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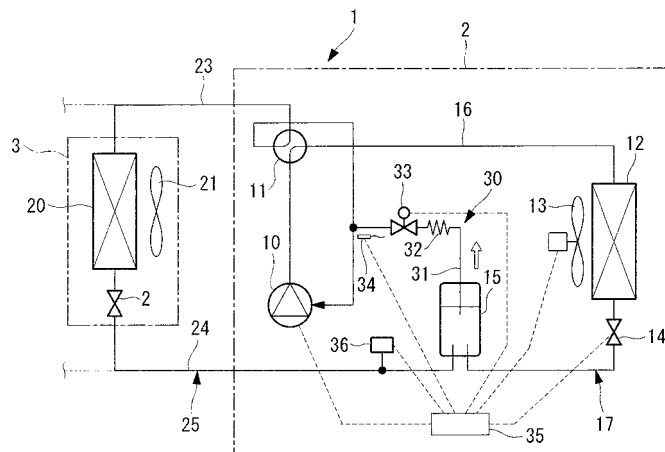
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(54) **AIR CONDITIONER AND METHOD FOR DETECTING AMOUNT OF REFRIGERANT IN AIR CONDITIONER**

(57) Provided is an air conditioner and a method of detecting the amount of refrigerant in an air conditioner that always enables the amount of refrigerant filled to be detected with high precision, without providing a heating unit in a liquid-surface detecting circuit. An air conditioner (1), in which an outdoor unit (2) and an indoor unit (3) is connected, includes a liquid-surface detecting circuit (30) in which a bypass circuit (31) connecting a predetermined height position in a receiver (15) to an intake side of a compressor (10) has an on/off valve (33) and a decompression mechanism (32); a temperature detecting unit (34) that detects the temperature of the refrigerant de-

compressed by a decompression mechanism (32) and flowing in the liquid-surface detecting circuit (30); and a refrigerant-amount detecting unit (35) that controls the intermediate pressure in the receiver (15) such that the degree of superheating is 5 deg or more higher than a low-pressure saturated gas temperature and such that a saturated gas line on a pressure-enthalpy diagram is inclined toward the upper right, and that detects the temperature of the refrigerant extracted from the receiver (15) into the liquid-surface detecting circuit (30) with the temperature detecting unit (34), thereby determining the amount of refrigerant filled based on the detected temperature.

FIG. 1



Description

{Technical Field}

[0001] The present invention relates to an air conditioner that always enables an appropriate amount of refrigerant to be filled at the time of installation and to a method of detecting the amount of refrigerant in an air conditioner.

{Background Art}

[0002] In a multi-type air conditioner used for air-conditioning in a building or the like, an outdoor unit including a compressor, a four-way control valve, an outdoor heat exchanger, a heating-mode expansion valve, a receiver, and an outdoor fan is connected to a plurality of indoor units each including an indoor heat exchanger, a cooling-mode expansion valve, and an indoor fan via a gas refrigerant pipe and a liquid refrigerant pipe at the installation site. In this multi-type air conditioner, the outdoor unit is filled with a predetermined amount of refrigerant in advance, and, when a test run is performed on the air conditioner after installation at the installation site, the refrigerant is added in an amount equal to a shortfall, based on the lengths of the pipes connecting the outdoor unit and the indoor units and the number of the indoor units connected.

[0003] In this air conditioner, in order to always enable an appropriate amount of refrigerant to be filled regardless of the degree of completion of the construction at the installation site, PTL 1 (see FIG. 1) and PTL 2 (see FIG. 1) disclose techniques in which a liquid-surface detecting circuit that detects that liquid refrigerant collected in a receiver in a refrigerant circuit during a refrigerant filling operation has reached a predetermined liquid surface level is provided, and it is determined that the refrigerant circuit is filled with the necessary amount of refrigerant when the liquid-surface detecting circuit detects that the liquid refrigerant collected in the receiver has reached a predetermined liquid surface level.

[0004] In the technique disclosed in PTL 1, a bypass circuit, which extends from a predetermined height position in the receiver and in which an on/off valve, a decompression mechanism, and a temperature detecting unit are provided, is connected to an intake side of the compressor. In the technique disclosed in PTL 2, an on/off valve, a decompression mechanism, a heating unit, and a temperature detecting unit are provided in a bypass circuit, and the temperature of the refrigerant after decompression is measured for the cases where saturated gas refrigerant is extracted from the receiver into the bypass circuit and where saturated liquid refrigerant is extracted. Then, from the temperature difference, it is detected that the liquid refrigerant collected in the receiver has reached a predetermined liquid surface level, and thus, the amount of refrigerant is determined.

{Citation List}

{Patent Literature}

5 **[0005]**

{PTL 1} Japanese Unexamined Patent Application, Publication No. 2002-350014

{PTL 2} Publication of Japanese Patent No. 3719246

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{Summary of Invention}

{Technical Problem}

15 **[0006]** However, in the case of the disclosure in PTL 1, under pressure conditions in which the discharge-side pressure of the compressor (high pressure) is high because of high outside air temperature, and in which a saturated gas line on a pressure-enthalpy diagram is inclined toward the upper left, when saturated gas refrigerant is extracted and decompressed, it may enter a gas-liquid two-phase state. In this case, a sharp drop in refrigerant temperature is detected, which may result in an erroneous decision that the liquid refrigerant has reached a predetermined liquid surface level. Thus, there has been a problem in that the detection accuracy cannot be ensured.

20 **[0007]** On the other hand, in order to overcome the above-described problem, in the disclosure in PTL 2, the heating unit for heating the refrigerant decompressed in the decompression mechanism is provided in the liquid-surface detecting circuit, so as to ensure a sufficient temperature difference, utilizing the tendency that the temperature rise due to heating is large if the refrigerant extracted from the receiver is in a gas state and the temperature rise is small if the refrigerant is in a liquid state because the thermal energy generated by heating is consumed as latent heat of vaporization, thereby increasing the detection accuracy. However, it is necessary to provide the heating unit in the liquid-surface detecting circuit, which results in a problem in that the structure becomes complex. Both the disclosures in PTLs 1 and 2 involve a problem in that, if the discharge-side pressure (high pressure) is not sufficiently raised due to a low outside air temperature or the like, superheating of the gas refrigerant extracted from the receiver cannot be ensured, lowering the detection accuracy.

30 **[0008]** The present invention has been made in view of the above-described circumstances, and an object thereof is to provide an air conditioner that always enables an amount of refrigerant filled to be detected with high precision, without providing a heating unit in a liquid-surface detecting circuit, and a method of detecting the amount of refrigerant in an air conditioner.

35

{Solution to Problem}

40 **[0009]** To solve the above-described problems, an air

conditioner and a method of detecting an amount of refrigerant in an air conditioner according to the present invention employ the following solutions.

That is, an air conditioner, according to a first aspect of the present invention, in which an outdoor unit including a compressor, an outdoor heat exchanger, a heating-mode expansion valve, and a receiver storing liquid refrigerant is connected to an indoor unit including an indoor heat exchanger and a cooling-mode expansion valve by a gas refrigerant pipe and a liquid refrigerant pipe, thereby forming a closed-cycle refrigerant circuit, includes a liquid-surface detecting circuit in which a bypass circuit connecting a predetermined height position in the receiver to an intake side of the compressor has an on/off valve and a decompression mechanism; a temperature detecting unit that detects a temperature of the refrigerant decompressed by the decompression mechanism and flowing in the liquid-surface detecting circuit; and a refrigerant-amount detecting unit that controls an intermediate pressure in the receiver such that a degree of superheating is 5 deg or more higher than a low-pressure saturated gas temperature and such that a saturated gas line on a pressure-enthalpy diagram is inclined toward an upper right, and that detects the temperature of the refrigerant extracted from the receiver into the liquid-surface detecting circuit with the temperature detecting unit, thereby determining an amount of refrigerant filled based on the detected temperature.

[0010] According to the first aspect of the present invention, the air conditioner includes a liquid-surface detecting circuit in which a bypass circuit connecting a predetermined height position in the receiver to an intake side of the compressor has an on/off valve and a decompression mechanism; a temperature detecting unit that detects the temperature of the refrigerant decompressed by the decompression mechanism and flowing in the liquid-surface detecting circuit; and a refrigerant-amount detecting unit that controls the intermediate pressure in the receiver such that the degree of superheating is 5 deg or more higher than a low-pressure saturated gas temperature and such that a saturated gas line on a pressure-enthalpy diagram is inclined toward the upper right, and that detects the temperature of the refrigerant extracted from the receiver into the liquid-surface detecting circuit with the temperature detecting unit, thereby determining the amount of refrigerant filled based on the detected temperature. Thus, by detecting the temperature of the refrigerant after decompression when the saturated gas refrigerant is extracted from the receiver whose intermediate pressure is controlled such that the degree of superheating is 5 deg or more higher than the low-pressure saturated gas temperature and such that a saturated gas line on a pressure-enthalpy diagram is inclined toward the upper right and when saturated liquid refrigerant is extracted, the fact that the liquid refrigerant collected in the receiver has reached a predetermined liquid surface level can be detected from the temperature difference. Accordingly, it is possible to ensure a suffi-

cient temperature difference and enable precise detection of the amount of refrigerant filled without being influenced by the discharge-side pressure (high pressure) of the refrigerant or without providing a refrigerant heating unit, thereby making it possible to fill an appropriate amount of refrigerant (neither too much nor too little) and stably operate the air conditioner.

[0011] Furthermore, in the air conditioner according to the first aspect of the present invention, in the above-described air conditioner, the refrigerant-amount detecting unit is configured to control the intermediate pressure in the receiver to the above pressure by detecting the intermediate pressure based on a detected value or a converted value obtained by an intermediate pressure sensor, a temperature sensor that detects the temperature of the refrigerant extracted into the liquid-surface detecting circuit, a high pressure sensor, or a temperature sensor that detects a degree of supercooling of the refrigerant at an outlet of the outdoor heat exchanger, and by controlling a rotational speed of the compressor, a rotational speed of an outdoor fan that sends outside air to the outdoor heat exchanger, or a degree of opening of a heating-mode expansion valve.

[0012] According to the first aspect of the present invention, the refrigerant-amount detecting unit is configured to control the intermediate pressure in the receiver to the above pressure by detecting the intermediate pressure based on a detected value or a converted value obtained by an intermediate pressure sensor, a temperature sensor that detects the temperature of the refrigerant extracted into the liquid-surface detecting circuit, a high pressure sensor, or a temperature sensor that detects the degree of supercooling of the refrigerant at an outlet of the outdoor heat exchanger, and by controlling the rotational speed of the compressor, the rotational speed of an outdoor fan that sends outside air to the outdoor heat exchanger, or the degree of opening of a heating-mode expansion valve. Accordingly, the intermediate pressure in the receiver can be controlled, by software, such that the degree of superheating is 5 deg or more higher than the low-pressure saturated gas temperature and such that a saturated gas line on a pressure-enthalpy diagram is inclined toward the upper right, by controlling the rotational speed of the compressor, the rotational speed of the outdoor fan that sends outside air to the outdoor heat exchanger, or the degree of opening of the heating-mode expansion valve. Accordingly, instead of providing a refrigerant heating unit in hardware, by detecting the temperature of the refrigerant after decompression with the liquid-surface detecting circuit, the amount of refrigerant filled can be accurately detected, and an appropriate amount of refrigerant (neither too much nor too little) can be filled.

[0013] Furthermore, in the air conditioner according to the first aspect of the present invention, in any one of the above-described air conditioners, a hot-gas bypass circuit that raises the intermediate pressure in the receiver to the above pressure by introducing hot gas discharged

from the compressor is provided between the discharge side of the compressor and the receiver.

[0014] According to the first aspect of the present invention, a hot-gas bypass circuit that raises the intermediate pressure in the receiver to the above pressure by introducing hot gas discharged from the compressor is provided between the discharge side of the compressor and the receiver. Thus, for example, even under conditions where the outside air temperature is low, and the intermediate pressure in the receiver does not rise to the above-described pressure, the intermediate pressure can be controlled to the above-described pressure by introducing a portion of the hot gas into the receiver via the hot-gas bypass circuit. Accordingly, even under conditions where the outside air temperature is low, the amount of refrigerant filled can be accurately detected, and an appropriate amount of refrigerant can be filled. Furthermore, because this configuration makes it easy to raise the pressure even under conditions where the outside air temperature is low, it can be effectively applied to high pressure control in a cooling operation when the outside air temperature is low.

[0015] Furthermore, a method of detecting an amount of refrigerant in an air conditioner according to a second aspect of the present invention, in which an outdoor unit including a compressor, an outdoor heat exchanger, a heating-mode expansion valve, and a receiver storing liquid refrigerant is connected to an indoor unit including an indoor heat exchanger and a cooling-mode expansion valve by a gas refrigerant pipe and a liquid refrigerant pipe, thereby forming a closed-cycle refrigerant circuit, includes controlling an intermediate pressure in the receiver such that a degree of superheating is 5 deg or more higher than a low-pressure saturated gas temperature and such that a saturated gas line on a pressure-enthalpy diagram is inclined toward an upper right during a refrigerant filling operation; extracting the intermediate pressure refrigerant into a liquid-surface detecting circuit connecting a predetermined height position in the receiver to an intake side of the compressor; and detecting a temperature of the refrigerant decompressed to a low-pressure state in the liquid-surface detecting circuit, thereby determining the amount of refrigerant filled.

[0016] According to the second aspect of the present invention, the amount of refrigerant filled is determined by controlling the intermediate pressure in the receiver such that the degree of superheating is 5 deg or more higher than the low-pressure saturated gas temperature and such that a saturated gas line on a pressure-enthalpy diagram is inclined toward the upper right during a refrigerant filling operation, extracting the intermediate pressure refrigerant into the liquid-surface detecting circuit connecting a predetermined height position in the receiver to an intake side of the compressor, and detecting the temperature of the refrigerant decompressed to a low-pressure state in the liquid-surface detecting circuit. Thus, by detecting the temperature of the refrigerant after decompression when the saturated gas refrigerant is ex-

tracted from the receiver whose intermediate pressure is controlled such that the degree of superheating is 5 deg or more higher than the low-pressure saturated gas temperature and such that a saturated gas line on a pressure-enthalpy diagram is inclined toward the upper right and the temperature of the refrigerant after decompression when saturated liquid refrigerant is extracted, the fact that the liquid refrigerant collected in the receiver has reached a predetermined liquid surface level can be detected from the temperature difference. Accordingly, it is possible to ensure a sufficient temperature difference and enable precise detection of the amount of refrigerant filled without being influenced by the discharge-side pressure (high pressure) of the refrigerant or without providing a refrigerant heating unit, thereby making it possible to fill an appropriate amount of refrigerant (neither too much nor too little) in the air conditioner.

{Advantageous Effects of Invention}

[0017] With the air conditioner and the method of detecting the amount of refrigerant in an air conditioner according to the present invention, by detecting the temperature of the refrigerant after decompression when the saturated gas refrigerant is extracted from the receiver whose intermediate pressure is controlled such that the degree of superheating is 5 deg or more higher than the low-pressure saturated gas temperature and such that a saturated gas line on a pressure-enthalpy diagram is inclined toward the upper right and the temperature of the refrigerant after decompression when saturated liquid refrigerant is extracted, the fact that the liquid refrigerant collected in the receiver has reached a predetermined liquid surface level can be detected from the temperature difference. Accordingly, it is possible to ensure a sufficient temperature difference and enable precise detection of the amount of refrigerant filled, without being influenced by the discharge-side pressure of the refrigerant or without providing a refrigerant heating unit, thereby making it possible to fill an appropriate amount of refrigerant (neither too much nor too little) and stably operate the air conditioner.

{Brief Description of Drawings}

[0018]

{FIG. 1} FIG. 1 is a refrigerant circuit diagram of an air conditioner according to a first embodiment of the present invention.

{FIG. 2} FIG. 2 is a refrigerant circuit diagram of a modification of the air conditioner shown in FIG. 1, in which a portion is omitted.

{FIG. 3} FIG. 3 is a refrigerant circuit diagram of another modification of the air conditioner shown in FIG. 1, in which a portion is omitted.

{FIG. 4} FIG. 4 is a pressure-enthalpy diagram in which the pressure in a receiver of the air conditioner

shown in FIG. 1 is set close to the maximum enthalpy on the saturated gas line.

{FIG. 5} FIG. 5 is a pressure-enthalpy diagram in which the intermediate pressure in the receiver of the air conditioner shown in FIG. 1 is set close to the maximum enthalpy on the saturated gas line by controlling the intermediate pressure.

{FIG. 6} FIG. 6 is a refrigerant circuit diagram of an air conditioner according to a second embodiment of the present invention, in which a portion is omitted.

{Description of Embodiments}

[0019] Embodiments of the present invention will be described below with reference to the drawings.

[First Embodiment]

[0020] A first embodiment of the present invention will be described using FIGS. 1 to 5.

[0021] FIG. 1 shows a refrigerant circuit diagram of an air conditioner according to the first embodiment of the present invention.

An air conditioner 1 is a multi-type air conditioner used for air-conditioning in a building or the like and includes an outdoor unit 2 and a plurality of indoor units 3 (FIG. 1 shows only one of them) connected to one another in parallel.

[0022] The outdoor unit 2 accommodates a compressor 10 that compresses refrigerant, a four-way control valve 11 that changes the circulation direction of the refrigerant, an outdoor heat exchanger 12 that performs heat exchange between the outside air and the refrigerant, an outdoor fan 13 that sends the outside air to the outdoor heat exchanger 12, a heating-mode electric expansion valve (heating-mode expansion valve) 14, a receiver 15 that stores condensed liquid refrigerant, etc. The compressor 10, the four-way control valve 11, the outdoor heat exchanger 12, the heating-mode electric expansion valve 14, and the receiver 15 are connected in sequence via a refrigerant pipe 16, thereby forming an outdoor refrigerant circuit 17.

[0023] The indoor units 3 each accommodate an indoor heat exchanger 20, an indoor fan 21 that circulates the indoor air through the indoor heat exchanger 20, a cooling-mode electric expansion valve (cooling-mode expansion valve) 22, etc. The indoor units 3 and the outdoor unit 2 are connected via a gas refrigerant pipe 23 and a liquid refrigerant pipe 24, thereby forming a closed-cycle refrigerant circuit 25. The plurality of indoor units 3 are connected to one another in parallel via portions of the gas refrigerant pipe 23 and the liquid refrigerant pipe 24 that are branched off from the gas refrigerant pipe 23 and the liquid refrigerant pipe 24.

[0024] The air conditioner 1 circulates refrigerant discharged from the compressor 10 toward the outdoor heat exchanger 12 via the four-way control valve 11 and then circulates the refrigerant clockwise through, in sequence,

the refrigerant receiver 15, a cooling-mode electric expansion valve 22, the indoor heat exchanger 20, the four-way control valve 11, and the compressor 10, thereby making the outdoor heat exchanger 12 serve as a condenser and making the indoor heat exchanger 20 serve as an evaporator. Thus, the air conditioner 1 can perform a cooling operation. On the other hand, the air conditioner 1 circulates refrigerant discharged from the compressor 10 toward the indoor heat exchanger 20 via the four-way control valve 11 and then circulates the refrigerant counterclockwise through, in sequence, the receiver 15, the heating-mode electric expansion valve 14, the outdoor heat exchanger 12, the four-way control valve 11, and the compressor 10, thereby making the indoor heat exchanger 20 serve as a condenser and making the outdoor heat exchanger 12 serve as an evaporator. Thus, the air conditioner 1 can perform a heating operation.

[0025] In the above-described air conditioner 1, the lengths of the gas refrigerant pipe 23 and the liquid refrigerant pipe 24 connecting the outdoor unit 2 and the indoor units 3 vary depending on the environment in which the air conditioner 1 is installed. Therefore, it is necessary that the outdoor unit 2 be filled with a predetermined amount of refrigerant in advance, and that, when a test run is performed on the air conditioner 1 after installation at the installation site, the refrigerant is added in an amount equal to a shortfall, based on the lengths of the pipes connecting the refrigerant outdoor unit 2 and the indoor units 3 and the number of the indoor units 3 connected. In order to always enable an appropriate amount of refrigerant to be filled regardless of the degree of completion of the construction at the installation site when adding the refrigerant, a liquid-surface detecting circuit 30 and a refrigerant-amount detecting unit 35 described below are incorporated.

[0026] The liquid-surface detecting circuit 30 includes a bypass circuit 31 that can extract the refrigerant from a predetermined height position in the receiver 15 into the intake side of the compressor 10, a decompression mechanism 32 composed of a capillary tube, an expansion valve, etc., provided in the bypass circuit 31, an electromagnetic on/off valve 33, and a temperature sensor (temperature detecting unit) 34, such as a thermistor, that detects the temperature of the refrigerant extracted into the bypass circuit 31 and decompressed by the decompression mechanism 32.

[0027] The refrigerant-amount detecting unit 35 determines whether or not an appropriate amount of refrigerant is filled based on the temperature detected by the temperature sensor 34, and is configured to be able to determine whether or not an appropriate amount of refrigerant is filled based on the difference in temperature, detected by the temperature sensor 34, between when the liquid surface level of the liquid refrigerant collected in the receiver 15 during a refrigerant filling operation has reached the height at which the bypass circuit 31 is provided and the saturated liquid refrigerant is extracted into the bypass circuit 31, and when the saturated gas refrigerant

erant is extracted from the receiver 15 into the bypass circuit 31 until the liquid refrigerant has reached a predetermined height position.

[0028] Furthermore, during a refrigerant filling operation, the refrigerant-amount detecting unit 35 serves to control the intermediate pressure in the receiver 15 to such a pressure that the degree of superheating is 5 deg or more higher than the low-pressure saturated gas temperature, and in a region in which a saturated gas line on a pressure-enthalpy diagram is inclined toward the upper right. This control is performed by, for example, adjusting the rotational speed of the compressor 10, the rotational speed of the outdoor fan 13, or the degree of opening of the heating-mode electric expansion valve 14, such that the intermediate pressure detected by the intermediate pressure sensor 36 becomes a pressure at which the degree of superheating is 5 deg or more higher than the low-pressure saturated gas temperature, and in a region in which the saturated gas line is inclined toward the upper right on the pressure-enthalpy diagram.

[0029] Instead of the intermediate pressure sensor 36, the intermediate pressure in the receiver 15 may be detected either by converting the temperature detected by a temperature sensor 37 provided at a refrigerant-extracting portion of the bypass circuit 31, as the saturated gas temperature of the refrigerant, into pressure as shown in FIG. 2, or by converting detected values obtained by a high pressure sensor 38 provided at a discharge pipe of the compressor 10 and a temperature sensor 39 provided at an outlet of the outdoor heat exchanger 12 to detect the degree of supercooling of the refrigerant into saturated liquid pressure with a constant enthalpy, as shown in FIG. 3.

[0030] Next, the refrigerant filling operation and a method of detecting the amount of refrigerant filled will be described in more detail below with reference to FIGS. 4 and 5.

The refrigerant filling operation is performed with the refrigerant circuit 25 being used as a cooling cycle. At this time, the outdoor fan 13 is controlled such that the condensing pressure of the outdoor heat exchanger 12 is a predetermined value, and the degree of opening of the cooling-mode electric expansion valve 22 is controlled such that a predetermined degree of superheating is given to the refrigerant at the outlet of the indoor heat exchanger 20. By doing so, the refrigerant circuit 25 can be filled with refrigerant, with the liquid refrigerant pipe 24 being filled with liquid refrigerant having a predetermined density. At this time, the electromagnetic on/off valve 33 of the liquid-surface detecting circuit 30 is open.

[0031] If the operation is continued in this state, the amount of refrigerant circulated in the refrigerant circuit 25 gradually increases, and the liquid surface of the refrigerant in the receiver 15 gradually rises. This is because the amount of refrigerant evaporated in the indoor heat exchanger 20 and the amount of refrigerant condensed in the outdoor heat exchanger 12 are balanced, and the liquid refrigerant is gradually collected in the re-

ceiver 15 because of the refrigerant filled from the outside. At this time, the saturated gas refrigerant in the receiver 15 flows through the bypass circuit 31 until the liquid refrigerant collected in the receiver 15 has reached the height at which the bypass circuit 31 of the liquid-surface detecting circuit 30 is provided. When the liquid surface level of the liquid refrigerant has risen to the height at which the bypass circuit 31 is provided, the saturated liquid refrigerant flows through the bypass circuit 31.

[0032] This saturated gas refrigerant or saturated liquid refrigerant is decompressed by the decompression mechanism 33 into a low-pressure state, and the temperature thereof decreases. From the difference in temperature between the case where the temperature decreases from a saturated gas refrigerant state and the case where the temperature decreases from a saturated liquid refrigerant state, which is obtained by detecting the temperature of the refrigerant with the temperature sensor 34, the refrigerant-amount detecting unit 35 detects that the liquid refrigerant collected in the receiver 15 has reached a predetermined liquid surface level, thereby determining that a required amount of refrigerant is filled. At this point in time, the refrigerant filling operation is completed.

[0033] Herein, in order to accurately detect if an appropriate amount of refrigerant is filled, it is desirable that the difference in temperature be large enough. Typically, because the saturated liquid refrigerant flowing into the bypass circuit 31 is decompressed into a gas-liquid two-phase state by the decompression mechanism 33 and is evaporated, the temperature detected by the temperature sensor 34 sharply drops. In contrast, the saturated gas refrigerant flowing into the bypass circuit 31 sometimes enters a gas-liquid two-phase state when decompressed by the decompression mechanism 33 under pressure conditions in which the discharge-side pressure of the compressor 10 is raised due to, for example, a rise in outside air temperature, and in which a saturated gas line on a pressure-enthalpy diagram is inclined toward the upper left. In this case, a sharp drop in temperature due to evaporation of the refrigerant is detected, which may result in the refrigerant-amount detecting unit 35 erroneously determining that the liquid refrigerant has reached a predetermined liquid surface level.

[0034] In this embodiment, however, as shown in FIG. 4, the intermediate pressure of the refrigerant in the receiver 15 is controlled such that the degree of superheating is 5 deg or more higher than the low-pressure saturated gas temperature and such that a saturated gas line on a pressure-enthalpy diagram is inclined toward the upper right, and the saturated gas refrigerant in this state is extracted into the bypass circuit 31, decompressed, and reduced in temperature. Thus, it is possible to always ensure a degree of superheating SH of 5 deg or higher than the saturated gas temperature of the refrigerant which is decompressed to a low pressure.

[0035] That is, in FIG. 4, when the saturated liquid re-

frigerant is decompressed, the temperature drops at point A, whereas when refrigerant in a saturated gas state is decompressed, in the case where the refrigerant enters a gas-liquid two-phase state as a result of the decompression, the temperature drops substantially on the saturated gas line, and the degree of superheating may reach 2 to 3 °C at most. In this case, a sufficient difference in temperature cannot be ensured, which may cause erroneous decision. However, in this embodiment, it is possible to always make the temperature drop at point B, at which a degree of superheating SH of at least 5 deg is ensured. Thus, erroneous decision can be reliably eliminated.

[0036] FIG. 4 is a pressure-enthalpy diagram in which the pressure in the receiver 15 is set close to the maximum enthalpy on the saturated gas line, and in which R410A refrigerant at around 2 MPa is extracted into the bypass circuit 31, reducing the temperature. The pressure-enthalpy diagram in an actual refrigerant filling operation is shown in FIG. 5. That is, although the discharge-side pressure of the compressor 10 is higher than the intermediate pressure in the receiver 15, without being influenced by this high pressure, by detecting the intermediate pressure in the receiver 15 from detected values obtained by the intermediate pressure sensor 36, the temperature sensor 37 that detects the temperature of the refrigerant flowing into the bypass circuit 31, the high pressure sensor 38, and the temperature sensor 39 that detects the degree of supercooling of the refrigerant at the outlet of the outdoor heat exchanger 13, or their converted values, and by controlling the intermediate pressure to the above-described value by controlling the rotational speed of the compressor 10, the rotational speed of the outdoor fan 13 that sends the outside air to the outdoor heat exchanger 12, or the degree of opening of the heating-mode expansion valve 14, the liquid refrigerant in the receiver 15 is on the saturated liquid line.

[0037] The saturated gas refrigerant and the saturated liquid refrigerant are extracted from the receiver 15 into the bypass circuit 31 and decompressed by the decompression mechanism 33 to reduce the temperature. By detecting the temperatures thereof with the temperature sensor 34, the amount of refrigerant can be accurately detected via the refrigerant-amount detecting unit 35 from the temperature difference.

According to this embodiment, without being influenced by the discharge-side pressure (high pressure) of the refrigerant that is affected by the outside air temperature or the like, or without providing a refrigerant heating unit in the bypass circuit 31, it is possible to ensure a sufficient temperature difference and enable precise detection of the amount of refrigerant filled, thereby making it possible to fill an appropriate amount of refrigerant (neither too much nor too little) and making it possible to operate the air conditioner stably.

[Second Embodiment]

[0038] Next, a second embodiment of the present invention will be described using FIG. 6.

5 This embodiment differs from the above-described first embodiment in that a hot-gas bypass circuit 40 is additionally provided. Because the other configurations are the same as those according to the first embodiment, the description thereof will be omitted.

10 In this embodiment, as shown in FIG. 6, the hot-gas bypass circuit 40 that can introduce a portion of the hot gas discharged from the compressor 10 into the receiver 15 is provided between the discharge pipe from the compressor 10 and the receiver 15. In this hot-gas bypass circuit 40, an electromagnetic on/off valve 41 and a decompression mechanism 42, such as a capillary tube or an expansion valve, are provided.

[0039] In this manner, by providing the hot-gas bypass circuit 40 having the electromagnetic on/off valve 41 and the decompression mechanism 42 between the discharge-side of the compressor 10 and the receiver 15 to allow a portion of the hot gas discharged from the compressor 10 to be introduced into the receiver 15, even when the intermediate pressure in the receiver 15 does not rise to the above-described pressure because of low outside air temperature during a refrigerant filling operation, by opening the electromagnetic on/off valve 41 to introduce the hot gas into the receiver 15 via the hot-gas bypass circuit 40, the intermediate pressure of the receiver 15 can be controlled to the above-described pressure.

[0040] Accordingly, even under conditions where the outside air temperature is low, the amount of refrigerant filled can be accurately detected, and hence, it is possible to fill an appropriate amount of refrigerant. Furthermore, this configuration makes it possible to easily raise the pressure under conditions where the outside air temperature is low. In general, the control to reduce the pressure is easy, and the control to raise the pressure is difficult. With this embodiment, however, the ease of pressure control when the outside air temperature is low can be increased. Furthermore, the hot-gas bypass circuit 40 can be effectively applied not only to the refrigerant filling operation, but also to high pressure control in a cooling operation when the outside air temperature is low, which is beneficial for increasing the area in which the air conditioner 1 can perform the cooling operation.

[0041] The present invention is not limited to the invention according to the above-described embodiments, but may be appropriately modified within a scope not departing from the spirit thereof. For example, although the bypass circuit 31 of the liquid-surface detecting circuit 30 is configured to be inserted from the top surface of the receiver 15 and connected thereto in the above-described embodiments, the bypass circuit 31 may be connected so as to be open at a predetermined height position in the receiver 15, and thus, the bypass circuit 31 may be inserted from the side surface or the lower surface

of the receiver 15 such that it is open at a predetermined height position.

{Reference Signs List}

[0042]

- 1 air conditioner
- 2 outdoor unit
- 3 indoor units
- 10 compressor
- 12 outdoor heat exchanger
- 13 outdoor fan
- 14 heating-mode electric expansion valve (heating-mode expansion valve)
- 15 receiver
- 20 indoor heat exchanger
- 22 cooling-mode electric expansion valve (cooling-mode expansion valve)
- 23 gas refrigerant pipe
- 24 liquid refrigerant pipe
- 25 refrigerant circuit
- 30 liquid-surface detecting circuit
- 31 bypass circuit
- 32 decompression mechanism
- 33 electromagnetic on/off valve
- 34 temperature sensor (temperature detecting unit)
- 35 refrigerant-amount detecting unit
- 36 intermediate pressure sensor
- 37 temperature sensor
- 38 high pressure sensor
- 39 temperature sensor
- 40 hot-gas bypass circuit

Claims

1. An air conditioner in which an outdoor unit including a compressor, an outdoor heat exchanger, a heating-mode expansion valve, and a receiver storing liquid refrigerant is connected to an indoor unit including an indoor heat exchanger and a cooling-mode expansion valve by a gas refrigerant pipe and a liquid refrigerant pipe, thereby forming a closed-cycle refrigerant circuit, the air conditioner comprising:
 - a liquid-surface detecting circuit in which a bypass circuit connecting a predetermined height position in the receiver to an intake side of the compressor has an on/off valve and a decompression mechanism;
 - a temperature detecting unit that detects a temperature of the refrigerant decompressed by the decompression mechanism and flowing in the liquid-surface detecting circuit; and
 - a refrigerant-amount detecting unit that controls an intermediate pressure in the receiver such

that a degree of superheating is 5 deg or more higher than a low-pressure saturated gas temperature and such that a saturated gas line on a pressure-enthalpy diagram is inclined toward an upper right, and that detects the temperature of the refrigerant extracted from the receiver into the liquid-surface detecting circuit with the temperature detecting unit, thereby determining an amount of refrigerant filled based on the detected temperature.

2. An air conditioner according to Claim 1, wherein the refrigerant-amount detecting unit is configured to control the intermediate pressure in the receiver to the above pressure by detecting the intermediate pressure based on a detected value or a converted value obtained by an intermediate pressure sensor, a temperature sensor that detects the temperature of the refrigerant extracted into the liquid-surface detecting circuit, a high pressure sensor, or a temperature sensor that detects a degree of supercooling of the refrigerant at an outlet of the outdoor heat exchanger, and by controlling a rotational speed of the compressor, a rotational speed of an outdoor fan that sends outside air to the outdoor heat exchanger, or a degree of opening of a heating-mode expansion valve.
3. An air conditioner according to Claim 1 or 2, wherein a hot-gas bypass circuit that raises the intermediate pressure in the receiver to the above pressure by introducing hot gas discharged from the compressor is provided between the discharge side of the compressor and the receiver.
4. A method of detecting an amount of refrigerant in an air conditioner in which an outdoor unit including a compressor, an outdoor heat exchanger, a heating-mode expansion valve, and a receiver storing liquid refrigerant is connected to an indoor unit including an indoor heat exchanger and a cooling-mode expansion valve by a gas refrigerant pipe and a liquid refrigerant pipe, thereby forming a closed-cycle refrigerant circuit, the method comprising:

controlling an intermediate pressure in the receiver such that a degree of superheating is 5 deg or more higher than a low-pressure saturated gas temperature and such that a saturated gas line on a pressure-enthalpy diagram is inclined toward the upper right during a refrigerant filling operation; extracting the intermediate pressure refrigerant into a liquid-surface detecting circuit connecting a predetermined height position in the receiver to an intake side of the compressor; and detecting a temperature of the refrigerant decompressed to a low-pressure state in the liquid-

surface detecting circuit, thereby determining the amount of refrigerant filled.

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FIG. 1

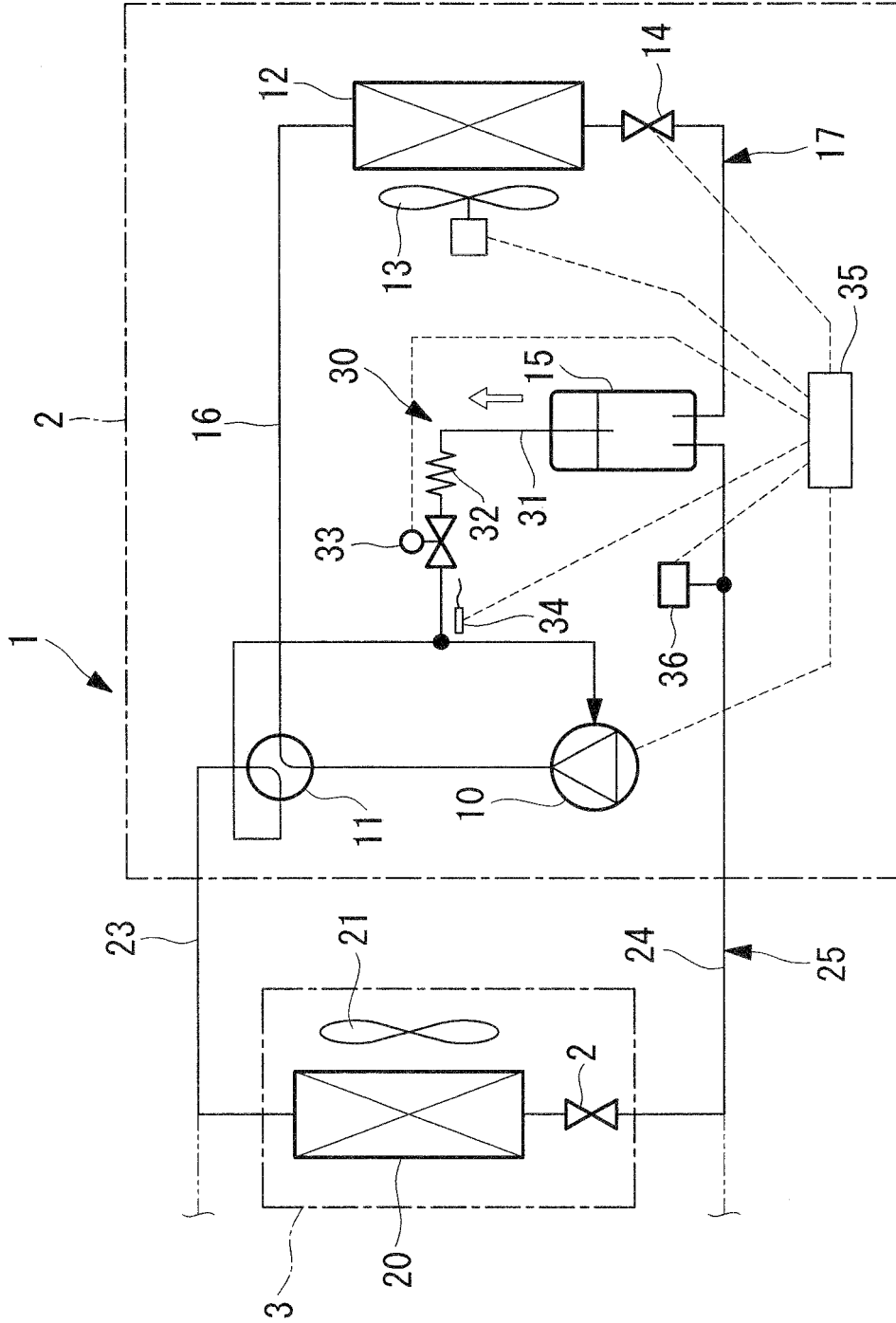


FIG. 2

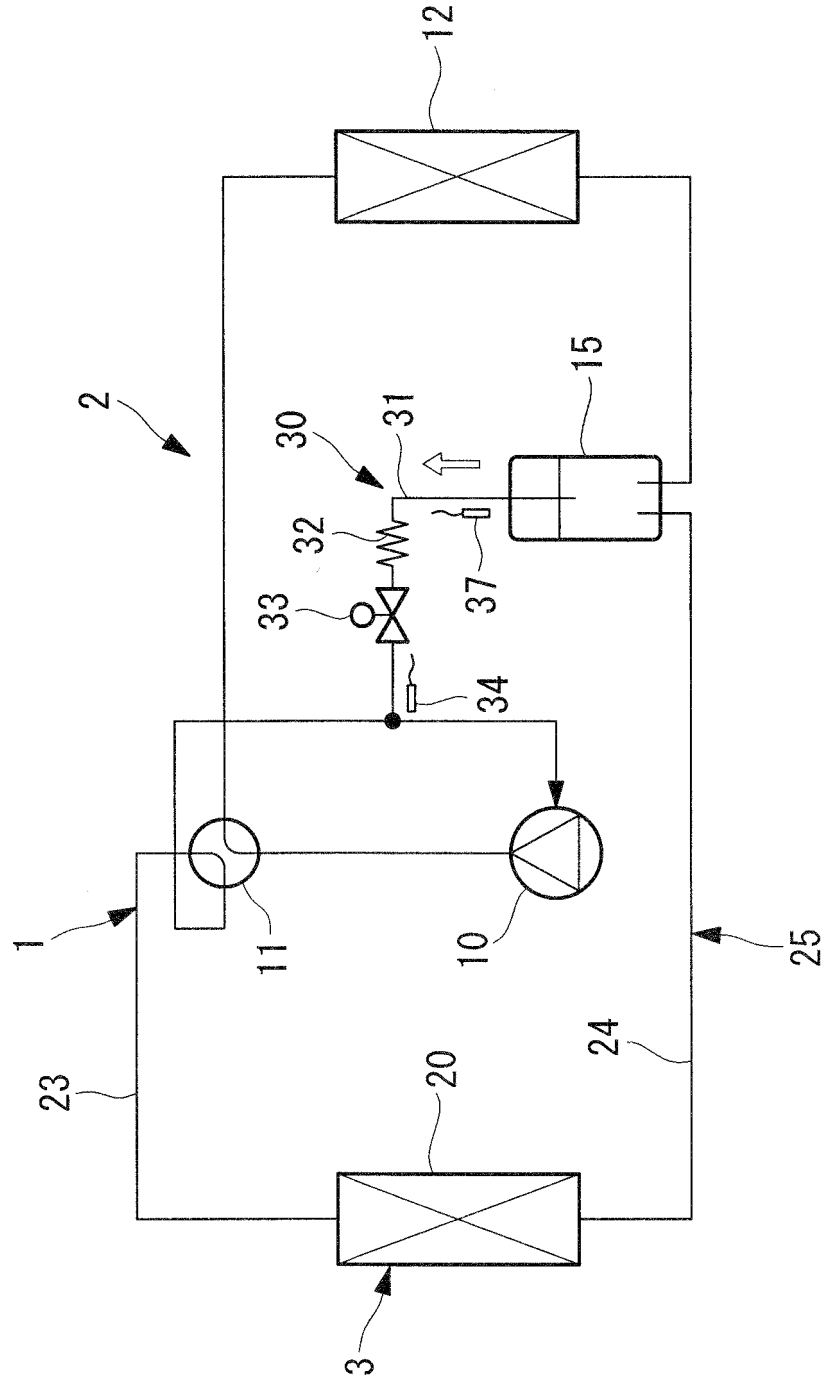


FIG. 3

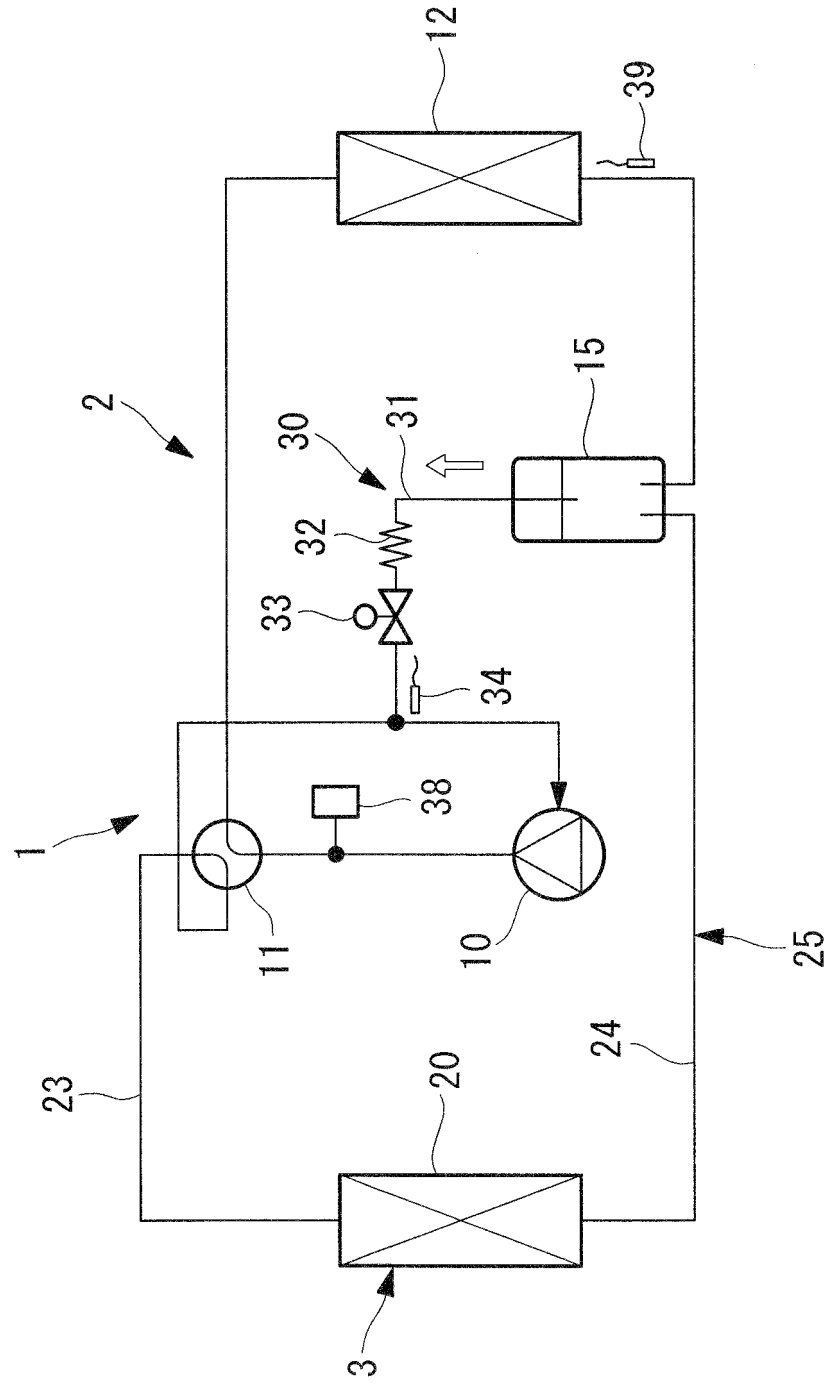


FIG. 4

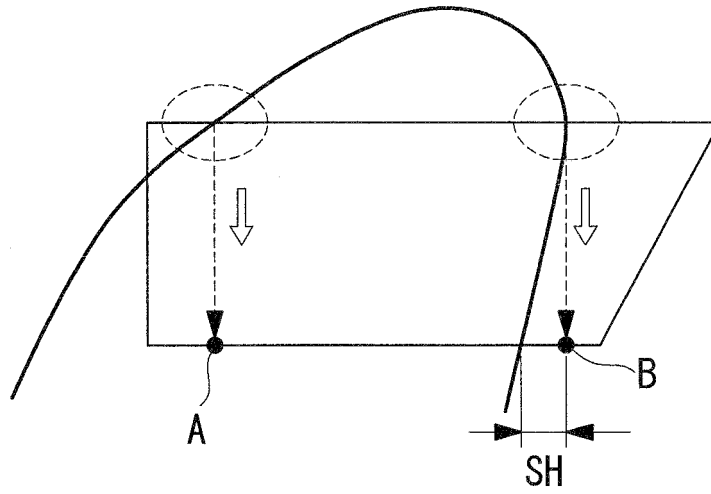


FIG. 5

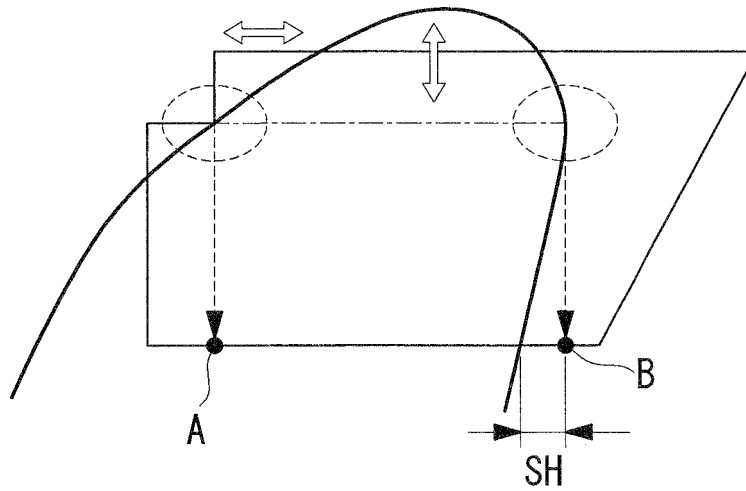
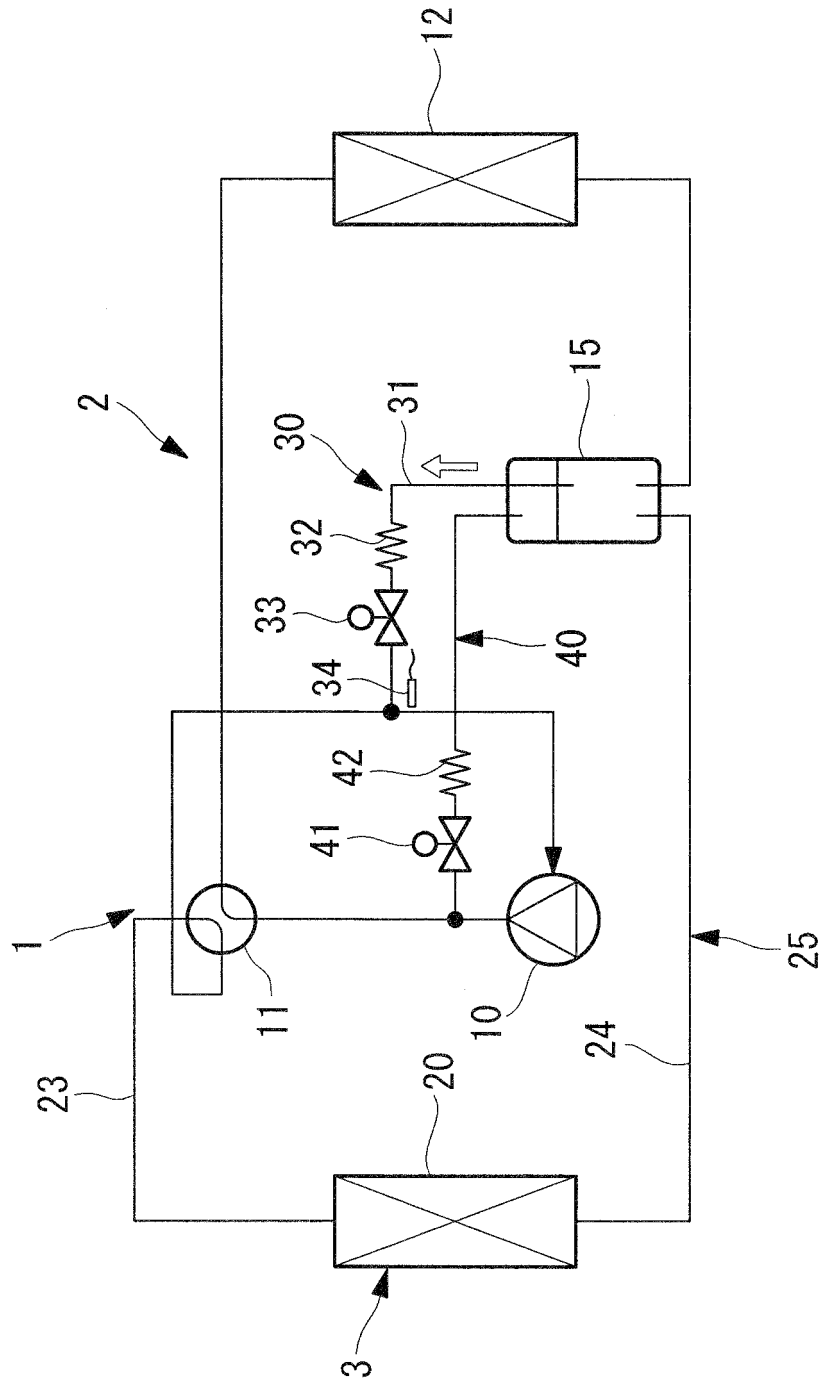


FIG. 6



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2010/071064

A. CLASSIFICATION OF SUBJECT MATTER F25B45/00(2006.01) i, F25B49/02(2006.01) i		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols) F25B45/00, F25B49/02		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2011 Kokai Jitsuyo Shinan Koho 1971-2011 Toroku Jitsuyo Shinan Koho 1994-2011		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 6-201234 A (Hitachi, Ltd.), 19 July 1994 (19.07.1994), paragraphs [0020] to [0038]; fig. 1 to 9 (Family: none)	1-4
Y	JP 2008-298335 A (Fujitsu General Ltd.), 11 December 2008 (11.12.2008), paragraphs [0059] to [0063]; fig. 1 to 3 (Family: none)	1-4
Y	JP 2004-218865 A (Daikin Industries, Ltd.), 05 August 2004 (05.08.2004), paragraphs [0002] to [0019]; fig. 10 to 15 & US 2008/0134700 A1 & EP 1582827 A1 & DE 60322589 D & CN 1692263 A & AT 403124 T & ES 2311746 T	1-4
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed		"I" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family
Date of the actual completion of the international search 18 February, 2011 (18.02.11)		Date of mailing of the international search report 01 March, 2011 (01.03.11)
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer
Facsimile No.		Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2010/071064

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 63-231154 A (Nakano Refrigerators Co., Ltd.), 27 September 1988 (27.09.1988), page 3, lower right column, lines 5 to 9; fig. 1 to 3 (Family: none)	3

REFERENCES CITED IN THE DESCRIPTION

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