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(54) Refrigeration cycle apparatus and hot water heater

(57) A refrigeration cycle apparatus 1 includes: a refrigerant circuit 2 including a condenser 22 and a subcooling heat exchanger 23; and a bypass passage 3 that extends through the subcooling heat exchanger 23. In the bypass passage 3, a dryness fraction of the refrigerant that has flowed out of the subcooling heat exchanger 23 is adjusted. Since the subcooling heat exchanger 23 is configured appropriately, a ratio of an amount of heat exchange between, in the bypass passage 3, the refrigerant decompressed by the bypass expansion means 31 and the refrigerant passing through the refrigerant circuit 2 with respect to an amount of heat exchange between, in the condenser 22, the refrigerant that has flowed into the condenser 22 and a fluid to be heated falls in a specified range even during the operation using the adjusted dryness fraction. As a result, the subcooling effect of the subcooling heat exchanger 23 is secured.

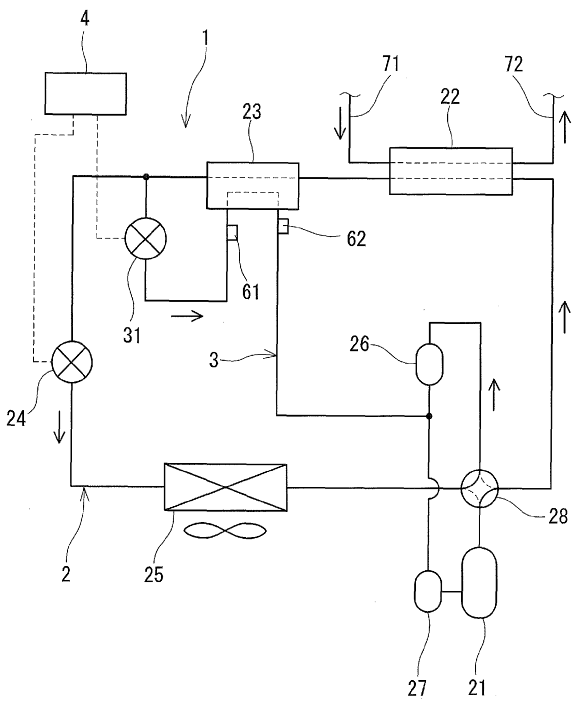

FIG. 1

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Description

[0001] The present invention relates to a refrigeration cycle apparatus for subcooling a refrigerant, and a hot water heater including the refrigeration cycle apparatus.

[0002] Conventionally, there is known a refrigeration cycle apparatus in which a subcooling heat exchanger is provided in a refrigerant circuit downstream of a condenser and an expanded refrigerant is made to flow into the subcooling heat exchanger so that the refrigerant that has flowed out of the condenser is subcooled. For example, JP 4036288 B discloses a refrigeration cycle apparatus 100 as shown in FIG. 6.

[0003] The refrigeration cycle apparatus 100 includes a refrigerant circuit 110 in which a refrigerant circulates, and a bypass passage 120. The refrigerant circuit 110 includes a compressor 111, a condenser 112, a subcooling heat exchanger 113, a main expansion valve 114 and an evaporator 115 that are connected circularly with pipes. The bypass passage 120 is branched from the refrigerant circuit 110 between the condenser 112 and the subcooling heat exchanger 113, and extends through the subcooling heat exchanger 113 to join to the refrigerant circuit 110 between the evaporator 115 and the compressor 111. A bypass expansion valve 121 is provided in the bypass passage 120 upstream of the subcooling heat exchanger 113.

[0004] JP 4036288 B also describes that in order to enhance the refrigerating capacity, the bypass expansion valve 121 is controlled so that a ratio (a bypass ratio) of a flow rate of the bypass refrigerant flowing through the bypass passage 120 with respect to the total flow rate of the refrigerant flowing through the condenser 112 falls in the range of 1% to 25% both inclusive.

[0005] Preferably, in order to operate a refrigeration cycle apparatus highly efficiently as mentioned above, the refrigerant flowing through the bypass passage is not superheated in the subcooling heat exchanger and the refrigerant flowing through the refrigerant circuit is subcooled into a specified state. For realizing this, the subcooling heat exchanger needs to be configured appropriately. In this respect, however, JP 4036288 B does not describe particularly the configuration of the subcooling heat exchanger.

[0006] In view of the foregoing, the present invention is intended to provide a refrigerating cycle apparatus that includes an appropriately-configured subcooling heat exchanger and can be operated highly efficiently, and a hot water heater including the refrigeration cycle apparatus.

[0007] As a result of intensive studies, the inventors of the present invention have found that a high COP (Coefficient of Performance) can be achieved when a dryness fraction of the refrigerant that has flowed out of the subcooling heat exchanger in the bypass passage is maintained at at least 0.8 but less than 1.0. However, in the case where the refrigerating cycle apparatus is controlled so that the dryness fraction falls in such a range, the subcooling of the refrigerant flowing through the refrigerant circuit becomes insufficient or excessive depending on the volumetric capacity of the subcooling heat exchanger, when the outside air temperature is low and a condenser is required to have a higher heating capacity. The present invention has been accomplished from this viewpoint.

[0008] More specifically, the present invention provides a refrigeration cycle apparatus including: a refrigerant circuit including a compressor, a condenser, a subcooling heat exchanger, a main expansion means and an evaporator that are connected circularly; a bypass passage that is branched from the refrigerant circuit between the subcooling heat exchanger and the main expansion means or between the condenser and the subcooling heat exchanger, and extends through the subcooling heat exchanger to join to the refrigerant circuit between the evaporator and the compressor; and a bypass expansion means provided in the bypass passage upstream of the subcooling heat exchanger. The subcooling heat exchanger is configured so that a ratio of an amount of heat exchange between, in the subcooling heat exchanger, the refrigerant that has been decompressed by the bypass expansion means and the refrigerant that has flowed out of the condenser with respect to an amount of heat exchange between, in the condenser, the refrigerant that has flowed into the condenser and a fluid to be heated is at least 0.2 but not more than 0.8, when an opening of the bypass expansion means is adjusted so that a dryness fraction of the refrigerant that has flowed out of the subcooling heat exchanger in the bypass passage is at least 0.8 but less than 1.0.

[0009] The present invention also provides a hot water heater that performs heating by utilizing hot water produced by a heating means. The hot water heater includes the refrigeration cycle apparatus as the heating means.

[0010] As described above, since the subcooling heat exchanger is configured appropriately, it is possible to subcool the refrigerant flowing through the refrigerant circuit into an appropriate state when the dryness fraction of the refrigerant that has flowed out of the subcooling heat exchanger in the bypass passage is maintained at at least 0.8 but less than 1.0, even in the case where the outside air temperature is low and the condenser is required to have a higher heating capacity. Therefore, the present invention can realize the highly efficient operation.

FIG. 1 is a schematic configuration diagram of a refrigeration cycle apparatus according to one embodiment of the present invention.

FIG. 2 shows correlation diagrams between a dryness fraction of a refrigerant at an inlet of an evaporator and a heat exchange ratio. (a) indicates a case in which R407C is used as the refrigerant. (b) indicates a case in which R410A is used as the refrigerant.

FIG. 3 shows Mollier diagrams of the refrigeration cycle apparatus when R407C is used as the refrigerant. (a) indicates a case in which the dryness fraction of the refrigerant at the inlet of the evaporator is 0.55. (b) indicates a case in which the dryness fraction of the refrigerant at the inlet of the evaporator is 0.

FIG. 4 shows Mollier diagrams of the refrigeration cycle apparatus when R410A is used as the refrigerant. (a) indicates a case in which the dryness fraction of the refrigerant at the inlet of the evaporator is 0.45. (b) indicates a case in which the dryness fraction of the refrigerant at the inlet of the evaporator is 0.

FIG. 5 is a correlation diagram between the outside air temperature and the heat exchange ratio at each condensation temperature of the refrigerant in the condenser.

FIG. 6 is a schematic configuration diagram of a conventional refrigeration cycle apparatus.

[0011] FIG. 1 shows a refrigeration cycle apparatus 1 according to one embodiment of the present invention. The refrigeration cycle apparatus 1 includes: a refrigerant circuit 2 in which a refrigerant circulates; a bypass passage 3; and a controller 4. Examples of the refrigerant include a zeotropic refrigerant mixture such as R407C, a nearly-azeotropic refrigerant mixture such as R410A, and a single refrigerant.

[0012] The refrigerant circuit 2 includes a compressor 21, a condenser 22, a subcooling heat exchanger 23, a main expansion valve 24 and an evaporator 25 that are connected circularly with pipes. In the present embodiment, a sub accumulator 26 and a main accumulator 27 for performing gas-liquid separation are provided between the evaporator 25 and the compressor 21. The refrigerant circuit 2 is also provided with a four-way valve 28 for switching between a normal operation and a defrosting operation.

[0013] In the present embodiment, the refrigeration cycle apparatus 1 constitutes the heating means of the hot water heater that performs heating by utilizing hot water produced by the heating means, and the condenser 22 is a heat exchanger that heats water by exchanging heat between the refrigerant and the water. Specifically, a supply pipe 71 and a recovery pipe 72 are connected to the condenser 22, so that water is supplied to the condenser 22 through the supply pipe 71 and the water (hot water) heated in the condenser 22 is recovered through the recovery pipe 72. The water (hot water) recovered through the recovery pipe 72 is sent to, for example, a heater such as a radiator, directly or through a hot water reservoir tank, and thereby heating is performed.

[0014] The bypass passage 3 is branched from the refrigerant circuit 2 between the subcooling heat exchanger 23 and the main expansion valves 24, and extends through the subcooling heat exchanger 23 to join to the refrigerant circuit 2 between the evaporator 25 and the compressor 21. In the present embodiment, the bypass passage 3 joins to the refrigerant circuit 2 between the sub accumulator 26 and the main accumulator 27. A bypass expansion valve 31 is provided in the bypass passage 3 upstream of the subcooling heat exchanger 23.

[0015] In the normal operation, the refrigerant discharged from the compressor 21 is sent to the condenser 22 through the four-way valve 28. In the defrosting operation, the refrigerant discharged from the compressor 21 is sent to the evaporator 25 through the four-way valve 28. In FIG. 1, the flowing directions of the refrigerant in the normal operation are indicated by arrows. Hereinafter, the state change of the refrigerant in the normal operation will be described.

[0016] The high pressure refrigerant discharged from the compressor 21 flows into the condenser 22 and radiates heat to the water passing through the condenser 22. The high pressure refrigerant that has flowed out of the condenser 22 flows into the subcooling heat exchanger 23 and is subcooled with the low pressure refrigerant decompressed by the bypass expansion valve 31. The high pressure refrigerant that has flowed out of the subcooling heat exchanger 23 is divided to flow separately to the main expansion valve 24 and the bypass expansion valve 31.

[0017] The high pressure refrigerant divided to flow to the main expansion valve 24 is decompressed and expanded by the main expansion valve 24, and then flows into the evaporator 25. The low pressure refrigerant that has flowed into the evaporator 25 absorbs heat from the air therein. On the other hand, the high pressure refrigerant divided to flow to the bypass expansion valve 31 is decompressed and expanded by the bypass expansion valve 31, and then flows into the subcooling heat exchanger 23. The low pressure refrigerant that has flowed into the subcooling heat exchanger 23 is heated with the high pressure refrigerant that has flowed out of the condenser 22. Thereafter, the low pressure refrigerant that has flowed out of the subcooling heat exchanger 23 is merged into the low pressure refrigerant that has flowed out of the evaporator 25 and the resulted refrigerant is drawn into the compressor 21 once again.

[0018] The refrigeration cycle apparatus 1 of the present embodiment is configured so as to prevent the situation in which when the outside air temperature is low, the pressure of the refrigerant to be drawn into the compressor 21 is lowered and the circulating amount of the refrigerant is reduced, and thus the heating capacity of the condenser 22 is reduced. In order to realize this configuration, it is important to increase an enthalpy difference in the evaporator 25 by subcooling the refrigerant, and to suppress the amount of the gaseous phase refrigerant that has a low effect of absorbing heat flowing through a low pressure side of the refrigerant circuit 2 by bypassing the refrigerant with the bypass passage 3, and thereby reducing the pressure loss in the low pressure side of the refrigerant circuit 2. When the pressure loss in the low pressure side of the refrigerant circuit 2 is reduced, the pressure of the refrigerant to be drawn into the compressor 21 increases by the amount of the reduced pressure loss, reducing the specific volume of the refrigerant. Accordingly, the circulating amount of the refrigerant increases. Moreover, by increasing the enthalpy difference in the evaporator 25, it is possible to ensure the amount of heat absorption in the evaporator 25 even when the mass flow rate of the refrigerant passing through the evaporator 25 lowers due to the bypassing. More specifically, by adjusting the degree of subcooling the refrigerant and the bypassing amount of the refrigerant, it is possible to obtain both of the effect of enhancing the heating capacity of the condenser 22 and the effect of enhancing the COP of the refrigeration cycle apparatus 1.

[0019] In the present embodiment, the subcooling heat exchanger 23 is designed to have a heat transfer area that allows a heat exchange ratio Qsc/Qc that is a ratio of an amount of heat exchange Qsc between, in the subcooling heat exchanger 23, the refrigerant that has been decompressed by the bypass expansion means 31 and the refrigerant that has flowed out of the condenser 22 with respect to an amount of heat exchange Qc between, in the condenser 22, the refrigerant that has flowed into the condenser 22 and water is at least 0.2 but not more than 0.8, when openings of the main expansion valve 24 and the bypass expansion valve 31 are adjusted so that a dryness fraction of the refrigerant that has flowed out of the subcooling heat exchanger 23 in the bypass passage 3 is at least 0.8 but less than 1.0.

[0020] In this configuration, since the heat transfer area of the subcooling heat exchanger 23 is determined appropriately, it is possible to subcool the refrigerant flowing through the refrigerant circuit 2 into an appropriate state when the dryness fraction of the refrigerant that has flowed out of the subcooling heat exchanger 23 in the bypass passage 3 is maintained at at least 0.8 but less than 1.0, even in the case where the outside air temperature is low and the condenser 22 is required to have a higher heating capacity.

[0021] For example, in the case where R407C is used as the refrigerant, a dryness fraction Xei of the refrigerant to flow into the evaporator 25 falls in the range of 0 to 0.55 both inclusive when the heat exchange ratio Qsc/Qc is in the range of 0.2 to 0.8 both inclusive under the conditions in which an outside air temperature AT is equal to -25°C and a condensation temperature Tc of the refrigerant in the condenser 22 is equal to 70°C, as shown in FIG. 2 (a). Furthermore, as shown in FIG. 3 (a) and (b), the refrigerant that has flowed out of the subcooling heat exchanger 23 is in a subcooled state when the dryness fraction Xei of the refrigerant to flow into the evaporator 25 is in the range of 0 to 0.55 both inclusive. Likewise, also in the case where R410A is used as the refrigerant, the refrigerant that has flowed out of the subcooling heat exchanger 23 is in the subcooled state when the heat exchange ratio Qsc/Qc is in the range of 0.2 to 0.8 both inclusive under the conditions in which the outside air temperature AT is equal to -25°C and the condensation temperature Tc of the refrigerant in the condenser 22 is equal to 60°C, as shown in FIG. 2 (b), and FIG. 4 (a) and (b). Therefore, in the present embodiment, the heat transfer area of the subcooling heat exchanger 23 is determined so that the heat exchange ratio Qsc/Qc is in the range of 0.2 to 0.8 both inclusive. In FIG. 3 and FIG. 4, Pc denotes the pressure of the refrigerant passing through the condenser 22, and Ps denotes the pressure of the refrigerant passing through the evaporator 25.

[0022] In a more preferred configuration, the subcooling heat exchanger 23 in the bypass passage 3 has a heat transfer area that allows the heat exchange ratio Qsc/Qc to be at least 0.2 but not more than 0.7 when the dryness fraction of the refrigerant that has flowed out of the subcooling heat exchanger 23 is maintained at at least 0.8 but less than 1.0. When thus configured, the dryness fraction Xei in the case where R410A is used as the refrigerant can be maintained at at least 0 but not more than 0.45, and the refrigerant that has flowed out of the subcooling heat exchanger 23 is in the subcooled state (see FIG. 2 (b), and FIG. 4 (a) and (b)).

[0023] Next, the control performed by the controller 4 will be described.

[0024] As shown in Fig. 1, the bypass passage 3 is provided with an inlet temperature sensor 61 for detecting a temperature (an inflow temperature) Tbi of the refrigerant to flow into the subcooling heat exchanger 23, and an outlet temperature sensor 62 for detecting a temperature (an outflow temperature) Tbo of the refrigerant that has flowed out of the subcooling heat exchanger 23. The controller 4 controls the rotation speed of the compressor 21, the switching of the four-way valve 28, and the openings of the main expansion valve 24 and the bypass expansion valve 31, based on the detected values detected by the sensors 61 and 62, etc.

[0025] In the present embodiment, the controller 4 controls the main expansion valve 24 and the bypass expansion valve 31 so that, in the normal operation, the dryness fraction of the refrigerant that has flowed out of the subcooling heat exchanger 23 in the bypass passage 3 is at least 0.8 but less than 1.0. Here, the heat exchange ratio Qsc/Qc is at least 0.2 but not more than 0.8 because the heat transfer area of the subcooling heat exchanger 23 is determined appropriately.

[0026] The method of controlling the heat exchange ratio Qsc/Qc to be at least 0.2 but not more than 0.8 is not limited to the use of the heat transfer area of the subcooling heat exchanger 23. For example, the control can be performed by: providing a pressure sensor or a temperature sensor to the condenser 22 to detect the condensation temperature in the condenser 22; providing a temperature sensor at an outlet of the condenser 22; while maintaining the degree of subcooling at the outlet side of the condenser 22, which is the difference between the condensation temperature and the temperature detected by the temperature sensor, at about 1 K to 5 K, controlling the main expansion valve 24 and the bypass expansion valve 31 so that the dryness fraction of the refrigerant that has flowed out of the subcooling heat exchanger 23 is at least 0.8 but less than 1.0.

[0027] By controlling the main expansion valve 24 and the bypass expansion valve 31 so that the dryness fraction of the refrigerant that has flowed out of the subcooling heat exchanger 23 in the bypass passage 3 is at least 0.8 but less than 1.0, it is possible to ensure the maximum subcooling effect of the subcooling heat exchanger 23. Thereby, it is possible to increase the difference between the enthalpy of the refrigerant at an inlet of the evaporator 25 and the enthalpy of the refrigerant at an outlet of the evaporator 25. At the same time, it is possible to increase the degree of wetness of the refrigerant at the inlet of the evaporator 25, and accordingly the meaningless increase of the pressure loss in the evaporator 25 can be suppressed, that is, the suction pressure of the compressor 21 can be increased. As a result, the flow rate of the refrigerant and the condensation (heating) capacity can be increased.

[0028] Specifically, the controller 4 controls the main expansion valve 24 and the bypass expansion valve 31 so that the inflow temperature Tbi and the outflow temperature Tbo are approximately equal to each other.

[0029] Instead of the inlet temperature sensor 61, a pressure sensor may be provided at an outlet of the subcooling heat exchanger 23 in the bypass passage 3 or may be provided between the evaporator 25 and the compressors 21 in order to control the main expansion valve 24 and the bypass expansion valve 31 based on the pressure detected by the pressure sensor so that the dryness fraction of the refrigerant that has flowed out of the subcooling heat exchanger 23 in the bypass passage 3 is at least 0.8 but less than 1.0.

[0030] Specifically, it is possible to determine a saturation temperature from the pressure detected by the pressure sensor, and the main expansion valve 24 and the bypass expansion valve 31 may be controlled so that the outflow temperature Tbo conforms to the saturation temperature.

[0031] Generally, the evaporating pressure in the evaporator 25 decreases as the outside air temperature AT decreases. Thus, when the degree of subcooling in the subcooling heat exchanger 23 is constant, the dryness fraction of the refrigerant to flow into the evaporator 25 increases, that is, the gaseous refrigerant component that makes no contribution to the evaporation increases. Accordingly, the heat absorbing capacity of the evaporator is lowered. In such a case, it is preferable that, as shown in FIG. 5, the controller 4 controls the main expansion valve 24 and the bypass expansion 31 so that the heat exchange ratio Qsc/Qc increases as the outside air temperature AT decreases.

[0032] Thereby, it is possible to increase the degree of subcooling at the outlet of the subcooling heat exchanger 23. Also, by lowering the enthalpy of the refrigerant to flow into the evaporator 25, it is possible to increase the amount of change in the enthalpy of the refrigerant in the evaporator 25, that is, it is possible to increase the heat absorbing capacity of the evaporator 25, compared to the case where the heat exchange ratio Qsc/Qc is low. As a result, when the outside air temperature AT is low, it is possible to complement the decrease in the amount of heat absorbed by the refrigerant in the evaporator 25 caused by the increase in the enthalpy of the refrigerant to flow into the evaporator 25. The outside air temperature AT may be detected by an outside air temperature sensor, for example.

[0033] Moreover, as the condensation temperature Tc of the refrigerant increases, it is necessary to increase the degree of subcooling at the outlet of the subcooling heat exchanger 23 when the enthalpy of the refrigerant at the inlet of the evaporator 25 is constant. For that purpose, a rate at which the amount of heat exchange is increased in the subcooling heat exchanger 23 needs to be higher than a rate at which the amount of heat exchange is increased in the condenser 22. In this case, as shown in FIG. 5, it is preferable to control the main expansion valve 24 and the bypass expansion 31 so that the heat exchange ratio Qsc/Qc increases as the condensation temperature Tc of the refrigerant in the condenser 22 increases.

[0034] Thereby, the rate at which the amount of heat exchange is increased in the subcooling heat exchanger 23 becomes higher than the rate at which the amount of heat exchange is increased in the condenser 22, and the enthalpy of the refrigerant at the inlet of the evaporator 25 can be lowered. Thus, compared to the case where the heat exchange ratio Qsc/Qc is low, it is possible to increase the amount of change in the enthalpy of the refrigerant in the evaporator 25, that is, it is possible to increase the heat absorbing capacity of the evaporator 25. As a result, it is possible to complement the decrease in the amount of heat absorbed by the refrigerant in the evaporator 25 caused by the increase in the enthalpy of the refrigerant to flow into the evaporator 25 resulting from the increase in the condensation temperature Tc.

[0035] As the condensation temperature Tc, the outflow temperature Tbo may be used.

[0036] The bypass passage 3 does not necessarily have to be branched from the refrigerant circuit 2 between the subcooling heat exchanger 23 and the main expansion valves 24. It may be branched from the refrigerant circuit 2 between the condenser 22 and the subcooling heat exchangers 23.

[0037] Furthermore, the main expansion means and the bypass expansion means of the present invention do not necessarily have to be expansion valves. Each of them may be an expander that recovers power from the refrigerant expanding. In this case, the rotation speed of the expander may be controlled by, for example, changing the load by using a power generator connected to the expander.

[0038] The fluid to be heated in the condenser 22 does not necessarily have to be water, and it may be air. That is, the present invention is applicable also to air conditioners.

[0039] The present invention is particularly useful for hot water heaters that heat water with a refrigeration cycle apparatus and perform heating by utilizing the heated water.

Claims

1. A refrigeration cycle apparatus comprising:

a refrigerant circuit including a compressor, a condenser, a subcooling heat exchanger, a main expansion means and an evaporator that are connected circularly;
a bypass passage that is branched from the refrigerant circuit between the subcooling heat exchanger and the main expansion means or between the condenser and the subcooling heat exchanger, and extends through the subcooling heat exchanger to join to the refrigerant circuit between the evaporator and the compressor; and
a bypass expansion means provided in the bypass passage upstream of the subcooling heat exchanger,
wherein the subcooling heat exchanger is configured so that a heat exchange ratio that is a ratio of an amount of heat exchange between, in the subcooling heat exchanger, the refrigerant that has been decompressed by the bypass expansion means and the refrigerant that has flowed out of the condenser with respect to an amount of heat exchange between, in the condenser, the refrigerant that has flowed into the condenser and a fluid to be heated is at least 0.2 but not more than 0.8, when an opening of the bypass expansion means is adjusted so that a dryness fraction of the refrigerant that has flowed out of the subcooling heat exchanger in the bypass passage is at least 0.8 but less than 1.0.

2. The refrigeration cycle apparatus according to claim 1, further comprising a controller for controlling the bypass expansion means so that the dryness fraction of the refrigerant that has flowed out of the subcooling heat exchanger in the bypass passage is at least 0.8 but less than 1.0.

3. The refrigeration cycle apparatus according to claim 2, further comprising:

an inlet temperature sensor for detecting a temperature of the refrigerant to flow into the subcooling heat exchanger in the bypass passage; and
an outlet temperature sensor for detecting a temperature of the refrigerant that has flowed out of the subcooling heat exchanger in the bypass passage,
wherein the controller controls the bypass expansion means so that the temperature detected by the outlet temperature sensor is approximately equal to the temperature detected by the inlet temperature sensor.

4. The refrigeration cycle apparatus according to claim 2, further comprising:

an outlet temperature sensor for detecting a temperature of the refrigerant that has flowed out of the subcooling heat exchanger in the bypass passage; and
a pressure sensor for detecting a pressure of the refrigerant to be drawn into the compressor, wherein the controller controls the bypass control means so that the temperature detected by the outlet temperature sensor conforms to a saturation temperature determined from the pressure detected by the pressure sensor.

5. The refrigeration cycle apparatus according to any one of claims 2 to 4, wherein the controller controls the bypass expansion means so that the heat exchange ratio increases as an outside air temperature decreases.

6. The refrigeration cycle apparatus according to any one of claims 2 to 4, wherein the controller controls the bypass expansion means so that the heat exchange ratio increases as a condensation temperature of the refrigerant in the condenser increases.

7. The refrigeration cycle apparatus according to any one of claims 1 to 6, wherein the condenser is a heat exchanger that heats the fluid to be heated by exchanging heat between the refrigerant and the fluid to be heated.

8. A hot water heater that performs heating by utilizing hot water produced by a heating means, comprising the refrigeration cycle apparatus according to claim 7 as the heating means.

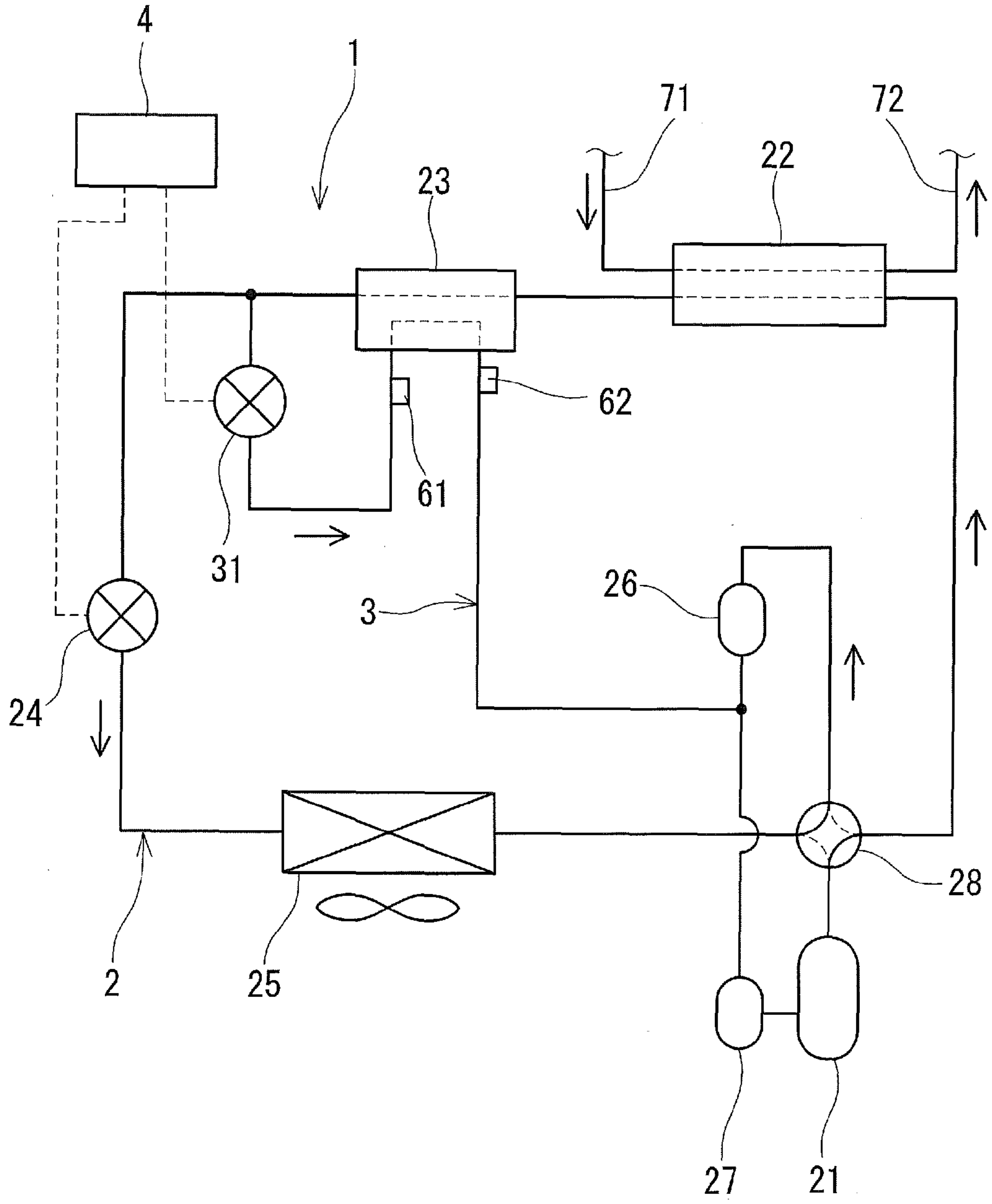

FIG. 1

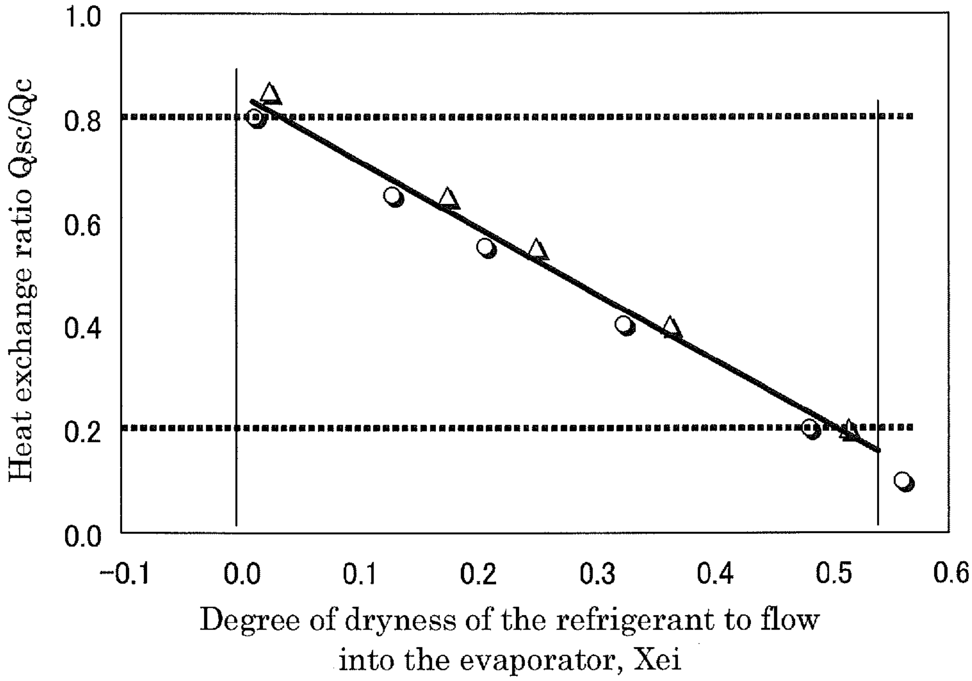
1.0
0.8
0.6
0.4
0.2
0.0
Heat exchange ratio Qsc/Qc
−0.1
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Degree of dryness of the refrigerant to flow into the evaporator, Xei

FIG. 2a

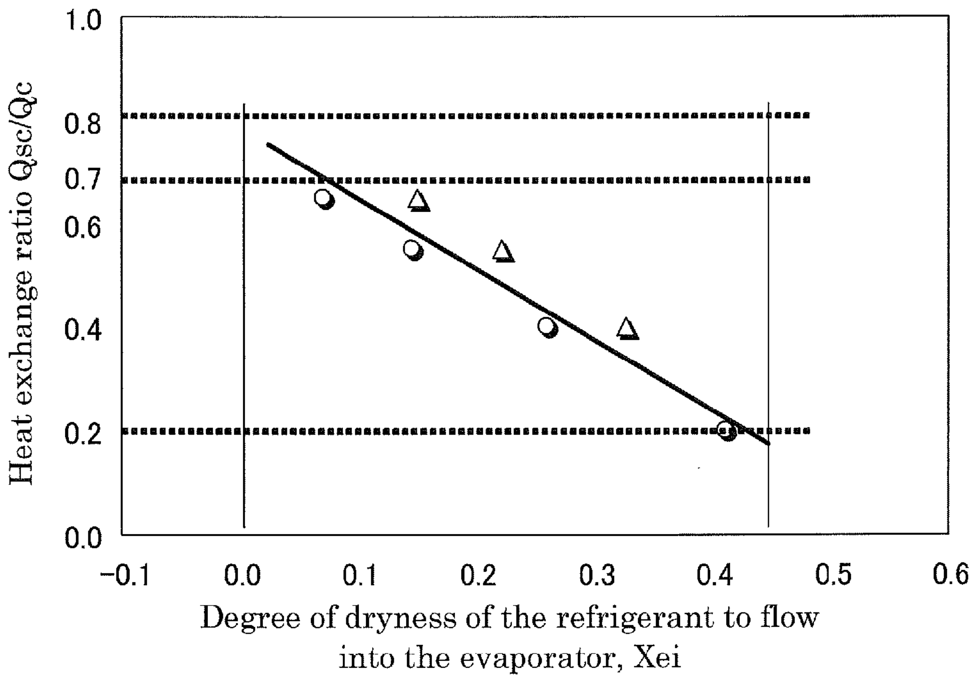
1.0
0.8
0.7
0.6
0.4
0.2
0.0
Heat exchange ratio Qsc/Qc
−0.1
0.0
0.1
0.2
0.3
0.4
0.5
0.6
Degree of dryness of the refrigerant to flow into the evaporator, Xei

FIG. 2b

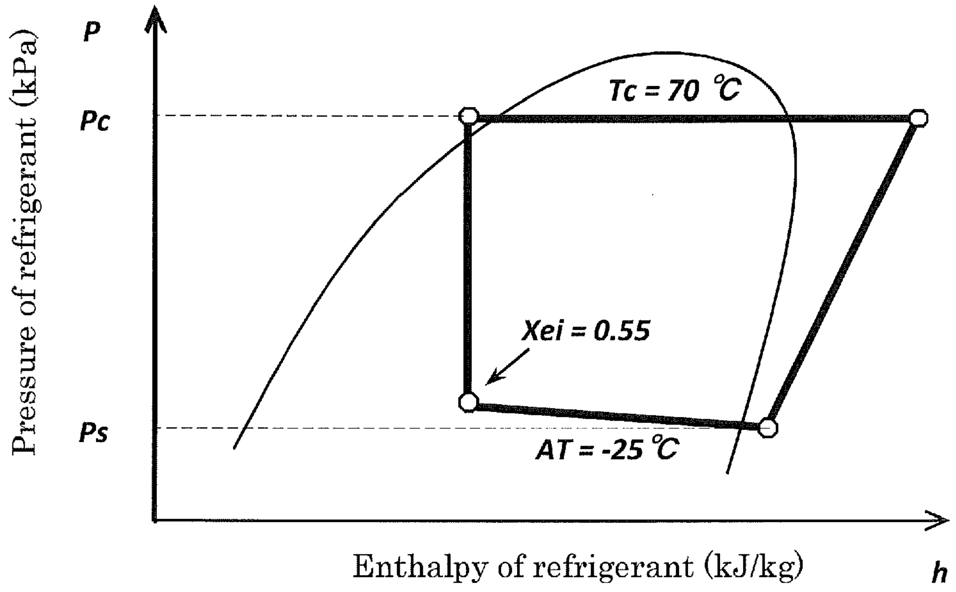
P
Pressure of refrigerant (kPa)
Pc
Ps
Tc = 70 ℃
Xei = 0.55
AT = -25 ℃
Enthalpy of refrigerant (kJ/kg)
h

FIG. 3a

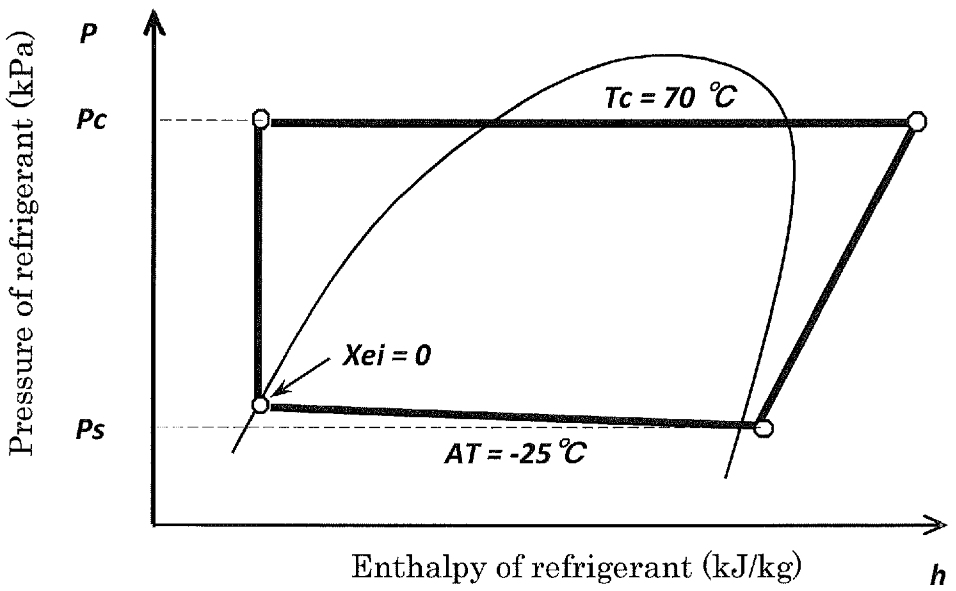
P
Pressure of refrigerant (kPa)
Pc
Ps
Tc = 70 ℃
Xei = 0
AT = -25 ℃
Enthalpy of refrigerant (kJ/kg)
h

FIG. 3b

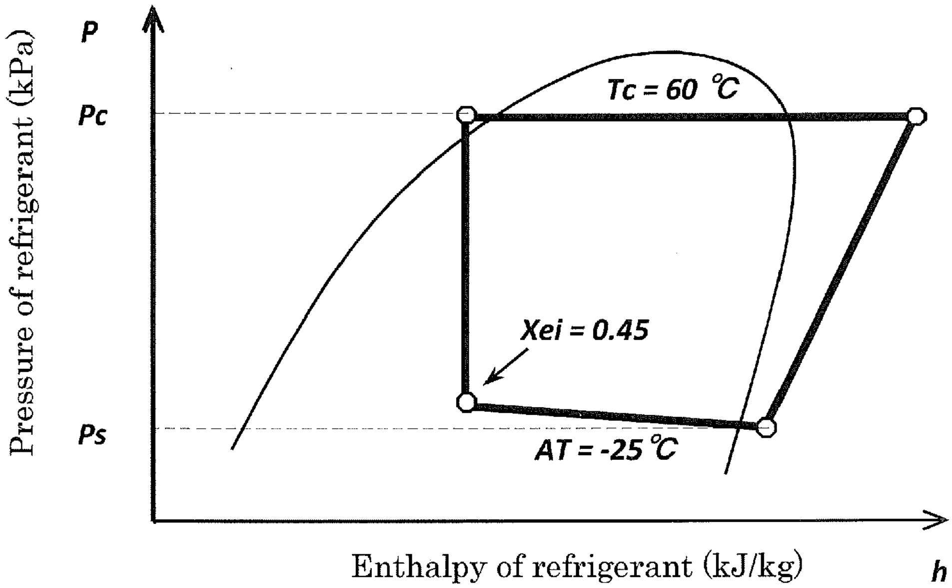
P
Pc
Ps
Pressure of refrigerant (kPa)
Tc = 60 ℃
Xei = 0.45
AT = -25℃
Enthalpy of refrigerant (kJ/kg)
h

FIG. 4a

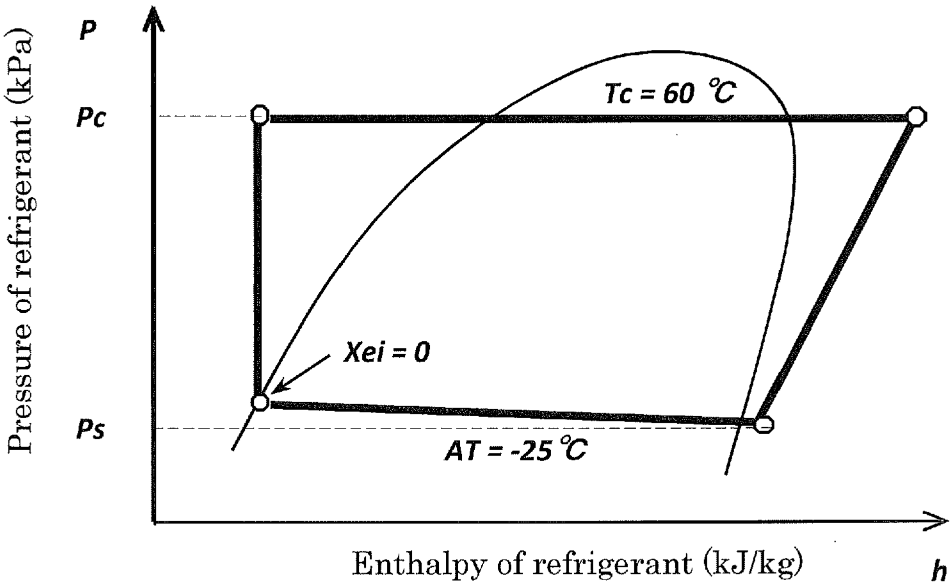
P
Pc
Ps
Pressure of refrigerant (kPa)
Tc = 60 ℃
Xei = 0
AT = -25℃
Enthalpy of refrigerant (kJ/kg)
h

FIG. 4b

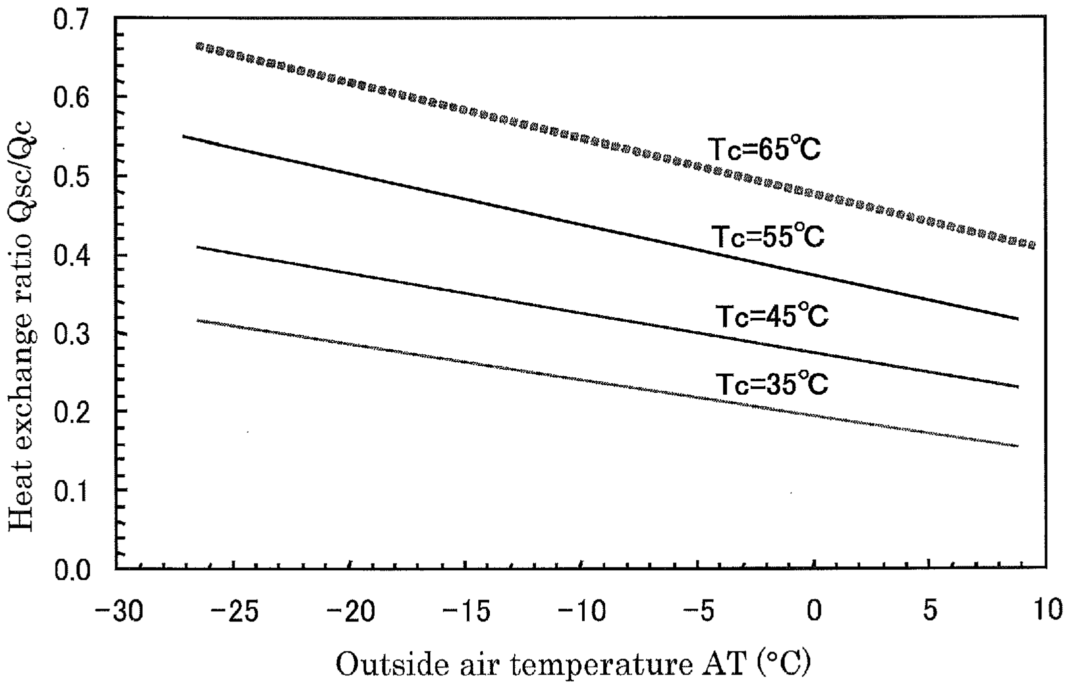
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Heat exchange ratio Qsc/Qc
Tc=65°C
Tc=55°C
Tc=45°C
Tc=35°C
−30
−25
−20
−15
−10
−5
0
5
10
Outside air temperature AT (°C)

FIG. 5

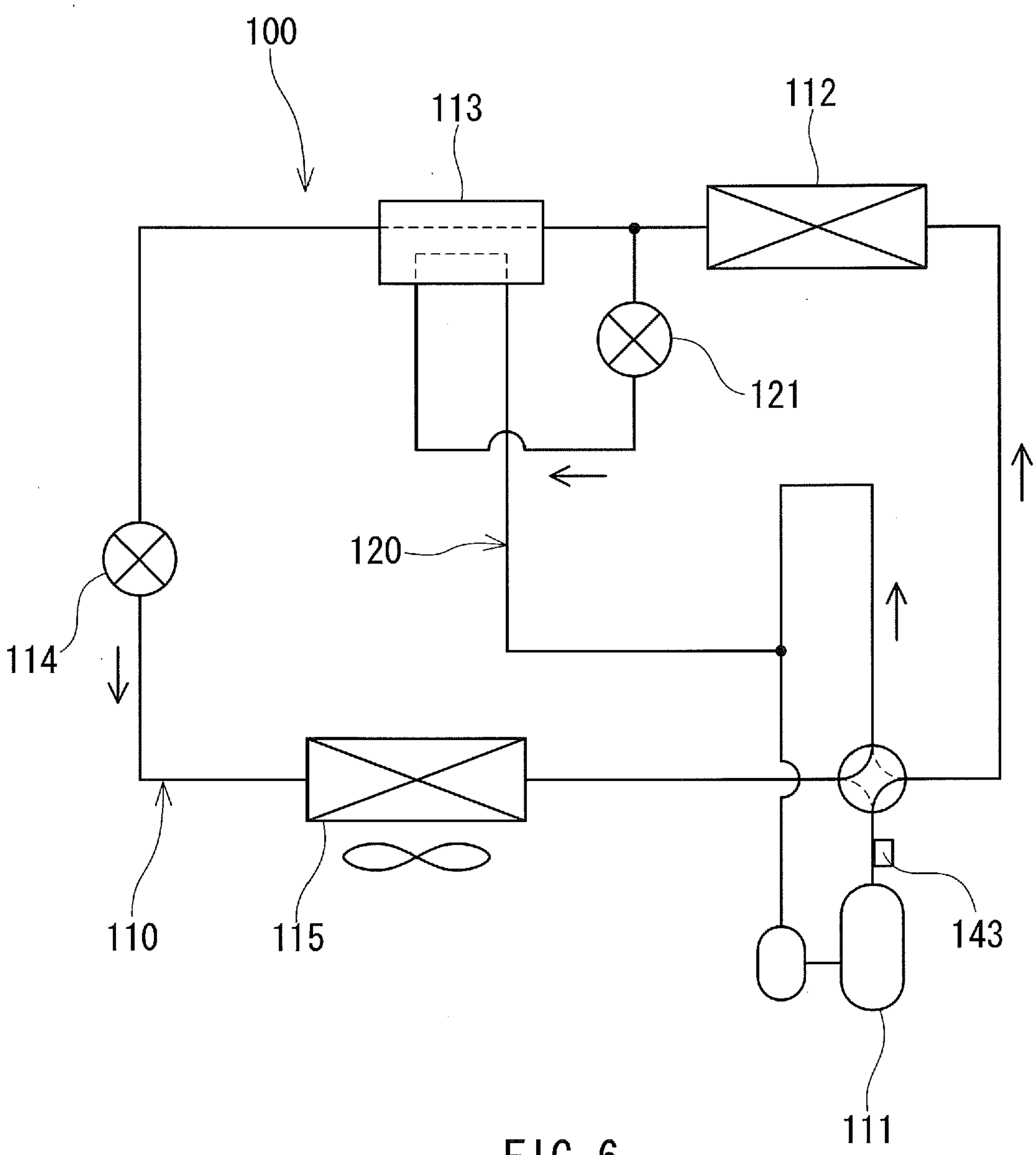

FIG. 6

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 4036288 B **[0002] [0004] [0005]**