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## (54) REFRIGERATION DEVICE

KÜHLVORRICHTUNG

DISPOSITIF DE RÉFRIGÉRATION

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(56) References cited:
**WO-A1-2004/076945**
**WO-A1-2008/150289**
**JP-A- H0 439 574**
**JP-A- H0 682 107**
**JP-A- H0 814 673**
**JP-A- 2004 301 461**
**JP-A- 2006 038 290**
**JP-A- 2006 275 440**





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## Description

Technical Field

**[0001]** The present invention relates to a refrigeration apparatus and, more particularly, to a binary refrigeration apparatus including a first refrigerant circuit having an evaporator, a second refrigerant circuit having a condenser, and a cascade condenser formed by the evaporator and the condenser.

Background Art

**[0002]** WO 2008/150289 A1 discloses a refrigerant system according to the preamble of claim 1, which incorporates at least two circuits arranged in a cascaded relationship. Preferably, the upper circuit utilizes a hydrocarbon refrigerant and preferably the lower circuit utilizes CO2 refrigerant. Preferably, the CO2 cascaded circuit mainly operates in a subcritical region. To improve the efficiency and capacity control of the cascaded refrigerant system, at least one of the circuits is equipped with performance enhancement features such as, for example, an economized function provided by a flash tank or economizer heat exchanger. Additional enhancement features can also include a liquid-suction heat exchanger and bypass function.

**[0003]** As a typical refrigeration apparatus, a binary refrigeration apparatus has conventionally been proposed. This refrigeration apparatus includes a first refrigerant circuit having an evaporator, a second refrigerant circuit having a condenser, and a cascade condenser formed by the evaporator and the condenser. Another binary refrigeration apparatus of this type has also been proposed in which the second refrigerant circuit is configured so that "an expansion tank 65 is connected to a pipe 20S of the compressor 20 on the suction side via a capillary tube 66, the capillary tube 66 is connected in parallel with a check valve 67, and the direction of the expansion tank 65 is defined as the forward direction of the check valve" (see Patent Literature 1).

**[0004]** Such a refrigeration apparatus generally quickly collects the refrigerant in the second refrigerant circuit through a check valve during the stop of a compressor of the second refrigerant circuit in order to prevent an increase in pressure of the refrigerant in the second refrigerant circuit. In addition, in the refrigeration apparatus, the refrigerant gradually returns from the expansion tank to the second refrigerant circuit through a pressure reducing unit after the start of the compressor of the second refrigerant circuit in order to reduce the start load of the compressor of the second refrigerant circuit.

Citation List

Patent Literature

**[0005]** Patent Literature 1: Japanese Unexamined Patent Application Publication 2007-303792 (Abstract, Fig. 6)

Summary of Invention

Technical Problem

**[0006]** In a typical binary refrigeration apparatus, assume that the ambient temperature of a second refrigerant circuit is higher than the saturation temperature of the refrigerant (the saturation temperature of the refrigerant flowing through a circuit portion of the second refrigerant circuit on the high-pressure side) on the high-pressure side of the second refrigerant circuit during the operation of the refrigeration apparatus. In this case, when a compressor of the second refrigerant circuit stops, the pressure in the second refrigerant circuit increases to a pressure corresponding to the ambient temperature. Then, the typical binary refrigeration apparatus recovers the refrigerant from the second refrigerant circuit to the expansion tank in order to prevent an increase in pressure of the refrigerant in the second refrigerant circuit, as described above.

**[0007]** In the second refrigerant circuit of the binary refrigeration apparatus during operation, the refrigerant density in a circuit portion on the high-pressure side (a circuit portion from the discharge port of the compressor to the pressure reducing unit) is higher than that in a circuit portion on the low-pressure side (a circuit portion from the pressure reducing unit to the suction port of the compressor). Thus, when the compressor of the second refrigerant circuit stops, the pressure in the circuit portion of the second refrigerant circuit on the high-pressure side is higher than that in the circuit portion of the second refrigerant circuit on the low-pressure side. However, in the typical binary refrigeration apparatus, the expansion tank is connected to a pipe on the suction side of the compressor of the second refrigerant circuit, that is, the circuit portion of the second refrigerant circuit on the low-pressure side. Accordingly, the typical binary refrigeration apparatus has a problem that an abnormal increase in pressure cannot be avoided in the circuit portion of the second refrigerant circuit on the high-pressure side when the compressor of the second refrigerant circuit stops.

**[0008]** In some cases, an on-off valve (an on-off valve that blocks traffic between the circuit portion of the second refrigerant circuit on the high-pressure side and the circuit portion of the second refrigerant circuit on the low-pressure side) for preventing the refrigerant from flowing into the evaporator at the stop of the compressor of the second refrigerant circuit is provided upstream of the evaporator of the second refrigerant circuit. Such an on-off valve further reduces the area of the passage through which the refrigerant flows from the circuit portion of the second refrigerant circuit on the high-pressure side into the circuit portion of the second refrigerant circuit on the low-pressure side. This often makes it impossible to avoid an abnormal increase in pressure of the refrigerant in the circuit portion of the second refrigerant circuit on the high-pressure side, so the above-described problem becomes more serious.

**[0009]** In addition, in the binary refrigeration apparatus, even when the compressor of the second refrigerant circuit stops, operating the first refrigerant circuit to cool the second refrigerant circuit makes it possible to avoid an abnormal increase in pressure of the refrigerant in the second refrigerant circuit. Thus, the function of the expansion tank is disabled except for the case where the first refrigerant circuit cannot operate because of, for example, power failures. Thus, since the typical binary refrigeration apparatus includes the expansion tank which may not be used, the cost of the binary refrigeration apparatus increases disadvantageously.

**[0010]** The present invention has been made to solve at least one of the above-described problems, and has as its object to provide a refrigeration apparatus that can prevent an abnormal increase in pressure of a refrigerant in a circuit portion of a second refrigerant circuit on the high-pressure side when a compressor of the second refrigerant circuit stops.

Solution to Problem

**[0011]** A refrigeration apparatus according to the present invention includes a first refrigerant circuit, a second refrigerant circuit, a cascade condenser, a receiver, a tank, a bypass, and a first on-off valve. The first refrigerant circuit includes a first compressor, a first condenser, a first pressure reducing unit, and a first evaporator that are sequentially connected to each other by pipes. The second refrigerant circuit includes a second compressor, a second condenser, a second pressure reducing unit, and a second evaporator that are sequentially connected to each other by pipes. The cascade condenser is formed by the first evaporator of the first refrigerant circuit and the second condenser of the second refrigerant circuit. The receiver is connected between the second condenser and the second pressure reducing unit of the second refrigerant circuit and stores an excess refrigerant. The tank is connected to the second compressor of the second refrigerant circuit and stores excess refrigerating machine oil in the second compressor so as to adjust an amount of refrigerating machine oil in the second compressor. The bypass connects the receiver and the tank to each other. The first on-off valve is disposed in the bypass, opens the bypass when a high-side pressure in the second refrigerant circuit increases to not less than a predetermined pressure, and closes the bypass when the high-side pressure in the second refrigerant circuit decreases to not more than the predetermined pressure.

Advantageous Effects of Invention

**[0012]** In the refrigeration apparatus of the present invention, when the second compressor of the second refrigerant circuit stops so that the high-side pressure in the second refrigerant circuit increases to the predetermined pressure or more, the refrigerant in the second refrigerant circuit flows from the receiver disposed in the circuit portion of the second refrigerant circuit on the high-pressure side through the bypass and the first on-off valve and is stored in the tank. Thus, in the refrigeration apparatus of the present invention, when the second compressor of the second refrigerant circuit stops, an abnormal increase in pressure can be avoided in the circuit portion of the second refrigerant circuit on the high-pressure side.

**[0013]** In addition, in the refrigeration apparatus of the present invention, the tank serving as an expansion tank of a typical refrigeration apparatus also serves as an oil tank of the second compressor during the operation of the second refrigerant circuit. Thus, the refrigeration apparatus can prevent failure of the second compressor caused by shortage of refrigerating machine oil.

Brief Description of Drawings

**[0014]**

[Fig. 1] Fig. 1 is a refrigerant circuit diagram illustrating an exemplary configuration of a refrigeration apparatus according to Embodiment 1 of the present invention.

[Fig. 2] Fig. 2 is a Mollier chart showing the operating state of the refrigeration apparatus of Embodiment 1 of the present invention.

[Fig. 3] Fig. 3 is a graph showing the relationship among the refrigerant density, the refrigerant temperature, and the refrigerant pressure of a second refrigerant of Embodiment 1 of the present invention.

[Fig. 4] Fig. 4 is a graph showing the relationship among the internal volume of each component of a second refrigerant circuit, the amount of refrigerant (the amount of second refrigerant) stored in the component, the refrigerant density in the second refrigerant circuit, and the refrigerant pressure, in the refrigeration apparatus of Embodiment 1 of the present invention.

[Fig. 5] Fig. 5 is a refrigerant circuit diagram showing a portion near the tank of the second refrigerant circuit of Embodiment 1 of the present invention.

[Fig. 6] Fig. 6 is a refrigerant circuit diagram illustrating an exemplary configuration of a refrigeration apparatus according to Embodiment 2 of the present invention.

[Fig. 7] Fig. 7 is a refrigerant circuit diagram illustrating an exemplary configuration of a refrigeration apparatus according to Embodiment 3 of the present invention.

Description of Embodiments

Embodiment 1

**[0015]** Fig. 1 illustrates an exemplary configuration of a refrigerant circuit in a refrigeration apparatus according to Embodiment 1 of the present invention.

**[0016]** As illustrated in Fig. 1, a refrigeration apparatus 100 of Embodiment 1 is implemented in a binary refrigeration apparatus and includes a first refrigerant circuit 50 and a second refrigerant circuit 60.

**[0017]** The first refrigerant circuit 50 serves as a refrigerant circuit in which a first refrigerant circulates, and includes a first compressor 1, a first condenser 2, a first expansion valve 3, and a first evaporator 4 that are sequentially connected to each other by pipes. The first compressor 1 draws by suction a low-pressure gas first refrigerant, and compresses the first refrigerant into a high-pressure gas refrigerant. The first condenser 2 exchanges heat between the first refrigerant compressed into a high-pressure gas refrigerant by the first compressor 1 and a heat exchange object such as air, and compresses the first refrigerant into a high-pressure liquid refrigerant. The first expansion valve 3 expands the first refrigerant condensed into a high-pressure liquid refrigerant in the first condenser 2 and reduces its pressure to obtain a low-pressure, two-phase gas-liquid refrigerant. The first evaporator 4 exchanges heat between the first refrigerant expanded and reduced in pressure into a low-pressure, two-phase gas-liquid refrigerant in the first expansion valve 3, and a second refrigerant flowing through the second condenser 7 of the second refrigerant circuit 60, and evaporates the first refrigerant into a low-pressure gas refrigerant. That is, in the refrigeration apparatus 100 of Embodiment 1, the first evaporator 4 of the first refrigerant circuit 50 and the second condenser 7 of the second refrigerant circuit 60 constitute a cascade condenser 15.

**[0018]** The first expansion valve 3 corresponds to a first pressure reducing unit of the present invention. The first pressure reducing unit may be implemented using, for example, a capillary tube. The "high pressure" and "low pressure" used for the first refrigerant circuit 50 in the above description, and the "high pressure" and "low pressure" to be used for the first refrigerant circuit 50 in the following description refer to relative pressures of the first refrigerant in the first refrigerant circuit 50, and do not refer to absolute pressures of the first refrigerant.

**[0019]** The second refrigerant circuit 60 serves as a refrigerant circuit in which a second refrigerant circulates, and includes a second compressor 5, a second condenser 7, a second expansion valve 10, and a second evaporator 11 that are sequentially connected to each other by pipes. The second compressor 5 draws by suction a low-pressure gas second refrigerant, and compresses the second refrigerant into a high-pressure gas refrigerant. The second condenser 7 exchanges heat between the second refrigerant compressed into a high-pressure gas refrigerant in the second compressor 5, and the first refrigerant flowing through the first evaporator 4 of the first refrigerant circuit 50, and condenses the second refrigerant into a high-pressure liquid refrigerant or a high-pressure, two-phase gas-liquid refrigerant. The second expansion valve 10 expands the second refrigerant condensed into a high-pressure liquid refrigerant or a high-pressure, two-phase gas-liquid refrigerant in the second condenser 7, and reduces its pressure to obtain a low-pressure, two-phase gas-liquid refrigerant. The second evaporator 11 exchanges heat between the second refrigerant expanded and reduced in pressure into a low-pressure, two-phase gas-liquid refrigerant in the second expansion valve 10, and a heat exchange object such as air, and evaporates the second refrigerant into a low-pressure gas refrigerant.

**[0020]** The second expansion valve 10 corresponds to a second pressure reducing unit of the present invention. The second pressure reducing unit may be implemented using, for example, a capillary tube. The "high pressure" and "low pressure" used for the second refrigerant circuit 60 in the above description, and the "high pressure" and "low pressure" to be used for the second refrigerant circuit 60 in the following description refer to relative pressures of a second refrigerant in the second refrigerant circuit 60, and do not refer to absolute pressures of the second refrigerant.

**[0021]** The second refrigerant circuit 60 of Embodiment 1 also includes an oil separator 6, a receiver 8, an on-off valve 9, an accumulator 12, a bypass 13, a bypass valve 13a, and a tank 14.

**[0022]** The oil separator 6 is disposed between the second compressor 5 and the second condenser 7, and separates refrigerating machine oil from the second refrigerant discharged from the second compressor 5. The oil separator 6 includes an oil return pipe 6a. The oil return pipe 6a is connected to the suction port of the second compressor 5, and the refrigerating machine oil separated by the oil separator 6 returns to the suction side of the second compressor 5. The receiver 8 is disposed between the second condenser 7 and the second expansion valve 10, and stores an excess second refrigerant. When the two-phase gas-liquid second refrigerant flows out of the second condenser 7, the receiver 8 separates the second refrigerant into gas and liquid second refrigerants, and supplies the liquid second refrigerant to the second expansion valve 10.

**[0023]** The on-off valve 9 is disposed between the receiver 8 and the second expansion valve 10, and opens and closes a circuit portion between the receiver 8 and the second expansion valve 10. That is, the on-off valve 9 prevents the second refrigerant from flowing into the second evaporator 11. More specifically, the on-off valve 9 blocks traffic between a circuit portion (a circuit portion from the discharge port of the second compressor 5 to the second expansion valve 10) of the second refrigerant circuit 60 on the high-pressure side, and a circuit portion (a circuit portion from the second expansion valve 10 to the suction port of the second compressor 5) of the second refrigerant circuit 60 on the low-pressure side.

**[0024]** The on-off valve 9 corresponds to a second on-off valve of the present invention.

**[0025]** The accumulator 12 is disposed between the second evaporator 11 and the second compressor 5. The accumulator 12 separates the second refrigerant that has flowed out of the second evaporator 11 into gas and liquid second refrigerants, and draws the gas second refrigerant by suction into the second compressor 5, thereby preventing liquid back in the second compressor 5. The accumulator 12 stores an excess second refrigerant. The second refrigerant circuit 60 of Embodiment 1 also includes the receiver 8 to store the excess second refrigerant. Thus, if there is no possibility of occurrence of liquid back in the second compressor 5, the accumulator 12 need not be provided.

**[0026]** The tank 14 has the same function as that of an expansion tank of a typical refrigeration apparatus (more specifically a binary refrigeration apparatus). The tank 14 is connected to the receiver 8 by the bypass 13. More specifically, in the refrigeration apparatus 100 of Embodiment 1, the circuit portion of the second refrigerant circuit 60 on the high-pressure side is connected to the tank 14 serving as an expansion tank. The bypass 13 includes the bypass valve 13a that opens and closes the bypass 13. The bypass valve 13a is kept closed (the bypass 13 is kept closed) during normal operation. When the second compressor 5 stops and the pressure of the refrigerant on the high-pressure side of the second refrigerant circuit 60 reaches a predetermined pressure or more, the bypass valve 13a is opened (the bypass 13 is opened). That is, in the refrigeration apparatus 100 of Embodiment 1, when the pressure of the refrigerant on the high-pressure side of the second refrigerant circuit 60 reaches the predetermined pressure or more, the second refrigerant in the second refrigerant circuit 60 is stored in the tank 14.

**[0027]** The bypass valve 13a corresponds to a first on-off valve of the present invention.

**[0028]** The predetermined pressure refers to a pressure higher than a high-side pressure (the pressure of the refrigerant in the circuit portion of the second refrigerant circuit 60 on the high-pressure side) expected in normal operation, and a pressure lower than an allowable pressure set to prevent a failure of the second refrigerant circuit 60. The high-side pressure of the refrigerant in the second refrigerant circuit 60 is detected by, for example, a pressure sensor (not shown) provided in the circuit portion of the second refrigerant circuit 60 on the high-pressure side.

**[0029]** The refrigeration apparatus 100 with the aforementioned configuration operates in the following manner.

**[0030]** Fig. 2 is a Mollier chart showing the operating state of a refrigeration apparatus according to Embodiment 1 of the present invention.

**[0031]** The operation of the first refrigerant circuit 50 will be described first. A low-pressure gas first refrigerant (point A) in the first refrigerant circuit 50 is drawn by suction into and compressed in the first compressor 1, transforms into a high-pressure gas refrigerant (point B) in the first refrigerant circuit 50, and is discharged from the first compressor 1. The first refrigerant (point B) discharged from the first compressor 1 flows into the first condenser 2, is cooled and condensed by heat exchange with an object such as air (by heating the heat exchange object such as air), and transforms into a high-pressure liquid first refrigerant (point C) in the first refrigerant circuit 50. The first refrigerant flows out of the first condenser 2 flows into the first expansion valve 3, and is expanded and reduced in pressure into a low-pressure, two-phase gas-liquid refrigerant (point D) in the first refrigerant circuit 50. The first refrigerant that has flowed out of the first expansion valve 3 flows into the first evaporator 4 (the cascade condenser 15), is heated and evaporated by the second refrigerant flowing through the second condenser 7 of the second refrigerant circuit 60 (by cooling the second refrigerant flowing through the second condenser 7 of the second refrigerant circuit 60), and transforms into a low-pressure gas first refrigerant (point A) in the first refrigerant circuit 50. Then, the first refrigerant is drawn by suction into the first compressor 1 again. The first refrigerant circuit 50 repeats the above-mentioned series of operations.

**[0032]** The operation of the second refrigerant circuit 60 will be described next. A low-pressure gas second refrigerant (point E) in the second refrigerant circuit 60 is drawn by suction into and compressed in the second compressor 5, transforms into a high-pressure gas refrigerant (point F) in the second refrigerant circuit 60, and is discharged from the second compressor 5. Refrigerating machine oil is separated by the oil separator 6 from the second refrigerant (point F) discharged from the second compressor 5, and the resulting second refrigerant flows into the second condenser 7 (the cascade condenser 15), is cooled and condensed by the first refrigerant flowing through the first evaporator 4 of the first refrigerant circuit 50 (by heating the first refrigerant flowing through the first evaporator 4 of the first refrigerant circuit 50) and transforms into a high-pressure liquid second refrigerant (point G) in the second refrigerant circuit 60. Upon flowing out of the second condenser 7, the second refrigerant flows into the second expansion valve 10 through the receiver 8 and the on-off valve 9, is expanded and reduced in pressure, and transforms into a low-pressure, two-phase gas-liquid refrigerant (point H) in the second refrigerant circuit 60. Then, the second refrigerant that has flowed out of the second expansion valve 10 is heated and evaporated by a heat exchange object such as air (by cooling the heat exchange object such as air) and transforms into a low-pressure gas first refrigerant (point E) in the second refrigerant circuit 60. Thereafter, the second refrigerant passes through the accumulator 12, and is drawn by suction into the second compressor 5 again. The second refrigerant circuit 60 repeats the above-mentioned series of operations.

[0033] When the refrigeration apparatus 100 that performs the foregoing operation uses the second evaporator 11 of the second refrigerant circuit 60 as a use-side heat exchanger, that is, the second evaporator 11 cools air in a storage space where an object to be cooled is stored, the capacity of the second evaporator 11 is the product of the enthalpy difference between points H and E and the amount of second refrigerant flowing through the second evaporator 11. When the refrigeration apparatus 100 of Embodiment 1 needs to cool the second evaporator 11, the on-off valve 9 is opened so that the second refrigerant flows into the second evaporator 11 and the second compressor 5 is operated. Similarly, the first refrigerant circuit is operated. When cooling of the second evaporator 11 becomes unnecessary, the on-off valve 9 is closed so that the flow of second refrigerant stops, the second compressor 5 is stopped, and the first refrigerant circuit is also stopped.

[0034] If the ambient temperature of the second refrigerant circuit 60 is higher than the saturation temperature of the refrigerant (the saturation temperature of the second refrigerant flowing through the circuit portion of the second refrigerant circuit 60 on the high-pressure side) on the high-pressure side of the second refrigerant circuit 60 during operation, when the second compressor 5 of the second refrigerant circuit 60 stops, the pressure in the second refrigerant circuit 60 increases to a pressure corresponding to the ambient temperature.

[0035] The refrigeration apparatus 100 of Embodiment 1 is assumed to use, for example, a $CO_2$ refrigerant as the second refrigerant. It is also assumed that the saturation temperature of the refrigerant on the high-pressure side during the operation of the second refrigerant circuit 60 is lower than a critical temperature (31.1 [degrees C]) of the $CO_2$ refrigerant. In such a case, the pressure of the refrigerant in the second refrigerant circuit 60 in an OFF state is illustrated in Fig. 3.

[0036] Fig. 3 illustrates the relationship among the refrigerant density, the refrigerant temperature, and the refrigerant pressure of the second refrigerant of Embodiment 1 of the present invention. Referring to Fig. 3, the abscissa indicates the temperature of the second refrigerant, and the ordinate indicates the pressure of the second refrigerant. The lines marked with "150", "230", "260", "350", "400", "450", "500", and "550" in Fig. 3 represent the relationships between the refrigerant temperature and the pressure when the refrigerant density (amount of refrigerant [kg]/volume [$m^3$]) of the second refrigerant is 150 [kg/$m^3$], 230 [kg/$m^3$], 260 [kg/$m^3$], 350 [kg/$m^3$], 400 [kg/$m^3$], 450 [kg/$m^3$], 500 [kg/$m^3$], and 550 [kg/$m^3$], respectively.

[0037] As illustrated in Fig. 3, as the temperature of the second refrigerant increases, the pressure of the second refrigerant also increases. As the refrigerant density of the second refrigerant increases, the pressure of the second refrigerant also increases. If, for example, the refrigerant density of the second refrigerant is about 350 [kg/$m^3$] and its temperature is 60 [degrees C], the pressure of the second refrigerant is 10.894 [MPa].

[0038] Thus, in Embodiment 1, the internal volume of the tank 14 is determined such that the pressure of the refrigerant in the second refrigerant circuit 60 falls within an allowable range even when the second refrigerant circuit 60 stops so that the ambient temperature of the second refrigerant circuit 60 increases and the pressure of the refrigerant in the second refrigerant circuit 60 increases.

[0039] Fig. 4 illustrates the relationship among the internal volume of each component of the second refrigeration circuit, the amount of refrigerant (the amount of second refrigerant) stored in the component, the refrigerant density in the second refrigerant circuit, and the refrigerant pressure in the refrigeration apparatus of Embodiment 1 of the present invention. The internal volume of each component of the second refrigerant circuit 60 illustrated in Fig. 4 is determined assuming a second refrigerant circuit 60 exhibiting 10 horsepower ([Hp] = $\times$745.7 [W]). The amount of refrigerant stored in the component of the second refrigerant circuit 60 shown in Fig. 4 refers to the amount of refrigerant stored in the component during the operation of a second refrigerant circuit 60 exhibiting 10 horsepower. The "discharge pipe" illustrated in Fig. 4 refers to a pipe extending from the discharge port of the second compressor 5 to the second condenser. The "liquid pipe" refers to a pipe extending from the second condenser 7 to the second expansion valve 10. The "suction pipe" refers to a pipe extending from the second evaporator 11 to the suction port of the second compressor 5. The pipe extending from the second expansion valve 10 to the second evaporator 11 is short and has an internal volume and a refrigerant storage capacity, which are small and ignored in Fig. 4.

[0040] In the second refrigerant circuit 60 shown in Fig. 4, the total internal volume of the second refrigerant circuit 60 is 0.084 [$m^3$] and the amount of refrigerant is 19.36 [kg], and thus the refrigerant density is 230.6 [kg/$m^3$]. At this refrigerant density, when the ambient temperature is 43 [degrees C], the pressure of the refrigerant in the second refrigerant circuit 60 is about 7.696 [MPa], as illustrated in Fig. 2. In this case, to reduce the pressure of the refrigerant in the second refrigerant circuit 60 to a refrigerant pressure of 6.2 [MPa] or less, which is lower than the allowable pressure (6.2 + $\alpha$ [MPa]), the refrigerant density in the second refrigerant circuit 60 needs to be 150 [kg/$m^3$] or lower. More specifically, when the amount of second refrigerant remains the same in the second refrigerant circuit 60 (when the amount of second refrigerant is kept constant at 19.36 [kg]), the necessary internal volume of the second refrigerant circuit 60 is 0.1291 [$m^3$]. That is, the tank 14 needs to have an internal volume of 0.0451 [$m^3$] (= 0.1291 - 0.084).

[0041] The internal volume of the expansion tank of the typical refrigeration apparatus (binary refrigeration apparatus) is similarly determined.

[0042] As illustrated in Fig. 4, in the second refrigerant circuit 60 during operation, the refrigerant density in a circuit portion on the high-pressure side is higher than that in a circuit portion on the low-pressure side. Thus, when the second compressor 5 of the second refrigerant circuit 60 stops so that the second refrigerant in the second refrigerant circuit 60 increases to almost the ambient temperature, the pressure of the refrigerant in the circuit portion of the second refrigerant circuit 60 on the high-pressure side becomes higher than that in the circuit portion of the second refrigerant circuit 60 on the low-pressure side. This is because in the interval from the outlet of the second condenser 7 (cascade condenser 15) on the high-pressure side to the second expansion valve 10, a liquid second refrigerant flows in large amounts and this results in a high refrigerant density, while in the interval from the outlet of the second evaporator 11 on the low-pressure side to the second compressor 5, a gas second refrigerant flows in large amounts and this results in a low refrigerant density. Thus, in a typical refrigeration apparatus in which a refrigerant is guided from the circuit portion of the second refrigerant circuit 60 on the low-pressure side to the expansion tank, the pressure of the refrigerant in the circuit portion of the second refrigerant circuit 60 on the high-pressure side is often higher than the allowable pressure of the refrigerant in the second refrigerant circuit. In particular, when, as in Embodiment 1, the on-off valve 9 for opening and closing a circuit portion between the receiver 8 and the second expansion valve 10 is provided, the aforementioned problem is more serious. That is, in this case, when the second compressor 5 stops with the on-off valve 9 being closed, the area of the passage through which the second refrigerant flows from the circuit portion of the second refrigerant circuit 60 on the high-pressure side to the circuit portion of the second refrigerant circuit 60 on the low-pressure side further decreases. This often makes it impossible to avoid an abnormal increase in pressure of the refrigerant in the circuit portion of the second refrigerant circuit 60 on the high-pressure side.

**[0043]** To solve this problem, the second refrigerant circuit 60 of Embodiment 1 has a configuration in which the tank 14 serving as an expansion tank is connected through the bypass 13 and the bypass valve 13a to the receiver 8 disposed in the circuit portion of the second refrigerant circuit 60 on the high-pressure side. When the pressure of the refrigerant in the high-pressure portion of the second refrigerant circuit 60 increases to a predetermined pressure or more, the bypass valve 13a opens, and the second refrigerant on the high-pressure side flows into the tank 14 on the low-pressure side so that the pressure of the refrigerant on the high-pressure side decreases.

**[0044]** If the second compressor 5 to which electric power is supplied is stopped in normal operation, the pressure of the refrigerant on the high-pressure side can be reduced by opening the on-off valve 9 so that the refrigerant on the high-pressure side flows to the low-pressure side and the pressure of the refrigerant on the high-pressure side is reduced, or the refrigerant on the high-pressure side of the second refrigerant circuit 60 can be cooled so that the pressure of the refrigerant is reduced by operating the first refrigerant circuit 50. Thus, the bypass valve 13a is preferably operable even in a situation, including a power failure, where the on-off valve 9 and the first refrigerant circuit 50 cannot operate. For this reason, the bypass valve 13a is preferably implemented using an on-off valve that mechanically opens and closes in accordance with the high-side pressure of the refrigerant in the second refrigerant circuit 60.

**[0045]** In this manner, the tank 14 serves as an expansion tank. That is, the tank 14 is used to keep as low as an allowable pressure or less the pressure of the refrigerant in the second refrigerant circuit 60 when the operation of the second refrigerant circuit 60 stops. However, the tank 14 is rarely used to reduce the pressure of the refrigerant in the refrigerant circuit when the second refrigerant circuit 60 stops because of, for example, a power failure.

**[0046]** In view of this, in Embodiment 1, the tank 14 serving as an expansion tank is used as an oil tank in normal operation.

**[0047]** Fig. 5 is a refrigerant circuit diagram showing a portion near the tank of the second refrigerant circuit of Embodiment 1 of the present invention.

**[0048]** As illustrated in Fig. 5, since the second compressor 5 and the tank 14 are disposed on, for example, the same bottom surface, the bottoms of the second compressor 5 and the tank 14 are flush with each other. The tank 14 stores refrigerating machine oil 18. The second compressor 5 and the tank 14 are connected to each other by two pipes 17. More specifically, one pipe 17 is set closer to the bottom surface shared between the second compressor 5 and the tank 14, and connects the second compressor 5 to the tank 14 at the position where the refrigerating machine oil 18 is present (e.g., at the position near their bottom surface). The other pipe 17 connects the second compressor 5 to the tank 14 at the position where the refrigerating machine oil 18 is absent (e.g., at the position, including the upper part of the tank 14, where a gas second refrigerant fills a vacant space).

**[0049]** As illustrated in Fig. 1, the tank 14 is also connected to the oil return pipe 6a of the oil separator 6, and the refrigerating machine oil 18 separated in the oil separator 6 returns into the tank 14.

**[0050]** In this manner, by connecting the second compressor 5 and the tank 14 to each other, the oil surface (the upper surface of the refrigerating machine oil 18) in the second compressor 5 can be made equal in level to the oil surface in the tank 14. Thus, when the amount of refrigerating machine oil in the second compressor 5 decreases, the refrigerating machine oil is supplied from the tank 14, whereas when the amount of refrigerating machine oil 18 in the second compressor 5 increases (when excess refrigerating machine oil 18 is generated), the refrigerating machine oil 18 is discharged to the tank 14 so that variations in amount of refrigerating machine oil 18 can be adjusted. Accordingly, oil shortage and oil compression due to an increase in amount of oil in the second compressor 5 can be avoided.

**[0051]** Depending, for example, on the operating conditions and configuration of the second refrigerant circuit 60, the maximum amount of refrigerating machine oil 18 stored in components other than the second compressor 5, that is, the maximum amount of refrigerating machine oil 18 stored in pipes (e.g., the discharge pipe, the liquid pipe, and the suction pipe), the oil separator 6, the second condenser 7, the receiver 8, the second evaporator 11, and the accumulator 12 may be approximately equal to the amount of refrigerating machine oil that can be stored in the second compressor 5 during the operation of the second refrigerant circuit 60. For example, in a second refrigerant circuit 60 exhibiting 10 horsepower ([Hp] = ×745.7 [W]) shown in Fig. 4, the amount of refrigerating machine oil that can be stored in the second compressor 5 is about 3 [L]. In this case, depending, for example, on the operating conditions of the second refrigerant circuit 60, the maximum amount of refrigerating machine oil 18 stored in components other than the second compressor 5 may be about 3 [L]. In view of this, to reliably prevent oil shortage in the second compressor 5, the amount of refrigerating machine oil 18 that can be stored in the tank 14 is preferably two or more times that of refrigerating machine oil 18 that can be stored in the second compressor 5. The bottom surfaces of the second compressor 5 and the tank 14 need not always be flush with each other, and the bottom surface of the tank 14 may be set at a level corresponding to the volume, shape, and oil storage capacity of the tank 14 so as to obtain a target amount of oil stored in the second compressor 5 during the operation of the second compressor 5. Although Fig. 1 illustrates a circuit that returns to the tank 14 the refrigerating machine oil separated by the oil separator 6 of the second refrigerant circuit 60, the destination to which the oil return pipe 6a of the oil separator 6 is connected is not limited to the tank 14 as long as the oil return pipe 6a is connected to a member on the suction side of the second compressor 5.

**[0052]** In the refrigeration apparatus 100 configured as described above in Embodiment 1, when the second compressor 5 of the second refrigerant circuit 60 stops so that the high-side pressure of the refrigerant in the second refrigerant circuit 60 increases to a predetermined pressure or more, the second refrigerant in the second refrigerant circuit 60 flows from the receiver 8 in the circuit portion of the second refrigerant circuit 60 on the high-pressure side through the bypass 13 and the bypass valve 13a and is stored in the tank 14. Thus, in the refrigeration apparatus 100 configured as described above in Embodiment 1, when the second compressor 5 of the second refrigerant circuit 60 stops, an abnormal increase in pressure can be prevented in the circuit portion of the second refrigerant circuit 60 on the high-pressure side.

**[0053]** In the refrigeration apparatus 100 configured as described above in Embodiment 1 as well, the tank 14 serving as an expansion tank of a typical refrigeration apparatus also serves as an oil tank of the second compressor 5 during the operation of the second refrigerant circuit 60. Thus, in the refrigeration apparatus 100 configured as described in Embodiment 1, a failure of the second compressor 5 due, for example, to shortage of refrigerating machine oil 18 can be prevented.

Embodiment 2

**[0054]** Embodiment 1 assumes a refrigeration apparatus 100 in which the second refrigerant circuit 60 includes only one second compressor 5. Alternatively, the second refrigerant circuit 60 may include a plurality of second compressors 5. In such a case, the tank 14 may have the following configuration to suppress an increase in cost of the refrigeration apparatus 100. Details which are not particularly referred to in Embodiment 2 are the same as in Embodiment 1, and the same reference numerals denote components having the same functions and configurations.

**[0055]** Fig. 6 is a refrigerant circuit diagram illustrating an exemplary configuration of a refrigeration apparatus according to Embodiment 2 of the present invention.

**[0056]** Unlike Embodiment 1, a refrigeration apparatus 100 of Embodiment 2 includes a second refrigerant circuit 60 including two second compressors 5. The two second compressors 5 are connected to a tank 14 through pipes 17.

**[0057]** The configuration of the refrigeration apparatus 100 of Embodiment 2 has the same advantages as those of Embodiment 1.

**[0058]** Also, the configuration of the refrigeration apparatus 100 of Embodiment 2 implements a refrigeration apparatus equipped with tanks 14 fewer than the number of second compressors 5. Thus, an increase in cost of the refrigeration apparatus 100 can be suppressed.

**[0059]** In Embodiment 2, the refrigeration apparatus 100 includes the two second compressors 5. Alternatively, the refrigeration apparatus 100 may include three or more second compressors 5, as a matter of course. In this case, all the second compressors 5 may be connected to one tank 14, or a plurality of tanks 14 may be provided and connected to the respective second compressors 5. In providing a plurality of tanks 14, some of them may be connected to one second compressor 5, as a matter of course.

Embodiment 3

**[0060]** When the second refrigerant circuit 60 also serves as an accumulator, the tank 14 as described in Embodiments 1 and 2 may be replaced with a tank 16, which will be described below. Details which are not particularly referred to in Embodiment 3 are the same as in Embodiment 1 or 2, and the same reference numerals denote components having the same functions and configurations.

**[0061]** Fig. 7 is a refrigerant circuit diagram illustrating an exemplary configuration of a refrigeration apparatus according to Embodiment 3 of the present invention.

**[0062]** As in Embodiments 1 and 2, a tank 16 of Embodiment 3 is connected to a second compressor 5 through pipes 17, and is connected to a receiver 8 through a bypass 13 and a bypass valve 13a.

**[0063]** The tank 16 of Embodiment 3 is also connected to a second evaporator 11 and the suction port of the second compressor 5 through refrigerant pipes. With this arrangement, the tank 16 of Embodiment 3 separates a second refrigerant, upon flowing out of the second evaporator 11, into gas and liquid second refrigerants, and draws the gas second refrigerant by suction into the second compressor 5, thereby preventing liquid back in the second compressor 5.

**[0064]** That is, the tank 16 of Embodiment 3 implements the functions of both the accumulator 12 as described in Embodiments 1 and 2 and the tank 14 as described in Embodiments 1 and 2.

**[0065]** The configuration of the refrigeration apparatus 100 of Embodiment 3 can have the same advantages as those of Embodiments 1 and 2.

**[0066]** The configuration of the refrigeration apparatus 100 of Embodiment 3 allows the tank 16 to serve as an accumulator. This obviates the need to separately provide an accumulator to suppress an increase in cost of the refrigeration apparatus 100.

Reference Signs List

**[0067]** 1 first compressor, 2 first condenser, 3 first expansion valve, 4 first evaporator, 5 second compressor, 6 oil separator, 6a oil return pipe, 7 second condenser, 8 receiver, 9 on-off valve, 10 second expansion valve, 11 second evaporator, 12 accumulator, 13 bypass, 13a bypass valve, 14 tank, 15 cascade condenser, 16 tank, 17 pipe, 18 refrigerating machine oil, 50 first refrigerant circuit, 60 second refrigerant circuit, 100 refrigeration apparatus

## Claims

**1.** A refrigeration apparatus (100) comprising:

a first refrigerant circuit (50) including a first compressor (1), a first condenser (2), a first pressure reducing unit (3), and a first evaporator (4) that are sequentially connected to each other by pipes;
a second refrigerant circuit (60) including a second compressor (5), a second condenser (7), a second pressure reducing unit (10), and a second evaporator (11) that are sequentially connected to each other by pipes;
a cascade condenser (15) formed by the first evaporator (4) of the first refrigerant circuit (50) and the second condenser (7) of the second refrigerant circuit (60); and
a receiver (8) that is connected between the second condenser (7) and the second pressure reducing unit (10) of the second refrigerant circuit (60) and stores an excess refrigerant;
**characterized in that**

the refrigeration apparatus (100) further comprises:

a tank (14, 16) that is connected to the second compressor (5) of the second refrigerant circuit (60) and stores excess refrigerating machine oil (18) in the second compressor (5) so as to adjust an amount of refrigerating machine oil (18) in the second compressor (5);
a bypass (13) connecting the receiver (8) and the tank (14, 16) to each other; and
a first on-off valve (13a) that is disposed in the bypass (13) and that is configured to open the bypass (13) when a high-side pressure in the second refrigerant circuit (60) increases to not less than a predetermined pressure, and to close the bypass (13) when the high-side pressure in the second refrigerant circuit (60) decreases to not more than the predetermined pressure.

**2.** The refrigeration apparatus (100) of claim 1, wherein the second compressor (5) comprises a plurality of second compressors (5), and
the tank (14, 16) is connected to at least two second compressors (5) of the plurality of second compressors (5) and is used to adjust an amount of refrigerating machine oil (18) in the at least two second compressors (5) of the plurality of second compressors (5).

**3.** The refrigeration apparatus (100) of claim 1 or 2, wherein
an outlet of the second evaporator (11) is connected to the tank (16),
a portion of the tank (16) located above the refrigerating machine oil (18) is connected to a suction port of the second compressor (5), and
the tank (16) also serves as an accumulator.

**4.** The refrigeration apparatus (100) of any one of claims 1 to 3, further comprising:

an oil separator (6) disposed between the second compressor (5) and the second condenser (7); and
an oil return pipe (6a) which is connected to the oil separator (6) and a pipe extending from one of the tank (14, 16) and a suction port of the second compressor (5).

**5.** The refrigeration apparatus (100) of any one of claims 1 to 4, wherein the first on-off valve (13a) includes an on-off valve that mechanically opens and closes in accordance with the high-side pressure in the second refrigerant circuit (60).

**6.** The refrigeration apparatus (100) of any one of claims 1 to 5, further comprising: a second on-off valve (9) that is disposed between the receiver (8) and the second pressure reducing unit (10), and that is configured to open and close a circuit portion between the receiver (8) and the second pressure reducing unit (10).

## Patentansprüche

**1.** Kühlvorrichtung (100), umfassend:

einen ersten Kältemittelkreislauf (50) mit einem ersten Kompressor (1), einem ersten Kondensator (2), einer ersten Druckverringerungseinheit (3) und einem ersten Verdampfer (4), die durch Rohre sequentiell miteinander verbunden sind;
einen zweiten Kältemittelkreislauf (60) mit einem zweiten Kompressor (5), einem zweiten Kondensator (7), einer zweiten Druckverringerungseinheit (10) und einem zweiten Verdampfer (11), die durch Rohre sequentiell miteinander verbunden sind;
einen Kaskadenkondensator (15), der von dem ersten Verdampfer (4) des ersten Kältemittelkreislaufs (50) und dem zweiten Kondensator (7) des zweiten Kältemittelkreislaufs (60) gebildet ist; und
einen Empfänger (8), der zwischen den zweiten Kondensator (7) und die zweite Druckverringerungseinheit (10) des zweiten Kältemittelkreislaufs (60) geschaltet ist und ein überschüssiges Kältemittel speichert;
**dadurch gekennzeichnet, dass**
die Kühlvorrichtung (100) ferner Folgendes umfasst:

einen Tank (14, 16), der mit dem zweiten Kompressor (5) des zweiten Kältemittelkreislaufs (60) verbunden ist und überschüssiges Kühlmaschinenöl (18) in dem zweiten Kompressor (5) speichert, um eine Menge von Kühlmaschinenöl (18) in dem zweiten Kompressor (5) anzupassen;
einen Bypass (13), der den Empfänger (8) und den Tank (14, 16) miteinander verbindet; und
ein erstes Ein-Aus-Ventil (13a), das in dem Bypass (13) angeordnet ist und das dazu ausgebildet ist, den Bypass (13) zu öffnen, wenn ein Hochdruckseitendruck in dem zweiten Kältemittelkreislauf (60) auf nicht weniger als einen vorbestimmten Druck ansteigt, und den Bypass (13) zu schließen, wenn der Hochdruckseitendruck in dem zweiten Kältemittelkreislauf (60) auf nicht mehr als den vorbestimmten Druck abfällt.

**2.** Kühlvorrichtung (100) nach Anspruch 1, wobei der zweite Kompressor (5) eine Mehrzahl von zweiten Kompressoren (5) umfasst, und der Tank (14, 16) mit mindestens zwei Kompressoren (5) der Mehrzahl von zweiten Kompressoren (5) verbunden ist und dafür genutzt wird, eine Menge von Kühlmaschinenöl (18) in den mindestens zwei Kompressoren (5) der Mehrzahl von zweiten Kompressoren (5) anzupassen.

**3.** Kühlvorrichtung (100) nach Anspruch 1 oder 2, wobei ein Auslass des zweiten Verdampfers (11) mit dem Tank (16) verbunden ist, ein Teilbereich des Tanks (16), der sich über dem Kühlmaschinenöl (18) befindet, mit einer Ansaugöffnung des zweiten Kompressors (5) verbunden ist, und der Tank (16) ebenfalls als ein Sammler dient.

**4.** Kühlvorrichtung (100) nach einem der Ansprüche 1 bis 3, ferner umfassend:

einen Ölabscheider (6), der zwischen dem zweiten Kompressor (5) und dem zweiten Verdampfer (7) angeordnet ist; und
ein Ölrückführrohr (6a), das mit dem Ölabscheider (6) verbunden ist, und ein Rohr, das sich von einem von dem Tank (14, 16) und einer Ansaugöffnung des zweiten Kompressors (5) erstreckt.

**5.** Kühlvorrichtung (100) nach einem der Ansprüche 1 bis 4, wobei das erste Ein-Aus-Ventil (13a) ein Ein-Aus-Ventil enthält, das sich entsprechend dem Hochdruckseitendruck in dem zweiten Kältemittelkreislauf (60) mechanisch öffnet und schließt.

**6.** Kühlvorrichtung (100) nach einem der Ansprüche 1 bis 5, ferner umfassend: ein zweites Ein-Aus-Ventil (9), das zwischen dem Empfänger (8) und der zweiten Druckverringerungseinheit (10) angeordnet ist, und das dazu ausgebildet ist, einen Kreislaufabschnitt zwischen dem Empfänger (8) und der zweiten Druckverringerungseinheit (10) zu öffnen und zu schließen.

## Revendications

**1.** Appareil frigorifique (100) comprenant :

un premier circuit de fluide frigorigène (50) comprenant un premier compresseur (1), un premier condenseur (2), une première unité de réduction de pression (3), et un premier évaporateur (4) qui sont reliés séquentiellement les uns aux autres par des tuyaux ;
un deuxième circuit de fluide frigorigène (60) comprenant un deuxième compresseur (5), un deuxième condenseur (7), une deuxième unité de réduction de pression (10), et un deuxième évaporateur (11) qui sont reliés séquentiellement les uns aux autres par des tuyaux ;
un condenseur cascade (15) formé par le premier évaporateur (4) du premier circuit de fluide frigorigène (50) et le deuxième condenseur (7) du deuxième circuit de fluide frigorigène (60) ; et
un récepteur (8) qui est relié entre le deuxième condenseur (7) et la deuxième unité de réduction de pression (10) du deuxième circuit de fluide frigorigène (60) et qui stocke un fluide frigorigène en excès ;
**caractérisé en ce que**
l'appareil frigorifique (100) comprend en outre :

un réservoir (14, 16) qui est relié au deuxième compresseur (5) du deuxième circuit de fluide frigorigène (60) et qui stocke une huile de machine de réfrigération en excès (18) dans le deuxième compresseur (5) de manière à ajuster une quantité d'huile de machine de réfrigération (18) dans le deuxième compresseur (5) ;
une dérivation (13) reliant le récepteur (8) et le réservoir (14, 16) l'un à l'autre ; et
une première vanne tout ou rien (13a) qui est disposée dans la dérivation (13) et qui est configurée pour ouvrir la dérivation (13) lorsqu'une pression côté haut dans le deuxième circuit de fluide frigorigène (60) augmente à des valeurs supérieures ou égales à une pression prédéterminée, et pour fermer la dérivation (13) lorsque la pression côté haut dans le deuxième circuit de fluide frigorigène (60) diminue à des valeurs inférieures ou égales à la pression prédéterminée.

**2.** Appareil frigorifique (100) selon la revendication 1, dans lequel
le deuxième compresseur (5) comprend une pluralité de deuxièmes compresseurs (5), et
le réservoir (14, 16) est relié à au moins deux deuxièmes compresseurs (5) de la pluralité de deuxièmes compresseurs (5) et est utilisé pour ajuster une quantité d'huile de machine de réfrigération (18) dans lesdits au moins deux deuxièmes compresseurs (5) de la pluralité de deuxièmes compresseurs (5).

**3.** Appareil frigorifique (100) selon la revendication 1 ou 2, dans lequel
une sortie du deuxième évaporateur (11) est relié au réservoir (16),
une partie du réservoir (16) située au-dessus de l'huile de machine de réfrigération (18) est reliée à un orifice d'aspiration du deuxième compresseur (5), et
le réservoir (16) sert également en tant qu'accumulateur.

**4.** Appareil frigorifique (100) selon l'une quelconque des revendications 1 à 3, comprenant en outre :

un séparateur d'huile (6) disposé entre le deuxième compresseur (5) et le deuxième condenseur (7) ; et
un tuyau de retour d'huile (6a) qui est relié au séparateur d'huile (6) et un tuyau s'étendant de l'un du réservoir (14, 16) et d'un orifice d'aspiration du deuxième compresseur (5).

**5.** Appareil frigorifique (100) selon l'une quelconque des revendications 1 à 4, dans lequel
la première vanne tout ou rien (13a) comprend une vanne tout ou rien qui s'ouvre et se ferme mécaniquement conformément à la pression côté haut dans le deuxième circuit de fluide frigorigène (60).

**6.** Appareil frigorifique (100) selon l'une quelconque des revendications 1 à 5, comprenant en outre :
une deuxième vanne tout ou rien (9) qui est disposée entre le récepteur (8) et la deuxième unité de réduction de pression (10), et qui est configurée pour ouvrir et fermer une partie de circuit entre le récepteur (8) et la deuxième unité de réduction de pression (10).

FIG. 1

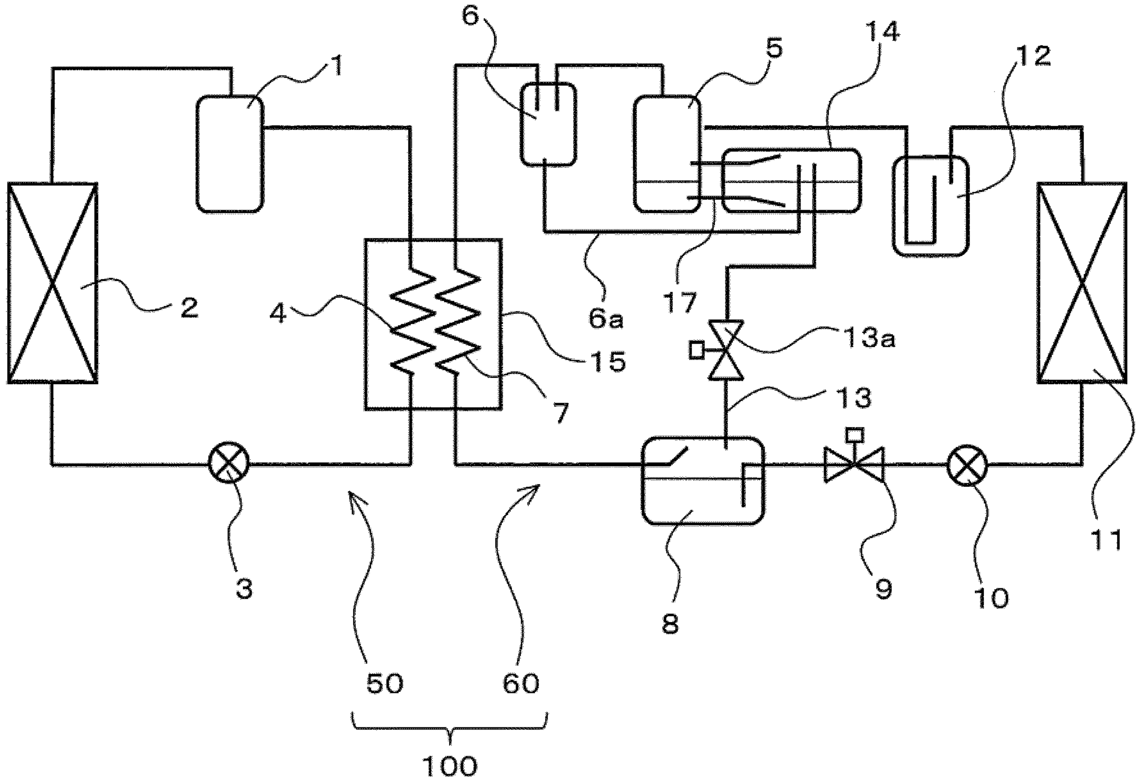

6
1
5
14
12
2
4
6a
15
17
13a
7
13
11
3
9
10
8
50
60
100

FIG. 2

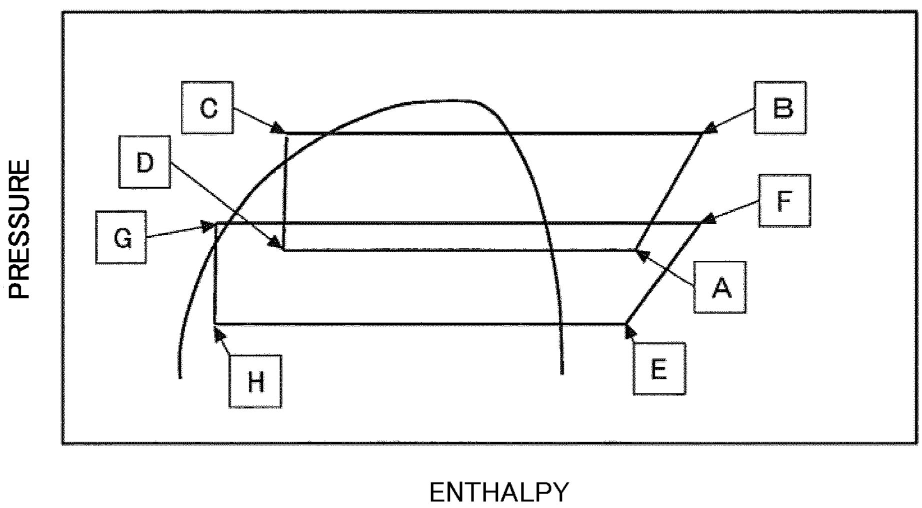

C
B
D
F
G
A
H
E
PRESSURE
ENTHALPY

FIG. 3

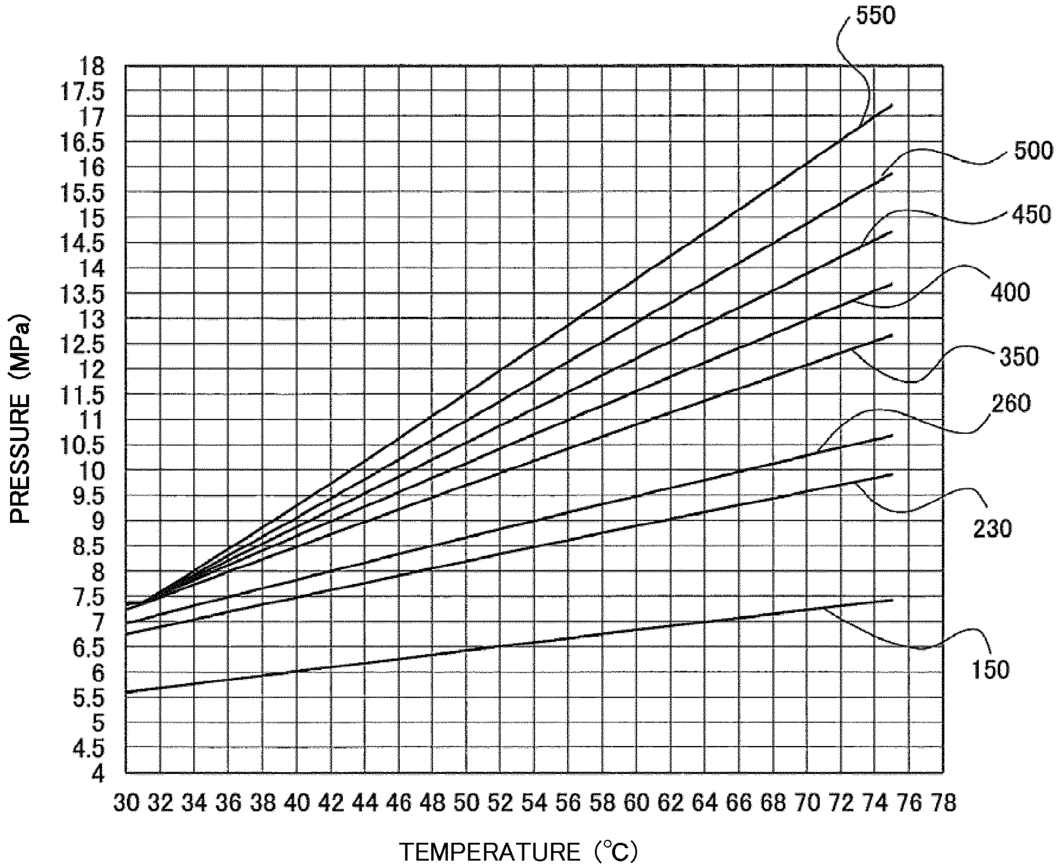


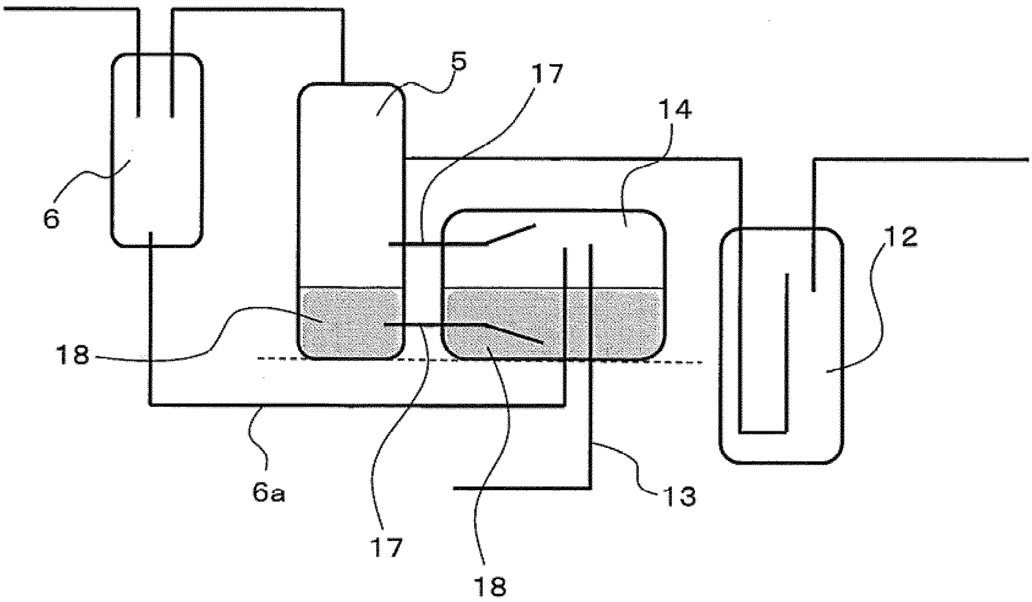

FIG. 4

| | REGION | INTERNAL VOLUME ($m^3$) | AMOUNT OF REFRIGERANT (kg) | REFRIGERANT DENSITY ($kg/m^3$) | PRESSURE AT 43°C (MPa·abs) |
|---|---|---|---|---|---|
| HIGH-PRESSURE SIDE | DISCHARGE PIPE | 0.0013 | 0.110 | | |
| | OIL SEPARATOR | 0.0030 | 0.247 | | |
| | CONDENSER | 0.0082 | 3.106 | | |
| | RECEIVER | 0.0130 | 3.600 | | |
| | LIQUID PIPE | 0.0087 | 7.532 | 426.2 | |
| LOW-PRESSURE SIDE | EVAPORATOR (UC) | 0.0200 | 2.520 | | |
| | SUCTION PIPE | 0.0197 | 1.490 | | |
| | ACCUMULATOR | 0.0100 | 0.755 | 95.8 | |
| TOTAL | | 0.0840 | 19.36 | 230.6 | 7.696 |

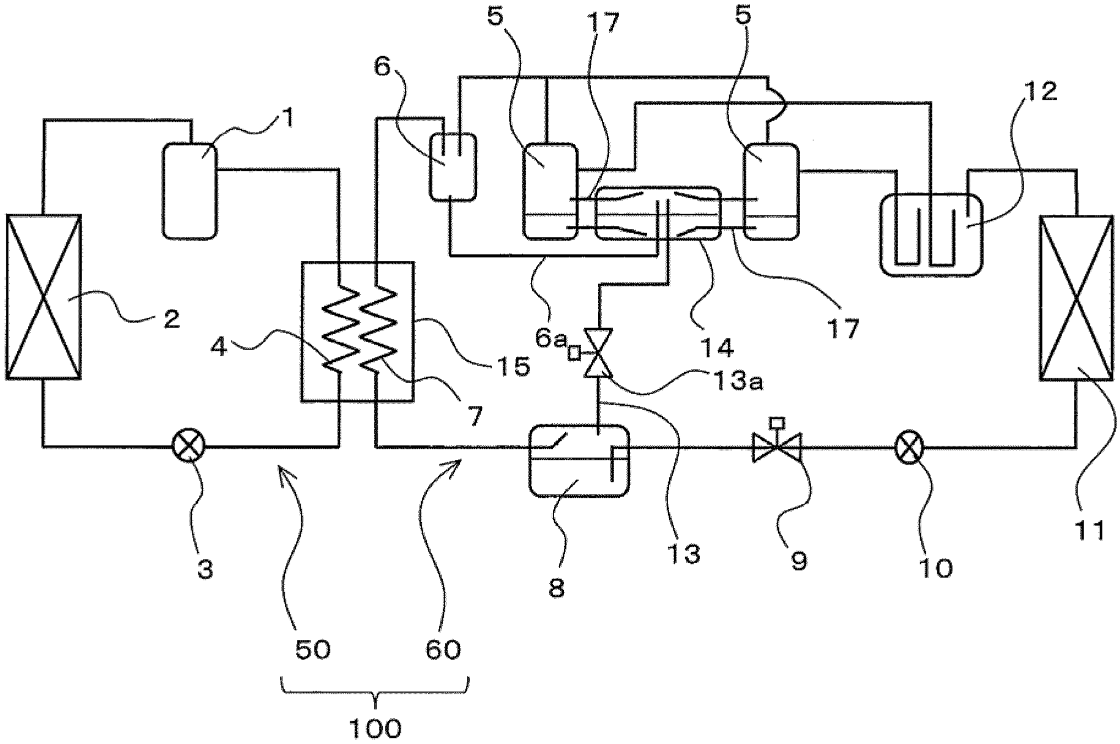
⇕

| | | | |
|---|---|---|---|
| 0.1291 | 19.36 | 150.0 | 6.1418 |

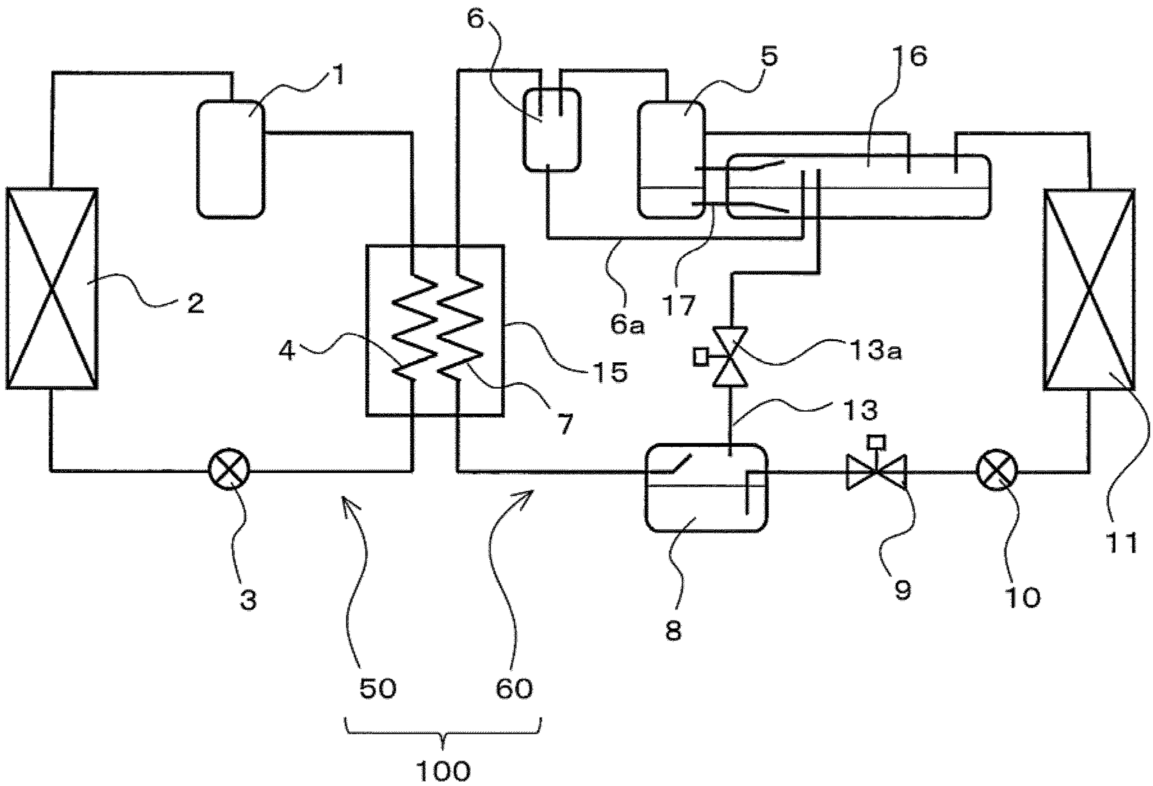
F I G. 5


5
17
14
6
12
18
6a
17
18
13

F I G. 6


5
17
5
6
12
1
2
4
15
7
6a
14
17
13a
3
50
60
8
13
9
10
11
100

ＦＩＧ．７



## REFERENCES CITED IN THE DESCRIPTION

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### Patent documents cited in the description


- WO 2008150289 A1 **[0002]**
- JP 2007303792 A **[0005]**