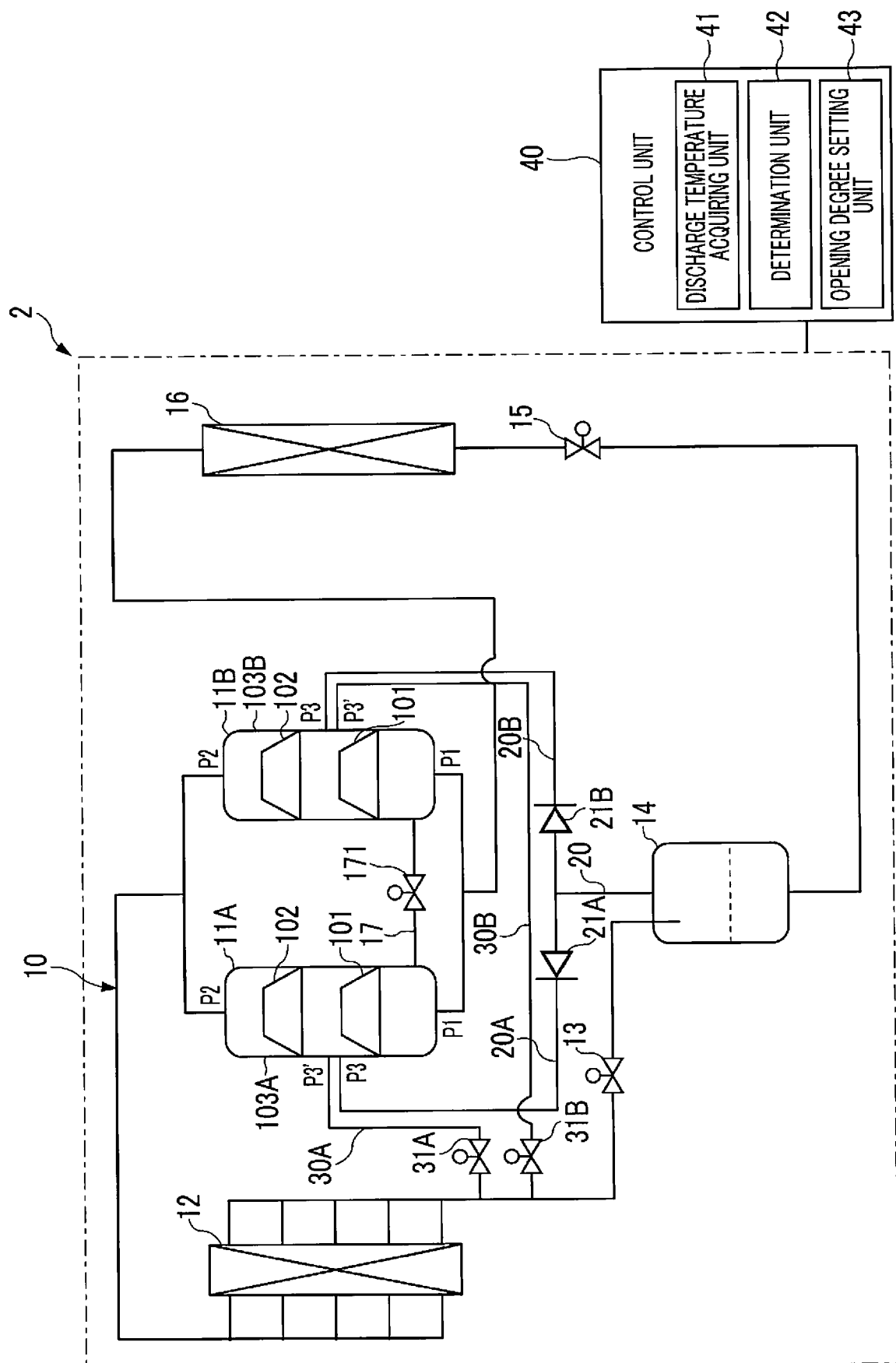


FIG. 3

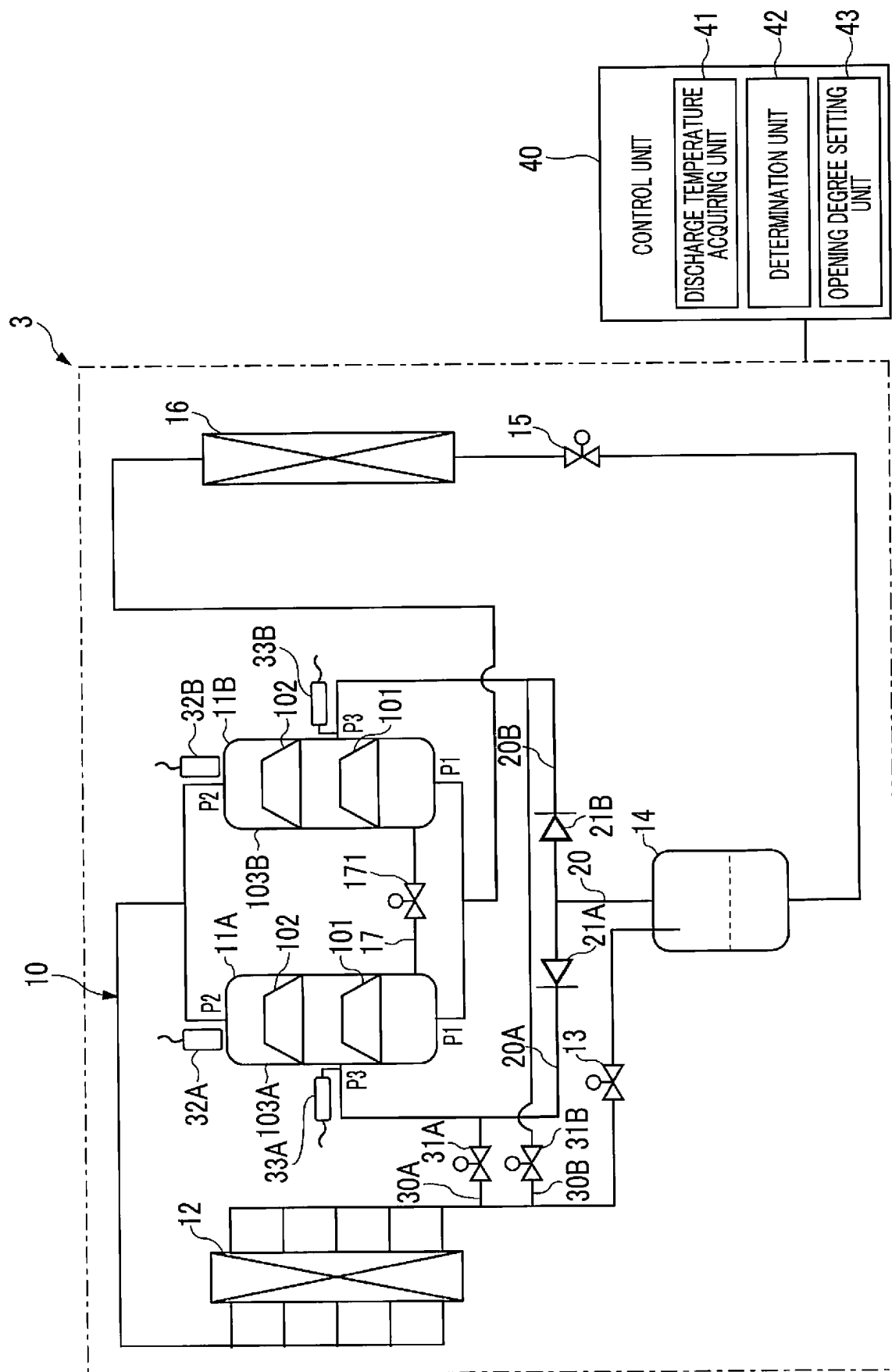


FIG. 4

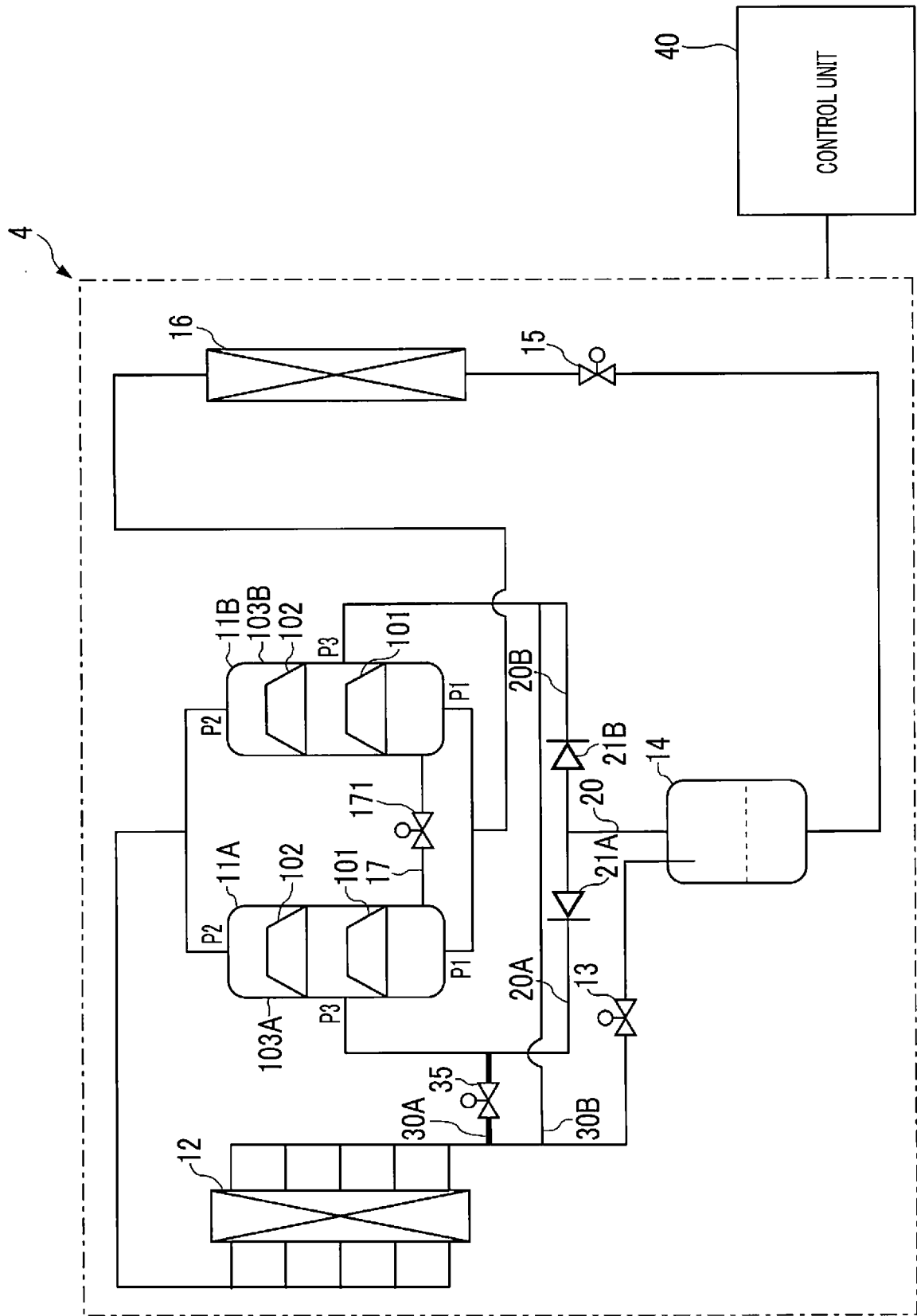
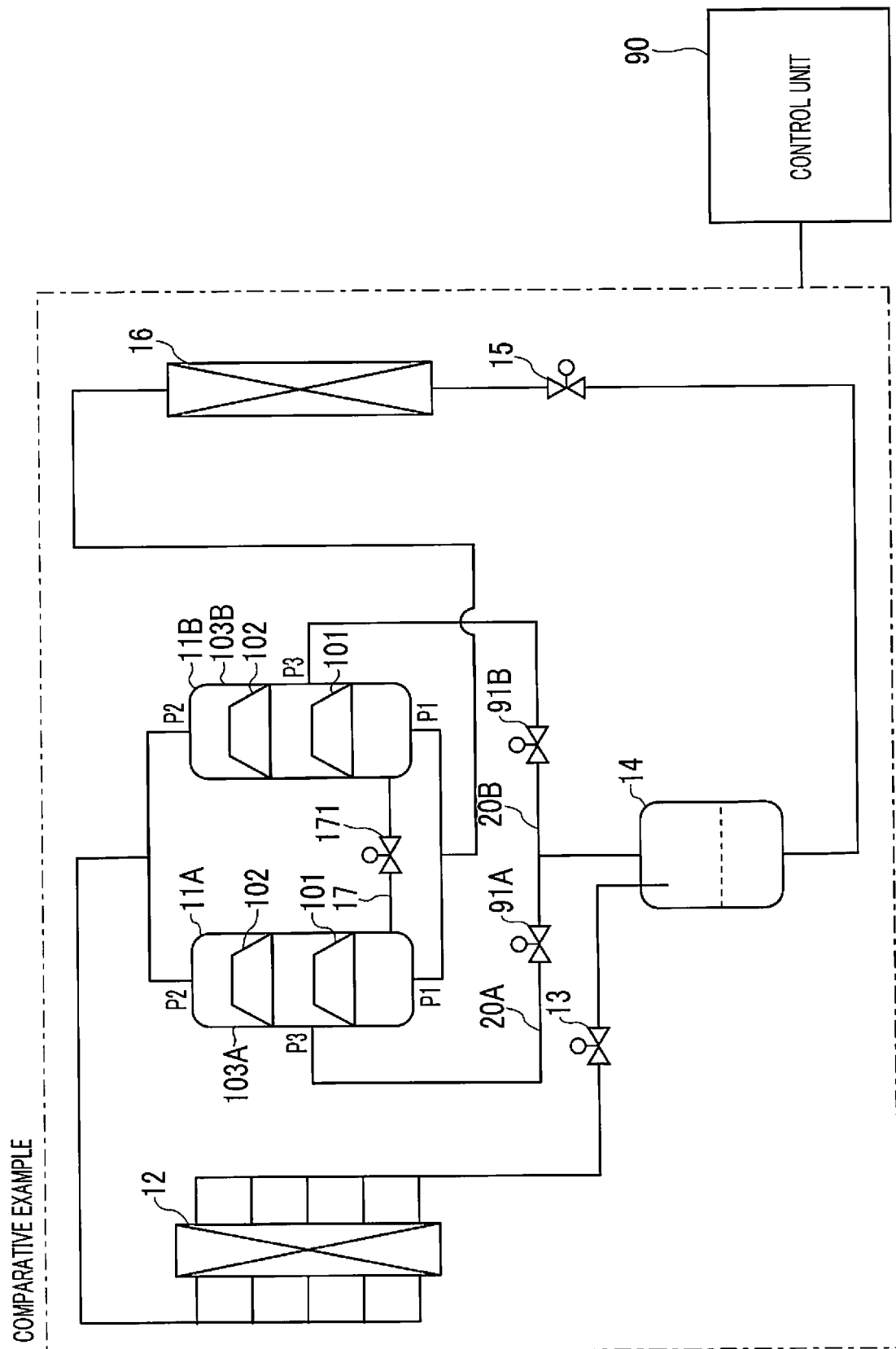


FIG. 5



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2017/001519

A. CLASSIFICATION OF SUBJECT MATTER

F25B1/00(2006.01)i, F25B1/10(2006.01)i, F25B31/00(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)

F25B1/00, F25B1/10, F25B31/00

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

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2017

Kokai Jitsuyo Shinan Koho 1971-2017 Toroku Jitsuyo Shinan Koho 1994-2017

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 5193011 B2 (Mitsubishi Heavy Industries, Ltd.), 08 May 2013 (08.05.2013), paragraphs [0011] to [0041]; fig. 8 & JP 2010-139109 A	1, 4-9 2-3
Y A	JP 2009-109065 A (Hitachi Appliances, Inc.), 21 May 2009 (21.05.2009), paragraphs [0012] to [0024]; fig. 1 (Family: none)	1, 4-9 2-3

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

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T"

later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X"

document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y"

document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&"

document member of the same patent family

Date of the actual completion of the international search
07 April 2017 (07.04.17)Date of mailing of the international search report
18 April 2017 (18.04.17)Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

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

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2017/001519

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 2013-53758 A (Mitsubishi Heavy Industries, Ltd.), 21 March 2013 (21.03.2013), paragraphs [0019] to [0025]; fig. 1 & WO 2013/031591 A1 & EP 2752628 A1 paragraphs [0020] to [0030]; fig. 1 & CN 103403475 A & KR 10-2013-0140843 A	6 1-5, 7-9
Y A	JP 2001-116376 A (Sharp Corp.), 27 April 2001 (27.04.2001), paragraphs [0030] to [0031]; fig. 1 (Family: none)	6 1-5, 7-9
A	JP 8-200852 A (Daikin Industries, Ltd.), 06 August 1996 (06.08.1996), paragraph [0042]; fig. 3 (Family: none)	1-9
A	JP 2011-179783 A (Hitachi Appliances, Inc.), 15 September 2011 (15.09.2011), paragraphs [0037] to [0041]; fig. 5 (Family: none)	1-9

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

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 5193011 B [0008]