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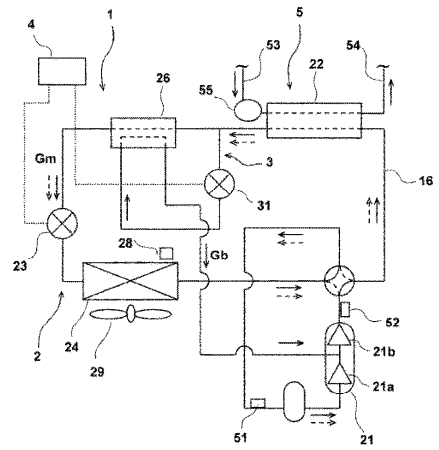
(54) REFRIGERATION CYCLE DEVICE AND LIQUID HEATING DEVICE HAVING THE SAME

(57) The present invention provides a refrigeration cycle device and a liquid heating device having the same including a heating operation mode for heating usage-side heat medium in a usage-side heat exchanger 22 by refrigerant discharged from a compression mechanism 21, and a defrosting operation mode for removing frost of a heat source-side heat exchanger 24 by the refrigerant discharged from the compression mechanism 21. In the heating operation mode which is executed after the defrosting operation mode is completed, at least for a predetermined period during execution of the heating operation mode, the control device 4 sets opening degrees of a first expansion device 23 and the second expansion device 31 to such values that a flow rate of refrigerant flowing through the first expansion device 23 becomes greater than a flow rate of refrigerant flowing through the second expansion device 31, and a blowing device 29 which supplies air to the heat source-side heat exchanger 24 is operated. According to this, even when the heating operation is executed in the usage-side heat exchanger after the defrosting operation of the heat source-side heat exchanger is completed, it is possible to suppress deterioration of heating ability in the usage-side heat exchanger.

[Fig. 1]



1 Refrigeration cycle device
2 Main refrigerant circuit
3 Bypass refrigerant circuit
4 Control device
5 Usage-side heat medium circuit
16 Pipe
21 Compression mechanism
21a Low stage-side compression rotation element
21b High stage-side compression rotation element
22 Usage-side heat exchanger
23 First expansion device
24 Heat source-side heat exchanger
26 Intermediate heat exchanger
28 Temperature thermistor
29 Blowing device
31 Second expansion device
51 Low pressure side detecting section
52 High pressure side detecting section
53 Heat medium returning pipe
54 Heat medium going pipe
55 Conveying device

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Description

[TECHNICAL FIELD]

[0001] The present invention relates to a refrigeration cycle device and a liquid heating device having the same.

[BACKGROUND TECHNIQUE]

[0002] As a refrigeration cycle device of this kind, there is conventionally disclosed a refrigeration cycle device having a two-stage compression mechanism in which a portion of refrigerant is expanded from a downstream side of a usage-side heat exchanger, and intermediate refrigerant is bypassed to a middle stage location of compression of the two-stage compression mechanism (see patent document 1 for example).

[0003] Fig. 4 shows the conventional refrigeration cycle device described in patent document 1.

[0004] As shown in Fig. 4, the refrigeration cycle device 100 includes a refrigerant circuit 110 through which refrigerant is circulated, and a rear stage-side injection pipe 120. A compression mechanism 111 having a plurality of compression rotation elements which are connected to one another in series, a heat source-side heat exchanger 112, expansion mechanisms 113a and 113b and a usage-side heat exchanger 114 are annularly connected to the refrigerant circuit 110 through a pipe. The refrigerant circuit 110 includes a switching mechanism 115 for switching over between a heating operation and a cooling operation.

[0005] The refrigeration cycle device 100 is provided with an intermediate refrigerant pipe 116 for allowing refrigerant discharged from a front stage-side compression rotation element to be sucked into a rear stage-side compression rotation element. The intermediate refrigerant pipe 116 is provided with an intermediate cooler 117 which functions as a cooler of refrigerant discharged from the front stage-side compression rotation element and sucked into the rear stage-side compression rotation element. The intermediate refrigerant pipe 116 is provided with an intermediate cooler bypass pipe 130. The intermediate cooler bypass pipe 130 is connected such that refrigerant discharged from the front stage-side compression rotation element bypasses the intermediate cooler 117.

[0006] The rear stage-side injection pipe 120 is connected such that refrigerant which branches off from the refrigerant circuit 110 between the heat source-side heat exchanger 112 and the usage-side heat exchanger 114 returns to the rear stage-side compression rotation element of the compression mechanism 111. The injection pipe 120 is provided with a rear stage-side injection valve 121 whose opening degree can be controlled.

[0007] Further, the refrigeration cycle device 100 carries out a reverse cycle defrosting operation for defrosting the heat source-side heat exchanger 112 by switching the switching mechanism 115 into the cooling operation. In the reverse cycle defrosting operation, refrigerant is made to flow into the heat source-side heat exchanger 112, the intermediate cooler 117 and the rear stage-side injection pipe 120. If it is detected that the defrosting operation of the intermediate cooler 117 is completed during the reverse cycle defrosting operation, control is performed such that refrigerant does not flow into the intermediate cooler 117 using the intermediate cooler bypass pipe 130, and control is performed such that the opening degree of the rear stage-side injection valve 121 is increased.

[PRIOR ART DOCUMENT]

[PATENT DOCUMENT]

[0008] [Patent Document1] Japanese Patent Application Laid-open No.2009-133581

[SUMMARY OF THE INVENTION]

[PROBLEM TO BE SOLVED BY THE INVENTION]

[0009] However, in the above-described conventional refrigeration cycle device, although deterioration of performance of the device caused by defrosting ability can be suppressed, there is no disclosure concerning the operation control when a heating operation is started after the defrosting operation of the heat source-side heat exchanger is completed.

[0010] The present invention has been accomplished to solve the above-described conventional problem, and it is an object of the invention to provide a refrigeration cycle device and a liquid heating device having the same capable of suppressing deterioration of the heating ability in the usage-side heat exchanger also when the heating operation in the usage-side heat exchanger is executed after the defrosting operation of the heat source-side heat exchanger is completed.

[MEANS FOR SOLVING THE PROBLEM]

[0011] To solve the above-described conventional problem, the present invention provides a refrigeration cycle device including: a main refrigerant circuit formed by sequentially connecting, to one another through a pipe, a compression mechanism composed of compression rotation elements, a usage-side heat exchanger for heating usage-side heat medium by refrigerant discharged from the compression rotation element, an intermediate heat exchanger, a first expansion device and a heat source-side heat exchanger; a bypass refrigerant circuit which exchanges heat with refrigerant flowing through the main refrigerant circuit by the intermediate heat exchanger after refrigerant branching off from the pipe between the usage-side heat exchanger and the first expansion device is decompressed by the second expansion device, the bypass refrigerant circuit joining up with refrigerant which is being compressed of the compression rotation element; a blowing device for supplying air to the heat source-side heat exchanger; and a control device, wherein the refrigeration cycle device further includes a heating operation mode for heating the usage-side heat medium in the usage-side heat exchanger by refrigerant discharged from the compression rotation element, and a defrosting operation mode for removing frost of the heat source-side heat exchanger by refrigerant discharged from the compression rotation element, and in the heating operation mode which is executed after the defrosting operation mode is completed, at least for a predetermined period during execution of the heating operation mode, the control device sets opening degrees of the first expansion device and the second expansion device to such values that a flow rate of refrigerant flowing through the first expansion device becomes greater than a flow rate of refrigerant flowing through the second expansion device, and the blowing device is operated.

[0012] According to this, by reducing the flow rate of the refrigerant flowing through the second expansion device, the temperature of the refrigerant discharged from the compression mechanism can be increased.

[0013] By increasing the flow rate of the refrigerant flowing through the first expansion device, density of the refrigerant sucked into the compression mechanism can be increased. Therefore, it is possible to secure the flow rate of the refrigerant flowing through the usage-side heat exchanger.

[0014] That is, during execution of the heating operation mode, the control device can secure the flow rate of the refrigerant flowing through the usage-side heat exchanger while rising the temperature of the refrigerant discharged from the compression rotation element by setting the opening degree of the first expansion device and the opening degree of the second expansion device to such a value that the flow rate of the refrigerant flowing through the first expansion device becomes greater than the flow rate of the refrigerant flowing through the second expansion device at least during a predetermined period, and it is possible to suppress the deterioration of the heating ability in the usage-side heat exchanger in the heating operation mode which is executed after the defrosting operation mode is completed.

[0015] Further, by operating the blowing device which supplies air to the heat source-side heat exchanger, it is possible to enhance the heat absorbing effect in the heat source-side heat exchanger, and to enhance the heating ability in the usage-side heat exchanger.

[EFFECT OF THE INVENTION]

[0016] According to the present invention, it is possible to provide a refrigeration cycle device and a liquid heating device having the same capable of suppressing the deterioration of the heating ability in the usage-side heat exchanger even when the heating operation in the usage-side heat exchanger is executed after the defrosting operation of the heat source-side heat exchanger is completed.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[0017]

Fig. 1 is a block diagram of a liquid heating device in an embodiment of the present invention;
Fig. 2 is a Mollier diagram when a heating operation mode is executed after a defrosting operation mode of a refrigeration cycle device is executed;
Fig. 3 is a flow chart showing control when the heating operation mode is executed after the defrosting operation mode of the refrigeration cycle device is executed; and
Fig. 4 is a block diagram of a conventional refrigeration cycle device.

[MODE FOR CARRYING OUT THE INVENTION]

[0018] A first aspect of the present invention provides a refrigeration cycle device including: a main refrigerant circuit formed by sequentially connecting, to one another through a pipe, a compression mechanism composed of compression rotation elements, a usage-side heat exchanger for heating usage-side heat medium by refrigerant discharged from the compression rotation element, an intermediate heat exchanger, a first expansion device and a heat source-side heat exchanger; a bypass refrigerant circuit which exchanges heat with refrigerant flowing through the main refrigerant circuit by the intermediate heat exchanger after refrigerant branching off from the pipe between the usage-side heat exchanger and the first expansion device is decompressed by the second expansion device, the bypass refrigerant circuit joining up with refrigerant which is being compressed of the compression rotation element; a blowing device for supplying air to the heat source-side heat exchanger; and a control device, wherein the refrigeration cycle device further includes a heating operation mode for heating the usage-side heat medium in the usage-side heat exchanger by refrigerant discharged from the compression rotation element, and a defrosting operation mode for removing frost of the heat source-side heat exchanger by refrigerant discharged from the compression rotation element, and in the heating operation mode which is executed after the defrosting operation mode is completed, at least for a predetermined period during execution of the heating operation mode, the control device sets opening degrees of the first expansion device and the second expansion device to such values that a flow rate of refrigerant flowing through the first expansion device becomes greater than a flow rate of refrigerant flowing through the second expansion device, and the blowing device is operated.

[0019] According to this, by reducing the flow rate of the refrigerant flowing through the second expansion device, the temperature of the refrigerant discharged from the compression mechanism can be increased.

[0020] By increasing the flow rate of the refrigerant flowing through the first expansion device, density of the refrigerant sucked into the compression mechanism can be increased. Therefore, it is possible to secure the flow rate of the refrigerant flowing through the usage-side heat exchanger.

[0021] That is, during execution of the heating operation mode, the control device can secure the flow rate of the refrigerant flowing through the usage-side heat exchanger while rising the temperature of the refrigerant discharged from the compression rotation element by setting the opening degree of the first expansion device and the opening degree of the second expansion device to such a value that the flow rate of the refrigerant flowing through the first expansion device becomes greater than the flow rate of the refrigerant flowing through the second expansion device at least during a predetermined period, and it is possible to suppress the deterioration of the heating ability in the usage-side heat exchanger in the heating operation mode which is executed after the defrosting operation mode is completed.

[0022] Further, by operating the blowing device which supplies air to the heat source-side heat exchanger, it is possible to enhance the heat absorbing effect in the heat source-side heat exchanger, and to enhance the heating ability in the usage-side heat exchanger.

[0023] Therefore, the heating ability can be enhanced even in the heating operation mode after the defrosting operation mode under a high humidity outside air temperature condition having a high frosting amount is executed, and it is possible to provide a refrigeration cycle device capable of to suppress the deterioration of the heating ability of the heating operation.

[0024] According to a second aspect of the invention, especially in the first aspect, the refrigeration cycle device further includes a high pressure side detecting section for detecting temperature of refrigerant on a high pressure side of the main refrigerant circuit or pressure of refrigerant on the high pressure side of the main refrigerant circuit, wherein the predetermined period is such a period that a detected value of the high pressure side detecting section is equal to or smaller than a predetermined value.

[0025] According to this, it can be determined that heating ability in the usage-side heat exchanger cannot sufficiently be secured until temperature or pressure of refrigerant which is discharged from the compression mechanism and which flows into the usage-side heat exchanger to a preset predetermined value. In this case, the opening degree of the first expansion device and the opening degree of the second expansion device are set to such a value that the flow rate of the refrigerant flowing through the first expansion device becomes greater than the flow rate of the refrigerant flowing through the second expansion device.

[0026] According to a third aspect of the invention, especially in the first aspect, the predetermined period is time elapsed after the heating operation mode is started.

[0027] According to this, the predetermined period is set as time which is started when the heating operation mode is started and which is elapsed when the opening degree of the first expansion device and the opening degree of the second expansion device are set to such a value that the flow rate of the refrigerant flowing through the first expansion device becomes greater than the flow rate of the refrigerant flowing through the second expansion device. With this, it is possible to suppress the deterioration of the heating ability in the usage-side heat exchanger even when the heating operation in the usage-side heat exchanger is executed after the defrosting operation of the heat source-side heat exchanger is completed.

[0028] According to a fourth aspect of the invention, especially in any one of the first to third aspects, in the defrosting operation mode, refrigerant discharge from the compression rotation element flows through the usage-side heat exchanger, the first expansion device and the heat source-side heat exchanger in this order.

[0029] According to this, even during execution of the defrosting operation mode, high temperature discharged refrigerant flows into the usage-side heat exchanger. Therefore, temperature drop of the usage-side heat exchanger is suppressed, and temperature rise of the usage-side heat exchanger can be facilitated in the heating operation mode which is executed after the defrosting operation mode is completed, and the heating ability can be enhanced quickly even in the heating operation mode after the defrosting operation mode under the high humidity outside air temperature condition having a high frosting amount is executed.

[0030] According to a fifth aspect of the invention, especially in any one of the first to fourth aspects, carbon dioxide is used as the refrigerant.

[0031] According to this, as compared with a case where fluorocarbon-based refrigerant is used, an enthalpy difference of refrigerant in the heat source-side heat exchanger is largely increased, and it is possible to increase the temperature of usage-side heat medium in the usage-side heat exchanger.

[0032] A sixth aspect of the invention provides a liquid heating device including the refrigeration cycle device according to any one of the first to fifth aspects, and a usage-side heat medium circuit through which the usage-side heat medium is circulated by a conveying device.

[0033] According to this, it is possible to provide a liquid heating device capable of increasing the embodiment of the usage-side heat medium when the usage-side heat medium is heated by refrigerant.

[0034] An embodiment of the present invention will be described below with reference to the drawings. The invention is not limited to the embodiment.

(Embodiment)

[0035] Fig. 1 is a block diagram of a liquid heating device in an embodiment of the present invention. The liquid heating device is composed of a refrigeration cycle device 1, a usage-side heat medium circuit 5 and a control device 4 which controls an operation of the liquid heating device.

[0036] The refrigeration cycle device 1 is composed of a main refrigerant circuit 2 and a bypass refrigerant circuit 3.

[0037] The main refrigerant circuit 2 is formed by connecting, to one another through pipes 16, a compression mechanism 21, a usage-side heat exchanger 22 which is a radiator, an intermediate heat exchanger 26 which is a cooling heat exchanger, a first expansion device 23 which is a main expansion valve, and a heat source-side heat exchanger 24 which is an evaporator. Carbon dioxide (CO_2) is used as refrigerant. A blowing device 29 supplies air to the heat source-side heat exchanger 24.

[0038] It is most suitable to use the carbon dioxide as the refrigerant, but it is also possible to use non-azeotropic refrigerant mixture such as R407, pseudoazeotropic refrigerant mixture such as R410A, and single refrigerant such as R32.

[0039] The compression mechanism 21 which compresses refrigerant is composed of a low stage-side compression rotation element 21a and a high stage-side compression rotation element 21b. The usage-side heat exchanger 22 heats the usage-side heat medium by refrigerant which is discharged from the high stage-side compression rotation element 21b.

[0040] Although this embodiment is described using the compression mechanism 21 which is composed of the low stage-side compression rotation element 21a and the high stage-side compression rotation element 21b, the present invention can also be applied to a single compression rotation element.

[0041] When the single compression rotation element is used, a position where refrigerant from the bypass refrigerant circuit 3 joins up is defined as a middle stage location of compression of a compression rotation element, a compression rotation element up to the position where the refrigerant from the bypass refrigerant circuit 3 joins up is defined as the low stage-side compression rotation element 21a, and a compression rotation element after the former position where the refrigerant from the bypass refrigerant circuit 3 joins up is defined as the high stage-side compression rotation element 21b.

[0042] The compression mechanism 21 may be composed of the low stage-side compression rotation element 21a and the high stage-side compression rotation element 21b each of which is composed of two compressors.

[0043] The bypass refrigerant circuit 3 branches off from the pipe 16 between the usage-side heat exchanger 22 and the first expansion device 23, and is connected to the pipe 16 between the low stage-side compression rotation element 21a and the high stage-side compression rotation element 21b.

[0044] The bypass refrigerant circuit 3 is provided with a second expansion device 31 which is a bypass expansion valve. A portion of high pressure refrigerant after it passes through the usage-side heat exchanger 22 or a portion of high pressure refrigerant after it passes through the intermediate heat exchanger 26 is decompressed by the second expansion device 31 and becomes intermediate pressure refrigerant. Thereafter, the intermediate pressure refrigerant exchanges heat with high pressure refrigerant which flows through the main refrigerant circuit 2 in the intermediate heat exchanger 26, and joins up with refrigerant between the low stage-side compression rotation element 21a and the high stage-side compression rotation element 21b.

[0045] In the usage-side heat medium circuit 5, a heat medium returning pipe 53 and a heat medium going pipe 54 are connected to the usage-side heat exchanger 22. The heat medium returning pipe 53 is provided with a conveying device 55 which is a conveying pump.

[0046] By operating the conveying device 55, usage-side heat medium is supplied to the usage-side heat exchanger 22 through the heat medium returning pipe 53, usage-side heat medium heated by the usage-side heat exchanger 22 is supplied from the heat medium going pipe 54 to a hot water tank (not shown) or a heater (not shown) of a floor heating for example.

[0047] According to this, a room is heated or hot water is supplied. Thereafter, the usage-side heat medium again returns to the usage-side heat exchanger 22 through the heat medium returning pipe 53. Water or antifreeze liquid is used as the usage-side heat medium.

[0048] The pipe 16 on the high pressure side of the main refrigerant circuit 2 which connects a discharge side of the compression mechanism 21 and the first expansion device 23 to each other is provided with a high pressure side pressure sensor 52. The high pressure side pressure sensor 52 detects evaporating pressure on the high pressure side as a high pressure side detecting section.

[0049] A discharge temperature thermistor (not shown) may be used as the high pressure side detecting section. The discharge temperature thermistor is provided in the pipe 16 on the high pressure side of the main refrigerant circuit 2 which connects a discharge side of the compression mechanism 21 of the main refrigerant circuit 2 and the usage-side heat exchanger 22 to each other, and detects temperature of refrigerant which is discharged from the compression mechanism 21.

[0050] The pipe 16 on the low pressure side of the main refrigerant circuit 2 which connects a downstream side of the first expansion device 23 and a suction side of the compression mechanism 21 is provided with a low pressure side pressure sensor 51. The low pressure side pressure sensor 51 detects low pressure side evaporating pressure as the low pressure side detecting section.

[0051] An evaporating temperature thermistor (not shown) may be used as the low pressure side detecting section. The evaporating temperature thermistor is provided in the pipe 16 on the low pressure side of the main refrigerant circuit 2 which connects the downstream side of the first expansion device 23 and the suction side of the compression mechanism 21 to each other, and detects evaporating temperature of refrigerant which is in a low pressure side gas-liquid two-layer state.

[0052] A temperature thermistor 28 is provided around the heat source-side heat exchanger 24. By operating the blowing device 29, the temperature thermistor 28 detects temperature of air which supplies heat to the heat source-side heat exchanger 24.

[0053] The refrigeration cycle device 1 of the embodiment includes a heating operation mode which is a normal operation mode. The heating operation mode operates the conveying device 55, allows the usage-side heat medium to circulate in the usage-side heat medium circuit 5, and heats the usage-side heat medium in the usage-side heat exchanger 22 by refrigerant discharged from the high stage-side compression rotation element 21b of the compression mechanism 21.

[0054] Further, the refrigeration cycle device 1 also includes a defrosting operation mode for defrosting the heat source-side heat exchanger 24 by refrigerant discharged from the high stage-side compression rotation element 21b of the compression mechanism 21.

[0055] In the defrosting operation mode, when pressure detected by the low pressure side pressure sensor 51 becomes equal to or lower than a first predetermined value or temperature detected by the evaporating temperature thermistor becomes equal to or lower than a second predetermined value, or when execution time of the heating operation mode is continued for predetermined time or longer in a state where temperature of air which supplies heat to the heat source-side heat exchanger 24 detected by the temperature thermistor 28 is equal to or lower than a third predetermined value, it is determined that the heat source-side heat exchanger 24 is frosted.

[0056] The frost which is adhered to the heat source-side heat exchanger 24 is melted and removed by heat of refrigerant discharged from the high stage-side compression rotation element 21b of the compression mechanism 21.

[0057] In Fig. 1, solid arrows show flowing directions of refrigerant when the normal heating operation mode is executed. Variation of a state of refrigerant when the normal heating operation mode is executed will be described below.

[0058] High pressure refrigerant discharged from the compression mechanism 21 flows into the usage-side heat exchanger 22, and releases heat to the usage-side heat medium which passes through the usage-side heat exchanger 22. High pressure refrigerant which flows out from the usage-side heat exchanger 22 is distributed to the intermediate heat exchanger 26 and the second expansion device 31. High pressure refrigerant which flows into the intermediate heat exchanger 26 is cooled by the intermediate pressure refrigerant which is decompressed by the second expansion device 31.

[0059] The high pressure refrigerant distributed to the first expansion device 23 is decompressed and expanded by the first expansion device 23 and thereafter, the refrigerant flows into the heat source-side heat exchanger 24. The low pressure refrigerant which flows into the heat source-side heat exchanger 24 exchanges heat with air supplied into the heat source-side heat exchanger 24 by the blowing device 29 and absorbs heat.

[0060] The high pressure refrigerant distributed to the second expansion device 31 is decompressed and expanded by the second expansion device 31 and thereafter, the refrigerant flows into the intermediate heat exchanger 26. The intermediate pressure refrigerant which flows into the intermediate heat exchanger 26 is heated by high pressure refrigerant which flows out from the usage-side heat exchanger 22.

[0061] Thereafter, the intermediate pressure refrigerant which flows out from the intermediate heat exchanger 26 joins up with intermediate pressure refrigerant which is discharged from the low stage-side compression rotation element 21a of the compression mechanism 21, and is sucked into the high stage-side compression rotation element 21b.

[0062] According to the refrigeration cycle device 1 of the embodiment, a portion of high pressure refrigerant bypasses through the intermediate heat exchanger 26 at the time of the heating operation, and a compressing force of the low stage-side compression rotation element 21a is reduced.

[0063] Density of refrigerant is increased by reduction in enthalpy of suction refrigerant of the high stage-side compression rotation element 21b of the compression mechanism 21, and this increase of density increases a flow rate of refrigerant flowing through the usage-side heat exchanger 22, and enhances heating ability or coefficient of performance.

[0064] However, if the heating operation mode is executed in this manner, moisture and the like in air is frozen and frost is generated in the heat source-side heat exchanger 24, and heating ability or the coefficient of performance is deteriorated by deterioration of heat conductivity of the heat source-side heat exchanger 24.

[0065] Therefore, when pressure detected by the low pressure side pressure sensor 51 becomes equal to or lower than the first predetermined value or temperature detected by the evaporating temperature thermistor becomes equal to or lower than the second predetermined value, or when execution time of the heating operation mode is continued for predetermined time or longer in the state where temperature of air which supplies heat to the heat source-side heat exchanger 24 detected by the temperature thermistor 28 is equal to or lower than the third predetermined value, it is determined that the heat source-side heat exchanger 24 is frosted.

[0066] Hence, it is necessary to execute the defrosting operation mode for melting and removing frost adhering to the heat source-side heat exchanger 24 by means of heat of refrigerant discharged from the high stage-side compression rotation element 21b of the compression mechanism 21.

[0067] As a typical defrosting operation mode, there is a reverse cycle defrosting type defrosting operation mode. In the reverse cycle defrosting type defrosting operation mode, flow paths with which a four-way valve is in communication are switched when the heating operation mode is executed, thereby reversing a circulation direction of refrigerant. That is, high temperature and high pressure refrigerant discharged from the compression mechanism 21 is made to flow into the heat source-side heat exchanger 24, and frost of the heat source-side heat exchanger 24 is melted by condensation heat of the high temperature and high pressure refrigerant.

[0068] There also exists a hot gas defrosting type defrosting operation mode in which a four-way valve is not switched and the same flow path as that when the heating operation mode is executed is used, and high temperature and high pressure refrigerant discharged from the compression mechanism 21 is made to flow into the usage-side heat exchanger 22. In the hot gas defrosting type defrosting operation mode, a valve opening degree of the first expansion device 23 is made large, high temperature and high pressure gas refrigerant discharged from the compression mechanism 21 is made to pass through the first expansion device 23 without decompressing the gas refrigerant and thereafter, the gas refrigerant is made to flow into the heat source-side heat exchanger 24 to melt frost of the heat source-side heat exchanger 24.

[0069] In this embodiment, the defrosting operation mode is executed using the hot gas defrosting type defrosting operation mode. Variation of a state of refrigerant in this case will be described below using Fig. 1.

[0070] Broken arrows in Fig. 1 show flowing directions of refrigerant when the defrosting operation mode is executed using the hot gas defrosting type defrosting operation mode.

[0071] High pressure refrigerant discharged from the compression mechanism 21 flows into the usage-side heat exchanger 22, the refrigerant which flows out from the usage-side heat exchanger 22 passes through the first expansion device 23 and then, the refrigerant flows into the heat source-side heat exchanger 24, releases heat to deposited frost and melts the frost. Thereafter, the refrigerant flows out from the heat source-side heat exchanger 24 and again returns to the compression mechanism 21.

[0072] In this case, also during execution of the defrosting operation mode, since high temperature discharged refrigerant flows into the usage-side heat exchanger 22, temperature drop of the usage-side heat exchanger 22 is suppressed, and enhancement of the heating ability in the heating operation mode which is started after the defrosting operation mode is executed becomes faster as compared with the reverse cycle defrosting operation.

[0073] To enhance the defrosting efficiency, circulation of the usage-side heat medium which flows through the usage-side heat exchanger 22 is stopped. That is, the operation of the conveying device 55 is stopped or the number of operational rotations of the conveying device 55 is reduced, and a flow rate of the usage-side heat medium flowing through the usage-side heat exchanger 22 is reduced.

[0074] To enhance the defrosting efficiency, in order to reduce heat quantity which is released to the usage-side heat medium, or in order to suppress the temperature drop of refrigerant which flows into the heat source-side heat exchanger 24, a valve opening degree of the first expansion device 23 is increased and a decompression amount is reduced.

[0075] The defrosting operation mode is absolutely necessary to stably continue the heating operation mode as described above.

[0076] During execution of the defrosting operation mode on the other hand, since the operation of the blowing device 29 is stopped or the number of operational rotations thereof is reduced, heat is not absorbed in the heat source-side heat exchanger 24.

[0077] According to this, since heat accumulated in the compression mechanism 21 whose temperature is increased in the heating operation mode is utilized by refrigerant discharged from the compression mechanism 21 for melting frost which adheres to the heat source-side heat exchanger 24, temperature of the compression mechanism 21 and refrigerant drops.

[0078] As a result, when the heating operation mode is started after the defrosting operation mode is completed, temperature of refrigerant which is discharged from the compression mechanism 21 and which flows into the usage-side heat exchanger 22 is not sufficiently high with respect to temperature of the usage-side heat medium. Therefore, the heating ability is deteriorated.

[0079] There are problems that by the temperature drop of the usage-side heat medium which is caused when the heating ability is deteriorated, room-heating ability and coefficient of performance by the usage-side heat medium are deteriorated for example.

[0080] To solve these problems, it is necessary to increase the temperature of refrigerant which is compressed by the compression mechanism 21 when the heating operation mode is started after the defrosting operation mode is completed.

[0081] Hence, in this embodiment, when the heating operation mode for allowing the conveying device 55 to start the normal operation is started after the defrosting operation mode is completed, the control device 4 adjusts valve opening degrees of the first expansion device 23 and the second expansion device 31 such that a flow rate of refrigerant flowing through the first expansion device 23 becomes greater than a flow rate of refrigerant flowing through second expansion device 31.

[0082] According to this, enthalpy of refrigerant sucked into the high stage-side compression rotation element 21b of the compression mechanism 21 increases from a point b to a point b', and enthalpy of refrigerant discharged from the high stage-side compression rotation element 21b also increases from a point c to a point c' as shown in Fig. 2. According to this, discharge temperature rises, and a temperature difference with respect to the usage-side heat medium increases.

[0083] By increasing a flow rate of refrigerant flowing on the side of the first expansion device 23, density of refrigerant sucked into the low stage-side compression rotation element 21a increases. Therefore, it is possible to sufficiently secure a flow rate of refrigerant which is discharged from the compression mechanism 21 and which flows into the usage-side heat exchanger 22.

[0084] When the heating operation mode is started after the defrosting operation mode is completed, endothermic quantity in the heat source-side heat exchanger 24 increases by operating the blowing device 29, suction pressure of the compression mechanism 21 rises from the point a to the point a', and suction temperature also rises.

[0085] According to this, it is possible to swiftly rise temperature of refrigerant discharged from the compression mechanism 21 even in a state where refrigerant flows through the second expansion device 31.

[0086] As described above, the control device 4 appropriately adjusts a flow rate ratio of a flow rate of refrigerant flowing through the first expansion device 23 and a flow rate of refrigerant flowing through the second expansion device 31.

[0087] That is, by appropriately adjusting the valve opening degree of the first expansion device 23 and the valve opening degree of the second expansion device 31, refrigerant discharged from the low stage-side compression rotation element 21a of the compression mechanism 21 is sucked into the high stage-side compression rotation element 21b without being excessively cooled by refrigerant flowing into the bypass refrigerant circuit 3, and temperature of refrigerant discharged from the compression mechanism 21 rises.

[0088] Further, by operating the blowing device 29, endothermic quantity in the heat source-side heat exchanger 24 increases, and discharge temperature rise of refrigerant from the compression mechanism 21 is facilitated.

[0089] According to this, since the heating ability rises, it is possible to immediately rise the heating ability in the heating operation mode which is executed after the defrosting operation mode is completed in a state where deterioration of coefficient of performance is suppressed.

[0090] Operation of the valve opening degrees of the first expansion device 23 and the second expansion device 31 in the heating operation mode which is executed after the defrosting operation mode is completed will be described based on a flow chart shown in Fig. 3.

[0091] First, the control device 4 executes the defrosting operation mode to melt frost adhering to the heat source-side heat exchanger 24 and thereafter, the execution of the defrosting operation mode is completed (step S1).

[0092] At that time, an operating state of the blowing device 29 is detected (step S2). When the blowing device 29 is stopped, operation of the blowing device 29 is started, and when the blowing device 29 is operated, the operation of the blowing device 29 is continued (step S3).

[0093] Then, the valve opening degree of the first expansion device 23 and the valve opening degree of the second expansion device 31 are set in a state where the compression mechanism 21 is operated such that these valve opening degrees respectively become Om and Ob which are previously set in the control device 4 (step S4).

[0094] The valve opening degree Om of the first expansion device 23 and the valve opening degree Ob of the second expansion device 31 are such opening degrees that a flow rate Gm of refrigerant flowing through the first expansion device 23 becomes greater than a flow rate Gb of refrigerant flowing through the second expansion device 31 (step S4).

[0095] When the defrosting operation mode is executed, the valve opening degree of the first expansion device 23 is set substantially maximum and the valve opening degree of the second expansion device 31 is set substantially minimum, and high temperature and high pressure gas refrigerant discharged from the compression mechanism 21 is made to flow into the heat source-side heat exchanger 24.

[0096] Therefore, when the heating operation mode for allowing the conveying device 55 to start the normal operation in step S4 is started, the control device 4 operates the valve opening degree of the first expansion device 23 into a closing direction and operates the valve opening degree of the second expansion device 31 into an opening direction or does not operate the second expansion device 31 and maintains its substantially minimum opening degree.

[0097] That is, when the heating operation mode for allowing the conveying device 55 to start the normal operation is started, the control device 4 sets the valve opening degrees of the first expansion device 23 and the second expansion device 31 such that the flow rate of refrigerant flowing through the first expansion device 23 becomes greater than the flow rate of refrigerant flowing through the second expansion device 31.

[0098] Alternatively, it is also possible to normally operate the conveying device 55 and start the heating operation mode after the valve opening degrees of the first expansion device 23 and the second expansion device 31 respectively become Om and Ob which are previously set in the control device 4.

[0099] That is, the control device 4 may normally operate the conveying device 55 and start the heating operation mode after the valve opening degrees of the first expansion device 23 and the second expansion device 31 are set such that the flow rate of refrigerant flowing through the first expansion device 23 becomes greater than the flow rate of refrigerant flowing through the second expansion device 31.

[0100] Next, the control device 4 detects high pressure side pressure Pd of the main refrigerant circuit 2 by the high pressure side pressure sensor 52 which is the high pressure side detecting section (step S5).

[0101] Then, the high pressure side pressure sensor 52 detects the high pressure side pressure Pd of the main refrigerant circuit 2, i.e., detects discharge pressure of the compression mechanism 21 (discharge pressure of high stage-side compression rotation element 21b), and it is determined whether the detected value is equal to or smaller than a preset fourth predetermined value (predetermined pressure Pdt) (step S6) .

[0102] When YES in step S6, i.e., when the discharge pressure Pd is equal to or smaller than Pdt which is a second predetermined value, the valve opening degree of the first expansion device 23 and the valve opening degree of the second expansion device 31 are maintained as Om and Ob which are previously set in the control device 4.

[0103] That is, a state where the flow rate Gm of refrigerant flowing through the first expansion device 23 becomes greater than the flow rate Gb of refrigerant flowing through the second expansion device 31 is continued.

[0104] When NO in step S6 on the other hand, i.e., when the discharge pressure Pd is higher than Pdt which is the second predetermined value, the control for making the valve opening degrees of the first expansion device 23 and the second expansion device 31 equal to Om and Ob which are previously set in the control device 4 is dissolved.

[0105] That is, control is shifted to operation control of the valve opening degree of the first expansion device 23 and the valve opening degree of the second expansion device 31 in the normal heating operation mode, and the heating operation mode is continued.

[0106] As the high pressure side detecting section, a discharge temperature thermistor (not shown) which detects temperature of refrigerant discharged from the compression mechanism 21 may be used instead of the high pressure side pressure sensor 52. The discharge temperature thermistor is provided in the pipe 16 on the high pressure side of the main refrigerant circuit 2 which connects the discharge side of the compression mechanism 21 of the main refrigerant circuit 2 and the usage-side heat exchanger 22 to each other.

[0107] In this case, like the flow chart shown in Fig. 3 using the high pressure side pressure sensor 52, during a period when a detected value of the discharge temperature thermistor is equal to or lower than a fifth predetermined value, the valve opening degrees of the first expansion device 23 and the second expansion device 31 are set such that the flow rate of refrigerant flowing through the first expansion device 23 becomes greater than the flow rate of refrigerant flowing through the second expansion device 31.

[0108] Within predetermined time after the heating operation mode is started, the valve opening degrees of the first expansion device 23 and the second expansion device 31 may be set such that the flow rate of refrigerant flowing through the first expansion device 23 becomes greater than the flow rate of refrigerant flowing through the second expansion device 31.

[0109] In this case, after predetermined time is elapsed from the start of the heating operation mode, control is shifted to the operation control of the valve opening degrees of the first expansion device 23 and the second expansion device 31 in the normal heating operation mode, and the heating operation mode is continued.

[0110] In this embodiment, the valve opening degree Om of the first expansion device 23 and the valve opening degree Ob of the second expansion device 31 are previously set in the control device 4, but the flow rates may be actually detected and control may be performed such that the flow rate Gm of the main refrigerant becomes greater than the flow rate Gb of the bypass refrigerant.

[0111] As a flow rate detecting device (not shown) in this case, flowmeters may be provided in a refrigerant circuit and a bypass path on the side of the first expansion device 23, or flow rates of refrigerants may be calculated from functions of a pressure difference and opening degrees of outlet and inlet ports of the expansion valves.

[0112] It is not absolutely necessary that the bypass refrigerant circuit 3 is branched off from the main refrigerant circuit 2 between the usage-side heat exchanger 22 and the intermediate heat exchanger 26, and the bypass refrigerant circuit 3 may be branched off from the main refrigerant circuit 2 between the intermediate heat exchanger 26 and the first expansion device 23.

[0113] It is not absolutely necessary that the first expansion device 23 and the second expansion device 31 in this embodiment are expansion valves, and these devices 23 and 31 may be expanders which collect power from expanding refrigerant. In this case, a load may be changed by a dynamo-electric generator which is connected to the expander, and the number of rotations of the expander may be controlled.

[INDUSTRIAL APPLICABILITY]

[0114] As described above, the refrigeration cycle device of the present invention is composed of the main refrigerant circuit having the intermediate heat exchanger and the bypass refrigerant circuit, and the refrigeration cycle device can suppress the deterioration in the heating ability even when heating operation is executed after the defrosting operation of the heat source-side heat exchanger is completed. Therefore, the invention useful for a freezing device, an air conditioner, a hot water supplying device and a heating device using the refrigeration cycle device.

[EXPLANATION OF SYMBOLS]

[0115]

1	refrigeration cycle device
2	main refrigerant circuit
3	bypass refrigerant circuit
4	control device
5	usage-side heat medium circuit
16	pipe
21	compression mechanism
21a	low stage-side compression rotation element
21b	high stage-side compression rotation element
22	usage-side heat exchanger
23	first expansion device
24	heat source-side heat exchanger
26	intermediate heat exchanger
28	temperature thermistor
29	blowing device
31	second expansion device
51	low pressure side pressure sensor (low pressure side detecting section)
52	high pressure side pressure sensor (high pressure side detecting section)
53	heat medium returning pipe
54	heat medium going pipe
55	conveying device

Claims

1. A refrigeration cycle device (1) comprising:

   a main refrigerant circuit (2) formed by sequentially connecting, to one another through a pipe (16), a compression mechanism (21) composed of compression rotation elements (21a, 21b), a usage-side heat exchanger (22) for heating usage-side heat medium by refrigerant discharged from the compression rotation element (21b), an intermediate heat exchanger (26), a first expansion device (23) and a heat source-side heat exchanger (24);
   a bypass refrigerant circuit (3) which exchanges heat with refrigerant flowing through the main refrigerant circuit (2) by the intermediate heat exchanger (26) after refrigerant branching off from the pipe (16) between the usage-side heat exchanger (22) and the first expansion device (23) is decompressed by the second expansion device (31), the bypass refrigerant circuit (3) joining up with refrigerant which is being compressed of the compression rotation element (21b);
   a blowing device (29) for supplying air to the heat source-side heat exchanger (24); and
   a control device (4),
   the refrigeration cycle device (1) further includes a heating operation mode for heating the usage-side heat medium in the usage-side heat exchanger (22) by refrigerant discharged from the compression rotation element (21b), and
   a defrosting operation mode for removing frost of the heat source-side heat exchanger (24) by refrigerant discharged from the compression rotation element (21b), wherein
   in the heating operation mode which is executed after the defrosting operation mode is completed,
   at least for a predetermined period during execution of the heating operation mode, the control device (4) sets opening degrees of the first expansion device (23) and the second expansion device (31) to such values that a flow rate of refrigerant flowing through the first expansion device (23) becomes greater than a flow rate of refrigerant flowing through the second expansion device (31), and the blowing device (29) is operated.

2. The refrigeration cycle device (1) according to claim 1, further comprising a high pressure side detecting section (52) for detecting temperature of refrigerant on a high pressure side of the main refrigerant circuit (2) or pressure of refrigerant on the high pressure side of the main refrigerant circuit (2), wherein the predetermined period is such a period that a detected value of the high pressure side detecting section (52) is equal to or smaller than a predetermined value.

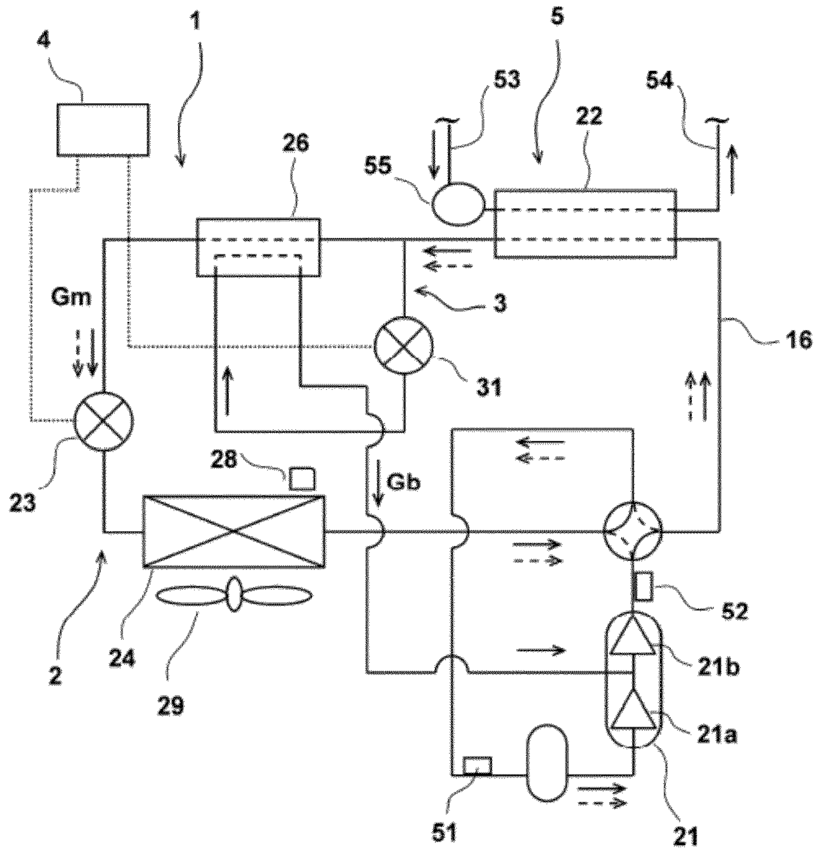
3. The refrigeration cycle device (1) according to claim 1, wherein the predetermined period is time elapsed after the heating operation mode is started.

4. The refrigeration cycle device (1) according to any one of claims 1 to 3, wherein in the defrosting operation mode, refrigerant discharge from the compression rotation element (21b) flows through the usage-side heat exchanger (22), the first expansion device (23) and the heat source-side heat exchanger (24) in this order.

5. The refrigeration cycle device (1) according to any one of claims 1 to 4, wherein carbon dioxide is used as the refrigerant.

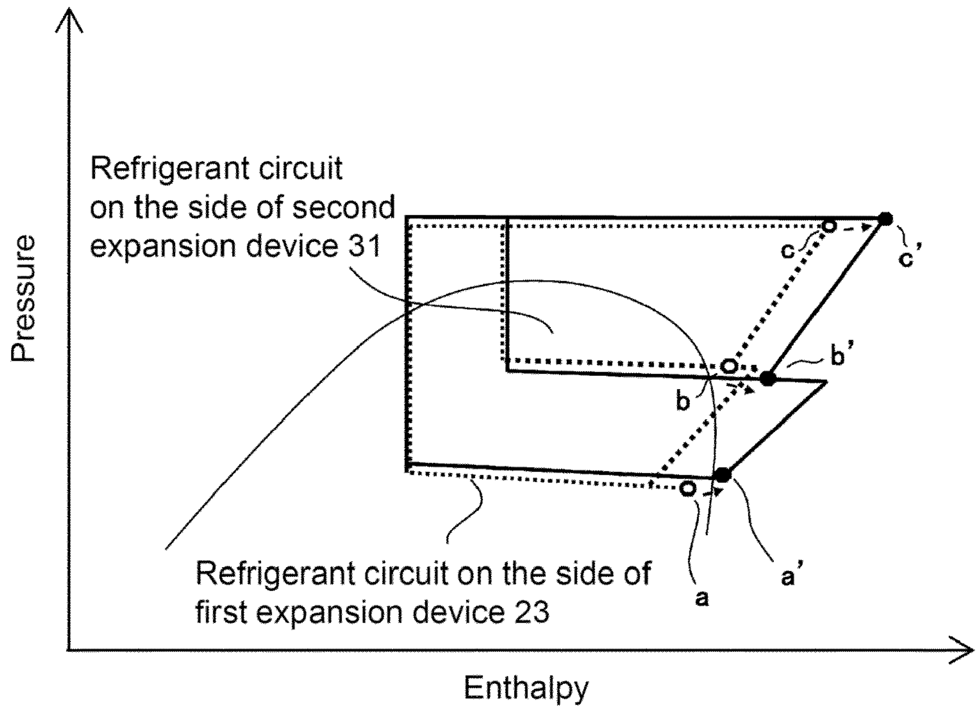
6. A liquid heating device including the refrigeration cycle device (1) according to any one of claims 1 to 5, and a usage-side heat medium circuit (5) through which the usage-side heat medium is circulated by a conveying device (55) .

[Fig. 1]



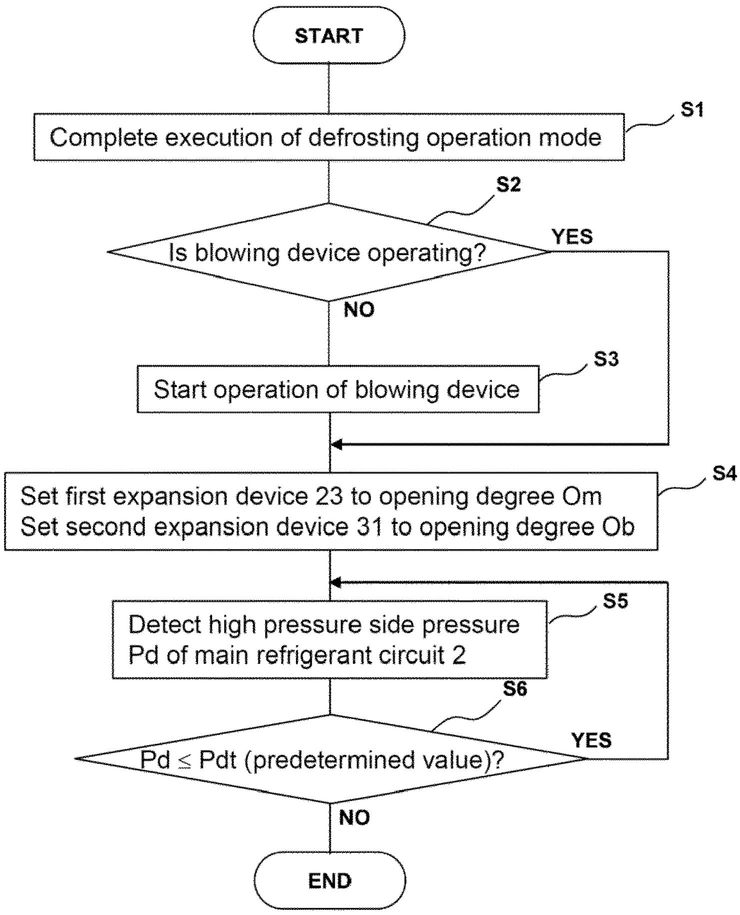
1 Refrigeration cycle device
2 Main refrigerant circuit
3 Bypass refrigerant circuit
4 Control device
5 Usage-side heat medium circuit
16 Pipe
21 Compression mechanism
21a Low stage-side compression rotation element
21b High stage-side compression rotation element
22 Usage-side heat exchanger
23 First expansion device
24 Heat source-side heat exchanger
26 Intermediate heat exchanger
28 Temperature thermistor
29 Blowing device
31 Second expansion device
51 Low pressure side detecting section
52 High pressure side detecting section
53 Heat medium returning pipe
54 Heat medium going pipe
55 Conveying device

[Fig. 2]

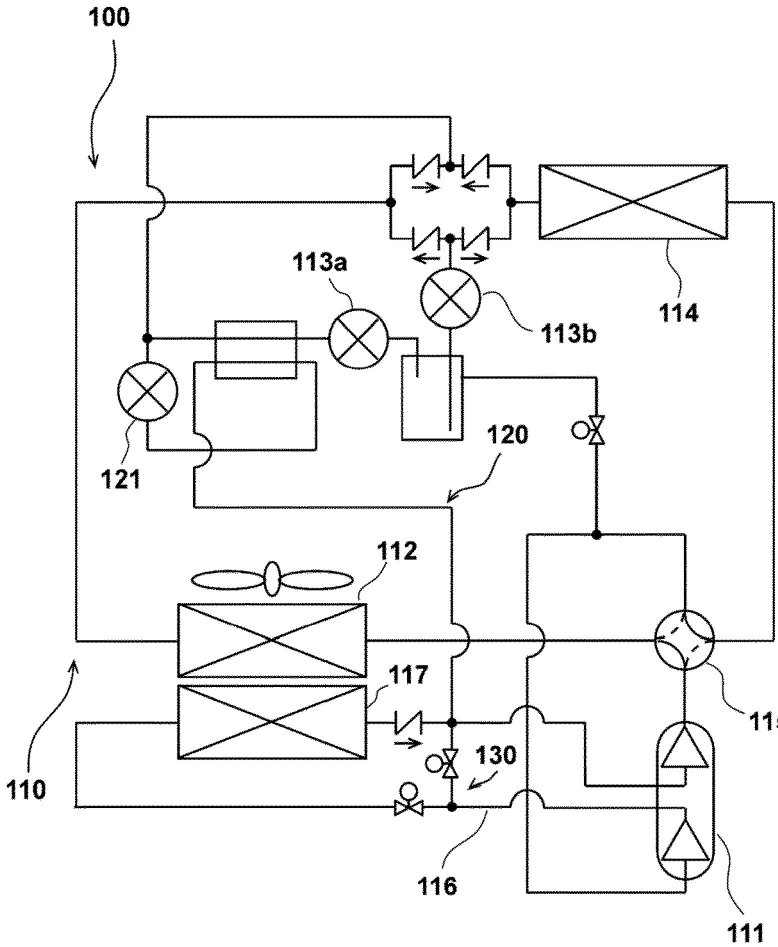


Pressure
Refrigerant circuit
on the side of second
expansion device 31
c
c'
b'
b
Refrigerant circuit on the side of
first expansion device 23
a
a'
Enthalpy

[Fig. 3]


START
Complete execution of defrosting operation mode
S1
S2
Is blowing device operating?
YES
NO
Start operation of blowing device
S3
Set first expansion device 23 to opening degree Om
Set second expansion device 31 to opening degree Ob
S4
Detect high pressure side pressure
Pd of main refrigerant circuit 2
S5
S6
Pd ≤ Pdt (predetermined value)?
YES
NO
END

[Fig. 4]



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EUROPEAN SEARCH REPORT

Application Number
EP 20 15 6001

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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	14 July 2020	Amous, Moez

CATEGORY OF CITED DOCUMENTS

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