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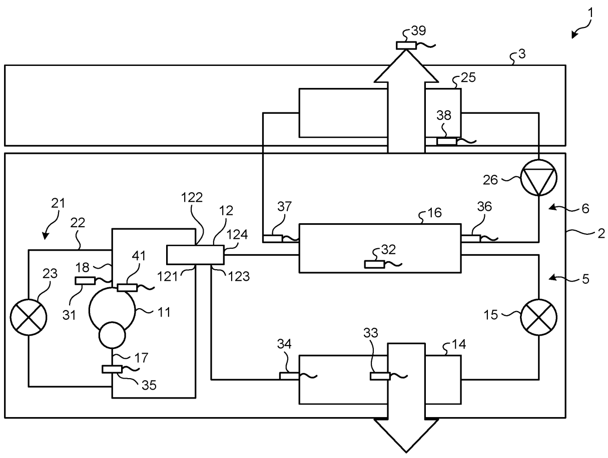
(54) **AIR CONDITIONER**

(57) An air conditioning unit (1) includes a compressor (11); a condenser (16) that is connected to the compressor (11) via an ejection pipe (18); an evaporator (14) that is connected to the compressor (11) via an intake pipe (17); a main expansion valve (15) that decompresses a refrigerant that is supplied from the condenser (16) and supplies the refrigerant to the evaporator (14); a bypass expansion valve (23) that is provided on a bypass (22) connecting the ejection pipe (18) and the intake pipe (17); and a control device (43) that controls the bypass expansion valve (23) while the compressor (11) is compressing the refrigerant of the intake pipe (17) and ejecting the refrigerant to the ejection pipe (18) and that switches a first state in which the refrigerant does not flow through the bypass (22) and a second state in which the refrigerant flows into the intake pipe (17) from the ejection pipe (18) via the bypass (22).

FIG.1



Description

Field

[0001] The present invention relates to an air conditioning unit.

Background

[0002] An air conditioning unit provided with a bypass for a hot gas bypass that supplies a refrigerant on an ejection side of a compressor to an intake side of the compressor has been known (Patent Literatures 1 to 3). Such an air conditioning unit supplies a refrigerant on an ejection side of a compressor to an intake side of the compressor via a bypass, thereby making it possible to increase enthalpy of the refrigerant on the intake side and prevent a carry-over and prevent stagnation of the refrigerant.

Citation List

Patent Literature

[0003]

Patent Literature 1: Japanese Laid-open Patent Publication No. 2018-112396
Patent Literature 2: Japanese Laid-open Patent Publication No. 2004-020064
Patent Literature 3: Japanese Laid-open Patent Publication No. 2003-156258

Summary

Technical Problem

[0004] If the type of refrigerant differs, even when a refrigerant is compressed at the same compression ratio, an ejection temperature of the refrigerant that is ejected from a compressor sometimes differs. For example, compared to a R32 refrigerant, the ejection temperature of a R290 refrigerant is low compared to a R32 refrigerant because of its properties even when the R290 refrigerant is compressed at the same compression ratio. In an air conditioning unit, an ejection temperature lowers and accordingly a difference in temperature from the air decreases in a condenser and therefore a heat exchange rate lowers. By increasing a rotational frequency of the compressor, the air condoning unit is able to increase the ejection temperature and inhibit the heat exchange rate in the condenser from lowering. There is however the problem that increasing the rotational frequency of the compressor sometimes increases the compression ratio and thereby a load applied to sliding portions in the compressor increases and the reliability of the compressor lowers. It is possible to increase an ejection temperature without increasing a rotational frequency of a compressor by providing a bypass for a hot gas bypass that supplies a refrigerant on an ejection side of the compressor to an intake side of the compressor as according to Patent Literatures 1 to **3;** however, any of them is for the purpose of inhibiting the ejection temperature from excessively increasing and therefore there is room for improvement in the control method.

[0005] The disclosed technique was made in view of the above-described aspects and an object of the technique is to provide an air conditioning unit that increases a temperature of a refrigerant that is ejected from a compressor while inhibiting a load on the compressor from increasing.

Solution to Problem

[0006] According to an aspect of an embodiment, an air conditioning unit includes a compressor, a condenser that is connected to the compressor via an ejection pipe, an evaporator that is connected to the compressor via an intake pipe, a main expansion valve that decompresses a refrigerant that is supplied from the condenser and supplies the refrigerant to the evaporator, a bypass expansion valve that is provided on a bypass connecting the ejection pipe and the intake pipe, an ejection temperature sensor that detects an ejection temperature that is a temperature of an ejection refrigerant that is ejected from the compressor, a condensing pressure calculator that calculates a condensing pressure that is a pressure of the refrigerant flowing through the condenser, and a controller that controls the bypass expansion valve and that switches between a first state in which the refrigerant does not flow through the bypass and a second state in which the refrigerant flows into the intake pipe from the ejection pipe via the bypass, wherein, when the refrigerant does not flow through the bypass, the controller controls an opening of the main expansion valve such that the ejection temperature is at a predetermined target ejection temperature, and when the refrigerant flows through the bypass, the controller controls the opening of the main expansion valve such that the condensing pressure is at a predetermined target condensing pressure.

Advantageous Effects of Invention

[0007] The disclosed air conditioning unit makes it possible to increase a temperature of a refrigerant that is ejected from a compressor while inhibiting a load on a compressor from increasing.

Brief Description of Drawings

[0008]

FIG. 1 is a circuitry diagram illustrating an air conditioning unit of First Embodiment.
FIG. 2 is a block diagram illustrating the air condi-

tioning unit of First Embodiment.

FIG. 3 is a flowchart illustrating control on a main expansion valve and a bypass expansion valve.

FIG. 4 is a Mollier diagram illustrating a change in a state of a refrigerant in a case where the refrigerant flows through a bypass.

FIG. 5 is a Mollier diagram illustrating another change in the state of the refrigerant in a case where the refrigerant flows through the bypass.

FIG. 6 is a flowchart illustrating control on a main expansion valve and a bypass expansion valve of an air conditioning unit of Second Embodiment.

Description of Embodiments

[0009] An air conditioning unit according to embodiments disclosed by the present application will be described in detail below with reference to the drawings. Note that the following description does not limit the technique of the present disclosure. In the following description, the same components are denoted with the same reference numerals and redundant description will be omitted.

First Embodiment

[0010] An air conditioning unit 1 of First Embodiment includes an outdoor unit 2 and an indoor unit 3 as illustrated in FIG. 1. FIG. 1 is a circuitry diagram illustrating the air conditioning unit 1 of First Embodiment. The outdoor unit 2 is set outdoors. The indoor unit 3 is set in a room that is cooled and heated by the air conditioning unit 1. The air conditioning unit 1 further includes a refrigerant line 5 and a water line 6. The refrigerant line 5 is arranged in the outdoor unit 2. The refrigerant line 5 includes a compressor 11, a four-way valve 12, an outdoor heat exchanger 14, a main expansion valve 15, and an intermediate heat exchanger 16.

[0011] The refrigerant line 5 includes an intake pipe 17 and an ejection pipe 18. The compressor 11 includes a rotator and the rotator rotates and accordingly compresses a gas-phase refrigerant that is supplied to the compressor 11 via the intake pipe 17 and ejects the compressed gas-phase refrigerant to the ejection pipe 18. The larger the rotational frequency of the rotator is, the larger the volume of the refrigerant that the compressor 11 ejects per unit of time is. Refrigerant oil is stored in the compressor 11. The refrigerant oil lubricates a sliding portion that is provided in the compressor 11 and prevents occurrence of abrasion and galling in the sliding portion. The refrigerant oil further seals a clearance (minute gap) that is formed in the compressor 11 and prevents the refrigerant from leaking from a high-pressure side to a low-pressure side in the compressor 11 via the clearance.

[0012] The four-way valve 12 includes a first connecting port 121, a second connecting port 122, a third connecting port 123, and a fourth connecting port 124. The intake pipe 17 is connected to the first connecting port 121 and the first connecting port 121 is connected to the compressor 11 via the intake pipe 17. The ejection pipe 18 is connected to the second connecting port 122 and the second connecting port 122 is connected to the compressor 11 via the ejection pipe 18. The outdoor heat exchanger 14 is connected to the third connecting port 123. The intermediate heat exchanger 16 is connected to the fourth connecting port 124 via the refrigerant pipe. The four-way valve 12 includes a valve body and the valve body is arranged in a heating position and thus the four-way valve 12 is switched to the heating position and the valve body is arranged in a cooling position and thus the four-way valve 12 is switched to the cooling position. When the four-way valve 12 is switched to the heating position, the second connecting port 122 is connected to the fourth connecting port 124 and the third connecting port 123 is connected to the first connecting port 121. When the four-way valve 12 is switched to the cooling position, the second connecting port is connected to the third connecting port 123 and the fourth connecting port 124 is connected to the first connecting port 121.

[0013] The outdoor heat exchanger 14 is connected to the main expansion valve 15 via the refrigerant pipe. The intermediate heat exchanger 16 is connected to the main expansion valve 15 via the cooling pipe. In other words, the outdoor heat exchanger 14 is connected to the intermediate heat exchanger 16 via the main expansion valve 15. The opening of the main expansion valve 15 is adjusted and accordingly the flow of the refrigerant flowing between the outdoor heat exchanger 14 and the intermediate heat exchanger 16 is changed via the main expansion valve 15. The larger the opening of the main expansion valve 15 is, the larger the flow of the refrigerant flowing through the main expansion valve 15 per unit of time is.

[0014] The refrigerant line 5 further includes a bypass line 21. A bypass 22 is formed in the bypass line 21. One end of the bypass 22 is connected to the ejection pipe 18. The other end of the bypass 22 is connected to the intake pipe 17. The bypass line 21 includes a bypass expansion valve 23. The bypass expansion valve 23 is provided on the bypass 22. The bypass expansion valve 23 connects the ejection pipe 18 and the intake pipe 17 to let the refrigerant flow through the bypass 22 or blocks the bypass 22 so as not to let the refrigerant flow into the bypass 22. The opening of the bypass expansion valve 23 is further changed and accordingly the flow of the refrigerant flowing through the bypass 22 per unit of time is changed. The larger the opening of the bypass expansion valve 23 is, the larger the flow of the refrigerant flowing through the bypass 22 per unit of time is.

[0015] The water line 6 includes an indoor heat exchanger 25 and a pump 26. The indoor heat exchanger 25 is arranged in the indoor unit 3. The indoor heat exchanger 25 is connected to the intermediate heat exchanger 16. The pump 26 is arranged in the outdoor unit 2. The pump 26 is connected to the intermediate heat exchanger 16 and is connected to the indoor heat exchanger 25. The pump 26 circulates water through the water line 6 and supplies the water that is supplied from the indoor heat exchanger 25 to the intermediate heat exchanger 16.

[0016] The air conditioning unit 1 further includes an ejection temperature sensor 31, an intermediate heat exchange temperature sensor 32, an outdoor heat exchange temperature sensor 33, an outdoor heat exchange gas side temperature sensor 34, an inlet temperature sensor 35, a return temperature sensor 36, an outward temperature sensor 37, an indoor temperature sensor 38, and a vent temperature sensor 39. The ejection temperature sensor 31 measures a temperature of an ejection refrigerant that is ejected from the compressor 11 into the ejection pipe 18. The intermediate heat exchange temperature sensor 32 measures a temperature of the refrigerant flowing through the intermediate heat exchanger 16. The outdoor heat exchange temperature sensor 33 measures a temperature of the refrigerant flowing through the outdoor heat exchanger 14. The outdoor heat exchange gas side temperature sensor 34 measures a temperature of an outdoor heat exchange outlet refrigerant that is supplied from the outdoor heat exchanger 14 to the four-way valve 12 at the time of a heating operation. The inlet temperature sensor 35 measures a temperature of the intake refrigerant that is supplied to the compressor 11 via the intake pipe 17. The return temperature sensor 36 measures a temperature of the water that is supplied from the pump 26 to the intermediate heat exchanger 16. The outward temperature sensor 37 measures a temperature of the water that is supplied from the intermediate heat exchanger 16 to the indoor heat exchanger 25. The indoor temperature sensor 38 measures a temperature in the room in which the indoor unit 3 is arranged. The vent temperature sensor 39 measures a temperature of air that the indoor unit 3 vents into the room.

[0017] The air conditioning unit 1 further includes an ejection pressure sensor 41. The ejection pressure sensor 41 measures a pressure of the ejection refrigerant that is ejected from the compressor 11 to the ejection pipe 18.

[0018] FIG. 2 is a block diagram illustrating the air conditioning unit 1 of First Embodiment. The air conditioning unit 1 further includes an input device 42 and a control device 43. The input device 42 is operated by a user and accordingly generates information on instructions to start and stop a cooling operation or the heating operation, changing a setting temperature, and the like, and outputs the generated information to the control device 43.

[0019] The control device 43 is a computer and includes a storage device 44 and a CPU 45 (Central Processing Unit). The storage device 44 stores a computer program to be installed in the control device 43 and stores information to be used by the CPU 45. The CPU 45 executes the computer program installed in the control device 43, thereby performs information processing, and reads data from the storage device 44. The CPU 45 further receives information from the compressor 11, the four-way valve 12, the main expansion valve 15, the bypass expansion valve 23, the pump 26, the ejection temperature sensor 31, the intermediate heat exchange temperature sensor 32, the outdoor heat exchange temperature sensor 33, the indoor temperature sensor 38, the ejection pressure sensor 41, and the input device 42.

[0020] Operations that the air conditioning unit 1 executes include the heating operation and the cooling operation.

Heating Operation

[0021] The heating operation is executed when the air conditioning unit 1 is operated by the user to execute the heating operation. When the air conditioning unit 1 executes the heating operation, the control device 43 controls the four-way valve 12 and switches the four-way valve 12 such that the first connecting port 121 and the third connecting port 123 are connected and the second connecting port 122 and the fourth connecting port 124 are connected (in the heating position). The control device 43 controls the compressor 11 to compress the low-pressure gas-phase refrigerant that is supplied via the intake pipe 17. The low-pressure gas-phase refrigerant is compressed by the compressor 11 and turns into a high-pressure gas-phase refrigerant. The compressor 11 further ejects the high-pressure gas-phase refrigerant to the ejection pipe 18. The four-way valve 12 is switched to the heating position and thus the high-pressure gas-phase refrigerant that is ejected to the ejection pipe 18 is supplied to the intermediate heat exchanger 16.

[0022] The intermediate heat exchanger 16 performs heat exchange between the high-pressure gas-phase refrigerant that is supplied from the four-way valve 12 and the water circulating through the water line 6. The high-pressure gas-phase refrigerant radiates heat to the water in the intermediate heat exchanger 16 and turns into a high-pressure liquid-phase refrigerant in an overcooled state. In other words, the intermediate heat exchanger 16 functions as a condenser when the air conditioning unit 1 executes the heating operation. The high-pressure liquid phase refrigerant that flows out of the intermediate heat exchanger 16 is supplied to the main expansion valve 15.

[0023] The main expansion valve 15 adjusts the flow of the refrigerant flowing from the intermediate heat exchanger 16 into the outdoor heat exchanger 14 to decompress the high-pressure liquid-phase refrigerant flowing from the intermediate heat exchanger 16. The high-pressure liquid-phase refrigerant is decompressed by the main expansion valve 15 and turns into a low-pressure gas-liquid two-phase refrigerant. The low-pressure gas-liquid two-phase refrigerant that flows out of the main expansion valve 15 is supplied to the outdoor heat exchanger 14.

[0024] The outdoor heat exchanger 14 performs heat exchange between the low-pressure gas-liquid two-phase refrigerant that is supplied from the main expansion valve 15 and the outdoor air. The low-pressure gas-liquid two-phase refrigerant radiates heat to the outdoor air in the outdoor heat exchanger 14 and turns into a low-pressure gas-phase refrigerant. In other words, when the air conditioning unit 1 executes the heating operation, the outdoor heat exchanger 14 functions as an evaporator. The low-pressure gas-phase refrigerant flowing out of the outdoor heat exchanger 14 is supplied to the four-way valve 12. The four-way valve 12 is switched to the heating position and accordingly the low-pressure gas-phase refrigerant supplied to the four-way valve 12 is supplied to the intake pipe 17 and is taken into the compressor 11 via the intake pipe 17.

[0025] When the air conditioning unit 1 executes the heating operation, the control device 43 further controls the pump 26 to supply water to the intermediate heat exchanger 16 and circulate water through the water line 6. The water that is heated by the intermediate heat exchanger 16 is supplied to the indoor heat exchanger 25. The indoor heat exchanger 25 performs heat exchange between the heated water flowing through the indoor heat exchanger 25 and the air in the room where the indoor unit 3 is set. By venting the air on which heat exchange with the heated water is performed into the room with the indoor heat exchanger 25, the indoor unit 3 heats the room.

[0026] When the air conditioning unit 1 executes the heating operation, the control device 43 further executes rotational frequency control on the compressor 11. In the rotational frequency control on the compressor 11, the control device 43 calculates a target rotational frequency based on a temperature difference between a setting temperature that is input via the input device 42 and an indoor temperature that is measured by the indoor temperature sensor 38. For example, the larger an absolute value of the temperature difference is, the larger the target rotational frequency is. The control device 43 controls the compressor 11 such that the rotational frequency of the compressor 11 is equal to the target rotational frequency.

[0027] When the air conditioning unit 1 executes the heating operation, the control device 43 further executes control on the main expansion valve 15 and the bypass expansion valve 23. FIG. 3 is a flowchart illustrating control on the main expansion valve 15 and the bypass expansion valve 23. This control is executed during the heating operation. The control device 43 executes the ejection temperature control on the main expansion valve 15 to close the bypass expansion valve 23 and blocks the bypass 22 such that the refrigerant does not flow into the bypass 22 (step S1). In the ejection temperature control on the main expansion valve 15, the control device 43 measures the temperature of the ejection refrigerant that is ejected from the compressor 11 to the ejection pipe 18 using the ejection temperature sensor 31.

[0028] The control device 43 reduces the opening of the main expansion valve 15 when the ejection temperature that is measured by the ejection temperature sensor 31 is higher than a predetermined target ejection temperature. The opening of the main expansion valve 15 decreases and accordingly the flow of the low-pressure gas-liquid two-phase refrigerant supplied to the outdoor heat exchanger 14 decreases and the pressure of the low-pressure gas-liquid two-phase refrigerant supplied to the outdoor heat exchanger 14 lowers. The target ejection temperature is calculated based on a detected value (condensing temperature) of the intermediate heat exchange temperature sensor 32 and a detected value (evaporation temperature) of the outdoor heat exchange temperature sensor 33. The pressure of the low-pressure gas-liquid two-phase refrigerant supplied to the outdoor heat exchanger 14 lowers and accordingly the evaporation temperature representing the temperature of the refrigerant flowing through the outdoor heat exchanger 14 lowers. The evaporation temperature lowers and accordingly the temperature of an evaporator outlet refrigerant that is supplied from the outdoor heat exchanger 14 to the intake pipe 17 lowers. The temperature of the evaporator outlet refrigerant lowers and accordingly the temperature of the intake refrigerant supplied from the intake pipe 17 to the compressor 11 lowers. The temperature of the intake refrigerant lower and accordingly the temperature of the ejection refrigerant that is ejected from the compressor 11 lowers.

[0029] The control device 43 increases the opening of the main expansion valve 15 when the ejection temperature that is measured by the ejection temperature sensor 31 is lower the target ejection temperature. The opening of the main expansion valve 15 increases and accordingly the flow of the low-pressure gas-liquid two-phase refrigerant supplied to the outdoor heat exchanger 14 increases and the pressure of the low-pressure gas-liquid two-phase refrigerant supplied to the outdoor heat exchanger 14 increases. The pressure of the low-pressure gas-liquid two-phase refrigerant supplied to the outdoor heat exchanger 14 increases and accordingly the evaporation temperature increases. The evaporation temperature increases and accordingly the temperature of the evaporator outlet refrigerant increases. The temperature of the evaporator outlet refrigerant increases and accordingly the temperature of the intake refrigerant supplied from the intake pipe 17 to the compressor 11 increases. The temperature of the intake refrigerant increases and accordingly the temperature of the ejection refrigerant that is ejected from the compressor 11 increases. In other words, the ejection temperature control on the main expansion valve 15 is executed covering the case where the ejection temperature is higher than the target ejection temperature and accordingly the temperature of the ejection refrigerant gets close to the target ejection temperature.

[0030] When the ejection temperature control on the main expansion valve 15 is being executed, the control device 43 measures a temperature of the ejection refrigerant that is ejected from the compressor 11 using the ejection temperature sensor 31 and measures a condensing temperature of the refrigerant flowing through the intermediate heat exchanger 16 using the intermediate heat exchange temperature sensor 32. Based on the ejection temperature that is measured by the ejection temperature sensor 31 and the condensing temperature, the control device 43 calculates an ejection degree-of-overheating that is a degree of overheating of the ejection refrigerant. When the condensing temperature that is measured by the intermediate heat exchange temperature sensor 32 is smaller than a condensing temperature threshold or the ejection degree-of-overheating is larger than a first degree-of-overheating threshold (step S2, No), the control device 43 continuously executes the ejection temperature control on the main expansion valve 15 with the bypass 22 being blocked. The condensing temperature threshold is a condensing temperature with a risk of a compression ratio that is determined previously by a test, or the like, and that has an effect on reliability of the compressor 11. The first degree-of-overheating threshold is an ejection degree-of-overheating that is determined previously by a test, or the like, and that is needed to sufficiently ensure a rate of heat exchange with water in the intermediate heat exchanger 16.

[0031] When the condensing temperature that is measured by the intermediate heat exchange temperature sensor 32 is at or above the condensing temperature threshold and the ejection degree-of-overheating is at or under the first degree-of-overheating threshold (step S2, Yes), the control device 43 executes pressure control on the main expansion valve 15 and executes the ejection temperature control on the bypass expansion valve 23 (step S3).

[0032] In the pressure control on the main expansion valve 15, the control device 43 measures a pressure of the ejection refrigerant that is ejected from the compressor 11 to the ejection pipe 18 using the ejection pressure sensor 41. Based on the ejection pressure that is measured by the ejection pressure sensor 41, the control device 43 calculates a condensing pressure representing a pressure of the refrigerant flowing through the intermediate heat exchanger 16. The control device 43 increase the opening of the main expansion valve 15 when the condensing pressure is higher than a predetermined target condensing pressure. The opening of the main expansion valve 15 increases and accordingly the flow of the low-pressure gas-liquid two-phase refrigerant supplied from the intermediate heat exchanger 16 to the outdoor heat exchanger 14 increases and therefore the condensing pressure lowers.

[0033] When the condensing pressure is lower than the target condensing pressure, the control device 43 reduces the opening of the main expansion valve 15. The opening of the main expansion valve 15 decreases and accordingly the flow of the low-pressure gas-liquid two-phase refrigerant supplied from the intermediate heat exchanger 16 to the outdoor heat exchanger 14 decreases and therefore the condensing pressure increases. In other words, pressure control on the main expansion valve 15 is executed covering the case where the condensing pressure is higher than the target condensing pressure and accordingly the condensing pressure gets close to the target condensing pressure.

[0034] In the ejection temperature control on the bypass expansion valve 23, the control device 43 opens the bypass expansion valve 23 and connects the ejection pipe 18 and the intake pipe 17 such that the refrigerant flows into the bypass 22. Before the bypass expansion valve 23 is opened, the compressor 11 compresses an evaporator outlet refrigerant 51 that is supplied from the outdoor heat exchanger 14 to the intake pipe 17 as illustrated in FIG. 4. FIG. 4 is a Mollier diagram illustrating a change in a state of the refrigerant in a case where the refrigerant flows into the bypass 22. The diagram schematically illustrates a process of decompression by the main expansion valve 15 and the bypass expansion valve 23. The low-pressure gas-phase refrigerant that flows out of the evaporator outlet refrigerant 51 is compressed by the compressor 11 and turns into an ejection refrigerant 52. The bypass expansion valve 23 is opened and accordingly part of the ejection refrigerant 52 that is ejected from the compressor 11 is supplied to the bypass expansion valve 23. The bypass expansion valve 23 adjusts the flow of the refrigerant flowing through the bypass 22 and decompresses part of the ejection refrigerant 52 supplied to the bypass expansion valve 23. Part of the ejection refrigerant 52 is decompressed by the bypass expansion valve 23 and turns into a bypass refrigerant 53. The evaporator outlet refrigerant 51 is mixed with the bypass refrigerant 53 that flows through the bypass 22 and is supplied to the intake pipe 17 in the intake pipe 17 and turns into an intake refrigerant 54. The degree of overheating of the intake refrigerant 54 is higher than the degree of overheating of the evaporator outlet refrigerant 51. The compressor 11 compresses the intake refrigerant 54. The intake refrigerant 54 is compressed by the compressor 11 and turns into another ejection refrigerant 55. The degree of overheating of the intake refrigerant 54 is higher than the degree of overheating of the evaporator outlet refrigerant 51 and accordingly the temperature of the ejection refrigerant 55 is higher than the temperature of the ejection refrigerant 52 before opening of the bypass expansion valve 23.

[0035] In the ejection temperature control on the bypass expansion valve 23, the control device 43 further measures a temperature of the ejection refrigerant that is ejected from the compressor 11 to the ejection pipe 18. When the ejection temperature that is measured by the ejection temperature sensor 31 is lower than the target ejection temperature, the control device 43 increases the opening of the bypass expansion valve 23. The opening of the bypass expansion valve 23 increases and accordingly the flow of the bypass refrigerant that is supplied to the intake pipe 17 via the bypass 22 increases. The flow of the bypass refrigerant supplied to the intake pipe 17 via the bypass 22 increases and accordingly more bypass refrigerant is mixed with the intake refrigerant that is supplied to the compressor 11. The bypass refrigerant that is mixed with the intake refrigerant increases and accordingly the degree of overheating of the intake refrigerant supplied to the compressor 11 increases. The degree of overheating of the intake refrigerant increases and accordingly the temperature of the ejection refrigerant that is ejected from the compressor 11 increases.

[0036] When the ejection temperature that is measured by the ejection temperature sensor 31 is higher than the target ejection temperature, the control device 43 reduces the opening of the bypass expansion valve 23. The opening of the bypass expansion valve 23 decreases and accordingly the flow of the bypass refrigerant supplied to the intake pipe 17 via the bypass 22 decreases. The flow of the bypass refrigerant supplied to the intake pipe 17 via the bypass 22 decreases and accordingly less bypass refrigerant is mixed in the intake refrigerant that is supplied to the compressor 11. The bypass refrigerant mixed with the intake refrigerant decreases and accordingly the degree of overheating of the intake refrigerant supplied to the compressor 11 lowers. The degree of overheating of the intake refrigerant lowers and accordingly the temperature of the ejection refrigerant ejected from the compressor 11 lowers. In other words, the ejection temperature control on the bypass expansion valve 23 is executed covering the case where the ejection temperature is lower than the target ejection temperature and accordingly the temperature of the ejection refrigerant gets close to the target ejection temperature.

[0037] When the pressure control on the main expansion valve 15 and the ejection temperature control on the bypass expansion valve 23 are being executed, the control device 43 measures a temperature of the ejection refrigerant ejected from the compressor 11 using the ejection temperature sensor 31 and measures a temperature of the refrigerant flowing through the intermediate heat exchanger 16 using the intermediate heat exchange temperature sensor 32. Based on the ejection temperature that is measured by the ejection temperature sensor 31 and a condensing temperature that is measured by the intermediate heat exchange temperature sensor 32, the control device 43 calculates an ejection degree-of-overheating that is a degree of overheating of the ejection refrigerant.

[0038] When the condensing temperature that is measured by the intermediate heat exchange temperature sensor 32 is higher than the condensing temperature sensor threshold, or when the ejection degree-of-overheating is lower than a second degree-of-overheating threshold that is determined previously (step S4, No), the control device 43 continuously executes the pressure control on the main expansion valve 15 and the ejection temperature control on the bypass expansion valve 23. The second degree-of-overheating threshold is larger than the first degree-of-overheating threshold and an ejection degree-of-overheating that makes it possible to ensure an ejection degree-of-overheating needed to sufficiently ensure a rate of heat exchange with water in the intermediate heat exchanger 16 even when the bypass expansion valve 23 is closed is set. When the condensing temperature is at or under the condensing temperature threshold and the ejection degree-of-overheating is at or above the second degree-of-overheating threshold (step S4, Yes), the control device 43 closes the bypass expansion valve 23 and executes the ejection temperature control on the main expansion valve 15 (step S1).

[0039] When the opening of the main expansion valve 15 increases, as illustrated in FIG. 5, the pressure of a refrigerant 61 flowing through the outdoor heat exchanger 14 is higher than the pressure of an evaporator outlet refrigerant 62 supplied from the outdoor heat exchanger 14 to the intake pipe 17 before the opening of the main expansion valve 15 increases. FIG. 5 is a Mollier diagram illustrating another change in the state of the refrigerant in the case where the refrigerant flows through the bypass 22. The temperature of the refrigerant 61 is in a state of being higher than the temperature of a refrigerant 63 flowing thorough the outdoor heat exchanger 14 before the opening of the main expansion valve 15 increases. The temperature of the refrigerant 61 increases and accordingly an absolute value of a difference between the temperature of the refrigerant 61 and the temperature of the outdoor air is small and the performance of the outdoor heat exchanger 14 in heat exchange between the refrigerant 61 and the outdoor air is small. The performance of the outdoor heat exchanger 14 in heat exchange decreases and accordingly the degree of overheating of an evaporator outlet refrigerant 64 supplied from the outdoor heat exchanger 14 to the intake pipe 17 lowers or the refrigerant 61 sometimes does not evaporate completely and sometimes enters not an overheating state but a wet state.

[0040] The evaporator outlet refrigerant 64 is mixed with the bypass refrigerant that flows through the bypass 22 and that is supplied to the intake pipe 17 in the intake pipe 17 and turns into an intake refrigerant 66. In other words, when the evaporator outlet refrigerant 64 is in the overheating state, the degree of overheating of the intake refrigerant 66 is higher than the degree of overheating of the evaporator outlet refrigerant 64 and, even when the evaporator outlet refrigerant 64 is not in the overheating state, the evaporator outlet refrigerant 64 turns into the intake refrigerant 66 in the overheating state. The compressor 11 compresses the intake refrigerant 66. In other words, even when the evaporator outlet refrigerant supplied from the outdoor heat exchanger 14 to the intake pipe 17 does not evaporate completely, the air conditioning unit 1 is able to prevent the refrigerant in the wet state from being supplied to the compressor 11 and supply the refrigerant in the overheating state to the compressor 11. The refrigerant in the wet state is prevented from being supplied to the compressor 11 and thus the air conditioning unit 1 is able to increase reliability of the compressor 11.

[0041] In the air conditioning unit 1, even when it is not possible to increase the ejection temperature of the refrigerant to the target ejection temperature in the process of step S1, the process of step S2 is executed and thus it is possible to increase the ejection temperature of the refrigerant to the target ejection temperature. For example, when a R290 refrigerant of which ejection temperature is low compared to a R32 refrigerant is used, the air conditioning unit 1 is able to increase the ejection temperature of the refrigerant to the target ejection temperature without increasing the rotational frequency of the compressor 11. In the air conditioning unit 1, because the ejection temperature of the refrigerant increases to the target ejection temperature, it is possible to heat the room appropriately.

Cooling Operation

[0042] The cooling operation is executed when the air conditioning unit 1 is operated by the user to execute the cooling operation. When the air conditioning unit 1 executes the cooling operation, the control device 43 controls the four-way valve 12 and switches the four-way valve 12 to the cooling position. The control device 43 controls the compressor 11 and compresses the low-pressure gas-phase refrigerant that is supplied via the intake pipe 17. The low-pressure gas-phase refrigerant is compressed by the compressor 11 and turns into a high-pressure gas-phase refrigerant. The compressor 11 further ejects the high-pressure gas-phase refrigerant to the ejection pipe 18. The four-way valve 12 is switched to the cooling position and thus the high-pressure gas-phase refrigerant that is ejected to the ejection pipe 18 is supplied to the outdoor heat exchanger 14.

[0043] The outdoor heat exchanger 14 performs heat exchange between the high-pressure gas-phase refrigerant supplied from the four-way valve 12 and outdoor air and radiates heat from the high-pressure gas-phase refrigerant to the outdoor air. The high-pressure gas-phase refrigerant radiates heat in the outdoor heat exchanger 14 and turns into a high-pressure liquid-phase refrigerant in the overcooled state. In other words, the outdoor heat exchanger 14 functions as a condenser when the air conditioning unit 1 executes the cooling operation. The high-pressure liquid-phase refrigerant is supplied to the main expansion valve 15.

[0044] The main expansion valve 15 adjusts the flow of the refrigerant flowing from the outdoor heat exchanger 14 into the intermediate heat exchanger 16 and decompresses the high-pressure liquid-phase refrigerant supplied from the outdoor heat exchanger 14. The high-pressure liquid-phase refrigerant is decompressed by the main expansion valve 15 and turns into a low-pressure gas-liquid two-phase refrigerant. The low-pressure gas-liquid two-phase refrigerant is supplied to the intermediate heat exchanger 16.

[0045] The intermediate heat exchanger 16 performs heat exchange between the low-pressure gas-liquid two-phase refrigerant supplied from the main expansion valve 15 and the water circulating through the water line 6. The low-pressure gas-liquid two-phase refrigerant absorbs heat from the water in the intermediate heat exchanger 16 and turns into a low-pressure gas-phase refrigerant. In other words, when the air conditioning unit 1 executes the cooling operation, the intermediate heat exchanger 16 functions as an evaporator. The low-pressure gas-phase refrigerant is supplied to the four-way valve 12. The four-way valve 12 is switched to the cooling position and accordingly the low-pressure gas-phase refrigerant is supplied to the intake pipe 17 and is supplied to the compressor 11 via the intake pipe 17.

[0046] When the air conditioning unit 1 executes the cooling operation, the control device 43 further controls the pump 26 and supplies water to the intermediate heat exchanger 16 such that the water circulates through the water line 6. The water cooled by the intermediate heat exchanger 16 is supplied to the indoor heat exchanger 25. The indoor heat exchanger 25 performs heat exchange between the water circulating through the water line 6 and the air in the room where the indoor unit 3 is set. The indoor unit 3 vents the air on which heat exchange with the water is performed into the room, thereby cooling the room.

[0047] When the air conditioning unit 1 executes the cooling operation, the control device 43 further executes the rotational frequency control on the compressor 11 as in the case where the air conditioning unit 1 executes the heating operation. When the air conditioning unit 1 executes the cooling operation, the control device 43 further executes control on the main expansion valve 15 and the bypass expansion valve 23 in FIG. 3 as in the case where the air conditioning unit 1 executes the heating operation.

[0048] Even when the cooling operation is executed, the air conditioning unit 1 is able to increase the ejection temperature of the refrigerant to the target ejection temperature as in the case where the heating operation is executed. The ejection temperature of the refrigerant increases to the target ejection temperature and accordingly the air conditioning unit 1 is able to cool the room appropriately.

Effect of Air Conditioning Unit 1 of First Embodiment

[0049] The air conditioning unit 1 of First Embodiment includes the compressor 11; the intermediate heat exchanger 16, the outdoor heat exchanger 14, the main expansion valve 15, the bypass expansion valve 23, the ejection temperature sensor 31, the ejection pressure sensor 41, and the control device 43. The intermediate heat exchanger 16 is connected to the compressor 11 via the ejection pipe 18. The outdoor heat exchanger 14 is connected to the compressor 11 via the intake pipe 17. The main expansion valve 15 decompresses the refrigerant that is supplied from the intermediate heat exchanger 16 and supplies the refrigerant to the outdoor heat exchanger 14. The bypass expansion valve 23 is provided on the bypass 22 that connects the ejection pipe 18 and the intake pipe 17. The ejection temperature sensor 31 measures an ejection temperature that is a temperature of the ejection refrigerant that is ejected from the compressor 11. The ejection pressure sensor 41 measures a pressure of the ejection refrigerant that is ejected from the compressor 11. The control device 43 controls the bypass expansion valve 23 while the compressor 11 is compressing the refrigerant of the intake pipe 17 and ejecting the refrigerant to the ejection pipe 18 and switches between a first state where the refrigerant does not flow through the bypass 22 and a second state where the refrigerant flows into the intake pipe 17 from the ejection pipe 18 via the bypass 22. The control device 43 further calculates a condensing pressure that is a pressure of the refrigerant flowing through the intermediate heat exchanger 16 based on the ejection pressure measured by the ejection pressure sensor 41. When the refrigerant does not flow through the bypass 22, the control device 43 controls the opening of the main expansion valve 15 such that the ejection temperature is at the predetermined target ejection temperature and, when the refrigerant flows through the bypass 22, the control device 43 controls the opening of the main expansion valve 15 such that the condensing pressure is at a predetermined target condensing pressure.

[0050] At that time, when part of the ejection refrigerant is supplied to the intake pipe 17, the air conditioning unit 1 of First Embodiment is able to increase the degree of overheating of the intake refrigerant and is able to increase the temperature of the ejection refrigerant without increasing the compression ratio at which the compressor 11 compresses the refrigerant. For this reason, when increasing the temperature of the ejection refrigerant, the air conditioning unit 1 of First Embodiment is able to reduce the load applied to the compressor 11 and increase reliability of the compressor 11.

[0051] The control device 43 of the air conditioning unit 1 of First Embodiment controls the bypass expansion valve 23 such that the refrigerant flows through the bypass 22 when the refrigerant does not flow through the bypass 22 and the condensing temperature that is a temperature of the refrigerant flowing through the intermediate heat exchanger 16 is at or above the condensing temperature threshold and a degree of overheating of the ejection refrigerant is at or under the first degree-of-overheating. The control device 43 controls the bypass expansion valve 23 such that the refrigerant does not flow through the bypass 22 when the refrigerant flows through the bypass 22 and the condensing temperature is at or under the condensing temperature threshold and the degree of overheating of the ejection refrigerant is at or above the second degree-of-overheating threshold that is larger than the first degree-of-overheating threshold.

[0052] The control device 43 of the air conditioning unit 1 of First Embodiment controls the bypass expansion valve 23 such that the ejection temperature is at or under the threshold when the refrigerant flows through the bypass 22.

Second Embodiment

[0053] In the air conditioning unit 1 of Second Embodiment, the above-described control on the main expansion valve 15 and the bypass expansion valve 23 in FIG. 3 is replaced with other control and other aspects are the same as those of the air conditioning unit of Embodiment1. FIG. 6 is a flowchart illustrating control on the main expansion valve 15 and the bypass expansion valve 23 of the air conditioning unit of Second Embodiment. This control is executed during the heating operation. When the air conditioning unit of Second Embodiment executes the heating operation, the control device 43 executes the ejection temperature control on the main expansion valve 15 and closes the bypass expansion valve 23, thereby blocking the bypass 22 such that the refrigerant does not flow into the bypass 22 as in the case of the above-described air conditioning unit 1 of First Embodiment(step S11).

[0054] When control on the main expansion valve 15 and the bypass expansion valve 23 is executed, the control device 43 calculates a compression ratio at which the compressor 11 compresses the refrigerant based on the condensing temperature that is a detected value of the intermediate heat exchange temperature sensor 32 and the evaporation temperature that is a detection value of the outdoor heat exchange temperature sensor 33. When the compression ratio is smaller than a first compression ratio threshold (step S12, No), the control device 43 continuously executes the ejection temperature control on the main expansion valve 15 with the bypass 22 being blocked. The first compression ratio threshold is a compression ratio that is determined previously by a test, or the like, and on which it is known that, when the compressor 11 operates exceeding this compression ratio that is determined previously by a test, or the like, reliability of the compressor 11 lowers. When the compression ratio is at or above the first compression ratio threshold (step S12, Yes), the control device 43 executes pressure control on the main expansion valve 15 and executes ejection temperature control on the bypass expansion valve 23 (step S13).

[0055] When the compression ratio is larger than the second compression ratio threshold (step S14, No), the control device 43 continuously executes the pressure control on the main expansion valve 15 and the ejection temperature control on the bypass expansion valve 23. The second compression ratio threshold is smaller than the first compression ratio threshold and a compression ratio that does not have an effect on reliability of the compressor 11 even when the bypass expansion valve 23 is closed and the compression ratio increases is set. When the compression ratio is at or under the second compression ratio threshold (step S14, Yes), the control device 43 closes the bypass expansion valve 23 and executes the ejection temperature control on the main expansion valve 15 (step S11).

[0056] When the air conditioning unit of Second Embodiment executes the cooling operation, the control device 43 executes control on the main expansion valve 15 and the bypass expansion valve 23 in FIG. 6 as in the case where the air conditioning unit of Second Embodiment executes the heating operation. According to such control, the air conditioning unit of Second Embodiment is able to increase the ejection temperature of the refrigerant to the target ejection temperature without increasing the compression ratio to a value larger than a predetermined value and cool and heat the room appropriately as in the above-described air conditioning unit 1 of Second Embodiment.

[0057] By further switching between flowing the refrigerant into the bypass 22 and not flowing the refrigerant into the bypass 22 based on the compression ratio, the air conditioning unit of Second Embodiment is able to prevent the compression ratio from being larger than the predetermined value more assuredly. The compression ratio is prevented from increasing and thus the air conditioning unit of Second Embodiment is able to reduce the load applied to the compressor 11 and is able to increase reliability of the compressor 11.

[0058] Water circulates through the water line 6 of the above-described air conditioning unit 1 of Embodiments 1 and **2;** however, another heat medium different from water may circulate. An antifreeze is exemplified as the heat medium. Even when another heat medium different from water circulates through the water line **6,** it is possible to increase the temperature of the ejection refrigerant that is ejected from the compressor 11 while inhibiting the load on the compressor from increasing.

Third Embodiment

[0059] In an air conditioning unit of Third Embodiment, the water line 6 of the air conditioning unit 1 of Embodiments 1 and 2 described above is omitted and the intermediate heat exchanger 16 is replaced with another indoor heat exchanger and other aspects are the same as those of the air conditioning unit 1 of First Embodiment. The indoor heat exchanger is arranged in the indoor unit 3. One end of the indoor heat exchanger is connected to the fourth connecting port 124 of the four-way valve 12 and the other end of the indoor heat exchanger is connected to the main expansion valve 15. The indoor heat exchanger performs heat exchange between the refrigerant circulating through the refrigerant line 5 and the air in the room.

[0060] The control device 43 of the air conditioning unit of Third Embodiment controls the main expansion valve 15 and the bypass expansion valve 23 as in the air conditioning unit 1 of First Embodiment described above or as in the air conditioning unit 1 of First Embodiment described above. For this reason, the air conditioning unit of Third Embodiment is able to increase the temperature of the ejection refrigerant that is ejected from the compressor 11 while inhibiting the load on the compressor 11 from increasing as the air conditioning unit of First Embodiment and Second Embodiment is.

[0061] The above-described control device 43 calculates a condensing pressure based on the ejection pressure that is measured by the ejection pressure sensor 41; however a condensing pressure may be calculated based on another physical quantity different from the ejection pressure. The condensing temperature that is measured by the intermediate heat exchange temperature sensor 32 at the time of the heating operation is exemplified as the physical quantity. Even when the condensing pressure is calculated as described above, the air conditioning unit is able to increase the temperature of the ejection refrigerant that is ejected from the compressor 11 while inhibiting the load on the compressor 11 from increasing as the above-described air conditioning unit of the embodiment is.

[0062] The embodiments have been described and the content of the above description does not limit the embodiments. The above-described components include those easily assumed by those skilled in the art and those substantially the same, that is, in a range of equivalence. Furthermore, the components described above can be combined as appropriate. Furthermore, it is possible to make various omissions, replacements, and changes of the components without departing from the scope of the embodiments.

Reference Signs List

[0063]

1	AIR CONDITIONING UNIT
5	REFRIGERANT LINE
6	WATER LINE
11	COMPRESSOR
14	OUTDOOR HEAT EXCHANGER
15	MAIN EXPANSION VALVE
16	INTERMEDIATE HEAT EXCHANGER
17	INTAKE PIPE
18	EJECTION PIPE
21	BYPASS LINE
22	BYPASS
23	BYPASS EXPANSION VALVE
31	EJECTION TEMPERATURE SENSOR
43	CONTROL DEVICE

Claims

1. An air conditioning unit comprising:

a compressor;
a condenser that is connected to the compressor via an ejection pipe;

an evaporator that is connected to the compressor via an intake pipe;

a main expansion valve that decompresses a refrigerant that is supplied from the condenser and supplies the refrigerant to the evaporator;

a bypass expansion valve that is provided on a bypass connecting the ejection pipe and the intake pipe;

an ejection temperature sensor that detects an ejection temperature that is a temperature of an ejection refrigerant that is ejected from the compressor;

a condensing pressure calculator that calculates a condensing pressure that is a pressure of the refrigerant flowing through the condenser; and

a controller that controls the bypass expansion valve and that switches between a first state in which the refrigerant does not flow through the bypass and a second state in which the refrigerant flows into the intake pipe from the ejection pipe via the bypass,

wherein, when the refrigerant does not flow through the bypass, the controller controls an opening of the main expansion valve such that the ejection temperature is at a predetermined target ejection temperature, and

when the refrigerant flows through the bypass, the controller controls the opening of the main expansion valve such that the condensing pressure is at a predetermined target condensing pressure.

2. The air conditioning unit according to claim 1, wherein, when the refrigerant does not flow through the bypass, a condensing temperature that is a temperature of the refrigerant flowing through the condenser is at or above a condensing temperature threshold, and a degree of overheating of the ejection refrigerant is at or under a first degree-of-overheating threshold, the controller controls the bypass expansion valve such that the refrigerant flows through the bypass, and

when the refrigerant flows through the bypass, the condensing temperature is at or under the condensing temperature threshold, and the degree of overheating of the ejection refrigerant is at or above a second degree-of-overheating threshold that is larger than the first degree-of-overheating threshold, the controller controls the bypass expansion valve such that the refrigerant does not flow through the bypass.

3. The air conditioning unit according to claim **1,** wherein, when the refrigerant does not flow through the bypass and a compression ratio at which the compressor compresses the refrigerant is larger than a first threshold, the controller controls the bypass expansion valve such that the refrigerant flows through the bypass, and

when the refrigerant flows through the bypass and the compression ratio is smaller than a second threshold that is smaller than the first threshold, the controller controls the bypass expansion valve such that the refrigerant does not flow through the bypass.

4. The air conditioning unit according to claim 1, further comprising an indoor heat exchanger that performs heat exchange between another refrigerant circulating through an indoor unit and an outdoor unit and air in a room, wherein

one of the condenser and the evaporator performs heat exchange between the refrigerant and outdoor air, and

the other one of the condenser and the evaporator performs heat exchange between the refrigerant and the another refrigerant.

FIG.1

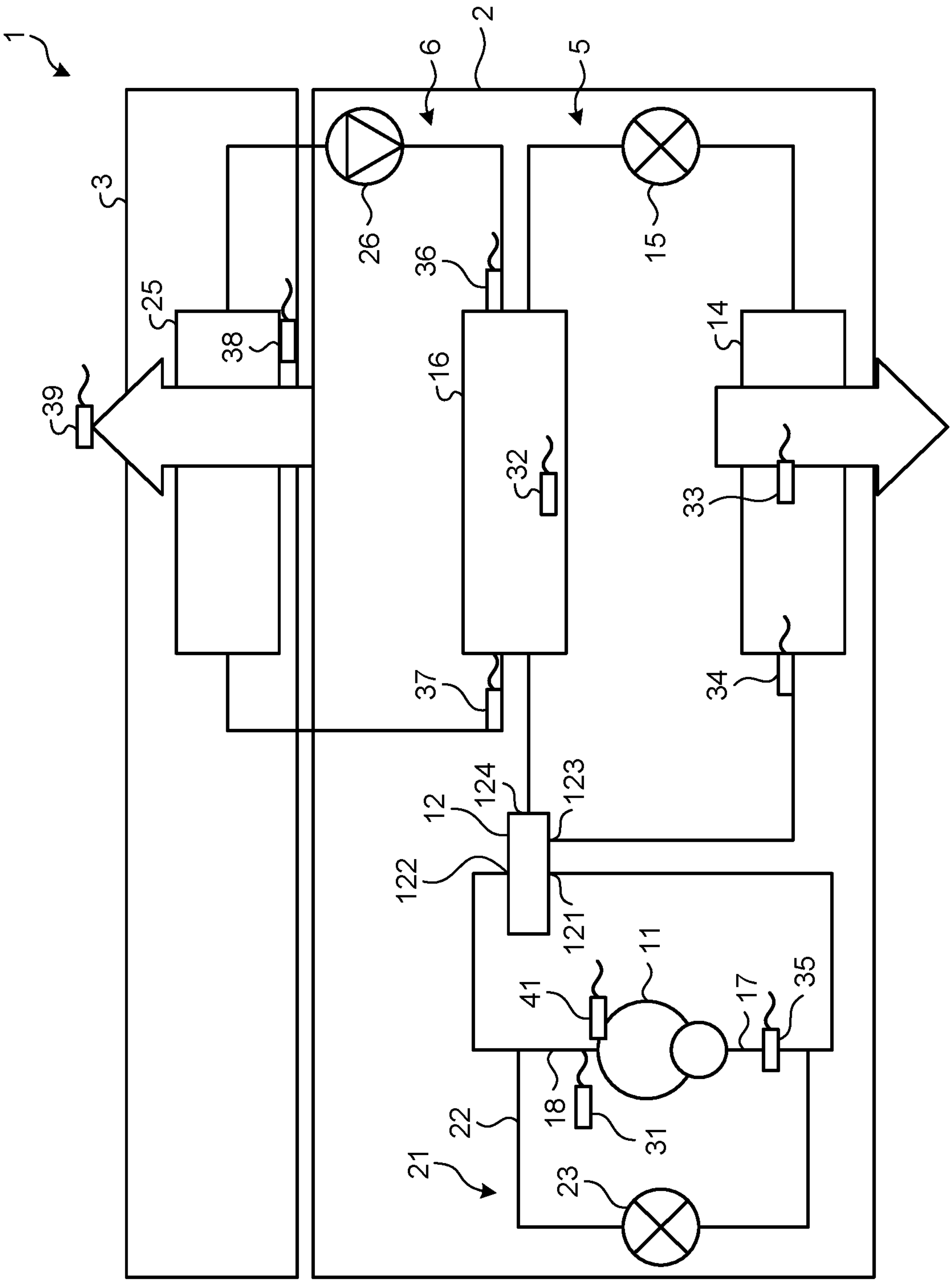

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FIG.2

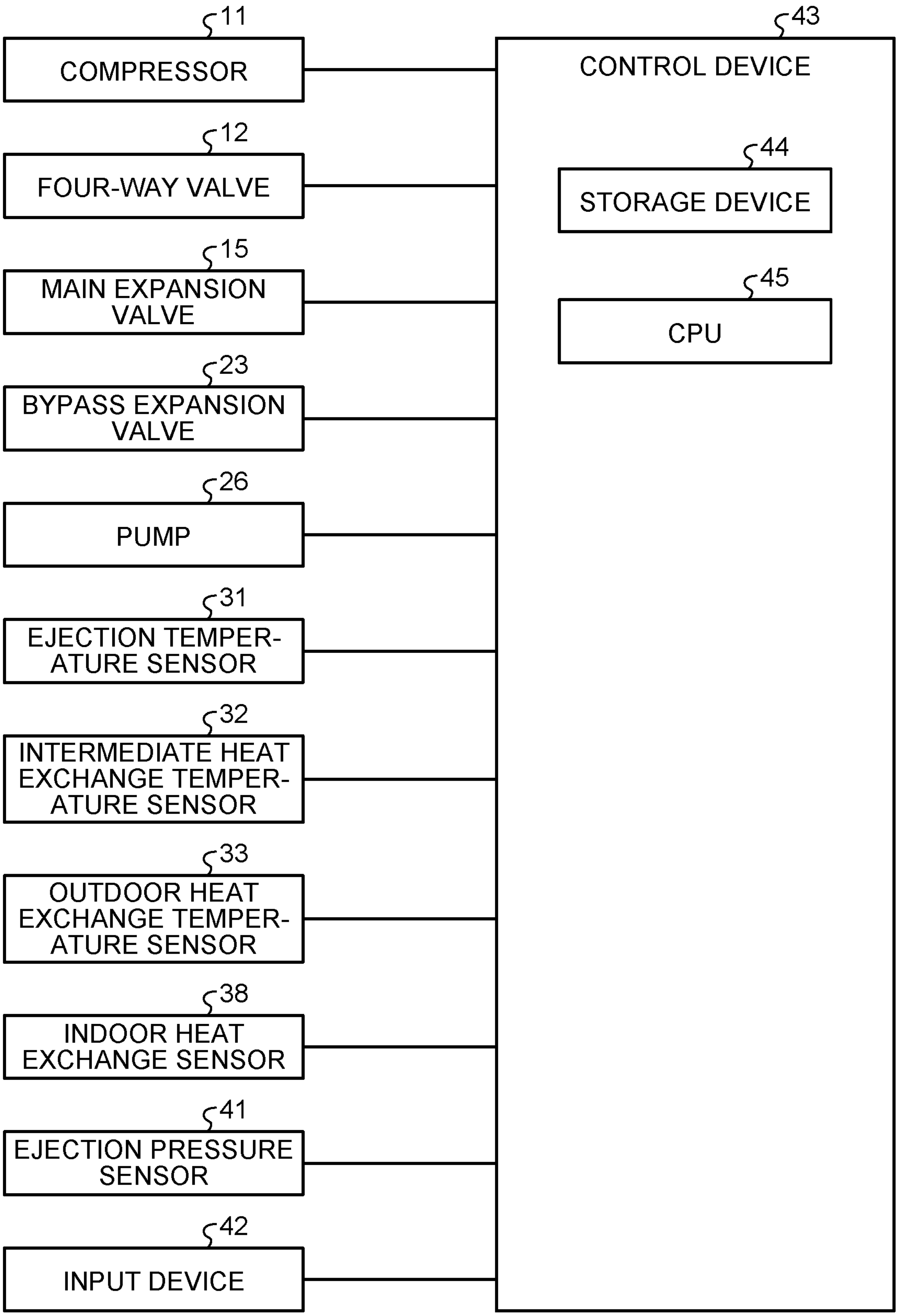

11
COMPRESSOR
12
FOUR-WAY VALVE
15
MAIN EXPANSION VALVE
23
BYPASS EXPANSION VALVE
26
PUMP
31
EJECTION TEMPER-ATURE SENSOR
32
INTERMEDIATE HEAT EXCHANGE TEMPER-ATURE SENSOR
33
OUTDOOR HEAT EXCHANGE TEMPER-ATURE SENSOR
38
INDOOR HEAT EXCHANGE SENSOR
41
EJECTION PRESSURE SENSOR
42
INPUT DEVICE
43
CONTROL DEVICE
44
STORAGE DEVICE
45
CPU

FIG.3

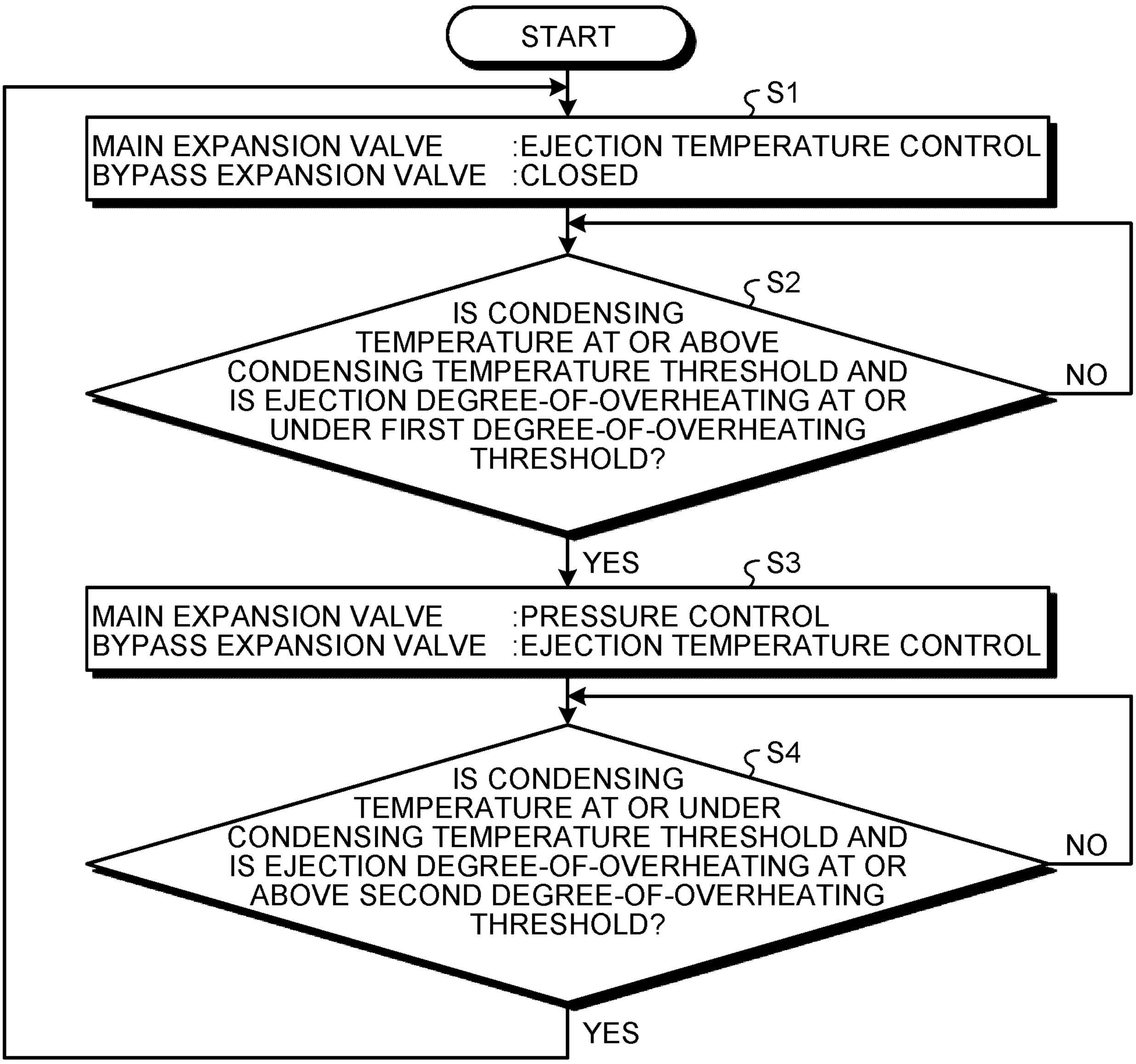

START
S1
MAIN EXPANSION VALVE :EJECTION TEMPERATURE CONTROL
BYPASS EXPANSION VALVE :CLOSED
S2
IS CONDENSING TEMPERATURE AT OR ABOVE CONDENSING TEMPERATURE THRESHOLD AND IS EJECTION DEGREE-OF-OVERHEATING AT OR UNDER FIRST DEGREE-OF-OVERHEATING THRESHOLD?
NO
YES
S3
MAIN EXPANSION VALVE :PRESSURE CONTROL
BYPASS EXPANSION VALVE :EJECTION TEMPERATURE CONTROL
S4
IS CONDENSING TEMPERATURE AT OR UNDER CONDENSING TEMPERATURE THRESHOLD AND IS EJECTION DEGREE-OF-OVERHEATING AT OR ABOVE SECOND DEGREE-OF-OVERHEATING THRESHOLD?
NO
YES

FIG.4

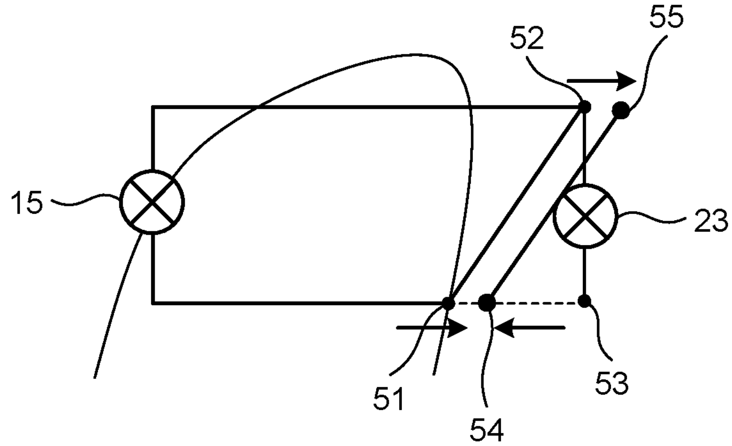


FIG.5

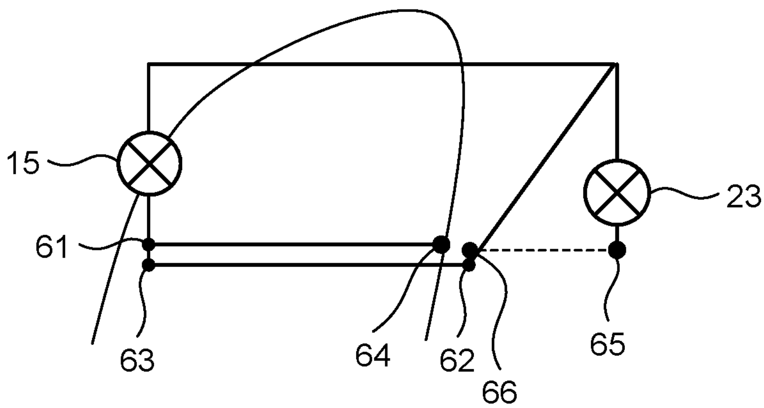
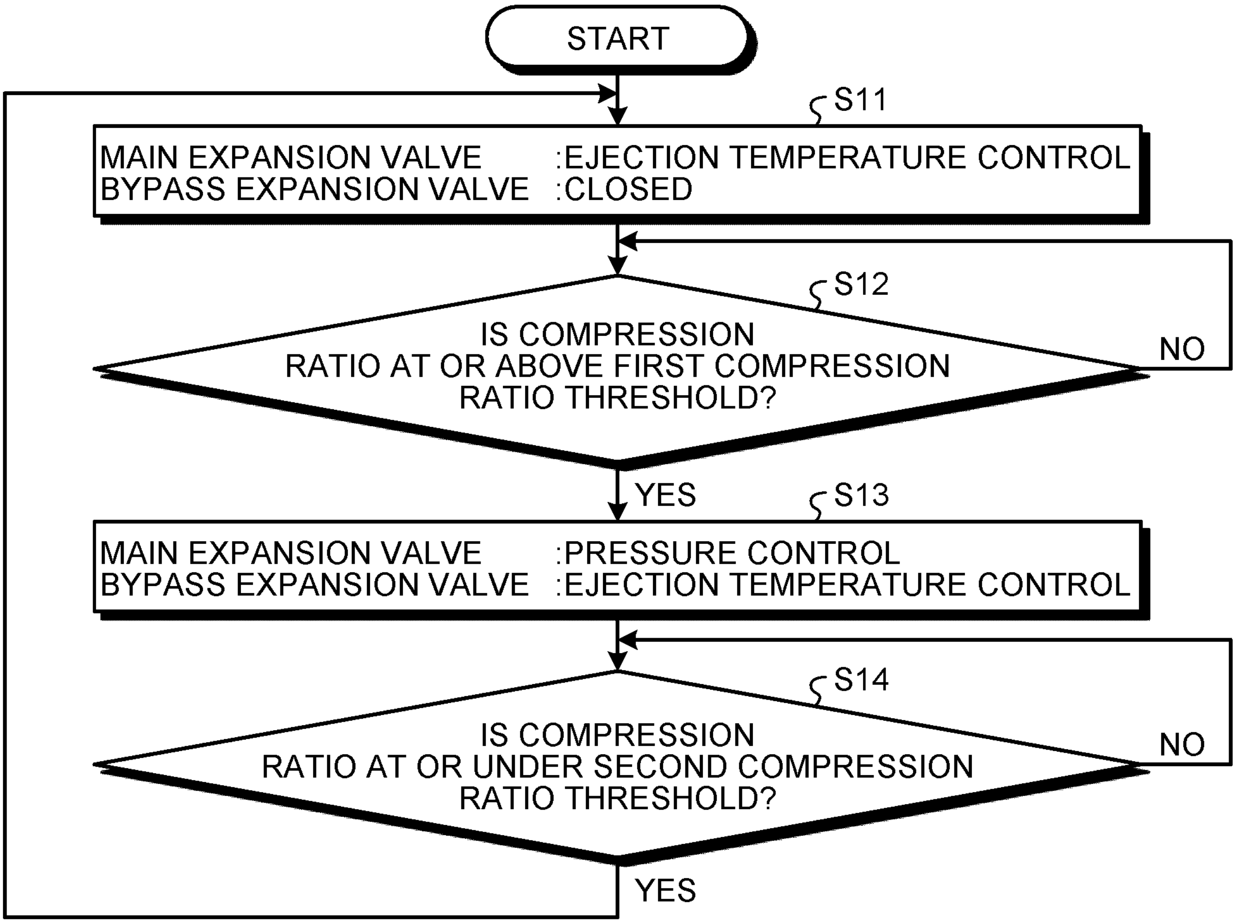


FIG.6


START
S11
MAIN EXPANSION VALVE :EJECTION TEMPERATURE CONTROL
BYPASS EXPANSION VALVE :CLOSED
S12
IS COMPRESSION RATIO AT OR ABOVE FIRST COMPRESSION RATIO THRESHOLD?
NO
YES
S13
MAIN EXPANSION VALVE :PRESSURE CONTROL
BYPASS EXPANSION VALVE :EJECTION TEMPERATURE CONTROL
S14
IS COMPRESSION RATIO AT OR UNDER SECOND COMPRESSION RATIO THRESHOLD?
NO
YES

INTERNATIONAL SEARCH REPORT

International application No. **PCT/JP2023/025193**

A. CLASSIFICATION OF SUBJECT MATTER

F25B 1/00(2006.01)i
FI: F25B1/00 101Z; F25B1/00 304P

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; F25B13/00; F24F11/00

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

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2023
Registered utility model specifications of Japan 1996-2023
Published registered utility model applications of Japan 1994-2023

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2015-68609 A (DAIKIN IND LTD) 13 April 2015 (2015-04-13) entire text, all drawings	1-4
A	JP 2011-257100 A (YANMAR CO LTD) 22 December 2011 (2011-12-22) entire text, all drawings	1-4
A	JP 2015-94558 A (MITSUBISHI HEAVY IND LTD) 18 May 2015 (2015-05-18) entire text, all drawings	1-4
A	JP 2018-77037 A (SAMSUNG ELECTRONICS CO., LTD.) 17 May 2018 (2018-05-17) entire text, all drawings	1-4
A	JP 2004-20064 A (FUJITSU GENERAL LTD) 22 January 2004 (2004-01-22) entire text, all drawings	1-4

☐ 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	Date of mailing of the international search report
30 August 2023	**12 September 2023**

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

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

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2023/025193

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 2015-68609 A	13 April 2015	WO 2015/046367 A1 entire text, all drawings	
JP 2011-257100 A	22 December 2011	EP 2581689 A1 entire text, all drawings WO 2011/155386 A1	
JP 2015-94558 A	18 May 2015	EP 2873936 A2 entire text, all drawings	
JP 2018-77037 A	17 May 2018	US 2018/0112899 A1 entire text, all drawings WO 2018/080150 A1 EP 3516305 A1 KR 10-2018-0045797 A	
JP 2004-20064 A	22 January 2004	(Family: none)	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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- JP 2018112396 A **[0003]**
- JP 2004020064 A **[0003]**
- JP 2003156258 A **[0003]**