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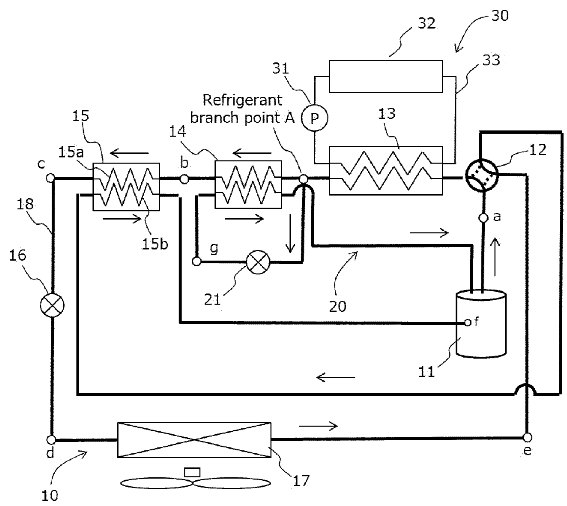
(54) REFRIGERATION CYCLE DEVICE

(57) [Object] It is an object of the present invention to provide a refrigeration cycle device capable of sufficiently securing discharge superheat degree (discharge SH) even if injection is carried out using R290 refrigerant, capable of efficiently operating a device, and capable of enhancing reliability of the device.

[Solving Means] A refrigeration cycle device including: a main refrigerant circuit 10 formed by sequentially connecting, to one another through a refrigerant pipe 18, a compressor 11, a four-way valve 12, a use-side heat exchanger 13, an economizer 14, an internal heat exchanger 15, a first expansion device 16 and a heat source-side heat exchanger 17; and a bypass refrigerant circuit 20 in which refrigerant branches off from the refrigerant pipe 18 between the use-side heat exchanger 13 and the economizer 14, the branched refrigerant is decompressed by a second expansion device 21 and then, the refrigerant exchanges heat with refrigerant which flows through the main refrigerant circuit 10 in the economizer 14, and the former refrigerant joins up with the refrigerant which is in the middle of compression stroke of the compressor 11, wherein when the use-side heat exchanger 13 is used as a condenser, in the internal heat exchanger 15, high pressure refrigerant which flows through the main refrigerant circuit 10 and low pressure refrigerant which flows out from the heat source-side heat exchanger 17 and which flows through the main refrigerant circuit 10 exchange heat with each other.

[Fig. 1]



10 Main refrigerant circuit
11 Compressor
12 Four-way valve
13 Use-side heat exchanger
14 Economizer
15 Internal heat exchanger
15a High pressure-side flow path
15b Low pressure-side flow path
16 First expansion device
17 Heat source-side heat exchanger
18 Refrigerant pipe
20 Bypass refrigerant circuit
21 Second expansion device
30 Use-side heat medium circuit
31 Circulation pump
32 Load termination
33 Heat medium pipe

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Description

[TECHNICAL FIELD]

[0001] The present invention relates to a refrigeration cycle device using propane as refrigerant.

[BACKGROUND TECHNIQUE]

[0002] Patent document 1 proposes an air conditioner including: a refrigeration cycle formed by connecting a compressor, an indoor heat exchanger, an upstream side expansion valve, an intermediate pressure receiver, a downstream side expansion valve and an outdoor heat exchanger to one another such that refrigerant flow these elements in this order at the time of a heating operation; an injection circuit for injecting refrigerant of the intermediate pressure receiver into the compressor; an injection expansion valve provided in the injection circuit to adjust an amount of refrigerant which is injected; and control means for controlling the upstream side expansion valve, the downstream side expansion valve and the injection expansion valve.

[0003] The control means includes a liquid accumulating determining section which determines whether liquid refrigerant is accumulated in the intermediate pressure receiver. If it is determined that the liquid refrigerant is accumulated in the intermediate pressure receiver, the injection expansion valve is opened to carry out the injection, thereby preventing variation in oil dilution degree in the compressor caused by unevenness of blowout temperature or reduction of discharge temperature.

[0004] In the air conditioner having such an injection circuit, by injecting refrigerant in the middle of compression stroke of the compressor, density of refrigerant discharged from the compressor rises, a circulation amount of refrigerant is increased and heating ability is enhanced. In addition, in the above-described configuration, by increasing supercooling degree of refrigerant which flows into a heat source-side heat exchanger through an intermediate heat exchanger, thereby increasing an endothermic energy amount.

[0005] Such a conventional technique is effective for enhancing the heating ability specially when outdoor air temperature is low or when refrigerant such as R290 having lower density as compared with R410A and R32 is used, and such an injection circuit is mounted in a hydronic heater.

[PRIOR ART DOCUMENT]

[PATENT DOCUMENT]

[0006] [Patent Document 1] Japanese Patent Application Laidopen No.2019-148394

[SUMMARY OF THE INVENTION]

[PROBLEM TO BE SOLVED BY THE INVENTION]

[0007] When propane (R290 refrigerant) is used as refrigerant, a device can be operated most efficiently by carrying out injection in a gas-liquid two-phase state, but if the injection is carried out using R230 refrigerant as refrigerant in the air conditioner described in patent document 1, the following problems occur.

[0008] In the R290 refrigerant, since discharge temperature does not easily rise in terms of physical property as compared with R410 refrigerant of R32 refrigerant, if gas-liquid two-phase injection is carried out, discharge superheat degree cannot be obtained mostly depending upon operational conditions, and it is difficult to control an expansion valve using discharge temperature.

[0009] Further, if the R290 refrigerant is injected in the gas-liquid two-phase state, since the discharge temperature is lowered, in a condenser, a temperature difference between refrigerant and heat medium to be heated becomes small, a radiation amount of the condenser is reduced.

[0010] If the R290 refrigerant is injected in the gas-liquid two-phase state, a rate occupied by liquid refrigerant in the compressing chamber is increased, and if liquid refrigerant and lubricant oil are mixed, viscosity of the lubricant oil is lowered, lubrication of a mechanism becomes insufficient.

[0011] Hence, it is an object of the present invention to provide a refrigeration cycle device capable of sufficiently securing discharge superheat degree (discharge SH) even if R290 refrigerant is injected, capable of efficiently operating the device, and capable of enhancing reliability of the device.

[MEANS FOR SOLVING THE PROBLEM]

[0012] A refrigeration cycle device of the present invention described in claim 1 including a main refrigerant circuit 10 formed by sequentially connecting, to one another through a refrigerant pipe 18, a compressor 11, a four-way valve 12, a use-side heat exchanger 13, an economizer 14, an internal heat exchanger 15, a first expansion device 16 and a heat source-side heat exchanger 17; and a bypass refrigerant circuit 20 in which refrigerant branches off from the refrigerant pipe 18 between the use-side heat exchanger 13 and the economizer 14, the branched refrigerant is decompressed by a second expansion device 21 and then, the branched refrigerant exchanges heat with the refrigerant which flows through the main refrigerant circuit 10 in the economizer 14, and the branched refrigerant joins up with the refrigerant which is in the middle of compression stroke of the compressor 11, wherein propane is used as the refrigerant, and when the use-side heat exchanger 13 is used as a condenser, in the internal heat exchanger 15, high pressure refrigerant which flows through the main refrigerant circuit 10 and low pressure refrigerant which flows out from the heat source-side heat exchanger 17 and which flows through the main refrigerant circuit 10 exchange heat with each other.

[0013] According to the invention described in claim 2, in the refrigeration cycle device described in claim 1, the high pressure refrigerant which flows through the internal heat exchanger 15 is the high pressure refrigerant after it flows through the economizer 14.

[0014] According to the invention described in claim 3, in the refrigeration cycle device described in claim 1 or claim 2, the high pressure refrigerant flowing through the internal heat exchanger 15 and the low pressure refrigerant flowing through the internal heat exchanger 15 are opposite flows.

[0015] According to the invention described in claim 4, in the refrigeration cycle device described in claim 1, when the use-side heat exchanger 13 is used as an evaporator, in the internal heat exchanger 15, the low pressure refrigerant flowing through the main refrigerant circuit 10 at a location upstream of the economizer 14 and the low pressure refrigerant before it is sucked into the compressor 11 at a location downstream of the four-way valve 12 exchange heat with each other.

[0016] According to the invention described in claim 5, in the refrigeration cycle device described in any one of claims 1 to 4, in the internal heat exchanger 15, a high pressure-side flow path 15a through which the high pressure refrigerant flows is made narrower than a low pressure-side flow path 15b through which the low pressure refrigerant flows.

[EFFECT OF THE INVENTION]

[0017] According to the present invention, high pressure refrigerant which flows through a main refrigerant circuit and low pressure refrigerant which flows out from a heat source-side heat exchanger and which flows through the main refrigerant circuit exchange heat with each other by an internal heat exchanger. According to this, a suction superheat degree of refrigerant which is sucked into a compressor can be increased, and even if propane is injected as refrigerant, it is possible to reliably secure a discharge superheat degree. Therefore, it is possible to stably control an expansion valve. Since discharge temperature from the compressor rises, a temperature difference between refrigerant and heat medium to be heated is increased in the condenser. Therefore, a radiation amount from the condenser is increased, and energy saving performance of a device is enhanced. Further, low pressure gas refrigerant having a large suction superheat degree and refrigerant which is injected in a two-phase state are mixed in a compression chamber, and a rate occupied by liquid refrigerant is reduced in the compression chamber. Therefore, reduction in viscosity of lubricant oil is suppressed, and reliability of the device is enhanced.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[0018]

Fig. 1 is a block diagram of a refrigeration cycle device according to an embodiment of the present invention;

Fig. 2 is a pressure-enthalpy diagram (P-h diagram) in the refrigeration cycle device;

Fig. 3 is a block diagram of the refrigeration cycle device;

Figs. 4 are graphs comparing COP depending upon existence or non-existence of an internal heat exchanger and a discharge superheat degree with each other;

Figs. 5 are T-h diagrams of a radiator (use-side heat exchanger) depending upon existence or non-existence of the internal heat exchanger; and

Figs. 6 are diagrams for explaining a logarithm average temperature difference of radiator (use-side heat exchanger) depending upon existence or non-existence of the internal heat exchanger.

[MODE FOR CARRYING OUT THE INVENTION]

[0019] According to a refrigeration cycle device of a first embodiment of the present invention, propane is used as the refrigerant, and when the use-side heat exchanger is used as a condenser, in the internal heat exchanger, high pressure refrigerant which flows through the main refrigerant circuit and low pressure refrigerant which flows out from the heat source-side heat exchanger and which flows through the main refrigerant circuit exchange heat with each other. According to this embodiment, high pressure refrigerant which flows through the main refrigerant circuit and low pressure refrigerant which flows out from the heat source-side heat exchanger and which flows through the main refrigerant circuit exchange heat with each other by the internal heat exchanger and therefore, a suction superheat degree of refrigerant which is sucked into the compressor can be increased. Even if propane is injected as the refrigerant, it is possible to reliably secure the discharge superheat and thus, it is possible to stably control the expansion valve. Since discharge temperature from the compressor rises, a temperature difference between the refrigerant and the heat medium to be heated is increased in the condenser, a radiation amount from the condenser is increased, and the energy saving performance of the device is enhanced. Further, low pressure gas refrigerant having a large suction superheat degree in the compression chamber and refrigerant which is injected in the two-phase state are mixed with each other, and a rate occupied by the liquid refrigerant in the compression chamber is reduced. Therefore, reduction in viscosity of lubricant oil is suppressed, and reliability of the device is enhanced.

[0020] According to a second embodiment of the invention, in the refrigeration cycle device of the first embodiment, the high pressure refrigerant which flows through the internal heat exchanger is the high pressure refrigerant after it flows through the economizer. According to this embodiment, by exchanging heat between the high pressure refrigerant after it flows through the economizer and low pressure refrigerant which flows out from the heat source-side heat exchanger, an enthalpy difference in the heat source-side heat exchanger can further be increased, the endothermic energy amount is increased and therefore, energy saving performance of the device is enhanced.

[0021] According to a third embodiment of the invention, in the refrigeration cycle device of the first or second embodiment, the high pressure refrigerant flowing through the internal heat exchanger and the low pressure refrigerant flowing through the internal heat exchanger are opposite flows. According to this embodiment, heat exchanging efficiency of the internal heat exchanger is enhanced because the high pressure refrigerant and the low pressure refrigerant flow oppositely, and discharge temperature further rises. Therefore, a radiation amount in the use-side heat exchanger further increases, and energy saving performance of the device is enhanced.

[0022] According to a fourth embodiment of the invention, in the refrigeration cycle device of the first embodiment, when the use-side heat exchanger is used as an evaporator, in the internal heat exchanger, the low pressure refrigerant flowing through the main refrigerant circuit at a location upstream of the economizer and the low pressure refrigerant before it is sucked into the compressor at a location downstream of the four-way valve exchange heat with each other. According to this embodiment, when the use-side heat exchanger is used as the evaporator by switching the four-way valve,

in the internal heat exchanger, low pressure refrigerants which are radiated heat by the heat source-side heat exchanger, and which are decompressed by the first expansion device exchange heat with each other. Therefore, even if the internal heat exchanger is provided, temperature of refrigerant which flows into the heat source-side heat exchanger is not lowered at the time of cooling operation, and cooling performance is not deteriorated.

[0023] According to a fifth embodiment of the invention, in the refrigeration cycle device of any one of the first to fourth embodiments, in the internal heat exchanger, a high pressure-side flow path through which the high pressure refrigerant flows is made narrower than a low pressure-side flow path through which the low pressure refrigerant flows. According to this embodiment, the high pressure-side flow path into which high density liquid refrigerant flows is made narrower than the low pressure-side flow path into which low density gas refrigerant flows. Therefore, flow speed of refrigerant becomes fast, and the heat transfer coefficient is enhanced. On the other hand, the low pressure-side flow path into which the low density gas refrigerant flows is made wider than the high pressure-side flow path into which the high density liquid refrigerant flows. Therefore, pressure loss of refrigerant which flows through the low pressure-side flow path is reduced and thus, the energy saving performance of the device is enhanced.

[EMBODIMENT]

[0024] An embodiment of the present invention will be described below.

Fig. 1 is a block diagram of a refrigeration cycle device of the embodiment, and shows a flow of refrigerant in a heating operation. The refrigeration cycle device is composed of a main refrigerant circuit 10 and a bypass refrigerant circuit 20.

[0025] The refrigeration cycle device of the embodiment uses propane as refrigerant.

[0026] The main refrigerant circuit 10 is formed by sequentially connecting, to one another through a refrigerant pipe 18, a compressor 11 which compresses refrigerant, a four-way valve 12, a use-side heat exchanger 13 which functions as a radiator at the time of heating operation, an economizer 14 which functions as an intermediate heat exchanger, an internal heat exchanger 15, a first expansion device 16 which is a main expansion valve, and a heat source-side heat exchanger 17 which functions as an evaporator at the time of heating operation.

[0027] The four-way valve 12 is provided between the compressor 11 and the use-side heat exchanger 13. The four-way valve 12 can change a direction of refrigerant which flows through the main refrigerant circuit 10. That is, by switching the four-way valve 12, at the time of cooling operation, refrigerant which is discharged from the compressor 11 flows through the heat source-side heat exchanger 17, the first expansion device 16, the internal heat exchanger 15, the economizer 14 and the use-side heat exchanger 13 in this order, and the refrigerant is sucked into the compressor 11. In this case, the heat source-side heat exchanger 17 functions as a radiator, and the use-side heat exchanger 13 functions as an evaporator.

[0028] The bypass refrigerant circuit 20 branches off from the refrigerant pipe 18 located between the use-side heat exchanger 13 and the economizer 14 (refrigerant branch point A), and the bypass refrigerant circuit 20 is connected to the compression chamber in the middle of compression stroke of the compressor 11.

[0029] The bypass refrigerant circuit 20 is provided with a second expansion device 21. A portion of high pressure refrigerant after it passes through the use-side heat exchanger 13 is decompressed by the second expansion device 21 and becomes intermediate pressure refrigerant and then, it exchanges heat in the economizer 14 with high pressure refrigerant which flows through the main refrigerant circuit 10, and itis injected into the compressor 11. The refrigerant which is injected into the compressor 11 joins up with refrigerant which is in the middle of compression stroke of the compressor 11.

[0030] In the compressor 11, injected refrigerant and refrigerant which is in the middle of compression stroke join up with each other and recompression is carried out.

[0031] The use-side heat medium circuit 30 is formed by connecting the use-side heat exchanger 13 the circulation pump 31 and the load termination 32 to one another through a heat medium pipe 33. Water or antifreeze liquid can be used as the use-side heat medium which flows through the use-side heat medium circuit 30.

[0032] In the heating operation, the use-side heat exchanger 13 heats the use-side heat medium discharged from the compressor 11.

[0033] The use-side heat medium which is heated by the use-side heat exchanger 13 radiates heat in the load termination 32 and is utilized for heating a room, the use-side heat medium radiates heat in the load termination 32 and become low in temperature and the use-side heat medium low is again heated by the use-side heat exchanger 13.

[0034] The internal heat exchanger 15 is provided between the economizer 14 and the first expansion device 16.

[0035] Operation of the refrigeration cycle device will be described using Figs. 1 and 2.

[0036] Fig. 2 is a pressure-enthalpy diagram (P-h diagram) in the refrigeration cycle device of the embodiment. Points (a) to (h) in Fig. 2 correspond to points (a) to (h) in Fig. 1.

[0037] Fig. 1 shows heating operation using the use-side heat exchanger 13 as a condenser.

[0038] First, high pressure refrigerant (a) discharged from the compressor 11 radiates heat in the use-side heat exchanger 13. A partial high pressure refrigerant after it radiates heat in the use-side heat exchanger 13 branches off from the main refrigerant circuit 10 (refrigerant branch point A), it is decompressed to the intermediate pressure by the second expansion device 21 and becomes intermediate pressure refrigerant (g), and the intermediate pressure refrigerant exchanges heat in the economizer 14 with high pressure refrigerant which flows through the main refrigerant circuit 10.

[0039] The high pressure refrigerant which flows through the main refrigerant circuit 10 after it radiates heat in the use-side heat exchanger 13 is cooled by the intermediate pressure refrigerant (g) which flows through the bypass refrigerant circuit 20, and its enthalpy is reduced (b).

[0040] The high pressure refrigerant (b) flowing through the main refrigerant circuit 10 after it radiates heat in the economizer 14 flows out from the heat source-side heat exchanger 17 in the internal heat exchanger 15, exchanges heat with low pressure refrigerant which flows through the main refrigerant circuit 10, the high pressure refrigerant (b) is cooled (c) and thereafter, the high pressure refrigerant (b) is decompressed by the first expansion device 16 (d).

[0041] The refrigerant (d) decompressed by the first expansion device 16 is reduced in refrigerant dryness (weight rate occupied by gas-phase component in the entire refrigerant) when the refrigerant (d) flows into the heat source-side heat exchanger 17, liquid component of refrigerant is increased, the refrigerant (d) evaporates (e) in the heat source-side heat exchanger 17, the refrigerant (d) absorbs heat in the internal heat exchanger 15 and returns to a suction side (f) of the compressor 11.

[0042] On the other hand, intermediate pressure refrigerant (g) which is decompressed to the intermediate pressure by the second expansion device 21 is heated by high pressure refrigerant which flows through the main refrigerant circuit 10 in the economizer 14, and the intermediate pressure refrigerant (g) joins up (h) with refrigerant which is in the middle of compression stroke of the compressor 11 in a state where refrigerant enthalpy becomes high.

[0043] By exchanging heat, by the internal heat exchanger 15, between the high pressure refrigerant which flows through the main refrigerant circuit 10 and the low pressure refrigerant which flows out from the heat source-side heat exchanger 17 and which flows through the main refrigerant circuit 10 in this manner, a suction superheat degree of refrigerant sucked into the compressor 11 can be increased, and even if injection is carried out using propane as refrigerant, it is possible to reliably secure a discharge superheat degree and therefore, it is possible to stably control the expansion valve. Since discharge temperature from the compressor 11 rises, a temperature difference between refrigerant and heat medium which is to be heated is increased in the condenser (use-side heat exchanger 13), a radiation amount from the condenser (use-side heat exchanger 13) is increased and energy saving performance of a device is enhanced. Further, low pressure gas refrigerant having a large suction superheat degree in the compression chamber and refrigerant which is injected in the two-phase state are mixed with each other, and a rate occupied by the liquid refrigerant in the compression chamber is reduced. Therefore, reduction in viscosity of lubricant oil is suppressed, and reliability of the device is enhanced.

[0044] High pressure refrigerant which flows through the internal heat exchanger 15 is high pressure refrigerant after it flows through the economizer 14, and by exchanging heat between high pressure refrigerant after it flows through the economizer 14 and low pressure refrigerant which flows out from the heat source-side heat exchanger 17, an enthalpy difference in the heat source-side heat exchanger 17 can further be increased, and since the endothermic energy amount is increased, energy saving performance of the device is enhanced.

[0045] The high pressure refrigerant flowing through the internal heat exchanger 15 and the low pressure refrigerant flowing through the internal heat exchanger 15 are opposite flows. By making the opposite flows in this manner, heat exchanging efficiency of the internal heat exchanger 15 is enhanced, and discharge temperature further increased. Therefore, the radiation amount in the use-side heat exchanger 13 is further increased, and energy saving performance of the device is enhanced.

[0046] In the internal heat exchanger 15, a high pressure-side flow path 15a through which high pressure refrigerant flows is made narrower than a low pressure-side flow path 15b through which low pressure refrigerant flows. That is, a flow path sectional area of the high pressure-side flow path 15a is made smaller than that of the low pressure-side flow path 15b. Since the high pressure-side flow path 15a into which high density liquid refrigerant flows is made narrower than the low pressure-side flow path 15b into which low density gas refrigerant flows as described above, the flow speed of refrigerant becomes faster, and the transfer coefficient is enhanced. On the other hand, since the low pressure-side flow path 15b into which the low density gas refrigerant flows is made wider than the high pressure-side flow path 15a into which high density liquid refrigerant flows, pressure loss of refrigerant which flows through the low pressure-side flow path 15b is reduced and thus, energy saving performance of the device is enhanced.

[0047] Fig. 3 is a block diagram of the refrigeration cycle device of the embodiment, and shows a flow of refrigerant in a cooling operation. In the cooling operation, the use-side heat exchanger 13 is used as an evaporator.

[0048] High pressure refrigerant which is discharged from the compressor 11 radiates heat in the heat source-side heat exchanger 17 and then, the high pressure refrigerant is decompressed by the first expansion device 16, the high pressure refrigerant passes through the internal heat exchanger 15, the high pressure refrigerant evaporates in the economizer 14 and the use-side heat exchanger 13, and the high pressure refrigerant again passes through the internal heat exchanger 15 and returns to the suction side of the compressor 11.

[0049] As described above, the low pressure refrigerant flowing through the main refrigerant circuit 10 at a location upstream of the economizer 14 and the low pressure refrigerant before it is sucked into the compressor 11 at a location downstream of the four-way valve 12 exchange heat in the internal heat exchanger 15. When the use-side heat exchanger 13 is used as an evaporator by switching the four-way valve in this manner, in the internal heat exchanger 15, the low pressure refrigerants which are radiated heat by the heat source-side heat exchanger 17, and which are decompressed by the first expansion device 16 exchange heat with each other. Therefore, even if the internal heat exchanger 15 is provided, temperature of refrigerant which flows into the heat source-side heat exchanger 17 is not lowered at the time of cooling operation, and cooling performance is not deteriorated.

[0050] Refrigerant which branches off from the main refrigerant circuit 10 at the refrigerant branch point A is decompressed to the intermediate pressure by the second expansion device 21 and becomes intermediate pressure refrigerant, and the intermediate pressure refrigerant exchanges heat with high pressure refrigerant which flows through the main refrigerant circuit 10 in the economizer 14.

[0051] Figs. 4 are graphs comparing COP depending upon existence or non-existence of an internal heat exchanger and a discharge superheat degree with each other.

[0052] A case where the internal heat exchanger 15 exists shows the refrigeration cycle device illustrated in Figs. 1 to 3, and a case where there is no internal heat exchanger 15 shows a comparative device using no internal heat exchanger 15 in the refrigeration cycle device illustrated in Figs. 1 to 3.

[0053] In any of the devices, propane is used as the refrigerant.

[0054] In Fig. 4(a), a lateral axis shows a bypass ratio and a vertical axis shows COP. A case where the bypass ratio in a comparative device having no internal heat exchanger 15 is 0% is shown as 100%.

[0055] As shown in Fig. 4(a), the refrigeration cycle device according to this embodiment having the internal heat exchanger 15 has higher COP as compared with the comparative device using no internal heat exchanger 15 where the bypass ratio is in a range of 0% to 40%.

[0056] In Fig. 4(b), a lateral axis shows the bypass ratio and a vertical axis shows a discharge superheat degree.

[0057] As shown in Fig. 4(b), the refrigeration cycle device of this embodiment having the internal heat exchanger 15 has a higher discharge superheat degree as compared with the comparative device using no internal heat exchanger 15 where the bypass ratio is in a range of 0% to 20%.

[0058] Figs. 5 and 6 are T-h diagrams of a radiator (use-side heat exchanger) depending upon existence or non-existence of the internal heat exchanger.

[0059] A case where the internal heat exchanger 15 exists shows the refrigeration cycle device illustrated in Figs. 1 to 3, and a case where there is no internal heat exchanger 15 shows a comparative device using no internal heat exchanger 15 in the refrigeration cycle device illustrated in Figs. 1 to 3.

[0060] In any of the devices, propane is used as the refrigerant.

[0061] Fig. 5(a) is a T-h diagram in a comparative device having no internal heat exchanger 15, and Fig. 5(b) is T-h diagram in the refrigeration cycle device of this embodiment having the internal heat exchanger 15.

[0062] It can be found that the refrigeration cycle device of this embodiment shown in Fig. 5(b) has a larger temperature difference between water and refrigerant as compared with the comparative device using no internal heat exchanger 15 shown in Fig. 5(a).

[0063] As shown Figs. 6, a logarithm average temperature difference is 0.7K in the comparative device using no internal heat exchanger 15, and is 4.2K in the refrigeration cycle device of this embodiment.

[0064] As apparent from Figs. 5 to 6, the refrigeration cycle device of the embodiment is provided with the internal heat exchanger 15. According to this, discharge temperature rises, and a temperature difference between water and refrigerant is increased.

[0065] Therefore, by providing the internal heat exchanger 15 as in the refrigeration cycle device of the embodiment, the suction superheat degree of refrigerant sucked into the compressor 11 can be increased, and even if injection is carried out using propane as the refrigerant, it is possible to reliably secure the discharge superheat degree, and COP is also enhanced. Since the discharge temperature from the compressor 11 rises, a temperature difference between refrigerant and heat medium to be heated is increased in the condenser (use-side heat exchanger 13). Therefore, a radiation amount from the condenser 13 is increased.

[INDUSTRIAL APPLICABILITY]

[0066] As described above, according to the refrigeration cycle device of the present invention, even if injection is carried out using propane as the refrigerant, it is possible to sufficiently secure discharge SH, and to efficiently operate the device.

[EXPLANATION OF SYMBOLS]

[0067]

10	main refrigerant circuit
11	compressor
12	four-way valve
13	use-side heat exchanger
14	economizer
15	internal heat exchanger
15a	high pressure-side flow path
15b	low pressure-side flow path
16	first expansion device
17	heat source-side heat exchanger
18	refrigerant pipe
20	bypass refrigerant circuit
21	second expansion device
30	use-side heat medium circuit
31	circulation pump
32	load termination
33	heat medium pipe

Claims

1. A refrigeration cycle device comprising:

a main refrigerant circuit (10) formed by sequentially connecting, to one another through a refrigerant pipe (18), a compressor (11), a four-way valve (12), a use-side heat exchanger (13), an economizer (14), an internal heat exchanger (15), a first expansion device (16) and a heat source-side heat exchanger (17); and

a bypass refrigerant circuit (20) in which refrigerant branches off from the refrigerant pipe (18) between the use-side heat exchanger (13) and the economizer (14), the branched refrigerant is decompressed by a second expansion device (21) and then, the branched refrigerant exchanges heat with the refrigerant which flows through the main refrigerant circuit (10) in the economizer (14), and the branched refrigerant joins up with the refrigerant which is in the middle of compression stroke of the compressor (11), wherein

propane is used as the refrigerant, and

when the use-side heat exchanger (13) is used as a condenser, in the internal heat exchanger (15), high pressure refrigerant which flows through the main refrigerant circuit (10) and low pressure refrigerant which flows out from the heat source-side heat exchanger (17) and which flows through the main refrigerant circuit (10) exchange heat with each other.

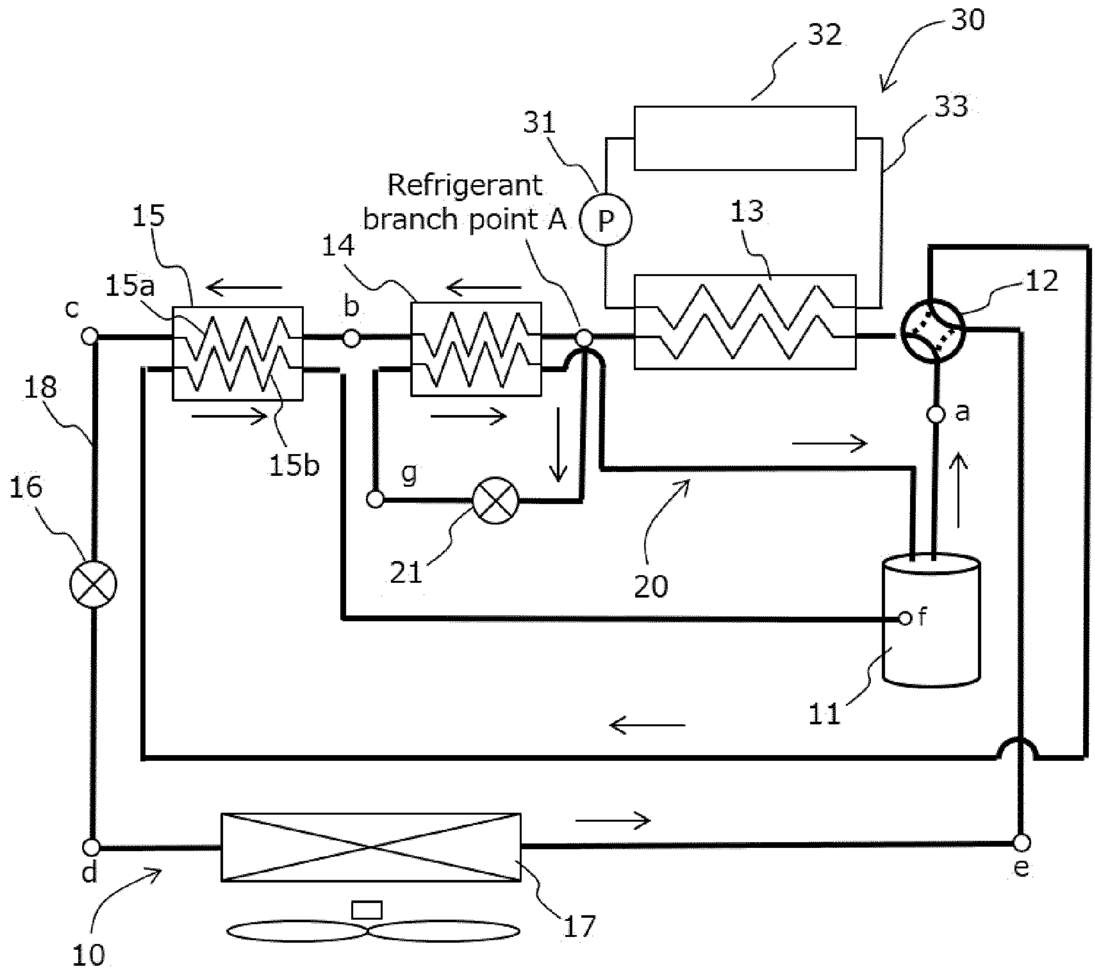
2. The refrigeration cycle device according to claim 1, wherein the high pressure refrigerant which flows through the internal heat exchanger (15) is the high pressure refrigerant after it flows through the economizer (14).

3. The refrigeration cycle device according to claim 1 or claim 2, wherein the high pressure refrigerant flowing through the internal heat exchanger (15) and the low pressure refrigerant flowing through the internal heat exchanger (15) are opposite flows.

4. The refrigeration cycle device according to claim 1, wherein when the use-side heat exchanger (13) is used as an evaporator, in the internal heat exchanger (15), the low pressure refrigerant flowing through the main refrigerant circuit (10) at a location upstream of the economizer (14) and the low pressure refrigerant before it is sucked into the compressor (11) at a location downstream of the four-way valve (12) exchange heat with each other.

5. The refrigeration cycle device according to any one of claims 1 to 4, wherein in the internal heat exchanger (15), a high pressure-side flow path (15a) through which the high pressure refrigerant flows is made narrower than a low pressure-side flow path (15b) through which the low pressure refrigerant flows.

[Fig. 1]



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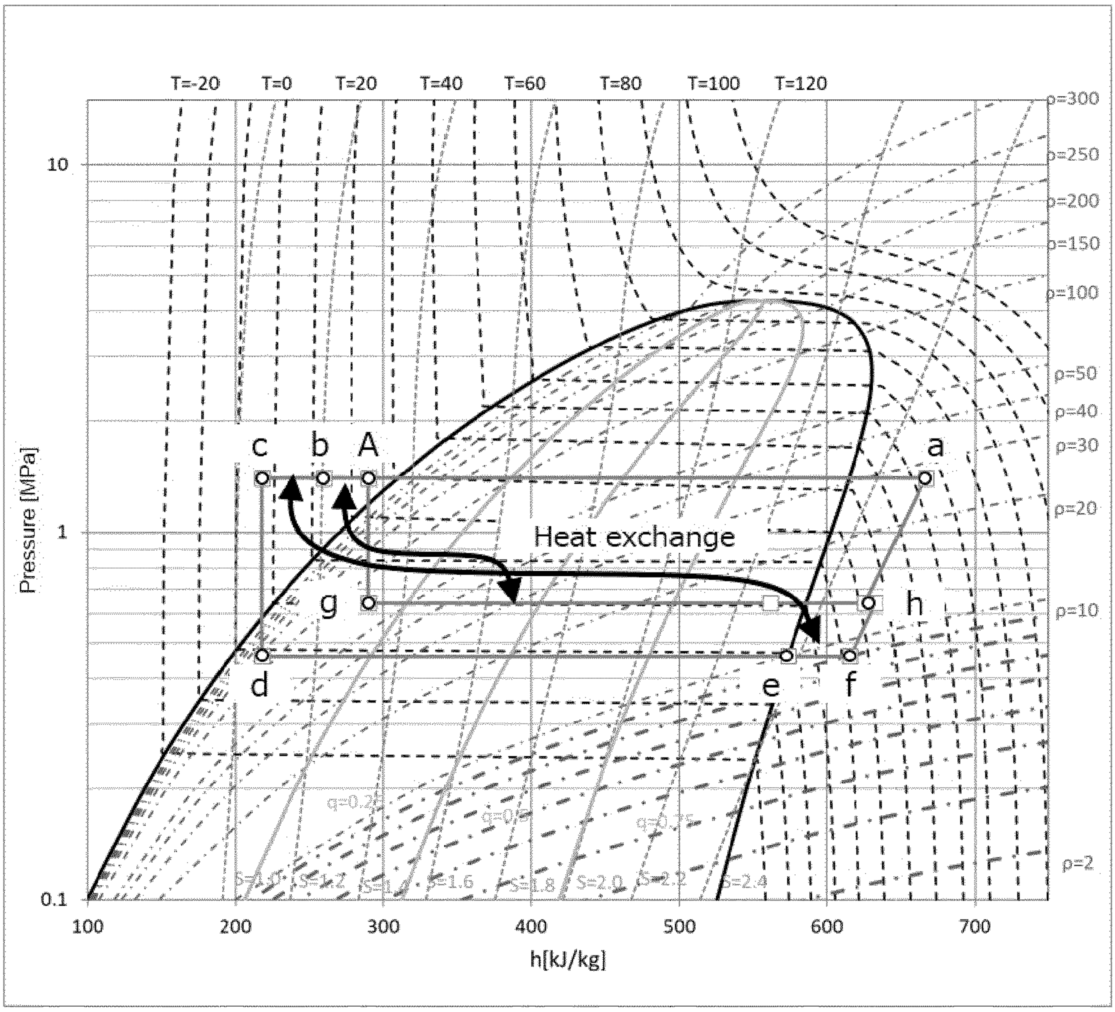
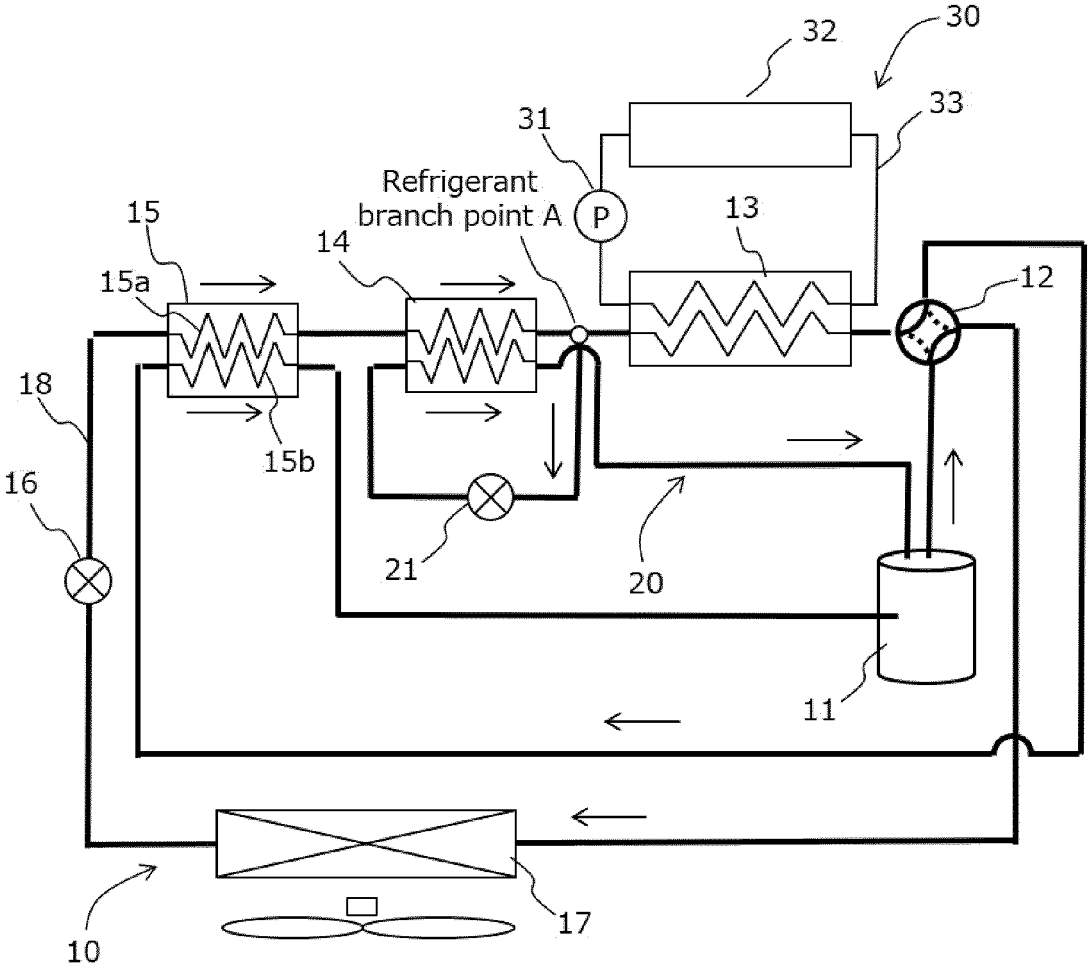
15b Low pressure-side flow path
16 First expansion device
17 Heat source-side heat exchanger
18 Refrigerant pipe
20 Bypass refrigerant circuit
21 Second expansion device
30 Use-side heat medium circuit
31 Circulation pump
32 Load termination
33 Heat medium pipe

[Fig. 2]



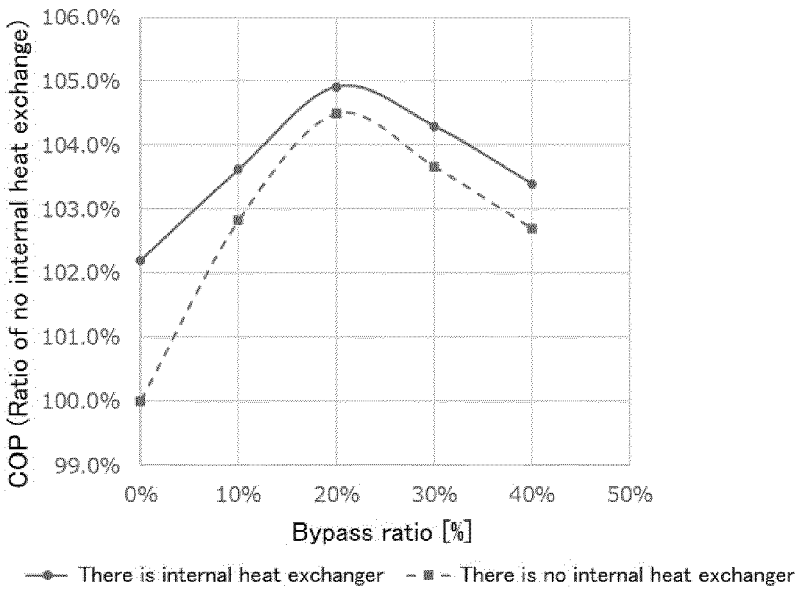
Pressure P-enthalpy-h diagram of the present invention

[Fig. 3]


32
30
31
33
Refrigerant
branch point A
P
15
13
14
12
15a
18
15b
16
21
20
11
17
10

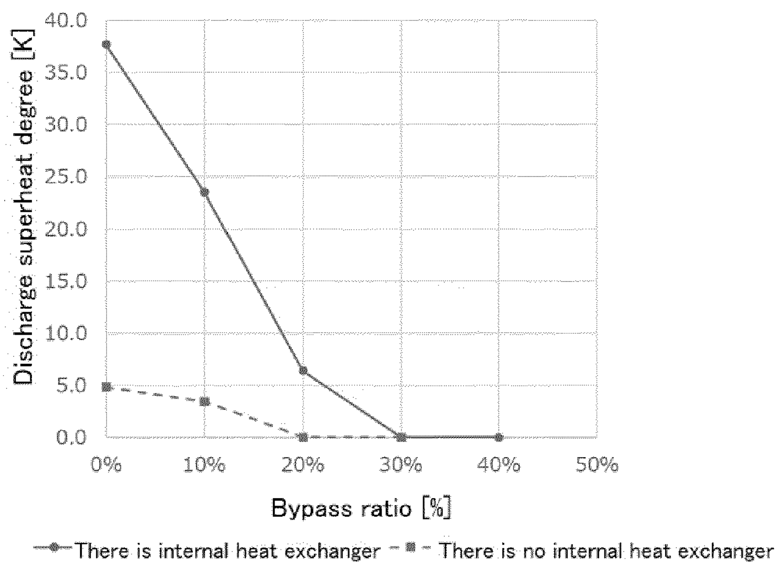
[Figs. 4]

(a)



Relation of bypass ratio and COP depending upon existence or non-existence of internal heat exchanger (condensation temperature = 41℃, evaporation temperature = −1℃, water−entering temperature = 34℃)

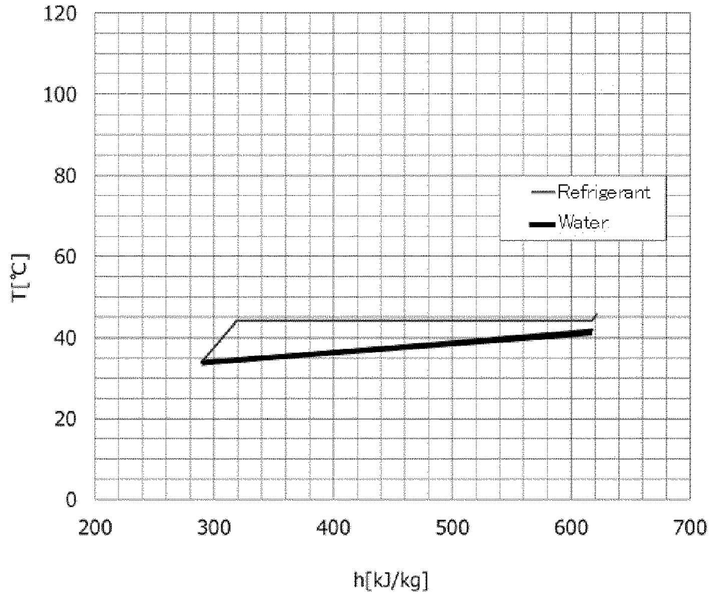
(b)



Relation of bypass ratio and Discharge superheat degree depending upon existence or non−existence of internal heat exchanger (condensation temperature = 41℃, evaporation temperature = −1℃, water−entering temperature = 34℃)

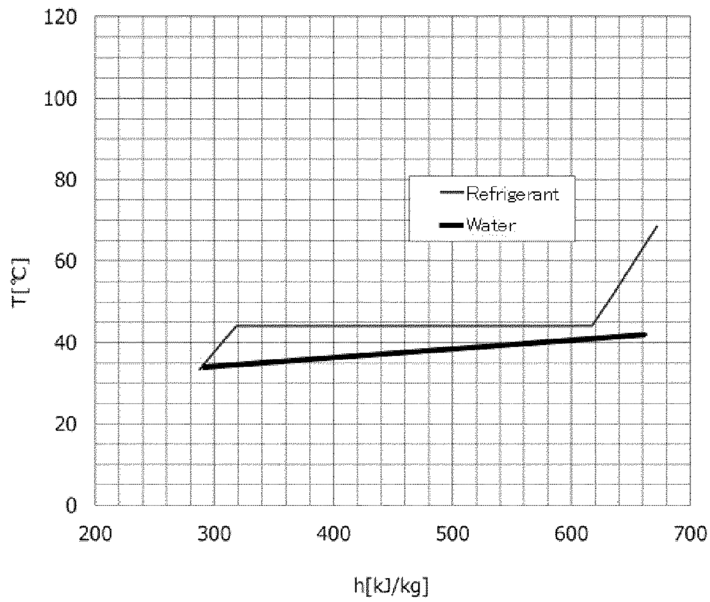
[Figs. 5]

(a)



Radiator-side T-h diagram when there is no internal heat exchanger
(condensation temperature = 41℃, water-entering temperature = 34℃, bypass ratio = 10%)

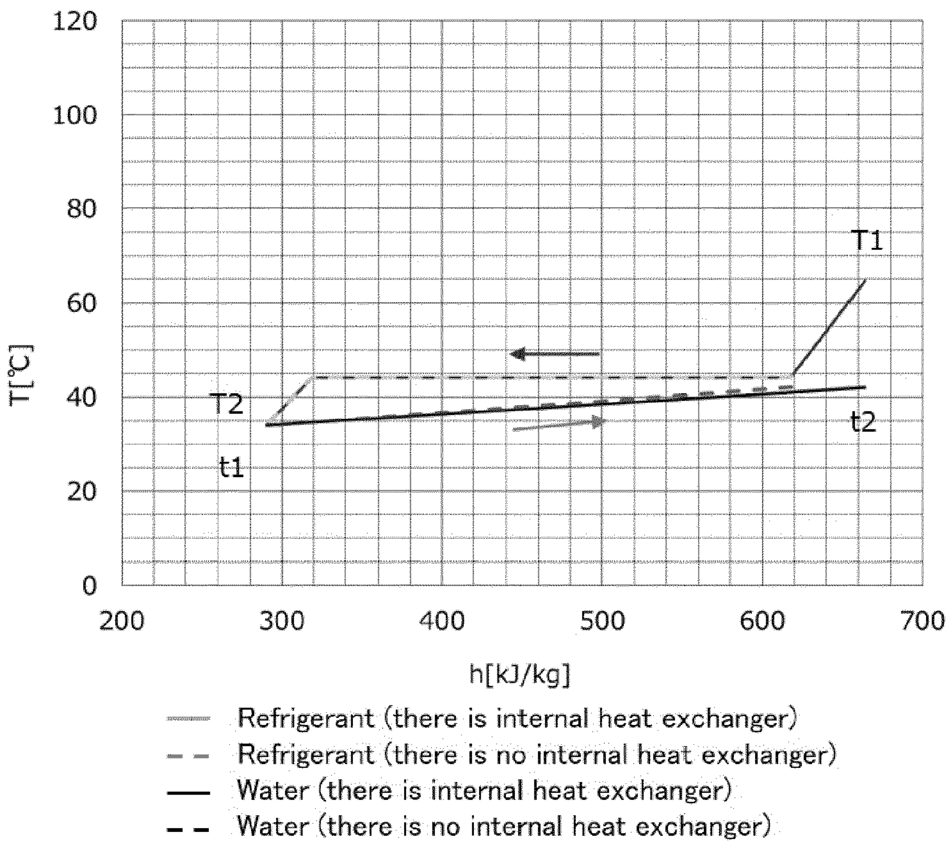
(b)



Radiator-side T-h diagram when there is internal heat exchanger
(condensation temperature = 41℃, water-entering temperature = 34℃, bypass ratio = 10%)

[Figs. 6]

Internal heat exchange	-	existence	non-existence
Refrigerant entrance temperature T1	°C	44.4	64.6
Refrigerant exit temperature T2	°C	34.1	34.1
Water-entering temperature t1	°C	34.0	34.0
Hot water-going temperature t2	°C	42.0	42.0
Logarithm average temperature difference	K	0.7	4.2



$$\text{Opposite logarithm average temperature difference} = \frac{(T_1 - t_2) - (T_2 - t_1)}{ln\left(\frac{(T_1 - t_1)}{(T_2 - t_2)}\right)}$$

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EUROPEAN SEARCH REPORT

Application Number
EP 23 21 7474

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 4 089 345 A1 (PANASONIC IP MAN CO LTD [JP]) 16 November 2022 (2022-11-16) * paragraphs [0037] - [0054]; figure 1 * -----	1-5	INV. F25B13/00 F25B40/00
A	WO 2022/208727 A1 (MITSUBISHI ELECTRIC CORP [JP]) 6 October 2022 (2022-10-06) * paragraphs [0018] - [0023]; figure 1 * -----	1-5	
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			F25B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	9 April 2024	Amous, Moez

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