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(54) **AIR CONDITIONER**

(57) An object of the present invention is to control a high pressure gas pipe so as to reduce the pressure to a low level in order to prevent accumulation of liquid refrigerant in the high pressure gas pipe resulting from condensation. An air conditioner (1) is an air conditioner that performs a refrigerant quantity judging operation to judge the refrigerant quantity in a refrigerant circuit (10), and includes a heat source unit (2), utilization units (3a to 3c), expansion mechanisms (V2, V9a to V9c), a first refrigerant gas pipe (52), a second refrigerant gas pipe (53),

a refrigerant liquid pipe (51), switching mechanisms (4a to 4c), bypass circuits (27, 43a to 43c), bypass circuit opening/closing means (V3, V13a to V13c), and a controller (8). The switching mechanism can switch between a first state and a second state. The bypass circuit opening/closing means are provided in the bypass circuits that bypass the first refrigerant gas pipe to the second refrigerant gas pipe, and open and close the bypass circuits. The controller opens the bypass circuit opening/closing means before performing the refrigerant quantity judging operation.

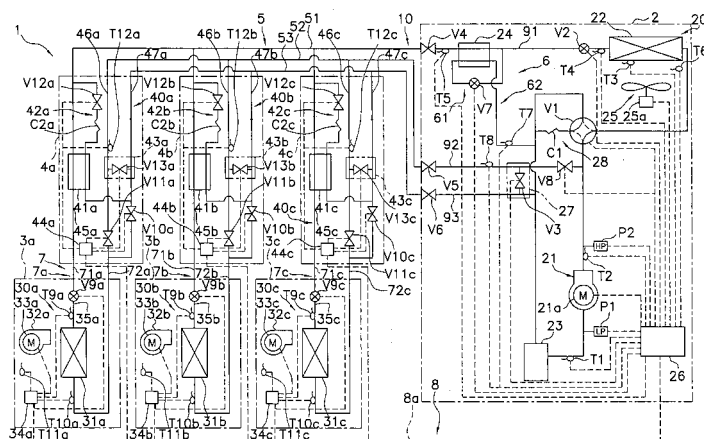


FIG. 1

## Description

### TECHNICAL FIELD

5 [0001] The present invention relates to a refrigerant circuit of an air conditioner and an air conditioner provided therewith.

### BACKGROUND ART

10 [0002] Conventionally, an approach has been proposed in which a simulation of refrigeration cycle characteristics is performed and the excess or deficiency of the refrigerant quantity is judged by using a result of the calculation, in order to judge the excess or deficiency of the refrigerant quantity in a refrigerant circuit of an air conditioner (for example, see Patent Document 1).

<Patent Document 1>

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[0003] JP-A Publication No. 3-186170

### DISCLOSURE OF THE INVENTION

20 <OBJECT TO BE ACHIEVED BY THE INVENTION>

[0004] However, according to the technology disclosed in Patent Document 1, with the multi-air conditioner capable of performing a simultaneous cooling and heating operation, when performing the refrigerant quantity judging operation while the cooling operation is performed in all rooms, the high pressure gas pipe extending from the outdoor unit to the cooling/heating selection unit will be in a shut-off state on the cooling/heating selection unit side. Thereby the refrigerant condenses and accumulates in the pipe and thus the detection error may be increased.

[0005] An object of the present invention is to control the high pressure gas pipe so as to reduce the pressure to a low level in order to prevent accumulation of liquid refrigerant in the high pressure gas pipe resulting from condensation during the refrigerant quantity judging operation of the multi-air conditioner capable of performing the simultaneous cooling and heating operation.

<MEANT TO ACHIEVE THE OBJECT>

[0006] An air conditioner according to a first aspect of the present invention is an air conditioner that performs a refrigerant quantity judging operation to judge the refrigerant quantity in a refrigerant circuit, the air conditioner including a heat source unit, a utilization unit, an expansion mechanism, a first gas refrigerant pipe, a second gas refrigerant pipe, a liquid refrigerant pipe, a switching mechanism, a bypass circuit, a bypass circuit opening/closing means, and a controller. The heat source unit includes a compression means that compresses refrigerant gas and a heat source side heat exchanger. The utilization unit includes a utilization side heat exchanger. The first gas refrigerant pipe extends from the discharge side of the compression means to the utilization unit. The second gas refrigerant pipe extends from the suction side of the compression means to the utilization unit. The liquid refrigerant pipe extends from the heat source side heat exchanger to the utilization unit. The switching mechanism can switch between a first state and a second state. The first state is a state in which the refrigerant flowing through the liquid refrigerant pipe evaporates in the utilization side heat exchanger and then flows into the second gas refrigerant pipe. The second state is a state in which the refrigerant flowing through the first gas refrigerant pipe condenses in the utilization side heat exchanger and then flows into the liquid refrigerant pipe. The bypass circuit bypasses the first gas refrigerant pipe to the second gas refrigerant pipe. The bypass circuit opening/closing means is provided in the bypass circuit and opens and closes the bypass circuit. The controller opens the bypass circuit opening/closing means before performing the refrigerant quantity judging operation.

[0007] In this air conditioner, the refrigerant pipe comprises two gas pipe systems, and the switching mechanism switches between the first state (cooling state) and the second state (heating state). Thereby the air conditioner can be freely set to the cooling operation and the heating operation. With this air conditioner capable of performing a simultaneous cooling and heating operation, the refrigerant quantity judging operation is performed by, for example, setting all the rooms (all the utilization units) to the first state (cooling state) by the switching mechanism (cooling/heating selection unit). However, because the first gas refrigerant pipe (high pressure gas pipe) extending from the heat source unit to the switching mechanism will be in a shut-off state, the refrigerant condenses and accumulates in the pipe, which may increase the detection error.

[0008] Therefore, in this present invention, the bypass circuit opening/closing means (bypass valve) that bypasses the first gas refrigerant pipe to the second gas refrigerant pipe is provided, and the bypass circuit opening/closing means

(bypass valve) is set to an opened state during the refrigerant quantity judging operation, thereby reducing the pressure difference between the first gas refrigerant pipe and the second gas refrigerant pipe and preventing accumulation of liquid refrigerant in the first gas refrigerant pipe resulting from condensation. Thus, the refrigerant quantity judging operation with high accuracy can be achieved.

**[0009]** An air conditioner according to a second aspect of the present invention is the air conditioner according to the first aspect of the present invention, wherein the bypass circuit opening/closing means is provided in the heat source unit.

**[0010]** In this air conditioner, the bypass circuit opening/closing means is provided in the heat source unit. Accordingly, the bypass circuit can be provided in the refrigerant circuit even without laying pipes for the bypass circuit at the time of construction. Therefore, it is possible to reduce the labors for construction and the cost.

**[0011]** An air conditioner according to a third aspect of the present invention is the air conditioner according to the first or second aspect of the present invention, further including a switching unit. The switching unit is a unit different from the heat source unit and the utilization unit. The switching unit includes the switching mechanism. The bypass circuit opening/closing means is provided in the switching unit.

**[0012]** With this air conditioner, the bypass circuit opening/closing means is provided in the switching unit. The refrigerant hardly flows through the first gas refrigerant pipe when the bypass circuit opening/closing means is provided only in the heat source unit. Therefore, there is a possibility that the temperature of the gas refrigerant in the pipe may change because of the incoming heat from the outside air and thereby the density of the refrigerant may change, which may increase the detection error.

**[0013]** Thus, in the present invention, the bypass circuit opening/closing means that bypasses the first gas refrigerant pipe to the second gas refrigerant pipe is provided in the switching unit. By using this bypass circuit opening/closing means together with the bypass circuit opening/closing means provided in the heat source unit, the low pressure gas refrigerant is caused to easily flow through the first gas refrigerant pipe. Therefore, it is possible to prevent the temperature of the gas refrigerant in the pipe from being changed by the incoming heat from the outside air and to reduce the detection error. In addition, the bypass circuit can be provided in the refrigerant circuit even without laying pipes for the bypass circuit at the time of construction. Accordingly, it is possible to reduce the labors for construction and the cost.

**[0014]** An air conditioner according to a fourth aspect of the present invention is the air conditioner according to any one of the first through third aspects of the present invention, further including a temperature detecting means. The temperature detecting means detects the refrigerant temperature in the first gas refrigerant pipe and outputs a refrigerant temperature detection value. The controller corrects the refrigerant quantity judged by the refrigerant quantity judging operation based on the refrigerant temperature detection value.

**[0015]** In this air conditioner, the refrigerant does not easily flow through the first gas refrigerant pipe even after the first gas refrigerant pipe is bypassed to the second gas refrigerant pipe by the provision of the bypass circuit and the distribution of the refrigerant gas pressure in the pipe is equalized. Therefore, there is a possibility that the temperature of the gas refrigerant in the pipe may change because of the incoming heat from the outside air and thereby the density of the refrigerant may change, which may increase the detection error.

**[0016]** Thus, in the present invention, the temperature detecting means is provided in the first gas refrigerant pipe, and the density of the refrigerant in the pipe is corrected by utilizing the refrigerant temperature detection value. Thereby it is possible to reduce the detection error. Thus, the refrigerant quantity judging operation with higher accuracy can be achieved.

**[0017]** An air conditioner according to a fifth aspect of the present invention is the air conditioner according to the fourth aspect of the present invention, wherein the temperature detecting means is provided in the switching unit.

**[0018]** In this air conditioner, the temperature detecting means is mounted on the first gas refrigerant pipe in the switching unit. Therefore, the temperature detecting means can be mounted on the first gas refrigerant pipe even without providing the temperature detecting means to the refrigerant communication pipe at the time of construction. Therefore, it is possible to reduce the labors for construction and the cost.

**[0019]** An air conditioner according to a sixth aspect of the present invention is the air conditioner according to the fourth or fifth aspect of the present invention, wherein the temperature detection device is provided in the heat source unit.

**[0020]** In this air conditioner, the temperature detecting means is mounted on the first gas refrigerant pipe in the heat source unit. Therefore, the temperature detecting means can be mounted on the first gas refrigerant pipe even without providing the temperature detecting means to the refrigerant communication pipe at the time of construction. Therefore, it is possible to reduce the labors for construction and the cost. In addition, by using this temperature detecting means together with the temperature detecting means provided in the switching unit in the fifth aspect of the present invention, it is possible to more accurately correct the density of the refrigerant in the pipe.

#### <EFFECTS OF THE INVENTION>

**[0021]** In the air conditioner according to the first aspect of the present invention, the bypass circuit opening/closing means (bypass valve) that bypasses the first gas refrigerant pipe to the second gas refrigerant pipe is provided, and the

bypass circuit opening/closing means is set to an opened state during the refrigerant quantity judging operation, thereby reducing the pressure difference between the first gas refrigerant pipe and the second gas refrigerant pipe and preventing accumulation of liquid refrigerant in the first gas refrigerant pipe resulting from condensation. Thus, the refrigerant quantity judging operation with high accuracy can be achieved.

[0022] In the air conditioner according to the second aspect of the present invention, the bypass circuit can be provided in the refrigerant circuit even without laying pipes for the bypass circuit at the time of construction. Therefore, it is possible to reduce the labors for construction and the cost.

[0023] In the air conditioner according to the third aspect of the present invention, the bypass circuit opening/closing means that bypasses the first gas refrigerant pipe to the second gas refrigerant pipe is provided in the switching unit, and the low pressure gas refrigerant is caused to easily flow through the first gas refrigerant pipe by using this bypass circuit opening/closing means together with the bypass circuit opening/closing means provided in the heat source unit. Accordingly, it is possible to prevent the temperature of the gas refrigerant in the pipe from being changed by the incoming heat from the outside air and to reduce the detection error. In addition, the bypass circuit can be provided in the refrigerant circuit even without laying pipes for the bypass circuit at the time of construction. Therefore, it is possible to reduce the labors for construction and the cost.

[0024] With the air conditioner according to the fourth aspect of the present invention, the temperature detecting means is provided in the first gas refrigerant pipe, and the density of the refrigerant in the pipe is corrected by utilizing the refrigerant temperature detection value. Thereby it is possible to reduce the detection error. Thus, the refrigerant quantity judging operation with higher accuracy can be achieved.

[0025] In the air conditioner according to the fifth aspect of the present invention, the temperature detecting means can be mounted on the first gas refrigerant pipe even without providing the temperature detecting means to the refrigerant communication pipe at the time of construction. Therefore, it is possible to reduce the labors for construction and the cost.

[0026] In the air conditioner according to the sixth aspect of the present invention, the temperature detecting means can be mounted on the first gas refrigerant pipe even without providing the temperature detecting means to the refrigerant communication pipe at the time of construction. Therefore, it is possible to reduce the labors for construction and the cost. In addition, by using this temperature detecting means together with the temperature detecting means provided in the switching unit in the fifth aspect of the present invention, it is possible to more accurately correct the density of the refrigerant in the pipe.

## BRIEF DESCRIPTION OF THE DRAWINGS

### [0027]

Figure 1 is a schematic configuration view of an air conditioner according to an embodiment of the present invention.

Figure 2 is a control block diagram of the air conditioner.

Figure 3 is a flowchart of a test operation mode.

Figure 4 is a flowchart of an automatic refrigerant charging operation.

Figure 5 is a schematic diagram to show a state of the refrigerant flowing in a refrigerant circuit in a refrigerant quantity judging operation (illustrations of a four-way switching valve and the like are omitted).

Figure 6 is a flowchart of a pipe volume judging operation.

Figure 7 is a Mollier diagram to show a refrigerating cycle of the air conditioner in the pipe volume judging operation for a liquid refrigerant communication pipe.

Figure 8 is a Mollier diagram to show a refrigerating cycle of the air conditioner in the pipe volume judging operation for a gas refrigerant communication pipe.

Figure 9 is a flowchart of an initial refrigerant quantity detection operation.

Figure 10 is a flowchart of a refrigerant leak detection operation mode.

## DESCRIPTION OF THE REFERENCE SYMBOLS

### [0028]

|            |                                                           |
|------------|-----------------------------------------------------------|
| 1          | Air conditioner                                           |
| 2          | Outdoor unit (heat source unit)                           |
| 21         | Compressor (compression means)                            |
| 22         | Outdoor heat exchanger (heat source side heat exchanger)  |
| 27         | First bypass refrigerant circuit (bypass circuit)         |
| 3a to 3c   | Indoor units (utilization units)                          |
| 31a to 31c | Indoor heat exchangers (utilization side heat exchangers) |

|                |                                                                                 |
|----------------|---------------------------------------------------------------------------------|
| 4a to 4c       | Connection units (switching mechanism/switching units)                          |
| 43a to 43c     | Third bypass refrigerant circuits (bypass circuits)                             |
| 8              | Controller                                                                      |
| V3             | First bypass on/off valve (bypass circuit opening/closing means)                |
| 5 V13a to V13c | Second bypass on/off valves (bypass circuit opening/closing means)              |
| T8             | First high pressure gas pipe temperature sensor (temperature detecting means)   |
| T12a to T12c   | Second high pressure gas pipe temperature sensors (temperature detecting means) |

## BEST MODE FOR CARRYING OUT THE INVENTION

**[0029]** In the following, an embodiment of an air conditioner according to the present invention is described based on the drawings.

### (1) CONFIGURATION OF THE AIR CONDITIONER

**[0030]** Figure 1 is a schematic configuration view of an air conditioner 1 according to an embodiment of the present invention. The air conditioner 1 is a device that is used to cool and heat a room in a building and the like by performing a vapor compression-type refrigeration cycle operation. The air conditioner 1 mainly includes one outdoor unit 2 as a heat source unit, a plurality (three in the present embodiment) of indoor units 3a to 3c as utilization units connected in parallel to the outdoor unit 2, connection units 4a to 4c provided respectively correspondingly to the indoor units 3a to 3c, a first refrigerant communication pipe group 5 that interconnects the outdoor unit 2 and the connection units 4a to 4c, and a second refrigerant communication pipe group 7 that interconnects the connection units 4a to 4c and the indoor units 3a to 3c. The first refrigerant communication pipe group 5 is configured by a first liquid refrigerant communication pipe 51, a high pressure gas refrigerant communication pipe 52, and a low pressure gas refrigerant communication pipe 53, and the second refrigerant communication pipe group 7 is configured by second liquid refrigerant communication pipes 71a to 71c and second gas refrigerant communication pipes 72a to 72c. This air conditioner 1 is configured to be able to perform a simultaneous cooling and heating operation according to the demand of the air-conditioned space in a room, where the indoor units 3a to 3c are installed, for example, as in the case where a cooling operation is performed in one air-conditioned space and a heating operation is performed in another air conditioned-space or the like. In other words, the vapor compression-type refrigerant circuit 10 of the air conditioner 1 in the present embodiment is configured by the interconnection of the outdoor unit 2, the indoor units 3a to 3c, the connection units 4a to 4c, the first refrigerant communication pipe group 5, and the second refrigerant communication pipe group 7.

#### <INDOOR UNIT>

**[0031]** The indoor units 3a to 3c are installed by being embedded in or hung from a ceiling of a room in a building and the like or by being mounted or the like on a wall surface of a room. The indoor units 3a to 3c are connected to the connection units 4a to 4c via the second refrigerant communication pipe group 7, and configure a part of the refrigerant circuit 10.

**[0032]** Next, the configurations of the indoor units 3a to 3c are described. Note that, because the indoor units 3a, 3b, and 3c all have the same configuration, only the configuration of the indoor unit 3a is described here, and in regard to the configurations of the indoor units 3b and 3c, reference symbols Xb and Xc are used instead of reference symbols Xa representing the respective portions of the indoor unit 3a, and descriptions of those respective portions are omitted. For example, an indoor fan 32a of the indoor unit 3a corresponds to indoor fans 32b and 32c of the indoor units 3b and 3c.

**[0033]** The indoor unit 3a mainly includes an indoor side refrigerant circuit 30a that configures a part of the refrigerant circuit 10. The indoor side refrigerant circuit 30a mainly includes an indoor expansion valve V9a as an expansion mechanism and an indoor heat exchanger 31a as a utilization side heat exchanger.

**[0034]** The indoor expansion valve V9a is an electrically powered expansion valve connected to the liquid side of the indoor heat exchanger 31a in order to adjust the flow rate or the like of the refrigerant flowing in the indoor side refrigerant circuit 30a.

**[0035]** The indoor heat exchanger 31a is a fin-and-tube type heat exchanger of a cross fin system configured by a heat transfer tube and numerous fins, and is a heat exchanger that functions as an evaporator for the refrigerant during the cooling operation to cool the indoor air and functions as a condenser for the refrigerant during the heating operation to heat the indoor air.

**[0036]** In addition, the indoor unit 3a includes the indoor fan 32a as a ventilation fan for sucking indoor air into the unit, causing the air to heat exchange with the refrigerant in the indoor heat exchanger 31a, and then supplying the air to the room as supply air. The indoor fan 32a is a fan capable of varying an air flow rate  $W_r$  of the air which is supplied to the indoor heat exchanger 31a, and in the present embodiment, is a centrifugal fan, multi-blade fan, or the like, which

is driven by a motor 33a comprising a DC fan motor.

[0037] In addition, various sensors are disposed in the indoor unit 3a. A liquid side temperature sensor T9a that detects the temperature of the refrigerant (i.e., the refrigerant temperature corresponding to a condensation temperature  $T_c$  during the heating operation or an evaporation temperature  $T_e$  during the cooling operation) is disposed at the liquid side of the indoor heat exchanger 31a. A gas side temperature sensor T10a that detects a temperature  $T_{eo}$  of the refrigerant is disposed at the gas side of the indoor heat exchanger 31a. A room temperature sensor T11a that detects the temperature of the indoor air that flows into the unit (i.e., a room temperature  $T_r$ ) is disposed at the indoor air suction side of the indoor unit 3a. In the present embodiment, the liquid side temperature sensor T9a, the gas side temperature sensor T10a, and the room temperature sensor T11a comprise thermistors. In addition, the indoor unit 3a includes an indoor side controller 34a that controls the operation of each portion constituting the indoor unit 3a. Additionally, the indoor side controller 34a includes a microcomputer, a memory and the like disposed in order to control the indoor unit 3a, and is configured such that it can exchange control signals and the like with a remote controller (not shown) for individually operating the indoor unit 3a, exchange control signals and the like with the outdoor unit 2 and the connection units 4a to 4c via a transmission line 8a, and the like.

#### <OUTDOOR UNIT>

[0038] The outdoor unit 2 is installed outside of a building and the like, is connected to the connection units 4a to 4c via the first refrigerant communication pipe group 5, configuring the refrigerant circuit 10.

[0039] Next, the configuration of the outdoor unit 2 is described. The outdoor unit 2 mainly includes an outdoor side refrigerant circuit 20 that configures a part of the refrigerant circuit 10. This outdoor side refrigerant circuit 20 mainly includes a compressor 21, a four-way switching valve V1, an outdoor heat exchanger 22 as a heat source side heat exchanger, an outdoor expansion valve V2 as an expansion mechanism, an accumulator 23, a subcooler 24 as a temperature adjustment mechanism, a first bypass refrigerant circuit 27, a pressure reducing circuit 28, a liquid side stop valve V4, and a high pressure gas side stop valve V5, a low pressure gas side stop valve V6, and a first high pressure gas on/off valve V8.

[0040] The compressor 21 is a compressor whose operation capacity can be varied, and in the present embodiment, is a positive displacement-type compressor driven by a motor 21 whose rotation frequency  $R_m$  is controlled by an inverter. In the present embodiment, only one compressor 21 is provided, but it is not limited thereto, and two or more compressors may be connected in parallel according to the number of connected units of indoor units and the like.

[0041] The four-way switching valve V1 is a valve provided for causing the outdoor heat exchanger 22 to function as an evaporator and a condenser. The four-way switching valve V1 is connected to the refrigerant gas side of the outdoor heat exchanger 22, the accumulator 23 on the suction side of the compressor 21, the discharge side of the compressor 21, and the pressure reducing circuit 28. Additionally, when causing the outdoor heat exchanger 22 to function as a condenser, the discharge side of the compressor 21 is connected to the refrigerant gas side of the outdoor heat exchanger 22, and the accumulator 23 on the suction side of the compressor 21 is connected to the pressure reducing circuit 28. On the other hand, when causing the outdoor heat exchanger 22 to function as an evaporator, the refrigerant gas side of the outdoor heat exchanger 22 is connected to the accumulator 23 on the suction side of the compressor 21, and the discharge side of the compressor 21 is connected to the pressure reducing circuit 28.

[0042] The outdoor heat exchanger 22 is a heat exchanger capable of functioning as an evaporator for the refrigerant and also as a condenser for the refrigerant. In this embodiment, it is a fin-and-tube type heat exchanger of a cross fin system that exchanges heat with the refrigerant using air as a heat source. The gas side of the outdoor heat exchanger 22 is connected to the four-way switching valve V1, and the liquid side thereof is connected to the first liquid refrigerant communication pipe 51.

[0043] The outdoor expansion valve V2 is an electrically powered expansion valve connected to the liquid side of the outdoor heat exchanger 22 in order to adjust the pressure, flow rate, or the like of the refrigerant flowing in the outdoor side refrigerant circuit 20.

[0044] In addition, the outdoor unit 2 includes an outdoor fan 25 as a ventilation fan for sucking outdoor air into the unit, causing the air to exchange heat with the refrigerant in the outdoor heat exchanger 22, and then exhausting the air to the outside. The outdoor fan 25 is a fan capable of varying an air flow rate  $W_o$  of the air which is supplied to the outdoor heat exchanger 22, and in the present embodiment, is a propeller fan or the like driven by a motor 25a comprising a DC fan motor.

[0045] The accumulator 23 is connected between the four-way switching valve V1 and the compressor 21, and is a container capable of accumulating excess refrigerant generated in the refrigerant circuit 10 in accordance with the change in the operation load of the indoor units 3a to 3c and the like. In addition, the accumulator 23 is connected to the connection units 4a to 4c via the low pressure gas side stop valve V6 and the low pressure gas refrigerant communication pipe 53.

[0046] In the present embodiment, the subcooler 24 is a double tube heat exchanger, and is disposed to cool the refrigerant sent to the indoor expansion valves V9a to V9c after the refrigerant is condensed in the outdoor heat exchanger

22. The subcooler 24 is connected between the outdoor expansion valve V2 and the liquid side stop valve V4.

**[0047]** In addition, a second bypass refrigerant circuit 6 as a cooling source of the subcooler 24 is disposed. Note that, in the description below, a portion corresponding to the refrigerant circuit 10 excluding the second bypass refrigerant circuit 6 is referred to as a main refrigerant circuit for convenience sake.

**[0048]** The second bypass refrigerant circuit 6 is connected to the main refrigerant circuit so as to cause a portion of the refrigerant sent from the outdoor heat exchanger 22 to the indoor expansion valves V9a to V9c via the connection units 4a to 4c to branch from the main refrigerant circuit and return to the suction side of the compressor 21. Specifically, the second bypass refrigerant circuit 6 includes a branch circuit 61 connected so as to branch a portion of the refrigerant sent from the outdoor expansion valve V2 to the indoor expansion valves V9a to V9c via the connection units 4a to 4c at a position between the outdoor heat exchanger 22 and the subcooler 24, and a merging circuit 62 connected to the suction side of the compressor 21 so as to return a portion of refrigerant from an outlet on the second bypass refrigerant circuit 6 side of the subcooler 24 to the suction side of the compressor 21. Further, the branch circuit 61 is disposed with a bypass expansion valve V7 for adjusting the flow rate of the refrigerant flowing in the second bypass refrigerant circuit 6. Here, the bypass expansion valve V7 comprises an electrically operated expansion valve. In this way, the refrigerant sent from the outdoor heat exchanger 22 to the indoor expansion valves V9a to V9c via the connection units 4a to 4c is cooled in the subcooler 24 by the refrigerant flowing in the second bypass refrigerant circuit 6 which has been depressurized by the bypass expansion valve V7. In other words, performance of the subcooler 24 is controlled by adjusting the opening degree of the bypass expansion valve V7.

**[0049]** The first bypass refrigerant circuit 27 is a circuit that bypasses the pipe between the high pressure gas side stop valve V5 and the discharge side of the compressor 21 to the pipe between the low pressure gas side stop valve V6 and the accumulator 23. A first bypass on/off valve V3 is provided in the first bypass refrigerant circuit 27. Here, the first bypass on/off valve V3 is a solenoid valve capable of distributing and blocking the refrigerant.

**[0050]** The pressure reducing circuit 28 includes a capillary tube C1 and is connected to the four-way switching valve V1 and the accumulator 23.

**[0051]** The liquid side stop valve V4, the high pressure gas side stop valve V5, and the low pressure gas side stop valve V6 are valves disposed at ports connected to external equipment and pipes (specifically, the first liquid refrigerant communication pipe 51, the high pressure gas refrigerant communication pipe 52, and the low pressure gas refrigerant communication pipe 53). The liquid side stop valve V4 is connected to the outdoor heat exchanger 22 via the subcooler 24 and the outdoor expansion valve V2. The high pressure gas side stop valve V5 is connected to the discharge side of the compressor 21. The low pressure gas side stop valve V6 is connected to the suction side of the compressor 21 via the accumulator 23.

**[0052]** The first high pressure gas on/off valve V8 is provided on the pipe on the high pressure gas side which is branched from the discharge side of the compressor 21, and is a solenoid valve capable of distributing and blocking the high pressure gas refrigerant through the high pressure gas refrigerant communication pipe 52.

**[0053]** In addition, various sensors are disposed in the outdoor unit 2. Specifically, disposed in the outdoor unit 2 are a suction pressure sensor P1 that detects a suction pressure  $P_s$  of the compressor 21, a discharge pressure sensor P2 that detects a discharge pressure  $P_d$  of the compressor 21, a suction temperature sensor T1 that detects a suction temperature  $T_s$  of the compressor 21, and a discharge temperature sensor T2 that detects a discharge temperature  $T_d$  of the compressor 21. The suction temperature sensor T1 is disposed at a position between the accumulator 23 and the compressor 21. The outdoor heat exchanger 22 is provided with a heat exchanger temperature sensor T3 that detects the temperature of the refrigerant flowing through the outdoor heat exchanger 22 (i.e., the refrigerant temperature corresponding to the condensation temperature  $T_c$  during the cooling operation or the evaporation temperature  $T_e$  during the heating operation). A liquid side temperature sensor T4 that detects a refrigerant temperature  $T_{co}$  is disposed at the liquid side of the outdoor heat exchanger 22. A liquid pipe temperature sensor T5 that detects the temperature of the refrigerant (i.e., a liquid pipe temperature  $T_{lp}$ ) is disposed at the outlet on the main refrigerant circuit side of the subcooler 24. An outdoor temperature sensor T6 that detects the temperature of the outdoor air that flows into the unit (i.e., an outdoor temperature  $T_a$ ) is disposed at the outdoor air suction side of the outdoor unit 2. The merging circuit 62 of the second bypass refrigerant circuit 6 is disposed with a bypass temperature sensor T7 for detecting the refrigerant temperature flowing at the outlet on the second bypass refrigerant circuit 6 side of the subcooler 24. A first high pressure gas pipe temperature sensor T8 that detects the temperature of the refrigerant (i.e., a first high pressure gas pipe temperature  $T_{h1}$ ) is provided to the high pressure gas pipe extending from the high pressure gas side stop valve V5 to the first high pressure gas on/off valve V8. In the present embodiment, the suction temperature sensor T1, the discharge temperature sensor T2, the heat exchanger temperature sensor T3, the liquid side temperature sensor T4, the liquid pipe temperature sensor T5, the outdoor temperature sensor T6, the bypass temperature sensor T7, and the first high pressure gas pipe temperature sensor T8 comprise thermistors.

**[0054]** In addition, the outdoor unit 2 includes an outdoor side controller 26 that controls the operation of each portion constituting the outdoor unit 2. Additionally, the outdoor side controller 26 includes a microcomputer and a memory disposed in order to control the outdoor unit 2, an inverter circuit that controls the motor 21 a, and the like, and is

configured such that it can exchange control signals and the like with the indoor side controllers 34a to 34c of the indoor units 3a to 3c and connection side controllers 44a to 44c of the connection units 4a to 4c (described later) via the transmission line 8a. In other words, a controller 8 that performs the operation control of the entire air conditioner 1 is configured by the indoor side controllers 34a to 34c, the connection side controllers 44a to 44c, the outdoor side controller 26, and the transmission line 8a that interconnects each of these controllers.

[0055] As shown in Figure 2, the controller 8 is connected so as to be able to receive detection signals of various sensors P1, P2, T1 to T8, T9a to T9c, T10a to T10c, T11a to T11c, T12a to T12c and also to be able to control various equipment and valves 21, 25, 32a to 32c, V1 to V3, V7, V8, V9a to V9c, V10a to V10c, V11a to V11c, V12a to V12c, V13a to V13c based on these detection signals and the like. In addition, a warning display 9 comprising LEDs and the like, which is configured to indicate that a refrigerant leak is detected in the below described refrigerant leak detection operation, is connected to the controller 8. Here, Figure 2 is a control block diagram of the air conditioner 1.

#### <CONNECTION UNIT>

[0056] The connection units 4a to 4c are installed with the indoor units 3a to 3c in the room of a building or the like. The connection units 4a to 4c are interposed, together with the first refrigerant communication pipe group 5 and the second refrigerant communication pipe group 7, between the indoor units 3a to 3c and the outdoor unit 2, and configure a part of the refrigerant circuit 10.

[0057] Next, the configurations of the connection units 4a to 4c are described. Note that, because the connection units 4a, 4b, and 4c all have the same configuration, only the configuration of the connection unit 4a is described here, and in regard to the configurations of the connection units 4b and 4c, reference symbols Yb and Yc are used instead of reference symbols Ya representing the respective portions of the connection unit 4a, and descriptions of those respective portions are omitted. For example, a subcooler 41a of the connection unit 4a corresponds to subcoolers 41b and 41c of the connection units 4b and 4c.

[0058] The connection unit 4a configures a part of the refrigerant circuit 10 and is provided with a connection side refrigerant circuit 40a. The connection side refrigerant circuit 40a mainly includes the subcooler 41 a, a pressure reducing circuit 42a, a third bypass refrigerant circuit 43a, the low pressure gas on/off valve V10a, and the second high pressure gas on/off valve V11a.

[0059] The subcooler 41 a is a device in which a portion of the liquid refrigerant to be returned to the first liquid refrigerant communication pipe 51 is sent to the subcooler 41 a via the pressure reducing circuit 42a (described later) so as to subcool the liquid refrigerant to be returned to the first liquid refrigerant communication pipe 51 when the indoor units 3a to 3c perform the simultaneous cooling and heating operation. A portion of the liquid refrigerant introduced into the subcooler 41a evaporates as a result of heat exchange, and is returned to the outdoor side refrigerant circuit 20 through the low pressure gas refrigerant communication pipe 53. The pressure reducing circuit 42a has a pressure reducing circuit on/off valve V12a and a capillary tube C2a which are connected in series.

[0060] The third bypass refrigerant circuit 43a is a circuit that bypasses the high pressure gas refrigerant communication pipe 52 to the low pressure gas refrigerant communication pipe 53. A second bypass on/off valve V13a is provided in the third bypass refrigerant circuit 43a. Here, the second bypass on/off valve V13a is a solenoid valve capable of distributing and blocking the refrigerant.

[0061] The low pressure gas on/off valve V10a is connected to the low pressure gas refrigerant communication pipe 53, and is a solenoid valve capable of distributing and blocking the refrigerant.

[0062] The second high pressure gas on/off valve V11a is connected to the high pressure gas refrigerant communication pipe 52, and is a solenoid valve capable of distributing and blocking the refrigerant.

[0063] The connection unit 4a sets the low pressure gas on/off valve V10a to an opened state and closes the second high pressure gas on/off valve V11a when the indoor unit 3a performs the cooling operation. Accordingly, the connection unit 4a can function to send the liquid refrigerant that flows in from the first liquid refrigerant communication pipe 51 to the indoor expansion valve V9a of the indoor side refrigerant circuit 30a and to return the gas refrigerant that is depressurized in the indoor expansion valve V9a and evaporated in the indoor heat exchanger 31a to the low pressure gas refrigerant communication pipe 53.

[0064] In addition, the connection unit 4a closes the low pressure gas on/off valve V10a and sets the second high pressure gas on/off valve V11a to an opened state when the indoor unit 3a performs the heating operation. Accordingly, the connection unit 4a can function to send the high pressure gas refrigerant that flows in from the high pressure gas refrigerant communication pipe 52 to the gas side of the indoor heat exchanger 31 a in the indoor side refrigerant circuit 30a and to return the liquid refrigerant condensed in the indoor heat exchanger 31a to the first liquid refrigerant communication pipe 51.

[0065] In addition, the connection unit 4a is provided with a second high pressure gas pipe temperature sensor T12a that detects the temperature of the refrigerant (i.e., a second high pressure gas pipe temperature Th2) in the high pressure gas refrigerant flow path. In the present embodiment, the second high pressure gas pipe temperature sensor

T12a comprises a thermistor.

**[0066]** Further, the connection unit 4a includes a connection side controller 44a that controls the operation of each portion constituting the connection unit 4a. Additionally, the connection side controller 44a includes a microcomputer and a memory disposed in order to control the indoor unit 4a, and is configured such that it can exchange control signals and the like with the indoor side controller 34a of the indoor unit 3a.

**[0067]** As described above, the outdoor side refrigerant circuit 20 is connected to the indoor side refrigerant circuits 30a to 30c via the connection side refrigerant circuits 40a to 40c, and thereby the refrigerant circuit 10 of the air conditioner 1 is configured. Additionally, the air conditioner 1 in the present embodiment can perform the so-called simultaneous cooling and heating operation where, for example, the indoor unit 3c performs the heating operation while the indoor units 3a and 3b perform the cooling operation, and the like.

#### <FIRST REFRIGERANT COMMUNICATION PIPE GROUP AND SECOND REFRIGERANT COMMUNICATION PIPE GROUP>

**[0068]** The first refrigerant communication pipe group 5 and the second refrigerant communication pipe group 7 are refrigerant pipes that are arranged on site when installing the air conditioner 1 at an installation location such as a building and the like. Pipes having various lengths and pipe diameters are used according to the installation conditions such as an installation location, combination of an outdoor unit, an indoor unit, and a connection unit, and the like. Accordingly, for example, when installing a new air conditioner 1, in order to calculate the charging quantity of the refrigerant, it is necessary to obtain accurate information regarding the lengths and pipe diameters and the like of the first refrigerant communication pipe group 5 and the second refrigerant communication pipe group 7. However, management of such information and the calculation itself of the refrigerant quantity are difficult. In addition, when utilizing an existing pipe to renew an indoor unit, an outdoor unit, or a connection unit, there is a case where information regarding the lengths and pipe diameters and the like of the first refrigerant communication pipe group 5 and the second refrigerant communication pipe group 7 has been lost.

**[0069]** As described above, the refrigerant circuit 10 of the air conditioner 1 is configured by the interconnection of the indoor side refrigerant circuits 30a to 30c, the outdoor side refrigerant circuit 20, the connection side refrigerant circuits 40a to 40c, the first refrigerant communication pipe group 5, and the second refrigerant communication pipe group 7. In addition, it can also be said that this refrigerant circuit 10 is configured by the second bypass refrigerant circuit 6 and the main refrigerant circuit excluding the second bypass refrigerant circuit 6. Additionally, the controller 8 constituted by the indoor side controllers 34a to 34c, the connection side controllers 44a to 44c, and the outdoor side controller 26 allows the air conditioner 1 in the present embodiment to operate the cooling operation, the heating operation, and the simultaneous cooling and heating operation by switching thereamong by the four-way switching valve V1 and the first high pressure on/off valve V8 in the outdoor unit 2 and the low pressure gas on/off valve V10a and the second high pressure gas on/off valve V11a in the connection units 4a to 4c, and also to control each equipment of the outdoor unit 2, the indoor units 3a to 3c, and the connection units 4a to 4c according to the operation load of each of the indoor units 3a to 3c.

#### (2) OPERATION OF THE AIR CONDITIONER

**[0070]** Next, the operation of the air conditioner 1 in the present embodiment is described.

**[0071]** The operation modes of the air conditioner 1 in the present embodiment include: a normal operation mode where control of constituent equipment of the outdoor unit 2, the indoor units 3a to 3c, and the connection units 4a to 4c is performed according to the operation load of each of the indoor units 3a to 3c; a test operation mode where a test operation to be performed after installation of constituent equipment of the air conditioner 1 is performed (specifically, it is not limited to after the first-time installation of equipment: it also includes, for example, after modification by adding or removing constituent equipment such as an indoor unit, after repair of damaged equipment, and the like); and a refrigerant leak detection operation mode where, after the test operation is finished and the normal operation has started, whether or not the refrigerant is leaking from the refrigerant circuit 10 is judged.

**[0072]** The normal operation mode mainly includes the following operations according to the cooling and heating load of the indoor units 3a to 3c: the cooling operation where all the indoor units 3a to 3c perform cooling; the heating operation where all the indoor units 3a to 3c perform heating; and the simultaneous cooling and heating operation where one or some of the indoor units 3a to 3c perform cooling and the other indoor unit(s) performs heating. In addition, according to the air-conditioning load of the entire indoor units 3a to 3c, the simultaneous cooling and heating operation can be divided into a case where the operation is performed by causing the outdoor heat exchanger 22 of the outdoor unit 2 to function as an evaporator (evaporation operation state), and a case where the operation is performed by causing the outdoor heat exchanger 22 of the outdoor unit 2 to function as a condenser (condensation operation state). Note that, the simultaneous cooling and heating operation described here specifically refers to, for example, an operation where

the indoor unit 3a performs the cooling operation and the other indoor units 3b and 3c perform the heating operation.

**[0073]** In addition, the test operation mode mainly includes an automatic refrigerant charging operation to charge refrigerant into the refrigerant circuit 10; a pipe volume judging operation to detect the volumes of the first refrigerant communication pipe group 5 and the second refrigerant communication pipe group 7; and an initial refrigerant quantity detection operation to detect the initial refrigerant quantity after installing constituent equipment or after charging refrigerant into the refrigerant circuit 10.

**[0074]** Operation in each operation mode of the air conditioner 1 is described below.

<NORMAL OPERATION MODE>

(Cooling Operation)

**[0075]** First, the cooling operation in the normal operation mode is described with reference to Figures 1 and 2.

**[0076]** During the cooling operation, in the outdoor side refrigerant circuit 20 of the outdoor unit 2, the four-way switching valve V1 is switched to a state indicated by solid lines in Figure 1, and thereby the outdoor heat exchanger 22 is caused to function as a condenser. The outdoor expansion valve V2 is in a fully opened state. The liquid side stop valve V4, the high pressure gas side stop valve V5, and the low pressure gas side stop valve V6 are set to an opened state, and the first high pressure gas on/off valve V8 is set to a closed state.

**[0077]** In the indoor units 3a to 3c, the opening degree of each of the indoor expansion valves V9a to V9c is adjusted such that a superheating degree SHr of the refrigerant at the outlet of each of the indoor heat exchangers 31a to 31c (i.e., the gas sides of the indoor heat exchangers 31a to 31c) becomes constant at a target superheating degree SHrs. In the present embodiment, the superheating degree SHr of the refrigerant at the outlet of each of the indoor heat exchangers 31a to 31c is detected by subtracting the refrigerant temperature (which corresponds to the evaporation temperature  $T_e$ ) detected by the liquid side temperature sensors T9a to T9c from the refrigerant temperature detected by the gas side temperature sensors T10a to T10c, or is detected by converting the suction pressure  $P_s$  of the compressor 21 detected by the suction pressure sensor P1 to saturation temperature corresponding to the evaporation temperature  $T_e$ , and subtracting this saturation temperature of the refrigerant from the refrigerant temperature detected by the gas side temperature sensors T10a to T10c. Note that, although it is not employed in the present embodiment, a temperature sensor that detects the temperature of the refrigerant flowing through each of the indoor heat exchangers 31a to 31c may be disposed such that the superheating degree SHr of the refrigerant at the outlet of each of the indoor heat exchangers 31a to 31c is detected by subtracting the refrigerant temperature corresponding to the evaporation temperature  $T_e$  which is detected by this temperature sensor from the refrigerant temperature detected by the gas side temperature sensors T10a to T10c.

**[0078]** In addition, the opening degree of the bypass expansion valve V7 is adjusted such that a superheating degree SHb of the refrigerant at the outlet on the second bypass refrigerant circuit 6 side of the subcooler 24 becomes a target superheating degree SHbs. In the present embodiment, the superheating degree SHb of the refrigerant at the outlet on the second bypass refrigerant circuit 6 side of the subcooler 24 is detected by converting the suction pressure  $P_s$  of the compressor 21 detected by the suction pressure sensor P1 to saturation temperature corresponding to the evaporation temperature  $T_e$ , and subtracting this saturation temperature of the refrigerant from the refrigerant temperature detected by the bypass temperature sensor T7. Note that, although it is not employed in the present embodiment, a temperature sensor may be disposed at an inlet on the second bypass refrigerant circuit 6 side of the subcooler 24 such that the superheating degree SHb of the refrigerant at the outlet on the second bypass refrigerant circuit 6 side of the subcooler 24 is detected by subtracting the refrigerant temperature detected by this temperature sensor from the refrigerant temperature detected by the bypass temperature sensor T7.

**[0079]** In the connection units 4a to 4c, the second high pressure gas on/off valves V11a to V11c are closed, and at the same time, the low pressure gas on/off valves V10a to V10c are opened. Thereby, the indoor heat exchangers 31a to 31c of the indoor units 3a to 3c function as evaporators, and at the same time, a state is achieved where the indoor heat exchangers 31a to 31c of the indoor units 3a to 3c are connected to the suction side of the compressor 21 of the outdoor unit 2 via the low pressure gas refrigerant communication pipe 53. In addition, the pressure reducing circuit on/off valves V12a to V12c are in a closed state.

**[0080]** When the compressor 21, the outdoor fan 25, and the indoor fans 32a to 32c are started in this state of the refrigerant circuit 10, the low pressure gas refrigerant is sucked into the compressor 21 and compressed into high pressure gas refrigerant. Subsequently, the high pressure gas refrigerant is sent to the outdoor heat exchanger 22 via the four-way switching valve V1, exchanges heat with the outdoor air supplied by the outdoor fan 25, and becomes condensed into high pressure liquid refrigerant. Then, this high pressure liquid refrigerant passes through the outdoor expansion valve V2, flows into the subcooler 24, exchanges heat with the refrigerant flowing in the second bypass refrigerant circuit 6, is further cooled, and becomes subcooled. At this time, a portion of the high pressure liquid refrigerant condensed in the outdoor heat exchanger 22 is branched into the second bypass refrigerant circuit 6 and is depressurized

by the bypass expansion valve V7. Subsequently, it is returned to the suction side of the compressor 21. Here, the refrigerant that passes through the bypass expansion valve V7 is depressurized close to the suction pressure  $P_s$  of the compressor 21 and thereby a portion of the refrigerant evaporates. Then, the refrigerant flowing from the outlet of the bypass expansion valve V7 of the second bypass refrigerant circuit 6 toward the suction side of the compressor 21 passes through the subcooler 24 and exchanges heat with high pressure liquid refrigerant sent from the outdoor heat exchanger 22 on the main refrigerant circuit side to the indoor units 3 a to 3c.

**[0081]** Then, the high pressure liquid refrigerant in a subcooled state is sent to the indoor units 3a to 3c via the liquid side stop valve V4, the first liquid refrigerant communication pipe 51, and each connection units 4a to 4c. The high pressure liquid refrigerant sent to the indoor units 3a to 3c is depressurized close to the suction pressure  $P_s$  of the compressor 21 by the indoor expansion valves V9a to V9c, becomes refrigerant in a low pressure gas-liquid two-phase state, is sent to the indoor heat exchangers 31a to 31c, exchanges heat with the indoor air in the indoor heat exchangers 31a to 31c, and is evaporated into low pressure gas refrigerant.

**[0082]** Then, the low pressure gas refrigerant is sent to the low pressure gas refrigerant communication pipe 53 through the low pressure gas on/off valves V10a to V10c of the connection units 4a to 4c. This low pressure gas refrigerant is sent to the outdoor unit 2 via the low pressure gas refrigerant communication pipe 53, and flows into the accumulator 23 via the low pressure gas side stop valve V6. Then, the low pressure gas refrigerant that flowed into the accumulator 23 is again sucked into the compressor 21.

(Heating Operation)

**[0083]** During the heating operation, in the outdoor side refrigerant circuit 20 of the outdoor unit 2, the four-way switching valve V1 is switched to a state indicated by dotted lines in Figure 1, and thereby the outdoor heat exchanger 22 functions as an evaporator. At the same time, the high pressure gas refrigerant compressed in and discharged from the compressor 21 is supplied to the indoor units 3a to 3c through the high pressure gas refrigerant communication pipe 52. The opening degree of the outdoor expansion valve V2 is adjusted so as to be able to depressurize the refrigerant that flows into the outdoor heat exchanger 22 to a pressure where the refrigerant can be evaporated (i.e., an evaporation pressure  $P_e$ ) in the outdoor heat exchanger 22. The liquid side stop valve V4, the high pressure gas side stop valve V5, and the low pressure gas side stop valve V6 are in an opened state, and the bypass expansion valve V7 and the first high pressure gas on/off valve V8 are in an opened state.

**[0084]** In the indoor units 3a to 3c, the opening degree of each of the indoor expansion valves V9a to V9c is adjusted such that a subcooling degree  $SC_r$  of the refrigerant at the outlet of each of the indoor heat exchangers 31a to 31c (i.e., the liquid sides of the indoor heat exchangers 31 a to 31 c) becomes constant at a target subcooling degree  $SC_r$ s. In the present embodiment, the subcooling degree  $SC_r$  of the refrigerant at the outlet of each of the indoor heat exchangers 31a to 31c is detected by converting the discharge pressure  $P_d$  of the compressor 21 detected by the discharge pressure sensor P2 to saturation temperature corresponding to the condensation temperature  $T_c$ , and by subtracting the refrigerant temperature detected by the liquid side temperature sensors T9a to T9c from the refrigerant saturation temperature. Note that, although it is not employed in the present embodiment, a temperature sensor that detects the temperature of the refrigerant flowing through each of the indoor heat exchangers 31a to 31c may be disposed such that the subcooling degree  $SC_r$  of the refrigerant at the outlet of each of the indoor heat exchangers 31a to 31c is detected by subtracting the refrigerant temperature corresponding to the condensation temperature  $T_c$  which is detected by this temperature sensor from the refrigerant temperature detected by the liquid side temperature sensors T9a to T9c.

**[0085]** In the connection units 4a to 4c, as the low pressure gas on/off valve V10a to V10c are closed and the second high pressure gas on/off valves V11a to V11c are opened at the same time, the indoor heat exchangers 31a to 31c of the indoor units 3a to 3c are brought into a state where they function as condensers. In addition, the pressure reducing circuit on/off valves V12a to V12c are in an opened state.

**[0086]** When the compressor 21, the outdoor fan 25, and the indoor fans 32a to 32c are started in this state of the refrigerant circuit 10, the low pressure gas refrigerant is sucked into the compressor 21 and compressed into high pressure gas refrigerant. Then, this high pressure gas refrigerant is sent to the high pressure gas refrigerant communication pipe 52 via the four-way switching valve V1 and the high pressure gas side stop valve V5.

**[0087]** Then, the high pressure gas refrigerant sent to the high pressure gas refrigerant communication pipe 52 is sent to each of the connection units 4a to 4c. The high pressure gas refrigerant sent to the connection units 4a to 4c is sent to the indoor units 3a to 3a through the second high pressure gas on/off valves V11a to V11c. The high pressure gas refrigerant sent to the indoor units 3a to 3c exchanges heat with the indoor air in the indoor heat exchangers 31a to 31c and is condensed into high pressure liquid refrigerant. Subsequently, it is depressurized according to the opening degree of the indoor expansion valves V9a to V9c when passing through the indoor expansion valves V9a to V9c.

**[0088]** Then, the refrigerant that passed through the indoor expansion valves V9a to V9c is sent to the subcoolers 41a to 41c of the connection units 4a to 4c. This subcooled liquid refrigerant is sent to the outdoor unit 2 via the first liquid refrigerant communication pipe 51, is further depressurized via the liquid side stop valve V4 and the outdoor

expansion valve V2, and then flows into the outdoor heat exchanger 22. Then, the refrigerant in a low pressure gas-liquid two-phase state that flowed into the outdoor heat exchanger 22 exchanges heat with the outdoor air supplied by the outdoor fan 25, is evaporated into low pressure gas refrigerant, and flows into the accumulator 23 via the four-way switching valve V1. Then, the low pressure gas refrigerant that flowed into the accumulator 23 is again sucked into the compressor 21.

(Simultaneous Cooling and Heating Operation/Evaporation Load)

**[0089]** An operation (evaporation operation) is described which is the simultaneous cooling and heating operation where, for example, among the indoor units 3a to 3c, the indoor unit 3a performs the cooling operation and at the same time the indoor units 3b and 3c perform the heating operation, and in which the outdoor heat exchanger 22 of the outdoor unit 2 is caused to function as an evaporator according to the air conditioning load of the entire indoor units 3a to 3c. At this time, as is the case with the above described heating operation mode, the four-way switching valve V1 is switched to a state indicated by dotted lines in Figure 1. Thereby the outdoor heat exchanger 22 functions as an evaporator and also the high pressure gas refrigerant compressed in and discharged from the compressor 21 is supplied to the two indoor units 3b and 3c performing the heating operation through the high pressure gas refrigerant communication pipe 52. At this time, the bypass expansion valve V7 is closed, and the first high pressure gas on/off valve V8 is set to an opened state.

**[0090]** In the indoor unit 3a, the opening degree of the indoor expansion valve V9a is adjusted according to the cooling load of the indoor unit 3a. For example, adjustment of the opening degree is performed based on the superheating degree of the indoor heat exchanger 31a (specifically, the temperature difference between the refrigerant temperature detected by the liquid side temperature sensor T9a and the refrigerant temperature detected by the gas side temperature sensor T10a).

**[0091]** In the connection unit 4a, the second high pressure gas on/off valve V11a is closed and at the same time the low pressure gas on/off valve V10a is opened. Accordingly, the indoor heat exchanger 31a of the indoor unit 3a is caused to function as an evaporator and at the same time a state is achieved where the indoor heat exchanger 31a of the indoor unit 3a is connected to the suction side of the compressor 21 of the outdoor unit 2 via the low pressure gas refrigerant communication pipe 53. In addition, the pressure reducing circuit on/off valve V12a is in a closed state.

**[0092]** In addition, in the indoor units 3b and 3c, the opening degree of each of the indoor expansion valves V9b and V9c is adjusted such that the subcooling degree SCr of the refrigerant at the outlet of each of the indoor heat exchangers 31b and 31c (i.e., the liquid sides of the indoor heat exchangers 31b and 31c) becomes constant at the target subcooling degree SCrs.

**[0093]** In the connection units 4b and 4c, the low pressure gas on/off valves V10b and V10c are closed and at the same time the second high pressure gas on/off valves V11b and V11c are opened. Thereby the indoor heat exchangers 31b and 31c of the indoor units 3b and 3c are brought into a state where they function as condensers. In addition, the pressure reducing circuit on/off valves V12b and V12c are in an opened state.

**[0094]** In this state of the refrigerant circuit 10, the high pressure gas refrigerant compressed in and discharged from the compressor 21 is sent to the high pressure gas refrigerant communication pipe 52 through the high pressure gas side stop valve V5.

**[0095]** Then, the high pressure gas refrigerant sent to the high pressure gas refrigerant communication pipe 52 is sent to each of the indoor units 3b and 3c through each of the connection units 4b and 4c and the second high pressure gas on/off valves V11b and V11c. Then, the high pressure gas refrigerant sent to the indoor units 3b and 3c exchanges heat with the indoor air in the indoor heat exchangers 31b and 31c and is condensed into high pressure liquid refrigerant. Subsequently, it is depressurized according to the opening degree of the indoor expansion valves V9b and V9c when passing through the indoor expansion valves V9b and V9c. On the other hand, the indoor air is heated and supplied to the room.

**[0096]** The refrigerant that passed through the indoor expansion valves V9b and V9c is sent to the subcoolers 41b and 41c of the connection units 4b and 4c and is subcooled. This subcooled liquid refrigerant is sent to the first liquid refrigerant communication pipe 51, and a portion of the liquid refrigerant sent to the first liquid refrigerant communication pipe 51 is sent to the connection unit 4a. Then, the refrigerant sent to the connection unit 4a is sent to the indoor expansion valve V9a of the indoor unit 3a.

**[0097]** The refrigerant sent to the indoor expansion valve V9a is depressurized by the indoor expansion valve V9a. Thereafter, the refrigerant exchanges heat with the indoor air in the indoor heat exchangers 31a and is thereby evaporated into low pressure gas refrigerant. On the other hand, the indoor air is cooled and supplied to the room. Then, the low pressure gas refrigerant is sent to the connection unit 4a.

**[0098]** The low pressure gas refrigerant sent to the connection unit 4a is sent to the outdoor unit 2 through the low pressure gas on/off valve V10a and the low pressure gas refrigerant communication pipe 53, and flows into the accumulator 23 via the low pressure gas side stop valve V6. Then, the low pressure gas refrigerant that flowed into the

accumulator 23 is again sucked into the compressor 21.

**[0099]** On the other hand, the remaining portion of the refrigerant from which the refrigerant sent from the first liquid refrigerant communication pipe 51 to the connection unit 4a and the indoor unit 3a is excluded is sent to the outdoor heat exchanger 22 via the liquid side stop valve V4 of the outdoor unit 2, is evaporated in the outdoor heat exchanger 22, and becomes low pressure gas refrigerant. This gas refrigerant is sucked into the compressor 21 via the four-way switching valve V 1 and the accumulator 23.

(Simultaneous Cooling and Heating Operation/Condensation Load)

**[0100]** An operation (condensation operation) is described which is the simultaneous cooling and heating operation mode where, for example, among the indoor units 3a to 3c, the indoor unit 3a and 3b perform the cooling operation and at the same time the indoor unit 3c performs the heating operation, and in which the outdoor heat exchanger 22 of the outdoor unit 2 is caused to function as a condenser according to the air conditioning load of the entire indoor units 3a to 3c. At this time, the four-way switching valve V1 is switched to a state indicated by solid lines in Figure 1. Thereby the outdoor heat exchanger 22 functions as a condenser and also the high pressure gas refrigerant compressed in and discharged from the compressor 21 is supplied to the indoor unit 3c through the high pressure gas refrigerant communication pipe 52. At this time, the first high pressure gas on/off valve V8 is set to an opened state.

**[0101]** In the indoor units 3a and 3b, the opening degree of each of the indoor expansion valves V9a and V9b is adjusted according to the cooling load of each of the indoor units 3a and 3b. For example, adjustment of the opening degree is performed based on the superheating degree of each of the indoor heat exchangers 31a and 31b (specifically, the temperature difference between the refrigerant temperature detected by the liquid side temperature sensors T9a and T9b and the refrigerant temperature detected by the gas side temperature sensors T110a and T10b, respectively).

**[0102]** In the connection units 4a and 4b, the second high pressure gas on/off valves V11a and V11b are closed and at the same time the low pressure gas on/off valves V10a and V10b are opened. Thereby, the indoor heat exchangers 31a and 31b of the indoor units 3a and 3b will function as evaporators and at the same time a state is achieved where the indoor heat exchangers 31a and 31b of the indoor units 3a and 3b are connected to the suction side of the compressor 21 of the outdoor unit 2 via the low pressure gas refrigerant communication pipe 53. In addition, the pressure reducing circuit on/off valves V12a and V12b are in a closed state.

**[0103]** In the indoor unit 3c, the opening degree of the indoor expansion valve V9c is adjusted according to the heating load of the indoor unit 3c. For example, adjustment of the opening degree is performed based on the subcooling degree of the indoor heat exchanger 31c (specifically, the temperature difference between the refrigerant temperature detected by the liquid side temperature sensor T9c and the refrigerant temperature detected by the gas side temperature sensor T10c).

**[0104]** In the connection unit 4c, the low pressure gas on/off valve V10c is closed and at the same time the second high pressure gas on/off valve V11c is opened. Accordingly, a state is achieved where the indoor heat exchanger 31c of the indoor unit 3c functions as a condenser. In addition, the pressure reducing circuit on/off valve V12c is in an opened state.

**[0105]** In such a state of the refrigerant circuit 10, the high pressure gas refrigerant compressed in and discharged from the compressor 21 is sent to the outdoor heat exchanger 22 through the four-way switching valve V1 and is also sent to the high pressure gas refrigerant communication pipe 52 through the high pressure gas side stop valve V5.

**[0106]** The high pressure gas refrigerant sent to the outdoor heat exchanger 22 is condensed in the outdoor heat exchanger 22 and becomes liquid refrigerant. Then, the liquid refrigerant is sent to the first liquid refrigerant communication pipe 51 through the liquid side stop valve V4.

**[0107]** In addition, the high pressure gas refrigerant sent to the high pressure gas refrigerant communication pipe 52 is sent to the connection unit 4c. The high pressure gas refrigerant sent to the connection unit 4c is sent to the indoor heat exchanger 31c of the indoor unit 3c through the second high pressure gas on/off valve V11c.

**[0108]** The high pressure gas refrigerant sent to the indoor heat exchanger 31c exchanges heat with the indoor air in the indoor heat exchanger 31c of the indoor unit 3c and thereby is condensed. On the other hand, the indoor air is heated and supplied to the room. The refrigerant condensed in the indoor heat exchanger 31c passes through the indoor expansion valve V9c and then is sent to the connection unit 4c.

**[0109]** The refrigerant sent to the connection unit 4c is sent to the first liquid refrigerant communication pipe 51, and merges with the refrigerant that is sent to the first liquid refrigerant communication pipe 51 through the liquid side stop valve V4. The refrigerant that flows through the first liquid refrigerant communication pipe 51 is sent to the indoor expansion valves V9a and V9b of the indoor units 3a and 3b via the connection units 4a and 4b.

**[0110]** The refrigerant sent to the indoor expansion valves V9a and V9b is depressurized by the indoor expansion valves V9a and V9b. Then, the refrigerant evaporates as a result of heat exchange with the indoor air in the indoor heat exchangers 31a and 31b and becomes low pressure gas refrigerant. On the other hand, the indoor air is cooled and supplied to the room. Then, the low pressure gas refrigerant is sent to the connection units 4a and 4b.

**[0111]** The low pressure gas refrigerant sent to the connection units 4a and 4b is sent to the low pressure gas refrigerant communication pipe 53 through the low pressure gas on/off valves V10a and V10b. The low pressure gas refrigerant sent to the low pressure gas refrigerant communication pipe 53 is sucked into the compressor 21 via the low pressure gas side stop valve V6 and the accumulator 23.

**[0112]** Such operation control as described above in the normal operation mode is performed by the controller 8 (more specifically, the indoor side controllers 34a to 34c, the connection side controllers 44a to 44c, the outdoor side controller 26, and the transmission line 8a that interconnects each of the controllers 34a to 34c, 44a to 44c, and 26) that functions as a normal operation controlling means to perform the normal operation that includes the cooling operation and the heating operation.

<TEST OPERATION MODE>

**[0113]** Next, the test operation mode is described with reference to Figures 1 to 3. Here, Figure 3 is a flowchart of the test operation mode. In the present embodiment, in the test operation mode, first, the automatic refrigerant charging operation in Step S1 is performed. Subsequently, the pipe volume judging operation in Step S2 is performed, and then the initial refrigerant quantity detection operation in Step S3 is performed.

**[0114]** In the present embodiment, an example of a case is described where the outdoor unit 2 into which the refrigerant is charged in advance, the indoor units 3a to 3c, and the connection units 4a to 4c are installed at an installation location such as a building and the like and interconnected via the first refrigerant communication pipe group 5 and the second refrigerant communication pipe group 7 to configure the refrigerant circuit 10; and subsequently additional refrigerant is charged into the refrigerant circuit 10 whose refrigerant quantity is insufficient according to the volumes of the first refrigerant communication pipe group 5 and the second refrigerant communication pipe group 7.

(Step S1: Automatic Refrigerant Charging Operation)

**[0115]** First, the liquid side stop valve V4, the high pressure gas side stop valve V5, and the low pressure gas side stop valve V6 of the outdoor unit 2 are opened and the refrigerant circuit 10 is filled with the refrigerant that is charged in the outdoor unit 2 in advance.

**[0116]** Next, when a worker performing the test operation connects a refrigerant cylinder for additional charging to a service port (not shown) of the refrigerant circuit 10 and issues a command to start the test operation directly to the controller 8 or remotely by a remote controller (not shown) and the like, the controller 8 starts the process from Step S11 to Step S13 shown in Figure 4. Here, Figure 4 is a flowchart of the automatic refrigerant charging operation.

(Step S11: Refrigerant Quantity Judging Operation)

**[0117]** When a command to start the automatic refrigerant charging operation is issued, with the four-way switching valve V1 of the outdoor unit 2 in a state indicated by solid lines in Figure 1, the refrigerant circuit 10 becomes a state where the indoor expansion valves V9a to V9c of the indoor units 3a to 3c, the low pressure gas on/off valves V10a to V10c of the connection units 4a to 4c, and the outdoor expansion valve V2 are opened, and the first high pressure gas on/off valve V8 of the outdoor unit 2 and the second high pressure gas on/off valves V11a to V11c of the connection units 4a to 4c are closed. Then, the compressor 21, the outdoor fan 25, and the indoor fans 32a to 32c are started, and all of the indoor units 3a to 3c are forcibly caused to perform the cooling operation (hereinafter referred to as "all indoor unit operation"). At this time, the first bypass on/off valve V3 in the first bypass refrigerant circuit 27 in the outdoor unit 2 and the second bypass on/off valves V13a to V13c in the third bypass refrigerant circuits 43a to 43c in the connection units 4a to 4c are in an opened state, and the pressure of the refrigerant in the high pressure gas refrigerant communication pipe 52 and in the low pressure gas refrigerant communication pipe 53 becomes equalized.

**[0118]** Consequently, as shown in Figure 5, in the refrigerant circuit 10, the high pressure gas refrigerant compressed and discharged in the compressor 21 flows along a flow path from the compressor 21 to the outdoor heat exchanger 22 that functions as a condenser (see the portion from the compressor 21 to the outdoor heat exchanger 22 in the area indicated by diagonal hatching in Figure 5); the high pressure refrigerant that undergoes phase-change from a gas state to a liquid state by heat exchange with the outdoor air flows in the outdoor heat exchanger 22 that functions as a condenser (see the portion corresponding to the outdoor heat exchanger 22 in the area indicated by diagonal hatching and black hatching in Figure 5); the high pressure liquid refrigerant flows along a flow path from the outdoor heat exchanger 22 to the indoor expansion valves V9a to V9c (including the outdoor expansion valve V2, the portion corresponding to the main refrigerant circuit side of the subcooler 24, and the first liquid refrigerant communication pipe 51) and a flow path from the outdoor heat exchanger 22 to the bypass expansion valve V7 (see the portions from the outdoor heat exchanger 22 to the indoor expansion valves V9a to V9c and to the bypass expansion valve V7 in the area indicated by black hatching in Figure 5); the low pressure refrigerant that undergoes a phase change from a gas-liquid two-phase

state to a gas state by heat exchange with the indoor air and the like flows in the portions corresponding to the indoor heat exchangers 31a to 31c that function as evaporators and the portion corresponding to the second bypass refrigerant circuit 6 side of the subcooler 24 (see the portions corresponding to the indoor heat exchangers 31a to 31c and the portion corresponding to the subcooler 24 in the area indicated by lattice hatching and diagonal hatching in Figure 5); and, within a flow path from the indoor heat exchangers 31a to 31c to the compressor 21, the low pressure gas refrigerant flows along flow paths on the high pressure gas side and the low pressure gas side of the connection units 4a to 4c (including the third bypass refrigerant circuits 43a to 43c), a flow path including the high pressure gas refrigerant communication pipe 52, the low pressure gas refrigerant communication pipe 53, the first bypass refrigerant circuit 27, and the accumulator 23, and a flow path from the portion corresponding to the second bypass refrigerant circuit 6 side of the subcooler 24 to the compressor 21 (see the portion from the indoor heat exchangers 31a to 31c to the compressor 21 ((including the high pressure gas refrigerant connection pipe 52 and the low pressure gas refrigerant communication pipe 53 and the connection units 4a to 4c)) and the portion from the portion corresponding to the second bypass refrigerant circuit 6 side of the subcooler 24 to the compressor 21 in the area indicated by diagonal hatching in Figure 5). Figure 5 is a schematic diagram to show a state of the refrigerant flowing in the refrigerant circuit 10 in a refrigerant quantity judging operation (illustrations of the four-way switching valve V1 and the like are omitted).

**[0119]** Next, equipment control as described below is performed to proceed to operation to stabilize the state of the refrigerant circulating in the refrigerant circuit 10. Specifically, the indoor expansion valves V9a to V9c are controlled such that the superheating degree SHr of each of the indoor heat exchangers 31 a to 31c that function as evaporators becomes constant (hereinafter referred to as "superheating degree control"); the operation capacity of the compressor 21 is controlled such that the evaporation pressure  $P_e$  becomes constant (hereinafter referred to as "evaporation pressure control"); the air flow rate  $W_o$  of outdoor air supplied to the outdoor heat exchanger 22 by the outdoor fan 25 is controlled such that a condensation pressure  $P_c$  of the refrigerant in the outdoor heat exchanger 22 becomes constant (hereinafter referred to as "condensation pressure control"); the operation capacity of the subcooler 24 is controlled such that the temperature of the refrigerant sent from the subcooler 24 to the indoor expansion valves V9a to V9c becomes constant (hereinafter referred to as "liquid pipe temperature control"); and the air flow rate  $W_r$  of indoor air supplied to the indoor heat exchangers 31a to 31c by the indoor fans 32a to 32c is maintained constant such that the evaporation pressure  $P_e$  of the refrigerant is stably controlled by the above described evaporation pressure control.

**[0120]** Here, the reason to perform the evaporation pressure control is because the evaporation pressure  $P_e$  of the refrigerant in the indoor heat exchangers 31a to 31c that function as evaporators is greatly affected by the refrigerant quantity in the indoor heat exchangers 31a to 31c where the low pressure refrigerant flows while undergoing a phase change from a gas-liquid two-phase state to a gas state as a result of heat exchange with the indoor air (see the portions corresponding to the indoor heat exchangers 31a to 31c in the area indicated by lattice hatching and diagonal hatching in Figure 5, which is hereinafter referred to as "evaporator portion C"). Then, here, the state of the refrigerant flowing in the evaporator portion C is stabilized by causing the evaporation pressure  $P_e$  of the refrigerant in the indoor heat exchangers 31a to 31c to become constant as a result of controlling the operation capacity of the compressor 21 by the motor 21a whose rotation frequency  $R_m$  is controlled by an inverter. In other words, a state is created in which the refrigerant quantity in the evaporator portion C changes mainly by the evaporation pressure  $P_e$ . Note that, the control of the evaporation pressure  $P_e$  by the compressor 21 in the present embodiment is achieved in the following manner: the refrigerant temperature (which corresponds to the evaporation temperature  $T_e$ ) detected by the liquid side temperature sensors T9a to T9c of the indoor heat exchangers 31a to 31c is converted to saturation pressure; the operation capacity of the compressor 21 is controlled such that the saturation pressure becomes constant at a target low pressure  $P_{es}$  (in other words, the control to change the rotation frequency  $R_m$  of the motor 21a is performed); and then a refrigerant circulation flow rate  $W_e$  flowing in the refrigerant circuit 10 is increased or decreased. Note that, although it is not employed in the present embodiment, the operation capacity of the compressor 21 may be controlled such that the suction pressure  $P_s$  of the compressor 21 detected by the suction pressure sensor P1, which is the operation state quantity equivalent to the pressure of the refrigerant at the evaporation pressure  $P_e$  of the refrigerant in the indoor heat exchangers 31a to 31c, becomes constant at the target low pressure  $P_{es}$ , or the saturation temperature (which corresponds to the evaporation temperature  $T_e$ ) corresponding to the suction pressure  $P_s$  becomes constant at a target low pressure  $T_{es}$ . Also, the operation capacity of the compressor 21 may be controlled such that the refrigerant temperature (which corresponds to the evaporation temperature  $T_e$ ) detected by the liquid side temperature sensors T9a to T9c of the indoor heat exchangers 31a to 31c becomes constant at the target low pressure  $T_{es}$ .

**[0121]** Then, by performing such evaporation pressure control, the state of the refrigerant flowing through the refrigerant pipes from the indoor heat exchangers 31 a to 31 c to the compressor 21 including the low pressure gas refrigerant communication pipe 53 and the accumulator 23 (see the portion from the indoor heat exchangers 31a to 31c to the compressor 21 in the area indicated by diagonal hatching in Figure 5, which is hereinafter referred to as "gas refrigerant distribution portion D") becomes stabilized, creating a state where the refrigerant quantity in the gas refrigerant distribution portion D changes mainly by the evaporation pressure  $P_e$  (i.e., the suction pressure  $P_s$ ), which is the operation state quantity equivalent to the pressure of the refrigerant in the gas refrigerant distribution portion D.

**[0122]** In addition, the reason to perform the condensation pressure control is because the condensation pressure  $P_c$  of the refrigerant is greatly affected by the refrigerant quantity in the outdoor heat exchanger 22 where the high pressure refrigerant flows while undergoing a phase change from a gas state to a liquid state as a result of heat exchange with the outdoor air (see the portion corresponding to the outdoor heat exchanger 22 in the area indicated by diagonal hatching and black hatching in Figure 5, which is hereinafter referred to as "condenser portion A"). The condensation pressure  $P_c$  of the refrigerant in the condenser portion A greatly changes due to the effect of the outdoor temperature  $T_a$ . Therefore, the air flow rate  $W_o$  of the indoor air supplied from the outdoor fan 25 to the outdoor heat exchanger 22 is controlled by the motor 25a, and thereby the condensation pressure  $P_c$  of the refrigerant in the outdoor heat exchanger 22 is maintained constant and the state of the refrigerant flowing in the condenser portion A is stabilized. In other words, a state is created where the refrigerant quantity in the condenser portion A changes mainly by a subcooling degree  $SC_o$  at the liquid side of the outdoor heat exchanger 22 (hereinafter referred to as the outlet of the outdoor heat exchanger 22 in the description regarding the refrigerant quantity judging operation). Note that, for the control of the condensation pressure  $P_c$  by the outdoor fan 25 in the present embodiment, the discharge pressure  $P_d$  of the compressor 21 detected by the discharge pressure sensor P2, which is the operation state quantity equivalent to the condensation pressure  $P_c$  of the refrigerant in the outdoor heat exchanger 22, or the temperature of the refrigerant flowing through the outdoor heat exchanger 22 (i.e., the condensation temperature  $T_c$ ) detected by the heat exchanger temperature sensor T3 is used.

**[0123]** Then, by performing such condensation pressure control, the high pressure liquid refrigerant flows along the flow path from the outdoor heat exchanger 22 to the indoor expansion valves V9a to V9c (including the outdoor expansion valve V2, the portion on the main refrigerant circuit side of the subcooler 24, and the first liquid refrigerant communication pipe 51) and the flow path from the outdoor heat exchanger 22 to the bypass expansion valve V7 of the second bypass refrigerant circuit 6, the pressure of the refrigerant in the portions from the outdoor heat exchanger 22 to the indoor expansion valves V9a to V9c and to the bypass expansion valve V7 (see the area indicated by black hatching in Figure 5, which is hereinafter referred to as "liquid refrigerant distribution portion B") becomes stabilized, and the liquid refrigerant distribution portion B is sealed by the liquid refrigerant, thereby becoming a stable state.

**[0124]** In addition, the reason to perform the liquid pipe temperature control is to prevent a change in the density of the refrigerant in the refrigerant pipes from the subcooler 24 to the indoor expansion valves V9a to V9c including the first liquid refrigerant communication pipe 51 (see the portion from the subcooler 24 to the indoor expansion valves V9a to V9c in the liquid refrigerant distribution portion B shown in Figure 5). Performance of the subcooler 24 is controlled by increasing or decreasing the flow rate of the refrigerant flowing in the second bypass refrigerant circuit 6 such that the refrigerant temperature  $T_{lp}$  detected by the liquid pipe temperature sensor T5 disposed at the outlet on the main refrigerant circuit side of the subcooler 24 becomes constant at a target liquid pipe temperature  $T_{lps}$ , and by adjusting the quantity of heat exchange between the refrigerant flowing in the main refrigerant circuit side and the refrigerant flowing in the second bypass refrigerant circuit 6 side of the subcooler 24. Note that, the flow rate of the refrigerant in the second bypass refrigerant circuit 6 is increased or decreased by adjustment of the opening degree of the bypass expansion valve V7. In this way, the liquid pipe temperature control is achieved in which the refrigerant temperature in the refrigerant pipes from the subcooler 24 to the indoor expansion valves V9a to V9c including the first liquid refrigerant communication pipe 51 becomes constant.

**[0125]** Then, even when the refrigerant temperature  $T_{co}$  at the outlet of the outdoor heat exchanger 22 (i.e., the subcooling degree  $SC_o$  of the refrigerant at the outlet of the outdoor heat exchanger 22) changes along with an increase in the refrigerant quantity by charging refrigerant into the refrigerant circuit 10, the effect of a change in the refrigerant temperature  $T_{co}$  at the outlet of the outdoor heat exchanger 22 will remain only within the refrigerant pipes from the outlet of the outdoor heat exchanger 22 to the subcooler 24 as a result of performing such liquid pipe temperature constant control. Accordingly, the effect of a change in the refrigerant temperature  $T_{co}$  at the outlet of the outdoor heat exchanger 22 will not extend to the refrigerant pipes from the subcooler 24 to the indoor expansion valves V9a to V9c including the first liquid refrigerant communication pipe 51 in the liquid refrigerant distribution portion B.

**[0126]** Further, the reason to perform the superheating degree control is because the refrigerant quantity in the evaporator portion C greatly affects the quality of wet vapor of the refrigerant at the outlets of the indoor heat exchangers 31a to 31c. The superheating degree  $SH_r$  of the refrigerant at the outlet of each of the indoor heat exchangers 31a to 31c is controlled such that the superheating degree  $SH_r$  of the refrigerant at the gas sides of the indoor heat exchangers 31a to 31c (hereinafter referred to as the outlets of the indoor heat exchangers 31a to 31c in the description regarding the refrigerant quantity judging operation) becomes constant at the target superheating degree  $SH_{rs}$  (in other words, such that the gas refrigerant at the outlet of each of the indoor heat exchangers 31a to 31c is in a superheat state) by controlling the opening degree of the indoor expansion valves V9a to V9c, and thereby the state of the refrigerant flowing in the evaporator portion C is stabilized.

**[0127]** Consequently, by performing such superheating degree control, a state is created in which the gas refrigerant reliably flows in the gas refrigerant distribution portion D.

**[0128]** By various control described above, the state of the refrigerant circulating in the refrigerant circuit 10 becomes stabilized, and the distribution of the refrigerant quantity in the refrigerant circuit 10 becomes constant. Therefore, when

refrigerant starts to be charged into the refrigerant circuit 10 by additional refrigerant charging, which is subsequently performed, it is possible to create a state where a change in the refrigerant quantity in the refrigerant circuit 10 mainly appears as a change of the refrigerant quantity in the outdoor heat exchanger 22 (hereinafter this operation is referred to as "refrigerant quantity judging operation").

**[0129]** Such control as described above is performed as the process in Step S11 by the controller 8 (more specifically, by the indoor side controllers 34a to 34c, the connection side controllers 44a to 44c, the outdoor side controller 26, and the transmission line 8a that interconnects each of the controllers 34a to 34c, 44a to 44c, 26) that functions as a refrigerant quantity judging operation controlling means for performing the refrigerant quantity judging operation.

**[0130]** Note that, unlike the present embodiment, when refrigerant is not charged in advance in the outdoor unit 2, it is necessary prior to Step S11 to charge refrigerant until the refrigerant quantity reaches a level where constituent equipment will not abnormally stop during the above described refrigerant quantity judging operation.

(Step S12: Refrigerant Quantity Calculation)

**[0131]** Next, additional refrigerant is charged into the refrigerant circuit 10 while performing the above described refrigerant quantity judging operation. At this time, the controller 8 that functions as a refrigerant quantity calculating means calculates the refrigerant quantity in the refrigerant circuit 10 from the operation state quantity of constituent equipment or refrigerant flowing in the refrigerant circuit 10 during additional refrigerant charging in Step S12.

**[0132]** First, the refrigerant quantity calculating means in the present embodiment is described. The refrigerant quantity calculating means divides the refrigerant circuit 10 into a plurality of portions, calculates the refrigerant quantity for each divided portion, and thereby calculates the refrigerant quantity in the refrigerant circuit 10. More specifically, a relational expression between the refrigerant quantity in each portion and the operation state quantity of constituent equipment or refrigerant flowing in the refrigerant circuit 10 is set for each divided portion, and the refrigerant quantity in each portion can be calculated by using these relational expressions. In the present embodiment, when the four-way switching valve V1 is in a state indicated by solid lines in Figure 1, i.e., a state where the discharge side of the compressor 21 is connected to the gas side of the outdoor heat exchanger 22 and where the suction side of the compressor 21 is connected to the outlets of the indoor heat exchangers 31a to 31c via the low pressure gas side stop valve V6 and the low pressure gas refrigerant communication pipe 53, the refrigerant circuit 10 is divided into the following portions and a relational expression is set for each portion: a portion corresponding to the compressor 21 and a portion from the compressor 21 to the outdoor heat exchanger 22 including the four-way switching valve V1 (not shown in Figure 5) (hereinafter referred to as "high pressure gas pipe portion E"); a portion corresponding to the outdoor heat exchanger 22 (i.e., the condenser portion A); a portion from the outdoor heat exchanger 22 to the subcooler 24 and an inlet side half of a portion corresponding to the main refrigerant circuit side of the subcooler 24 in the liquid refrigerant distribution portion B (hereinafter referred to as "high temperature side liquid pipe portion B1"); an outlet side half of a portion corresponding to the main refrigerant circuit side of the subcooler 24 and a portion from the subcooler 24 to the liquid side stop valve V4 (not shown in Figure 5) in the liquid refrigerant distribution portion B (hereinafter referred to as "low temperature side liquid pipe portion B2"); a portion combining the first liquid refrigerant communication pipe 51, the liquid side refrigerant flow path of the connection units 4a to 4c, and the second liquid refrigerant communication pipe 71a to 71c in the liquid refrigerant distribution portion B (hereinafter referred to as "liquid refrigerant communication pipe portion B3"); a portion from the first liquid refrigerant communication pipe 51 in the liquid refrigerant distribution portion B up to the second gas refrigerant communication pipes 72a to 72c in the gas refrigerant distribution portion D including portions corresponding to the indoor expansion valves V9a to V9c and the indoor heat exchangers 31a to 31c (i.e., the evaporator portion C) (hereinafter referred to as "indoor unit portion F"); a portion combining the high pressure gas refrigerant communication pipe 52 and the high pressure gas side refrigerant flow path (including up to the second bypass on/off valves V13a to V13c on the high pressure gas side of the third bypass refrigerant circuits 43a to 43c) in the connection units 4a to 4c (hereinafter referred to as "high pressure gas refrigerant communication pipe portion G1") in the gas refrigerant distribution portion D; a portion combining the low pressure gas refrigerant communication pipe 53, the second gas refrigerant communication pipes 72a to 72c, and the low pressure gas side refrigerant flow path in the connection units 4a to 4c (including up to the second bypass on/off valves V13a to V13c on the low pressure gas side of the third bypass refrigerant circuits 43a to 43c) (hereinafter referred to as "low pressure gas refrigerant communication pipe portion G2") in the gas refrigerant distribution portion D; a portion from the high pressure gas side stop valve V5 (not shown in Figure 5) to the first high pressure gas on/off valve V8 (hereinafter referred to as "first low pressure low pressure gas pipe portion H") in the gas refrigerant distribution portion D; a portion combining a portion from the low pressure gas side stop valve V6 (not shown in Figure 5) to the first bypass refrigerant circuit 27 and the first bypass refrigerant circuit 27 and a portion from the first bypass refrigerant circuit 27 to the four-way switching valve V1 and a portion from the first bypass refrigerant circuit 27 to the compressor 21 including the accumulator 23 (hereinafter referred to as "second low pressure gas pipe portion I"); and a portion from the high temperature side liquid pipe portion B1 to the second low pressure gas pipe portion I including the bypass expansion valve V7 and a portion corresponding to the second bypass refrigerant circuit 6 side of the subcooler

24 in the liquid refrigerant distribution portion B (hereinafter referred to as "second bypass circuit portion J"). Note that the portion combining the high pressure gas refrigerant communication pipe portion G1 and the low pressure gas refrigerant communication pipe portion G2 is referred to as a gas refrigerant communication pipe portion G. Next, the relational expressions set for each portion described above are described.

[0133] In the present embodiment, a relational expression between a refrigerant quantity Mog1 in the high pressure gas pipe portion E and the operation state quantity of constituent equipment or refrigerant flowing in the refrigerant circuit 10 is expressed, for example, by

$$\text{Mog1} = \text{Vog1} \times \text{pd},$$

which is a function expression in which a volume Vog1 of the high pressure gas pipe portion E in the outdoor unit 2 is multiplied by a density pd of the refrigerant in high pressure gas pipe portion E. Note that, the volume Vog1 of the high pressure gas pipe portion E is a value that is known prior to installation of the outdoor unit 2 at the installation location and is stored in advance in the memory of the controller 8. In addition, the density pd of the refrigerant in the high pressure gas pipe portion E is obtained by converting the discharge temperature Td and the discharge pressure Pd.

[0134] A relational expression between a refrigerant quantity Mc in the condenser portion A and the operation state quantity of constituent equipment or refrigerant flowing in the refrigerant circuit 10 is expressed, for example, by

$$\text{Mc} = \text{kc1} \times \text{Ta} + \text{kc2} \times \text{Tc} + \text{kc3} \times \text{SHm} + \text{kc4} \times \text{Wc} + \text{kc5} \times \text{pc} + \text{kc6} \times \text{pco} + \text{kc7},$$

which is a function expression of the outdoor temperature Ta, the condensation temperature Tc, a compressor discharge superheating degree SHm, the refrigerant circulation flow rate Wc, the saturated liquid density pc of the refrigerant in the outdoor heat exchanger 22, and a density pco of the refrigerant at the outlet of the outdoor heat exchanger 22. Note that, the parameters kc1 to kc7 in the above described relational expression are derived from a regression analysis of results of tests and detailed simulations and are stored in advance in the memory of the controller 8. In addition, the compressor discharge superheating degree SHm is a superheating degree of the refrigerant at the discharge side of the compressor, and is obtained by converting the discharge pressure Pd to refrigerant saturation temperature and subtracting this refrigerant saturation temperature from the discharge temperature Td. The refrigerant circulation flow rate Wc is expressed as a function of the evaporation temperature Te and the condensation temperature Tc (i.e.,  $Wc = f(Te, Tc)$ ). A saturated liquid density pc of the refrigerant is obtained by converting the condensation temperature Tc. The density pco of the refrigerant at the outlet of the outdoor heat exchanger 22 is obtained by converting the condensation pressure Pc, which is obtained by converting the condensation temperature Tc, and the refrigerant temperature Tco.

[0135] A relational expression between a refrigerant quantity Mol1 in the high temperature side liquid pipe portion B1 and the operation state quantity of constituent equipment or refrigerant flowing in the refrigerant circuit 10 is expressed, for example, by

$$\text{Mol1} = \text{Vol1} \times \text{pco},$$

which is a function expression in which a volume Vol1 of the high temperature side liquid pipe portion B1 in the outdoor unit 2 is multiplied by the density pco of the refrigerant in the high temperature side liquid pipe portion B1 (i.e., the above described density of the refrigerant at the outlet of the outdoor heat exchanger 22). Note that, the volume Vol1 of the high pressure side liquid pipe portion B1 is a value that is known prior to installation of the outdoor unit 2 at the installation location and is stored in advance in the memory of the controller 8.

[0136] A relational expression between a refrigerant quantity Mol2 in the low temperature side liquid pipe portion B2 and the operation state quantity of constituent equipment or refrigerant flowing in the refrigerant circuit 10 is expressed, for example, by

$$\text{Mol2} = \text{Vol2} \times \text{plp},$$

which is a function expression in which a volume Vol2 of the low temperature side liquid pipe portion B2 in the outdoor unit 2 is multiplied by a density plp of the refrigerant in the low temperature side liquid pipe portion B2. Note that, the volume Vol2 of the low temperature side liquid pipe portion B2 is a value that is known prior to installation of the outdoor unit 2 at the installation location and is stored in advance in the memory of the controller 8. In addition, the density plp

of the refrigerant in the low temperature side liquid pipe portion B2 is the density of the refrigerant at the outlet of the subcooler 24, and is obtained by converting the condensation pressure  $P_c$  and the refrigerant temperature  $T_{lp}$  at the outlet of the subcooler 24.

**[0137]** A relational expression between a refrigerant quantity  $M_{lp}$  in the liquid refrigerant communication pipe portion B3 and the operation state quantity of constituent equipment or refrigerant flowing in the refrigerant circuit 10 is expressed, for example, by

$$M_{lp} = V_{lp} \times \rho_{lp},$$

which is a function expression in which a volume  $V_{lp}$  of the portion combining the first liquid refrigerant communication pipe 51, the liquid side refrigerant flow path in the connection units 4a to 4c, and the second liquid refrigerant communication pipes 71a to 71c is multiplied by the density  $\rho_{lp}$  of the refrigerant in the liquid refrigerant communication pipe portion B3 (i.e., the density of the refrigerant at the outlet of the subcooler 24). Here, the volume  $V_{lp}$  is divided into a volume  $V_{lp1}$  of the portion combining the first liquid refrigerant communication pipe 51 and the second liquid refrigerant communication pipes 71a to 71c and a volume  $V_{lp2}$  of the liquid side refrigerant flow path in the connection units 4a to 4c. As for the volume  $V_{lp1}$  of the portion combining the first liquid refrigerant communication pipe 51 and the second liquid refrigerant communication pipes 71a to 71c, because the first liquid refrigerant communication pipe 51 and the second liquid refrigerant communication pipes 71a to 71c are refrigerant pipes arranged on site when installing the air conditioner 1 at an installation location such as a building and the like, a value calculated on site from the information regarding the length, pipe diameter and the like is input, or information regarding the length, pipe diameter and the like is input on site, and the controller 8 calculates the volume  $V_{lp1}$  from the input information of the first liquid refrigerant communication pipe 51 and the second liquid refrigerant communication pipes 71a to 71c. Or, as described below, the volume  $V_{lp1}$  is calculated by using the operation results of the pipe volume judging operation. In addition, the volume  $V_{lp2}$  of the liquid side refrigerant flow path in the connection units 4a to 4c is a value that is known prior to installation of the connection units 4a to 4c at the installation location and is stored in advance in the memory of the controller 8.

**[0138]** A relational expression between a refrigerant quantity  $M_r$  in the indoor unit portion F and the operation state quantity of constituent equipment or refrigerant flowing in the refrigerant circuit 10 is expressed, for example, by

$$M_r = kr1 \times T_{lp} + kr2 \times \Delta T + kr3 \times SHr + kr4 \times W_r + kr5,$$

which is a function expression of the refrigerant temperature  $T_{lp}$  at the outlet of the subcooler 24, a temperature difference  $\Delta T$  in which the evaporation temperature  $T_e$  is subtracted from the room temperature  $T_r$ , the superheating degree  $SHr$  of the refrigerant at the outlets of the indoor heat exchangers 31a to 31c, and the air flow rate  $W_r$  of the indoor fans 32a to 32c. Note that, the parameters  $kr1$  to  $kr5$  in the above described relational expression are derived from a regression analysis of results of tests and detailed simulations and are stored in advance in the memory of the controller 8. Note that, here, the relational expression for the refrigerant quantity  $M_r$  is set for each of the three indoor units 3a to 3c, and the entire refrigerant quantity in the indoor unit portion F is calculated by adding the refrigerant quantity  $M_r$  in the indoor unit 3a, the refrigerant quantity  $M_r$  in the indoor unit 3b, and the refrigerant quantity  $M_r$  in the indoor unit 3c. Note that, relational expressions having parameters  $kr1$  to  $kr5$  with different values will be used when the model and/or capacity is different among the indoor unit 3a, the indoor unit 3b, and the indoor unit 3c.

**[0139]** The gas refrigerant communication pipe portion G is divided into a high pressure gas refrigerant communication pipe portion G1 and a low pressure gas refrigerant communication pipe portion G2, and a refrigerant quantity  $M_{gp}$  in the gas refrigerant communication pipe portion G is a value obtained by adding a refrigerant quantity  $M_{gph}$  in the high pressure gas refrigerant communication pipe portion G1 and a refrigerant quantity  $M_{gpl}$  in the low pressure gas refrigerant communication pipe portion G2. In addition, a volume  $V_{gp}$  of the gas refrigerant communication pipe portion G is a value obtained by adding a volume  $V_{gph}$  of the high pressure gas refrigerant communication pipe portion G1 and a volume  $V_{gpl}$  of the low pressure gas refrigerant communication pipe portion G2. In other words, these relational expressions are expressed as follows.

$$M_{gp} = M_{gph} + M_{gpl}$$

$$V_{gp} = V_{gph} + V_{gpl}$$

**[0140]** A relational expression between the refrigerant quantity  $M_{gph}$  in the high pressure gas refrigerant communication pipe portion G1 and the operation state quantity of constituent equipment or refrigerant flowing in the refrigerant circuit 10 is expressed, for example, by

$$M_{gph} = V_{gph} \times \rho_{gph},$$

which is a function expression in which the volume  $V_{gph}$  of the portion combining the high pressure gas refrigerant communication pipe 52 and the high pressure gas side refrigerant flow path (including up to the second bypass on/off valves V 13 a to V 13 c on the high pressure gas side of the third bypass refrigerant circuits 43a to 43c) is multiplied by a density  $\rho_{gph}$  of the refrigerant in the high pressure gas refrigerant communication pipe portion G1. Here, the volume  $V_{gph}$  is divided into a volume  $V_{gph1}$  of the high pressure gas refrigerant communication pipe 52 and a volume  $V_{gph2}$  of the high pressure gas side refrigerant flow path in the connection units 4a to 4c (including up to the second bypass on/off valves V13a to V13c on the high pressure gas side in the third bypass refrigerant circuits 43a to 43c). As for the volume  $V_{gph1}$  of the high pressure gas refrigerant communication pipe 52, as is the case with the portion combining the first liquid refrigerant communication pipe 51 and the second liquid refrigerant communication pipes 71a to 71c, because the high pressure gas refrigerant communication pipe 52 is a refrigerant pipe arranged on site when installing the air conditioner 1 at an installation location such as a building and the like, a value calculated on site from the information regarding the length, pipe diameter and the like is input, or information regarding the length, pipe diameter and the like is input on site, and the controller 8 calculates the volume  $V_{gph1}$  from the input information of the high pressure gas refrigerant communication pipe 52. Or, as described below, the volume  $V_{gph1}$  is calculated by using the operation results of the pipe volume judging operation. In addition, the density  $\rho_{gph}$  of the refrigerant in the high pressure gas refrigerant communication pipe portion G1 is an average value among: a density  $\rho_s$  of the refrigerant at the suction side of the compressor 21, a density  $\rho_{oh}$  of the refrigerant in the pipe on the high pressure gas side between the high pressure gas side stop valve V5 and the first high pressure gas on/off valve V8 in the outdoor unit 2, a density  $\rho_{bsh}$  of the refrigerant in the high pressure gas side refrigerant flow path in the connection units 4a to 4c, and a density  $\rho_{eo}$  of the refrigerant at the outlets of the indoor heat exchangers 31a to 31c (i.e., the inlets of the second gas refrigerant communication pipes 72a to 72c). The density  $\rho_s$  of the refrigerant is obtained by converting the suction pressure  $P_s$  and the suction temperature  $T_s$ . The density  $\rho_{oh}$  of the refrigerant is obtained by converting the first high pressure gas pipe temperature  $T_{h1}$ . The density  $\rho_{bsh}$  of the refrigerant is obtained by converting the second high pressure gas pipe temperature  $T_{h2}$ . The density  $\rho_{eo}$  of the refrigerant is obtained by converting the evaporation pressure  $P_e$ , which is a converted value of the evaporation temperature  $T_e$ , and an outlet temperature  $T_{eo}$  of each of the indoor heat exchangers 31a to 31c. In addition, the volume  $V_{gph2}$  of the high pressure gas side refrigerant flow path in the connection units 4a to 4c (including up to the second bypass on/off valves V13a to V13c on the high pressure gas side in the third bypass refrigerant circuits 43a to 43c) is a value that is known prior to installation of the connection units 4a to 4c at the installing location and is stored in advance in the memory of the controller 8.

**[0141]** A relational expression between the refrigerant quantity  $M_{gpl}$  in the low pressure gas refrigerant communication pipe portion G2 and the operation state quantity of constituent equipment or refrigerant flowing in the refrigerant circuit 10 is expressed, for example, by

$$M_{gpl} = V_{gpl} \times \rho_{gpl},$$

which is a function expression in which the volume  $V_{gpl}$  of a portion combining the low pressure gas refrigerant communication pipe 53, the second gas refrigerant communication pipes 72a to 72c, and the low pressure gas refrigerant flow path in the connection units 4a to 4c (including up to the second bypass on/off valves V13a to V13c on the low pressure gas side of the third bypass refrigerant circuit 43a to 43c) is multiplied by a density  $\rho_{gpl}$  of the refrigerant in the low pressure gas refrigerant communication pipe portion G2. Here, the volume  $V_{gpl}$  is divided into a volume  $V_{gpl1}$  of a portion combining the low pressure gas refrigerant communication pipe 53 and the second gas refrigerant communication pipes 72a to 72c, and a volume  $V_{gpl2}$  of the low pressure gas side refrigerant flow path in the connection units 4a to 4c (including up to the second bypass on/off valves V13a to V13c on the low pressure gas side in the third bypass refrigerant circuits 43a to 43c). As for the volume  $V_{gpl1}$  of the portion combining the low pressure gas refrigerant

communication pipe 53 and the second gas refrigerant communication pipes 72a to 72c, as is the case with the portion combining the first liquid refrigerant communication pipe 51 and the second liquid refrigerant communication pipes 71a to 71c and also as is the case with the high pressure gas refrigerant communication pipe 52, because the low pressure gas refrigerant communication pipe 53 and the second gas refrigerant communication pipes 72a to 72c are refrigerant pipes arranged on site when installing the air conditioner 1 at an installation location such as a building and the like, a value calculated on site from the information regarding the length, pipe diameter and the like is input, or information regarding the length, pipe diameter and the like is input on site, and the controller 8 calculates the volume  $V_{gpl1}$  from the input information of the low pressure gas refrigerant communication pipe 53 and the second gas refrigerant communication pipes 72a to 72c. Or, as described below, the volume  $V_{gpl1}$  is calculated by using the operation results of the pipe volume judging operation. In addition, the density  $p_{gp1}$  of the refrigerant in the low pressure gas refrigerant communication pipe portion G2 is an average value between the density  $p_s$  of the refrigerant at the suction side of the compressor 21 and the density  $p_{eo}$  of the refrigerant at the outlets of the indoor heat exchangers 31a to 31c (i.e., the inlet of the second gas refrigerant communication pipes 72a to 72c). The density  $p_s$  of the refrigerant is obtained by converting the suction pressure  $P_s$  and the suction temperature  $T_s$ , and the density  $p_{eo}$  of the refrigerant is obtained by converting the evaporation pressure  $P_e$ , which is a converted value of the evaporation temperature  $T_e$ , and the outlet temperature  $T_{eo}$  of each of the indoor heat exchangers 31 a to 31c. In addition, the volume  $V_{gpl2}$  of the low pressure gas side refrigerant flow path in the connection units 4a to 4c (including up to the second bypass on/off valves V13a to V13c on the low pressure gas side in the third bypass refrigerant circuits 43a to 43c) is a value that is known prior to installation of the connection units 4a to 4c at the installation location and is stored in advance in the memory of the controller 8.

**[0142]** A relational expression between a refrigerant quantity  $M_{og2}$  in the first low pressure gas pipe portion H and the operation state quantity of constituent equipment or refrigerant flowing in the refrigerant circuit 10 is expressed, for example, by

$$M_{og2} = V_{og2} \times p_{oh},$$

which is a function expression in which a volume  $V_{og2}$  of the first low pressure gas pipe portion H in the outdoor unit 2 is multiplied by the density  $p_{oh}$  of the refrigerant in the first low pressure gas pipe portion H. Note that, the volume  $V_{og2}$  of the first low pressure gas pipe portion H is a value that is known prior to shipment to the installation location and is stored in advance in the memory of the controller 8.

**[0143]** A relational expression between a refrigerant quantity  $M_{og3}$  in the second low pressure gas pipe portion I and the operation state quantity of constituent equipment or refrigerant flowing in the refrigerant circuit 10 is expressed, for example, by

$$M_{og3} = V_{og3} \times p_s,$$

which is a function expression in which a volume  $V_{og3}$  of the second low pressure gas pipe portion I in the outdoor unit 2 is multiplied by the density  $p_s$  of the refrigerant in the second low pressure gas pipe portion I. Note that, the volume  $V_{og3}$  of the second low pressure gas pipe portion I is a value that is known prior to shipment to the installation location and is stored in advance in the memory of the controller 8.

**[0144]** A relational expression between a refrigerant quantity  $M_{ob}$  in the second bypass circuit portion J and the operation state quantity of constituent equipment or refrigerant flowing in the refrigerant circuit 10 is expressed, for example, by

$$M_{ob} = k_{ob1} \times p_{co} + k_{ob2} \times p_s + k_{ob3} \times P_e + k_{ob4},$$

which is a function expression of the density  $p_{co}$  of the refrigerant at the outlet of the outdoor heat exchanger 22, and the density  $p_s$  of the refrigerant at the outlet on the bypass circuit side of the subcooler 24 and the evaporation pressure  $P_e$ . Note that, the parameters  $k_{ob1}$  to  $k_{ob3}$  in the above described relational expression are derived from a regression analysis of results of tests and detailed simulations and are stored in advance in the memory of the controller 8. In addition, the refrigerant quantity  $M_{ob}$  of the second bypass circuit portion J may be calculated using a simpler relational expression because the refrigerant quantity in that portion is smaller compared to other portions. For example, it is expressed as follows:

$$Mob = Vob \times pe \times kob5,$$

which is a function expression in which a volume  $Vob$  of the second bypass circuit portion J is multiplied by the saturated liquid density  $pe$  at the portion corresponding to the second bypass circuit side of the subcooler 24 and a correct coefficient  $kob$ . Note that, the volume  $Vob$  of the second bypass circuit portion J is a value that is known prior to installation of the outdoor unit 2 at the installation location and is stored in advance in the memory of the controller 8. In addition, the saturated liquid density  $pe$  at the portion on the second bypass circuit side of the subcooler 24 is obtained by converting the suction pressure  $Ps$  or the evaporation temperature  $Te$ .

[0145] Note that, in the present embodiment, one outdoor unit 2 is provided. However, when a plurality of outdoor units are connected, as for the refrigerant quantities in the outdoor unit such as  $Mog1$ ,  $Mc$ ,  $Mol1$ ,  $Mol2$ ,  $Mog2$ ,  $Mog3$ , and  $Mob$ , the relational expression for the refrigerant quantity in each portion is set for each of the plurality of outdoor units, and the entire refrigerant quantity in the outdoor units is calculated by adding the refrigerant quantity in each portion of the plurality of the outdoor units. Note that, relational expressions for the refrigerant quantity in each portion having parameters with different values will be used when a plurality of outdoor units with different models and capacities are connected.

[0146] As described above, in the present embodiment, by using the relational expressions for each portion in the refrigerant circuit 10, the refrigerant quantity in each portion is calculated from the operation state quantity of constituent equipment or refrigerant flowing in the refrigerant circuit 10 in the refrigerant quantity judging operation, and thereby the refrigerant quantity in the refrigerant circuit 10 can be calculated.

[0147] Further, this Step S12 is repeated until the condition for judging the adequacy of the refrigerant quantity in the below described Step S13 is satisfied. Therefore, in the period from the start to the completion of additional refrigerant charging, the refrigerant quantity in each portion is calculated from the operation state quantity during refrigerant charging by using the relational expressions for each portion in the refrigerant circuit 10. More specifically, a refrigerant quantity  $Mo$  in the outdoor unit 2, the refrigerant quantity  $Mr$  in each of the indoor units 3a to 3c, and a refrigerant quantity  $Mbs$  in each of the connection units 4a to 4c ( $= Vlp2 \times plp + Vgp2 \times pgp$ ) (i.e., the refrigerant quantity in each portion in the refrigerant circuit 10 excluding the first refrigerant communication pipe group 5 and the second refrigerant communication pipe group 7) necessary for judgment of the adequacy of the refrigerant quantity in the below described Step S13 are calculated. Here, the refrigerant quantity  $Mo$  in the outdoor unit 2 is calculated by adding the refrigerant quantity  $Mog1$ ,  $Mc$ ,  $Mol1$ ,  $Mol2$ ,  $Mog2$ ,  $Mog3$ , and  $Mob$  in the above described each portion in the outdoor unit 2.

[0148] In this way, the process in Step S12 is performed by the controller 8 that functions as the refrigerant quantity calculating means for calculating the refrigerant quantity in each portion in the refrigerant circuit 10 from the operation state quantity of constituent equipment or refrigerant flowing in the refrigerant circuit 10 in the automatic refrigerant charging operation.

(Step S13: Judging the Adequacy of the Refrigerant Quantity)

[0149] As described above, when additional refrigerant charging into the refrigerant circuit 10 starts, the refrigerant quantity in the refrigerant circuit 10 gradually increases. Here, when the volume of the first refrigerant communication pipe group 5 is unknown, the refrigerant quantity that should be charged into the refrigerant circuit 10 after additional refrigerant charging cannot be prescribed as the refrigerant quantity in the entire refrigerant circuit 10. However, when the focus is placed only on the outdoor unit 2, the indoor units 3a to 3c, and the connection units 4a to 4c (i.e., the refrigerant circuit 10 excluding the first refrigerant communication pipe group 5 and the second refrigerant communication pipe group 7), it is possible to know in advance the optimal refrigerant quantity in the outdoor unit 2 in the normal operation mode by tests and detailed simulations. Therefore, additional refrigerant can be charged by the following manner: a value of this refrigerant quantity is stored as a target charging value  $Ms$ , in advance, in the memory of the controller 8; the refrigerant quantity  $Mo$  in the outdoor unit 2, the refrigerant quantity  $Mr$  in each of the indoor units 3a to 3c, and the refrigerant quantity  $Mbs$  in each of the connection units 4a to 4c are calculated from the operation state quantity of constituent equipment or refrigerant flowing in the refrigerant circuit 10 in the automatic refrigerant charging operation by using the above described relational expressions; and additional refrigerant is charged until a value of the sum of the above calculated refrigerant quantities reaches the target charging value  $Ms$ . In other words, Step S13 is a process to judge the adequacy of the refrigerant quantity charged into the refrigerant circuit 10 by additional refrigerant charging by judging whether or not the refrigerant quantity, which is obtained by adding the refrigerant quantity  $Mo$  in the outdoor unit 2, the refrigerant quantity  $Mr$  in the indoor units 3a to 3c, and the refrigerant quantity  $Mbs$  in the connection units 4a to 4c in the automatic refrigerant charging operation, has reached the target charging value  $Ms$ .

[0150] Then, in Step S13, when a value of the refrigerant quantity obtained by adding the refrigerant quantity  $Mo$  in the outdoor unit 2, the refrigerant quantity  $Mr$  in each of the indoor units 3a to 3c, and the refrigerant quantity  $Mbs$  in

each of the connection units 4a to 4c is smaller than the target charging value  $M_s$  and additional refrigerant charging has not been completed, the process in Step S13 is repeated until the target charging value  $M_s$  is reached. In addition, when a value of the refrigerant quantity obtained by adding the refrigerant quantity  $M_o$  in the outdoor unit 2, the refrigerant quantity  $M_r$  in each of the indoor units 3a to 3c, and the refrigerant quantity  $M_{bs}$  in each of the connection units 4a to 4c reaches the target charging value  $M_s$ , additional refrigerant charging is completed, and Step S1 as the automatic refrigerant charging operation process is completed.

**[0151]** Note that, in the above described refrigerant quantity judging operation, as the amount of additional refrigerant charged into the refrigerant circuit 10 increases, a tendency of an increase in the subcooling degree  $SC_o$  at the outlet of the outdoor heat exchanger 22 appears, causing the refrigerant quantity  $M_c$  in the outdoor heat exchanger 22 to increase, and the refrigerant quantity in other portions tends to be maintained substantially constant. Therefore, the target charging value  $M_s$  may be set as a value corresponding to only the refrigerant quantity  $M_o$  in the outdoor unit 2 instead of corresponding to all of the outdoor unit 2, the indoor units 3a to 3c, and the connection units 4a to 4c; or may be set as a value corresponding to the refrigerant quantity  $M_c$  in the outdoor heat exchanger 22, and additional refrigerant may be charged until the target charging value  $M_s$  is reached under such setting.

**[0152]** In this way, the process in Step S13 is performed by the controller 8 that functions as the refrigerant quantity judging means for judging the adequacy of the refrigerant quantity in the refrigerant circuit 10 in the refrigerant quantity judging operation of the automatic refrigerant charging operation (i.e., for judging whether or not the refrigerant quantity has reached the target charging value  $M_s$ ).

(Step S2: Pipe Volume Judging Operation)

**[0153]** When the above described automatic refrigerant charging operation in Step S1 is completed, the process proceeds to the pipe volume judging operation in Step S2. In the pipe volume judging operation, the process from Step S21 to Step S25 as shown in Figure 6 is performed by the controller 8. Here, Figure 6 is a flowchart of the pipe volume judging operation.

(Steps S21, S22: Pipe Volume Judging Operation for the Liquid Refrigerant Communication Pipe and Volume Calculation)

**[0154]** In Step S21, as is the case with the above described refrigerant quantity judging operation in Step S11 of the automatic refrigerant charging operation as described above, the pipe volume judging operation for the liquid refrigerant communication pipe portion B3, including the all indoor unit operation, condensation pressure control, liquid pipe temperature control, superheating degree control, and evaporation pressure control, is performed. Here, the target liquid pipe temperature  $T_{lps}$  of the temperature  $T_{lp}$  of the refrigerant at the outlet on the main refrigerant circuit side of the subcooler 24 in the liquid pipe temperature control is regarded as a first target value  $T_{lps1}$ , and the state where the refrigerant quantity judging operation is stable at this first target value  $T_{lps1}$  is regarded as a first state (see the refrigerating cycle indicated by lines including dotted lines in Figure 7). Note that, Figure 7 is a Mollier diagram to show the refrigerating cycle of the air conditioner 1 in the pipe volume judging operation for the liquid refrigerant communication pipe.

**[0155]** Next, the first state where the temperature  $T_{lp}$  of the refrigerant at the outlet on the main refrigerant circuit side of the subcooler 24 in liquid pipe temperature control is stable at the first target value  $T_{lps1}$  is switched to a second state (see the refrigerating cycle indicated by solid lines in Figure 7) where the target liquid pipe temperature  $T_{lps}$  is changed to a second target value  $T_{lps2}$  different from the first target value  $T_{lps1}$  and stabilized without changing the conditions for other equipment controls, i.e., the conditions for the condensation pressure control, superheating degree control, and evaporation pressure control (i.e., without changing the target superheating degree  $SH_r$ s and the target low pressure  $T_{es}$ ). In the present embodiment, the second target value  $T_{lps2}$  is a temperature higher than the first target value  $T_{lps1}$ .

**[0156]** In this way, by changing from the stable state at the first state to the second state, the density of the refrigerant in the liquid refrigerant communication pipe portion B3 decreases, and therefore the refrigerant quantity  $M_{lp}$  in the liquid refrigerant communication pipe portion B3 in the second state decreases compared to the refrigerant quantity in the first state. Then, the refrigerant whose quantity has decreased in the liquid refrigerant communication pipe portion B3 moves to other portions in the refrigerant circuit 10. More specifically, as described above, the conditions for other equipment controls other than the liquid pipe temperature control are not changed, and therefore the refrigerant quantity  $M_{og1}$  in the high pressure gas pipe portion E, the refrigerant quantity  $M_{og2}$  in the first low pressure gas pipe portion H, the refrigerant quantity  $M_{og3}$  in the second low pressure gas pipe portion I, and the refrigerant quantity  $M_{gph}$  in the high pressure gas refrigerant communication pipe portion G1 and the refrigerant quantity  $M_{gp1}$  in the low pressure gas refrigerant communication pipe portion G2 are maintained substantially constant, and the refrigerant whose quantity has decreased in the liquid refrigerant communication pipe portion B3 will move to the condenser portion A, the high temperature side liquid pipe portion B1, the low temperature side liquid pipe portion B2, the indoor unit portion F, and the second bypass circuit portion J. In other words, the refrigerant quantity  $M_c$  in the condenser portion A, the refrigerant quantity  $M_{ol1}$  in the high temperature side liquid pipe portion B1, the refrigerant quantity  $M_{ol2}$  in the low temperature

side liquid pipe portion B2, the refrigerant quantity Mr in the indoor unit portion F, and the refrigerant quantity Mob in the second bypass circuit portion J will increase by the quantity of the refrigerant that has decreased in the liquid refrigerant communication pipe portion B3.

[0157] Such control as described above is performed as the process in Step S21 by the controller 8 (more specifically, by the indoor side controllers 34a to 34c, the connection side controllers 44a to 44c, the outdoor side controller 26, and the transmission line 8a that interconnects each of the controllers 34a to 34c, 44a to 44c, and 26) that functions as a pipe volume judging operation controlling means for performing the pipe volume judging operation to calculate the refrigerant quantity Mlp of the liquid refrigerant communication pipe portion B3.

[0158] Next, in Step S22, the volume Vlp of the liquid refrigerant communication pipe portion B3 is calculated by utilizing a phenomenon that the refrigerant quantity in the liquid refrigerant communication pipe portion B3 decreases and the refrigerant whose quantity has decreased moves to other portions in the refrigerant circuit 10 because of the change from the first state to the second state.

[0159] First, a calculation formula used in order to calculate the volume Vlp of the liquid refrigerant communication pipe portion B3 is described. Provided that the quantity of the refrigerant that has decreased in the liquid refrigerant communication pipe portion B3 and moved to other portions in the refrigerant circuit 10 by the above described pipe volume judging operation is a refrigerant increase/decrease quantity  $\Delta Mlp$ , and that the increase/decrease quantities of the refrigerant in each portion between the first state and the second state are  $\Delta Mc$ ,  $\Delta Mol1$ ,  $\Delta Mol2$ ,  $\Delta Mr$ , and  $\Delta Mob$  (here, the refrigerant quantity Mog1, the refrigerant quantity Mog2, the refrigerant quantity Mog3, the refrigerant quantity Mgp, and the refrigerant quantity Mgp1 are omitted because they are maintained substantially constant), the refrigerant increase/decrease quantity  $\Delta Mlp$  can be, for example, calculated by the following function expression:

$$\Delta Mlp = -(\Delta Mc + \Delta Mol1 + \Delta Mol2 + \Delta Mr + \Delta Mob).$$

Then, the value of  $\Delta Mlp$  is divided by a density change quantity  $\Delta plp$  of the refrigerant between the first state and the second state in the liquid refrigerant communication pipe portion B3, and thereby the volume Vlp of the liquid refrigerant communication pipe portion B3 can be calculated. Note that, although there is little effect on a calculation result of the refrigerant increase/decrease quantity  $\Delta Mlp$ , the refrigerant quantity Mog1 and the refrigerant quantity Mog2 may be included in the above described function expression.

$$Vlp = \Delta Mlp / \Delta plp$$

[0160] In addition, the volume Vlp2 of the liquid side refrigerant flow path in the connection units 4a to 4c is a value that is known prior to installation of the connection units 4a to 4c at the installation location. Thus, it is possible to determine the volume Vlp1 of the portion combining the first liquid refrigerant communication pipe 51 and the second liquid refrigerant communication pipes 71a to 71c, which are the refrigerant pipes arranged on site when installing the air conditioner 1 at an installation location such as a building and the like, by subtracting the volume Vlp2 from the volume Vlp of the liquid refrigerant communication pipe portion B3, which is determined by the calculation.

[0161] Note that,  $\Delta Mc$ ,  $\Delta Mol1$ ,  $\Delta Mol2$ ,  $\Delta Mr$ , and  $\Delta Mob$  can be obtained by calculating the refrigerant quantity in the first state and the refrigerant quantity in the second state by using the above described relational expression for each portion in the refrigerant circuit 10 and further by subtracting the refrigerant quantity in the first state from the refrigerant quantity in the second state. In addition, the density change quantity  $\Delta plp$  can be obtained by calculating the density of the refrigerant at the outlet of the subcooler 24 in the first state and the density of the refrigerant at the outlet of the subcooler 24 in the second state and further by subtracting the density of the refrigerant in the first state from the density of the refrigerant in the second state.

[0162] By using the calculation formula as described above, the volume Vlp of the liquid refrigerant communication pipe portion B3 can be calculated from the operation state quantity of constituent equipment or refrigerant flowing in the refrigerant circuit 10 in the first and second states.

[0163] Note that, in the present embodiment, the state is changed such that the second target value Tlps2 in the second state becomes a temperature higher than the first target value Tlps1 in the first state and therefore the refrigerant in the low temperature side liquid pipe portion B2 is moved to other portions to increase the refrigerant quantity in other portions; thereby the volume Vlp of the liquid refrigerant communication pipe portion B3 is calculated from the increased quantity. However, the state may be changed such that the second target value Tlps2 in the second state becomes a temperature lower than the first target value Tlps1 in the first state and therefore the refrigerant is moved from other portions to the liquid refrigerant communication pipe portion B3 to decrease the refrigerant quantity in other portions; thereby the volume Vlp of the liquid refrigerant communication pipe portion B3 is calculated from the decreased quantity.

**[0164]** In this way, the process in Step S22 is performed by the controller 8 that functions as the pipe volume calculating means for the liquid refrigerant communication pipe, which calculates the volume V<sub>lp</sub> of the liquid refrigerant communication pipe portion B3 from the operation state quantity of constituent equipment or refrigerant flowing in the refrigerant circuit 10 in the pipe volume judging operation for the liquid refrigerant communication pipe portion B3.

(Steps S23, S24: Pipe Volume Judging Operation and Volume Calculation for the Gas Refrigerant Communication Pipe)

**[0165]** After the above described Step S21 and Step S22 are completed, the pipe volume judging operation for the gas refrigerant communication pipe portion G, including the all indoor unit operation, condensation pressure control, liquid pipe temperature control, superheating degree control, and evaporation pressure control, is performed in Step S23. Here, the target low pressure P<sub>es</sub> of the suction pressure P<sub>s</sub> of the compressor 21 in the evaporation pressure control is regarded as a first target value P<sub>es1</sub>, and the state where the refrigerant quantity judging operation is stable at this first target value P<sub>es1</sub> is regarded as a first state (see the refrigerating cycle indicated by lines including dotted lines in Figure 8). Note that Figure 8 is a Mollier diagram to show the refrigerating cycle of the air conditioner 1 in the pipe volume judging operation for the gas refrigerant communication pipe.

**[0166]** Next, the first state where the target low pressure P<sub>es</sub> of the suction pressure P<sub>s</sub> in the compressor 21 in evaporation pressure control is stable at the first target value P<sub>es1</sub> is switched to a second state (see the refrigerating cycle indicated only by solid lines in Figure 8) where the target low pressure P<sub>es</sub> is changed to a second target value P<sub>es2</sub> different from the first target value P<sub>es1</sub> and stabilized without changing the conditions for other equipment controls, i.e., without changing the conditions for the liquid pipe temperature control, the condensation pressure control, and the superheating degree control (i.e., without changing the target liquid pipe temperature T<sub>lps</sub> and the target superheating degree SH<sub>rs</sub>). In the present embodiment, the second target value P<sub>es2</sub> is a pressure lower than the first target value P<sub>es1</sub>.

**[0167]** In this way, by changing from the stable state at the first state to the second state, the density of the refrigerant in the gas refrigerant communication pipe portion G decreases, and therefore the refrigerant quantity M<sub>gp</sub> in the gas refrigerant communication pipe portion G in the second state decreases compared to the refrigerant quantity in the first state. Then, the refrigerant whose quantity has decreased in the gas refrigerant communication pipe portion G will move to other portions in the refrigerant circuit 10. More specifically, as described above, the conditions for other equipment controls other than the evaporation pressure control are not changed, and therefore the refrigerant quantity M<sub>og1</sub> in the high pressure gas pipe portion E, the refrigerant quantity M<sub>ol1</sub> in the high temperature side liquid pipe portion B1, the refrigerant quantity M<sub>ol2</sub> in the low temperature side liquid pipe portion B2, and the refrigerant quantity M<sub>lp</sub> in the liquid refrigerant communication pipe portion B3 are maintained substantially constant, and the refrigerant whose quantity has decreased in the gas refrigerant communication pipe portion G will move to the first low pressure gas pipe portion H, the second low pressure gas pipe portion I, the condenser portion A, the indoor unit portion F, and the second bypass circuit portion J. In other words, the refrigerant quantity M<sub>og2</sub> in the first low pressure gas pipe portion H, the refrigerant quantity M<sub>og3</sub> in the second low pressure gas pipe portion I, the refrigerant quantity M<sub>c</sub> in the condenser portion A, the refrigerant quantity M<sub>r</sub> in the indoor unit portion F, and the refrigerant quantity M<sub>ob</sub> in the second bypass circuit portion J will increase by the quantity of the refrigerant that has decreased in the gas refrigerant communication pipe portion G.

**[0168]** Such control as described above is performed as the process in Step S23 by the controller 8 (more specifically, by the indoor side controllers 34a to 34c, the connection side controllers 44a to 44c, the outdoor side controller 26, and the transmission line 8a that interconnects each of the controllers 34a to 34c, 44a to 44c, and 26) that functions as the pipe volume judging operation controlling means for performing the pipe volume judging operation to calculate the volume V<sub>gp</sub> of the gas refrigerant communication pipe portion G.

**[0169]** Next in Step S24, the volume V<sub>gp</sub> of the gas refrigerant communication pipe portion G is calculated by utilizing a phenomenon that the refrigerant quantity in the gas refrigerant communication pipe portion G decreases and the refrigerant whose quantity has decreased moves to other portions in the refrigerant circuit 10 because of the change from the first state to the second state.

**[0170]** First, a calculation formula used in order to calculate the volume V<sub>gp</sub> of the gas refrigerant communication pipe portion G is described. Provided that the quantity of the refrigerant that has decreased in the gas refrigerant communication pipe portion G and moved to other portions in the refrigerant circuit 10 by the above described pipe volume judging operation is a refrigerant increase/decrease quantity ΔM<sub>gp</sub>, and that the increase/decrease quantities of the refrigerant in each portion between the first state and the second state are ΔM<sub>c</sub>, ΔM<sub>og2</sub>, ΔM<sub>og3</sub>, ΔM<sub>r</sub>, and ΔM<sub>ob</sub> (here, the refrigerant quantity M<sub>og1</sub>, the refrigerant quantity M<sub>ol1</sub>, the refrigerant quantity M<sub>ol2</sub>, and the refrigerant quantity M<sub>lp</sub> are omitted because they are maintained substantially constant), the refrigerant increase/decrease quantity ΔM<sub>gp</sub> can be, for example, calculated by the following function expression:

$$\Delta M_{gp} = - (\Delta M_c + \Delta M_{og2} + \Delta M_{og3} + \Delta M_r + \Delta M_{ob}).$$

Then, the value of  $\Delta M_{gp}$  is divided by a density change quantity  $\Delta \rho_{gp}$  of the refrigerant between the first state and the second state in the gas refrigerant communication pipe portion G, and thereby the volume  $V_{gp}$  of the gas refrigerant communication pipe portion G can be calculated. Note that, although there is little effect on a calculation result of the refrigerant increase/decrease quantity  $\Delta M_{gp}$ , the refrigerant quantity  $M_{og1}$ , the refrigerant quantity  $M_{ol1}$ , and the refrigerant quantity  $M_{ol2}$  may be included in the above described function expression.

$$V_{gp} = \Delta M_{gp} / \Delta \rho_{gp}$$

Note that,  $\Delta M_c$ ,  $\Delta M_{og2}$ ,  $\Delta M_{og3}$ ,  $\Delta M_r$  and  $\Delta M_{ob}$  can be obtained by calculating the refrigerant quantity in the first state and the refrigerant quantity in the second state by using the above described relational expression for each portion in the refrigerant circuit 10 and further by subtracting the refrigerant quantity in the first state from the refrigerant quantity in the second state. In addition, the density change quantity  $\Delta \rho_{gp}$  can be obtained by calculating an average density among the density  $\rho_s$  of the refrigerant at the suction side of the compressor 21, the density  $\rho_{oh}$  of the refrigerant in the pipe on the high pressure gas side between the high pressure gas side stop valve V5 and the first high pressure gas on/off valve V8 in the outdoor unit 2, the density  $\rho_{bsh}$  of the refrigerant in the high pressure gas side refrigerant flow path in the connection units 4a to 4c, and the density  $\rho_{eo}$  of the refrigerant at the outlets of the indoor heat exchangers 31a to 31c in the first state and by subtracting the average density in the first state from the average density in the second state.

**[0171]** By using such calculation formula as described above, the volume  $V_{gp}$  of the gas refrigerant communication pipe portion G can be calculated from the operation state quantity of constituent equipment or the refrigerant flowing in the refrigerant circuit 10 in the first and second states.

**[0172]** In addition, the volume  $V_{gp2}$  of the high pressure gas side refrigerant flow path and the low pressure gas side refrigerant flow path (including a portion corresponding to the third bypass refrigerant circuits 43a to 43c) in the connection units 4a to 4c is a value that is known prior to installation of the connection units 4a to 4c at the installation location. Thus, it is possible to determine the volume  $V_{gp1}$  of the portion combining the high pressure gas refrigerant communication pipe 52, the low pressure gas refrigerant communication pipe 53, and the second gas refrigerant communication pipes 72a to 72c, which are the refrigerant pipes arranged on site when installing the air conditioner 1 at an installation location such as a building and the like, by subtracting the volume  $V_{gp2}$  from the volume  $V_{gp}$  of the gas refrigerant communication pipe portion G, which is determined by the calculation.

**[0173]** Note that, in the present embodiment, the state is changed such that the second target value  $P_{es2}$  in the second state becomes a pressure lower than the first target value  $P_{es1}$  in the first state and therefore the refrigerant in the gas refrigerant communication pipe portion G is moved to other portions to increase the refrigerant quantity in other portions; thereby the volume  $V_{lp}$  in the gas refrigerant communication pipe portion G is calculated from the increased quantity. However, the state may be changed such that the second target value  $P_{es2}$  in the second state becomes a pressure higher than the first target value  $P_{es1}$  in the first state and therefore the refrigerant is moved from other portions to the gas refrigerant communication pipe portion G to decrease the refrigerant quantity in other portions; thereby the volume  $V_{lp}$  of the gas refrigerant communication pipe portion G may be calculated from the decreased quantity.

**[0174]** In this way, the process in Step S24 is performed by the controller 8 that functions as the pipe volume calculating means for a gas refrigerant communication pipe, which calculates the volume  $V_{gp}$  of the gas refrigerant communication pipe portion G from the operation state quantity of constituent equipment or the refrigerant flowing in the refrigerant circuit 10 during the pipe volume judging operation for the gas refrigerant communication pipe portion G.

(Step S25: Judging the validity of a Result of Pipe Volume Judging Operation)

**[0175]** After the above described Step S21 to Step S24 are completed, in Step S25, whether or not a result of the pipe volume judging operation is valid, in other words, whether or not the volume  $V_{lp}$  of the liquid refrigerant communication pipe portion B3 and the volume  $V_{gp}$  of the gas refrigerant communication pipe portion G calculated by the pipe volume calculating means are valid is judged.

**[0176]** Specifically, as shown in an inequality expression below, it is judged by whether or not the ratio of the volume  $V_{lp}$  of the liquid refrigerant communication pipe portion B3 to the volume  $V_{gp}$  of the gas refrigerant communication pipe portion G obtained by the calculations is in a predetermined numerical value range.

$$\varepsilon_1 < V_{lp} / V_{gp} < \varepsilon_2$$

Here,  $\epsilon_1$  and  $\epsilon_2$  are values that are changed based on the minimum value and the maximum value of the pipe volume ratio in feasible combinations of the heat source unit and the utilization unit.

**[0177]** Then, when the volume ratio  $V_{lp}/V_{gp}$  satisfies the above described numerical value range, the process in Step S2 for the pipe volume judging operation is completed. When the volume ratio  $V_{lp}/V_{gp}$  does not satisfy the above numerical value range, the process for the pipe volume judging operation and the volume calculation in Step S21 to Step S24 is performed again.

**[0178]** In this way, the process in Step S25 is performed by the controller 8 that functions as a validity judging means for judging whether or not a result of the above described pipe volume judging operation is valid, in other words, whether or not the volume  $V_{lp}$  of the liquid refrigerant communication pipe portion B3 and the volume  $V_{gp}$  of the gas refrigerant communication pipe portion G calculated by the pipe volume calculating means are valid.

**[0179]** Note that, in the present embodiment, the pipe volume judging operation (Steps S21, S22) for the liquid refrigerant communication pipe portion B3 is first performed and then the pipe volume judging operation for the gas refrigerant communication pipe portion G (Steps S23, S24) is performed. However, the pipe volume judging operation for the gas refrigerant communication pipe portion G may be performed first.

**[0180]** In addition, in the above described Step S25, when a result of the pipe volume judging operation in Steps S21 to S24 is judged to be invalid a plurality of times, or when it is desired to more simply judge the volume  $V_{lp}$  of the liquid refrigerant communication pipe portion B3 and the volume  $V_{gp}$  of the gas refrigerant communication pipe portion G, although it is not shown in Figure 6, for example, in Step S25, after a result of the pipe volume judging operation in Steps S21 to S24 is judged to be invalid, it is possible to proceed to the process for estimating, from the pressure loss in a portion combining the liquid refrigerant communication pipe portion B3 and the gas refrigerant communication pipe portion G (hereinafter referred to as "refrigerant communication pipe portion K"), the length of the refrigerant communication pipe portion K and calculating the volume  $V_{lp}$  of the liquid refrigerant communication pipe portion B3 and the volume  $V_{gp}$  of the gas refrigerant communication pipe portion G from the estimated pipe length and an average volume ratio, thereby obtaining the volume  $V_{lp}$  of the liquid refrigerant communication pipe portion B3 and the volume  $V_{gp}$  of the gas refrigerant communication pipe portion G.

**[0181]** In addition, in the present embodiment, the case where the pipe volume judging operation is performed to calculate the volume  $V_{lp}$  of the liquid refrigerant communication pipe portion B3 and the volume  $V_{gp}$  of the gas refrigerant communication pipe portion G is described on the premise that there is no information regarding the length, pipe diameter and the like of the refrigerant communication pipe portion K, and the volume  $V_{lp}$  of the liquid refrigerant communication pipe portion B3 and the volume  $V_{gp}$  of the gas refrigerant communication pipe portion G are unknown. However, when the pipe volume calculating means has a function to calculate the volume  $V_{lp}$  of the liquid refrigerant communication pipe portion B3 and the volume  $V_{gp}$  of the gas refrigerant communication pipe portion G by inputting information regarding the length, pipe diameters and the like of the refrigerant communication pipe portion K, such function may be used together.

**[0182]** Further, when the above described function to calculate the volume  $V_{lp}$  of the liquid refrigerant communication pipe portion B3 and the volume  $V_{gp}$  of the gas refrigerant communication pipe portion G by the pipe volume judging operation and by using the operation results is not used but only the function to calculate the volume  $V_{lp}$  of the liquid refrigerant communication pipe portion B3 and the volume  $V_{gp}$  of the gas refrigerant communication pipe portion G by inputting information regarding the length, pipe diameter and the like of the refrigerant communication pipe portion K is used, the above described validity judging means (Step S25) may be used to judge whether or not the input information regarding the lengths, pipe diameters and the like of the refrigerant communication pipe portion K is valid.

(Step S3: Initial Refrigerant Quantity Detection Operation)

**[0183]** When the above described pipe volume judging operation of Step S2 is completed, the process proceeds to the initial refrigerant quantity detection operation of Step S3. In the initial refrigerant quantity detection operation, the process in Step S31 and Step S32 shown in Figure 9 is performed by the controller 8. Here, Figure 9 is a flowchart of the initial refrigerant quantity detection operation.

(Step S31: Refrigerant Quantity Judging Operation)

**[0184]** In Step S31, as is the case with the above described refrigerant quantity judging operation of Step S11 in the automatic refrigerant charging operation, the refrigerant quantity judging operation, including the all indoor unit operation, condensation pressure control, liquid pipe temperature control, superheat degree control, and evaporation pressure control, is performed. Here, as a rule, values to be used for the target liquid pipe temperature value  $T_{lps}$  in the liquid pipe temperature control, the target superheat degree value  $SH_{rs}$  in the superheat degree control, and the target low pressure value  $P_{es}$  in the evaporation pressure control are same as the target values during the refrigerant quantity judging operation of Step S11 in the automatic refrigerant charging operation.

**[0185]** In this way, the process in Step S31 is performed by the controller 8 that functions as the refrigerant quantity

judging operation controlling means for performing the refrigerant quantity judging operation including the all indoor unit operation, condensation pressure control, liquid pipe temperature control, superheat degree control, and evaporation pressure control.

5 (Step S32: Refrigerant Quantity Calculation)

10 **[0186]** Next, the refrigerant quantity in the refrigerant circuit 10 is calculated from the operation state quantity of constituent equipment or refrigerant flowing in the refrigerant circuit 10 in the initial refrigerant quantity detection operation in Step S32 by the controller 8 that functions as the refrigerant quantity calculating means while performing the above described refrigerant quantity judging operation. Calculation of the refrigerant quantity in the refrigerant circuit 10 is performed by using the above described relational expression between the refrigerant quantity in each portion in the refrigerant circuit 10 and the operation state quantity of constituent equipment or refrigerant flowing in the refrigerant circuit 10. However, at this time, the volume Vlp of the liquid refrigerant communication pipe portion B3 and the volume Vgp of the gas refrigerant communication pipe portion G, which were unknown at the time of after installation of constituent equipment of the air conditioner 1, have been calculated and the values thereof are known by the above described pipe volume judging operation. Thus, by multiplying the volume Vlp of the liquid refrigerant communication pipe portion B3 and the volume Vgp of the gas refrigerant communication pipe portion G by the density of the refrigerant, the refrigerant quantity Mlp in the liquid refrigerant communication pipe portion B3 and the refrigerant quantity Mgp in the gas refrigerant communication pipe portion G can be calculated, and further by adding the refrigerant quantity in each of other portions, the initial refrigerant quantity in the entire refrigerant circuit 10 can be detected. This initial refrigerant quantity is used as a reference refrigerant quantity Mi of the entire refrigerant circuit 10, which serves as a reference for judging whether or not there is a refrigerant leak from the refrigerant circuit 10 during the below described refrigerant leak detection operation. Therefore, it is stored as a value of the operation state quantity in the memory of the controller 8 serving as the state quantity storing means.

25 **[0187]** In this way, the process in Step S32 is performed by the controller 8 that functions as the refrigerant quantity calculating means for calculating the refrigerant quantity in each portion in the refrigerant circuit 10 from the operation state quantity of constituent equipment or refrigerant flowing in the refrigerant circuit 10 in the initial refrigerant quantity detection operation.

30 <REFRIGERANT LEAK DETECTION OPERATION MODE>

**[0188]** Next, the refrigerant leak detection operation mode is described with reference to Figures 1, 2, 5, and 10. Here, Figure 10 is a flowchart of the refrigerant leak detection operation mode.

35 **[0189]** In the present embodiment, an example of a case is described where, whether or not the refrigerant in the refrigerant circuit 10 is leaking to the outside due to an unforeseen factor is detected periodically (for example, during a period of time such as on a holiday or in the middle of the night when air conditioning is not needed).

(Step S41: Refrigerant Quantity Judging Operation)

40 **[0190]** First, when operation in the normal operation mode such as the above described cooling operation and heating operation has gone on for a certain period of time (for example, half a year to a year), the normal operation mode is automatically or manually switched to the refrigerant leak detection operation mode, and as is the case with the refrigerant quantity judging operation of the initial refrigerant quantity detection operation, the refrigerant quantity judging operation, including the all indoor unit operation, condensation pressure control, liquid pipe temperature control, superheating degree control, and evaporation pressure control, is performed. Here, as a rule, values that are the same as the target values in Step S31 of the refrigerant quantity judging operation of the initial refrigerant quantity detection operation are used for the target liquid pipe temperature Tlps in the liquid pipe temperature control, the target superheating degree SHrs in the superheating degree control, and the target low pressure Pes in the evaporation pressure control.

50 **[0191]** Note that, this refrigerant quantity judging operation is performed for each time the refrigerant leak detection operation is performed. Even when the refrigerant temperature Tco at the outlet of the outdoor heat exchanger 22 changes due to the different operating conditions, for example, such as when the condensation pressure Pc is different or when the refrigerant is leaking, the refrigerant temperature Tlp in the liquid refrigerant communication pipe portion B3 is maintained constant at the same target liquid pipe temperature Tlps by the liquid pipe temperature control.

55 **[0192]** In this way, the process in Step S41 is performed by the controller 8 that functions as the refrigerant quantity judging operation controlling means for performing the refrigerant quantity judging operation, including the all indoor unit operation, condensation pressure control, liquid pipe temperature control, superheating degree control, and evaporation pressure control.

(Step S42: Refrigerant Quantity Calculation)

**[0193]** Next, the refrigerant quantity in the refrigerant circuit 10 is calculated from the operation state quantity of constituent equipment or refrigerant flowing in the refrigerant circuit 10 in the refrigerant leak detection operation in Step S42 by the controller 8 that functions as the refrigerant quantity calculating means while performing the above described refrigerant quantity judging operation. Calculation of the refrigerant quantity in the refrigerant circuit 10 is performed by using the above described relational expression between the refrigerant quantity in each portion in the refrigerant circuit 10 and the operation state quantity of constituent equipment or refrigerant flowing in the refrigerant circuit 10. However, at this time, as is the case with the initial refrigerant quantity detection operation, the volume V<sub>lp</sub> of the liquid refrigerant communication pipe portion B3 and the volume V<sub>gp</sub> of the gas refrigerant communication pipe portion G, which were unknown at the time of after installation of constituent equipment of the air conditioner 1, have been calculated and the values thereof are known by the above described pipe volume judging operation. Thus, by multiplying the volume V<sub>lp</sub> of the liquid refrigerant communication pipe portion B3 and the volume V<sub>gp</sub> of the gas refrigerant communication pipe portion G by the density of the refrigerant, the refrigerant quantity M<sub>lp</sub> in the liquid refrigerant communication pipe portion B3 and the refrigerant quantity M<sub>gp</sub> in the gas refrigerant communication pipe portion G can be calculated, and further by adding the refrigerant quantity in each of other portions, the refrigerant quantity M in the entire refrigerant circuit 10 can be calculated.

**[0194]** Here, as described above, the refrigerant temperature T<sub>lp</sub> in the liquid refrigerant communication pipe portion B3 is maintained constant at the target liquid pipe temperature T<sub>lps</sub> by the liquid pipe temperature control. Therefore, regardless of the difference in the operating conditions for the refrigerant leak detection operation, the refrigerant quantity M<sub>lp</sub> in the liquid refrigerant communication pipe portion B3 will be maintained constant even when the refrigerant temperature T<sub>co</sub> at the outlet of the outdoor heat exchanger 22 changes.

**[0195]** In this way, the process in Step S42 is performed by the controller 8 that functions as the refrigerant quantity calculating means for calculating the refrigerant quantity at each portion in the refrigerant circuit 10 from the operation state quantity of constituent equipment or refrigerant flowing in the refrigerant circuit 10 in the refrigerant leak detection operation.

(Steps S43, S44: Judging the Adequacy of the Refrigerant Quantity, Warning Display)

**[0196]** When refrigerant leaks from the refrigerant circuit 10, the refrigerant quantity in the refrigerant circuit 10 decreases. Then, when the refrigerant quantity in the refrigerant circuit 10 decreases, mainly, a tendency of a decrease in the subcooling degree SCo at the outlet of the outdoor heat exchanger 22 appears. Along with this, the refrigerant quantity M<sub>c</sub> in the outdoor heat exchanger 22 decreases, and the refrigerant quantities in other portions tend to be maintained substantially constant. Consequently, the refrigerant quantity M of the entire refrigerant circuit 10 calculated in the above described Step S42 is smaller than the reference refrigerant quantity M<sub>i</sub> detected in the initial refrigerant quantity detection operation when the refrigerant is leaking from the refrigerant circuit 10; whereas when the refrigerant is not leaking from the refrigerant circuit 10, the refrigerant quantity M is substantially the same as the reference refrigerant quantity M<sub>i</sub>.

**[0197]** By utilizing the above-described characteristics, whether or not the refrigerant is leaking is judged in Step S43. When it is judged in Step S43 that the refrigerant is not leaking from the refrigerant circuit 10, the refrigerant leak detection operation mode is finished.

**[0198]** On the other hand, when it is judged in Step S43 that the refrigerant is leaking from the refrigerant circuit 10, the process proceeds to Step S44, and a warning indicating that a refrigerant leak is detected is displayed on the warning display 9. Subsequently, the refrigerant leak detection operation mode is finished.

**[0199]** In this way, the process from Steps S42 to S44 is performed by the controller 8 that functions as a refrigerant leak detecting means, which is one of the refrigerant quantity judging means, and which detects whether or not the refrigerant is leaking by judging the adequacy of the refrigerant quantity in the refrigerant circuit 10 while performing the refrigerant quantity judging operation in the refrigerant leak detection operation mode.

**[0200]** As described above, in the air conditioner 1 in the present embodiment, the controller 8 functions as the refrigerant quantity judging operation means, the refrigerant quantity calculating means, the refrigerant quantity judging means, the pipe volume judging operation means, the pipe volume calculating means, the validity judging means, and the state quantity storing means, and thereby configures the refrigerant quantity judging system for judging the adequacy of the refrigerant quantity charged into the refrigerant circuit 10.

## (3) CHARACTERISTICS OF THE AIR CONDITIONER

(A)

5 **[0201]** With this air conditioner 1, when performing the refrigerant quantity judging operation while the indoor units 3a to 3c in all the rooms are set to the cooling operation state, the high pressure gas refrigerant communication pipe portion G1 extending from the outdoor unit 2 to the connection units 4a to 4c will be in a shut-off state. Thereby the refrigerant condenses and accumulates in the pipe, and thus the detection error may be increased. Therefore, the first bypass refrigerant circuit 27 and the third bypass refrigerant circuits 43a to 43c which bypass the high pressure gas refrigerant communication pipe portion G1 to the low pressure gas refrigerant communication pipe portion G2 are provided, and

10 the first bypass on/off valve V3 and the second bypass on/off valves V13a to V13c are set to an opened state during the refrigerant quantity judging operation, thereby reducing the pressure difference between the high pressure gas refrigerant communication pipe portion G1 and the low pressure gas refrigerant communication pipe portion G2 and preventing accumulation of liquid refrigerant in the high pressure gas refrigerant communication pipe portion G1 resulting

15 from condensation. Thus, the refrigerant quantity judging operation with high accuracy can be achieved. In addition, the first bypass on/off valve V3 and the third bypass on/off valves are provided in the outdoor unit 2 and in the connection units 4a to 4c, respectively. The first bypass on/off valve V3 is provided in the outdoor unit 2, and the third bypass on/off valves are provided in the connection units 4a to 4c. By using these valves in combination, the low pressure gas refrigerant can easily flow through the high pressure gas refrigerant communication pipe portion G1, and the temperature change

20 of the gas refrigerant can be minimized. Thus, the detection error can be reduced. In addition, the bypass circuit can be provided in the refrigerant circuit 10 even without laying pipes for the bypass circuit at the time of construction. Accordingly, it is possible to reduce the labors for construction and the cost.

(B)

25 **[0202]** This air conditioner 1 is further provided with the temperature sensor in the high pressure gas refrigerant communication pipe portion G1. Accordingly, even when the temperate of the gas refrigerant in the high pressure gas refrigerant communication pipe portion G1 changes because of the incoming heat from the outside air and the like and thereby the density of the refrigerant changes, it is possible to correct the density of the refrigerant based on the tem-

30 perature detection value by the temperature sensor. Thereby it is possible to reduce the detection error. Thus, the refrigerant quantity judging operation with higher accuracy can be achieved. In addition, with this air conditioner 1, in the high pressure gas refrigerant communication pipe portion G1, the first high pressure gas pipe temperature sensor T8 is provided in the heat source unit, and the second high pressure gas pipe temperature sensors T12a to T12c are provided in the connection units 4a to 4c. Accordingly, by using the first high pressure gas pipe temperature sensor T8

35 and the second high pressure gas pipe temperature sensors T12a to T12c in combination, it is possible to more accurately correct the density of the refrigerant in the pipe. In addition, the temperature detecting means can be provided in the refrigerant circuit 10 even without providing the temperature sensor in the high pressure gas refrigerant pipe at the time of construction. Therefore, it is possible to reduce the labors for construction and the cost.

## (4) ALTERNATIVE EMBODIMENT

40 **[0203]** While a preferred embodiment of the present invention has been described with reference to the figures, the scope of the present invention is not limited to the above embodiment, and the various changes and modifications may be made without departing from the scope of the present invention.

(A)

45 **[0204]** In the above described embodiment, an example in which the present invention is applied to an air conditioner including a single outdoor unit is described. However, it is not limited thereto, and the present invention may be applied

50 to an air conditioner including a plurality of outdoor units. In addition, although an air-cooled outdoor unit that uses the outdoor air as the heat source is used as the outdoor unit 2 of the air conditioner 1, a water-cooled type or ice thermal storage type outdoor unit may be used instead.

(B)

55 **[0205]** In the above described embodiment, as the bypass circuits, the first bypass refrigerant circuit 27 is provided on the outdoor unit 2 side and the third bypass refrigerant circuits 43a to 43c are provided on the connection units 4a to 4c side. However, the bypass circuits may be provided only on the outdoor unit 2 side or only on the connection units

4a to 4c side.

(C)

5 **[0206]** In the above described embodiment, as the temperature sensors, the first high pressure gas pipe temperature sensor T8 is mounted on the outdoor unit 2 side and the second high pressure gas pipe temperature sensors T12a to T12c are mounted on the connection units 4a to 4c side. However, the temperature sensors may be mounted only on the outdoor unit 2 side or only on the connection units 4a to 4c side. In addition, the temperature sensors may not necessarily be provided.

10

(D)

15 **[0207]** The controller 8 that performs the operation control of the entire air conditioner 1 is configured by the outdoor side controller 26, the indoor side controllers 34a to 34c, and the connection side controllers 44a to 44c as they exchange control signals via the transmission line 8a. However, it is not limited thereto. A controller that performs the operation control of the entire air conditioner 1 may be provided in the outdoor unit 2, in the indoor units 3a to 3c, or in the connection units 4a to 4c; or, a single unit may be provided as a control unit.

## INDUSTRIAL APPLICABILITY

20

**[0208]** The air conditioner according to the present invention reduces the pressure difference between the first gas refrigerant communication pipe and the second gas refrigerant communication pipe, prevents accumulation of liquid refrigerant in the first gas refrigerant communication pipe resulting from condensation, and can perform the refrigerant quantity judging operation with high accuracy. Thus, the present invention is useful as a refrigerant circuit of an air conditioner, an air conditioner provided therewith, and the like.

25

## Claims

30 **1.** An air conditioner (1) that performs a refrigerant quantity judging operation to judge the refrigerant quantity in a refrigerant circuit, comprising:

a heat source unit (2) including a compression means (21) configured to compress refrigerant gas and a heat source side heat exchanger (22);  
 35 a utilization unit (3a to 3c) including a utilization side heat exchanger (31a to 31c);  
 an expansion mechanism (V2, V9a to V9c);  
 a first gas refrigerant pipe (46a to 46c, 52, 92) extending from a discharge side of the compression means to the utilization unit;  
 a second gas refrigerant pipe (47a to 47c, 53, 93) extending from a suction side of the compression means to the utilization unit;  
 40 a liquid refrigerant pipe (35a to 35c, 45a to 45c, 51, 91) extending from the heat source side heat exchanger to the utilization unit;  
 a switching mechanism (4a to 4c) capable of switching between a first state in which the refrigerant flowing through the liquid refrigerant pipe evaporates in the utilization side heat exchanger and thereafter flows into the second gas refrigerant pipe, and a second state in which the refrigerant flowing through the first gas refrigerant pipe condenses in the utilization side heat exchanger and thereafter flows into the liquid refrigerant pipe;  
 45 a bypass circuit (27, 43a to 43c) configured to bypass the first gas refrigerant pipe to the second gas refrigerant pipe;  
 a bypass circuit opening/closing means (V3, V13a to V13c) provided in the bypass circuit and configured to open and close the bypass circuit; and  
 50 a controller (8) configured to open the bypass circuit opening/closing means before performing the refrigerant quantity judging operation.

**2.** The air conditioner (1) according to claim 1, wherein  
 55 the bypass circuit opening/closing means (V3) is provided in the heat source unit.

**3.** The air conditioner (1) according to claim 1 or claim 2, further comprising a switching unit (4a to 4c) different from a utilization unit and a heat source unit, wherein

the switching unit includes the switching mechanism, and  
the bypass circuit opening/closing means (V13a to V13c) is provided in the switching unit.

- 5       **4.** The air conditioner (1) according to any one of claim 1 through claim 3, further comprising  
a temperature detecting means (T8, T12a to T12c) configured to detect the refrigerant temperature in the first gas  
refrigerant pipe and output a refrigerant temperature detection value,  
wherein  
the controller corrects the refrigerant quantity judged by the refrigerant quantity judging operation based on the  
refrigerant temperature detection value.
- 10       **5.** The air conditioner (1) according to claim 4, wherein  
the temperature detecting means (T8) is provided in the switching unit.
- 15       **6.** The air conditioner (1) according to claim 4 or claim 5, wherein  
the temperature detecting means (T12a to T12c) is provided in the heat source unit.

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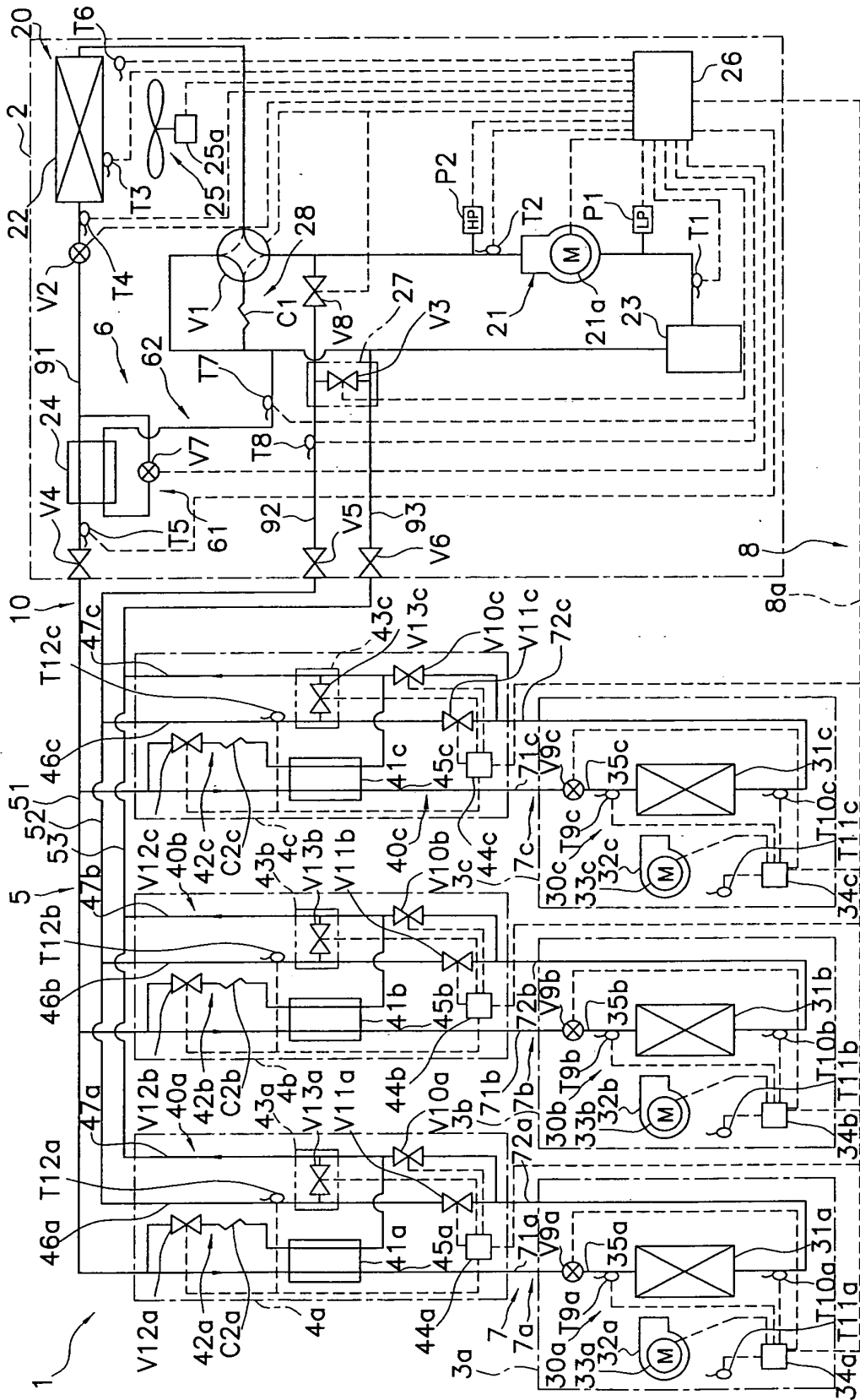
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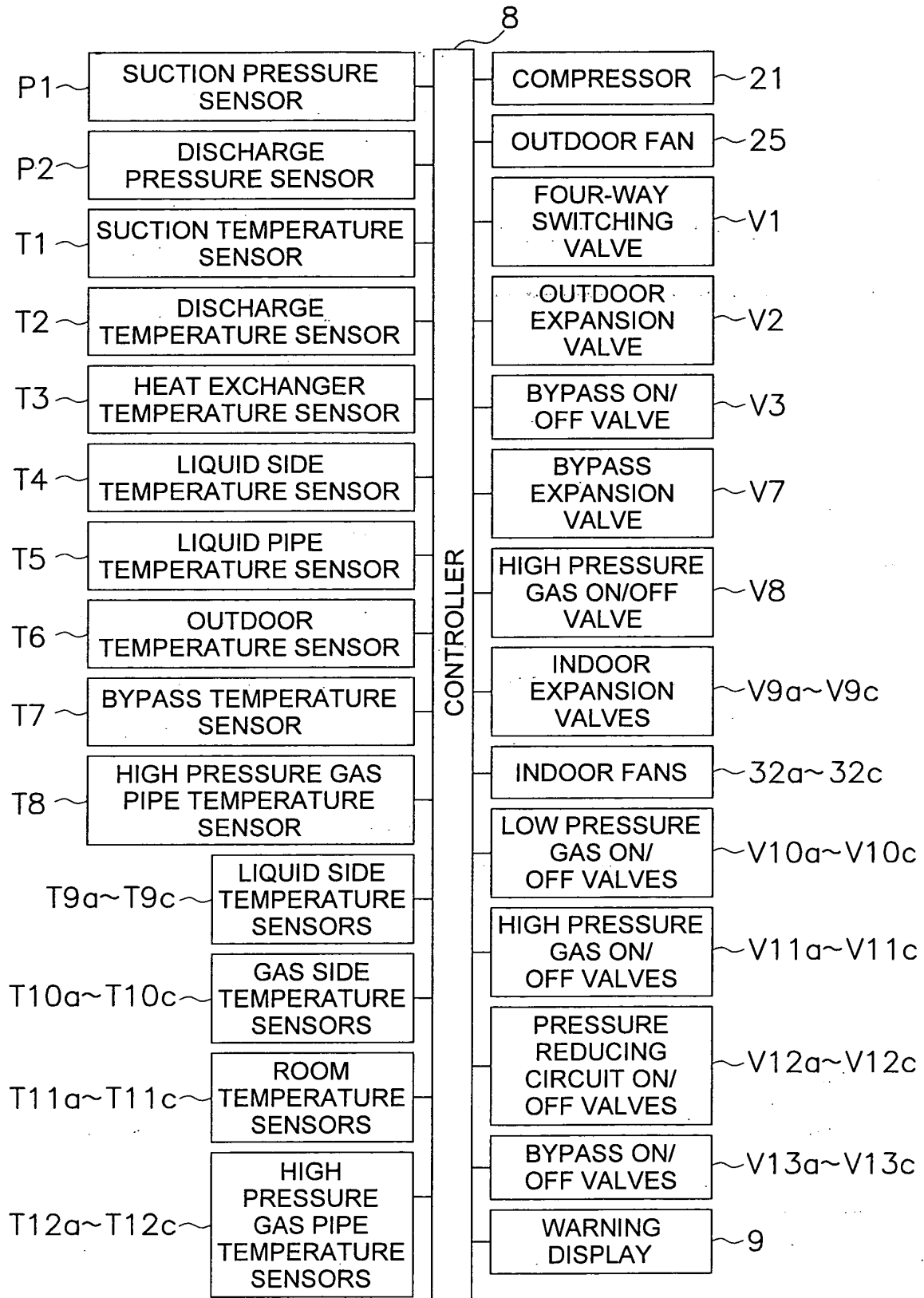


FIG. 2

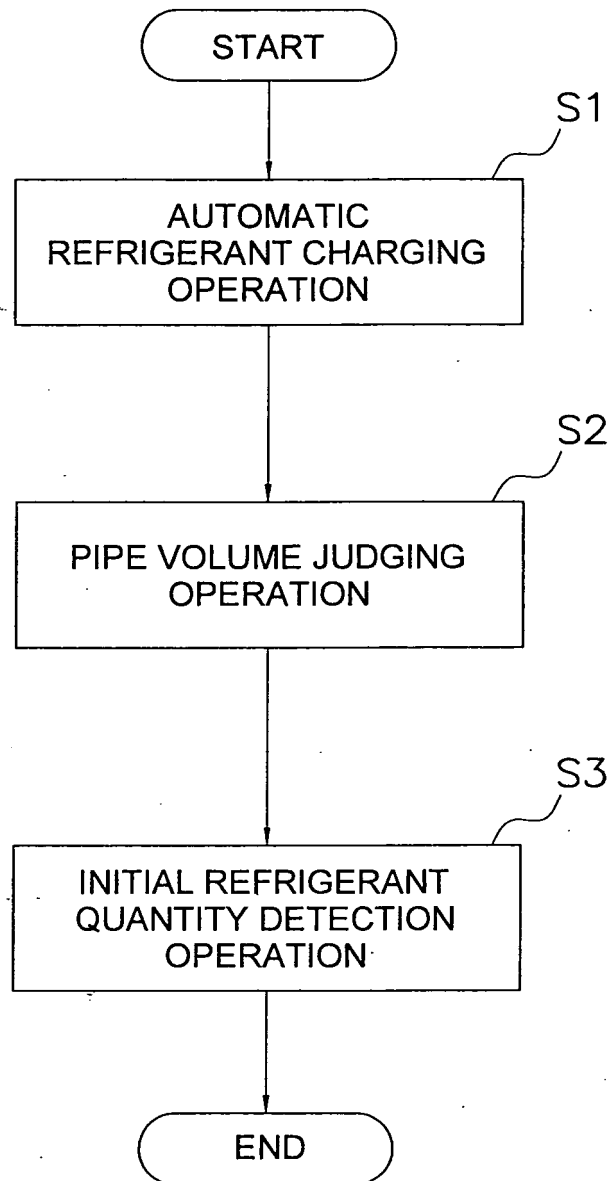


FIG. 3

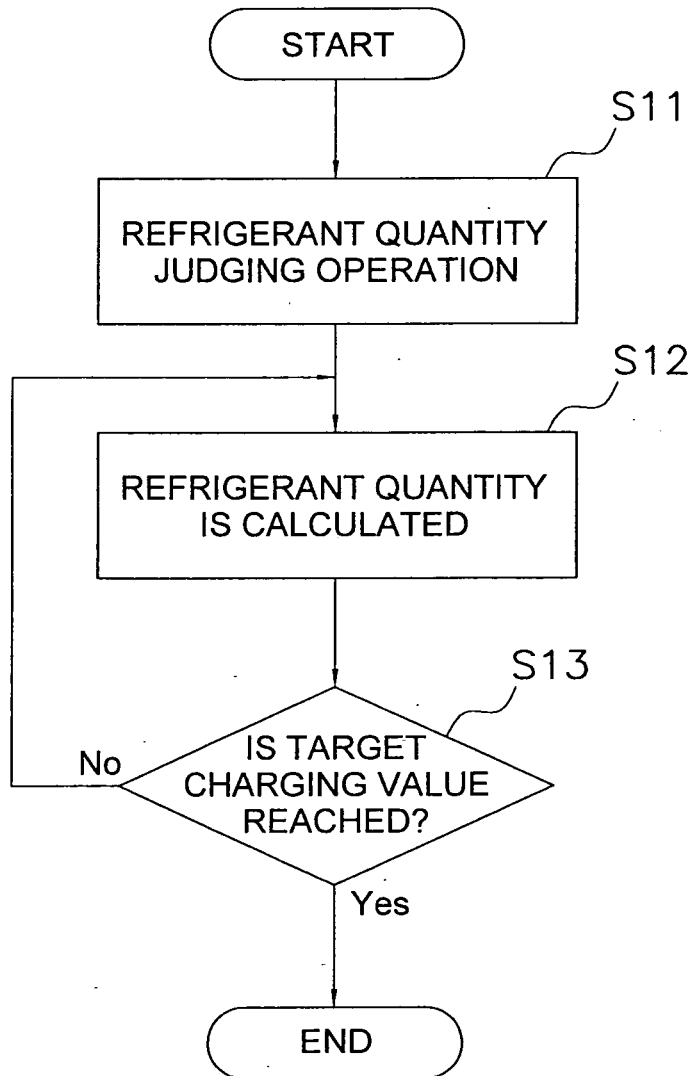


FIG. 4

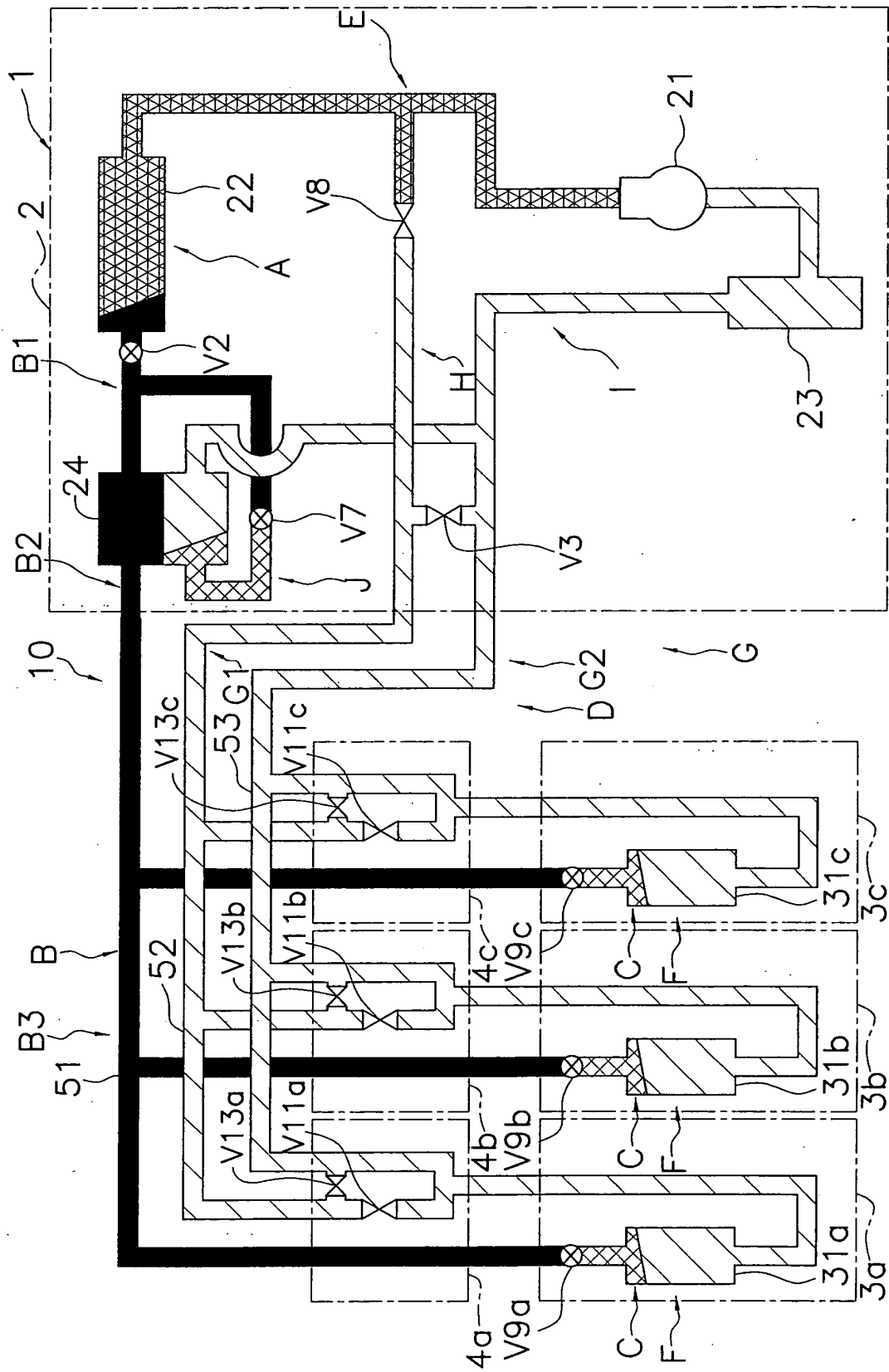


FIG. 5

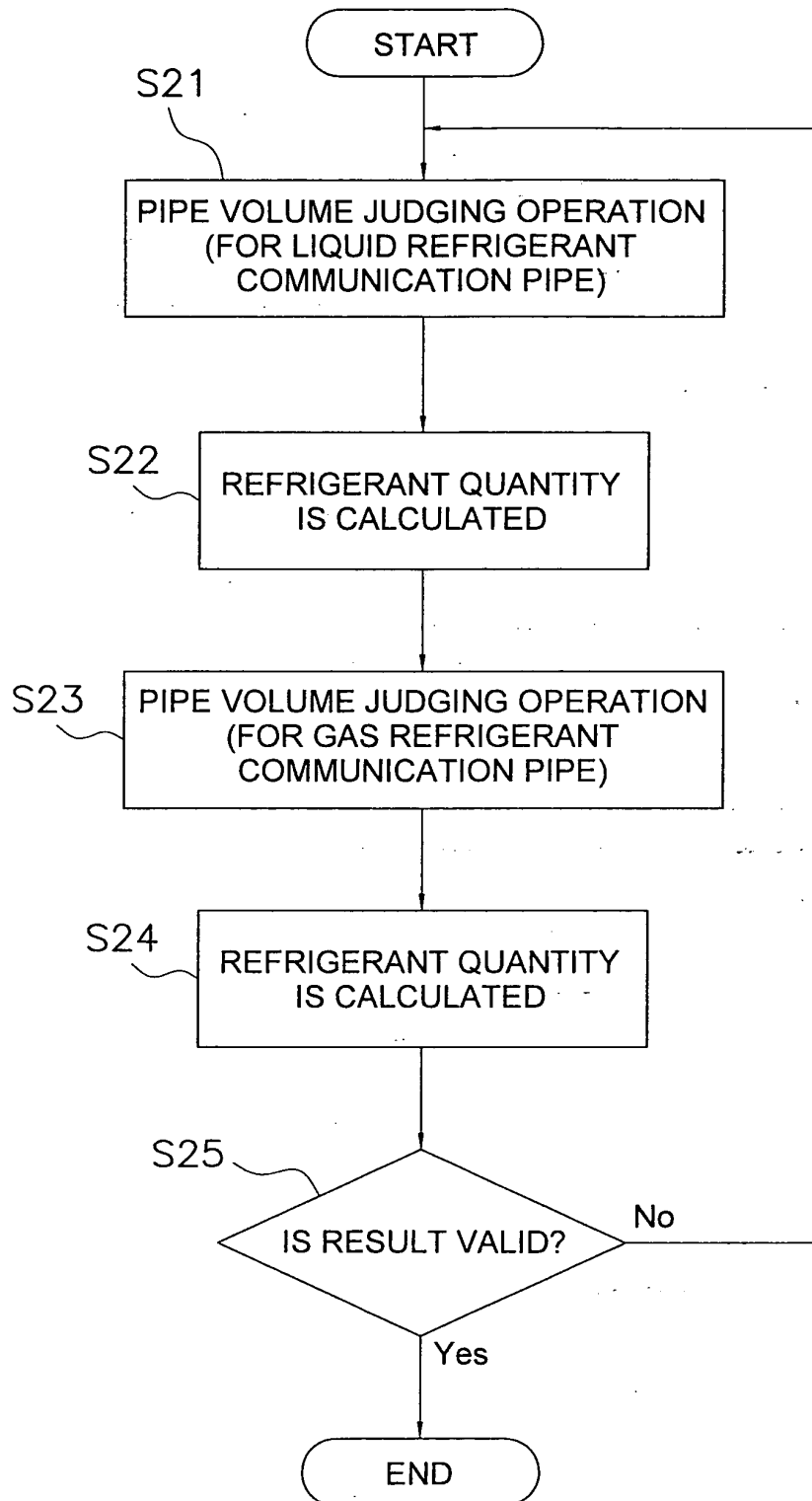


FIG. 6

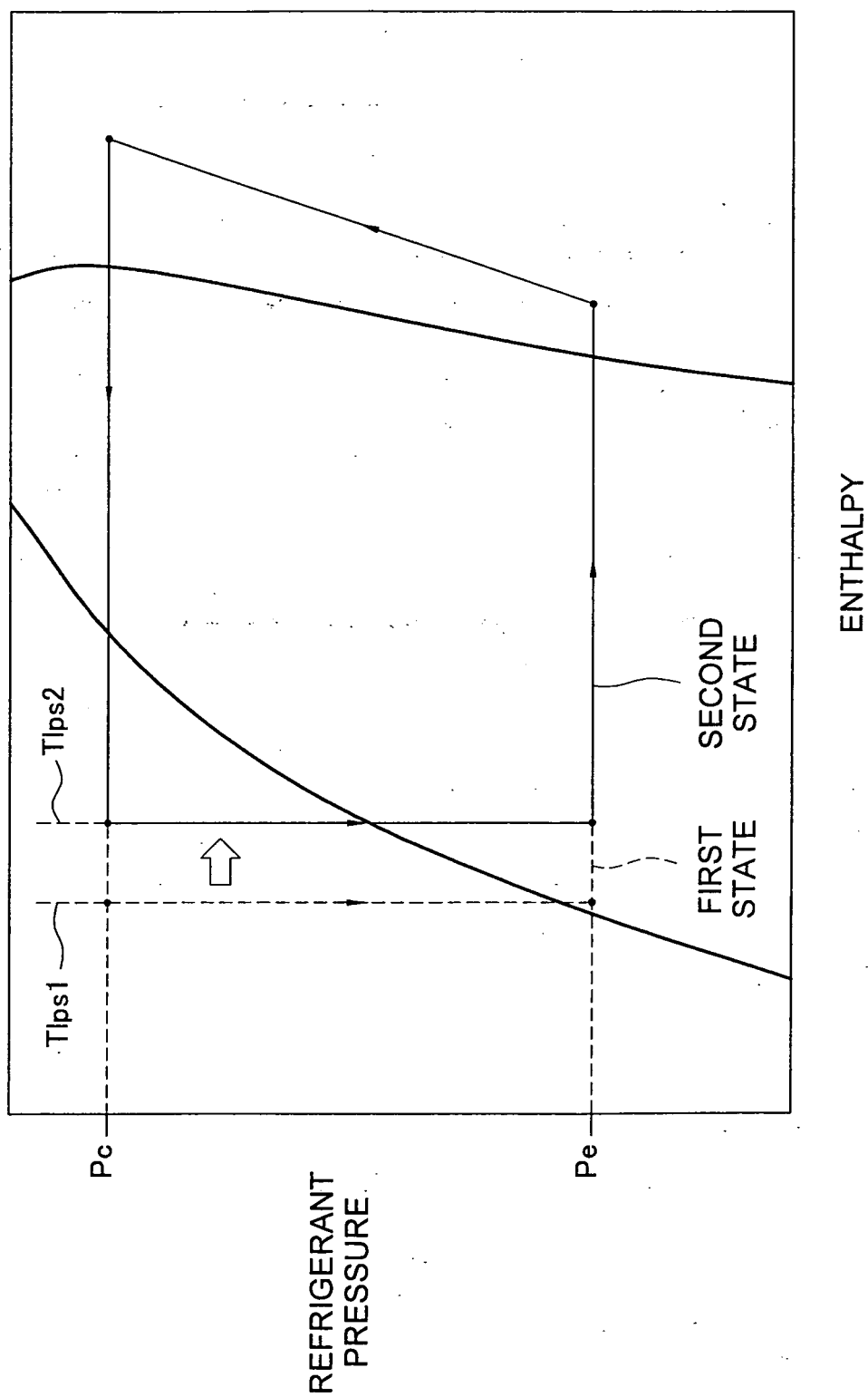


FIG. 7

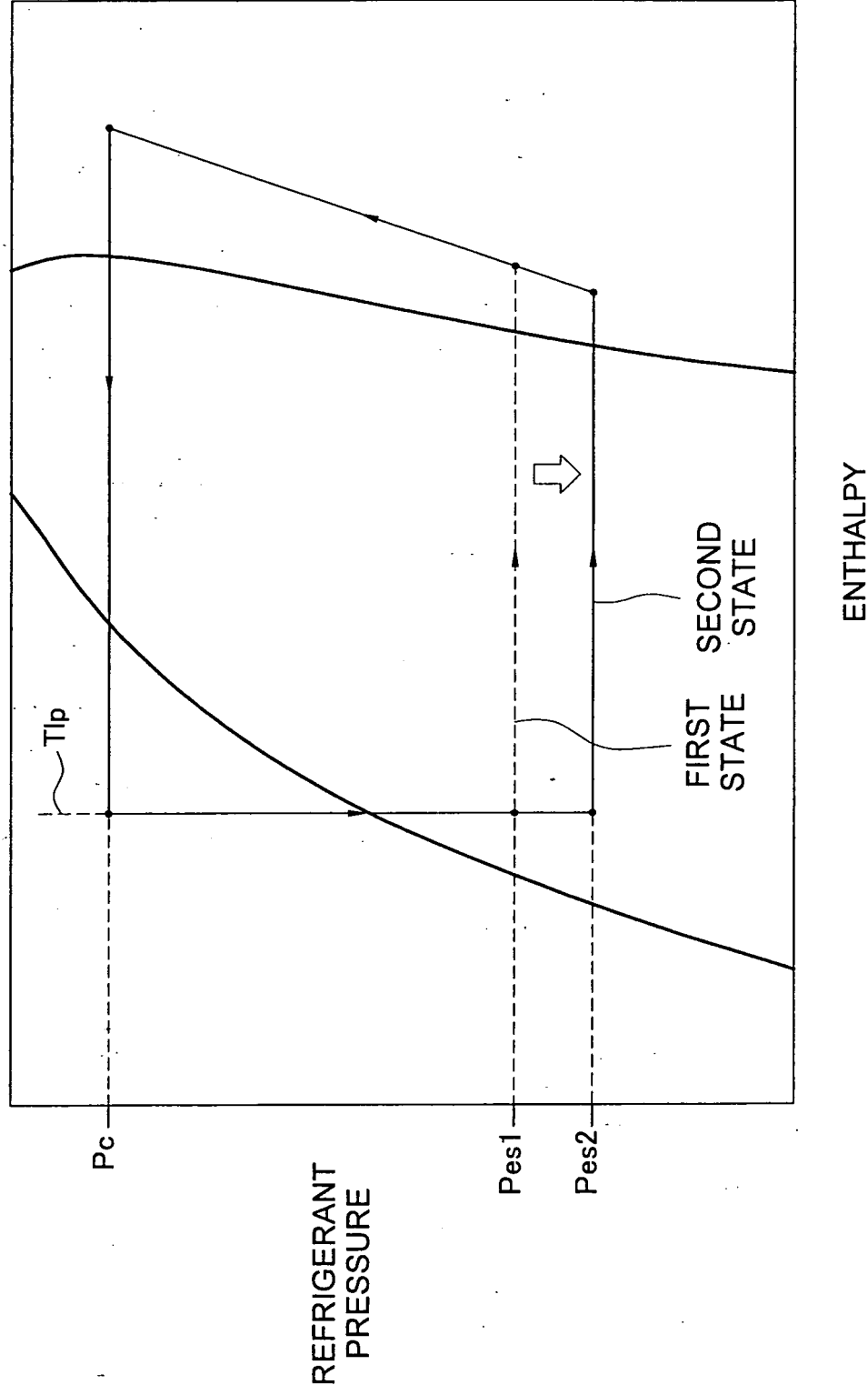


FIG. 8

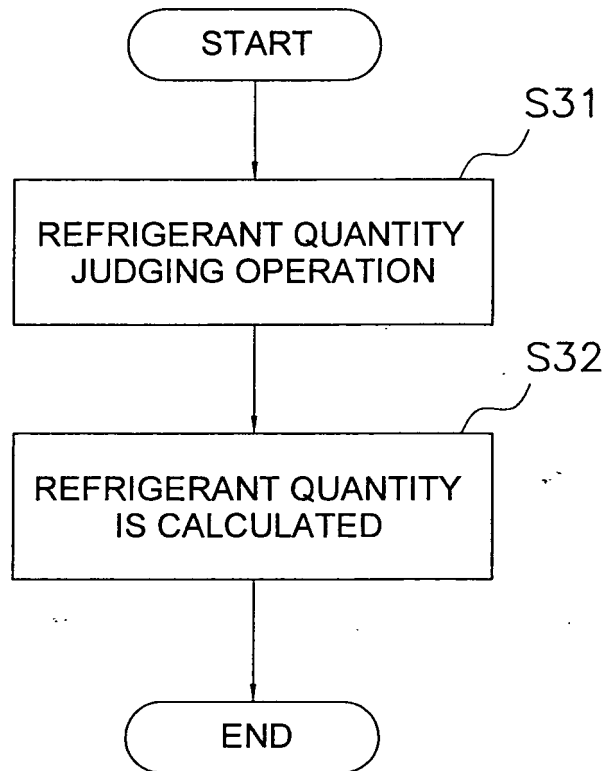


FIG. 9

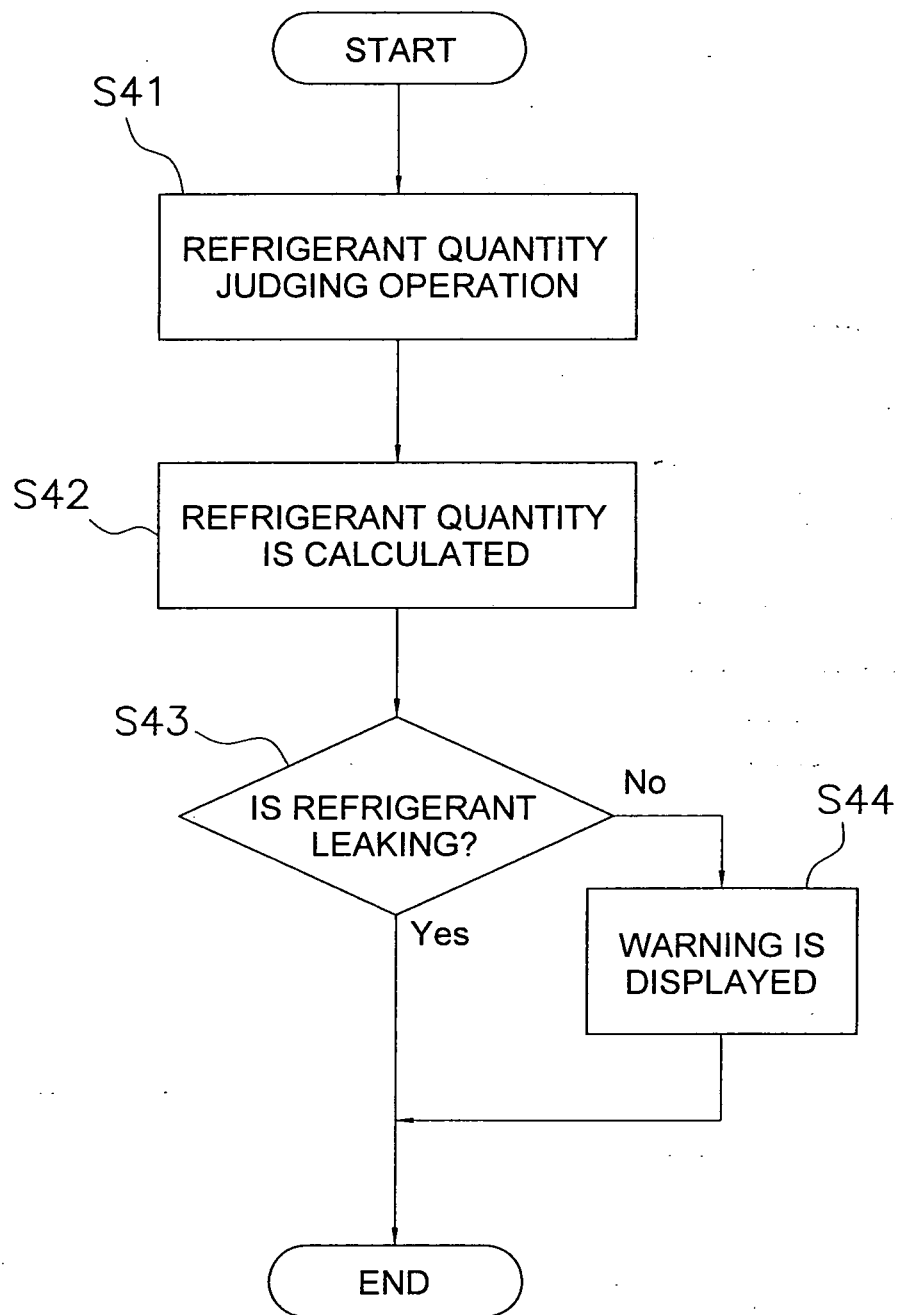


FIG. 10

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2007/054587

## A. CLASSIFICATION OF SUBJECT MATTER

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)

F25B49/02, F24F11/02, F25B1/00, F25B29/00

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 1996-2007

Kokai Jitsuyo Shinan Koho 1971-2007 Toroku Jitsuyo Shinan Koho 1994-2007

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. |
|-----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| A         | JP 2006-058007 A (Daikin Industries, Ltd.),<br>02 March, 2006 (02.03.06),<br>Par. Nos. [0015] to [0017], [0035], [0083] to<br>[0089]; Figs. 1 to 10<br>& JP 2006-23072 A & WO 2005/121664 A1                                                | 1-6                   |
| A         | JP 3-186170 A (Hitachi, Ltd.),<br>14 August, 1991 (14.08.91),<br>Page 5, lower right column, line 2 to page 8,<br>upper right column, line 20; Figs. 1 to 18<br>& US 5214918 A<br>Column 5, line 35 to column 10, line 60;<br>Figs. 1 to 18 | 1-6                   |

☒ Further documents are listed in the continuation of Box C.☐ See patent family annex.

\* Special categories of cited documents:

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"&amp;" document member of the same patent family

Date of the actual completion of the international search  
23 April, 2007 (23.04.07)Date of mailing of the international search report  
01 May, 2007 (01.05.07)Name and mailing address of the ISA/  
Japanese Patent Office

Authorized officer

Facsimile No.

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## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2007/054587

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                                                                                   | Relevant to claim No. |
|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|
| A         | JP 2002-340436 A (Fujitsu General Ltd.),<br>27 November, 2002 (27.11.02),<br>Par. Nos. [0010] to [0019]; Figs. 1, 2<br>(Family: none)                                                | 1-6                   |
| A         | JP 3-063468 A (Daikin Industries, Ltd.),<br>19 March, 1991 (19.03.91),<br>Page 2, lower right column, line 7 to page 3,<br>lower left column, line 6; Figs. 1 to 6<br>(Family: none) | 1-6                   |
| A         | JP 2004-332961 A (Samsung Electronics Co.,<br>Ltd.),<br>25 November, 2004 (25.11.04),<br>Par. Nos. [0007] to [0013], [0020] to [0027];<br>Figs. 1 to 4<br>(Family: none)             | 1-6                   |

Form PCT/ISA/210 (continuation of second sheet) (April 2005)

**REFERENCES CITED IN THE DESCRIPTION**

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**Patent documents cited in the description**

- JP 3186170 A [0003]