



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
01.01.2025 Bulletin 2025/01

(21) Application number: **24183883.8**

(22) Date of filing: **24.06.2024**

(51) International Patent Classification (IPC):
F25B 13/00 (2006.01) **F25B 25/00** (2006.01)
F25B 41/00 (2021.01) **F25B 41/24** (2021.01)
F25B 41/39 (2021.01) **F25B 49/02** (2006.01)

(52) Cooperative Patent Classification (CPC):
F25B 13/00; F25B 25/005; F25B 41/00;
F25B 41/24; F25B 41/39; F25B 49/02;
F25B 2313/02741; F25B 2339/047;
F25B 2400/0403; F25B 2400/0409;
F25B 2400/0411; F25B 2400/16; F25B 2500/23;
F25B 2500/24; F25B 2600/2501; (Cont.)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL
NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
GE KH MA MD TN

(30) Priority: **26.06.2023 KR 20230081987**

(71) Applicant: **LG Electronics Inc.**
Yeongdeungpo-gu
Seoul 07336 (KR)

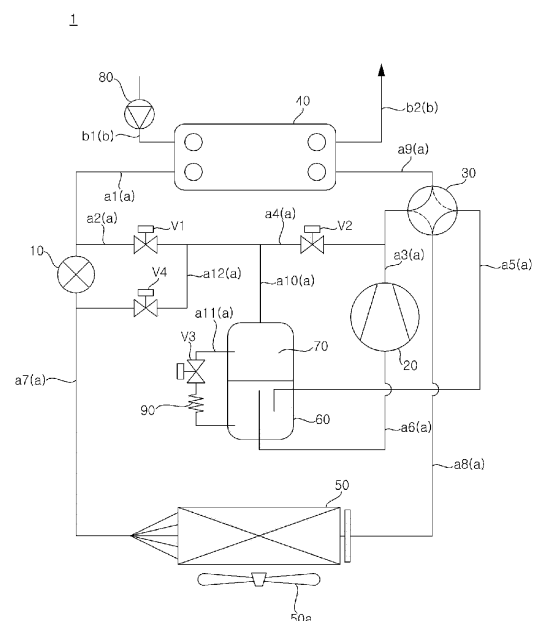
(72) Inventors:
• **HA, Doyong**
08592 Seoul (KR)
• **SHIN, Jeongseob**
08592 Seoul (KR)
• **OH, Seungtaek**
08592 Seoul (KR)
• **KIM, Hyunjong**
08592 Seoul (KR)
• **KWON, Kyongmin**
08592 Seoul (KR)

(74) Representative: **Vossius & Partner**
Patentanwälte Rechtsanwälte mbB
Siebertstrasse 3
81675 München (DE)

(54) **HEAT PUMP**

(57) A heat pump according to an embodiment of the present disclosure includes: a compressor configured to compress a refrigerant; an accumulator configured to supply the refrigerant to the compressor; a receiver connected to the accumulator; a water-refrigerant heat exchanger configured to exchange heat between water and the refrigerant; an outdoor heat exchanger configured to exchange heat between outdoor air and the refrigerant; a 4-way valve configured to guide the refrigerant, discharged from the compressor, to flow into the water-refrigerant heat exchanger or the outdoor heat exchanger; an expansion valve disposed between the water-refrigerant heat exchanger and the outdoor heat exchanger; a first valve disposed between the water-refrigerant heat exchanger and the receiver; a second valve disposed between the compressor and the receiver; and a third valve disposed between the receiver and the accumulator.

FIG. 1



(52) Cooperative Patent Classification (CPC): (Cont.)
F25B 2600/2513; F25B 2600/2519;
F25B 2600/2523

Description

[0001] The following description relates to a heat pump, and more particularly to a heat pump capable of operating in an optimal refrigerant condition.

[0002] Generally, a heat pump refers to a device for cooling or heating a room through processes of compression, condensation, expansion, and evaporation of a refrigerant. When an outdoor heat exchanger of the heat pump functions as a condenser and an indoor heat exchanger functions as an evaporator, the room may be cooled. When the indoor heat exchanger of the heat pump functions as a condenser and the outdoor heat exchanger functions as an evaporator, the room may be heated.

[0003] For example, the heat pump may be an Air-to-Water Heat Pump (AWHP) using water as a medium for heat exchange with the refrigerant. In this case, by using water heated by heat exchange with the refrigerant, the temperature of water stored in a water tank may increase such that hot water may be supplied to a room. Alternatively, as water heated by heat exchange with the refrigerant flows through a water pipe installed in an indoor space, the indoor space may be heated.

[0004] In a multi-heat pump in which multiple indoor units are connected to a single outdoor unit, a required amount of refrigerant varies depending on the number of operating indoor units. Even in the AWHP used for heating water, a cooling operation requires a large amount of refrigerant using a large outdoor heat exchanger, having a large internal volume, as a condenser, and a heating operation requires a small amount of refrigerant using a plate-shaped heat exchanger, having a small internal volume, as a condenser. If the amount of refrigerant is charged according to any one condition, performance is reduced in other conditions.

[0005] Published Korean Patent Publication No. 10-2023-0033633 (related art) discloses a structure for storing a refrigerant by connecting a buffer tank to a rear end of the condenser of a heat pump and for heating or cooling the buffer tank. As the structure disclosed in the related art is provided for adjusting the temperature of the buffer tank in a short time, it is difficult to selectively control a stored amount of refrigerant as desired.

[0006] It is an objective of the present disclosure to provide a heat pump capable of operating in an optimal refrigerant condition by adjusting a refrigerant amount according to an operating state.

[0007] It is another objective of the present disclosure to provide a heat pump capable of actively adjusting an amount of a circulating refrigerant according to a required amount of refrigerant.

[0008] It is yet another objective of the present disclosure to provide a heat pump with improved capability and efficiency.

[0009] It is further another objective of the present disclosure to provide a heat pump capable of operating at maximum capability and efficiency while ensuring there

is no shortage of refrigerant even during a cooling operation.

[0010] The objectives of the present disclosure are not limited to the aforementioned objectives and other objectives not described herein will be clearly understood by those skilled in the art from the following description.

[0011] In order to achieve the above objectives, a heat pump according to an embodiment of the present disclosure may actively adjust a refrigerant amount according to a required amount of refrigerant by storing a refrigerant in a refrigerant storage device (receiver) or by discharging the refrigerant therefrom, thereby operating in an optimal refrigerant condition.

[0012] In order to achieve the above objectives, by using a device for storing a refrigerant according to a required amount of refrigerant, a heat pump according to an embodiment of the present disclosure may operate in an optimal refrigerant condition regardless of operating conditions, such as indoor temperature, outdoor temperature, compressor frequency, etc., and operating modes such as cooling, heating, and the like.

[0013] In order to achieve the above objectives, a heat pump according to an embodiment of the present disclosure may operate with improved capability and efficiency by charging a refrigerant in an amount corresponding to the case where a maximum amount of refrigerant is required, and by adjusting the refrigerant amount according to an operating state. Particularly, the heat pump may operate at maximum capability and efficiency while ensuring there is no shortage of refrigerant even during a cooling operation.

[0014] In accordance with an aspect of the present disclosure, the above and other objectives can be accomplished by providing a heat pump including: a compressor configured to compress a refrigerant; an accumulator configured to supply the refrigerant to the compressor; a receiver connected to the accumulator; a water-refrigerant heat exchanger configured to exchange heat between water and the refrigerant; an outdoor heat exchanger configured to exchange heat between outdoor air and the refrigerant; a 4-way valve configured to guide the refrigerant, discharged from the compressor, to flow into the water-refrigerant heat exchanger or the outdoor heat exchanger; an expansion valve disposed between the water-refrigerant heat exchanger and the outdoor heat exchanger; a first valve disposed between the water-refrigerant heat exchanger and the receiver; a second valve disposed between the compressor and the receiver; and a third valve disposed between the receiver and the accumulator.

[0015] During a heating operation, in response to the first valve and the third valve being opened, a portion of a refrigerant having passed through the water-refrigerant heat exchanger may flow to the receiver, and in response to the second valve and the third valve being opened, a refrigerant stored in the receiver may flow to the accumulator.

[0016] The heat pump may further include a controller

configured to control opening and closing of the first to third valves based on a refrigerant amount during operation.

[0017] During the heating operation, in response to a subcooling degree being higher than an upper-limit reference value, the controller may be configured to control the first valve and the third valve to be opened; and during the heating operation, in response to the subcooling degree being lower than a lower-limit reference value, the controller may be configured to control the second valve and the third valve to be opened.

[0018] During the heating operation, the controller may be configured to control the 4-way valve to guide the refrigerant, discharged from the compressor, to flow into the water-refrigerant heat exchanger.

[0019] The heat pump may further include a capillary tube disposed between the third valve and the accumulator.

[0020] The heat pump may further include a fourth valve disposed between the outdoor heat exchanger and the receiver.

[0021] During a cooling operation, in response to the fourth valve and the third valve being opened, a portion of a refrigerant having passed through the outdoor heat exchanger may flow to the receiver, and in response to the second valve and the third valve being opened, a refrigerant stored in the receiver may flow to the accumulator.

[0022] The heat pump may further include a controller configured to control opening and closing of the first to fourth valves based on a refrigerant amount during operation.

[0023] During the heating operation, in response to a subcooling degree being higher than an upper-limit reference value, the controller may be configured to control the first valve and the third valve to be opened and the second valve and the fourth valve to be closed; and during the heating operation, in response to the subcooling degree being lower than a lower-limit reference value, the controller may be configured to control the second valve and the third valve to be opened and the first valve and the fourth valve to be closed.

[0024] During the cooling operation, in response to a subcooling degree being higher than an upper-limit reference value, the controller may be configured to control the fourth valve and the third valve to be opened and the first valve and the second valve to be closed; and during the cooling operation, in response to the subcooling degree being lower than a lower-limit reference value, the controller may be configured to control the second valve and the third valve to be opened and the first valve and the fourth valve to be closed.

[0025] During the cooling operation, the controller may be configured to control the 4-way valve to guide the refrigerant, discharged from the compressor, to flow into the outdoor heat exchanger; and during the heating operation, the controller may be configured to control the 4-way valve to guide the refrigerant, discharged from the

compressor, to flow into the water-refrigerant heat exchanger.

[0026] The controller may be configured to control the first to fourth valves to be closed during a set initial stabilization period.

[0027] The heat pump may further include: a first pipe connecting the water-refrigerant heat exchanger and the expansion valve; and a second pipe branching from the first pipe to be connected to the receiver, wherein the first valve may be located in the second pipe.

[0028] The expansion valve may include: a first expansion valve disposed between the water-refrigerant heat exchanger and the first valve; and a second expansion valve disposed between the outdoor heat exchanger and the second valve.

[0029] During the heating operation, the first expansion valve may be opened to a maximum opening degree, and the second expansion valve may expand the refrigerant; and during the cooling operation, the first expansion valve may expand the refrigerant, and the second expansion valve may be opened to a maximum opening degree.

[0030] A heat pump according to another embodiment of the present disclosure includes: a compressor configured to compress a refrigerant; an accumulator configured to supply the refrigerant to the compressor; a receiver connected to the accumulator; a water-refrigerant heat exchanger configured to exchange heat between water and the refrigerant; an outdoor heat exchanger configured to exchange heat between outdoor air and the refrigerant; a 4-way valve configured to guide the refrigerant, discharged from the compressor, to flow into the water-refrigerant heat exchanger or the outdoor heat exchanger; a first expansion valve and a second expansion valve disposed between the water-refrigerant heat exchanger and the outdoor heat exchanger; a first valve disposed between the water-refrigerant heat exchanger and the receiver; a second valve disposed between the compressor and the receiver; and a third valve disposed between the receiver and the accumulator, wherein the first valve may be connected between the first expansion valve and the second expansion valve.

[0031] A heat pump according to yet another embodiment of the present disclosure includes: a compressor configured to compress a refrigerant; an accumulator configured to supply the refrigerant to the compressor; a receiver connected to the accumulator; at least one two-way indoor unit for both cooling and heating, each indoor unit including an indoor heat exchanger; an outdoor heat exchanger configured to exchange heat between outdoor air and the refrigerant; a 4-way valve configured to guide the refrigerant, discharged from the compressor, to flow into the indoor unit or the outdoor heat exchanger; an expansion valve disposed between the indoor unit and the outdoor heat exchanger; a first valve disposed between the indoor unit and the receiver; a second valve disposed between the compressor and the receiver; and a third valve disposed between the receiver and the ac-

cumulator.

[0032] During the heating operation, the expansion valve may expand the refrigerant, and an expansion valve on an indoor unit side may be opened to a maximum opening degree; and during the cooling operation, the expansion valve may be opened to a maximum opening degree, and the expansion valve on the indoor unit side may expand the refrigerant.

[0033] A heat pump according to yet another embodiment of the present disclosure includes: a compressor configured to compress a refrigerant; an accumulator configured to supply the refrigerant to the compressor; a receiver connected to the accumulator; an indoor heat exchanger configured to exchange heat between water or indoor air and the refrigerant; an outdoor heat exchanger configured to exchange heat between outdoor air and the refrigerant; a 4-way valve configured to guide the refrigerant, discharged from the compressor, to flow into the indoor heat exchanger or the outdoor heat exchanger; an expansion valve disposed between the indoor heat exchanger and the outdoor heat exchanger; a first valve disposed between the indoor heat exchanger and the receiver; a second valve disposed between the compressor and the receiver; and a third valve disposed between the receiver and the accumulator; and a fourth valve disposed between the outdoor heat exchanger and the receiver.

[0034] According to at least one of the embodiments of the present disclosure, a heat pump may operate in an optimal refrigerant condition by adjusting a refrigerant amount according to an operating state.

[0035] According to at least one of the embodiments of the present disclosure, an amount of a circulating refrigerant may be actively adjusted according to a required amount of refrigerant.

[0036] According to at least one of the embodiments of the present disclosure, a heat pump with improved capability and efficiency may be provided.

[0037] According to at least one of the embodiments of the present disclosure, a heat pump may operate at maximum capability and efficiency while ensuring there is no shortage of refrigerant even during a cooling operation.

[0038] Various other effects will be directly or implicitly described below in the following detailed description of embodiments of the present disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0039]

FIG. 1 is a diagram illustrating the configuration of a heat pump according to an embodiment of the present disclosure.

FIGS. 2 to 4 are diagrams referred to in the description of a heating operation of a heat pump and a refrigerant flow therein according to an embodiment of the present disclosure.

FIGS. 5 to 7 are diagrams referred to in the description of a heating operation of a heat pump and a refrigerant flow therein according to an embodiment of the present disclosure.

FIG. 8 is a flowchart illustrating an operating method of a heat pump according to an embodiment of the present disclosure.

FIG. 9 is a diagram illustrating the configuration of a heat pump according to an embodiment of the present disclosure.

FIG. 10 is a diagram referred to in the description of a heating operation of a heat pump and a refrigerant flow therein according to an embodiment of the present disclosure.

FIG. 11 is a diagram referred to in the description of a cooling operation of a heat pump and a refrigerant flow therein according to an embodiment of the present disclosure.

FIG. 12 is a diagram illustrating the configuration of a heat pump according to an embodiment of the present disclosure.

FIG. 13 is a block diagram illustrating a heat pump according to an embodiment of the present disclosure.

[0040] Hereinafter, embodiments of the present disclosure will be described in detail with reference to the accompanying drawings. However, it is understood that the present disclosure is not limited to these embodiments and may be modified in various forms.

[0041] In the drawings, in order to clearly and briefly describe embodiments of the present disclosure, the illustration of parts irrelevant to the description is omitted, and the same reference numerals are used for the same or extremely similar parts throughout the specification.

[0042] The suffixes, such as "module" and "unit," for elements used in the following description are given simply in view of the ease of the description, and do not have a distinguishing meaning or role. Accordingly, the terms "module" and "unit" may be used interchangeably.

[0043] It will be understood that although the terms, "first," "second," etc., may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another.

[0044] FIG. 1 is a diagram illustrating the configuration of a heat pump according to an embodiment of the present disclosure.

[0045] Generally, a heat pump is a device for cooling or heating a room through processes of compression, condensation, expansion, and evaporation of a refrigerant. A heat pump 1 may include outdoor and indoor units for forming a cycle, and the outdoor unit and the indoor unit may respectively include an outdoor heat exchanger 50 located outdoors and an indoor heat exchanger 40 located indoors.

[0046] The heat pump 1 according to an embodiment of the present disclosure utilizes air and water as a heat

source. In the heat pump 1 according to an embodiment of the present disclosure, a refrigerant exchanges heat with outdoor air in the outdoor heat exchanger 50, and exchanges heat with water in the indoor heat exchanger 40. Here, various types of refrigerants, including R290,

[0047] The indoor heat exchanger 40 may be a water-refrigerant heat exchanger 40 for heat exchange between the refrigerant and water. The direction of heat transfer between the refrigerant and water in the water-refrigerant heat exchanger 40 may vary depending on cooling and heating operating modes of the heat pump 1. After water exchanges heat with the refrigerant in the water-refrigerant heat exchanger 40, the water is introduced into a room to cool or heat the room or to provide cold or hot water to the room.

[0048] The water-refrigerant heat exchanger 40 may be a plate heat exchanger. Here, the plate heat exchanger may include a plurality of heat transfer plates that are stacked on top of each other, and the refrigerant and water introduced into the plate heat exchanger may flow along a flow path formed between the plurality of heat transfer plates, and may exchange heat with each other in a noncontact manner.

[0049] As described above, the heat pump 1 according to an embodiment of the present disclosure is an air-to-water heat exchanger type heat pump, and may be referred to as an air-to-water heat pump (AWHP).

[0050] Referring to FIG. 1, the heat pump 1 may include a compressor 20 configured to compress a refrigerant, an accumulator 60 configured to supply a refrigerant to the compressor 20, a water-refrigerant heat exchanger 40 configured to exchange heat between water and refrigerant, an outdoor heat exchanger 50 configured to exchange heat between outdoor air and the refrigerant, a 4-way valve 30 configured to guide the refrigerant, discharged from the compressor 20, to the water-refrigerant heat exchanger 40 or the outdoor heat exchanger 50, and an expansion valve 10 disposed between the water-refrigerant heat exchanger 40 and the outdoor heat exchanger 50.

[0051] The compressor 20 may compress the refrigerant introduced from the accumulator 60, and may be driven by a compressor motor (not shown). The compressor 20 may compress the refrigerant introduced from the accumulator 60, and may discharge the compressed refrigerant in a high-temperature and high-pressure state. For example, the compressor 20 may be an inverter compressor capable of controlling an amount of refrigerant and a discharge pressure of the refrigerant by adjusting an operating frequency.

[0052] The refrigerant compressed by the compressor 20 may pass through the 4-way valve 30 to flow into the outdoor heat exchanger 50 or the indoor heat exchanger 40 according to a cooling or heating operation mode of the heat pump 1.

[0053] The outdoor heat exchanger 50 may exchange heat between the refrigerant and outdoor air. The direc-

tion of heat transfer between the refrigerant and the outdoor air in the outdoor heat exchanger 50 may vary according to a cooling or heating operation mode of the heat pump 1.

[0054] An outdoor fan 50a may be disposed on one side of the outdoor heat exchanger 50 to control an amount of air supplied to the outdoor heat exchanger 50. The outdoor fan 50a may be driven by the outdoor fan motor (not shown).

[0055] The expansion valve 10 may receive the condensed refrigerant from any one of the outdoor heat exchanger 50 and the indoor heat exchanger 40 according to a cooling or heating operation mode of the heat pump 1. The expansion valve 10 may expand the condensed refrigerant. The refrigerant expanded by the expansion valve 10 may flow into the outdoor heat exchanger 50 or the indoor heat exchanger 40 according to a cooling or heating operation mode of the heat pump 1. The expansion valve 10 may be an Electronic Expansion Valve (EEV).

[0056] The 4-way valve 30 may guide the refrigerant, discharged from the compressor 20, to selectively flow into either the outdoor heat exchanger 50 or the indoor heat exchanger 40 according to a cooling or heating operation mode of the heat pump 1.

[0057] A controller 1310 which will be described later may adjust the 4-way valve 30 to guide the refrigerant, discharged from the compressor 20, to flow into the outdoor heat exchanger when cooling a room, and may adjust the 4-way valve 30 to guide the refrigerant, discharged from the compressor 20, to flow into the water-refrigerant heat exchanger 40 when heating a room.

[0058] The controller 1310 may be electrically connected to the respective components of the heat pump 1. The controller 1310 may control the respective components of the heat pump according to an operation mode of the heat pump. As described above, the heat pump 1 may supply cold or hot water to a room according to an operation mode, and the cold water or hot water may be supplied to the kitchen, restroom or bathroom, etc., and may be provided for cooling or heating a room.

[0059] The heat exchanger in the AWHP is generally composed of a fin and tube heat exchanger for heat exchange between air and refrigerant, and a plate heat exchanger for heat exchange between refrigerant and water. During a heating operation, a high-temperature and high-pressure refrigerant discharged from the compressor passes through the plate heat exchanger to heat water, and the refrigerant is condensed and transformed into a liquid refrigerant, and then is expanded by the expansion device to change to a low-temperature and low-pressure two-phase refrigerant, to be evaporated by an evaporator (fin and tube heat exchanger) to enter the compressor.

[0060] The plate heat exchanger used as a condenser during a heating operation has a smaller internal volume than the fin and tube heat exchanger, such that an optimal refrigerant amount is smaller compared to a cooling op-

eration, and if an amount of refrigerant is excessive, high pressure rises excessively and efficiency is reduced.

[0061] The fin and tube heat exchanger used as a condenser during a cooling operation has a large internal volume and is filled with a high-pressure liquid refrigerant, such that a large optimal refrigerant amount is required. If an amount of refrigerant is small, sufficient subcooling may not be obtained due to the lack of refrigerant in the condenser (fin and tube heat exchanger), and a sufficient amount of refrigerant may not flow through the expansion device, thereby causing insufficient cooling capacity.

[0062] Accordingly, in the AWHP, it is required to charge an optimal amount of refrigerant by finding an appropriate value between cooling and heating operations, and no refrigerant amount is optimal for both the cooling and heating operations.

[0063] Referring to FIG. 1, the heat pump 1 further includes a receiver 70 connected to the accumulator 60. The receiver 70 may be disposed separately from the accumulator 60. Alternatively, the receiver 70 and the accumulator 60 may be integrally formed with each other. For example, the receiver 70 may be formed by dividing the upper part of an internal space of the accumulator 60.

[0064] The receiver 70 stores a refrigerant exceeding a refrigerant amount required for the heat exchangers 40 and 60. For example, if a refrigerant load or a heating load is reduced, a required amount of refrigerant decreases, and as the required amount of refrigerant decreases, a portion of the refrigerant may be stored in the receiver 70. If a refrigerant load or a heating load increases, a required amount of refrigerant increases, and as the required amount of refrigerant increases, the refrigerant stored in the receiver 70 may be discharged.

[0065] The heat pump 1 may actively adjust an amount of refrigerant according to a required amount of refrigerant by storing a refrigerant in the receiver 70 which is a refrigerant storage device, or by discharging the refrigerant stored in the receiver 70, such that a sufficient amount of refrigerant may be charged into the heat pump 1, and the heat pump 1 may operate in an optimal refrigerant condition.

[0066] That is, according to the present disclosure, a refrigerant is charged in an amount corresponding to the case where a maximum amount of refrigerant is required, and the refrigerant amount is adjusted according to an operating state, thereby improving capability and efficiency. Particularly, the heat pump may operate at maximum capability and efficiency while ensuring there is no shortage of refrigerant even during a cooling operation.

[0067] In addition, by using the receiver 70 capable of storing the refrigerant according to a required amount of refrigerant, the heat pump 1 may operate in an optimal refrigerant condition in response to each operating mode and operating condition, regardless of changes in operating modes, such as cooling, heating, etc., and operating conditions, such as indoor temperature, outdoor temperature, compressor frequency, and the like.

[0068] The receiver 70 may be mounted at an outlet

of the condenser based on heating. During the heating operation, the refrigerant passes through the receiver immediately after passing through the condenser (plate heat exchanger), such that the refrigerant, which is present in an amount more than necessary, may be stored as liquid in the receiver during a heating operation. During a cooling operation, after the refrigerant passes through the condenser and the expansion device, the refrigerant passes through the receiver in a low-pressure two-phase state, such that an amount of liquid refrigerant filled in the receiver is not large, and the refrigerant required for the cooling operation may be obtained.

[0069] However, by merely mounting the receiver 70 at the outlet of the condenser based on heating, it is not possible to precisely respond to a required amount of refrigerant under various operating conditions, such as indoor temperature (inflow temperature in the case of AWHP), outdoor temperature, compressor frequency, and the like. Particularly, in a multi-heat pump including a plurality of indoor units, an optimal amount of refrigerant varies according to the number of indoor units in operation, such that optimal operation cannot be provided using only the receiver 70.

[0070] Accordingly, the heat pump 1 according to the present disclosure further includes a refrigerant amount control valve 1320 (see FIG. 13) for controlling an amount of refrigerant to be stored in the receiver 70 or to be discharged from the receiver 70. The controller 1310 may adjust the refrigerant amount by controlling opening and closing of the refrigerant amount control valve 1320.

[0071] According to an embodiment of the present disclosure, the refrigerant amount control valve 1320 may include a first valve V1 disposed between the indoor heat exchanger 40 (e.g., the water-refrigerant heat exchanger 40) and the receiver 70, a second valve V2 disposed between the compressor 20 and the receiver 70, and a third valve V3 disposed between the receiver 70 and the accumulator 60.

[0072] According to an embodiment of the present disclosure, the refrigerant amount control valve 1320 may include a fourth valve V4 disposed between the outdoor heat exchanger 50 and the receiver 70.

[0073] Referring to FIG. 1, parts on the refrigerant side of the heat pump 1 includes the compressor 20, the 4-way valve 30, the water-refrigerant heat exchanger 40, the expansion valve 10, the outdoor heat exchanger 50, the accumulator 60, and the receiver 70. The refrigerant may exchange heat with water in the water-refrigerant heat exchanger 40.

[0074] The controller 1310 controls a refrigerant flow direction according to a cooling or heating operation. According to a cooling or heating operation, the controller 1310 controls the 4-way valve 30 to guide the refrigerant, discharged from the compressor 20, to flow into the water-refrigerant heat exchanger 40 or the outdoor heat exchanger 50.

[0075] FIGS. 2 to 4 are diagrams referred to in the description of a heating operation of a heat pump and a

refrigerant flow therein according to an embodiment of the present disclosure. FIG. 2 illustrates a refrigerant flow direction during a heating operation. FIG. 3 illustrates an example of using the receiver 70 when an amount of refrigerant is excessive, and FIG. 4 illustrates an example using the receiver 70 when an amount of refrigerant is insufficient.

[0076] The controller 1310 may adjust the amount of refrigerant according to an operating state by controlling the refrigerant amount control valve 1320 to store the refrigerant in the receiver 70 to discharge the refrigerant from the receiver 70. Accordingly, the refrigerant may be charged into the heat pump 1 in a sufficient amount that satisfies the case where a maximum amount of refrigerant is required. Accordingly, the heat pump 1 may operate at maximum capability and efficiency while ensuring there is no shortage of refrigerant even during a cooling operation.

[0077] During a heating operation, the controller 1310 controls the 4-way valve 40 to guide the refrigerant, discharged from the compressor 20, to flow into the water-refrigerant heat exchanger 40.

[0078] Referring to FIG. 2, during the heating operation, the refrigerant passes through the compressor 20, the 4-way valve 30, the water-refrigerant heat exchanger 40, the expansion valve 10, the outdoor heat exchanger 50, the 4-way valve 30, and the accumulator 60, to enter to the compressor 20 again.

[0079] A low-temperature and low-pressure refrigerant flowing from the accumulator 60 into the compressor 20 may be discharged in a high-temperature and high-pressure state from the compressor 20.

[0080] The refrigerant discharged from the compressor 20 flows into the water-refrigerant heat exchanger 40 through the 4-way valve 30, to exchange heat with water. In this case, as heat energy is transferred from the refrigerant to water, water temperature rises, and the refrigerant is condensed, such that the water-refrigerant heat exchanger 40 during the heating operation may be understood as a condenser. In this case, water with increased temperature is supplied to a room, thereby heating the indoor space. Alternatively, hot water may be supplied to the room.

[0081] The refrigerant, having passed through the water-refrigerant heat exchanger 40, may be expanded into a low-temperature and low-pressure state while passing through the expansion valve 10.

[0082] The refrigerant, having passed through the expansion valve 10, flows into the outdoor heat exchanger 50 to exchange heat with outdoor air. In this case, as heat energy of the outdoor air is transferred to the refrigerant, the outdoor air temperature decreases, and the refrigerant is evaporated, such that the outdoor heat exchanger 50 during the heating operation may be understood as an evaporator.

[0083] The refrigerant, having passed through the outdoor heat exchanger 50, flows into the accumulator 60 through the 4-way valve 30. The accumulator 60 may

supply a gaseous refrigerant to the compressor 20, thereby completing a heating cycle of the heat pump 1.

[0084] Referring to FIG. 3, when the first valve V1 and the third valve V3 are opened, a portion of the refrigerant having passed through the water-refrigerant heat exchanger 40 may flow into the receiver 70 to be stored therein.

[0085] During the heating operation, there is basically a large amount of refrigerant in the heat pump 1, such that the refrigerant is stored in the receiver 70. Upon determining that there is an excessive amount of refrigerant during the heating operation, the controller 1310 opens the first valve V1 and the third valve V3. During the heating operation, the refrigerant exiting the water-refrigerant heat exchanger 40 is a high-pressure liquid refrigerant, such that the refrigerant flows into the receiver 70 through the first valve V1 to be stored in the receiver 70.

[0086] The third valve V3 allows the refrigerant to smoothly enter the receiver 70 through the first valve V1. In addition, a capillary tube 90 may be disposed at a rear end of the third valve V3. The capillary tube 90 may be disposed between the third valve V3 and the accumulator 60. The capillary tube 90 may limit the amount and rate of refrigerant flowing into or discharged from the receiver 70. By providing the capillary tube 90 at the rear end of the third valve V3, it is possible to prevent a liquid refrigerant from directly entering the accumulator 60 when the third valve V3 is open.

[0087] Upon determining that a refrigerant amount is appropriate for heating, the controller 1310 closes the first valve V1 and the third valve V3.

[0088] If the refrigerant is charged based on a cooling operation, there is basically an excessive amount of refrigerant in many cases. However, even during the heating operation, an optimal amount of refrigerant may vary depending on the outdoor temperature, the inflow temperature in the water-refrigerant heat exchanger 40, a compressor frequency, etc., such that there may be cases of insufficient amount of refrigerant.

[0089] Upon determining that the refrigerant amount is insufficient during the heating operation, the controller 1310 opens the second valve V2 and the third valve V3. Referring to FIG. 4, when the second valve V2 and the third valve V3 are opened, the refrigerant stored in the receiver 70 flows to the accumulator 60 to be used again for a cooling cycle.

[0090] The controller 1310 opens the second valve V2 and the third valve V3 to guide the refrigerant in the receiver 70 to flow into the accumulator 60, thereby increasing an amount of a circulating refrigerant. When the second valve V2 and the third valve V3 are opened, high-pressure gas at the outlet of the compressor 20 pushes the liquid refrigerant so that the refrigerant in the receiver 70 is discharged through the third valve V3, and the receiver 70 is filled with the gas such that an amount of refrigerant flowing in the product increases.

[0091] The controller 1310 controls opening and closing of the first valve V1, the second valve V2, and the

third valve V3 based on a current refrigerant amount and a refrigerant amount required for heating load response during a heating operation.

[0092] Upon determining that the current refrigerant amount is greater than the required refrigerant amount, the controller 1310 opens the first valve V1 and the third valve V3 to store a remaining amount of refrigerant in the receiver 70.

[0093] In addition, upon determining that the current refrigerant amount is smaller than the required refrigerant amount, the controller 1310 opens the second valve V2 and the third valve V3 to discharge the refrigerant stored in the receiver 70, thereby increasing an amount of a circulating refrigerant.

[0094] Various methods of determining the amount of refrigerant may be used to determine whether an amount of refrigerant is excessive or insufficient. For example, an excessive or insufficient amount of refrigerant may be determined based on a degree of subcooling. By setting an upper-limit reference value and a lower-limit reference value of a subcooling degree, and if a subcooling degree is higher than the upper-limit reference value, it is determined that there is a large amount of refrigerant, and if a subcooling degree is lower than the lower-limit reference value, it is determined that there is a small amount of refrigerant. The upper-limit and lower-limit reference values of the subcooling degree may be set within an appropriate range of subcooling degrees for responding to a heating load or a cooling load.

[0095] A large or small amount of refrigerant may be checked based on the subcooling degree of the product during a cooling or heating operation. The controller 1310 may determine the subcooling degree based on data measured by sensors of a sensor unit 1330 (see FIG. 13).

[0096] For example, the controller 1310 may determine a subcooling degree of the water-refrigerant heat exchanger 40. The controller 1310 may measure a subcooling degree of the water-refrigerant heat exchanger 40 based on an inlet temperature and an outlet temperature of the water-refrigerant heat exchanger 40 which are detected by a temperature sensor. Alternatively, the controller 1310 may measure a subcooling degree of the outdoor heat exchanger 50 based on an inlet temperature and an outlet temperature of the outdoor heat exchanger 50 which are detected by the temperature sensor. In addition, in the case where the heat pump 1 further includes a supercooling apparatus, the temperature of a pipe connected to the supercooling apparatus may also be used to determine the subcooling degree. Further, the controller 1310 may determine a subcooling degree by comparing a condensing temperature with the pipe temperature or the outlet temperature of the indoor unit, depending on whether a cooling operation or a heating operation is performed.

[0097] If a subcooling degree is higher than an upper-limit reference value, the controller 1310 controls the first valve V1 and the second valve V2 to be opened, and if the subcooling degree is lower than a lower-limit refer-

ence value, the controller 1310 controls the second valve V2 and the third valve V3 to be opened.

[0098] During the heating operation, the controller 1310 controls opening and closing of the first valve V1, the second valve V2, the third valve V3, and the fourth valve V4 based on a current refrigerant amount and an amount of refrigerant required for responding to a heating load.

[0099] For example, if a subcooling degree is higher than an upper-limit reference value during the heating operation, the controller 1310 controls the first valve V1 and the third valve V3 to be opened and the second valve V2 and the fourth valve V4 to be closed.

[0100] In addition, if the subcooling degree is lower than a lower-limit reference value during the heating operation, the controller 1310 controls the second valve V2 and the third valve V3 to be opened and the first valve V1 and the fourth valve V4 to be closed.

[0101] FIGS. 5 to 7 are diagrams referred to in the description of a heating operation of a heat pump and a refrigerant flow therein according to an embodiment of the present disclosure. FIG. 5 illustrates a refrigerant flow direction during a cooling operation. FIG. 6 illustrates an example of using the receiver 70 when an amount of refrigerant is excessive, and FIG. 7 illustrates an example of using the receiver 70 when an amount of refrigerant is insufficient.

[0102] During the heating operation, the controller 1310 controls the 4-way valve 30 to guide the refrigerant, discharged from the compressor 20, to flow into the water-refrigerant heat exchanger 40.

[0103] In addition, during the cooling operation, the controller 1310 controls the 4-way valve 30 to guide the refrigerant, discharged from the compressor 20, to flow into the outdoor heat exchanger 50.

[0104] Referring to FIG. 5, during the cooling operation, the refrigerant passes through the compressor 20, the 4-way valve 30, the outdoor heat exchanger 50, the expansion valve 10, the water-refrigerant heat exchanger 40, the 4-way valve 30, and the accumulator 60, to enter the compressor 20 again.

[0105] The low-temperature and low-pressure refrigerant flowing from the accumulator 60 into the compressor 20 may be discharged in a high-temperature and high-pressure state from the compressor 20.

[0106] The refrigerant discharged from the compressor 20 flows into the outdoor heat exchanger 50 through the 4-way valve 30, to exchange heat with outdoor air. In this case, as heat energy is transferred from the refrigerant to the outdoor air, outdoor air temperature rises, and the refrigerant is condensed, such that the outdoor heat exchanger 50 during the cooling operation may be understood as a condenser.

[0107] The refrigerant, having passed through the outdoor heat exchanger 50, may be expanded into a low-temperature and low-pressure state while passing through the expansion valve 10.

[0108] The refrigerant, having passed through the ex-

pansion valve 10, flows into the water-refrigerant heat exchanger 40, to exchange heat with water. In this case, as heat energy of circulating water is transferred to the refrigerant, the water temperature decreases, and the refrigerant is evaporated, such that the water-refrigerant heat exchanger 40 during the heating operation may be understood as an evaporator. In this case, the water with lowered temperature is supplied to a room, thereby cooling the indoor space. Alternatively, cold water may be supplied to the room.

[0109] The refrigerant, having passed through the water-refrigerant heat exchanger 40, flows into the accumulator 60 through the 4-way valve 30.

[0110] The accumulator 60 may supply a gaseous refrigerant to the compressor 20, thereby completing a cooling cycle of the heat pump 1.

[0111] The controller 1310 controls opening and closing of the first valve V1, the second valve V2, the third valve V3, and the fourth valve V4 based on a current refrigerant amount and a refrigerant amount required for responding to a cooling load during a cooling operation.

[0112] If a subcooling degree is higher than an upper-limit reference value during the cooling operation, the controller 1310 controls the fourth valve V4 and the third valve V3 to be opened and the first valve V1 and the second valve V2 to be closed.

[0113] Referring to FIG. 6, if the fourth valve V4 and the third valve V3 are opened, a portion of the refrigerant, having passed through the outdoor heat exchanger 50, flows into the receiver 70.

[0114] If a subcooling degree is lower than a lower-limit reference value during the cooling operation, the controller 1310 controls the second valve V2 and the third valve V3 to be opened and the first valve V1 and the fourth valve V4 to be closed.

[0115] Referring to FIG. 7, if the second valve V2 and the third valve V3 are opened, the refrigerant stored in the receiver 70 flows to the accumulator 60.

[0116] If a cooling operation is performed while the refrigerant is stored in the receiver 70, an actual refrigerant amount is lower than an optimal refrigerant amount required for the cooling operation. In this case, the controller 1310 opens the second valve V2 and the third valve V3 to guide the refrigerant, stored in the receiver 70, to flow into the accumulator 60. When the second valve V2 and the third valve V3 are opened, high-pressure gas at the outlet of the compressor 20 pushes the liquid refrigerant so that the refrigerant in the receiver 70 is discharged through the third valve V3, and the receiver 70 is filled with the gas such that an amount of refrigerant flowing in the product increases.

[0117] Even in this case, if a liquid refrigerant is expanded through the capillary tube 90 at the rear end of the third valve V3, the refrigerant gradually flows into the accumulator 60, thereby preventing the risk that the liquid refrigerant directly enters the compressor 20.

[0118] Even during the cooling operation, an optimal refrigerant amount may vary depending on outdoor tem-

perature, inflow temperature, compressor frequency, and the like. Upon determining that there is an excessive amount of refrigerant during the cooling operation, the controller 1310 opens the fourth valve V4 and the third valve V3 to store the liquid refrigerant in the receiver 70. During the cooling operation, a high-pressure liquid refrigerant is present at the outlet of the outdoor heat exchanger 50, such that by opening the fourth valve V4, the liquid refrigerant may be stored in the receiver 40.

[0119] During the operation of the product, the accumulator 60 is in a low-pressure state with low temperature, and thus may serve to maintain the receiver 70 at a low temperature.

[0120] Referring to FIGS. 1 to 7, the expansion valve 10, the compressor 20, the 4-way valve 30, the water-refrigerant heat exchanger 40, the outdoor heat exchanger 50, and the accumulator 60 may be connected to each other by a refrigerant pipe a.

[0121] The water-refrigerant heat exchanger 40 and the expansion valve 10 may be connected by a first pipe a1. A second pipe a2 branches from the first pipe a1 to be connected to the receiver 70. A portion of the refrigerant exiting the water-refrigerant heat exchanger 40 may flow into the receiver 70 through the first pipe a1 and the second pipe a2. The first valve V1 is located in the second pipe a2 to allow the refrigerant to flow into the receiver 70 or to prevent the refrigerant from flowing through the second pipe a2.

[0122] A third pipe a3 is disposed between the compressor 20 and the 4-way valve 30 to form a refrigerant flow path extending from the compressor 20 to the 4-way valve 30. The flow path may be switched according to an operation mode of the heat pump, and the refrigerant introduced through the third pipe a3 may be guided selectively to the water-refrigerant heat exchanger 40 or the outdoor heat exchanger 50.

[0123] A fourth pipe a4 branches from the third pipe a3 to be connected to the receiver 70. In addition, the second valve V2 may be located in the fourth pipe a4. Accordingly, when the second valve V2 is opened, the high-pressure gas at the outlet of the compressor 20 may push the liquid refrigerant in the receiver 70.

[0124] A fifth pipe a5 is disposed between the 4-way valve 30 and the accumulator 60 to form a refrigerant flow path extending from the 4-way valve 30 to the accumulator 60. The accumulator 60 may provide a gaseous refrigerant to the compressor 20 through a sixth pipe a6.

[0125] The outdoor heat exchanger 50 and the expansion valve 10 may be connected by a seventh pipe a7. A twelfth pipe a12 branches from the seventh pipe a7 to be connected to the receiver 70. A portion of the refrigerant exiting the outdoor heat exchanger 50 may flow into the receiver 70 through the seventh pipe a7 and the twelfth pipe a12. The fourth valve V4 is located in the twelfth pipe a12 to allow the refrigerant to flow into the receiver 70 or to prevent the refrigerant from flowing through the twelfth pipe a12.

[0126] The second pipe a2 and the fourth pipe a4 may be combined into a tenth pipe a10 to be connected to the receiver 70. Alternatively, the second pipe a2 and the fourth pipe a4 each may be directly connected to the receiver 70.

[0127] The twelfth pipe a12 may also be combined into the second pipe a2 or the tenth pipe a10. Alternatively, the twelfth pipe a12 may be directly connected to the receiver 70.

[0128] By combining flow paths, through which the refrigerant flows into the receiver 70, into one tenth pipe a10, it is effective in that the receiver 70 requires only one refrigerant inlet port.

[0129] The receiver 70 and the accumulator 60 may be connected to an eleventh pipe a11. The third valve V3 is located in the eleventh pipe a11. In addition, the capillary tube 90 is further disposed in the eleventh pipe a11.

[0130] A pump 80 and the water-refrigerant heat exchanger 40 may be connected by a water pipe b. In addition, the pump 80 and the water-refrigerant heat exchanger 40 may be connected to a water tank (not shown), a water source, and the like by the water pipe b. Water may be introduced into the water-refrigerant heat exchanger 40 through a water inlet pipe b1, and water heat-exchanged in the water-refrigerant heat exchanger 40 may be discharged to the water tank, an indoor space, and the like through a water outlet pipe b2.

[0131] FIG. 8 is a flowchart illustrating an operating method of a heat pump according to an embodiment of the present disclosure.

[0132] Referring to FIG. 8, after the heat pump 1 operates during an initial stabilization period (S810), a control logic for controlling a refrigerant amount is executed (S820). For example, the controller 1310 controls the heat pump to perform an initial operation for five minutes (S810). In this case, the controller 1310 controls the first to fourth valves V1, V2, V3, and V4 to be closed during the set initial stabilization period (S815).

[0133] The controller 1310 determines whether a cooling operation or a heating operation is performed (S820), and may determine whether a refrigerant amount is excessive or insufficient based on a reference value set for each operation (S825, S835, S850, and S860).

[0134] While FIG. 8 illustrates an example in which an upper-limit reference value and a lower-limit reference value are set equal for both the cooling and heating operations, the present disclosure is not limited thereto. For example, it is possible to determine whether a refrigerant amount is excessive or insufficient based on different criteria according to the cooling and heating operations. In addition, during the cooling and heating operations, the upper-limit reference value and the lower-limit reference value may be set to different values.

[0135] If a subcooling degree exceeds an upper-limit reference value (e.g., 20 °C) (S825), the controller 1310 determines that an amount of refrigerant is excessive and performs an operation of storing the liquid refrigerant

in a receiver 70 (S830). In this case, the controller 1310 opens the first valve V1 and the third valve V3 and closes the second valve V2 and the fourth valve V4.

[0136] If a subcooling degree is lower than a lower-limit reference value (e.g., 5 °C) (S835), the controller 1310 determines that an amount of refrigerant is insufficient and performs an operation of discharging a liquid refrigerant from the receiver 70 (S845). In this case, the controller 1310 opens the second valve V2 and the third valve V3 and closes the first valve V1 and the fourth valve V4.

[0137] If a subcooling degree during a heating operation is within a range of upper-limit and lower-limit reference values (e.g., within a range of from 5 °C to 20 °C), the controller 1310 determines that an amount of refrigerant is appropriate, and controls the first to fourth valves V1, V2, V3, and V4 to be closed (S840).

[0138] If a subcooling degree during a cooling operation exceeds an upper-limit reference value (e.g., 20 °C) (S850), the controller 1310 determines that an amount of refrigerant is excessive and performs an operation of storing the liquid refrigerant in the receiver 70 (S855). In this case, the controller 1310 opens the third valve V3 and the fourth valve V4 and closes the first valve V1 and the second valve V2.

[0139] If a subcooling degree during a cooling operation is lower than a lower-limit reference value (e.g., 5 °C) (S860), the controller 1310 determines that an amount of refrigerant is insufficient and performs an operation of discharging the liquid refrigerant from the receiver 70 (S870). In this case, the controller 1310 opens the second valve V2 and the third valve V3 and closes the first valve V1 and the fourth valve V4.

[0140] If a subcooling degree during a cooling operation is within a range of upper-limit and lower-limit reference values (e.g., within a range of from 5 °C to 20 °C), the controller 1310 determines that an amount of refrigerant is appropriate, and controls the first to fourth valves V1, V2, V3, and V4 to be closed (S865).

[0141] According to an embodiment of the present disclosure, operations of adjusting a refrigerant amount by storing or discharging the liquid refrigerant according to a subcooling degree may be performed repeatedly in such a manner that after controlling the refrigerant amount control valve 1320 for 10 seconds, a system operates for five minutes while closing all the refrigerant amount control valves 1320 to check the subcooling degree, followed by controlling the refrigerant amount control valve 1320 again for 10 seconds.

[0142] The refrigerant amount control valve 1320 for adjusting a subcooling degree is turned on for 10 seconds, and then is closed. Thereafter, the system operates for five minutes to check a subcooling degree, followed by controlling on or off of the refrigerant amount control valve 1320. Accordingly, the refrigerant amount may be adjusted through monitoring, while controlling the refrigerant amount control valve 1320 for 10 seconds and operating the system for five minutes.

[0143] FIG. 9 is a diagram illustrating the configuration of a heat pump according to an embodiment of the present disclosure.

[0144] FIG. 10 is a diagram referred to in the description of a heating operation of a heat pump and a refrigerant flow therein according to an embodiment of the present disclosure, and FIG. 11 is a diagram referred to in the description of a cooling operation of a heat pump and a refrigerant flow therein according to an embodiment of the present disclosure.

[0145] In the heat pump 1 according to an embodiment of the present disclosure, two expansion devices may be used due to the use of a subcooler and an injection module during cooling and heating operations. For example, the injection module may inject a portion of a flowing refrigerant into the compressor 20. Here, the injection may refer to an operation of injecting a refrigerant into a compression chamber of the compressor 20, the refrigerant having an intermediate pressure between the pressure of a refrigerant flowing from the accumulator 60 into the compressor 20 and the pressure of a refrigerant discharged from the compressor 20. The injection module 40 may include an expansion valve for expanding a portion of the refrigerant.

[0146] Referring to FIG. 9, the expansion valve 10 includes a first expansion valve 10a disposed between the water-refrigerant heat exchanger 40 and the first valve V1, and a second expansion valve 10b disposed between the outdoor heat exchanger 50 and the second valve V2.

[0147] In this embodiment, the refrigerant amount control valve 1320 includes the first to third valves V1, V2, and V3.

[0148] The first valve V1 is disposed between the first expansion valve 10a and the second expansion valve 10b and delivers a refrigerant, introduced in any one direction, to the receiver 70.

[0149] The first valve V1 is located in a thirteenth pipe a13 connected between the first expansion valve 10a and the second expansion valve 10b. The first expansion valve 10a and the second expansion valve 10b may be connected by a fourteenth pipe a14. The thirteenth pipe a13 branches from the fourteenth pipe a14 to be connected to the receiver 70. The first valve V1 is located in the thirteenth pipe a13 to allow the refrigerant to flow into the receiver 70 or to prevent the inflow of refrigerant.

[0150] Components, other than the first expansion valve 10a, the second expansion valve 10b, the thirteenth pipe a13, and the fourteenth pipe a14, are the same as those in the embodiments of FIGS. 1 to 7. Accordingly, redundant portions in the embodiments of FIGS. 9 to 11 and the embodiments of FIGS. 1 to 7 will be briefly described below, or a description thereof will be omitted, but it is to be understood that the portions may apply in the same manner.

[0151] During the heating operation, the controller 1310 controls the 4-way valve 30 to guide the refrigerant, discharged from the compressor 20, to flow into the water-refrigerant heat exchanger 40.

[0152] Referring to FIG. 10, during the heating operation, the refrigerant passes through the compressor 20, the 4-way valve 30, the water-refrigerant heat exchanger 40, the first expansion valve 10a, the second expansion valve 10b, the outdoor heat exchanger 50, the 4-way valve 30, and the accumulator 60, to enter the compressor 20 again.

[0153] The first expansion valve 10a and the second expansion valve 10b may be Electronic Expansion Valves (EEVs) having an adjustable opening. An opening degree of the first expansion valve 10a and the second expansion valve 10b may be adjusted according to cooling and heating operating modes.

[0154] During the heating operation, the first expansion valve 10a is fully opened and the second expansion valve 10b is partially opened, such that the refrigerant, having passed through the water-refrigerant heat exchanger 40, passes through the first expansion valve 10a without state change, and then is expanded while passing through the second expansion valve 10b, to flow into the outdoor heat exchanger 50.

[0155] If a refrigerant amount is within a reference range, the controller 1310 maintains the first to third valves V1, V2, and V3 in a closed state.

[0156] Upon determining that a refrigerant amount is greater than a required amount, the controller 1310 opens the first valve V1 and the third valve V3 and stores a portion of the refrigerant in the receiver 70. If the refrigerant amount decreases to an amount that satisfies a reference range, the controller 1310 closes the first valve V1 and the third valve V3.

[0157] Upon determining that a refrigerant amount is smaller than a required amount, the controller 1310 opens the second valve V2 and the third valve V3, to deliver the refrigerant stored in the receiver 70 to the accumulator 60. If the refrigerant amount increases to an amount that satisfies the reference range, the controller 1310 closes the second valve V2 and the third valve V3.

[0158] During the cooling operation, the controller 1310 controls the 4-way valve 30 to guide the refrigerant, discharged from the compressor 20, to flow into the outdoor heat exchanger 50.

[0159] Referring to FIG. 11, during the cooling operation, the refrigerant passes through the compressor 20, the 4-way valve 30, the outdoor heat exchanger 50, the expansion valve 10, the water-refrigerant heat exchanger 40, the 4-way valve 30, and the accumulator 60, to enter the compressor 20 again.

[0160] During the cooling operation, the second expansion valve 10b is fully opened and the first expansion valve 10a is partially opened, such that the refrigerant, having passed through the water-refrigerant heat exchanger 40, passes through the second expansion valve 10b without state change, and then is expanded while passing through the first expansion valve 10a, to flow into the outdoor heat exchanger 50.

[0161] Even during the cooling operation, upon determining that a refrigerant amount is greater than a required

amount, the controller 1310 opens the first valve V1 and the third valve V3 and stores a portion of the refrigerant in the receiver 70. If the refrigerant amount decreases to an amount that satisfies a reference range, the controller 1310 closes the first valve V1 and the third valve V3.

[0162] Even during the cooling operation, upon determining that a refrigerant amount is smaller than a required amount, the controller 1310 opens the second valve V2 and the third valve V3, and delivers the refrigerant stored in the receiver 70 to the accumulator 60. If the refrigerant amount increases to an amount that satisfies the reference range, the controller 1310 closes the second valve V2 and the third valve V3.

[0163] FIG. 12 is a diagram illustrating the configuration of a heat pump according to an embodiment of the present disclosure.

[0164] Referring to FIG. 12, a heat pump 1 includes a compressor 20, an accumulator 60 configured to supply a refrigerant to the compressor 20, a receiver 70 connected to the accumulator 60, at least one two-way indoor unit I1 and I2 for both cooling and heating, each indoor unit including an indoor heat exchanger, an outdoor heat exchanger 50 configured to exchange heat between outdoor air and refrigerant, a 4-way valve 30 guiding refrigerant, discharged from the compressor 20, to flow into the indoor unit I1 and I2 or the outdoor heat exchanger 50, an expansion valve 10 disposed between the indoor unit I1 and I2 and the outdoor heat exchanger 50, the first valve V1 disposed between the indoor unit I1 and I2 and the receiver 70, a second valve V2 disposed between the compressor 20 and the receiver 70, and a third valve V3 disposed between the receiver 70 and the accumulator 60.

[0165] Referring to FIG. 12, the heat pump 1 may be a multi-heat pump in which a plurality of indoor units I1 and I2 are connected to the outdoor heat exchanger 50, and expansion devices E1 and E2 are included in the indoor units I1 and I2, respectively.

[0166] The indoor units I1 and I2 and the expansion valve 10 may be connected by a first pipe a1. A second pipe a2 branches from the first pipe a1 to be connected to the receiver 70. In addition, the expansion valve 10 may be connected to the outdoor heat exchanger 50 by a seventh pipe a7.

[0167] Refrigerant may flow into the receiver 70 through the first pipe a1 and the second pipe a2, or may flow into the receiver 70 through the seventh pipe a7 and the second pipe a2.

[0168] The first pipe a1 may be connected to each of the indoor units I1 and I2. The first pipe a1 is connected to a first indoor unit I1 through a 1-1 indoor unit pipe a21, and is connected to a second indoor unit I2 through a 2-1 indoor unit pipe a22.

[0169] A first indoor expansion valve E1 is located in the 1-1 indoor unit pipe a21, and a second indoor expansion valve E2 is located in the 2-1 indoor unit pipe a22. The indoor units I1 and I2 include an indoor heat exchanger configured to exchange heat between indoor air

and refrigerant, an indoor fan (not shown) configured to generate an air flow, and indoor expansion valves E1 and E2 configured to expand the refrigerant. The indoor expansion valves E1 and E2 may be EEVs. The refrigerant may be expanded by an outdoor expansion valve 10 or the indoor expansion valves E1 and E2.

[0170] In addition, a ninth pipe a9 may be connected to each of the indoor units I1 and I2. The ninth pipe a9 is connected to the first indoor unit I1 through a 1-2 indoor unit pipe a23 and is connected to the second indoor unit I2 through a 2-2 indoor unit pipe a24.

[0171] Components, other than the indoor units I1 and I2, are the same as those in the embodiments of FIGS. 1 to 7. Accordingly, redundant portions in the embodiment of FIG. 12 and the embodiments of FIGS. 1 to 7 will be briefly described below, or a description thereof will be omitted, but it is to be understood that the portions may apply in the same manner.

[0172] During the heating operation, the controller 1310 controls the 4-way valve 30 to guide the refrigerant, discharged from the compressor 20, to flow into the indoor units I1 and I2 operating in a heating mode. During the cooling operation, the controller 1310 controls the 4-way valve 30 to guide the refrigerant, discharged from the compressor 20, to flow into the outdoor heat exchanger 50.

[0173] During the heating operation, the refrigerant passes through the compressor 20, the 4-way valve 30, the indoor units I1 and I2, the first expansion valve 10a, the second expansion valve 10b, the outdoor heat exchanger 50, the 4-way valve 30, and the accumulator 60, to enter the compressor 20 again.

[0174] During the cooling operation, the refrigerant passes through the compressor 20, the 4-way valve 30, the outdoor heat exchanger 50, the expansion valve 10, the indoor units I1 and I2, the 4-way valve 30, and the accumulator 60, to enter the compressor 20 again.

[0175] During the heating operation, the expansion valve 10 expands the refrigerant, and the expansion valves E1 and E2 located on the side of the indoor units I1 and I2 are opened to a maximum opening degree. During the cooling operation, the expansion valve 10 is opened to a maximum opening degree, and the expansion valves E1 and E2 located on the side of the indoor units I1 and I2 expand the refrigerant.

[0176] The expansion valve 10 and the indoor expansion valves E1 and E2 may be EEVs having an adjustable opening. The opening degree of the expansion valve 10 and the indoor expansion valves E1 and E2 may be adjusted according to the cooling and heating operating modes.

[0177] During the heating operation, the indoor expansion valves E1 and E2 are fully opened and the expansion valve 10 is partially opened, such that the refrigerant, having passed through the heat exchanger on the side of the indoor units I1 and I2, may pass through the indoor expansion valves E1 and E2 without state change, and then may be expanded while passing through the expan-

sion valve 10, to flow into the outdoor heat exchanger 50.

[0178] During the cooling operation, the expansion valve 10 is fully opened and the indoor expansion valves E1 and E2 are partially opened, such that the refrigerant, having passed through the heat exchanger on the side of the indoor units I1 and I2, may pass through the expansion valve 10 without state change, and then may be expanded while passing through the indoor expansion valves E1 and E2, to flow into the outdoor heat exchanger 50.

[0179] If a refrigerant amount is within a reference range, the controller 1310 maintains the first to third valves V1, V2, and V3 in a closed state.

[0180] Upon determining that a refrigerant amount is greater than a required amount, the controller 1310 opens the first valve V1 and the third valve V3 and stores a portion of the refrigerant in the receiver 70. If the refrigerant amount decreases to an amount that satisfies a reference range, the controller 1310 closes the first valve V1 and the third valve V3.

[0181] Upon determining that a refrigerant amount is smaller than a required amount, the controller 1310 opens the second valve V2 and the third valve V3, and delivers the refrigerant stored in the receiver 70 to the accumulator 60. If the refrigerant amount increases to an amount that satisfies the reference range, the controller 1310 closes the second valve V2 and the third valve V3.

[0182] According to the present disclosure, the heat pump may operate in an optimal refrigerant condition according to an operating state, by using the receiver 70 capable of storing a refrigerant for products, such as a multi-heat pump or AWHF, in which an optimal refrigerant amount varies greatly depending on the number of operating indoor units or a cooling or heating operation mode.

[0183] FIG. 13 is a block diagram illustrating a heat pump according to an embodiment of the present disclosure.

[0184] Referring to FIG. 13, the heat pump 1 according to an embodiment of the present disclosure includes the compressor 20, the 4-way valve 30, and the expansion valve 10 which are described above.

[0185] In addition, the heat pump 1 includes a refrigerant amount control valve 1320 for adjusting an amount of a circulating refrigerant. For example, the refrigerant amount control valve 1320 may include the first to fourth valves V1, V2, V3, and V4 which are described above with reference to FIG. 1 and the like. Alternatively, the refrigerant amount control valve 1320 may include the first to third valves V1, V2, and V3 which are described above with reference to FIGS. 9 and 12, and the like.

[0186] In addition, the heat pump 1 may further include the controller 1310 configured to control the overall operation thereof. The controller 1310 may adjust a refrigerant flow direction by controlling the 4-way valve 30 according to the cooling or heating operation mode.

[0187] Further, the controller 1310 may adjust an opening degree of the expansion valve 10. To this end, the

expansion valve 10 may be an Electronic Expansion Valve (EEV).

[0188] Moreover, the controller 1310 may control opening and closing of the refrigerant amount control valve 1320 to store the refrigerant in the receiver 70 or to circulate the refrigerant stored in the receiver 70.

[0189] In addition, the controller 1310 may receive data measured by the sensors of the sensor unit 1330, and may control the heat pump 1 based on the received data.

[0190] The sensor unit 1330 includes a plurality of sensors. For example, the sensor unit 1330 may include an outdoor temperature sensor, and outdoor humidity sensor, an indoor temperature sensor, and indoor humidity sensor, etc., and may obtain indoor and outdoor temperature and humidity data.

[0191] For example, in order to measure a degree of compressor discharge superheat, the sensor unit 1330 may include a compressor outlet temperature sensor and an indoor heat exchanger pressure sensor.

[0192] The degree of compressor discharge superheat may be measured based on the compressor discharge temperature, measured by the compressor outlet temperature sensor installed at the outlet side of the compressor 20, and based on the saturation temperature of a refrigerant 40 condensed in the indoor heat exchanger 40 which may be obtained by converting the saturation pressure of a refrigerant condensed in the indoor heat exchanger 40, the saturation pressure measured by the indoor heat exchanger pressure sensor installed at the indoor heat exchanger 40. Alternatively, the sensor unit 1330 may directly measure the saturation temperature of the refrigerant, condensed in the indoor heat exchanger 40, by installing an indoor heat exchanger temperature sensor at the indoor heat exchanger 40.

[0193] If the compressor discharge temperature is greater than or equal to a reference discharge temperature, the controller 1310 may reduce the compressor discharge temperature by increasing a refrigerant amount.

[0194] For example, in order to measure a degree of suction superheat, the sensor unit 1330 may include a compressor inlet temperature sensor and an outdoor heat exchanger pressure sensor. The sensor unit 1330 may measure the degree of suction superheat based on compressor suction temperature, measured by the compressor inlet temperature sensor installed at the inlet side of the compressor 20, and based on the saturation temperature of a refrigerant evaporated in the outdoor heat exchanger 50 which is obtained by converting the saturation pressure of the refrigerant evaporated in the outdoor heat exchanger 50, the saturation pressure measured by the outdoor heat exchanger/pressure sensor installed at the outdoor heat exchanger 50. Alternatively, the sensor unit 1330 may directly measure the saturation temperature of the refrigerant, evaporated in the outdoor heat exchanger 50, by installing an outdoor heat exchanger temperature sensor at the outdoor heat exchanger 50 in some embodiments.

[0195] If the degree of suction superheat exceeds a

reference temperature value, the controller 1310 may reduce the degree of suction superheat by increasing an amount of refrigerant that passes through the outdoor heat exchanger 50.

[0196] The heat pump 1 includes the compressor 20, the expansion valve 10, the 4-way valve 30, the outdoor heat exchanger 50, one or more heat exchangers 40 for supplying heat, the accumulator 60, and the receiver 70.

[0197] According to an embodiment of the present disclosure, the heat pump 1 includes the second valve V2 connected from the outlet of the compressor 20 to the receiver 70, the fourth valve V4 connected from the outlet of the condenser based on the cooling operation (outdoor heat exchanger 50) to the receiver 70, the first valve V1 connected from the outlet of the condenser based on the heating operation (indoor heat exchanger or water-refrigerant heat exchanger 50) to the receiver 70, and the third valve V3 connected between the receiver 70 and the accumulator 60.

[0198] In addition, the heat pump 1 may further include the capillary tube 90 between the third valve V3 and the accumulator 60.

[0199] The controller 1310 may check a subcooling degree of a heat pump system, and if a subcooling degree is greater than or equal to a reference value (e.g., 20 °C), the controller 1310 determines that an amount of refrigerant is excessive, and may perform an operation of storing the refrigerant in the receiver 70.

[0200] In addition, if a subcooling degree is lower than a reference value (e.g., 5 °C), the controller 1310 determines that an amount of refrigerant is insufficient, and may perform an operation of discharging the liquid refrigerant in the receiver 70 to the accumulator 60.

[0201] As in the embodiments of FIGS. 9 to 11, if there are two or more expansion devices such that a subcooled liquid may be obtained at one point regardless of a cooling or heating operation, the fourth valve V4 may be omitted.

[0202] In some embodiments, the accumulator 60 and the receiver 70 may be adjacent to each other to be formed as one body. Alternatively, the accumulator 60 and the receiver 70 may be formed as separate bodies.

[0203] In order to achieve the above objectives, a heat pump according to an embodiment of the present disclosure may actively adjust a refrigerant amount according to a required amount of refrigerant by storing a refrigerant in a refrigerant storage device or by discharging the refrigerant therefrom, such that the heat pump may operate in an optimal refrigerant condition.

[0204] In order to achieve the above objectives, by using a device for storing a refrigerant according to a required amount of refrigerant, a heat pump according to an embodiment of the present disclosure may operate in an optimal refrigerant condition regardless of operating conditions, such as indoor temperature, outdoor temperature, compressor frequency, etc., and operating modes such as cooling, heating, and the like.

[0205] In order to achieve the above objectives, a heat

pump according to an embodiment of the present disclosure may operate with improved capability and efficiency by charging a refrigerant in an amount corresponding to the case where a maximum amount of refrigerant is required, and by adjusting the refrigerant amount according to an operating state. Particularly, the heat pump may operate at maximum capability and efficiency while ensuring there is no shortage of refrigerant even during a cooling operation.

[0206] In order to achieve the above objectives, by actively adjusting an amount of a circulating refrigerant, a heat pump according to an embodiment of the present disclosure may operate in an optimal refrigerant condition according to an operating state, even in a multi-heat pump or AHP in which an optimal refrigerant amount varies greatly depending on the number of operating indoor units or a cooling or heating operation mode.

[0207] While the present disclosure has been particularly shown and described with reference to preferred embodiments thereof, it will be understood by those skilled in the art that the present disclosure is not limited to those exemplary embodiments and various changes in form and details may be made therein without departing from the scope of the disclosure as defined by the appended claims.

Claims

1. A heat pump (1) comprising:

- a compressor (20) configured to compress a refrigerant;
- an accumulator (60) configured to supply the refrigerant to the compressor (20);
- a receiver (70) connected to the accumulator (60);
- a water-refrigerant heat exchanger (40) configured to exchange heat between water and the refrigerant;
- an outdoor heat exchanger (50) configured to exchange heat between outdoor air and the refrigerant;
- a 4-way valve (30) configured to guide the refrigerant, discharged from the compressor (20), to flow into the water-refrigerant heat exchanger (40) or the outdoor heat exchanger (50);
- an expansion valve (10) disposed between the water-refrigerant heat exchanger (40) and the outdoor heat exchanger (50);
- a first valve (V1) disposed between the water-refrigerant heat exchanger (40) and the receiver (70);
- a second valve (V2) disposed between the compressor (20) and the receiver (70); and
- a third valve (V3) disposed between the receiver (70) and the accumulator (60).

2. The heat pump (1) of claim 1, wherein during a heating operation, in response to the first valve (V1) and the third valve (V3) being opened, a portion of a refrigerant having passed through the water-refrigerant heat exchanger (40) flows to the receiver (70), and in response to the second valve (V2) and the third valve (V3) being opened, a refrigerant stored in the receiver (70) flows to the accumulator (60). 5
3. The heat pump (1) of claim 1 or 2, further comprising a controller (1310) configured to control opening and closing of the first to third valves (V1, V2, V3) based on a refrigerant amount during operation. 10
4. The heat pump (1) of claim 3, wherein: 15
 - during the heating operation, in response to a subcooling degree being higher than an upper-limit reference value, the controller (1310) is configured to control the first valve (V1) and the third valve (V3) to be opened; and 20
 - during the heating operation, in response to the subcooling degree being lower than a lower-limit reference value, the controller (1310) is configured to control the second valve (V2) and the third valve (V3) to be opened. 25
5. The heat pump (1) of claim 3 or 4, wherein during the heating operation, the controller (1310) is configured to control the 4-way valve (30) to guide the refrigerant, discharged from the compressor (20), to flow into the water-refrigerant heat exchanger (40). 30
6. The heat pump (1) according to any one of claims 1 to 5, further comprising a capillary tube (90) disposed between the third valve (V3) and the accumulator (60). 35
7. The heat pump (1) according to any one of claims 1 to 4, further comprising a fourth valve (V4) disposed between the outdoor heat exchanger (50) and the receiver (70). 40
8. The heat pump (1) of claim 7, wherein during a cooling operation, in response to the fourth valve (V4) and the third valve (V3) being opened, a portion of a refrigerant having passed through the outdoor heat exchanger (50) flows to the receiver (70), and in response to the second valve (V2) and the third valve (V3) being opened, a refrigerant stored in the receiver (70) flows to the accumulator (60). 45
9. The heat pump (1) of claim 7 or 8, further comprising a controller (1310) configured to control opening and closing of the first to fourth valves (V1, V2, V3, V4) based on a refrigerant amount during operation. 50
10. The heat pump (1) of claim 9, wherein:
 - during the heating operation, in response to a subcooling degree being higher than an upper-limit reference value, the controller (1310) is configured to control the first valve (V1) and the third valve (V3) to be opened and the second valve (V2) and the fourth valve (V4) to be closed; and
 - during the heating operation, in response to the subcooling degree being lower than a lower-limit reference value, the controller (1310) is configured to control the second valve (V2) and the third valve (V3) to be opened and the first valve (V1) and the fourth valve (V4) to be closed.
11. The heat pump (1) of claim 9 or 10, wherein:
 - during the cooling operation, in response to a subcooling degree being higher than an upper-limit reference value, the controller (1310) is configured to control the fourth valve (V4) and the third valve (V3) to be opened and the first valve (V1) and the second valve (V2) to be closed; and
 - during the cooling operation, in response to the subcooling degree being lower than a lower-limit reference value, the controller (1310) is configured to control the second valve (V2) and the third valve (V3) to be opened and the first valve (V1) and the fourth valve (V4) to be closed.
12. The heat pump (1) according to any one of claims 9 to 11, wherein:
 - during the cooling operation, the controller (1310) is configured to control the 4-way valve (30) to guide the refrigerant, discharged from the compressor (20), to flow into the outdoor heat exchanger (50); and
 - during the heating operation, the controller (1310) is configured to control the 4-way valve (30) to guide the refrigerant, discharged from the compressor (20), to flow into the water-refrigerant heat exchanger (40).
13. The heat pump (1) according to any one of claims 9 to 12, wherein the controller (1310) is configured to control the first to fourth valves (V1, V2, V3, V4) to be closed during a set initial stabilization period.
14. The heat pump (1) according to any one of claims 1 to 13, further comprising:
 - a first pipe (a1) connecting the water-refrigerant heat exchanger (40) and the expansion valve (10); and
 - a second pipe (a2) branching from the first pipe (a1) to be connected to the receiver (70), wherein the first valve (V1) is located in the sec-

ond pipe (a2).

15. The heat pump (1) according to any one of claims 1 to 14, wherein the expansion valve (10) comprises:

5

a first expansion valve (10a) disposed between the water-refrigerant heat exchanger (40) and the first valve (V1); and

a second expansion valve (10b) disposed between the outdoor heat exchanger (50) and the second valve (V2),

10

and, wherein: during the heating operation, the first expansion valve (10a) is opened to a maximum opening degree, and the second expansion valve (10b) expands the refrigerant; and during the cooling operation, the first expansion valve (10a) expands the refrigerant, and the second expansion valve (10b) is opened to a maximum opening degree.

15

20

25

30

35

40

45

50

55

FIG. 1

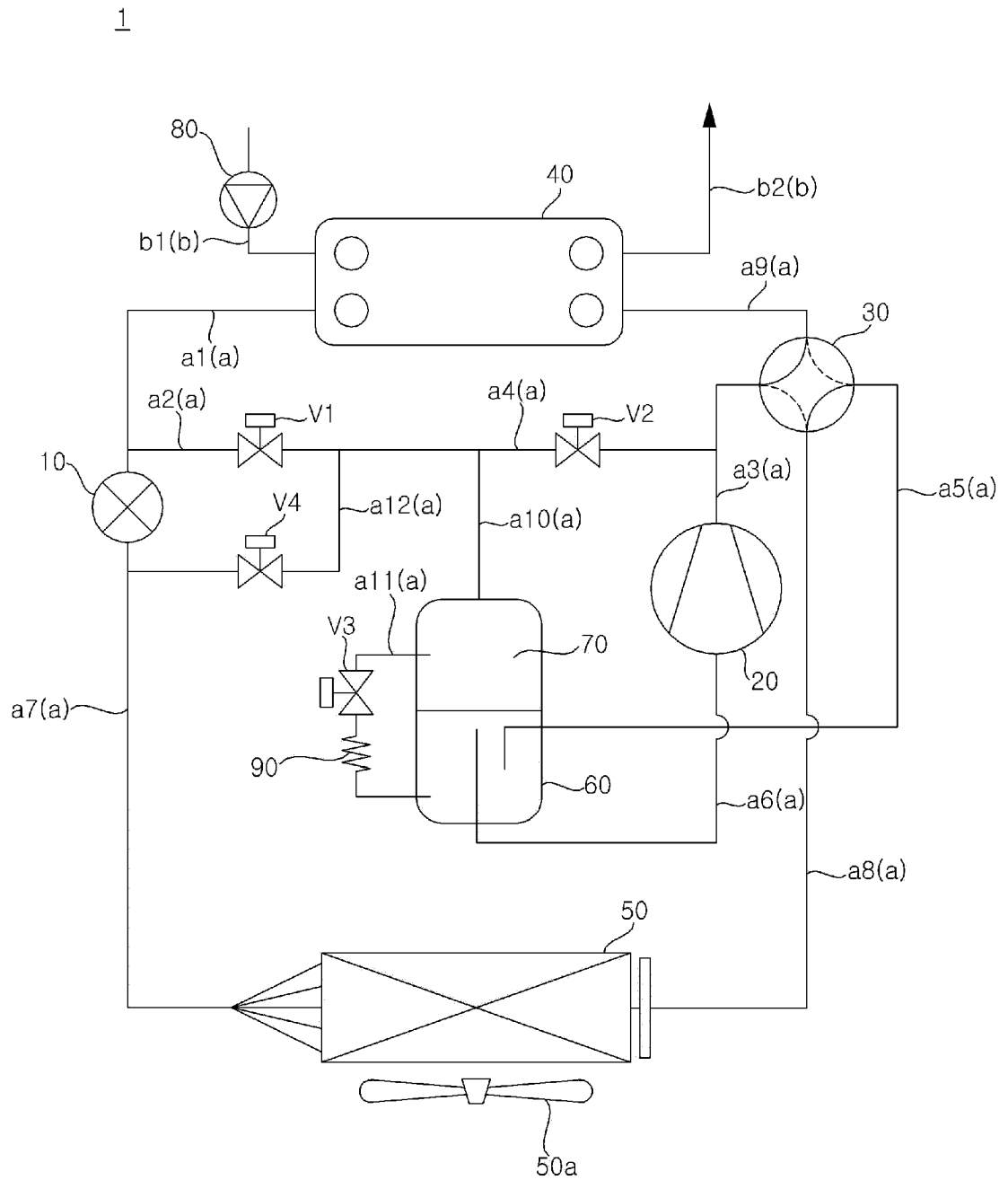


FIG. 2

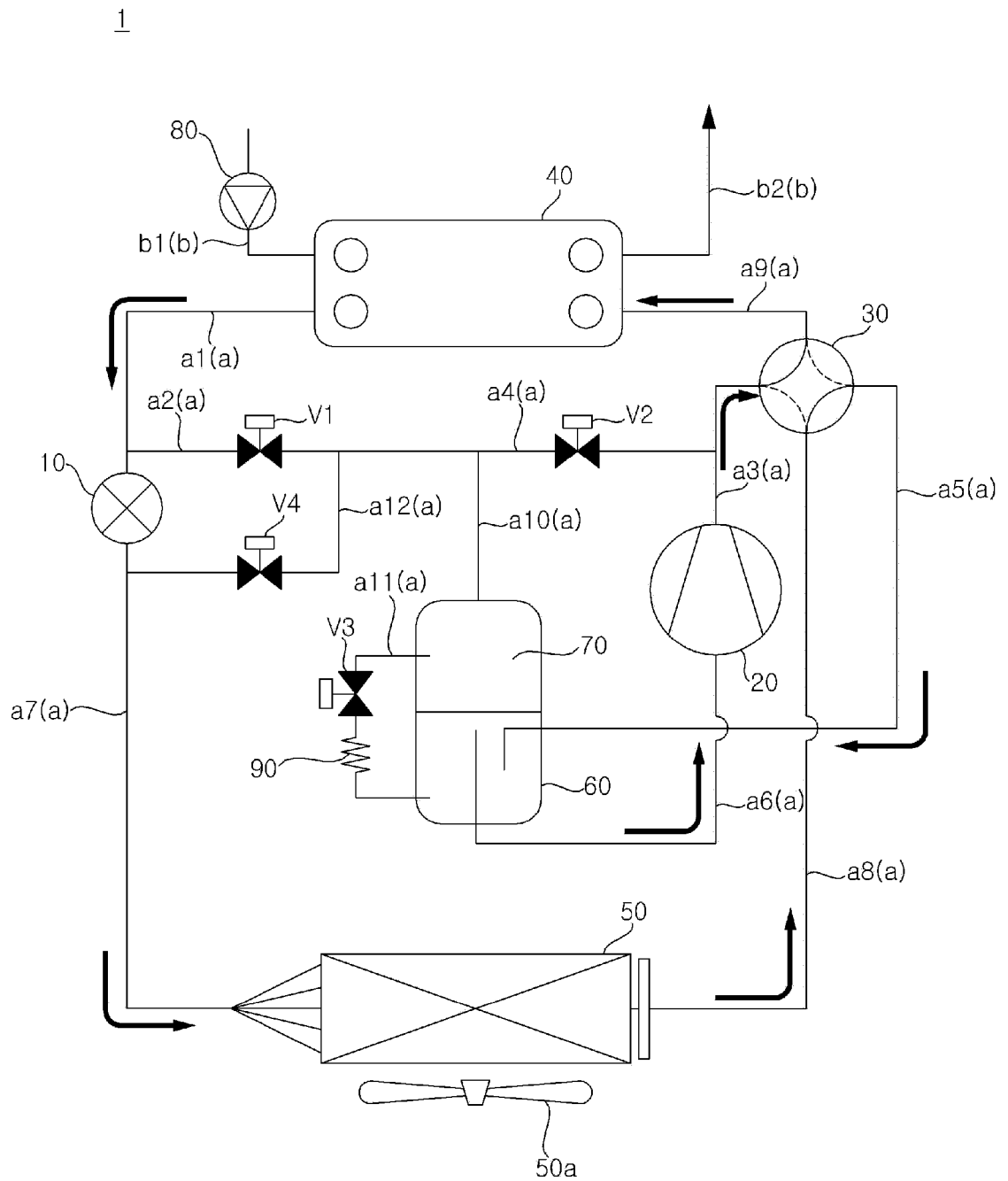


FIG. 3

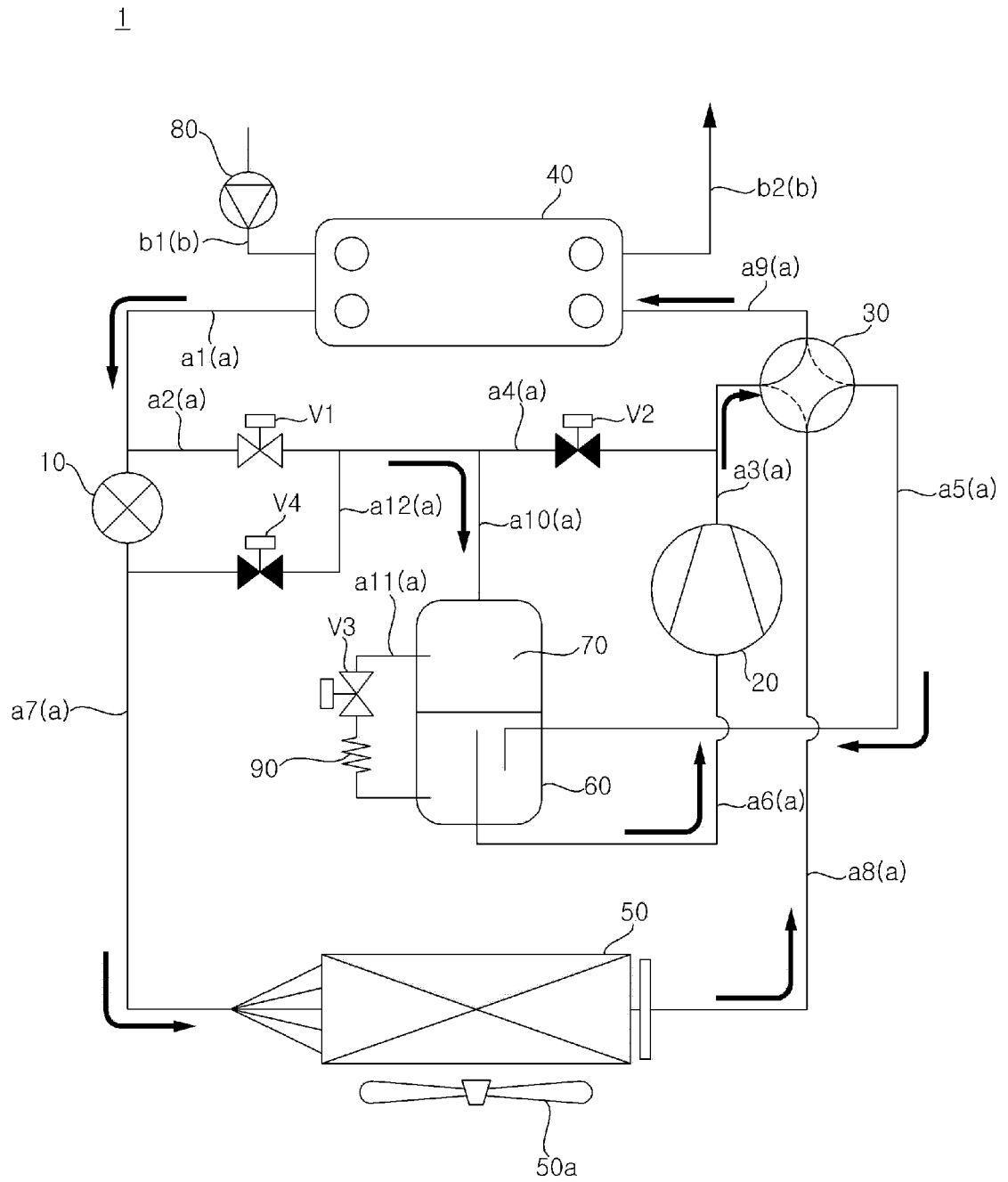


FIG. 4

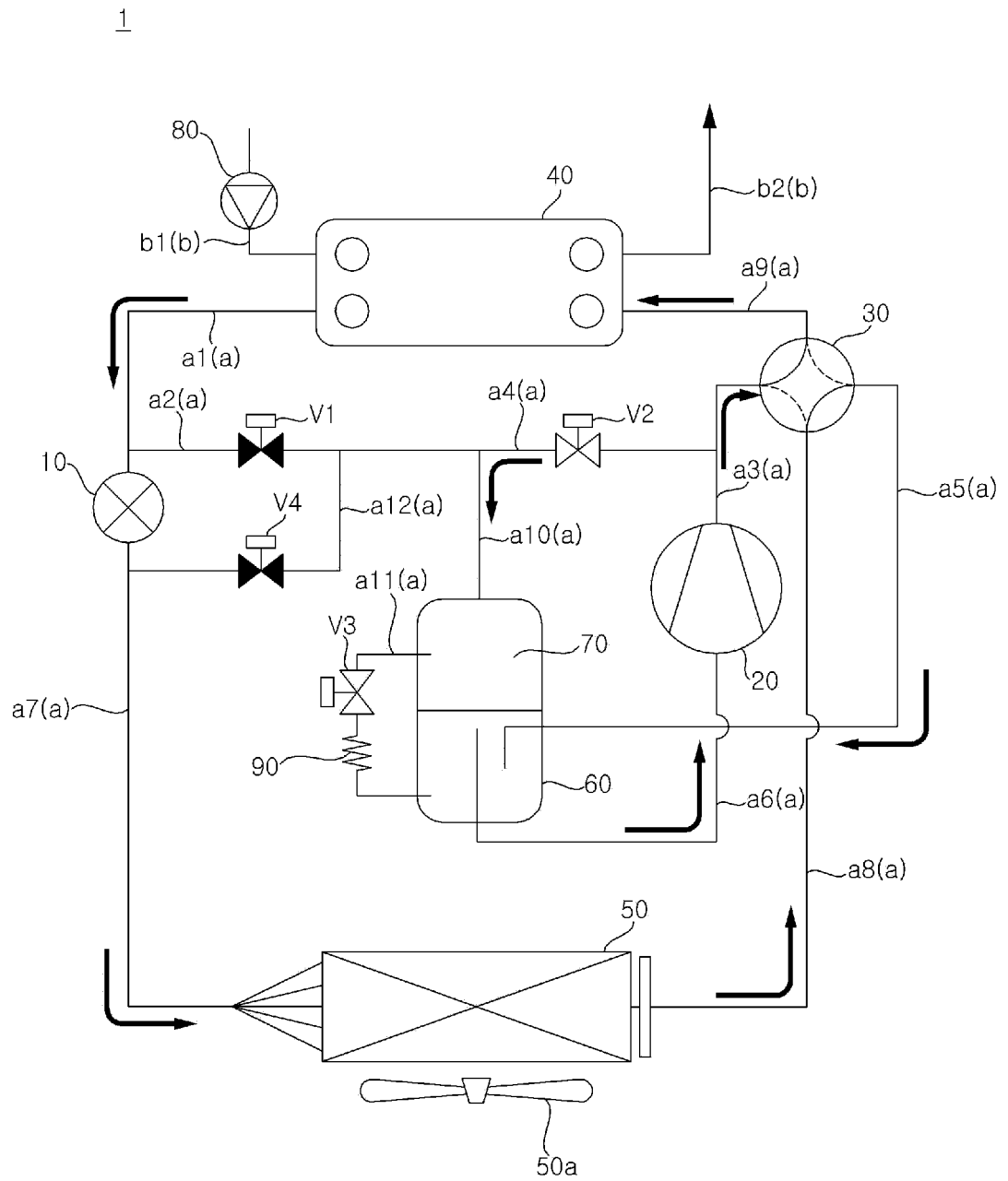


FIG. 5

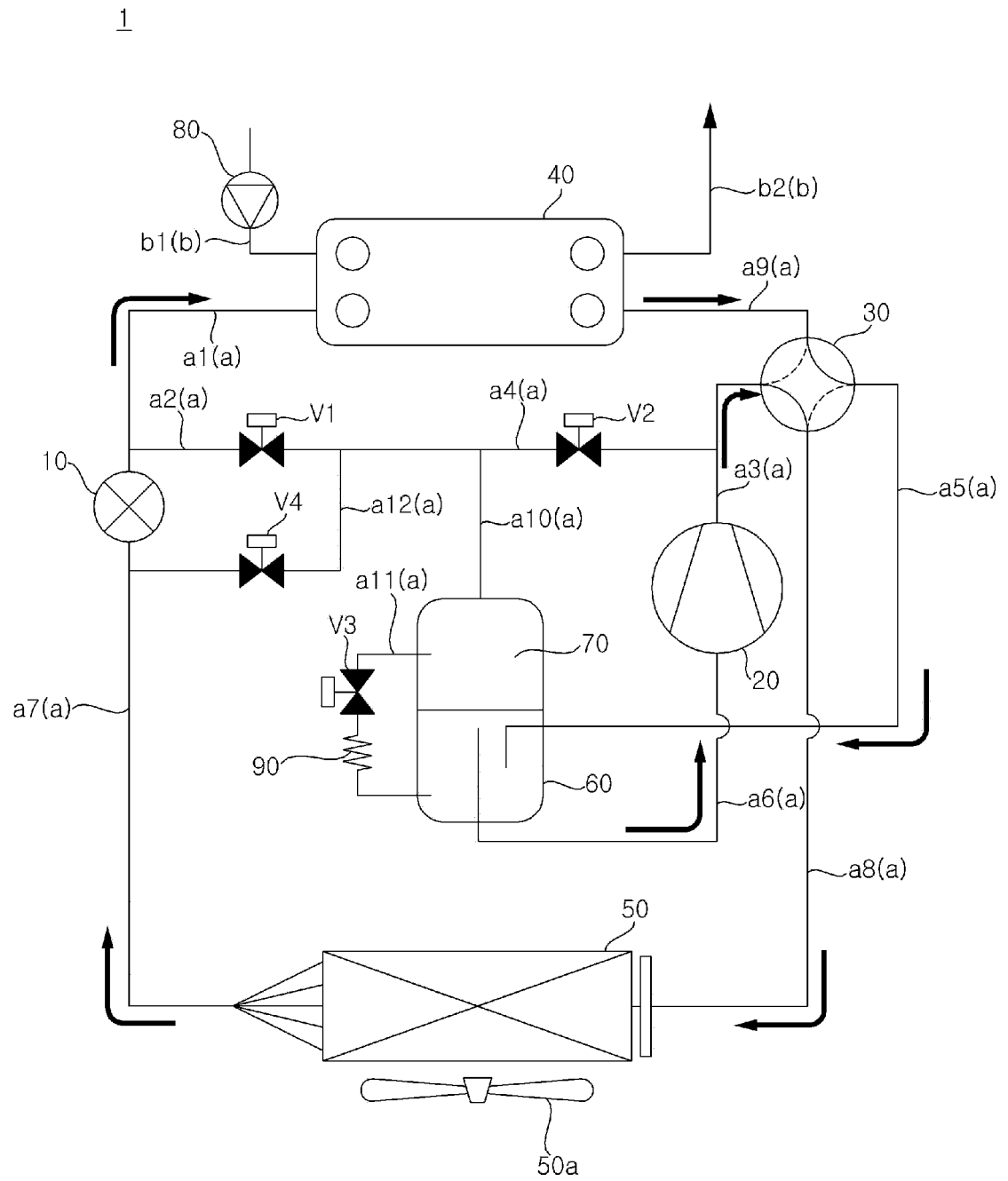


FIG. 6

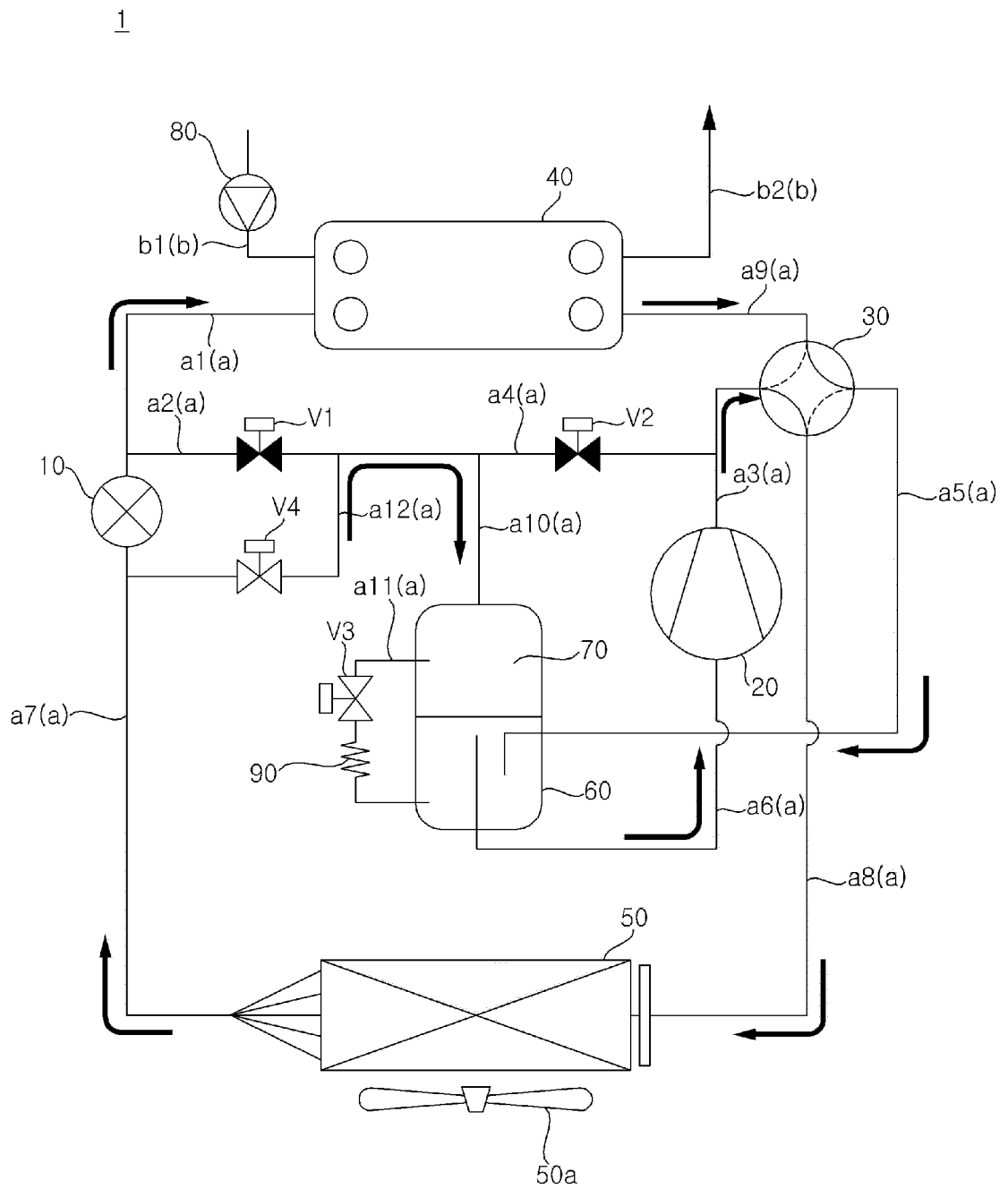


FIG. 7

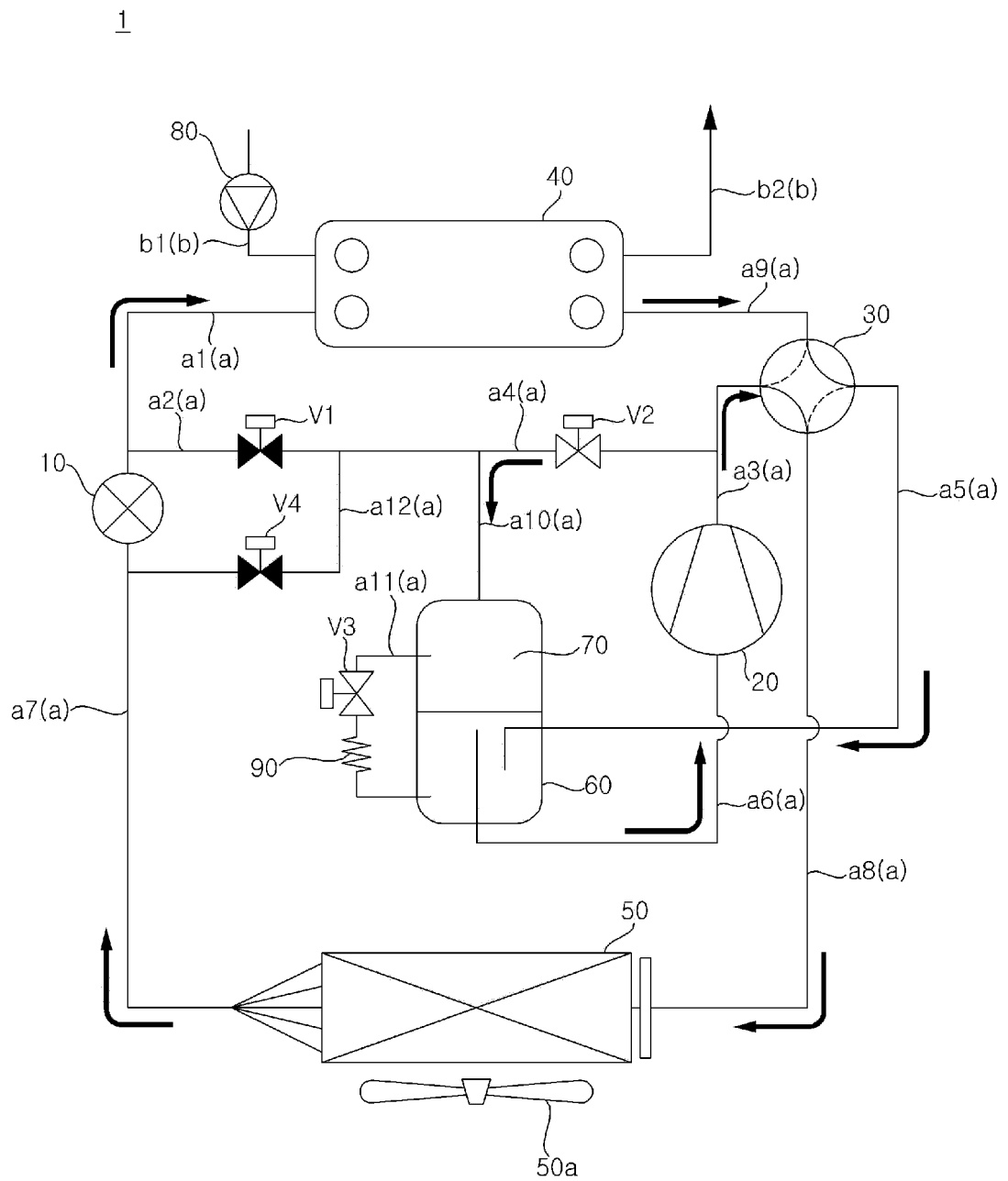


FIG. 8

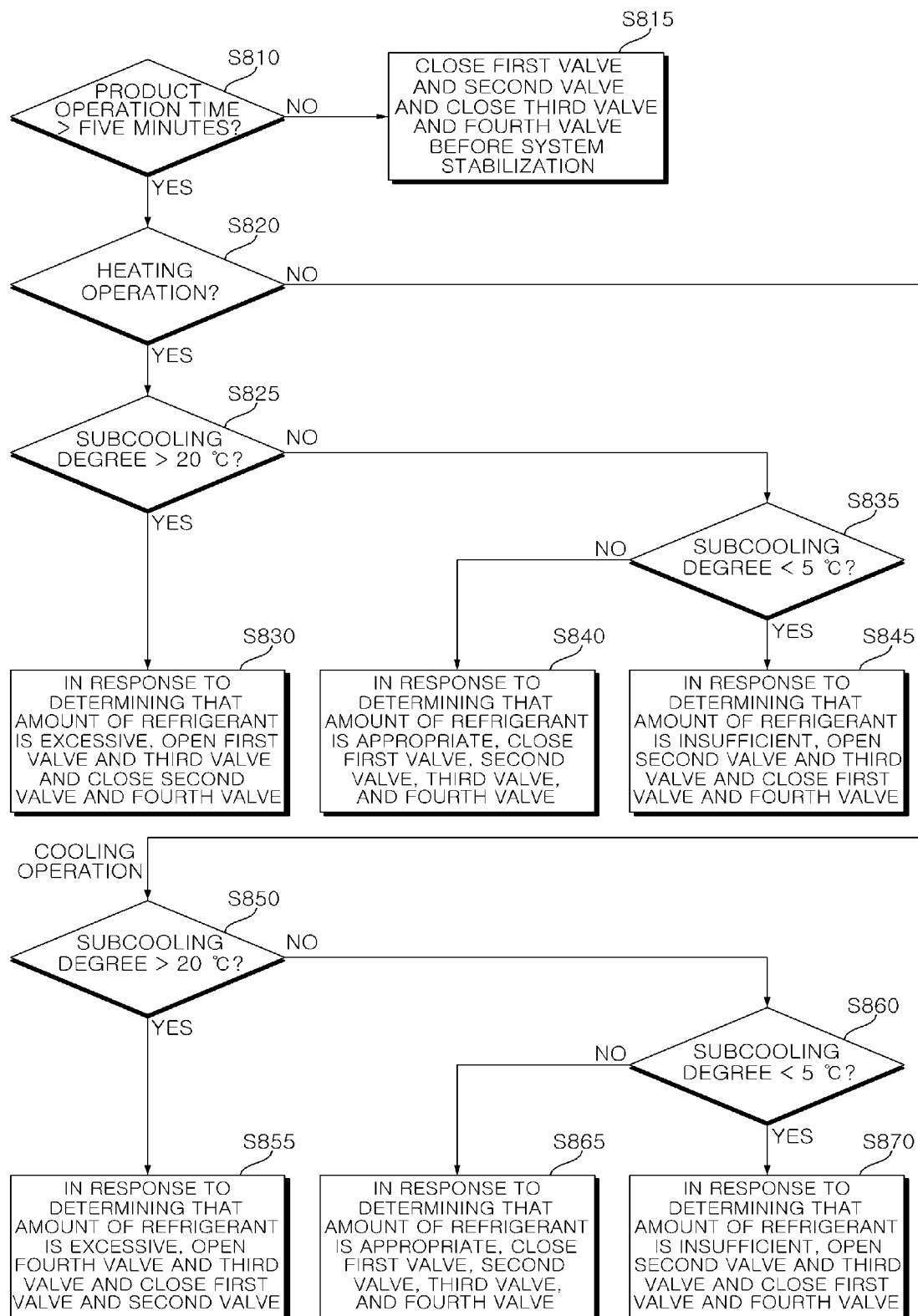


FIG. 9

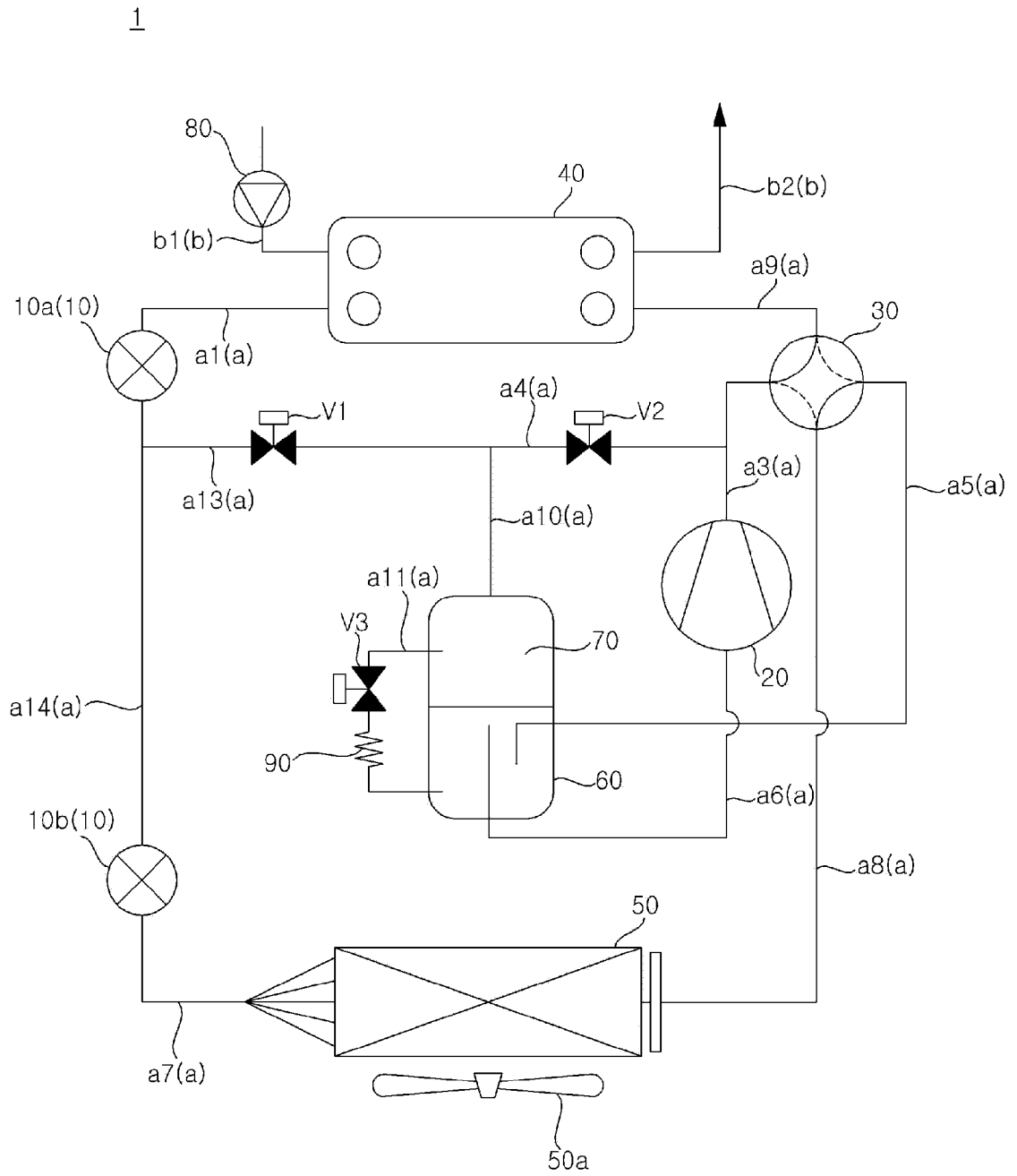


FIG. 10

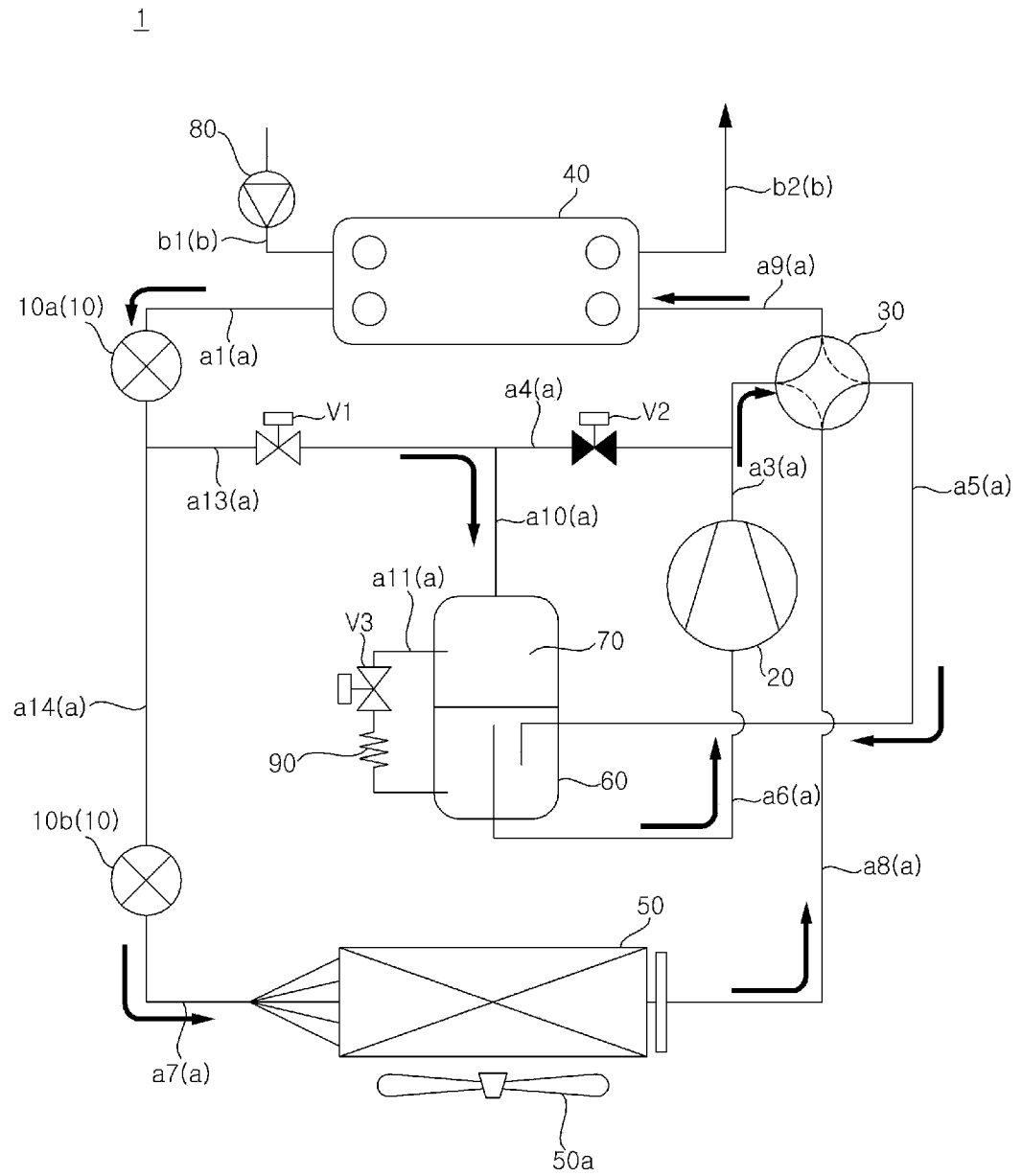


FIG. 11

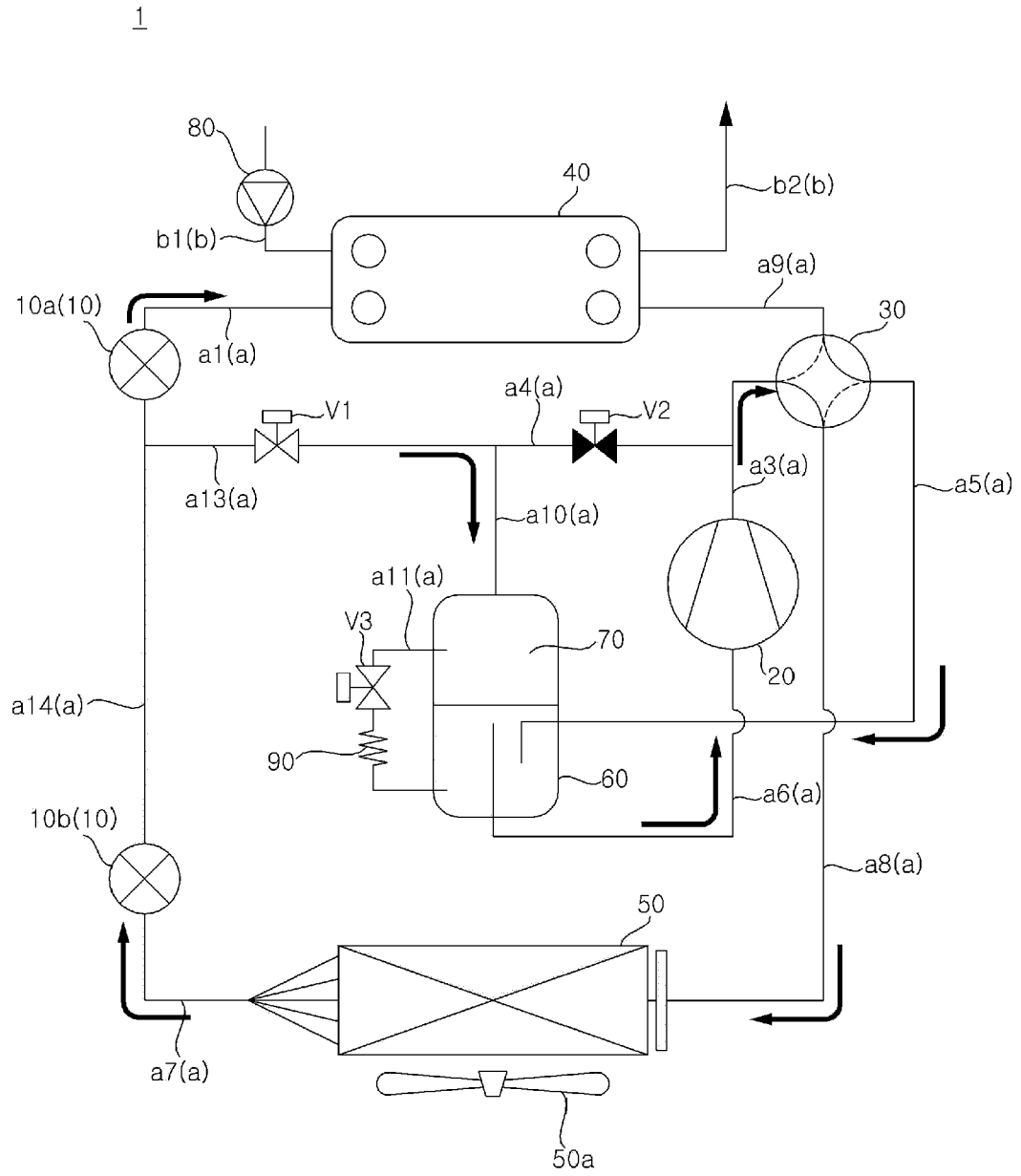


FIG. 12

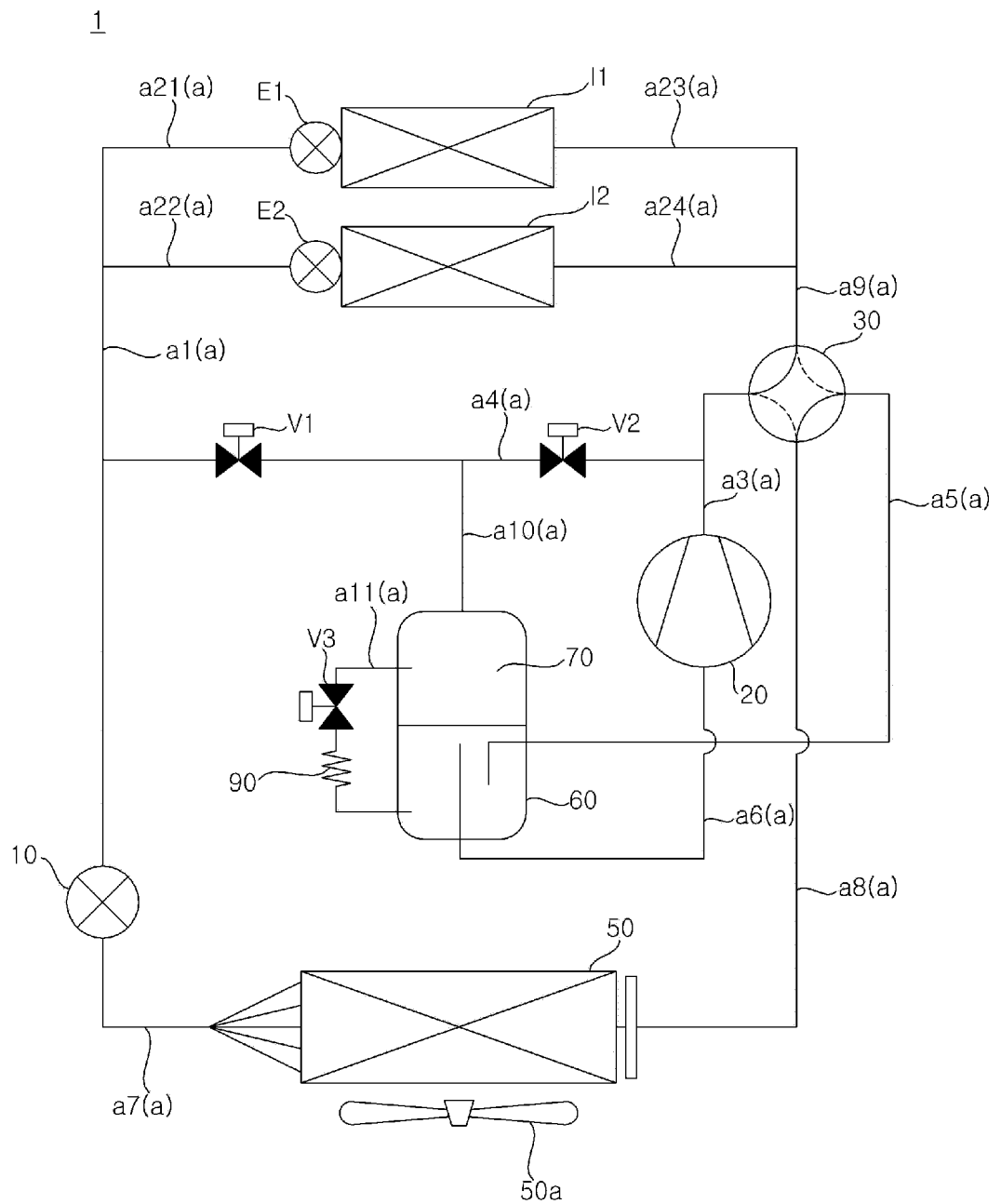
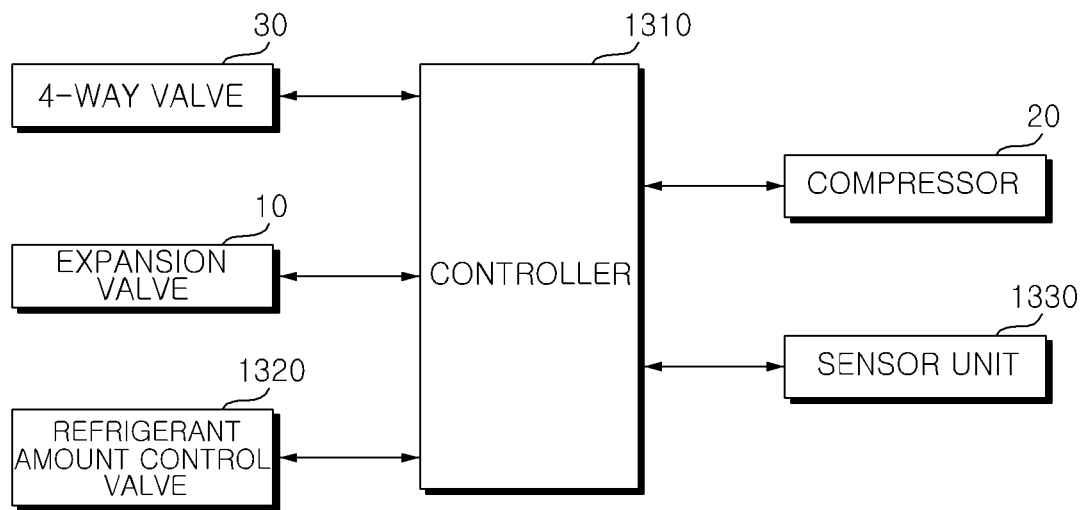


FIG. 13





EUROPEAN SEARCH REPORT

Application Number

EP 24 18 3883

5

10

15

20

25

30

35

40

45

50

55

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 9 587 865 B2 (JEONG HOJONG [KR]; JUNG JAEHWA [KR] ET AL.) 7 March 2017 (2017-03-07)	1,2,5, 14,15	INV. F25B13/00 F25B25/00
Y	* figure 2 *	6	F25B41/00 F25B41/24
X	EP 3 978 832 A1 (LG ELECTRONICS INC [KR]) 6 April 2022 (2022-04-06)	1-5,7-15	F25B41/39 F25B49/02
Y	* figure 2 *	6	
Y	WO 2015/064172 A1 (SHARP KK [JP]) 7 May 2015 (2015-05-07) * see the description of Figure 14 in the enclosed English translation of this document; figures 9,14 *	6	
A	EP 4 030 121 A1 (DAIKIN IND LTD [JP]) 20 July 2022 (2022-07-20) * figure 1 *	1	
A	JP 3 731174 B2 (MITSUBISHI ELECTRIC CORP) 5 January 2006 (2006-01-05) * figures 2-4 *	1	TECHNICAL FIELDS SEARCHED (IPC) F25B
The present search report has been drawn up for all claims			

4

EPO FORM 1503 03.82 (P04C01)

Place of search

Munich

Date of completion of the search

26 September 2024

Examiner

Lepers, Joachim

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 24 18 3883

5

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

26 - 09 - 2024

10

15

20

25

30

35

40

45

50

55

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 9587865 B2	07-03-2017	EP 2568234 A2	13-03-2013
		KR 20130028474 A	19-03-2013
		US 2013061614 A1	14-03-2013
EP 3978832 A1	06-04-2022	CN 114383227 A	22-04-2022
		EP 3978832 A1	06-04-2022
		KR 20220045360 A	12-04-2022
		US 2022107126 A1	07-04-2022
WO 2015064172 A1	07-05-2015	JP 6309739 B2	11-04-2018
		JP 2015087065 A	07-05-2015
		WO 2015064172 A1	07-05-2015
EP 4030121 A1	20-07-2022	CN 114450542 A	06-05-2022
		EP 4030121 A1	20-07-2022
		JP 6849036 B1	24-03-2021
		JP 2021055918 A	08-04-2021
		US 2022221208 A1	14-07-2022
		WO 2021065114 A1	08-04-2021
JP 3731174 B2	05-01-2006	JP 3731174 B2	05-01-2006
		JP H11173698 A	02-07-1999

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- KR 1020230033633 [0005]