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(54) **AIR CONDITIONING DEVICE AND INDOOR UNIT**

FIG. 2

Description**TECHNICAL FIELD**

5 **[0001]** The present disclosure relates to air conditioners and indoor units, and more particularly relates to an air conditioner configured such that an outdoor unit and an indoor unit arranged in an air-conditioning target space are connected to each other via a liquid-refrigerant connection pipe and a gas-refrigerant connection pipe, and an indoor unit used for the air conditioner.

BACKGROUND ART

10 **[0002]** An existing air conditioner is configured such that an outdoor unit and an indoor unit arranged in an air-conditioning target space are connected to each other via a liquid-refrigerant connection pipe and a gas-refrigerant connection pipe. An example of such an air conditioner, as disclosed in PTL 1 (International Publication No. 2015/029160), performs
15 two-phase refrigerant feed of decompressing a refrigerant to be brought into a gas-liquid two-phase state in an outdoor unit and then sending the refrigerant to an indoor unit via a liquid-refrigerant connection pipe. The air conditioner that performs the two-phase refrigerant feed can decrease the amount of refrigerant held by the entire air conditioner by the amount by which the refrigerant flowing through the liquid-refrigerant connection pipe turns into the gas-liquid two-phase state. The decrease in the amount of refrigerant can decrease the influence on environment in a case where the refrigerant
20 leaks outside the air conditioner.

SUMMARY OF THE INVENTION

25 **[0003]** Although the amount of refrigerant held by the entire air conditioner is decreased can be a certain degree by the two-phase refrigerant feed as disclosed in PTL 1, the decrease in the amount of refrigerant is not occasionally sufficient for the countermeasure to leakage of the refrigerant. This is because, when the refrigerant leaks from the indoor unit, the concentration of the refrigerant increases in the air-conditioning target space where the indoor unit involving leakage of the refrigerant is arranged, and the concentration may exceed its permissible value.

30 **[0004]** To address this, a shutoff valve may be added to each of both the liquid side and gas side of the indoor unit so as to isolate the indoor unit involving leakage of the refrigerant and to reduce leakage of the refrigerant into the air-conditioning target space.

[0005] Adding the shutoff valves to both the liquid side and gas side of the indoor unit, however, increases the cost, and further increases the size of the indoor unit if both the shutoff valves on the liquid side and gas side are arranged in the indoor unit.

35 **[0006]** Challenges of the present disclosure are, in an air conditioner configured such that an outdoor unit and an indoor unit arranged in an air-conditioning target space are connected to each other via a liquid-refrigerant connection pipe and a gas-refrigerant connection pipe as well as an indoor unit used for the air conditioner, to minimize increases in the cost and the size of the indoor unit and to allow addition of a refrigerant shutoff function when a refrigerant leaks from the indoor unit.

40 **[0007]** An air conditioner according to a first aspect is an air conditioner including an outdoor unit, a liquid-refrigerant connection pipe and a gas-refrigerant connection pipe, an indoor unit, a gas-side shutoff valve, refrigerant leakage detecting means, and a control unit. The indoor unit is connected to the outdoor unit via the liquid-refrigerant connection pipe and the gas-refrigerant connection pipe, is arranged in an air-conditioning target space, and includes an indoor heat exchanger, an indoor expansion valve, a heat-exchange-side indoor liquid-refrigerant pipe, and a connection-side
45 indoor liquid-refrigerant pipe. The indoor heat exchanger performs heat exchange between a refrigerant, which is circulated between the indoor unit and the outdoor unit via the liquid-refrigerant connection pipe and the gas-refrigerant connection pipe, and an air, which is sent to the air-conditioning target space. The indoor expansion valve decompresses the refrigerant. The heat-exchange-side indoor liquid-refrigerant pipe connects a liquid side of the indoor heat exchanger to the indoor expansion valve. The connection-side indoor liquid-refrigerant pipe connects the indoor expansion valve
50 to the liquid-refrigerant connection pipe. The gas-side shutoff valve is connected to a gas side of the indoor heat exchanger. The refrigerant leakage detecting means detects leakage of the refrigerant. The refrigerant leakage detecting means may be a refrigerant sensor that directly detects the leaked refrigerant, or may be one that estimates the presence or amount of leaked refrigerant on the basis of the relationship between the temperature of the refrigerant in the indoor heat exchanger and the atmospheric temperature of the indoor heat exchanger. The indoor expansion valve is connected
55 to the connection-side indoor liquid-refrigerant pipe by brazing. A brazing portion brazing the indoor expansion valve and the connection-side indoor liquid-refrigerant pipe is provided with a coating material. The control unit causes the indoor expansion valve and the gas-side shutoff valve to be closed in accordance with information of the refrigerant leakage detecting means when the refrigerant leaks.

[0008] To add the refrigerant shutoff function for the situation in which the refrigerant leaks from the indoor unit, providing shutoff valves on both the liquid side and the gas side of the indoor unit may increase the cost and the size of the indoor unit. To minimize the increase in the cost and the size of the indoor unit, it is desirable to use the indoor expansion valve also as the shutoff valve on the liquid side for the situation in which the refrigerant leaks from the indoor unit.

[0009] In the indoor unit arranged in the air-conditioning target space, however, the connection-side indoor liquid-refrigerant pipe that connects the indoor expansion valve to the liquid-refrigerant connection pipe is connected to the indoor expansion valve by brazing. The brazing portion brazing the indoor expansion valve and the connection-side indoor liquid-refrigerant pipe may corrode and the refrigerant may leak from the corroding portion. When the refrigerant leaks from the brazing portion brazing the indoor expansion valve and the connection-side indoor liquid-refrigerant pipe, the refrigerant is continuously supplied from the liquid-refrigerant connection pipe to the brazing portion although the indoor expansion valve is closed to function as the shutoff valve on the liquid side of the indoor unit. The refrigerant may continuously leak from the indoor unit to the air-conditioning target space. Thus, it is difficult to use the indoor expansion valve also as the shutoff valve on the liquid side of the indoor unit unless such leakage of the refrigerant from the brazing portion brazing the indoor expansion valve and the connection-side indoor liquid-refrigerant pipe is reduced.

[0010] In this case, by providing the coating material at the brazing portion brazing the indoor expansion valve and the connection-side indoor liquid-refrigerant pipe as described above, leakage of the refrigerant from the brazing portion brazing the indoor expansion valve and the connection-side indoor liquid-refrigerant pipe is reduced, and the indoor expansion valve can be used also as the shutoff valve on the liquid side of the indoor unit. As long as the indoor expansion valve can be used also as the shutoff valve on the liquid side of the indoor unit, the increase in the cost and the size of the indoor unit can be suppressed by that amount.

[0011] Accordingly, the refrigerant shutoff function for the situation in which the refrigerant leaks from the indoor unit can be added while the increase in the cost and the size of the indoor unit due to the provision of the shutoff valve on the liquid side of the indoor unit is reduced as much as possible.

[0012] For the coating material, any material can be employed as long as the material can suppress corrosion of the brazing portion. For example, a coating material made of resin can be employed. In particular, a water-repellent material and a heat-insulating material are suitable. For example, urethane resin can be employed.

[0013] An air conditioner according to a second aspect is the air conditioner according to the first aspect, in which the connection-side indoor liquid-refrigerant pipe includes a first connection-side indoor liquid-refrigerant pipe connected to the indoor expansion valve, a second connection-side indoor liquid-refrigerant pipe connected to the liquid-refrigerant connection pipe, and a filter that is connected between the first connection-side indoor liquid-refrigerant pipe and the second connection-side indoor liquid-refrigerant pipe. The filter is connected to the first connection-side indoor liquid-refrigerant pipe and the second connection-side indoor liquid-refrigerant pipe by brazing. Brazing portions brazing the filter with the first connection-side indoor liquid-refrigerant pipe and the second connection-side indoor liquid-refrigerant pipe each are provided with a coating material.

[0014] In the indoor unit arranged in the air-conditioning target space, a filter may be provided to reduce inflow of foreign substances and so forth into the connection-side indoor liquid-refrigerant pipe and the indoor expansion valve. The filter is also connected to the connection-side indoor liquid-refrigerant pipe (the first connection-side indoor liquid-refrigerant pipe and the second connection-side indoor liquid-refrigerant pipe) by brazing. Due to this, the brazing portions brazing the filter with the first connection-side indoor liquid-refrigerant pipe and the second connection-side indoor liquid-refrigerant pipe may corrode and the refrigerant may leak from the corroding portions. This makes difficult to use the indoor expansion valve also as the shutoff valve on the liquid side of the indoor unit, like the brazing portion brazing the indoor expansion valve and the connection-side indoor liquid-refrigerant pipe (the first connection-side indoor liquid-refrigerant pipe).

[0015] In this case, by providing the coating materials at the brazing portions brazing the filter with the first connection-side indoor liquid-refrigerant pipe and the second connection-side indoor liquid-refrigerant pipe as described above, leakage of the refrigerant from the brazing portions brazing the filter with the first connection-side indoor liquid-refrigerant pipe and the second connection-side indoor liquid-refrigerant pipe is reduced, and the indoor expansion valve can be used also as the shutoff valve on the liquid side of the indoor unit.

[0016] Even in the case where the filter is provided in the connection-side indoor liquid-refrigerant pipe, the refrigerant shutoff function for the situation in which the refrigerant leaks from the indoor unit can be added while the increase in the cost and the size of the indoor unit due to the provision of the shutoff valve on the liquid side of the indoor unit is reduced as much as possible.

[0017] For the coating material, any material can be employed as long as the material can suppress corrosion of the brazing portion. For example, a coating material made of resin can be employed. In particular, a water-repellent material and a heat-insulating material are suitable. For example, urethane resin can be employed.

[0018] An air conditioner according to a third aspect is the air conditioner according to the first or second aspect, in which the outdoor unit includes an outdoor heat exchanger and a liquid-pressure adjustment expansion valve. When

the refrigerant is sent from the outdoor heat exchanger to the indoor unit via the liquid-refrigerant connection pipe, the control unit controls the liquid-pressure adjustment expansion valve to decompress the refrigerant flowing through the liquid-refrigerant connection pipe to be brought into a gas-liquid two-phase state, and controls the indoor expansion valve to decompress the refrigerant decompressed by the liquid-pressure adjustment expansion valve.

[0019] Since the outdoor unit includes the liquid-pressure adjustment expansion valve as described above, the two-phase refrigerant feed of decompressing the refrigerant to be brought into the gas-liquid two-phase state in the outdoor unit and then sending the refrigerant to the indoor unit via the liquid-refrigerant connection pipe can be performed. Thus, the amount of refrigerant held by the entire air conditioner can be decreased by the amount by which the refrigerant flowing through the liquid-refrigerant connection pipe turns into the gas-liquid two-phase state through the two-phase refrigerant feed. However, although the amount of refrigerant held by the entire air conditioner can be decreased by a certain degree through the two-phase refrigerant feed, when the refrigerant leaks from the indoor unit, the concentration of the refrigerant increases in the air-conditioning target space where the indoor unit involving leakage of the refrigerant is arranged, and the concentration may exceed its permissible value. In such a case, the two-phase refrigerant feed is not occasionally sufficient for the countermeasure to leakage of the refrigerant.

[0020] In this case, by providing the coating material at the brazing portion brazing the indoor expansion valve and the connection-side indoor liquid-refrigerant pipe as described above, leakage of the refrigerant from the brazing portion brazing the indoor expansion valve and the connection-side indoor liquid-refrigerant pipe is reduced, and the indoor expansion valve can be used also as the shutoff valve on the liquid side of the indoor unit.

[0021] Accordingly, even in the case where the two-phase refrigerant feed is not sufficient for the countermeasure to leakage of the refrigerant, the refrigerant shutoff function for the situation in which the refrigerant leaks from the indoor unit can be added while the increase in the cost and the size of the indoor unit due to the provision of the shutoff valve on the liquid side of the indoor unit is reduced as much as possible. The addition of the refrigerant shutoff function makes the countermeasure to leakage of the refrigerant sufficient.

[0022] An air conditioner according to a fourth aspect is the air conditioner according to any one of the first to third aspects, in which the indoor unit includes a plurality of the indoor units, and the gas-side shutoff valve is provided to correspond to each of the indoor units.

[0023] In this case, the plurality of indoor units and the plurality of gas-side shutoff valves are provided as described above. Even with this configuration, the refrigerant shutoff function for the situation in which the refrigerant leaks from the indoor units can be added while the increase in the cost and the sizes of the indoor units due to the provision of the shutoff valves on the liquid sides of the indoor units is reduced as much as possible.

[0024] An air conditioner according to a fifth aspect is the air conditioner according to the fourth aspect, in which the control unit causes only the indoor expansion valve and the gas-side shutoff valve corresponding to the indoor unit in which the refrigerant leaks among the plurality of indoor units to be closed in accordance with information of the refrigerant leakage detecting means when the refrigerant leaks.

[0025] In this case, when the refrigerant leaks from the indoor unit, only the indoor unit in which the refrigerant leaks can be isolated as described above.

[0026] Accordingly, the indoor unit in which the refrigerant does not leak can continue the operation.

[0027] An air conditioner according to a sixth aspect is the air conditioner according to any one of the first to fifth aspects, in which the gas-refrigerant connection pipe is provided with an external shutoff valve unit including the gas-side shutoff valve.

[0028] In this case, since the gas-side shutoff valve is arranged outside the indoor unit as described above, the increase in the size of the indoor unit can be suppressed.

[0029] An air conditioner according to a seventh aspect is the air conditioner according to the sixth aspect, in which the gas-side shutoff valve is connected, by brazing, to an indoor-side gas connection pipe that is connected to a portion of the gas-refrigerant connection pipe on a side of the indoor unit, and an outdoor-side gas connection pipe that is connected to a portion of the gas-refrigerant connection pipe on a side of the outdoor unit. A brazing portion brazing the gas-side shutoff valve and the outdoor-side gas connection pipe is also provided with a coating material.

[0030] In the external shutoff valve unit, the gas-side shutoff valve is connected to the gas connection pipe connected to the gas-refrigerant connection pipe (the indoor-side gas connection pipe and the outdoor-side gas connection pipe) by brazing. Due to this, the brazing portion brazing the gas-side shutoff valve and the outdoor-side gas connection pipe may corrode and the refrigerant may leak from the corroding portion. In contrast, when the external shutoff valve unit is arranged in the air-conditioning target space together with the indoor unit, if the refrigerant leaks from the brazing portion brazing the gas-side shutoff valve and the outdoor-side gas connection pipe, the refrigerant is continuously supplied from the gas-refrigerant connection pipe to the brazing portion although the gas-side shutoff valve is closed, and the refrigerant may continuously leak from the external shutoff valve unit to the air-conditioning target space. Thus, it is required to reduce leakage of the refrigerant from the brazing portion brazing the gas-side shutoff valve and the outdoor-side gas connection pipe.

[0031] In this case, since the brazing portion brazing the gas-side shutoff valve and the outdoor-side gas connection

pipe is provided with the coating material as described above, leakage of the refrigerant from the brazing portion brazing the gas-side shutoff valve and the outdoor-side gas connection pipe is reduced, and the external shutoff valve unit can be arranged in the air-conditioning target space together with the indoor unit.

[0032] Accordingly, the degree of freedom is ensured for arrangement of the external shutoff valve unit.

[0033] For the coating material, any material can be employed as long as the material can suppress corrosion of the brazing portion. For example, a coating material made of resin can be employed. In particular, a water-repellent material and a heat-insulating material are suitable. For example, urethane resin can be employed.

[0034] An air conditioner according to an eighth aspect is the air conditioner according to the fourth or fifth aspect, in which the gas-refrigerant connection pipe is provided with a relay unit including a cooling/heating switching valve that individually switches corresponding one of the plurality of indoor heat exchangers to function as an evaporator or a radiator of the refrigerant. The control unit causes the indoor expansion valve and the cooling/heating switching valve serving as the gas-side shutoff valve to be closed in accordance with information of the refrigerant leakage detecting means when the refrigerant leaks.

[0035] In this case, as described above, the cooling/heating switching valve of the relay unit used for individually switching the operating state of corresponding one of the indoor units (that is, the state in which the indoor heat exchanger functions as the evaporator of the refrigerant and the state in which the indoor heat exchanger functions as the radiator of the refrigerant) is used also as the gas-side shutoff valve. As long as the cooling/heating switching valve can be used also as the shutoff valve on the gas side of the indoor unit, the increase in the cost and the size of the indoor unit can be suppressed by that amount.

[0036] Accordingly, the refrigerant shutoff function for the situation in which the refrigerant leaks from the indoor unit can be added while the increase in the cost and the size of the indoor unit due to the provision of the shutoff valve on the gas side of the indoor unit is reduced as much as possible.

[0037] An air conditioner according to a ninth aspect is the air conditioner according to the eighth aspect, in which the cooling/heating switching valve is connected, by brazing, to an indoor-side gas connection pipe that is connected to a portion of the gas-refrigerant connection pipe on a side of the indoor unit, and an outdoor-side gas connection pipe that is connected to a portion of the gas-refrigerant connection pipe on a side of the outdoor unit. A brazing portion brazing the cooling/heating switching valve and the outdoor-side gas connection pipe is also provided with a coating material.

[0038] In the relay unit, the cooling/heating switching valve is connected to the gas connection pipe connected to the gas-refrigerant connection pipe (the indoor-side gas connection pipe and the outdoor-side gas connection pipe) by brazing. Due to this, when the relay unit is arranged in the air-conditioning target space together with the indoor unit, the brazing portion brazing the cooling/heating switching valve and the outdoor-side gas connection pipe may corrode and the refrigerant may leak from the corroding portion. In this case, when the relay unit is arranged in the air-conditioning target space together with the indoor unit, if the refrigerant leaks from the brazing portion brazing the cooling/heating switching valve and the outdoor-side gas connection pipe, the refrigerant is continuously supplied from the gas-refrigerant connection pipe to the brazing portion although the cooling/heating switching valve is closed, and the refrigerant may continuously leak from the relay unit to the air-conditioning target space. Thus, it is required to reduce leakage of the refrigerant from the brazing portion brazing the cooling/heating switching valve and the outdoor-side gas connection pipe.

[0039] In this case, since the brazing portion brazing the cooling/heating switching valve and the outdoor-side gas connection pipe is provided with the coating material as described above, leakage of the refrigerant from the brazing portion brazing the cooling/heating switching valve and the outdoor-side gas connection pipe is reduced, and the relay unit can be arranged in the air-conditioning target space together with the indoor unit.

[0040] Accordingly, the degree of freedom is ensured for arrangement of the relay unit.

[0041] For the coating material, any material can be employed as long as the material can suppress corrosion of the brazing portion. For example, a coating material made of resin can be employed. In particular, a water-repellent material and a heat-insulating material are suitable. For example, urethane resin can be employed.

[0042] An air conditioner according to a tenth aspect is the air conditioner according to any one of the first to fifth aspects, in which the gas-side shutoff valve is provided in the indoor unit. The indoor unit includes a heat-exchange-side indoor gas-refrigerant pipe that connects the gas side of the indoor heat exchanger to the gas-side shutoff valve, and a connection-side indoor gas-refrigerant pipe that connects the gas-side shutoff valve to the gas-refrigerant connection pipe. The gas-side shutoff valve is connected to the connection-side indoor gas-refrigerant pipe by brazing. A brazing portion brazing the gas-side shutoff valve and the connection-side indoor gas-refrigerant pipe is also provided with a coating material.

[0043] To add the refrigerant shutoff function for the situation in which the refrigerant leaks from the indoor unit, the indoor expansion valve of the indoor unit may be used also as the liquid-side shutoff valve, and the gas-side shutoff valve may be provided at the indoor unit. In this case, the connection-side indoor gas-refrigerant pipe that connects the gas-side shutoff valve to the gas-refrigerant connection pipe is connected to the gas-side shutoff valve by brazing. Due to this, the brazing portion brazing the gas-side shutoff valve and the connection-side indoor gas-refrigerant pipe may corrode and the refrigerant may leak from the corroding portion. When the refrigerant leaks from the brazing portion

brazing the gas-side shutoff valve and the connection-side indoor gas-refrigerant pipe, the refrigerant is continuously supplied from the gas-refrigerant connection pipe to the brazing portion although the gas-side shutoff valve is closed. The refrigerant may continuously leak from the indoor unit to the air-conditioning target space. Thus, it is required to reduce leakage of the refrigerant from the brazing portion brazing the gas-side shutoff valve and the connection-side indoor gas-refrigerant pipe.

[0044] In this case, since the brazing portion brazing the gas-side shutoff valve and the connection-side indoor gas-refrigerant pipe is provided with the coating material as described above, leakage of the refrigerant from the brazing portion brazing the gas-side shutoff valve and the connection-side indoor gas-refrigerant pipe is reduced.

[0045] Accordingly, the shutoff valve provided in the indoor unit is provided on only the gas side, and the refrigerant shutoff function for the situation in which the refrigerant leaks from the indoor unit can be added.

[0046] For the coating material, any material can be employed as long as the material can suppress corrosion of the brazing portion. For example, a coating material made of resin can be employed. In particular, a water-repellent material and a heat-insulating material are suitable. For example, urethane resin can be employed.

[0047] An indoor unit according to an eleventh aspect is an indoor unit connected to an outdoor unit via a liquid-refrigerant connection pipe and a gas-refrigerant connection pipe, arranged in an air-conditioning target space, and including an indoor heat exchanger, an indoor expansion valve, a heat-exchange-side indoor liquid-refrigerant pipe, and a connection-side indoor liquid-refrigerant pipe. The indoor heat exchanger performs heat exchange between a refrigerant, which is circulated between the indoor unit and the outdoor unit via the liquid-refrigerant connection pipe and the gas-refrigerant connection pipe, and an air, which is sent to the air-conditioning target space. The indoor expansion valve decompresses the refrigerant. The heat-exchange-side indoor liquid-refrigerant pipe connects a liquid side of the indoor heat exchanger to the indoor expansion valve. The connection-side indoor liquid-refrigerant pipe connects the indoor expansion valve to the liquid-refrigerant connection pipe. The indoor expansion valve is connected to the connection-side indoor liquid-refrigerant pipe by brazing. A brazing portion brazing the indoor expansion valve and the connection-side indoor liquid-refrigerant pipe is provided with a coating material.

[0048] To add the refrigerant shutoff function for the situation in which the refrigerant leaks from the indoor unit, providing shutoff valves on both the liquid side and the gas side of the indoor unit may increase the cost and the size of the indoor unit. To minimize the increase in the cost and the size of the indoor unit, it is desirable to use the indoor expansion valve also as a shutoff valve on the liquid side for the situation in which the refrigerant leaks from the indoor unit.

[0049] In the indoor unit arranged in the air-conditioning target space, however, the connection-side indoor liquid-refrigerant pipe that connects the indoor expansion valve to the liquid-refrigerant connection pipe is connected to the indoor expansion valve by brazing. The brazing portion brazing the indoor expansion valve and the connection-side indoor liquid-refrigerant pipe may corrode and the refrigerant may leak from the corroding portion. When the refrigerant leaks from the brazing portion brazing the indoor expansion valve and the connection-side indoor liquid-refrigerant pipe, the refrigerant is continuously supplied from the liquid-refrigerant connection pipe to the brazing portion although the indoor expansion valve is closed to function as the shutoff valve on the liquid side of the indoor unit. The refrigerant may continuously leak from the indoor unit to the air-conditioning target space. Thus, it is difficult to use the indoor expansion valve also as the shutoff valve on the liquid side of the indoor unit unless such leakage of the refrigerant from the brazing portion brazing the indoor expansion valve and the connection-side indoor liquid-refrigerant pipe is reduced.

[0050] In this case, by providing the coating material at the brazing portion brazing the indoor expansion valve and the connection-side indoor liquid-refrigerant pipe as described above, leakage of the refrigerant from the brazing portion brazing the indoor expansion valve and the connection-side indoor liquid-refrigerant pipe is reduced, and the indoor expansion valve can be used also as the shutoff valve on the liquid side of the indoor unit. As long as the indoor expansion valve can be used also as the shutoff valve on the liquid side of the indoor unit, the increase in the cost and the size of the indoor unit can be suppressed by that amount.

[0051] Accordingly, the refrigerant shutoff function for the situation in which the refrigerant leaks from the indoor unit can be added while the increase in the cost and the size of the indoor unit due to the provision of the shutoff valve on the liquid side of the indoor unit is reduced as much as possible.

[0052] For the coating material, any material can be employed as long as the material can suppress corrosion of the brazing portion. For example, a coating material made of resin can be employed. In particular, a water-repellent material and a heat-insulating material are suitable. For example, urethane resin can be employed.

[0053] An indoor unit according to a twelfth aspect is the indoor unit according to the eleventh aspect further including a gas-side shutoff valve that is connected to a gas side of the indoor heat exchanger; a heat-exchange-side indoor gas-refrigerant pipe that connects the gas side of the indoor heat exchanger to the gas-side shutoff valve; and a connection-side indoor gas-refrigerant pipe that connects the gas-side shutoff valve to the gas-refrigerant connection pipe. The gas-side shutoff valve is connected to the connection-side indoor gas-refrigerant pipe by brazing. A brazing portion brazing the gas-side shutoff valve and the connection-side indoor gas-refrigerant pipe is also provided with a coating material.

[0054] To add the refrigerant shutoff function for the situation in which the refrigerant leaks from the indoor unit, the indoor expansion valve of the indoor unit may be used also as the liquid-side shutoff valve, and the gas-side shutoff

valve may be provided at the indoor unit. In this case, the connection-side indoor gas-refrigerant pipe that connects the gas-side shutoff valve to the gas-refrigerant connection pipe is connected to the gas-side shutoff valve by brazing. Due to this, the brazing portion brazing the gas-side shutoff valve and the connection-side indoor gas-refrigerant pipe may corrode and the refrigerant may leak from the corroding portion. When the refrigerant leaks from the brazing portion brazing the gas-side shutoff valve and the connection-side indoor gas-refrigerant pipe, the refrigerant is continuously supplied from the gas-refrigerant connection pipe to the brazing portion although the gas-side shutoff valve is closed. The refrigerant may continuously leak from the indoor unit to the air-conditioning target space. Thus, it is required to reduce leakage of the refrigerant from the brazing portion brazing the gas-side shutoff valve and the connection-side indoor gas-refrigerant pipe.

[0055] In this case, since the brazing portion brazing the gas-side shutoff valve and the connection-side indoor gas-refrigerant pipe is provided with the coating material as described above, leakage of the refrigerant from the brazing portion brazing the gas-side shutoff valve and the connection-side indoor gas-refrigerant pipe is reduced.

[0056] Accordingly, the shutoff valve provided in the indoor unit is provided on only the gas side, and the refrigerant shutoff function for the situation in which the refrigerant leaks from the indoor unit can be added.

[0057] For the coating material, any material can be employed as long as the material can suppress corrosion of the brazing portion. For example, a coating material made of resin can be employed. In particular, a water-repellent material and a heat-insulating material are suitable. For example, urethane resin can be employed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0058]

<Fig. 1> Fig. 1 is a schematic configuration diagram of an air conditioner according to a first embodiment of the present disclosure.

<Fig. 2> Fig. 2 illustrates a refrigerant system in the periphery of an indoor unit and an external shutoff valve unit constituting the air conditioner according to the first embodiment of the present disclosure.

<Fig. 3> Fig. 3 is a flowchart of an operation when a refrigerant leaks in the air conditioner according to the first embodiment of the present disclosure.

<Fig. 4> Fig. 4 illustrates a refrigerant system in the periphery of an indoor unit and an external shutoff valve unit constituting an air conditioner according to a first modification of the first embodiment of the present disclosure.

<Fig. 5> Fig. 5 illustrates a refrigerant system in the periphery of an indoor unit and an external shutoff valve unit constituting an air conditioner according to a second modification of the first embodiment of the present disclosure.

<Fig. 6> Fig. 6 is a schematic configuration diagram of an air conditioner according to a third modification of the first embodiment of the present disclosure.

<Fig. 7> Fig. 7 illustrates a refrigerant system in the periphery of an indoor unit constituting the air conditioner according to the third modification of the first embodiment of the present disclosure.

<Fig. 8> Fig. 8 is a flowchart of an operation when a refrigerant leaks in an air conditioner according to a fourth modification of the first embodiment of the present disclosure.

<Fig. 9> Fig. 9 is a schematic configuration diagram of an air conditioner according to a second embodiment of the present disclosure.

<Fig. 10> Fig. 10 illustrates a refrigerant system in the periphery of an indoor unit and a relay unit constituting the air conditioner according to the second embodiment of the present disclosure.

<Fig. 11> Fig. 11 is a flowchart of an operation when a refrigerant leaks in the air conditioner according to the second embodiment of the present disclosure.

<Fig. 12> Fig. 12 illustrates a refrigerant system in the periphery of an indoor unit and a relay unit constituting an air conditioner according to a first modification of the second embodiment of the present disclosure.

<Fig. 13> Fig. 13 illustrates a refrigerant system in the periphery of an indoor unit and a relay unit constituting an air conditioner according to a second modification of the second embodiment of the present disclosure.

<Fig. 14> Fig. 14 is a flowchart of an operation when a refrigerant leaks in an air conditioner according to a third modification of the second embodiment of the present disclosure.

DESCRIPTION OF EMBODIMENTS

[0059] An air conditioner and an indoor unit used for the air conditioner according to an embodiment of the present disclosure are described below with reference to the drawings. It is to be noted that specific configurations of an air conditioner and an indoor unit used for the air conditioner according to an embodiment of the present disclosure are not limited to those of the following embodiments and their modifications, and may be modified within the scope of the gist of the disclosure.

(1) First Embodiment

Configuration

[0060] Fig. 1 is a schematic configuration diagram of an air conditioner 1 according to a first embodiment of the present disclosure. Fig. 2 illustrates a refrigerant system in the periphery of indoor units 3a and 3b and external shutoff valve units 4a and 4b constituting the air conditioner 1 according to the first embodiment of the present disclosure.

[0061] The air conditioner 1 is an apparatus that performs air conditioning (cooling and heating) in an air-conditioning target space in a building or the like through a vapor compression refrigeration cycle. The air conditioner 1 mainly includes an outdoor unit 2; a plurality of (in this case, two) indoor units 3a and 3b mutually connected in parallel; a liquid-refrigerant connection pipe 5 and a gas-refrigerant connection pipe 6 that connect the outdoor unit 2 to the indoor units 3a and 3b; a plurality of (in this case, two) external shutoff valve units 4a and 4b provided at the gas-refrigerant connection pipe 5; and a control unit 19 that controls components of the outdoor unit 2, the indoor units 3a and 3b, and the external shutoff valve units 4a and 4b. A vapor compression refrigerant circuit 10 of the air conditioner 1 is constituted by connecting the outdoor unit 2, the plurality of indoor units 3a and 3b, and the plurality of external shutoff valve units 4a and 4b to one another via the liquid-refrigerant connection pipe 5 and the gas-refrigerant connection pipe 6. The refrigerant circuit 10 is filled with a refrigerant such as R32.

Connection Pipe

[0062] The liquid-refrigerant connection pipe 5 mainly includes a joint pipe portion extending from the outdoor unit 2, and branch pipe portions 5a and 5b branched at a position before the indoor units 3a and 3b into a plurality of (in this case, two) pipe portions. The gas-refrigerant connection pipe 6 mainly includes a joint pipe portion extending from the outdoor unit 2, first branch pipe portions 6a and 6b branched at a position before the indoor units 3a and 3b into a plurality of (in this case, two) pipe portions, and second branch pipe portions 6aa and 6bb that connect the external shutoff valve units 4a and 4b to the indoor units 3a and 3b.

Indoor Unit

[0063] The indoor units 3a and 3b are arranged in air-conditioning target spaces in a building or the like. Being "arranged in air-conditioning target spaces" includes a situation in which the indoor units 3a and 3b are installed in the air-conditioning target spaces and a situation in which the indoor units 3a and 3b are not arranged in the air-conditioning target spaces but the indoor units 3a and 3b are connected to the air-conditioning target spaces via air ducts or the like. The indoor units 3a and 3b are connected to the outdoor unit 2 via the liquid-refrigerant connection pipe 5, the gas-refrigerant connection pipe 6, and the external shutoff valve units 4a and 4b, and constitute part of the refrigerant circuit 10 as described above.

[0064] Configurations of the indoor units 3a and 3b are described next. The indoor unit 3a and the indoor unit 3b have configurations similar to each other. Hence only the configuration of the indoor unit 3a is described. For the configuration of the indoor unit 3b, the description of the components of the indoor unit 3b is omitted while an index "b" is applied to each component instead of the index "a" indicating each component of the indoor unit 3a.

[0065] The indoor unit 3a mainly includes an indoor expansion valve 51a and an indoor heat exchanger 52a. In addition, the indoor unit 3a includes an indoor liquid-refrigerant pipe 53a that connects the liquid side of the indoor heat exchanger 52a to the liquid-refrigerant connection pipe 5 (in this case, the branch pipe portion 5a), and an indoor gas-refrigerant pipe 54a that connects the gas side of the indoor heat exchanger 52a to the gas-refrigerant connection pipe 6 (in this case, the second branch pipe portion 6aa).

[0066] The indoor expansion valve 51a is an electric expansion valve that decompresses the refrigerant. The indoor expansion valve 51a is provided in the indoor liquid-refrigerant pipe 53a.

[0067] The indoor heat exchanger 52a is a heat exchanger that performs heat exchange between the refrigerant, which is circulated between the indoor unit 3a and the outdoor unit 2 via the liquid-refrigerant connection pipe 5 and the gas-refrigerant connection pipe 6, and the indoor air, which is sent to the air-conditioning target space. The indoor unit 3a includes an indoor fan 55a that sucks the indoor air into the indoor unit 3a, that causes the indoor air to exchange heat with the refrigerant in the indoor heat exchanger 52a, and then that sends the indoor air into the air-conditioning target space. That is, the indoor unit 3a includes the indoor fan 55a as a fan that sends the indoor air, which serves as a cooling source or a heating source of the refrigerant flowing through the indoor heat exchanger 52a, to the indoor heat exchanger 52a. The indoor fan 55a is driven by an indoor fan motor 56a.

[0068] The indoor liquid-refrigerant pipe 53a mainly includes a heat-exchange-side indoor liquid-refrigerant pipe 71a that connects the liquid side of the indoor heat exchanger 52a to the indoor expansion valve 51a, and a connection-side indoor liquid-refrigerant pipe 72a that connects the indoor expansion valve 51a to the liquid-refrigerant connection pipe

5 (in this case, the branch pipe portion 5a). The liquid side of the indoor heat exchanger 52a is connected to the heat-exchange-side indoor liquid-refrigerant pipe 71a by brazing. The heat-exchange-side indoor liquid-refrigerant pipe 71a is connected to the indoor expansion valve 51a by brazing (the brazing portion is referred to as brazing portion 81a). The indoor expansion valve 51a is connected to the connection-side indoor liquid-refrigerant pipe 72a by brazing (the brazing portion is referred to as brazing portion 82a). The connection-side indoor liquid-refrigerant pipe 72a is connected to the liquid-refrigerant connection pipe 5 (in this case, the branch pipe portion 5a) by mechanical pipe joint, such as flare connection (the portion of the mechanical pipe joint is referred to as pipe joint portion 83a). The pipe joint portion 83a is connected to the connection-side indoor liquid-refrigerant pipe 72a by brazing (the brazing portion is referred to as brazing portion 83aa). Although not illustrated here, the connection-side indoor liquid-refrigerant pipe 72a may be directly connected to the liquid-refrigerant connection pipe 5 (in this case, the branch pipe portion 5a) by brazing without the mechanical pipe joint such as the pipe joint portion 83a.

[0069] The brazing portion 82a brazing the indoor expansion valve 51a and the connection-side indoor liquid-refrigerant pipe 72a is provided with a coating material 11a. For the coating material 11a, any material can be employed as long as the material can suppress corrosion of the brazing portion 82a. For example, a coating material made of resin can be employed. In particular, a water-repellent material and a heat-insulating material are suitable. For example, urethane resin can be employed. The coating material 11a may be provided at the brazing portion 82a, or may be also provided at a portion other than the brazing portion 82a. For example, as illustrated in Fig. 2, the coating material 11a may be provided in a range from the indoor expansion valve 51a to the pipe joint portion 83a of the connection-side indoor liquid-refrigerant pipe 72a (that is, so as to include the brazing portion 82a and the brazing portion 83aa). When the connection-side indoor liquid-refrigerant pipe 72a is directly connected to the liquid-refrigerant connection pipe 5 (in this case, the branch pipe portion 5a) by brazing, the coating material 11a may be provided in a range from the indoor expansion valve 51a to the brazing portion brazing the connection-side indoor liquid-refrigerant pipe 72a and the liquid-refrigerant connection pipe 5 (in this case, the branch pipe portion 5a).

[0070] The gas side of the indoor heat exchanger 52a is connected to the indoor gas-refrigerant pipe 54a by brazing. The indoor gas-refrigerant pipe 54a is connected to the gas-refrigerant connection pipe 6 (in this case, the second branch pipe portion 6aa) by mechanical pipe joint, such as flare connection (the portion of the mechanical pipe joint is referred to as pipe joint portion 84a). The pipe joint portion 84a is connected to the indoor gas-refrigerant pipe 54a by brazing (the brazing portion is referred to as brazing portion 84aa). Although not illustrated here, the indoor gas-refrigerant pipe 54a may be directly connected to the gas-refrigerant connection pipe 6 (in this case, the second branch pipe portion 6aa) by brazing.

[0071] The indoor unit 3a is provided with a refrigerant sensor 57a serving as refrigerant leakage detecting means for detecting leakage of the refrigerant. The refrigerant sensor 57a is provided in the indoor unit 3a in this case; however, it is not limited thereto. The refrigerant sensor 57a may be provided, for example, at a remote controller for operating the indoor unit 3a, or in the air-conditioning target space where the indoor unit 3a is arranged. The refrigerant leakage detecting means may be the refrigerant sensor 57a that directly detects the leaked refrigerant as described above, or alternatively, although it is not employed in this case, the refrigerant leakage detecting means may be one that estimates the presence or amount of leaked refrigerant on the basis of the relationship between the temperature of the refrigerant in the indoor heat exchanger 52a and the atmospheric temperature of the indoor heat exchanger 52a.

Outdoor Unit

[0072] The outdoor unit 2 is arranged outside the air-conditioning target space or outside the building or the like. The outdoor unit 2 is connected to the indoor units 3a and 3b via the liquid-refrigerant connection pipe 5, the gas-refrigerant connection pipe 6, and the external shutoff valve units 4a and 4b, and constitutes part of the refrigerant circuit 10 as described above.

[0073] A configuration of the outdoor unit 2 is described next.

[0074] The outdoor unit 2 mainly includes a compressor 21 and an outdoor heat exchanger 23. In addition, the outdoor unit 2 includes a switching mechanism 22 that switches the operating state between a radiation operating state in which the outdoor heat exchanger 23 functions as a radiator of the refrigerant, and an evaporation operating state in which the outdoor heat exchanger 23 functions as an evaporator of the refrigerant. The switching mechanism 22 is connected to the suction side of the compressor 21 via a suction refrigerant pipe 31. The discharge side of the compressor 21 is connected to the switching mechanism 22 via a discharge refrigerant pipe 32. The switching mechanism 22 is connected to the gas side of the outdoor heat exchanger 23 via a first outdoor gas-refrigerant pipe 33. The liquid side of the outdoor heat exchanger 23 is connected to the liquid-refrigerant connection pipe 5 via an outdoor liquid-refrigerant pipe 34. The connection portion of the outdoor liquid-refrigerant pipe 34 with respect to the liquid-refrigerant connection pipe 5 is provided with a liquid-side shutoff valve 27. The switching mechanism 22 is connected to the gas-refrigerant connection pipe 6 via a second outdoor gas-refrigerant pipe 35. The connection portion of the second outdoor gas-refrigerant pipe 35 with respect to the gas-refrigerant connection pipe 6 is provided with a gas-side shutoff valve 28. The liquid-side

shutoff valve 27 and the gas-side shutoff valve 28 are valves that are manually opened and closed.

[0075] The compressor 21 is a device for compressing the refrigerant. For example, a closed-structure compressor in which a compression element (not illustrated) of positive-displacement type, such as rotary type or scroll type, is rotationally driven by a compressor motor 21a is used.

[0076] The switching mechanism 22 is a device that can switch the flow of the refrigerant in the refrigerant circuit 10 such that, when the outdoor heat exchanger 23 functions as the radiator of the refrigerant (hereinafter, the situation is referred to as "outdoor radiation state"), the switching mechanism 22 connects the discharge side of the compressor 21 to the gas side of the outdoor heat exchanger 23 (see solid lines of the switching mechanism 22 in Fig. 1); and, when the outdoor heat exchanger 23 functions as the evaporator of the refrigerant (hereinafter, the situation is referred to as "outdoor evaporation state"), the switching mechanism 22 connects the suction side of the compressor 21 to the gas side of the outdoor heat exchanger 23 (see broken lines of the switching mechanism 22 in Fig. 1). The switching mechanism 22 is, for example, a four-way switching valve.

[0077] The outdoor heat exchanger 23 is a heat exchanger that performs heat exchange between the outdoor air and the refrigerant, which is circulated between the outdoor unit 2 and the indoor units 3a and 3b via the liquid-refrigerant connection pipe 5 and the gas-refrigerant connection pipe 6. The outdoor unit 2 includes an outdoor fan 24 that sucks the outdoor air into the outdoor unit 2 that causes the outdoor air to exchange heat with the refrigerant in the outdoor heat exchanger 23, and then that discharges the outdoor air to the outside. That is, the outdoor unit 2 includes the outdoor fan 24 as a fan that sends the outdoor air, which serves as a cooling source or a heating source of the refrigerant flowing through the outdoor heat exchanger 23, to the outdoor heat exchanger 23. The outdoor fan 24 is driven by an outdoor fan motor 24a.

[0078] Focusing only on the compressor 21, the outdoor heat exchanger 23, the liquid-refrigerant connection pipe 5, the indoor expansion valves 51a and 51b, the indoor heat exchangers 52a and 52b, and the gas-refrigerant connection pipe 6, the air conditioner 1 performs an operation (cooling operation) of circulating the refrigerant in the order of the compressor 21, the outdoor heat exchanger 23, the liquid-refrigerant connection pipe 5, the indoor expansion valves 51a and 51b, the indoor heat exchangers 52a and 52b, the gas-refrigerant connection pipe 6, and the compressor 21. Focusing only on the compressor 21, the outdoor heat exchanger 23, the liquid-refrigerant connection pipe 5, the indoor expansion valves 51a and 51b, the indoor heat exchangers 52a and 52b, and the gas-refrigerant connection pipe 6, the air conditioner 1 performs an operation (heating operation) of circulating the refrigerant in the order of the compressor 21, the gas-refrigerant connection pipe 6, the indoor heat exchangers 52a and 52b, the indoor expansion valves 51a and 51b, the liquid-refrigerant connection pipe 5, the outdoor heat exchanger 23, and the compressor 21. The switching mechanism 22 is switched to the outdoor radiation state in cooling operation, and the switching mechanism 22 is switched to the outdoor evaporation state in heating operation.

[0079] In addition, an outdoor expansion valve 25 and a liquid-pressure adjustment expansion valve 26 are provided in the outdoor liquid-refrigerant pipe 34. The outdoor expansion valve 25 is an electric expansion valve that decompresses the refrigerant in heating operation, and is provided in a portion of the outdoor liquid-refrigerant pipe 34 near the liquid side of the outdoor heat exchanger 23. The liquid-pressure adjustment expansion valve 26 is an electric expansion valve that decompresses the refrigerant so that the refrigerant flowing through the liquid-refrigerant connection pipe 5 is brought into a gas-liquid two-phase state in cooling operation, and is provided in a portion of the outdoor liquid-refrigerant pipe 34 near the liquid-refrigerant connection pipe 5. That is, the liquid-pressure adjustment expansion valve 26 is provided in a portion of the outdoor liquid-refrigerant pipe 34 nearer to the liquid-refrigerant connection pipe 5 than the outdoor expansion valve 25.

[0080] The air conditioner 1 performs two-phase refrigerant feed of sending the refrigerant in the gas-liquid two-phase state to the liquid-refrigerant connection pipe 5 by the liquid-pressure adjustment expansion valve 26 and hence sending the refrigerant from the outdoor unit 2 to the indoor units 3a and 3b in cooling operation.

[0081] Furthermore, a refrigerant return pipe 41 is connected to the outdoor liquid-refrigerant pipe 34, and a refrigerant cooler 45 is provided. The refrigerant return pipe 41 is a refrigerant pipe that branches part of the refrigerant flowing through the outdoor liquid-refrigerant pipe 34 and sends the refrigerant to the compressor 21. The refrigerant cooler 45 is a heat exchanger that cools the refrigerant flowing through a portion of the outdoor liquid-refrigerant pipe 34 nearer to the outdoor heat exchanger 23 than the liquid-pressure adjustment expansion valve 26. The outdoor expansion valve 25 is provided in a portion of the outdoor liquid-refrigerant pipe 34 nearer to the outdoor heat exchanger 23 than the refrigerant cooler 45. The liquid-pressure adjustment expansion valve 26 is provided in a portion of the outdoor liquid-refrigerant pipe 34 nearer to the liquid-refrigerant connection pipe 5 than the portion to which the refrigerant cooler 45 is connected (in this case, between the refrigerant cooler 45 and the liquid-side shutoff valve 27).

[0082] The refrigerant return pipe 41 is a refrigerant pipe that sends the refrigerant branched from the outdoor liquid-refrigerant pipe 34 to the suction side of the compressor 21. The refrigerant return pipe 41 mainly includes a refrigerant return inlet pipe 42 and a refrigerant return outlet pipe 43. The refrigerant return inlet pipe 42 is a refrigerant pipe that branches part of the refrigerant flowing through the outdoor liquid-refrigerant pipe 34 from a portion between the liquid side of the outdoor heat exchanger 23 and the liquid-pressure adjustment expansion valve 26 (in this case, a portion

between the outdoor expansion valve 25 and the refrigerant cooler 45) and sends the refrigerant to the inlet of the refrigerant cooler 45 on the side of the refrigerant return pipe 41. The refrigerant return inlet pipe 42 is provided with a refrigerant return expansion valve 44 that adjusts the flow rate of the refrigerant flowing through the refrigerant cooler 45 while decompressing the refrigerant flowing through the refrigerant return pipe 41. The refrigerant return expansion valve 44 is an electric expansion valve. The refrigerant return outlet pipe 43 is a refrigerant pipe that sends the refrigerant from the outlet of the refrigerant cooler 45 on the side of the refrigerant return pipe 41 to the suction refrigerant pipe 31. The refrigerant cooler 45 cools the refrigerant flowing through the outdoor liquid-refrigerant pipe 34 by using the refrigerant flowing through the refrigerant return pipe 41.

[0083] The outdoor unit 2 is provided with various sensors. To be specific, the outdoor unit 2 is provided with a discharge pressure sensor 36 that detects a pressure (discharge pressure Pd) of the refrigerant discharged from the compressor 21. In addition, the outdoor unit 2 is provided with an outdoor heat-exchange liquid-side sensor 37 that detects a temperature Tol (outdoor heat-exchange outlet temperature Tol) of the refrigerant on the liquid side of the outdoor heat exchanger 23, and is provided with a liquid-pipe temperature sensor 38 that detects a temperature (liquid-pipe temperature Tip) of the refrigerant in a portion of the outdoor liquid-refrigerant pipe 34 between the refrigerant cooler 45 and the liquid-pressure adjustment expansion valve 26.

External Shutoff Valve Unit

[0084] The external shutoff valve units 4a and 4b are arranged in the building or the like. In this case, the external shutoff valve units 4a and 4b are arranged outside the air-conditioning target spaces unlike the indoor units 3a and 3b. The external shutoff valve units 4a and 4b, together with the gas-refrigerant connection pipe 6, are provided between the indoor units 3a and 3b and the outdoor unit 2, and constitute part of the refrigerant circuit 10.

[0085] Configurations of the external shutoff valve units 4a and 4b are described next. The external shutoff valve unit 4a and the external shutoff valve unit 4b have configurations similar to each other. Hence only the configuration of the external shutoff valve unit 4a is described. For the configuration of the external shutoff valve unit 4b, the description of the components of the external shutoff valve unit 4b is omitted while an index "b" is applied to each component instead of the index "a" indicating each component of the external shutoff valve unit 4a.

[0086] The external shutoff valve unit 4a is provided in the gas-refrigerant connection pipe 6, and mainly includes a gas-side shutoff valve 58a. In addition, the external shutoff valve unit 4a includes a gas connection pipe 62a that is connected to the first branch pipe portion 6a, which is a portion of the gas-refrigerant connection pipe 6 on the side of the outdoor unit 2, and that is connected to the second branch pipe portion 6aa, which is a portion of the gas-refrigerant connection pipe 6 on the side of the indoor unit 3a.

[0087] The gas-side shutoff valve 58a is an electric expansion valve that shuts off the flow of the refrigerant that is circulated between the indoor unit 3a and the outdoor unit 2 via the gas-refrigerant connection pipe 6. The gas-side shutoff valve 58a is provided in the gas connection pipe 62a. That is, the gas-side shutoff valve 58a is connected to the gas side of the indoor heat exchanger 52a via the indoor gas-refrigerant pipe 54a of the indoor unit 3a, the second branch pipe portion 6aa of the gas-refrigerant connection pipe 6, and the gas connection pipe 62a of the external shutoff valve unit 4a. The gas-side shutoff valve 58a may not be an electric expansion valve and may be an electromagnetic valve.

[0088] The gas connection pipe 62a mainly includes an indoor-side gas connection pipe 66a that is connected to a portion of the gas-refrigerant connection pipe 6 on the side of the indoor unit 3a (in this case, the second branch pipe portion 6aa), and an outdoor-side gas connection pipe 67a that is connected to a portion of the gas-refrigerant connection pipe 6 on the side of the outdoor unit 2 (in this case, the first branch pipe portion 6a). The gas-side shutoff valve 58a is connected to the indoor-side gas connection pipe 66a by brazing (the brazing portion is referred to as brazing portion 91a). The gas-side shutoff valve 58a is connected to the outdoor-side gas connection pipe 67a by brazing (the brazing portion is referred to as brazing portion 92a). The indoor-side gas connection pipe 66a is connected to the gas-refrigerant connection pipe 6 (in this case, the second branch pipe portion 6aa) by mechanical pipe joint, such as flare connection (the portion of the mechanical pipe joint is referred to as pipe joint portion 95a). The pipe joint portion 95a is connected to the indoor-side gas connection pipe 66a by brazing (the brazing portion is referred to as brazing portion 95aa). Although not illustrated here, the indoor-side gas connection pipe 66a may be directly connected to the gas-refrigerant connection pipe 6 (in this case, the second branch pipe portion 6aa) by brazing. The outdoor-side gas connection pipe 67a is connected to the gas-refrigerant connection pipe 6 (in this case, the first branch pipe portion 6a) by mechanical pipe joint, such as flare connection (the portion of the mechanical pipe joint is referred to as pipe joint portion 96a). The pipe joint portion 96a is connected to the outdoor-side gas connection pipe 67a by brazing (the brazing portion is referred to as brazing portion 96aa). Although not illustrated here, the outdoor-side gas connection pipe 67a may be directly connected to the gas-refrigerant connection pipe 6 (in this case, the first branch pipe portion 6a) by brazing.

Control Unit

[0089] The control unit 19 is constituted by being connected to control boards or the like (not illustrated) provided in, for example, the outdoor unit 2 and the indoor units 3a and 3b to communicate therewith. In Fig. 1, however, the control unit 19 is illustrated at a position separated from the outdoor unit 2, the indoor units 3a and 3b, and the external shutoff valve units 4a and 4b for the convenience of illustration. The control unit 19 controls the components 21, 22, 24, 25, 26, 44, 51a, 51b, 55a, 55b, 58a, and 58b of the air conditioner 1 (in this case, the outdoor unit 2, the indoor units 3a and 3b, and the external shutoff valve units 4a and 4b), that is, controls the entire operation of the air conditioner 1 in accordance with the detection signals of the above-described various sensors 36, 37, 38, 57a, and 57b.

Operation without Leakage of Refrigerant

[0090] The operation of the air conditioner 1 when the refrigerant does not leak is described next with reference to Fig. 1. The air conditioner 1 performs cooling operation and heating operation. The air conditioner 1 performs two-phase refrigerant feed of sending the refrigerant in the gas-liquid two-phase state to the liquid-refrigerant connection pipe 5 by the liquid-pressure adjustment expansion valve 26 provided in the outdoor liquid-refrigerant pipe 34 and hence sending the refrigerant from the outdoor unit 2 to the indoor units 3a and 3b in cooling operation. The operation of the air conditioner 1 which is described below is performed by the control unit 19 that controls the components of the air conditioner 1.

Cooling Operation

[0091] In cooling operation, for example, when all the indoor units 3a and 3b perform cooling operation (that is, operation in which all the indoor heat exchangers 52a and 52b function as the evaporators of the refrigerant and the outdoor heat exchanger 23 functions as the radiator of the refrigerant), the switching mechanism 22 is switched to the outdoor radiation state (the state in which the switching mechanism 22 is indicated by solid lines in Fig. 1), and the compressor 21, the outdoor fan 24, and the indoor fans 55a and 55b are driven.

[0092] Then, the high-pressure refrigerant discharged from the compressor 21 is sent to the outdoor heat exchanger 23 via the switching mechanism 22. The refrigerant sent to the outdoor heat exchanger 23 is condensed by being cooled through heat exchange with the outdoor air supplied by the outdoor fan 24 in the outdoor heat exchanger 23 that functions as the radiator of the refrigerant. The refrigerant flows out from the outdoor unit 2 via the outdoor expansion valve 25, the refrigerant cooler 45, the liquid-pressure adjustment expansion valve 26, and the liquid-side shutoff valve 27.

[0093] The refrigerant flowing out from the outdoor unit 2 is branched and sent to the indoor units 3a and 3b via the liquid-refrigerant connection pipe 5. The refrigerant sent to the indoor units 3a and 3b is decompressed by the indoor expansion valves 51a and 51b to be at low pressure. The refrigerant is sent to the indoor heat exchangers 52a and 52b. The refrigerant sent to the indoor heat exchangers 52a and 52b is evaporated by being heated through heat exchange with the indoor air supplied from the air-conditioning target spaces by the indoor fans 55a and 55b in the indoor heat exchangers 52a and 52b that function as the evaporators of the refrigerant. The refrigerant flows out from the indoor units 3a and 3b. The indoor air cooled by the indoor heat exchangers 52a and 52b is sent to the air-conditioning target spaces and the air-conditioning target spaces are cooled by using the cooled indoor air.

[0094] The refrigerant flowing out from the indoor units 3a and 3b is sent to the external shutoff valve units 4a and 4b via the second branch pipe portions 6aa and 6bb of the gas-refrigerant connection pipe 6. The refrigerant sent to the external shutoff valve units 4a and 4b passes through the gas-side shutoff valves 58a and 58b and then flows out from the external shutoff valve units 4a and 4b.

[0095] The refrigerant flowing out from the external shutoff valve units 4a and 4b is joined at the gas-refrigerant connection pipe 6 and sent to the outdoor unit 2. The refrigerant sent to the outdoor unit 2 is sucked into the compressor 21 via the gas-side shutoff valve 28 and the switching mechanism 22.

[0096] In the above-described cooling operation, the air conditioner 1 performs two-phase refrigerant feed of sending the refrigerant in the gas-liquid two-phase state to the liquid-refrigerant connection pipe 5 by the liquid-pressure adjustment expansion valve 26 and hence sending the refrigerant from the outdoor unit 2 to the indoor units 3a and 3b. In addition, the refrigerant flowing through the outdoor liquid-refrigerant pipe 34 is cooled by the refrigerant return pipe 41 and the refrigerant cooler 45 to reduce variation in the liquid-pipe temperature T_{lp} in the portion of the outdoor liquid-refrigerant pipe 34 between the refrigerant cooler 45 and the liquid-pressure adjustment expansion valve 26, so that the two-phase refrigerant feed can be properly performed.

[0097] First, the control unit 19 causes the liquid-pressure adjustment expansion valve 26 to decompress the refrigerant so that the refrigerant flowing through the liquid-refrigerant connection pipe 5 is brought into the gas-liquid two-phase state. The refrigerant decompressed by the liquid-pressure adjustment expansion valve 26 is the refrigerant at medium pressure that is lower than the pressure of the high-pressure refrigerant and higher than the pressure of the low-pressure refrigerant. The control unit 19 controls the opening degree of the liquid-pressure adjustment expansion valve 26 so that

a degree of subcooling SCo of the refrigerant on the liquid side of the outdoor heat exchanger 23 becomes a target degree of subcooling SCot. To be specific, the control unit 19 obtains the degree of subcooling SCo of the refrigerant on the liquid side of the outdoor heat exchanger 23 from the outdoor heat-exchange liquid-side temperature Tol. The control unit 19 obtains the degree of subcooling SCo of the refrigerant on the liquid side of the outdoor heat exchanger 23 by subtracting the outdoor heat-exchange outlet temperature Tol from a temperature Toc of the refrigerant, which is obtained by converting the discharge pressure Pd into a saturation temperature. The control unit 19 performs control to increase the opening degree of the liquid-pressure adjustment expansion valve 26 if the degree of subcooling SCo is larger than the target degree of subcooling SCot, and performs control to decrease the opening degree of the liquid-pressure adjustment expansion valve 26 if the degree of subcooling SCo is smaller than the target degree of subcooling SCot. At this time, the control unit 19 performs control to fix the opening degree of the outdoor expansion valve 25 to a fully opened state.

[0098] With this control, the refrigerant flowing through the liquid-refrigerant connection pipe 5 is brought into the gas-liquid two-phase state. Hence, the liquid-refrigerant connection pipe 5 is less likely filled with the refrigerant in the liquid state as compared with the case where the refrigerant flowing through the liquid-refrigerant connection pipe 5 is in the liquid state. The amount of refrigerant existing in the liquid-refrigerant connection pipe 5 can be decreased by that amount.

[0099] The control unit 19 causes the temperature (the liquid-pipe temperature Tlp) of the refrigerant in the portion of the outdoor liquid-refrigerant pipe 34 between the refrigerant cooler 45 and the liquid-pressure adjustment expansion valve 26 to be constant by cooling the refrigerant flowing through the portion of the outdoor liquid-refrigerant pipe 34 nearer to the outdoor heat exchanger 23 than the liquid-pressure adjustment expansion valve 26 by the refrigerant cooler 45 by using the refrigerant flowing through the refrigerant return pipe 41. The control unit 19 controls the opening degree of the refrigerant return expansion valve 44 so that the temperature (the liquid-pipe temperature Tlp) of the refrigerant in the portion of the outdoor liquid-refrigerant pipe 34 between the refrigerant cooler 45 and the liquid-pressure adjustment expansion valve 26 becomes a target liquid-pipe temperature Tlpt. To be specific, the control unit 19 performs control to increase the opening degree of the refrigerant return expansion valve 44 if the liquid-pipe temperature Tlp is higher than the target liquid-pipe temperature Tlpt, and performs control to decrease the opening degree of the refrigerant return expansion valve 44 if the liquid-pipe temperature Tlp is lower than the target liquid-pipe temperature Tlpt.

[0100] With the control, the temperature (the liquid-pipe temperature Tlp) of the refrigerant in the portion of the outdoor liquid-refrigerant pipe 34 between the refrigerant cooler 45 and the liquid-pressure adjustment expansion valve 26 can be maintained constant at the target liquid-pipe temperature Tlpt. By making the liquid-pipe temperature Tlp constant and reducing variation, the refrigerant flowing through the liquid-refrigerant connection pipe 5 after decompressed by the liquid-pressure adjustment expansion valve 26 can be reliably maintained in a desirable gas-liquid two-phase state.

Heating Operation

[0101] In heating operation, for example, when all the indoor units 3a and 3b perform heating operation (that is, operation in which all the indoor heat exchangers 52a and 52b function as the radiators of the refrigerant and the outdoor heat exchanger 23 functions as the evaporator of the refrigerant), the switching mechanism 22 is switched to the outdoor evaporation state (the state in which the switching mechanism 22 is indicated by broken lines in Fig. 1), and the compressor 21, the outdoor fan 24, and the indoor fans 55a and 55b are driven.

[0102] Then, the high-pressure refrigerant discharged from the compressor 21 flows out from the outdoor unit 2 via the switching mechanism 22 and the gas-side shutoff valve 28.

[0103] The refrigerant flowing out from the outdoor unit 2 is branched and sent to the external shutoff valve units 4a and 4b via the gas-refrigerant connection pipe 6. The refrigerant sent to the external shutoff valve units 4a and 4b passes through the gas-side shutoff valves 58a and 58b and then flows out from the external shutoff valve units 4a and 4b.

[0104] The refrigerant flowing out from the external shutoff valve units 4a and 4b is sent to the indoor units 3a and 3b via the second branch pipe portions 6aa and 6bb of the gas-refrigerant connection pipe 6. The refrigerant sent to the indoor units 3a and 3b is sent to the indoor heat exchangers 52a and 52b. The high-pressure refrigerant sent to the indoor heat exchangers 52a and 52b is condensed by being cooled through heat exchange with the indoor air supplied from the air-conditioning target spaces by the indoor fans 55a and 55b in the indoor heat exchangers 52a and 52b that function as the radiators of the refrigerant. The refrigerant flows out from the indoor units 3a and 3b via the indoor expansion valves 51a and 51b. The indoor air heated by the indoor heat exchangers 52a and 52b is sent to the air-conditioning target spaces and the air-conditioning target spaces are heated by using the heated indoor air.

[0105] The refrigerant flowing out from the indoor units 3a and 3b is joined at the liquid-refrigerant connection pipe 5 and sent to the outdoor unit 2. The refrigerant sent to the outdoor unit 2 is sent to the outdoor expansion valve 25 via the liquid-side shutoff valve 27, the liquid-pressure adjustment expansion valve 26, and the refrigerant cooler 45. The refrigerant sent to the outdoor expansion valve 25 is decompressed by the outdoor expansion valve 25 to be at low pressure and then is sent to the outdoor heat exchanger 23. The refrigerant sent to the outdoor heat exchanger 23 is evaporated by being heated through heat exchange with the outdoor air supplied by the outdoor fan 24. The refrigerant

is sucked into the compressor 21 via the switching mechanism 22.

[0106] In the above-described heating operation, unlike cooling operation, the control unit 19 performs control to fix the opening degree of the liquid-pressure adjustment expansion valve 26 to a fully opened state. The opening degree of the refrigerant return expansion valve 44 is brought into a fully closed state to inhibit the refrigerant from flowing to the refrigerant return pipe 41.

Operation with Leakage of Refrigerant

[0107] The operation of the air conditioner 1 when the refrigerant leaks is described next with reference to Figs. 1 to 3. Fig. 3 is a flowchart of an operation when a refrigerant leaks in the air conditioner 1 according to the first embodiment of the present disclosure. The operation of the air conditioner 1 when the refrigerant leaks which is described below is performed by the control unit 19 that controls the components of the air conditioner 1 (the outdoor unit 2, the indoor units 3a and 3b, and the external shutoff valve units 4a and 4b) like the operation when the refrigerant does not leak.

[0108] The air conditioner 1 is provided with the refrigerant sensors 57a and 57b serving as the refrigerant leakage detecting means as described above. When the refrigerant sensors 57a and 57b detect leakage of the refrigerant, the indoor expansion valves 51a and 51b and the gas-side shutoff valves 58a and 58b are closed in accordance with the information of the refrigerant sensors 57a and 57b. Thus, the indoor units 3a and 3b can be isolated. Accordingly, the refrigerant can be inhibited from flowing from the refrigerant connection pipes 5 and 6 to the indoor units 3a and 3b. That is, when the refrigerant leaks, the indoor expansion valves 51a and 51b are used also as liquid-side shutoff valves and are closed together with the gas-side shutoff valves 58a and 58b, thereby providing a refrigerant shutoff function when the refrigerant leaks from the indoor units 3a and 3b.

[0109] To be specific, when the refrigerant sensors 57a and 57b detect leakage of the refrigerant (step ST1), the control unit 19 closes the indoor expansion valves 51a and 51b and the gas-side shutoff valves 58a and 58b (step ST4). In addition, when leakage of the refrigerant is detected in step ST1, an alarm may be given (step ST2). Further, before the indoor expansion valves 51a and 51b and the gas-side shutoff valves 58a and 58b are closed, the compressor 21 may be stopped (step ST3) to suppress an excessive increase in the pressure of the refrigerant.

[0110] In this way, the indoor expansion valves 51a and 51b and the gas-side shutoff valves 58a and 58b are closed in accordance with the information of the refrigerant sensors 57a and 57b serving as the refrigerant leakage detecting means when the refrigerant leaks. Thus, the refrigerant is inhibited from flowing from the refrigerant connection pipes 5 and 6 to the indoor units 3a and 3b, and increase in concentration of the refrigerant in the air-conditioning target spaces can be suppressed.

Features

[0111] The air conditioner 1 and the indoor units 3a and 3b according to this embodiment have the following features.

[0112] To add the refrigerant shutoff function for the situation in which the refrigerant leaks from the indoor units 3a and 3b, providing shutoff valves on both the liquid sides and the gas sides of the indoor units 3a and 3b may increase the cost and the sizes of the indoor units 3a and 3b. To reduce the increase in the cost and the sizes of the indoor units 3a and 3b as much as possible, it is desirable to use the indoor expansion valves 51a and 51b also as liquid-side shutoff valves for the situation in which the refrigerant leaks from the indoor units 3a and 3b.

[0113] In the indoor units 3a and 3b arranged in the air-conditioning target spaces, however, the connection-side indoor liquid-refrigerant pipes 72a and 72b that connect the indoor expansion valves 51a and 51b to the liquid-refrigerant connection pipe 5 are connected to the indoor expansion valves 51a and 51b by brazing. The brazing portions 82a and 82b brazing the indoor expansion valves 51a and 51b and the connection-side indoor liquid-refrigerant pipes 72a and 72b may corrode and the refrigerant may leak from the corroding portions. When the refrigerant leaks from the brazing portions 82a and 82b, the refrigerant is continuously supplied from the liquid-refrigerant connection pipe 5 to the brazing portions 82a and 82b although the indoor expansion valves 51a and 51b are closed to function as the shutoff valves on the liquid sides of the indoor units 3a and 3b. The refrigerant may continuously leak from the indoor units 3a and 3b to the air-conditioning target spaces. Thus, it is difficult to use the indoor expansion valves 51a and 51b also as the shutoff valves on the liquid sides of the indoor units 3a and 3b unless such leakage of the refrigerant from the brazing portions 82a and 82b is reduced.

[0114] In this case, by providing the coating materials 11a and 11b at the brazing portions 82a and 82b as described above, leakage of the refrigerant from the brazing portions 82a and 82b is reduced, and the indoor expansion valves 51a and 51b can be used also as the shutoff valves on the liquid sides of the indoor units 3a and 3b. As long as the indoor expansion valves 51a and 51b can be used also as the shutoff valves on the liquid sides of the indoor units 3a and 3b, the increase in the cost and the sizes of the indoor units 3a and 3b can be suppressed by that amount.

[0115] Accordingly, the refrigerant shutoff function for the situation in which the refrigerant leaks from the indoor units 3a and 3b can be added while the increase in the cost and the sizes of the indoor units 3a and 3b due to the provision

of the shutoff valves on the liquid sides of the indoor units 3a and 3b is reduced as much as possible.

[0116] In particular, since the gas-side shutoff valves 58a and 58b are arranged in the external shutoff valve units 4a and 4b located outside the indoor units 3a and 3b as described above, the increase in the sizes of the indoor units 3a and 3b can be suppressed.

[0117] Since the outdoor unit 2 includes the liquid-pressure adjustment expansion valve 26 as described above, the two-phase refrigerant feed of decompressing the refrigerant to be brought into the gas-liquid two-phase state in the outdoor unit 2 and then sending the refrigerant to the indoor units 3a and 3b via the liquid-refrigerant connection pipe 5 can be performed. Thus, the amount of refrigerant held by the entire air conditioner can be decreased by the amount by which the refrigerant flowing through the liquid-refrigerant connection pipe 5 turns into the gas-liquid two-phase state through the two-phase refrigerant feed. However, although the amount of refrigerant held by the entire air conditioner can be decreased by a certain degree through the two-phase refrigerant feed, when the refrigerant leaks from the indoor units 3a and 3b, the concentration of the refrigerant increases in the air-conditioning target spaces where the indoor units 3a and 3b involving leakage of the refrigerant are arranged, and the concentration may exceed its permissible value. In such a case, the two-phase refrigerant feed is not occasionally sufficient for the countermeasure to leakage of the refrigerant.

[0118] In this case, by providing the coating materials 11a and 11b at the brazing portions 82a and 82b as described above, leakage of the refrigerant from the brazing portions 82a and 82b is reduced, and the indoor expansion valves 51a and 51b can be used also as the shutoff valves on the liquid sides of the indoor units 3a and 3b.

[0119] Accordingly, even in the case where the two-phase refrigerant feed is not sufficient for the countermeasure to leakage of the refrigerant, the refrigerant shutoff function for the situation in which the refrigerant leaks from the indoor units 3a and 3b can be added while the increase in the cost and the sizes of the indoor units 3a and 3b due to the provision of the shutoff valves on the liquid sides of the indoor units 3a and 3b is reduced as much as possible. The addition of the refrigerant shutoff function makes the countermeasure to leakage of the refrigerant sufficient.

First Modification

[0120] In this embodiment, only the indoor expansion valves 51a and 51b are provided in the indoor liquid-refrigerant pipes 53a and 53b as illustrated in Fig. 2 in the indoor units 3a and 3b arranged in the air-conditioning target spaces. In addition, filters 73a and 73b for reducing inflow of foreign substances and so forth to the indoor expansion valves 51a and 51b may be provided in the connection-side indoor liquid-refrigerant pipes 72a and 72b as illustrated in Fig. 4 in the indoor units 3a and 3b. The filters 73a and 73b are also connected to the connection-side indoor liquid-refrigerant pipes 72a and 72b by brazing. The connection-side indoor liquid-refrigerant pipes 72a and 72b include first connection-side indoor liquid-refrigerant pipes 74a and 74b connected to the indoor expansion valves 51a and 51b, and second connection-side indoor liquid-refrigerant pipes 75a and 75b connected to the liquid-refrigerant connection pipe 5 (in this case, the branch pipe portions 5a and 5b). The filters 73a and 73b are connected between the first connection-side indoor liquid-refrigerant pipes 74a and 74b and the second connection-side indoor liquid-refrigerant pipes 75a and 75b. The filters 73a and 73b are connected to the first connection-side indoor liquid-refrigerant pipes 74a and 74b and the second connection-side indoor liquid-refrigerant pipes 75a and 75b by brazing (the brazing portions are referred to as brazing portions 85a, 85b, 86a, and 86b). Due to this, the brazing portions 85a, 85b, 86a, and 86b may corrode and the refrigerant may leak from the corroding portions. This makes difficult to use the indoor expansion valves 51a and 51b also as the shutoff valves on the liquid sides of the indoor units 3a and 3b, like the brazing portions 82a and 82b brazing the indoor expansion valves 51a and 51b and the connection-side indoor liquid-refrigerant pipes 72a and 72b (the first connection-side indoor liquid-refrigerant pipes 74a and 74b).

[0121] To address this, as illustrated in Fig. 4, the brazing portions 85a, 85b, 86a, and 86b brazing the filters 73a and 73b with the first connection-side indoor liquid-refrigerant pipes 74a and 74b and the second connection-side indoor liquid-refrigerant pipes 75a and 75b are also provided with coating materials 11a, 11b, 12a, and 12b. The first connection-side indoor liquid-refrigerant pipes 74a and 74b including the brazing portions 82a and 82b and the brazing portions 85a and 85b are provided with the coating materials 11a and 11b. The second connection-side indoor liquid-refrigerant pipes 75a and 75b including the brazing portions 86a and 86b and the brazing portions 83aa and 83bb are provided with the coating materials 12a and 12b. When the second connection-side indoor liquid-refrigerant pipes 75a and 75b are directly connected to the liquid-refrigerant connection pipe 5 (in this case, the branch pipe portion 5a) by brazing, the coating materials 12a and 12b may be provided to include the brazing portions brazing the second connection-side indoor liquid-refrigerant pipes 75a and 75b and the liquid-refrigerant connection pipe 5 (in this case, the branch pipe portion 5a). The way of providing the coating materials is not limited to the above. A coating material may be provided at each of the brazing portions 82a, 82b, 85a, 85b, 86a, 86b, 83aa, and 83bb, or may be provided collectively at all the brazing portions 82a, 82b, 85a, 85b, 86a, 86b, 83aa, and 83bb including the filters 73a and 73b. Accordingly, leakage of the refrigerant from the brazing portions 85a, 85b, 86a, and 86b brazing the filters 73a and 73b with the first connection-side indoor liquid-refrigerant pipes 74a and 74b and the second connection-side indoor liquid-refrigerant pipes 75a and 75b is

suppressed, so that the indoor expansion valves 51a and 51b can be used also as the shutoff valves on the liquid sides of the indoor units 3a and 3b.

[0122] Even in the case where the filters 73a and 73b are provided in the connection-side indoor liquid-refrigerant pipes 72a and 72b, the refrigerant shutoff function for the situation in which the refrigerant leaks from the indoor units 3a and 3b can be added while the increase in the cost and the sizes of the indoor units 3a and 3b due to the provision of the shutoff valves on the liquid sides of the indoor units 3a and 3b is reduced as much as possible.

Second Modification

[0123] In the external shutoff valve units 4a and 4b, the gas-side shutoff valves 58a and 58b are connected to the gas connection pipes 62a and 62b connected to the gas-refrigerant connection pipe 6 (the indoor-side gas connection pipes 66a and 66b and the outdoor-side gas connection pipes 67a and 67b) by brazing. Due to this, the brazing portions 92a and 92b brazing the gas-side shutoff valves 58a and 58b and the outdoor-side gas connection pipes 67a and 67b may corrode and the refrigerant may leak from the corroding portions. In the above-described embodiment and first modification, however, the external shutoff valve units 4a and 4b are arranged outside the air-conditioning target spaces. Hence, even when the refrigerant leaks from the brazing portions 92a and 92b, the refrigerant hardly leaks to the air-conditioning target spaces. In contrast, when the external shutoff valve units 4a and 4b are arranged in the air-conditioning target spaces together with the indoor units 3a and 3b, if the refrigerant leaks from the brazing portions 92a and 92b, the refrigerant is continuously supplied from the gas-refrigerant connection pipe 6 to the brazing portions 92a and 92b although the gas-side shutoff valves 58a and 58b are closed, and the refrigerant may continuously leak from the external shutoff valve units 4a and 4b to the air-conditioning target spaces. Thus, it is required to reduce leakage of the refrigerant from the brazing portions 92a and 92b.

[0124] To address this, as illustrated in Fig. 5, the brazing portions 92a and 92b brazing the gas-side shutoff valves 58a and 58b and the outdoor-side gas connection pipes 67a and 67b are also provided with coating materials 13a and 13b. The coating materials 13a and 13b may be provided at only the brazing portions 92a and 92b, or may be also provided at a portion other than the brazing portions 92a and 92b. For example, as illustrated in Fig. 5, the coating materials 13a and 13b may be provided in a range from the gas-side shutoff valves 58a and 58b to the pipe joint portions 96a and 96b of the outdoor-side gas connection pipes 67a and 67b (that is, so as to include the brazing portions 92a and 92b and the brazing portions 96aa and 96bb). When the outdoor-side gas connection pipes 67a and 67b are directly connected to the gas-refrigerant connection pipe 6 (in this case, the first branch pipe portions 6a and 6b) by brazing, the coating materials 13a and 13b may be provided in a range from the gas-side shutoff valves 58a and 58b to the brazing portions brazing the outdoor-side gas connection pipes 67a and 67b and the gas-refrigerant connection pipe 6 (in this case, the first branch pipe portions 6a and 6b). Accordingly, leakage of the refrigerant from the brazing portions 92a and 92b brazing the gas-side shutoff valves 58a and 58b and the outdoor-side gas connection pipes 67a and 67b is reduced, and the external shutoff valve units 4a and 4b can be arranged in the air-conditioning target spaces together with the indoor units 3a and 3b. Referring to Fig. 5, in the configuration of the above-described embodiment (see Fig. 2) without the filters 73a and 73b, the brazing portions 92a and 92b brazing the gas-side shutoff valves 58a and 58b and the outdoor-side gas connection pipes 67a and 67b are provided with the coating materials 13a and 13b; however, it is not limited to the above. For example, in the configuration of the above-described first modification (see Fig. 4) with the filters 73a and 73b, the brazing portions 92a and 92b brazing the gas-side shutoff valves 58a and 58b and the outdoor-side gas connection pipes 67a and 67b may be provided with the coating materials 13a and 13b.

[0125] Accordingly, the degree of freedom is ensured for arrangement of the external shutoff valve units 4a and 4b.

Third Modification

[0126] In the above-described embodiment and first and second modifications, to add the refrigerant shutoff function for the situation in which the refrigerant leaks from the indoor units 3a and 3b, the indoor expansion valves 51a and 51b of the indoor units 3a and 3b are used also as the liquid-side shutoff valves. In addition, the gas-side shutoff valves 58a and 58b are provided at the external shutoff valve units 4a and 4b. However, to add the refrigerant shutoff function for the situation in which the refrigerant leaks from the indoor units, the gas-side shutoff valves 58a and 58b may be provided at the indoor units 3a and 3b as illustrated in Fig. 6 instead of providing the gas-side shutoff valves 58a and 58b in the external shutoff valve units 4a and 4b. The indoor gas-refrigerant pipes 54a and 54b mainly include heat-exchange-side indoor gas-refrigerant pipes 76a and 76b that connect the gas sides of the indoor heat exchangers 52a and 52b to the gas-side shutoff valves 58a and 58b, and connection-side indoor gas-refrigerant pipes 77a and 77b that connect the gas-side shutoff valves 58a and 58b to the gas-refrigerant connection pipe 6 (in this case, the branch pipe portions 6a and 6b). In this case, the heat-exchange-side indoor gas-refrigerant pipes 76a and 76b are connected to the gas-side shutoff valves 58a and 58b by brazing (the brazing portions are referred to as brazing portions 87a and 87b), and the gas-side shutoff valves 58a and 58b are connected to the connection-side indoor gas-refrigerant pipes 77a and 77b by

brazing (the brazing portions are referred to as brazing portions 88a and 88b). Due to this, the brazing portions 88a and 88b brazing the gas-side shutoff valves 58a and 58b and the connection-side indoor gas-refrigerant pipes 77a and 77b may corrode and the refrigerant may leak from the corroding portions. When the refrigerant leaks from the brazing portions 88a and 88b, the refrigerant is continuously supplied from the gas-refrigerant connection pipe 6 to the brazing portions 88a and 88b although the gas-side shutoff valves 58a and 58b are closed. The refrigerant may continuously leak from the indoor units 3a and 3b to the air-conditioning target spaces. Thus, it is required to reduce leakage of the refrigerant from the brazing portions 88a and 88b.

[0127] To address this, as illustrated in Fig. 7, the brazing portions 88a and 88b brazing the gas-side shutoff valves 58a and 58b and the connection-side indoor gas-refrigerant pipes 77a and 77b are provided with coating materials 15a and 15b. The coating materials 15a and 15b may be provided at only the brazing portions 88a and 88b, or may be also provided at a portion other than the brazing portions 88a and 88b. For example, as illustrated in Fig. 7, the coating materials 15a and 15b may be provided in a range from the gas-side shutoff valves 58a and 58b to the pipe joint portions 84a and 84b of the connection-side indoor gas-refrigerant pipes 77a and 77b (that is, so as to include the brazing portions 88a and 88b and the brazing portions 84aa and 84bb). When the connection-side indoor gas-refrigerant pipes 77a and 77b are directly connected to the gas-refrigerant connection pipe 6 (in this case, the branch pipe portions 6a and 6b) by brazing, the coating materials 15a and 15b may be provided in a range from the gas-side shutoff valves 58a and 58b to the brazing portions brazing the connection-side indoor gas-refrigerant pipes 77a and 77b and the gas-refrigerant connection pipe 6 (in this case, the branch pipe portions 6a and 6b). Accordingly, leakage of the refrigerant from the brazing portions 88a and 88b brazing the gas-side shutoff valves 58a and 58b and the connection-side indoor gas-refrigerant pipes 77a and 77b is reduced. Referring to Fig. 7, in the configuration of the above-described embodiment (see Fig. 2) without the filters 73a and 73b, the gas-side shutoff valves 58a and 58b are provided in the indoor units 3a and 3b, and the brazing portions 88a and 88b brazing the gas-side shutoff valves 58a and 58b and the connection-side indoor gas-refrigerant pipes 77a and 77b are provided with the coating materials 15a and 15b; however, it is not limited to the above. For example, in the configuration of the above-described first modification (see Fig. 4) with the filters 73a and 73b, the gas-side shutoff valves 58a and 58b may be provided at the indoor unit 3a and 3b, and the brazing portions 88a and 88b brazing the gas-side shutoff valves 58a and 58b and the connection-side indoor gas-refrigerant pipes 77a and 77b may be provided with the coating materials 15a and 15b.

[0128] Accordingly, the shutoff valves provided at the indoor units 3a and 3b are provided on only the gas side, and the refrigerant shutoff function for the situation in which the refrigerant leaks from the indoor units 3a and 3b can be added.

Fourth Modification

[0129] In the above-described embodiment and the first to third modifications, as illustrated in Fig. 3, when the refrigerant sensors 57a and 57b detect leakage of the refrigerant, all the indoor expansion valves 51a and 51b and the gas-side shutoff valves 58a and 58b are closed and the compressor 21 is stopped in accordance with the information of the refrigerant sensors 57a and 57b. Accordingly, the circulation of the refrigerant in the refrigerant circuit 10 is stopped, and the cooling operation or heating operation is stopped not only in the indoor unit in which the refrigerant leaks but also in the indoor unit in which the refrigerant does not leak.

[0130] It is desirable that only the indoor unit in which the refrigerant leaks is isolated whereas the indoor unit in which the refrigerant does not leak can continue cooling operation or heating operation.

[0131] As illustrated in Fig. 8, when the refrigerant sensors 57a and 57b detect leakage of the refrigerant (step ST1), the control unit 19 closes only the indoor expansion valve and the gas-side shutoff valve corresponding to the indoor unit in which the refrigerant leaks among a plurality of indoor units 3a and 3b (step ST5). Then, by continuing the circulation of the refrigerant in the refrigerant circuit 10 without stopping the compressor 21, the cooling operation or heating operation of the indoor unit in which the refrigerant does not leak is continued (step ST6).

[0132] When the refrigerant leaks from the indoor units 3a and 3b, only the indoor unit in which the refrigerant leaks is isolated whereas the indoor unit in which the refrigerant does not leak can continue the operation.

Fifth Modification

[0133] In the above-described embodiment and first and second modifications, when the gas-side shutoff valves 58a and 58b are provided, the external shutoff valve units 4a and 4b corresponding to the indoor units 3a and 3b are provided. However, it is not limited thereto. For example, an external shutoff valve unit in which the external shutoff valve units 4a and 4b may be integrated, that is, an external shutoff valve unit including both the gas-side shutoff valves 58a and 58b may be employed.

(2) Second Embodiment

Configuration

[0134] Fig. 9 is a schematic configuration diagram of an air conditioner 1 according to a second embodiment of the present disclosure. Fig. 10 illustrates a refrigerant system in the periphery of indoor units 3a, 3b, 3c, and 3d and relay units 4a, 4b, 4c, and 4d constituting the air conditioner 1 according to the second embodiment of the present disclosure.

[0135] The air conditioner 1 is an apparatus that performs air conditioning (cooling and heating) in an air-conditioning target space in a building or the like through a vapor compression refrigeration cycle. The air conditioner 1 mainly includes an outdoor unit 2; a plurality of (in this case, four) indoor units 3a, 3b, 3c, and 3d mutually connected in parallel; relay units 4a, 4b, 4c, and 4d respectively connected to the indoor units 3a, 3b, 3c, and 3d; a liquid-refrigerant connection pipe 5 and a gas-refrigerant connection pipe 6 that connect the outdoor unit 2 to the indoor units 3a, 3b, 3c, and 3d via the relay units 4a, 4b, 4c, and 4d; and a control unit 19 that controls components of the outdoor unit 2, the indoor units 3a, 3b, 3c, and 3d, and the relay units 4a, 4b, 4c, and 4d. A vapor compression refrigerant circuit 10 of the air conditioner 1 is constituted by connecting the outdoor unit 2, the plurality of indoor units 3a, 3b, 3c, and 3d, the plurality of relay units 4a, 4b, 4c, and 4d, the liquid-refrigerant connection pipe 5, and the gas-refrigerant connection pipe 6. The refrigerant circuit 10 is filled with a refrigerant such as R32. In the air conditioner 1, the indoor units 3a, 3b, 3c, and 3d can individually perform cooling operation or heating operation by using the relay units 4a, 4b, 4c, and 4d. By sending the refrigerant from the indoor unit that performs heating operation to the indoor unit that performs cooling operation, heat is recovered between the indoor units (in this case, cooling and heating mixed operation in which cooling operation and heating operation can be simultaneously performed).

Connection Pipe

[0136] The liquid-refrigerant connection pipe 5 mainly includes a joint pipe portion extending from the outdoor unit 2, first branch pipe portions 5a, 5b, 5c, and 5d branched at a position before the relay units 4a, 4b, 4c, and 4d into a plurality of (in this case, four) pipe portions, and second branch pipe portions 5aa, 5bb, 5cc, and 5dd that connect the relay units 4a, 4b, 4c, and 4d to the indoor units 3a, 3b, 3c, and 3d.

[0137] The gas-refrigerant connection pipe 6 mainly includes a high/low-pressure gas-refrigerant connection pipe 7, a low-pressure gas-refrigerant connection pipe 8, and branch pipe portions 6a, 6b, 6c, and 6d that connect the relay units 4a, 4b, 4c, and 4d to the indoor units 3a, 3b, 3c, and 3d. The high/low-pressure gas-refrigerant connection pipe 7 is a gas-refrigerant connection pipe that can switch connection to the discharge side or the suction side of a compressor 21 (described later), and includes a joint pipe portion extending from the outdoor unit 2, and a plurality of (in this case, four) branch pipe portions 7a, 7b, 7c, and 7d branched at a position before the relay units 4a, 4b, 4c, and 4d. The low-pressure gas-refrigerant connection pipe 8 is a gas-refrigerant connection pipe connected to the suction side of the compressor 21 (described later), and includes a joint pipe portion extending from the outdoor unit 2, and branch pipe portions 8a, 8b, 8c, and 8d branched at a position before the relay units 4a, 4b, 4c, and 4d into a plurality of (in this case, four) pipe portions. In this way, since the gas-refrigerant connection pipe 6 includes the high/low-pressure gas-refrigerant connection pipe 7 and the low-pressure gas-refrigerant connection pipe 8, the configuration includes three connection pipes including the liquid-refrigerant connection pipe 5 (that is, three-pipe configuration).

Indoor Unit

[0138] The indoor units 3a, 3b, 3c, and 3d are arranged in air-conditioning target spaces in a building or the like. Being "arranged in air-conditioning target spaces" includes a situation in which the indoor units 3a, 3b, 3c, and 3d are installed in the air-conditioning target spaces and a situation in which the indoor units 3a, 3b, 3c, and 3d are not arranged in the air-conditioning target spaces but the indoor units 3a, 3b, 3c, and 3d are connected to the air-conditioning target spaces via air ducts or the like. The indoor units 3a, 3b, 3c, and 3d are connected to the outdoor unit 2 via the liquid-refrigerant connection pipe 5, the gas-refrigerant connection pipe 6 (the high/low-pressure gas-refrigerant connection pipe 7, the low-pressure gas-refrigerant connection pipe 8, and the branch pipe portions 6a, 6b, 6c, and 6d), and the relay units 4a, 4b, 4c, and 4d, and constitute part of the refrigerant circuit 10 as described above.

[0139] Configurations of the indoor units 3a, 3b, 3c, and 3d are described next. The indoor unit 3a and the indoor units 3b, 3c, and 3d have configurations similar to one another. Hence only the configuration of the indoor unit 3a is described. For the configurations of the indoor units 3b, 3c, and 3d, the description of the components of the indoor units 3b, 3c, and 3d is omitted while an index "b", "c", or "d" is applied to each component instead of the index "a" indicating each component of the indoor unit 3a.

[0140] The indoor unit 3a mainly includes an indoor expansion valve 51a and an indoor heat exchanger 52a. In addition, the indoor unit 3a includes an indoor liquid-refrigerant pipe 53a that connects the liquid side of the indoor heat exchanger

52a to the liquid-refrigerant connection pipe 5 (in this case, the branch pipe portion 5a), and an indoor gas-refrigerant pipe 54a that connects the gas side of the indoor heat exchanger 52a to the gas-refrigerant connection pipe 6 (in this case, the second branch pipe portion 6aa). The indoor expansion valve 51a, the indoor heat exchanger 52a, the indoor liquid-refrigerant pipe 53a, and the indoor gas-refrigerant pipe 54a are similar to the indoor expansion valve 51a, the indoor heat exchanger 52a, the indoor liquid-refrigerant pipe 53a, and the indoor gas-refrigerant pipe 54a of the indoor unit 3a according to the first embodiment. Thus, the description thereof is omitted.

[0141] A brazing portion 82a brazing the indoor expansion valve 51a and a connection-side indoor liquid-refrigerant pipe 72a is provided with a coating material 11a, like the indoor unit 3a according to the first embodiment.

[0142] The indoor unit 3a is provided with a refrigerant sensor 57a serving as refrigerant leakage detecting means for detecting leakage of the refrigerant, like the indoor unit 3a according to the first embodiment.

Outdoor Unit

[0143] The outdoor unit 2 is arranged outside the air-conditioning target spaces or outside the building or the like. The outdoor unit 2 is connected to the indoor units 3a, 3b, 3c, and 3d via the liquid-refrigerant connection pipe 5, the gas-refrigerant connection pipe 6 (the high/low-pressure gas-refrigerant connection pipe 7, the low-pressure gas-refrigerant connection pipe 8, and the branch pipe portions 6a, 6b, 6c, and 6d), and the relay units 4a, 4b, 4c, and 4d, and constitutes part of the refrigerant circuit 10 as described above.

[0144] A configuration of the outdoor unit 2 is described next.

[0145] The outdoor unit 2 mainly includes a compressor 21 and at least one, in this case, two outdoor heat exchangers 23a and 23b. The compressor 21 is similar to the compressor 21 of the outdoor unit 2 according to the first embodiment, and hence the description thereof is omitted. In addition, the outdoor unit 2 includes switching mechanisms 22a and 22b that switch the operating state between a radiation operating state in which the outdoor heat exchangers 23a and 23b function as radiators of the refrigerant, and an evaporation operating state in which the outdoor heat exchangers 23a and 23b function as evaporators of the refrigerant. The switching mechanisms 22a and 22b are connected to the suction side of the compressor 21 via a suction refrigerant pipe 31. The discharge side of the compressor 21 is connected to the switching mechanisms 22a and 2b via a discharge refrigerant pipe 32. The switching mechanism 22a is connected to the gas-side ends of the outdoor heat exchangers 23a and 23b via first outdoor gas-refrigerant pipes 33a and 33b. The liquid sides of the outdoor heat exchangers 23a and 23b are connected to the liquid-refrigerant connection pipe 5 via an outdoor liquid-refrigerant pipe 34. The connection portion of the outdoor liquid-refrigerant pipe 34 with respect to the liquid-refrigerant connection pipe 5 is provided with a liquid-side shutoff valve 27. In addition, the outdoor unit 2 includes a third switching mechanism 22c that switches the operating state between a refrigerant lead-out state in which the refrigerant discharged from the compressor 21 is sent to the high/low-pressure gas-refrigerant connection pipe 7, and a refrigerant lead-in state in which the refrigerant flowing through the high/low-pressure gas-refrigerant connection pipe 7 is sent to the suction refrigerant pipe 31. The third switching mechanism 22c is connected to the high/low-pressure gas-refrigerant connection pipe 7 via a second outdoor gas-refrigerant pipe 35. The third switching mechanism 22c is connected to the suction side of the compressor 21 via the suction refrigerant pipe 31. The discharge side of the compressor 21 is connected to the third switching mechanism 22c via the discharge refrigerant pipe 32. The connection portion of the second outdoor gas-refrigerant pipe 35 with respect to the high/low-pressure gas-refrigerant connection pipe 7 is provided with a high/low-pressure gas-side shutoff valve 28a. The suction refrigerant pipe 31 is connected to the low-pressure gas-refrigerant connection pipe 8. The connection portion of the suction refrigerant pipe 31 with respect to the low-pressure gas-refrigerant connection pipe 8 is provided with a low-pressure gas-side shutoff valve 28b. The liquid-side shutoff valve 27 and the gas-side shutoff valves 28a and 28b are valves that are manually opened and closed.

[0146] The first switching mechanism 22a is a device that can switch the flow of the refrigerant in the refrigerant circuit 10 such that, when the first outdoor heat exchanger 23a functions as the radiator of the refrigerant (hereinafter, the situation is referred to as "outdoor radiation state"), the first switching mechanism 22a connects the discharge side of the compressor 21 to the gas side of the first outdoor heat exchanger 23a (see solid lines of the first switching mechanism 22a in Fig. 9); and, when the first outdoor heat exchanger 23a functions as the evaporator of the refrigerant (hereinafter, the situation is referred to as "outdoor evaporation state"), the first switching mechanism 22a connects the suction side of the compressor 21 to the gas side of the first outdoor heat exchanger 23a (see broken lines of the first switching mechanism 22a in Fig. 9). The first switching mechanism 22a is, for example, a four-way switching valve. The second switching mechanism 22b is a device that can switch the flow of the refrigerant in the refrigerant circuit 10 such that, when the second outdoor heat exchanger 23b functions as the radiator of the refrigerant (hereinafter, the situation is referred to as "outdoor radiation state"), the second switching mechanism 22b connects the discharge side of the compressor 21 to the gas side of the second outdoor heat exchanger 23b (see solid lines of the second switching mechanism 22b in Fig. 9); and, when the second outdoor heat exchanger 23b functions as the evaporator of the refrigerant (hereinafter, the situation is referred to as "outdoor evaporation state"), the second switching mechanism 22b connects the suction side of the compressor 21 to the gas side of the second outdoor heat exchanger 23b (see broken lines of

the switching mechanism 22 in Fig. 9). The second switching mechanism 22b is, for example, a four-way switching valve. By changing the switching states of the switching mechanisms 22a and 22b, the outdoor heat exchangers 23a and 23b can be individually switched to function as the evaporators or the radiators.

[0147] The first outdoor heat exchanger 23a and the second outdoor heat exchanger 23b are heat exchangers that exchange heat between the refrigerant, which is circulated among the outdoor unit 2 and the indoor units 3a, 3b, 3c, and 3d via the liquid-refrigerant connection pipe 5 and the gas-refrigerant connection pipe 6, and the outdoor air. The outdoor unit 2 includes an outdoor fan 24 that sucks the outdoor air into the outdoor unit 2, that causes the outdoor air to exchange heat with the refrigerant in the outdoor heat exchangers 23a and 23b, and then that discharges the outdoor air to the outside. That is, the outdoor unit 2 includes the outdoor fan 24 as a fan that sends the outdoor air, which serves as a cooling source or a heating source of the refrigerant flowing through the outdoor heat exchangers 23a and 23b, to the outdoor heat exchangers 23a and 23b. The outdoor fan 24 is driven by an outdoor fan motor 24a.

[0148] The third switching mechanism 22c is a device that can switch the flow of the refrigerant in the refrigerant circuit 10 such that, when the refrigerant discharged from the compressor 21 is sent to the high/low-pressure gas-refrigerant connection pipe 7 (hereinafter, the situation is referred to as "refrigerant lead-out state"), the third switching mechanism 22c connects the discharge side of the compressor 21 to the high/low-pressure gas-refrigerant connection pipe 7 (see broken lines of the third switching mechanism 22c in Fig. 9); and, when the refrigerant flowing through the high/low-pressure gas-refrigerant connection pipe 7 is sent to the suction refrigerant pipe 31 (hereinafter, the situation is referred to as "refrigerant lead-in state"), the third switching mechanism 22c connects the suction side of the compressor 21 to the high/low-pressure gas-refrigerant connection pipe 7 (see solid lines of the third switching mechanism 22c in Fig. 9). The third switching mechanism 22c is, for example, a four-way switching valve.

[0149] Focusing on the outdoor heat exchangers 23a and 23b, the liquid-refrigerant connection pipe 5, the relay units 4a, 4b, 4c, and 4d, and the indoor heat exchangers 52a, 52b, 52c, and 52d, the air conditioner 1 performs an operation (cooling only operation and cooling main operation) of circulating the refrigerant from the outdoor heat exchangers 23a and 23b, via the liquid-refrigerant connection pipe 5 and the relay units 4a, 4b, 4c, and 4d, to the indoor heat exchangers 52a, 52b, 52c, and 52d that function as the evaporators of the refrigerant. The cooling only operation is an operating state in which only the indoor heat exchangers that function as the evaporators of the refrigerant (that is, the indoor units that perform cooling operation) exist. The cooling main operation is an operating state in which both the indoor heat exchanger that functions as the evaporator of the refrigerant and the indoor heat exchanger that functions as the radiator of the refrigerant (that is, the indoor unit that performs heating operation) are mixed; however, the load on the evaporation side (that is, cooling load) is relatively large as a whole. Focusing on the compressor 21, the gas-refrigerant connection pipe 6, the relay units 4a, 4b, 4c, and 4d, and the indoor heat exchangers 52a, 52b, 52c, and 52d, the air conditioner 1 performs an operation (heating only operation and heating main operation) of circulating the refrigerant from the compressor 21, via the gas-refrigerant connection pipe 6 and the relay units 4a, 4b, 4c, and 4d, to the indoor heat exchangers 52a, 52b, 52c, and 52d that function as the radiators of the refrigerant. The heating only operation is an operating state in which only the indoor heat exchangers that function as the radiators of the refrigerant (that is, the indoor units that perform heating operation) exist. The heating main operation is an operating state in which both the indoor heat exchanger that functions as the radiator of the refrigerant and the indoor heat exchanger that functions as the evaporator of the refrigerant are mixed; however, the load on the radiation side (that is, heating load) is relatively large as a whole. In cooling only operation and cooling main operation, at least one of the switching mechanisms 22a and 22b is switched to the outdoor radiation state. In this state, the outdoor heat exchangers 23a and 23b function as the radiators of the refrigerant as a whole, and the refrigerant flows from the outdoor unit 2 to the indoor units 3a, 3b, 3c, and 3d via the liquid-refrigerant connection pipe 5 and the relay units 4a, 4b, 4c, and 4d. In heating only operation and heating main operation, at least one of the switching mechanisms 22a and 22b is switched to the outdoor evaporation state and the third switching mechanism 22c is switched to the refrigerant lead-out state. In this state, the outdoor heat exchangers 23a and 23b function as the evaporators of the refrigerant as a whole, and the refrigerant flows from the indoor units 3a, 3b, 3c, and 3d to the outdoor unit 2 via the liquid-refrigerant connection pipe 5 and the relay units 4a, 4b, 4c, and 4d.

[0150] In addition, outdoor expansion valves 25a and 25b and a liquid-pressure adjustment expansion valve 26 are provided in the outdoor liquid-refrigerant pipe 34. The outdoor expansion valves 25a and 25b are electric expansion valves that decompress the refrigerant in heating only operation and heating main operation, and are provided in portions of the outdoor liquid-refrigerant pipe 34 near the liquid sides of the outdoor heat exchangers 23a and 23b. The liquid-pressure adjustment expansion valve 26 is an electric expansion valve that decompresses the refrigerant so that the refrigerant flowing through the liquid-refrigerant connection pipe 5 is brought into a gas-liquid two-phase state in cooling only operation and cooling main operation, and is provided in a portion of the outdoor liquid-refrigerant pipe 34 near the liquid-refrigerant connection pipe 5. That is, the liquid-pressure adjustment expansion valve 26 is provided in a portion of the outdoor liquid-refrigerant pipe 34 nearer to the liquid-refrigerant connection pipe 5 than the outdoor expansion valves 25a and 25b.

[0151] The air conditioner 1 performs two-phase refrigerant feed of sending the refrigerant in the gas-liquid two-phase state to the liquid-refrigerant connection pipe 5 by the liquid-pressure adjustment expansion valve 26 and hence sending

the refrigerant from the outdoor unit 2 to the indoor units 3a, 3b, 3c, and 3d in cooling only operation and cooling main operation.

[0152] Furthermore, a refrigerant return pipe 41 is connected to the outdoor liquid-refrigerant pipe 34, and a refrigerant cooler 45 is provided. The refrigerant return pipe 41 and the refrigerant cooler 45 are similar to the refrigerant return pipe 41 and the refrigerant cooler 45 of the outdoor unit 2 according to the first embodiment, and hence the description thereof is omitted.

[0153] The outdoor unit 2 is provided with various sensors. To be specific, the outdoor unit 2 is provided with a discharge pressure sensor 36 that detects a pressure (discharge pressure Pd) of the refrigerant discharged from the compressor 21. In addition, the outdoor unit 2 is provided with outdoor heat-exchange liquid-side sensors 37a and 37b that detect temperatures Tol (outdoor heat-exchange outlet temperatures Tol) of the refrigerant on the liquid sides of the outdoor heat exchangers 23a and 23b, and is provided with a liquid-pipe temperature sensor 38 that detects a temperature (liquid-pipe temperature Tlp) of the refrigerant in a portion of the outdoor liquid-refrigerant pipe 34 between the refrigerant cooler 45 and the liquid-pressure adjustment expansion valve 26.

Relay Unit

[0154] The relay units 4a, 4b, 4c, and 4d are arranged in the building or the like. In this case, the relay units 4a, 4b, 4c, and 4d are arranged outside the air-conditioning target spaces unlike the indoor units 3a, 3b, 3c, and 3d. The relay units 4a, 4b, 4c, and 4d are connected between the indoor units 3a, 3b, 3c, and 3d and the outdoor unit 2, together with the liquid-refrigerant connection pipe 5, the gas-refrigerant connection pipe 6 (the high/low-pressure gas-refrigerant connection pipe 7, the low-pressure gas-refrigerant connection pipe 8, and the branch pipe portions 6a, 6b, 6c, and 6d), and constitute part of the refrigerant circuit 10.

[0155] Configurations of the relay units 4a, 4b, 4c, and 4d are described next. The relay unit 4a and the relay units 4b, 4c, and 4d have configurations similar to one another. Hence only the configuration of the relay unit 4a is described. For the configurations of the relay units 4b, 4c, and 4d, the description of the components of the relay units 4b, 4c, and 4d is omitted while an index "b", "c", or "d" is applied to each component instead of the index "a" indicating each component of the relay unit 4a.

[0156] The relay unit 4a mainly includes a liquid connection pipe 61a and a gas connection pipe 62a.

[0157] One end of the liquid connection pipe 61a is connected to the first branch pipe portion 5a of the liquid-refrigerant connection pipe 5. The other end of the liquid connection pipe 61a is connected to the second branch pipe portion 5aa of the liquid-refrigerant connection pipe 5.

[0158] The liquid connection pipe 61a is connected to a portion of the liquid-refrigerant connection pipe 5 on the side of the indoor unit 3a (in this case, the second branch pipe portion 5aa) by mechanical pipe joint, such as flare connection (the portion of the mechanical pipe joint is referred to as pipe joint portion 98a). The pipe joint portion 98a is connected to the liquid connection pipe 61a by brazing (the brazing portion is referred to as brazing portion 98aa). Although not illustrated here, the liquid connection pipe 61a may be directly connected to the liquid-refrigerant connection pipe 5 (in this case, the second branch pipe portion 5aa) by brazing. The liquid connection pipe 61a is connected to a portion of the liquid-refrigerant connection pipe 5 on the side of the outdoor unit 2 (in this case, the first branch pipe portion 5a) by mechanical pipe joint, such as flare connection (the portion of the mechanical pipe joint is referred to as pipe joint portion 99a). The pipe joint portion 99a is connected to the liquid connection pipe 61a by brazing (the brazing portion is referred to as brazing portion 99aa). Although not illustrated here, the liquid connection pipe 61a may be directly connected to the liquid-refrigerant connection pipe 5 (in this case, the first branch pipe portion 5a) by brazing.

[0159] The gas connection pipe 62a includes a high-pressure gas connection pipe 63a connected to the branch pipe portion 7a of the high/low-pressure gas-refrigerant connection pipe 7, a low-pressure gas connection pipe 64a connected to the branch pipe portion 8a of the low-pressure gas-refrigerant connection pipe 8, and a joint gas connection pipe 65a that joins the high-pressure gas connection pipe 63a and the low-pressure gas connection pipe 64a together. The joint gas connection pipe 65a is connected to the branch pipe portion 6a of the gas-refrigerant connection pipe 6. The high-pressure gas connection pipe 63a is provided with a first cooling/heating switching valve 58a. The low-pressure gas connection pipe 64a is provided with a second cooling/heating switching valve 59a. The first cooling/heating switching valve 58a and the second cooling/heating switching valve 59a are electric expansion valves. The first cooling/heating switching valve 58a and the second cooling/heating switching valve 59a may not be electric expansion valves and may be electromagnetic valves.

[0160] The relay unit 4a can function such that, when the indoor unit 3a performs cooling operation, the second cooling/heating switching valve 59a is opened to allow the refrigerant to flow into the liquid connection pipe 61a via the first branch pipe portion 5a of the liquid-refrigerant connection pipe 5, the refrigerant is sent to the indoor unit 3a via the second branch pipe portion 5aa of the liquid-refrigerant connection pipe 5, then the refrigerant evaporated through heat exchange with the indoor air in the indoor heat exchanger 52a is recovered to the branch pipe portion 8a of the low-pressure gas-refrigerant connection pipe 8 via the branch pipe portion 6a of the gas-refrigerant connection pipe 6, the

joint gas connection pipe 65a, and the low-pressure gas connection pipe 64a. In addition, the relay unit 4a can function such that, when the indoor unit 3a performs heating operation, the second cooling/heating switching valve 59a is closed and the first cooling/heating switching valve 58a is opened to allow the refrigerant to flow into the high-pressure gas connection pipe 63a and the joint gas connection pipe 65a via the branch pipe portion 7a of the high/low-pressure gas-refrigerant connection pipe 7, the refrigerant is sent to the indoor unit 3a via the branch pipe portion 6a of the gas-refrigerant connection pipe 6, then the refrigerant radiated through heat exchange with the indoor air in the indoor heat exchanger 52a is recovered to the first branch pipe portion 5a of the liquid-refrigerant connection pipe 5 via the second branch pipe portion 5aa of the liquid-refrigerant connection pipe 5 and the liquid connection pipe 61a. The first cooling/heating switching valve 58a and the second cooling/heating switching valve 59a are opened and closed through switching to cause the indoor heat exchanger 52a to function as the evaporator of the refrigerant or the radiator of the refrigerant. Not only the relay unit 4a but also the relay units 4b, 4c, and 4d have such a function. With the relay units 4a, 4b, 4c, and 4d, the indoor heat exchangers 52a, 52b, 52c, and 52d can be individually switched to function as the evaporators of the refrigerant or the radiators of the refrigerant.

[0161] The high-pressure gas connection pipe 63a mainly includes an indoor-side high-pressure gas connection pipe 66a that is connected to a portion of the gas-refrigerant connection pipe 6 on the side of the indoor unit 3a (in this case, the branch pipe portion 6a) via the joint gas connection pipe 65a, and an outdoor-side high-pressure gas connection pipe 67a that is connected to a portion of the gas-refrigerant connection pipe 6 on the side of the outdoor unit 2 (in this case, the branch pipe portion 7a of the high/low-pressure gas-refrigerant connection pipe 7). The first cooling/heating switching valve 58a is connected to the indoor-side high-pressure gas connection pipe 66a by brazing (the brazing portion is referred to as brazing portion 91a). The first cooling/heating switching valve 58a is connected to the outdoor-side high-pressure gas connection pipe 67a by brazing (the brazing portion is referred to as brazing portion 92a). The low-pressure gas connection pipe 64a mainly includes an indoor-side low-pressure gas connection pipe 68a that is connected to a portion of the gas-refrigerant connection pipe 6 on the side of the indoor unit 3a (in this case, the branch pipe portion 6a) via the joint gas connection pipe 65a, and an outdoor-side low-pressure gas connection pipe 69a that is connected to a portion of the gas-refrigerant connection pipe 6 on the side of the outdoor unit 2 (in this case, the branch pipe portion 8a of the low-pressure gas-refrigerant connection pipe 8). The second cooling/heating switching valve 59a is connected to the indoor-side low-pressure gas connection pipe 68a by brazing (the brazing portion is referred to as brazing portion 93a). The second cooling/heating switching valve 59a is connected to the outdoor-side low-pressure gas connection pipe 69a by brazing (the brazing portion is referred to as brazing portion 94a). The joint gas connection pipe 65a is connected to a portion of the gas-refrigerant connection pipe 6 on the side of the indoor unit 3a (in this case, the branch pipe portion 6a) by mechanical pipe joint, such as flare connection (the portion of the mechanical pipe joint is referred to as pipe joint portion 95a). The pipe joint portion 95a is connected to the joint gas connection pipe 65a by brazing (the brazing portion is referred to as brazing portion 95aa). Although not illustrated here, the joint gas connection pipe 65a may be directly connected to the gas-refrigerant connection pipe 6 (in this case, the branch pipe portion 6a) by brazing. The outdoor-side high-pressure gas connection pipe 67a is connected to a portion of the gas-refrigerant connection pipe 6 on the side of the outdoor unit 2 (in this case, the branch pipe portion 7a of the high/low-pressure gas-refrigerant connection pipe 7) by mechanical pipe joint, such as flare connection (the portion of the mechanical pipe joint is referred to as pipe joint portion 96a). The pipe joint portion 96a is connected to the outdoor-side high-pressure gas connection pipe 67a by brazing (the brazing portion is referred to as brazing portion 96aa). Although not illustrated here, the outdoor-side high-pressure gas connection pipe 67a may be directly connected to the gas-refrigerant connection pipe 6 (in this case, the branch pipe portion 7a of the high/low-pressure gas-refrigerant connection pipe 7) by brazing. The outdoor-side low-pressure gas connection pipe 69a is connected to a portion of the gas-refrigerant connection pipe 6 on the side of the outdoor unit 2 (in this case, the branch pipe portion 8a of the low-pressure gas-refrigerant connection pipe 8) by mechanical pipe joint, such as flare connection (the portion of the mechanical pipe joint is referred to as pipe joint portion 97a). The pipe joint portion 97a is connected to the outdoor-side low-pressure gas connection pipe 69a by brazing (the brazing portion is referred to as brazing portion 97aa). Although not illustrated here, the outdoor-side low-pressure gas connection pipe 69a may be directly connected to the gas-refrigerant connection pipe 6 (in this case, the branch pipe portion 8a of the low-pressure gas-refrigerant connection pipe 8) by brazing.

Control Unit

[0162] The control unit 19 is constituted by being connected to control boards or the like (not illustrated) provided in, for example, the outdoor unit 2, the indoor units 3a, 3b, 3c, and 3d, and the relay units 4a, 4b, 4c, and 4d to communicate therewith. In Fig. 9, however, the control unit 19 is illustrated at a position separated from the outdoor unit 2, the indoor units 3a, 3b, 3c, and 3d, and the relay units 4a, 4b, 4c, and 4d for the convenience of illustration. The control unit 19 controls the components 21, 22, 24, 25a, 25b, 26, 44, 51a to 51d, 55a to 55d, 58a to 58d, and 59a to 59d of the air conditioner 1 (in this case, the outdoor unit 2, the indoor units 3a, 3b, 3c, and 3d, and the relay units 4a, 4b, 4c, and 4d), that is, controls the entire operation of the air conditioner 1 in accordance with the detection signals of the above-described

various sensors 36, 37a, 37b, 38, 57a, 57b, 57c, and 57d.

Operation without Leakage of Refrigerant

[0163] The operation of the air conditioner 1 when the refrigerant does not leak is described next with reference to Fig. 9. The air conditioner 1 performs cooling only operation, heating only operation, cooling main operation, and heating main operation. The air conditioner 1 performs two-phase refrigerant feed of sending the refrigerant in the gas-liquid two-phase state to the liquid-refrigerant connection pipe 5 by the liquid-pressure adjustment expansion valve 26 provided in the outdoor liquid-refrigerant pipe 34 and hence sending the refrigerant from the outdoor unit 2 to the indoor units 3a, 3b, 3c, and 3d in cooling operation and cooling main operation. The operation of the air conditioner 1 which is described below is performed by the control unit 19 that controls the components of the air conditioner 1.

Cooling Only Operation

[0164] In cooling only operation, for example, when all the indoor units 3a, 3b, 3c, and 3d perform cooling operation (that is, operation in which all the indoor heat exchangers 52a, 52b, 52c, and 52d function as the evaporators of the refrigerant and the outdoor heat exchangers 23a and 23b function as the radiators of the refrigerant), the switching mechanisms 22a and 22b are switched to the outdoor radiation state (the state in which the switching mechanisms 22a and 22b are indicated by solid lines in Fig. 9), and the compressor 21, the outdoor fan 24, and the indoor fans 55a, 55b, 55c, and 55d are driven. In addition, the third switching mechanism 22c is switched to the refrigerant lead-in state (the state in which the switching mechanism 22c is indicated by solid lines in Fig. 9), and the first cooling/heating switching valves 58a, 58b, 58c, and 58d and the second cooling/heating switching valves 59a, 59b, 59c, and 59d of the relay units 4a, 4b, 4c, and 4d are opened.

[0165] Then, the high-pressure refrigerant discharged from the compressor 21 is sent to the outdoor heat exchangers 23a and 23b via the switching mechanisms 22a and 22b. The refrigerant sent to the outdoor heat exchangers 23a and 23b is condensed by being cooled through heat exchange with the outdoor air supplied by the outdoor fan 24 in the outdoor heat exchangers 23a and 23b that function as the radiators of the refrigerant. The refrigerant flows out from the outdoor unit 2 via the outdoor expansion valves 25a and 25b, the refrigerant cooler 45, the liquid-pressure adjustment expansion valve 26, and the liquid-side shutoff valve 27.

[0166] The refrigerant flowing out from the outdoor unit 2 is branched and sent to the relay units 4a, 4b, 4c, and 4d via the liquid-refrigerant connection pipe 5 (the joint pipe portion and the first branch pipe portions 5a, 5b, 5c, and 5d). The refrigerant sent to the relay units 4a, 4b, 4c, and 4d is sent to the indoor units 3a, 3b, 3c, and 3d. The refrigerant sent to the indoor units 3a, 3b, 3c, and 3d is decompressed by the indoor expansion valves 51a, 51b, 51c, and 51d and then sent to the indoor heat exchangers 52a, 52b, 52c, and 52d. The refrigerant sent to the indoor heat exchangers 52a, 52b, 52c, and 52d is evaporated by being heated through heat exchange with the indoor air supplied from the air-conditioning target spaces by the indoor fans 55a, 55b, 55c, and 55d in the indoor heat exchangers 52a, 52b, 52c, and 52d that function as the evaporators of the refrigerant. The refrigerant flows out from the indoor units 3a, 3b, 3c, and 3d. The indoor air cooled by the indoor heat exchangers 52a, 52b, 52c, and 52d is sent to the air-conditioning target spaces and the air-conditioning target spaces are cooled by using the cooled indoor air.

[0167] The refrigerant flowing out from the indoor units 3a, 3b, 3c, and 3d is sent to the relay units 4a, 4b, 4c, and 4d via the branch pipe portions 6a, 6b, 6c, and 6d of the gas-refrigerant connection pipe 6. The refrigerant sent to the relay units 4a, 4b, 4c, and 4d flows out from the relay units 4a, 4b, 4c, and 4d via the first cooling/heating switching valves 58a, 58b, 58c, and 58d and the second cooling/heating switching valves 59a, 59b, 59c, and 59d.

[0168] The refrigerant flowing out from the relay units 4a, 4b, 4c, and 4d is joined and sent to the outdoor unit 2 via the high/low-pressure gas-refrigerant connection pipe 7 (the joint pipe portion and the branch pipe portions 7a, 7b, 7c, and 7d) and the low-pressure gas-refrigerant connection pipe 8 (the joint pipe portion and the branch pipe portions 8a, 8b, 8c, and 8d). The refrigerant sent to the outdoor unit 2 is sucked into the compressor 21 via the gas-side shutoff valves 28a and 28b and the third switching mechanism 22c.

[0169] In the above-described cooling only operation, the air conditioner 1 performs two-phase refrigerant feed of sending the refrigerant in the gas-liquid two-phase state to the liquid-refrigerant connection pipe 5 by the liquid-pressure adjustment expansion valve 26 and hence sending the refrigerant from the outdoor unit 2 to the indoor units 3a, 3b, 3c, and 3d. In addition, the refrigerant flowing through the outdoor liquid-refrigerant pipe 34 is cooled by the refrigerant return pipe 41 and the refrigerant cooler 45 to reduce variation in the liquid-pipe temperature T_{lp} in the portion of the outdoor liquid-refrigerant pipe 34 between the refrigerant cooler 45 and the liquid-pressure adjustment expansion valve 26, so that the two-phase refrigerant feed can be properly performed. The control content relating to the two-phase refrigerant feed is similar to the control content relating to the two-phase refrigerant feed by the air conditioner 1 according to the first embodiment, and hence the description thereof is omitted. With this control, the refrigerant flowing through the liquid-refrigerant connection pipe 5 is brought into the gas-liquid two-phase state. Hence, the liquid-refrigerant connection pipe

5 is less likely filled with the refrigerant in the liquid state as compared with the case where the refrigerant flowing through the liquid-refrigerant connection pipe 5 is in the liquid state. The amount of refrigerant existing in the liquid-refrigerant connection pipe 5 can be decreased by that amount. By making the liquid-pipe temperature T_{lp} constant and reducing variation, the refrigerant flowing through the liquid-refrigerant connection pipe 5 after decompressed by the liquid-pressure adjustment expansion valve 26 can be reliably maintained in a desirable gas-liquid two-phase state.

Heating Only Operation

[0170] In heating only operation, for example, when all the indoor units 3a, 3b, 3c, and 3d perform heating operation (that is, operation in which all the indoor heat exchangers 52a, 52b, 52c, and 52d function as the radiators of the refrigerant and the outdoor heat exchangers 23a and 23b function as the evaporators of the refrigerant), the switching mechanisms 22a and 22b are switched to the outdoor evaporation state (the state in which the switching mechanisms 22a and 22b are indicated by broken lines in Fig. 9), and the compressor 21, the outdoor fan 24, and the indoor fans 55a, 55b, 55c, and 55d are driven. In addition, the third switching mechanism 22c is switched to the refrigerant lead-out state (the state in which the switching mechanism 22c is indicated by broken lines in Fig. 9), and the first cooling/heating switching valves 58a, 58b, 58c, and 58d and the second cooling/heating switching valves 59a, 59b, 59c, and 59d of the relay units 4a, 4b, 4c, and 4d are closed.

[0171] Then, the high-pressure refrigerant discharged from the compressor 21 flows out from the outdoor unit 2 via the third switching mechanism 22c and the gas-side shutoff valve 28a.

[0172] The refrigerant flowing out from the outdoor unit 2 is branched and sent to the relay units 4a, 4b, 4c, and 4d via the gas-refrigerant connection pipe 6 (the joint pipe portion and the branch pipe portions 7a, 7b, 7c, and 7d of the high/low-pressure gas-refrigerant connection pipe 7). The refrigerant sent to the relay units 4a, 4b, 4c, and 4d flows out from the relay units 4a, 4b, 4c, and 4d via the first cooling/heating switching valves 58a, 58b, 58c, and 58d.

[0173] The refrigerant flowing out from the relay units 4a, 4b, 4c, and 4d is sent to the indoor units 3a, 3b, 3c, and 3d via the branch pipe portions 6a, 6b, 6c, and 6d (the portions of the gas-refrigerant connection pipe 6 connecting the relay units 4a, 4b, 4c, and 4d to the indoor units 3a, 3b, 3c, and 3d). The refrigerant sent to the indoor units 3a, 3b, 3c, and 3d is sent to the indoor heat exchangers 52a, 52b, 52c, and 52d. The high-pressure refrigerant sent to the indoor heat exchangers 52a, 52b, 52c, and 52d is condensed by being cooled through heat exchange with the indoor air supplied from the air-conditioning target spaces by the indoor fans 55a, 55b, 55c, and 55d in the indoor heat exchangers 52a, 52b, 52c, and 52d that function as the radiators of the refrigerant. The refrigerant is decompressed by the indoor expansion valves 51a, 51b, 51c, and 51d and then flows out from the indoor units 3a, 3b, 3c, and 3d. The indoor air heated by the indoor heat exchangers 52a, 52b, 52c, and 52d is sent to the air-conditioning target spaces and the air-conditioning target spaces are heated by using the heated indoor air.

[0174] The refrigerant flowing out from the indoor units 3a, 3b, 3c, and 3d is sent to the relay units 4a, 4b, 4c, and 4d via the second branch pipe portions 5aa, 5bb, 5cc, and 5dd (the portions of the liquid-refrigerant connection pipe 5 connecting the relay units 4a, 4b, 4c, and 4d to the indoor units 3a, 3b, 3c, and 3d). The refrigerant sent to the relay units 4a, 4b, 4c, and 4d flows out from the relay units 4a, 4b, 4c, and 4d.

[0175] The refrigerant flowing out from the relay units 4a, 4b, 4c, and 4d is joined and sent to the outdoor unit 2 via the liquid-refrigerant connection pipe 5 (the joint pipe portion and the first branch pipe portions 5a, 5b, 5c, and 5d). The refrigerant sent to the outdoor unit 2 is sent to the outdoor expansion valves 25a and 25b via the liquid-side shutoff valve 27 and the refrigerant cooler 45. The refrigerant sent to the outdoor expansion valves 25a and 25b is decompressed by the outdoor expansion valves 25a and 25b and then is sent to the outdoor heat exchangers 23a and 23b. The refrigerant sent to the outdoor heat exchangers 23a and 23b is evaporated by being heated through heat exchange with the outdoor air supplied by the outdoor fan 24. The refrigerant is sucked into the compressor 21 via the switching mechanisms 22a and 22b.

[0176] In the above-described heating only operation, unlike cooling only operation, the control unit 19 performs control to fix the opening degree of the liquid-pressure adjustment expansion valve 26 in a fully opened state. Thus, the opening degree of the refrigerant return expansion valve 44 is brought into a fully closed state to inhibit the refrigerant from flowing to the refrigerant return pipe 41.

Cooling Main Operation

[0177] In cooling main operation, for example, when the indoor units 3b, 3c, and 3d perform cooling operation, the indoor unit 3a performs heating operation (that is, operation in which the indoor heat exchangers 52b, 52c, and 52d function as the evaporators of the refrigerant and the indoor heat exchanger 52a functions as the radiator of the refrigerant), and the indoor heat exchangers 23a and 23b function as the radiators of the refrigerant, the switching mechanisms 22a and 22b are switched to the outdoor radiation state (the state in which the switching mechanisms 22a and 22b are indicated by solid lines in Fig. 9), and the compressor 21, the outdoor fan 24, and the indoor fans 55a, 55b, 55c, and

55d are driven. In addition, the third switching mechanism 22c is switched to the refrigerant lead-out state (the state in which the switching mechanism 22c is indicated by broken lines in Fig. 9), the first cooling/heating switching valve 58a of the relay unit 4a and the second cooling/heating switching valves 59b, 59c, and 59d of the relay units 4b, 4c, and 4d are opened, and the second cooling/heating switching valve 59a of the relay unit 4a as well as the first cooling/heating switching valves 58b, 58c, and 58d of the relay units 4b, 4c, and 4d are closed.

[0178] Then, part of the high-pressure refrigerant discharged from the compressor 21 is sent to the outdoor heat exchangers 23a and 23b via the switching mechanisms 22a and 22b, and the residual part of the high-pressure refrigerant flows out from the outdoor unit 2 via the third switching mechanism 22c and the gas-side shutoff valve 28a. The refrigerant sent to the outdoor heat exchangers 23a and 23b is condensed by being cooled through heat exchange with the outdoor air supplied by the outdoor fan 24 in the outdoor heat exchangers 23a and 23b that function as the radiators of the refrigerant. The refrigerant flows out from the outdoor unit 2 via the outdoor expansion valves 25a and 25b, the refrigerant cooler 45, the liquid-pressure adjustment expansion valve 26, and the liquid-side shutoff valve 27.

[0179] The refrigerant flowing out from the outdoor unit 2 via the third switching mechanism 22c and so forth is sent to the relay unit 4a via the gas-refrigerant connection pipe 6 (the joint pipe portion and the branch pipe portion 7a of the high/low-pressure gas-refrigerant connection pipe 7). The refrigerant sent to the relay unit 4a flows out from the relay unit 4a via the first cooling/heating switching valve 58a.

[0180] The refrigerant flowing out from the relay unit 4a is sent to the indoor unit 3a via the branch pipe portion 6a (the portion of the gas-refrigerant connection pipe 6 connecting the relay unit 4a to the indoor unit 3a). The refrigerant sent to the indoor unit 3a is sent to the indoor heat exchanger 52a. The high-pressure refrigerant sent to the indoor heat exchanger 52a is condensed by being cooled through heat exchange with the indoor air supplied from the air-conditioning target space by the indoor fan 55a in the indoor heat exchanger 52a that functions as the radiator of the refrigerant. The refrigerant is decompressed by the indoor expansion valve 51a and then flows out from the indoor unit 3a. The indoor air heated by the indoor heat exchanger 52a is sent to the air-conditioning target space and the air-conditioning target space is heated by using the heated indoor air.

[0181] The refrigerant flowing out from the indoor unit 3a is sent to the relay unit 4a via the second branch pipe portion 5aa (the portion of the liquid-refrigerant connection pipe 5 connecting the relay unit 4a to the indoor unit 3a). The refrigerant sent to the relay unit 4a flows out from the relay unit 4a.

[0182] The refrigerant flowing out from the relay unit 4a is sent to the joint pipe portion of the liquid-refrigerant connection pipe 5 via the first branch pipe portion 5a, and is joined to the refrigerant flowing out from the outdoor unit 2 via the outdoor heat exchangers 23a and 23b. The refrigerant is branched and sent to the relay units 4b, 4c, and 4d via the first branch pipe portions 5b, 5c, and 5d of the liquid-refrigerant connection pipe 5. The refrigerant sent to the relay units 4b, 4c, and 4d flows out from the relay units 4b, 4c, and 4d.

[0183] The refrigerant flowing out from the relay units 4b, 4c, and 4d is sent to the indoor units 3b, 3c, and 3d via the second branch pipe portions 5bb, 5cc, and 5dd (the portions of the liquid-refrigerant connection pipe 5 connecting the relay units 4b, 4c, and 4d to the indoor units 3b, 3c, and 3d). The refrigerant sent to the indoor units 3b, 3c, and 3d is decompressed by the indoor expansion valves 51b, 51c, and 51d and then sent to the indoor heat exchangers 52b, 52c, and 52d. The refrigerant sent to the indoor heat exchangers 52b, 52c, and 52d is evaporated by being heated through heat exchange with the indoor air supplied from the air-conditioning target spaces by the indoor fans 55b, 55c, and 55d in the indoor heat exchangers 52b, 52c, and 52d that function as the evaporators of the refrigerant. The refrigerant flows out from the indoor units 3b, 3c, and 3d. The indoor air cooled by the indoor heat exchangers 52b, 52c, and 52d is sent to the air-conditioning target spaces and the air-conditioning target spaces are cooled by using the cooled indoor air.

[0184] The refrigerant flowing out from the indoor units 3b, 3c, and 3d is sent to the relay units 4b, 4c, and 4d via the branch pipe portions 6b, 6c, and 6d of the gas-refrigerant connection pipe 6. The refrigerant sent to the relay units 4b, 4c, and 4d flows out from the relay units 4b, 4c, and 4d via the second cooling/heating switching valves 59b, 59c, and 59d.

[0185] The refrigerant flowing out from the relay units 4b, 4c, and 4d is joined and sent to the outdoor unit 2 via the low-pressure gas-refrigerant connection pipe 8 (the joint pipe portion and the branch pipe portions 8b, 8c, and 8d). The refrigerant sent to the outdoor unit 2 is sucked into the compressor 21 via the gas-side shutoff valves 28a and 28b and the third switching mechanism 22c.

[0186] In the above-described cooling main operation, like cooling only operation, the air conditioner 1 performs two-phase refrigerant feed of sending the refrigerant in the gas-liquid two-phase state to the liquid-refrigerant connection pipe 5 by the liquid-pressure adjustment expansion valve 26 and hence sending the refrigerant from the outdoor unit 2 to the indoor units 3a, 3b, 3c, and 3d. In addition, the refrigerant flowing through the outdoor liquid-refrigerant pipe 34 is cooled by the refrigerant return pipe 41 and the refrigerant cooler 45 to reduce variation in the liquid-pipe temperature T_{lp} in the portion of the outdoor liquid-refrigerant pipe 34 between the refrigerant cooler 45 and the liquid-pressure adjustment expansion valve 26, so that the two-phase refrigerant feed can be properly performed.

Heating Main Operation

[0187] In heating main operation, for example, when the indoor units 3b, 3c, and 3d perform heating operation, the indoor unit 3a performs cooling operation (that is, operation in which the indoor heat exchangers 52b, 52c, and 52d function as the radiators of the refrigerant and the indoor heat exchanger 52a functions as the evaporator of the refrigerant), and the indoor heat exchangers 23a and 23b function as the evaporators of the refrigerant, the switching mechanisms 22a and 22b are switched to the outdoor evaporation state (the state in which the switching mechanisms 22a and 22b are indicated by solid lines in Fig. 9), and the compressor 21, the outdoor fan 24, and the indoor fans 55a, 55b, 55c, and 55d are driven. In addition, the third switching mechanism 22c is switched to the refrigerant lead-out state (the state in which the switching mechanism 22c is indicated by broken lines in Fig. 9), the second cooling/heating switching valves 59b, 59c, and 59d of the relay units 4b, 4c, and 4d are closed, and the second cooling/heating switching valve 59a of the relay unit 4a as well as the first cooling/heating switching valves 58b, 58c, and 58d of the relay units 4b, 4c, and 4d are opened.

[0188] Then, the high-pressure refrigerant discharged from the compressor 21 flows out from the outdoor unit 2 via the third switching mechanism 22c and the gas-side shutoff valve 28a.

[0189] The refrigerant flowing out from the outdoor unit 2 is branched and sent to the relay units 4b, 4c, and 4d via the gas-refrigerant connection pipe 6 (the joint pipe portion and the branch pipe portions 7b, 7c, and 7d of the high/low-pressure gas-refrigerant connection pipe 7). The refrigerant sent to the relay units 4b, 4c, and 4d flows out from the relay units 4b, 4c, and 4d via the first cooling/heating switching valves 58b, 58c, and 58d.

[0190] The refrigerant flowing out from the relay units 4b, 4c, and 4d is sent to the indoor units 3b, 3c, and 3d via the branch pipe portions 6b, 6c, and 6d (the portions of the gas-refrigerant connection pipe 6 connecting the relay units 4b, 4c, and 4d to the indoor units 3b, 3c, and 3d). The refrigerant sent to the indoor units 3b, 3c, and 3d is sent to the indoor heat exchangers 52b, 52c, and 52d. The high-pressure refrigerant sent to the indoor heat exchangers 52b, 52c, and 52d is condensed by being cooled through heat exchange with the indoor air supplied from the air-conditioning target spaces by the indoor fans 55b, 55c, and 55d in the indoor heat exchangers 52b, 52c, and 52d that function as the radiators of the refrigerant. The refrigerant is decompressed by the indoor expansion valves 51b, 51c, and 51d and then flows out from the indoor units 3b, 3c, and 3d. The indoor air heated by the indoor heat exchangers 52b, 52c, and 52d is sent to the air-conditioning target spaces and the air-conditioning target spaces are heated by using the heated indoor air.

[0191] The refrigerant flowing out from the indoor units 3b, 3c, and 3d is sent to the relay units 4b, 4c, and 4d via the second branch pipe portions 5bb, 5cc, and 5dd (the portions of the liquid-refrigerant connection pipe 5 connecting the relay units 4b, 4c, and 4d to the indoor units 3b, 3c, and 3d). The refrigerant sent to the relay units 4b, 4c, and 4d flows out from the relay units 4b, 4c, and 4d.

[0192] The refrigerant flowing out from the relay units 4a, 4b, 4c, and 4d is joined to the joint pipe portion via the first branch pipe portions 5a, 5b, 5c, and 5d of the liquid-refrigerant connection pipe 5, part of the refrigerant is branched to the first branch pipe portion 5a and sent to the relay unit 4a, and the residual part of the refrigerant is sent to the outdoor unit 2 via the joint pipe portion of the liquid-refrigerant connection pipe 5. The refrigerant sent to the relay unit 4a flows out from the relay unit 4a.

[0193] The refrigerant flowing out from the relay unit 4a is sent to the indoor unit 3a via the second branch pipe portion 5aa (the portion of the liquid-refrigerant connection pipe 5 connecting the relay unit 4a to the indoor unit 3a). The refrigerant sent to the indoor unit 3a is decompressed by the indoor expansion valve 51a and then sent to the indoor heat exchanger 52a. The refrigerant sent to the indoor heat exchanger 52a is evaporated by being heated through heat exchange with the indoor air supplied from the air-conditioning target space by the indoor fan 55a in the indoor heat exchanger 52a that functions as the evaporator of the refrigerant. The refrigerant flows out from the indoor unit 3a. The indoor air cooled by the indoor heat exchanger 52a is sent to the air-conditioning target space and the air-conditioning target space is cooled by using the cooled indoor air.

[0194] The refrigerant flowing out from the indoor unit 3a is sent to the relay unit 4a via the branch pipe portion 6a of the gas-refrigerant connection pipe 6. The refrigerant sent to the relay unit 4a flows out from the relay unit 4a via the second cooling/heating switching valve 59a.

[0195] The refrigerant flowing out from the relay unit 4a is sent to the outdoor unit 2 via the low-pressure gas-refrigerant connection pipe 8 (the joint pipe portion and the branch pipe portion 8a). The refrigerant sent to the outdoor unit 2 via the joint pipe portion of the liquid-refrigerant connection pipe 5 is sent to the outdoor expansion valves 25a and 25b via the liquid-side shutoff valve 27, the liquid-pressure adjustment expansion valve 26, and the refrigerant cooler 45. The refrigerant sent to the outdoor expansion valves 25a and 25b is decompressed by the outdoor expansion valves 25a and 25b and then is sent to the outdoor heat exchangers 23a and 23b. The refrigerant sent to the outdoor heat exchangers 23a and 23b is evaporated by being heated through heat exchange with the outdoor air supplied by the outdoor fan 24. The refrigerant is joined to the refrigerant sent to the outdoor unit 2 via the low-pressure gas-refrigerant connection pipe 8 and is sucked into the compressor 21, via the switching mechanisms 22a and 22b.

[0196] In the above-described heating main operation, like heating only operation, the control unit 19 performs control to fix the opening degree of the liquid-pressure adjustment expansion valve 26 in a fully opened state. Thus, the opening degree of the refrigerant return expansion valve 44 is brought into a fully closed state to inhibit the refrigerant from flowing to the refrigerant return pipe 41.

Operation with Leakage of Refrigerant

[0197] The operation of the air conditioner 1 when the refrigerant leaks is described next with reference to Figs. 9 to 11. Fig. 11 is a flowchart of an operation when a refrigerant leaks in the air conditioner 1 according to the second embodiment of the present disclosure. The operation of the air conditioner 1 which is described below is performed by the control unit 19 that controls the components of the air conditioner 1 (the outdoor unit 2, the indoor units 3a, 3b, 3c, and 3d, and the relay units 4a, 4b, 4c, and 4d) like the operation when the refrigerant does not leak.

[0198] The air conditioner 1 is provided with the refrigerant sensors 57a, 57b, 57c, and 57d serving as the refrigerant leakage detecting means as described above. When the refrigerant sensors 57a, 57b, 57c, and 57d detect leakage of the refrigerant, the indoor expansion valves 51a, 51b, 51c, and 51d and the cooling/heating switching valves 58a, 58b, 58c, 58d, 59a, 59b, 59c, and 59d are closed in accordance with the information of the refrigerant sensors 57a, 57b, 57c, and 57d. Thus, the indoor units 3a, 3b, 3c, and 3d can be isolated. Accordingly, the refrigerant can be inhibited from flowing from the refrigerant connection pipes 5 and 6 to the indoor units 3a, 3b, 3c, and 3d. That is, when the refrigerant leaks, the indoor expansion valves 51a, 51b, 51c, and 51d are used also as liquid-side shutoff valves, the cooling/heating switching valves 58a, 58b, 58c, 58d, 59a, 59b, 59c, and 59d are used also as gas-side shutoff valves, and these valves are closed, thereby providing a refrigerant shutoff function when the refrigerant leaks from the indoor units 3a, 3b, 3c, and 3d.

[0199] To be specific, when the refrigerant sensors 57a, 57b, 57c, and 57d detect leakage of the refrigerant (step ST1), the control unit 19 closes the indoor expansion valves 51a, 51b, 51c, and 51d and the cooling/heating switching valves 58a, 58b, 58c, 58d, 59a, 59b, 59c, and 59d (step ST4). In addition, when leakage of the refrigerant is detected in step ST1, an alarm may be given (step ST2). Further, before the indoor expansion valves 51a, 51b, 51c, and 51d and the cooling/heating switching valves 58a, 58b, 58c, 58d, 59a, 59b, 59c, and 59d are closed, the compressor 21 may be stopped (step ST3) to suppress an excessive increase in the pressure of the refrigerant.

[0200] In this way, the indoor expansion valves 51a, 51b, 51c, and 51d and the cooling/heating switching valves 58a, 58b, 58c, 58d, 59a, 59b, 59c, and 59d are closed in accordance with the information of the refrigerant sensors 57a, 57b, 57c, and 57d serving as the refrigerant leakage detecting means when the refrigerant leaks. Thus, the refrigerant is inhibited from flowing from the refrigerant connection pipes 5 and 6 to the indoor units 3a, 3b, 3c, and 3d, and increase in concentration of the refrigerant in the air-conditioning target spaces can be suppressed.

Features

[0201] The air conditioner 1 and the indoor units 3a, 3b, 3c, and 3d used for the air conditioner 1 according to this embodiment have the following features.

[0202] Like the air conditioner 1 and the indoor units 3a and 3b used for the air conditioner 1 according to the first embodiment, the air conditioner 1 and the indoor units 3a, 3b, 3c, and 3d used for the air conditioner 1 according to this embodiment also have a problem of leakage of the refrigerant from the brazing portions 82a, 82b, 82c, and 82d brazing the indoor expansion valves 51a, 51b, 51c, and 51d and the connection-side indoor liquid-refrigerant pipes 72a, 72b, 72c, and 72d when the indoor expansion valves 51a, 51b, 51c, and 51d are used also as the shutoff valves on the liquid sides of the indoor units 3a, 3b, 3c, and 3d.

[0203] In this case, like the air conditioner 1 and the indoor units 3a and 3b used for the air conditioner 1 according to the first embodiment, leakage of the refrigerant from the brazing portions 82a, 82b, 82c, and 82d is reduced by providing coating materials 11a, 11b, 11c, and 11d at the brazing portions 82a, 82b, 82c, and 82d.

[0204] Accordingly, like the air conditioner 1 and the indoor units 3a and 3b used for the air conditioner 1 according to the first embodiment, the refrigerant shutoff function for the situation in which the refrigerant leaks from the indoor units 3a, 3b, 3c, and 3d can be added while the increase in the cost and the sizes of the indoor units 3a, 3b, 3c, and 3d due to the provision of the shutoff valves on the liquid sides of the indoor units 3a, 3b, 3c, and 3d is reduced as much as possible.

[0205] In particular, as described above, the cooling/heating switching valves 58a, 58b, 58c, 58d, 59a, 59b, 59c, and 59d of the relay units 4a, 4b, 4c, and 4d used for individually switching the operating states of the indoor units 3a, 3b, 3c, and 3d (that is, the states in which the indoor heat exchangers 52a, 52b, 52c, and 52d function as the evaporators of the refrigerant and function as the radiators of the refrigerant) are used also as the gas-side shutoff valves. As long as the cooling/heating switching valves 58a, 58b, 58c, 58d, 59a, 59b, 59c, and 59d can be used also as the shutoff valves on the gas sides of the indoor units 3a, 3b, 3c, and 3d, the increase in the cost and the sizes of the indoor units

3a, 3b, 3c, and 3d can be suppressed by that amount.

[0206] Accordingly, the refrigerant shutoff function for the situation in which the refrigerant leaks from the indoor units 3a, 3b, 3c, and 3d can be added while the increase in the cost and the sizes of the indoor units 3a, 3b, 3c, and 3d due to the provision of the shutoff valves on the gas sides of the indoor units 3a, 3b, 3c, and 3d is reduced as much as possible.

[0207] Since the outdoor unit 2 includes the liquid-pressure adjustment expansion valve 26 like the air conditioner 1 according to the first embodiment, the two-phase refrigerant feed of decompressing the refrigerant to be brought into the gas-liquid two-phase state in the outdoor unit 2 and then sending the refrigerant to the indoor units 3a, 3b, 3c, and 3d via the liquid-refrigerant connection pipe 5 is performed. Accordingly, like the air conditioner 1 according to the first embodiment, even in the case where the two-phase refrigerant feed is not sufficient for the countermeasure to leakage of the refrigerant, the refrigerant shutoff function for the situation in which the refrigerant leaks from the indoor units 3a, 3b, 3c, and 3d can be added while the increase in the cost and the sizes of the indoor units 3a, 3b, 3c, and 3d due to the provision of the shutoff valves on the liquid sides of the indoor units 3a, 3b, 3c, and 3d is reduced as much as possible. The addition of the refrigerant shutoff function makes the countermeasure to leakage of the refrigerant sufficient.

First Modification

[0208] In this embodiment, only the indoor expansion valves 51a, 51b, 51c, and 51d are provided in the indoor liquid-refrigerant pipes 53a, 53b, 53c, and 53d as illustrated in Fig. 10 in the indoor units 3a, 3b, 3c, and 3d arranged in the air-conditioning target spaces. In addition, filters 73a, 73b, 73c, and 73d for reducing inflow of foreign substances and so forth to the indoor expansion valves 51a, 51b, 51c, and 51d may be provided in the connection-side indoor liquid-refrigerant pipes 72a, 72b, 72c, and 72d as illustrated in Fig. 12 in the indoor units 3a, 3b, 3c, and 3d. The filters 73a, 73b, 73c, and 73d are also connected to the connection-side indoor liquid-refrigerant pipes 72a, 72b, 72c, and 72d by brazing. The connection-side indoor liquid-refrigerant pipes 72a, 72b, 72c, and 72d include first connection-side indoor liquid-refrigerant pipes 74a, 74b, 74c, and 74d connected to the indoor expansion valves 51a, 51b, 51c, and 51d, and second connection-side indoor liquid-refrigerant pipes 75a, 75b, 75c, and 75d connected to the liquid-refrigerant connection pipe 5 (in this case, the branch pipe portions 5aa, 5bb, 5cc, and 5dd). In addition, the filters 73a, 73b, 73c, and 73d are connected between the first connection-side indoor liquid-refrigerant pipes 74a, 74b, 74c, and 74d and the second connection-side indoor liquid-refrigerant pipes 75a, 75b, 75c, and 75d. The filters 73a, 73b, 73c, and 73d are connected to the first connection-side indoor liquid-refrigerant pipes 74a, 74b, 74c, and 74d and the second connection-side indoor liquid-refrigerant pipes 75a, 75b, 75c, and 75d by brazing (the brazing portions are referred to as brazing portions 85a, 85b, 85c, 85d, 86a, 86b, 86c, and 86d). Due to this, the brazing portions 85a, 85b, 85c, 85d, 86a, 86b, 86c, and 86d may corrode and the refrigerant may leak from the corroding portions. This makes difficult to use the indoor expansion valves 51a, 51b, 51c, and 51d also as the shutoff valves on the liquid sides of the indoor units 3a, 3b, 3c, and 3d, like the brazing portions 85a, 85b, 86a, and 86b of the indoor units 3a and 3b according to the first embodiment.

[0209] To address this, as illustrated in Fig. 12, the brazing portions 85a, 85b, 85c, 85d, 86a, 86b, 86c, and 86d brazing the filters 73a, 73b, 73c, and 73d with the first connection-side indoor liquid-refrigerant pipes 74a, 74b, 74c, and 74d and the second connection-side indoor liquid-refrigerant pipes 75a, 75b, 75c, and 75d are also provided with coating materials 11a, 11b, 11c, 11d, 12a, 12b, 12c, and 12d. The first connection-side indoor liquid-refrigerant pipes 74a, 74b, 74c, and 74d including the brazing portions 82a, 82b, 82c, and 82d and the brazing portions 85a, 85b, 85c, and 85d are provided with the coating materials 11a, 11b, 11c, and 11d. The second connection-side indoor liquid-refrigerant pipes 75a, 75b, 75c, and 75d including the brazing portions 86a, 86b, 86c, and 86d and the brazing portions 83aa, 83bb, 83cc, and 83dd are provided with coating materials 12a, 12b, 12c, and 12d. When the second connection-side indoor liquid-refrigerant pipes 75a, 75b, 75c, and 75d are directly connected to the liquid-refrigerant connection pipe 5 (in this case, the branch pipe portions 5aa, 5bb, 5cc, and 5dd) by brazing, the coating materials 12a, 12b, 12c, and 12d may be provided to include the brazing portions brazing the second connection-side indoor liquid-refrigerant pipes 75a, 75b, 75c, and 75d and the liquid-refrigerant connection pipe 5 (in this case, the branch pipe portions 5aa, 5bb, 5cc, and 5dd). The way of providing the coating materials is not limited to the above-described way like the indoor units 3a and 3b according to the first embodiment. Accordingly, leakage of the refrigerant from the brazing portions 85a, 85b, 85c, 85d, 86a, 86b, 86c, and 86d brazing the filters 73a, 73b, 73c, and 73d with the first connection-side indoor liquid-refrigerant pipes 74a, 74b, 74c, and 74d and the second connection-side indoor liquid-refrigerant pipes 75a, 75b, 75c, and 75d is reduced, so that the indoor expansion valves 51a, 51b, 51c, and 51d can be used also as the shutoff valves on the liquid sides of the indoor units 3a, 3b, 3c, and 3d.

[0210] Even in the case where the filters 73a, 73b, 73c, and 73d are provided in the connection-side indoor liquid-refrigerant pipes 72a, 72b, 72c, and 72d, the refrigerant shutoff function for the situation in which the refrigerant leaks from the indoor units 3a, 3b, 3c, and 3d can be added while the increase in the cost and the sizes of the indoor units 3a, 3b, 3c, and 3d due to the provision of the shutoff valves on the liquid sides of the indoor units 3a, 3b, 3c, and 3d is reduced as much as possible.

Second Modification

[0211] In the external shutoff valve units 4a, 4b, 4c, and 4d, the cooling/heating switching valves 58a, 58b, 58c, 58d, 59a, 59b, 59c, and 59d serving as the gas-side shutoff valves are connected to the gas connection pipes 62a, 62b, 62c, and 62d connected to the gas-refrigerant connection pipe 6 (the indoor-side high-pressure gas connection pipes 66a, 66b, 66c, and 66d, the outdoor-side high-pressure gas connection pipes 67a, 67b, 67c, and 67d, the indoor-side low-pressure gas connection pipes 68a, 68b, 68c, and 68d, and the outdoor-side low-pressure gas connection pipes 69a, 69b, 69c, and 69d) by brazing. Due to this, the brazing portions 92a, 92b, 92c, and 92d brazing the first cooling/heating switching valves 58a, 58b, 58c, and 58d and the outdoor-side high-pressure gas connection pipes 67a, 67b, 67c, and 67d may corrode and the refrigerant may leak from the corroding portions. In addition, the brazing portions 94a, 94b, 94c, and 94d brazing the second cooling/heating switching valves 59a, 59b, 59c, and 59d and the outdoor-side high-pressure gas connection pipes 69a, 69b, 69c, and 69d may corrode and the refrigerant may leak from the corroding portions. In the above-described embodiment and first modification, however, the relay units 4a, 4b, 4c, and 4d are arranged outside the air-conditioning target spaces. Hence, even when the refrigerant leaks from the brazing portions 92a, 92b, 92c, 92d, 94a, 94b, 94c, and 94d, the refrigerant hardly leaks to the air-conditioning target spaces. In contrast, when the relay units 4a, 4b, 4c, and 4d are arranged in the air-conditioning target spaces together with the indoor units 3a, 3b, 3c, and 3d, if the refrigerant leaks from the brazing portions 92a, 92b, 92c, 92d, 94a, 94b, 94c, and 94d, the refrigerant is continuously supplied from the gas-refrigerant connection pipe 6 to the brazing portions 92a, 92b, 92c, 92d, 94a, 94b, 94c, and 94d, and the refrigerant may continuously leak from the external shutoff valve units 4a, 4b, 4c, and 4d to the air-conditioning target spaces although the cooling/heating switching valves 58a, 58b, 58c, 58d, 59a, 59b, 59c, and 59d are closed. Thus, it is required to reduce leakage of the refrigerant from the brazing portions 92a, 92b, 92c, 92d, 94a, 94b, 94c, and 94d.

[0212] To address this, as illustrated in Fig. 13, the brazing portions 92a, 92b, 92c, and 92d brazing the first cooling/heating switching valves 58a, 58b, 58c, and 58d and the outdoor-side high-pressure gas connection pipes 67a, 67b, 67c, and 67d are also provided with coating materials 13a, 13b, 13c, and 13d. In addition, the brazing portions 94a, 94b, 94c, and 94d brazing the second cooling/heating switching valves 59a, 59b, 59c, and 59d and the outdoor-side low-pressure gas connection pipes 69a, 69b, 69c, and 69d are also provided with coating materials 14a, 14b, 14c, and 14d. The coating materials 13a, 13b, 13c, 13d, 14a, 14b, 14c, and 14d may be also provided at only the brazing portions 92a, 92b, 92c, 92d, 94a, 94b, 94c, and 94d, or may be also provided at a portion other than the brazing portions 92a, 92b, 92c, 92d, 94a, 94b, 94c, and 94d. For example, as illustrated in Fig. 13, the coating materials 13a, 13b, 13c, and 13d may be provided in a range from the first cooling/heating switching valves 58a, 58b, 58c, and 58d to the pipe joint portions 96a, 96b, 96c, and 96d of the outdoor-side high-pressure gas connection pipes 67a, 67b, 67c, and 67d (that is, so as to include the brazing portions 92a, 92b, 92c, and 92d and the brazing portions 96aa, 96bb, 96cc, and 96dd). When the outdoor-side high-pressure gas connection pipes 67a, 67b, 67c, and 67d are directly connected to the gas-refrigerant connection pipe 6 (in this case, the first branch pipe portions 7a, 7b, 7c, and 7d of the high/low-pressure gas-refrigerant connection pipe 7) by brazing, the coating materials 13a, 13b, 13c, and 13d may be provided in a range from the first cooling/heating switching valves 58a, 58b, 58c, and 58d to the brazing portions brazing the outdoor-side gas connection pipes 67a, 67b, 67c, and 67d and the gas-refrigerant connection pipe 6 (in this case, the first branch pipe portions 7a, 7b, 7c, and 7d of the high/low-pressure gas-refrigerant connection pipe 7). The coating materials 14a, 14b, 14c, and 14d may be provided in a range from the second cooling/heating switching valves 59a, 59b, 59c, and 59d to the pipe joint portions 97a, 97b, 97c, and 97d of the outdoor-side low-pressure gas connection pipes 69a, 69b, 69c, and 69d (that is, so as to include the brazing portions 94a, 94b, 94c, and 94d and the brazing portions 97aa, 97bb, 97cc, and 97dd). When the outdoor-side low-pressure gas connection pipes 69a, 69b, 69c, and 69d are directly connected to the gas-refrigerant connection pipe 6 (in this case, the branch pipe portions 8a, 8b, 8c, and 8d of the low-pressure gas-refrigerant connection pipe 8) by brazing, the coating materials 14a, 14b, 14c, and 14d may be provided in a range from the second cooling/heating switching valves 59a, 59b, 59c, and 59d to the brazing portions brazing the outdoor-side low-pressure gas connection pipes 69a, 69b, 69c, and 69d and the gas-refrigerant connection pipe 6 (in this case, the branch pipe portions 8a, 8b, 8c, and 8d of the low-pressure gas-refrigerant connection pipe 8). Accordingly, leakage of the refrigerant from the brazing portions 92a, 92b, 92c, and 92d brazing the first cooling/heating switching valves 58a, 58b, 58c, and 58d and the outdoor-side high-pressure gas connection pipes 67a, 67b, 67c, and 67d is reduced, leakage of the refrigerant from the brazing portions 94a, 94b, 94c, and 94d brazing the second cooling/heating switching valves 59a, 59b, 59c, and 59d and the outdoor-side low-pressure gas connection pipes 69a, 69b, 69c, and 69d is reduced, and hence the relay units 4a, 4b, 4c, and 4d can be arranged in the air-conditioning target spaces together with the indoor units 3a, 3b, 3c, and 3d. Referring to Fig. 13, in the configuration of the above-described embodiment (see Fig. 10) without the filters 73a, 73b, 73c, and 73d, the brazing portions 92a, 92b, 92c, and 92d brazing the first cooling/heating switching valves 58a, 58b, 58c, and 58d and the outdoor-side high-pressure gas connection pipes 67a, 67b, 67c, and 67d as well as the brazing portions 94a, 94b, 94c, and 94d brazing the second cooling/heating switching valves 59a, 59b, 59c, and 59d and the outdoor-side low-pressure gas connection pipes 69a, 69b, 69c, and 69d are provided with

the coating materials 13a, 13b, 13c, 13d, 14a, 14b, 14c, and 14d; however, it is not limited to the above. For example, in the configuration of the above-described first modification (see Fig. 12) with the filters 73a, 73b, 73c, and 73d, the brazing portions 92a, 92b, 92c, and 92d brazing the first cooling/heating switching valves 58a, 58b, 58c, and 58d and the outdoor-side high-pressure gas connection pipes 67a, 67b, 67c, and 67d as well as the brazing portions 94a, 94b, 94c, and 94d brazing the second cooling/heating switching valves 59a, 59b, 59c, and 59d and the outdoor-side low-pressure gas connection pipes 69a, 69b, 69c, and 69d may be provided with the coating materials 13a, 13b, 13c, 13d, 14a, 14b, 14c, and 14d.

[0213] Accordingly, the degree of freedom is ensured for arrangement of the relay units 4a, 4b, 4c, and 4d.

Third Modification

[0214] In the above-described embodiment and the first and second modifications, as illustrated in Fig. 11, when the refrigerant sensors 57a, 57b, 57c, and 57d detect leakage of the refrigerant, all the indoor expansion valves 51a, 51b, 51c, and 51d and the cooling/heating switching valves 58a, 58b, 58c, 58d, 59a, 59b, 59c, and 59d are closed and the compressor 21 is stopped in accordance with the information of the refrigerant sensors 57a, 57b, 57c, and 57d. Accordingly, the circulation of the refrigerant in the refrigerant circuit 10 is stopped, and the cooling operation or heating operation is stopped not only in the indoor unit in which the refrigerant leaks but also in the indoor unit in which the refrigerant does not leak.

[0215] However, it is desirable that only the indoor unit in which the refrigerant leaks is isolated whereas the indoor unit in which the refrigerant does not leak can continue cooling operation or heating operation.

[0216] As illustrated in Fig. 14, when the refrigerant sensors 57a, 57b, 57c, and 57d detect leakage of the refrigerant (step ST1), the control unit 19 closes only the indoor expansion valve and the cooling/heating switching valve corresponding to the indoor unit in which the refrigerant leaks among the plurality of indoor units 3a, 3b, 3c, and 3d (step ST5). Then, by continuing the circulation of the refrigerant in the refrigerant circuit 10 without stopping the compressor 21, the cooling operation or heating operation of the indoor unit in which the refrigerant does not leak is continued (step ST6).

[0217] When the refrigerant leaks from the indoor units 3a, 3b, 3c, and 3d, only the indoor unit in which the refrigerant leaks is isolated whereas the indoor unit in which the refrigerant does not leak can continue the operation.

Fourth Modification

[0218] In the above-described embodiment and first to third modifications, the relay units 4a, 4b, 4c, and 4d respectively corresponding to the indoor units 3a, 3b, 3c, and 3d are provided; however, it is not limited thereto. For example, a relay unit may be collectively constituted of all the relay units 4a, 4b, 4c, and 4d, or some of the relay units 4a, 4b, 4c, and 4d.

INDUSTRIAL APPLICABILITY

[0219] The present disclosure can be widely applied to an air conditioner configured such that an outdoor unit and an indoor unit arranged in an air-conditioning target space are connected to each other via a liquid-refrigerant connection pipe and a gas-refrigerant connection pipe, and an indoor unit used for the air conditioner.

REFERENCE SIGNS LIST

[0220]

1	air conditioner
2	outdoor unit
3a, 3b, 3c, 3d	indoor unit
4a, 4b, 4c, 4d	external shutoff valve unit, relay unit
5	liquid-refrigerant connection pipe
6	gas-refrigerant connection pipe
11a, 11b, 11c, 11d	coating material
12a, 12b, 12c, 12d	coating material
13a, 13b, 13c, 13d	coating material
14a, 14b, 14c, 14d	coating material
15a, 15b	coating material
19	control unit
23, 23a, 23b	outdoor heat exchanger

26	liquid-pressure adjustment expansion valve
51a, 51b, 51c, 51d	indoor expansion valve
52a, 52b, 52c, 52d	indoor heat exchanger
57a, 57b, 57c, 57d	refrigerant sensor (refrigerant leakage detecting means)
5 58a, 58b, 58c, 58d	gas-side shutoff valve, first cooling/heating switching valve
59a, 59b, 59c, 59d	second cooling/heating switching valve (gas-side shutoff valve)
66a, 66b, 66c, 66d	indoor-side gas connection pipe
67a, 67b, 67c, 67d	outdoor-side gas connection pipe
68a, 68b, 68c, 68d	indoor-side gas connection pipe
10 69a, 69b, 69c, 69d	outdoor-side gas connection pipe
71a, 71b, 71c, 71d	heat-exchange-side indoor liquid-refrigerant pipe
72a, 72b, 72c, 72d	connection-side indoor liquid-refrigerant pipe
73a, 73b, 73c, 73d	filter
74a, 74b, 74c, 74d	first connection-side indoor liquid-refrigerant pipe
15 75a, 75b, 75c, 75d	second connection-side indoor liquid-refrigerant pipe
76a, 76b	heat-exchange-side indoor gas-refrigerant pipe
77a, 77b	connection-side indoor gas-refrigerant pipe
82a, 82b, 82c, 82d	brazing portion
85a, 85b, 85c, 85d	brazing portion
20 86a, 86b, 86c, 86d	brazing portion
88a, 88b	brazing portion
92a, 92b, 92c, 92d	brazing portion
94a, 94b, 94c, 94d	brazing portion

25 CITATION LIST

PATENT LITERATURE

[0221] PTL1 International Publication No. 2015/029160

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Claims

1. An air conditioner (1) comprising:

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an outdoor unit (2);
 a liquid-refrigerant connection pipe (5) and a gas-refrigerant connection pipe (6);
 an indoor unit (3a, 3b, 3c, 3d) connected to the outdoor unit via the liquid-refrigerant connection pipe and the
 40 gas-refrigerant connection pipe, arranged in an air-conditioning target space, and including an indoor heat
 exchanger (52a, 52b, 52c, 52d) that performs heat exchange between a refrigerant, which is circulated between
 the indoor unit and the outdoor unit via the liquid-refrigerant connection pipe and the gas-refrigerant connection
 pipe, and an air, which is sent to the air-conditioning target space, an indoor expansion valve (51a, 51b, 51c,
 51d) that decompresses the refrigerant, a heat-exchange-side indoor liquid-refrigerant pipe (71a, 71b, 71c, 71d)
 45 that connects a liquid side of the indoor heat exchanger to the indoor expansion valve, and a connection-side
 indoor liquid-refrigerant pipe (72a, 72b, 72c, 72d) that connects the indoor expansion valve to the liquid-refrig-
 erant connection pipe;
 a gas-side shutoff valve (58a, 58b, 58c, 58d, 59a, 59b, 59c, 59d) that is connected to a gas side of the indoor
 heat exchanger;
 refrigerant leakage detecting means (57a, 57b, 57c, 57d) for detecting leakage of the refrigerant; and
 50 a control unit (19), wherein
 the indoor expansion valve is connected to the connection-side indoor liquid-refrigerant pipe by brazing,
 brazing portions (82a, 82b, 82c, 82d) brazing the indoor expansion valve and the connection-side indoor liquid-
 refrigerant pipe each are provided with a coating material (11a, 11b, 11c, 11d), and
 the control unit causes the indoor expansion valve and the gas-side shutoff valve to be closed in accordance
 55 with information of the refrigerant leakage detecting means when the refrigerant leaks.

2. The air conditioner according to claim 1, wherein

the connection-side indoor liquid-refrigerant pipe includes a first connection-side indoor liquid-refrigerant pipe (74a, 74b, 74c, 74d) connected to the indoor expansion valve, a second connection-side indoor liquid-refrigerant pipe (75a, 75b, 75c, 75d) connected to the liquid-refrigerant connection pipe, and a filter (73a, 73b, 73c, 73d) that is connected between the first connection-side indoor liquid-refrigerant pipe and the second connection-side indoor liquid-refrigerant pipe,
 the filter is connected to the first connection-side indoor liquid-refrigerant pipe and the second connection-side indoor liquid-refrigerant pipe by brazing, and
 brazing portions (85a, 85b, 85c, 85d, 86a, 86b, 86c, 86d) brazing the filter with the first connection-side indoor liquid-refrigerant pipe and the second connection-side indoor liquid-refrigerant pipe each are provided with a coating material (11a, 11b, 11c, 11d, 12a, 12b, 12c, 12d).

3. The air conditioner according to claim 1 or 2, wherein

the outdoor unit includes an outdoor heat exchanger (23, 23a, 23b) and a liquid-pressure adjustment expansion valve (26), and
 when the refrigerant is sent from the outdoor heat exchanger to the indoor unit via the liquid-refrigerant connection pipe, the control unit controls the liquid-pressure adjustment expansion valve to decompress the refrigerant flowing through the liquid-refrigerant connection pipe to be brought into a gas-liquid two-phase state, and controls the indoor expansion valve to decompress the refrigerant decompressed by the liquid-pressure adjustment expansion valve.

4. The air conditioner according to any one of claims 1 to 3, wherein

the indoor unit includes a plurality of the indoor units, and
 the gas-side shutoff valve is provided to correspond to each of the indoor units.

5. The air conditioner according to claim 4, wherein

the control unit causes only the indoor expansion valve and the gas-side shutoff valve corresponding to the indoor unit in which the refrigerant leaks among the plurality of indoor units to be closed in accordance with information of the refrigerant leakage detecting means when the refrigerant leaks.

6. The air conditioner according to any one of claims 1 to 5, wherein

the gas-refrigerant connection pipe is provided with an external shutoff valve unit (4a, 4b) including the gas-side shutoff valve.

7. The air conditioner according to claim 6, wherein

the gas-side shutoff valve is connected, by brazing, to an indoor-side gas connection pipe (66a, 66b) that is connected to a portion of the gas-refrigerant connection pipe on a side of the indoor unit, and an outdoor-side gas connection pipe (67a, 67b) that is connected to a portion of the gas-refrigerant connection pipe on a side of the outdoor unit, and
 a brazing portion (92a, 92b) brazing the gas-side shutoff valve and the outdoor-side gas connection pipe is also provided with a coating material (13a, 13b).

8. The air conditioner according to claim 4 or 5, wherein

the gas-refrigerant connection pipe is provided with a relay unit (4a, 4b, 4c, 4d) including a cooling/heating switching valve (58a, 58b, 58c, 58d, 59a, 59b, 59c, 59d) that individually switches corresponding one of the plurality of indoor heat exchangers to function as an evaporator or a radiator of the refrigerant, and
 the control unit causes the indoor expansion valve and the cooling/heating switching valve serving as the gas-side shutoff valve to be closed in accordance with information of the refrigerant leakage detecting means when the refrigerant leaks.

9. The air conditioner according to claim 8, wherein

the cooling/heating switching valve is connected, by brazing, to an indoor-side gas connection pipe (66a, 66b, 66c, 66d, 68a, 68b, 68c, 68d) that is connected to a portion of the gas-refrigerant connection pipe on a side of the indoor unit, and an outdoor-side gas connection pipe (67a, 67b, 67c, 67d, 69a, 69b, 69c, 69d) that is

connected to a portion of the gas-refrigerant connection pipe on a side of the outdoor unit, and a brazing portion (92a, 92b, 92c, 92d, 94a, 94b, 94c, 94d) brazing the cooling/heating switching valve and the outdoor-side gas connection pipe is also provided with a coating material (13a, 13b, 13c, 13d, 14a, 14b, 14c, 14d).

5 **10.** The air conditioner according to any one of claims 1 to 5, wherein

the gas-side shutoff valve is provided in the indoor unit,
the indoor unit includes a heat-exchange-side indoor gas-refrigerant pipe (76a, 76b) that connects the gas side
of the indoor heat exchanger to the gas-side shutoff valve, and a connection-side indoor gas-refrigerant pipe
10 (77a, 77b) that connects the gas-side shutoff valve to the gas-refrigerant connection pipe,
the gas-side shutoff valve is connected to the connection-side indoor gas-refrigerant pipe by brazing, and
a brazing portion (88a, 88b) brazing the gas-side shutoff valve and the connection-side indoor gas-refrigerant
pipe is also provided with a coating material (15a, 15b).

15 **11.** An indoor unit (3a, 3b, 3c, 3d) connected to an outdoor unit (2) via a liquid-refrigerant connection pipe (5) and a gas-refrigerant connection pipe (6) and arranged in an air-conditioning target space, the indoor unit comprising:

an indoor heat exchanger (52a, 52b, 52c, 52d) that performs heat exchange between a refrigerant, which is
circulated between the indoor unit and the outdoor unit via the liquid-refrigerant connection pipe and the gas-
refrigerant connection pipe, and an air, which is sent to the air-conditioning target space;
20 an indoor expansion valve (51a, 51b, 51c, 51d) that decompresses the refrigerant;
a heat-exchange-side indoor liquid-refrigerant pipe (71a, 71b, 71c, 71d) that connects a liquid side of the indoor
heat exchanger to the indoor expansion valve; and
a connection-side indoor liquid-refrigerant pipe (72a, 72b, 72c, 72d) that connects the indoor expansion valve
25 to the liquid-refrigerant connection pipe, wherein
the indoor expansion valve is connected to the connection-side indoor liquid-refrigerant pipe by brazing, and
a brazing portion (82a, 82b, 82c, 82d) brazing the indoor expansion valve and the connection-side indoor liquid-
refrigerant pipe is provided with a coating material (11a, 11b, 11c, 11d).

30 **12.** The indoor unit according to claim 11, further comprising:

a gas-side shutoff valve (58a, 58b, 58c, 58d) that is connected to a gas side of the indoor heat exchanger;
a heat-exchange-side indoor gas-refrigerant pipe (76a, 76b) that connects the gas side of the indoor heat
exchanger to the gas-side shutoff valve; and
35 a connection-side indoor gas-refrigerant pipe (77a, 77b) that connects the gas-side shutoff valve to the gas-
refrigerant connection pipe, wherein
the gas-side shutoff valve is connected to the connection-side indoor gas-refrigerant pipe by brazing, and
a brazing portion (88a, 88b) brazing the gas-side shutoff valve and the connection-side indoor gas-refrigerant
pipe is also provided with a coating material (15a, 15b).

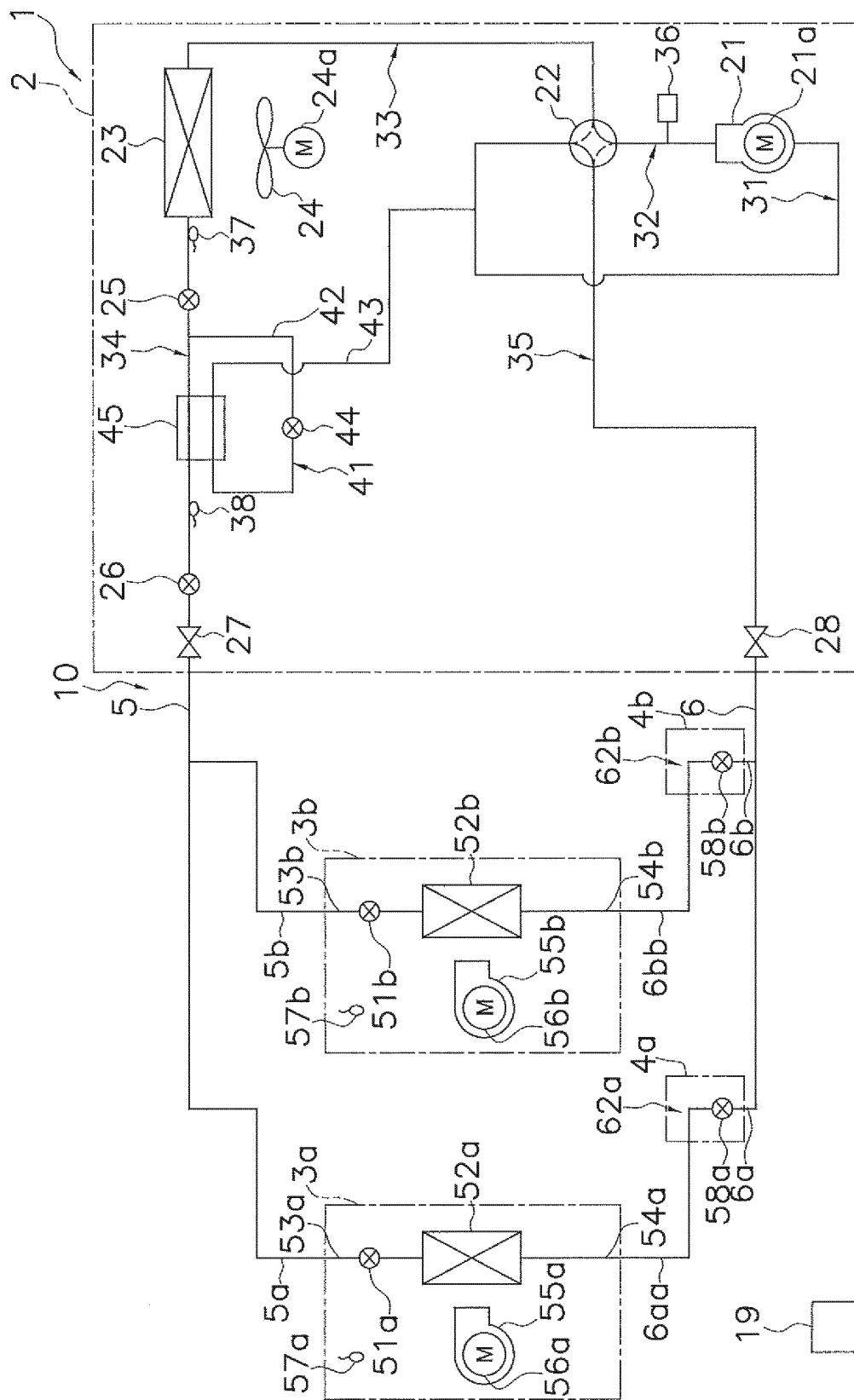


FIG. 1

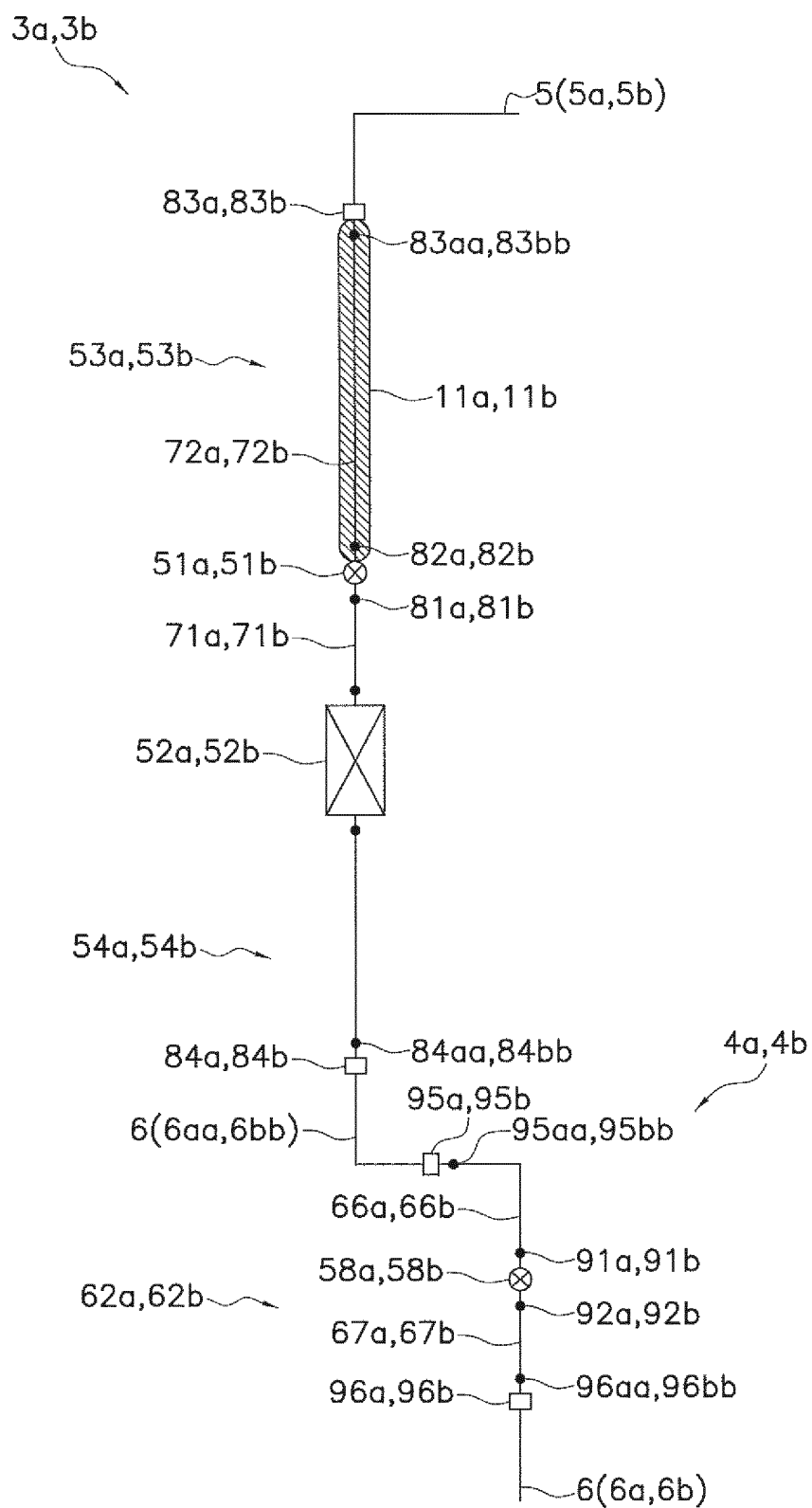


FIG. 2

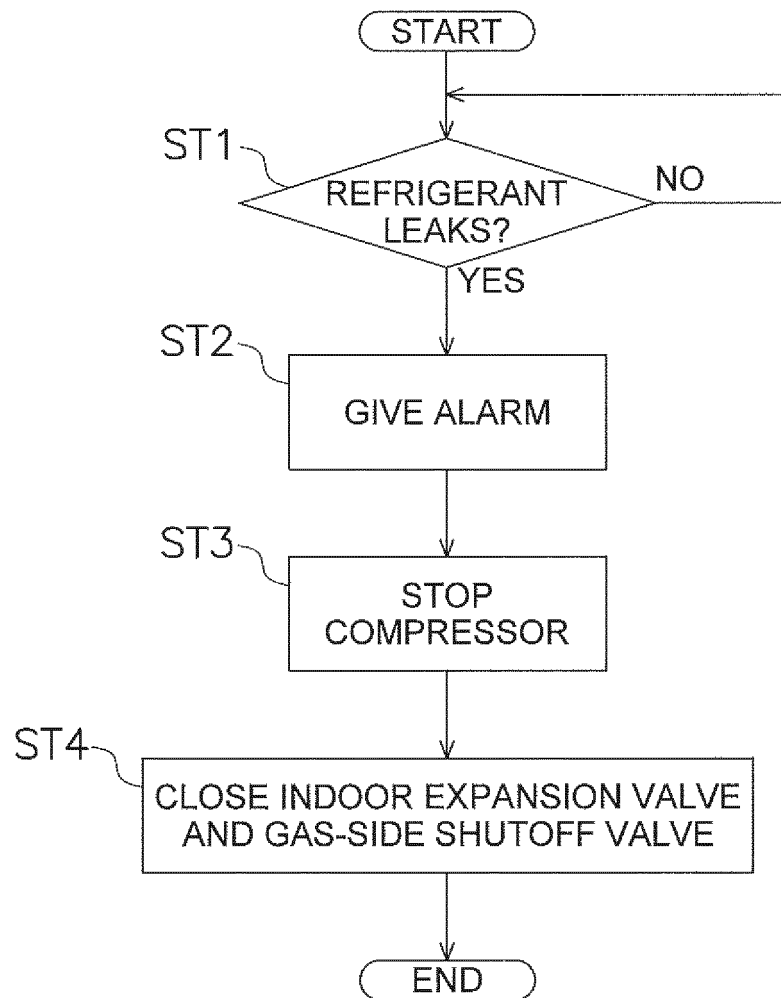


FIG. 3

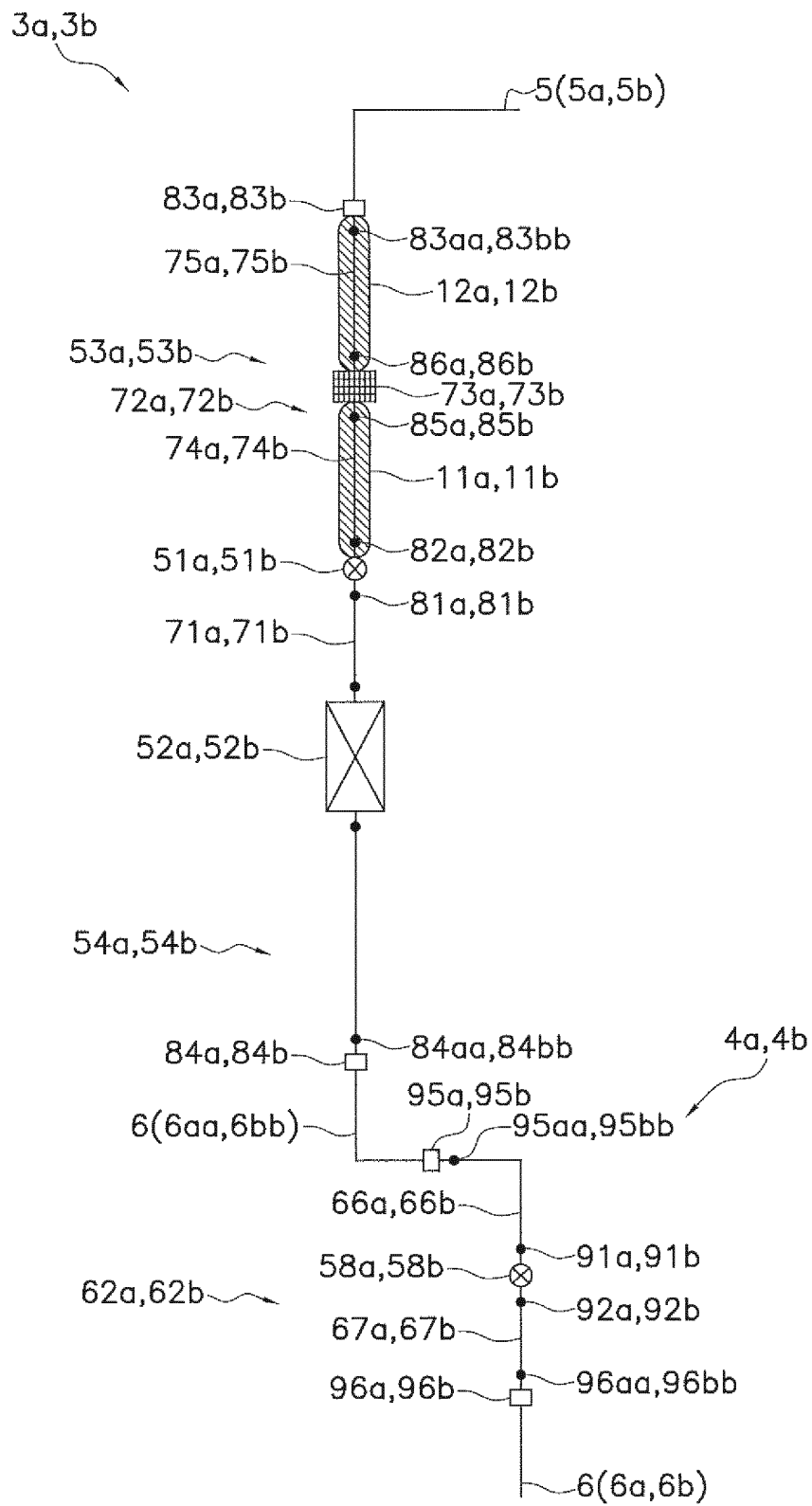


FIG. 4

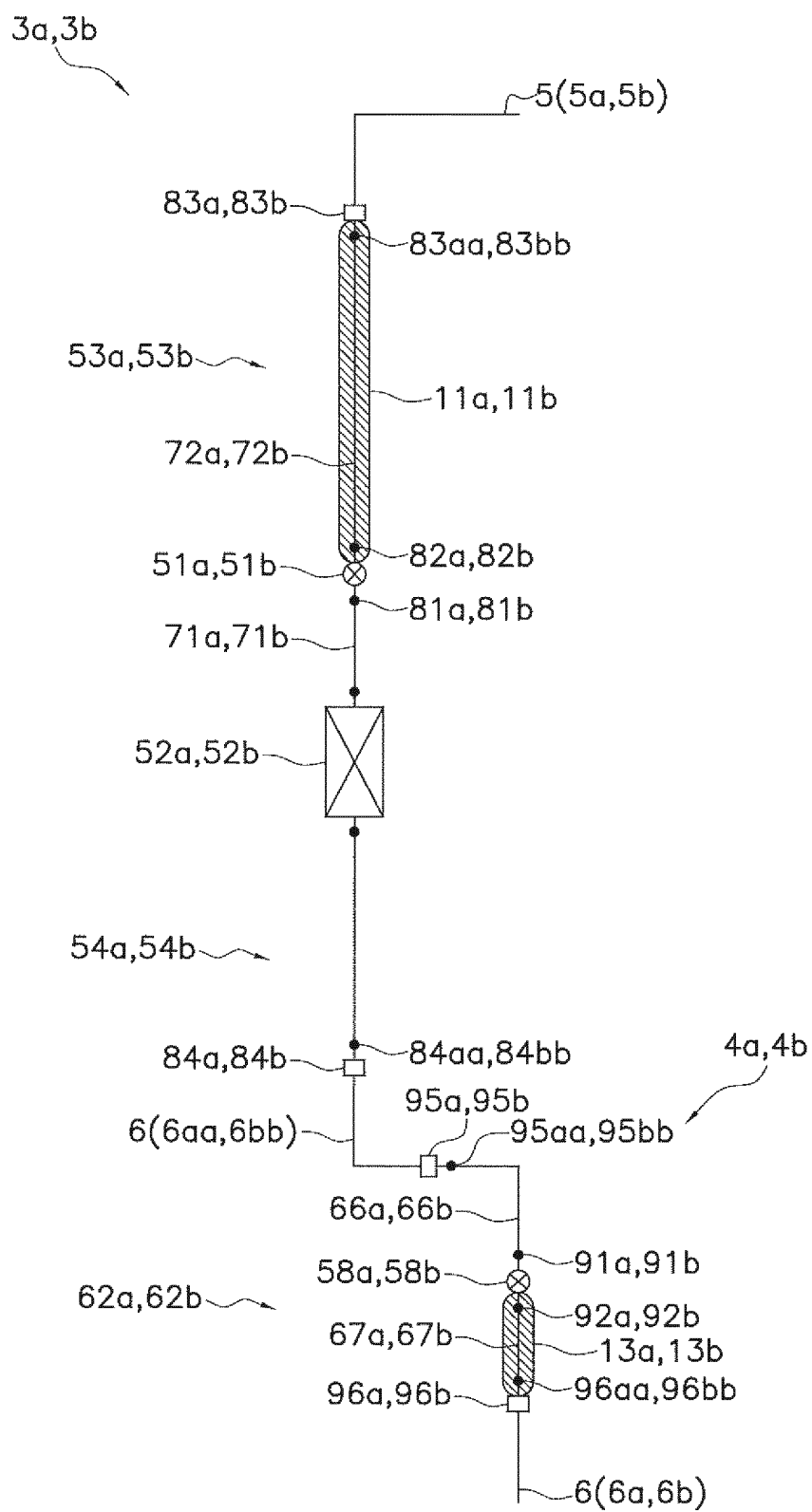


FIG. 5

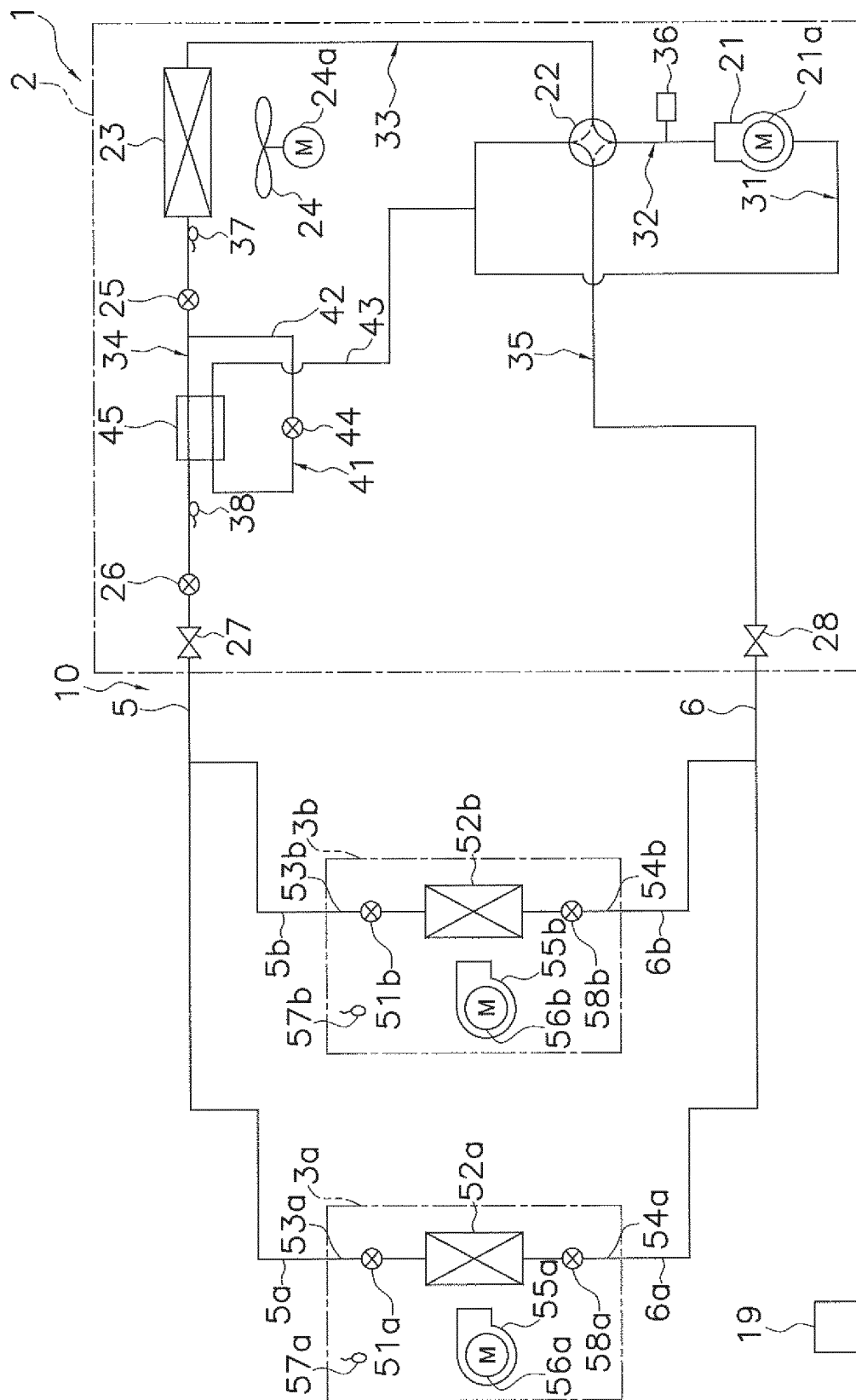


FIG. 6

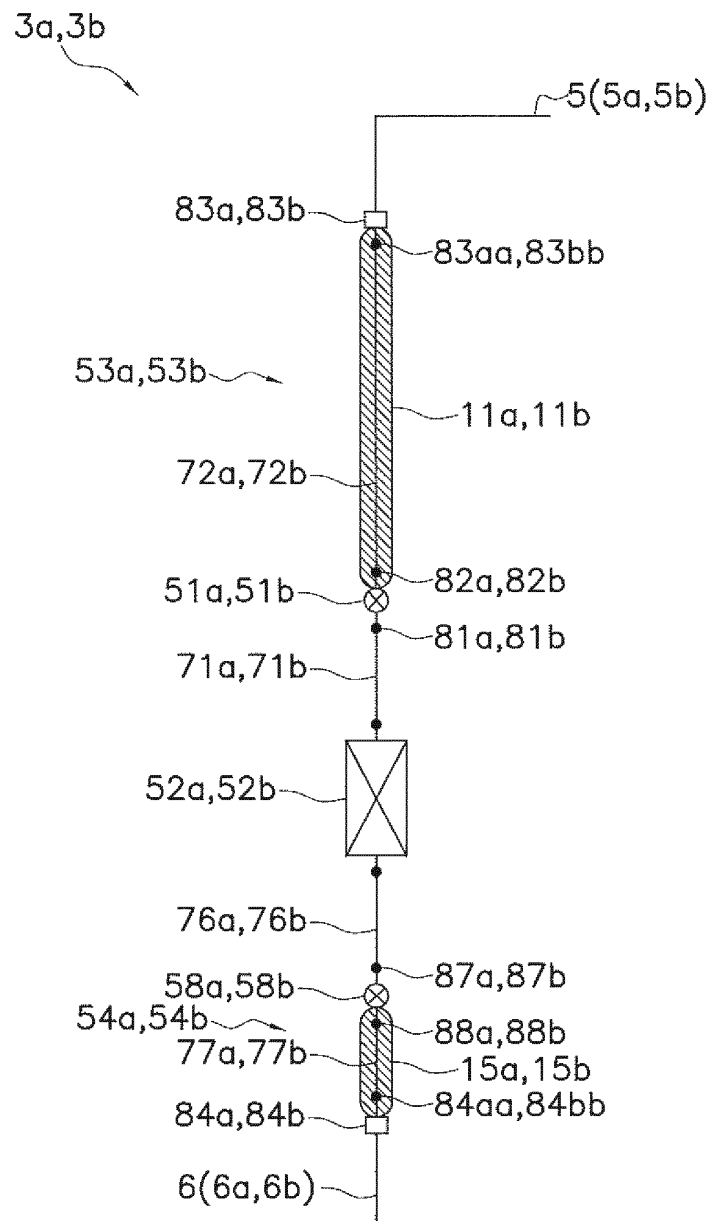


FIG. 7

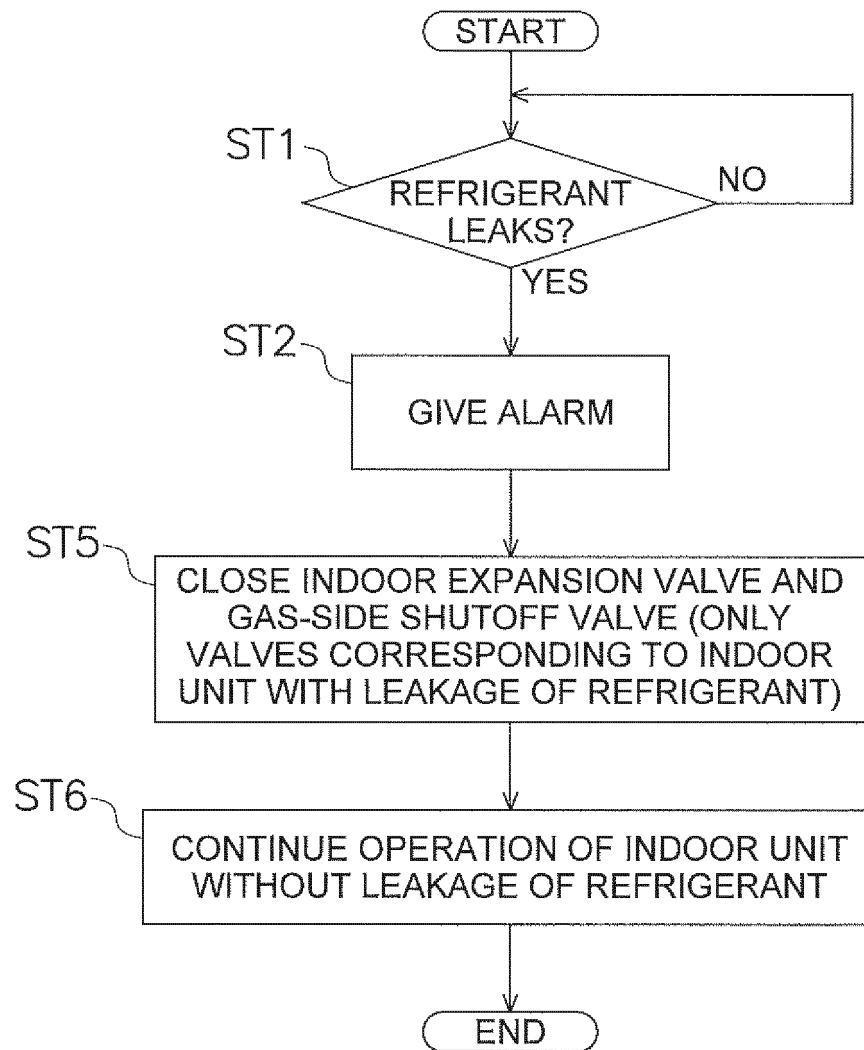


FIG. 8

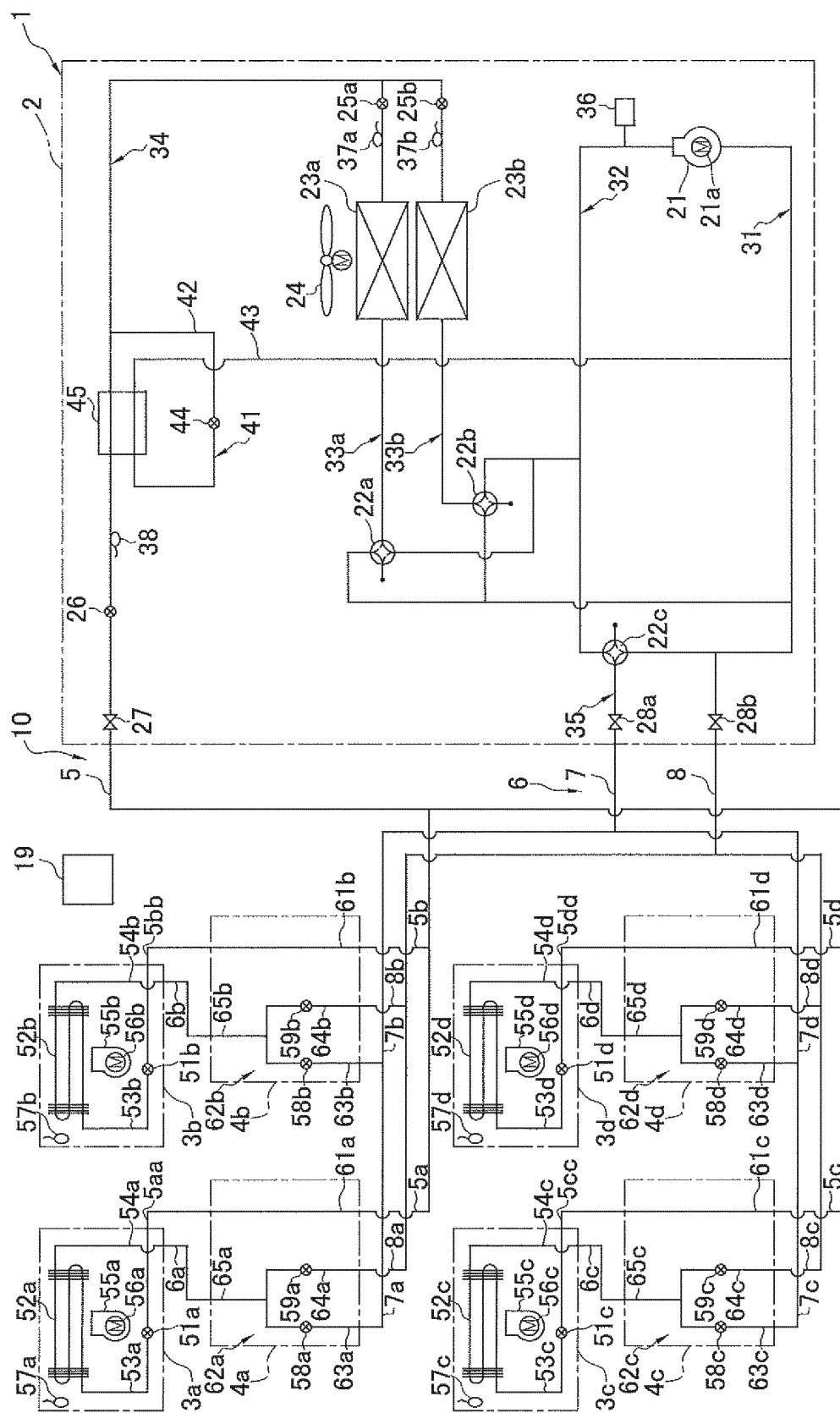


FIG. 9

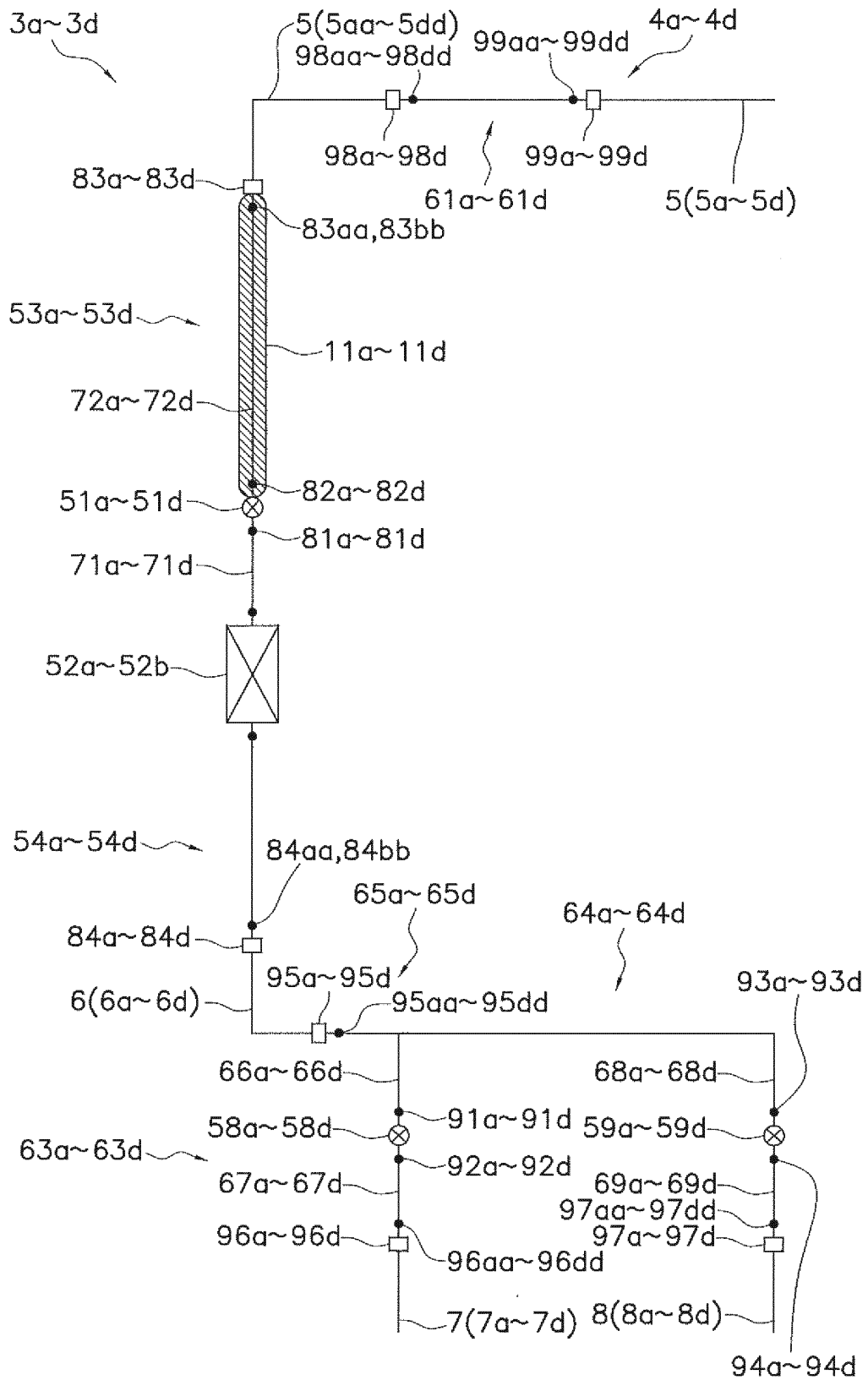


FIG. 10

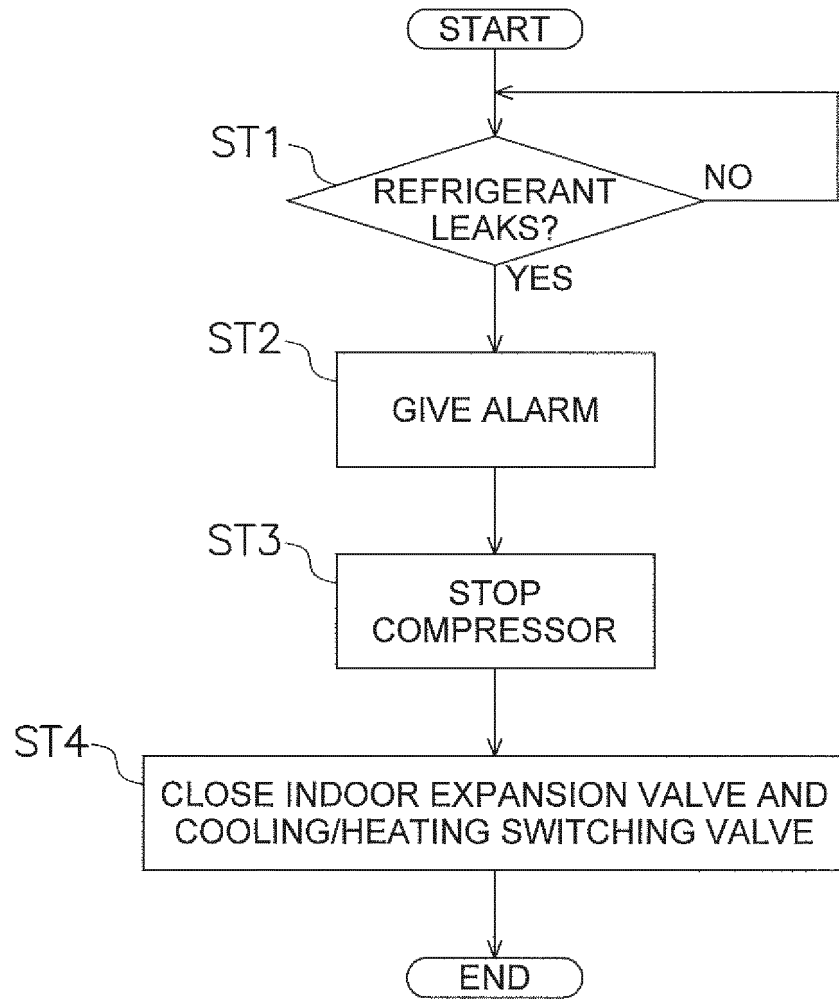


FIG. 11

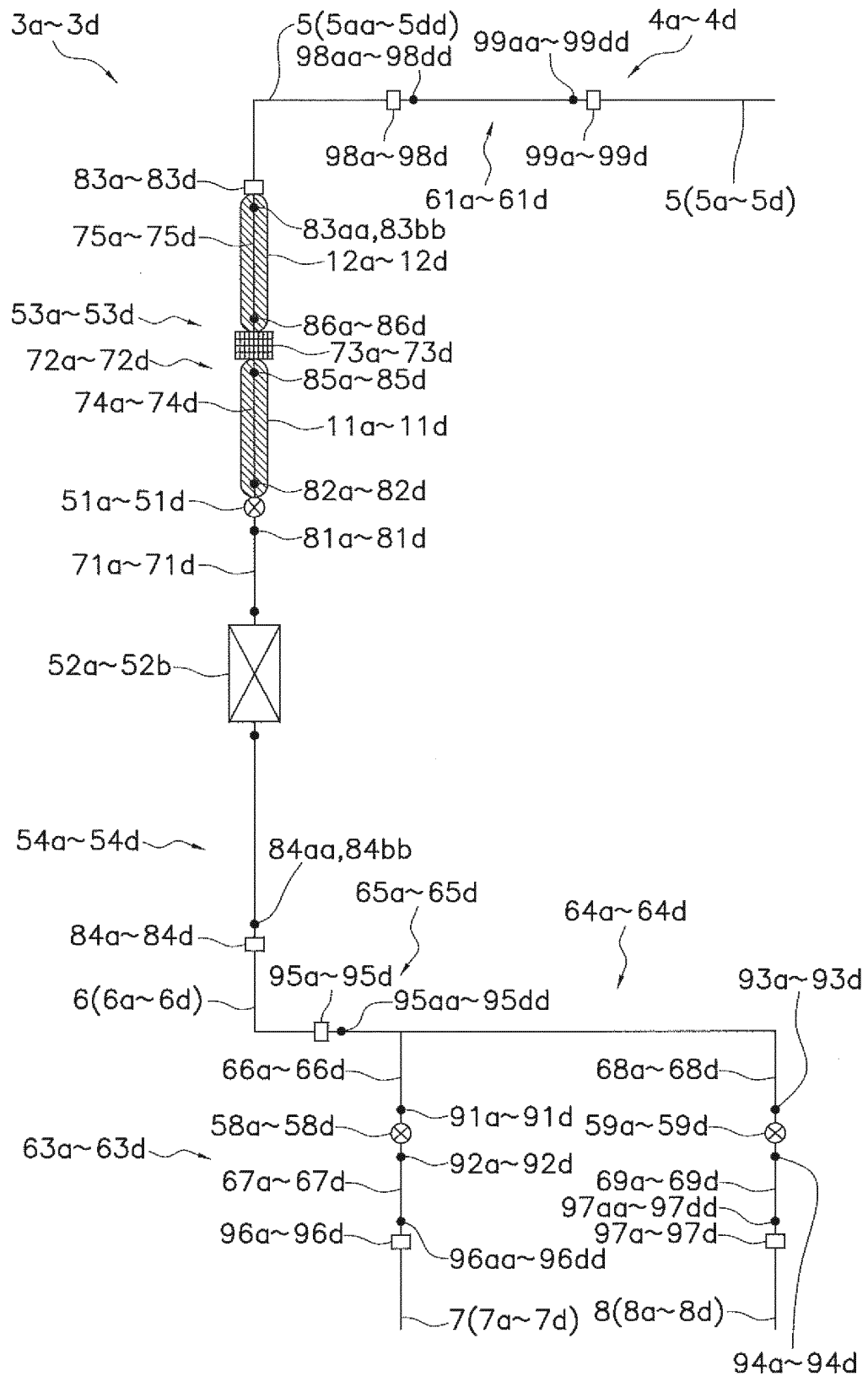


FIG. 12

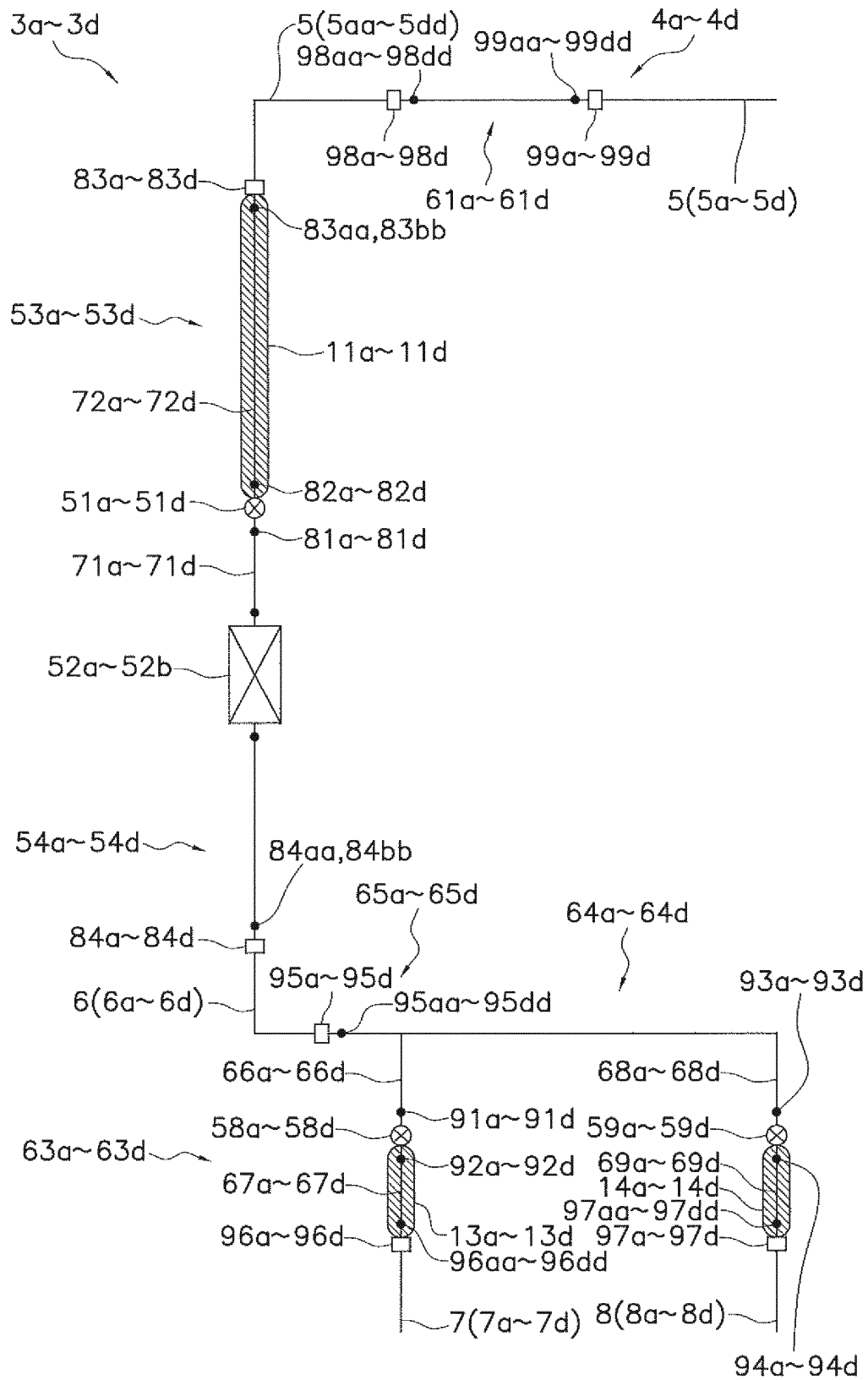


FIG. 13

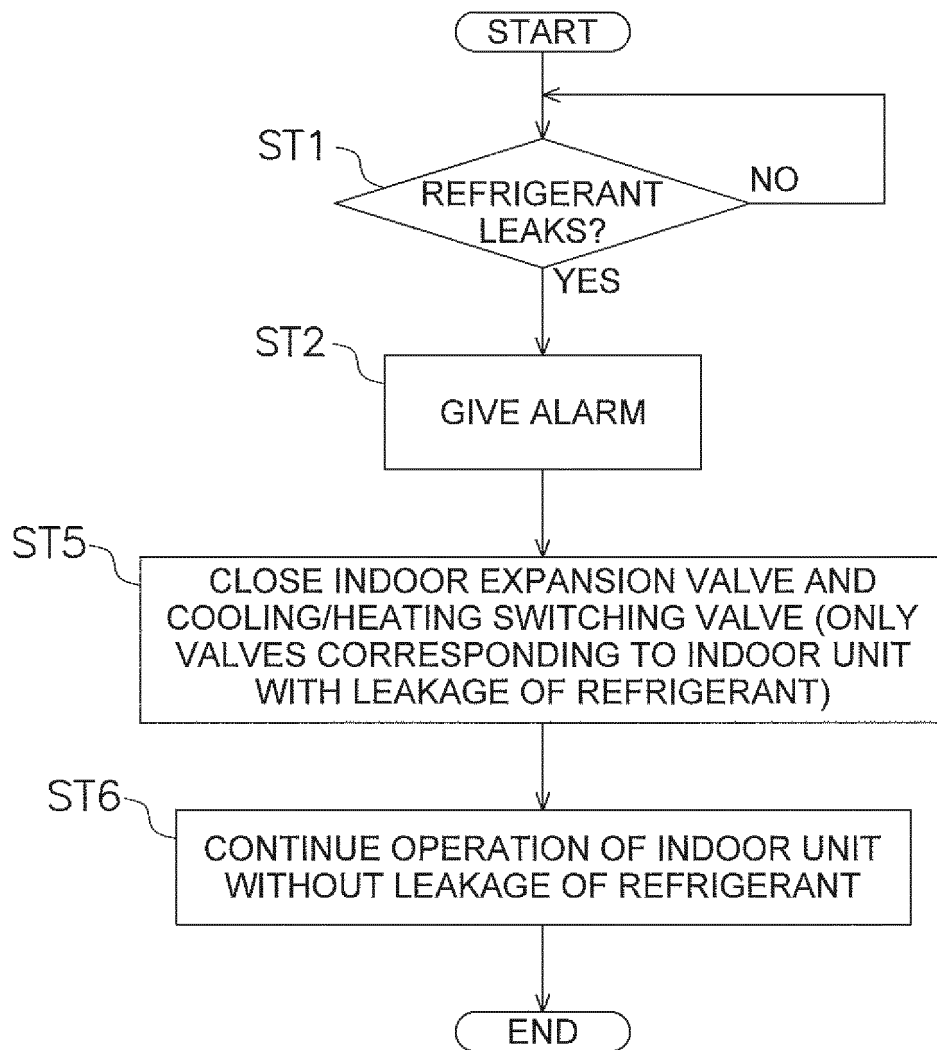


FIG. 14

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2017/046182

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. F24F11/84 (2018.01) i, F24F11/46 (2018.01) i, F24F11/49 (2018.01) i,
F24F11/88 (2018.01) i, F24F11/89 (2018.01) i, F24F11/00 (2018.01) i,
F25B41/00 (2006.01) i, F25B41/04 (2006.01) i, F25B49/02 (2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int.Cl. F24F11/84, F24F11/46, F24F11/49, F24F11/88, F24F11/89, F24F11/00,
F25B41/00, F25B41/04, F25B49/021

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996

Published unexamined utility model applications of Japan 1971-2018

Registered utility model specifications of Japan 1996-2018

Published registered utility model applications of Japan 1994-2018

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2016/208470 A1 (DAIKIN INDUSTRIES, LTD.) 29 December 2016, paragraphs [0107]-[0135], fig. 8-13 & JP 2017-009267 A	1-12
Y	JP 11-023104 A (HITACHI, LTD.) 26 January 1999, paragraph [0036], fig. 4 (Family: none)	1-12
Y	JP 2015-049016 A (SHINRYO CORPORATION) 16 March 2015, paragraph [0029], fig. 3 (Family: none)	1-12
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 068368/1989 (Laid-open No. 010172/1991) (MATSUSHITA REFRIGERATION COMPANY) 30 January 1991, specification, page 2, lines 2-15, fig. 3 (Family: none)	2-10
Y	WO 2016/204194 A1 (DAIKIN INDUSTRIES, LTD.) 22 December 2016, paragraphs [0058]-[0060], fig. 1, 3 & JP 2017-009155 A	3-10



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2017/046182

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2012-013339 A (HITACHI APPLIANCES, INC.) 19 January 2012, paragraphs [0017]-[0039], fig. 1-4 (Family: none)	5-10
Y	JP 02-052967 A (SANYO ELECTRIC CO., LTD.) 22 February 1990, page 3, upper left column, lines 7-20, fig. 2 (Family: none)	10, 12

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 2015029160 A [0002] [0221]