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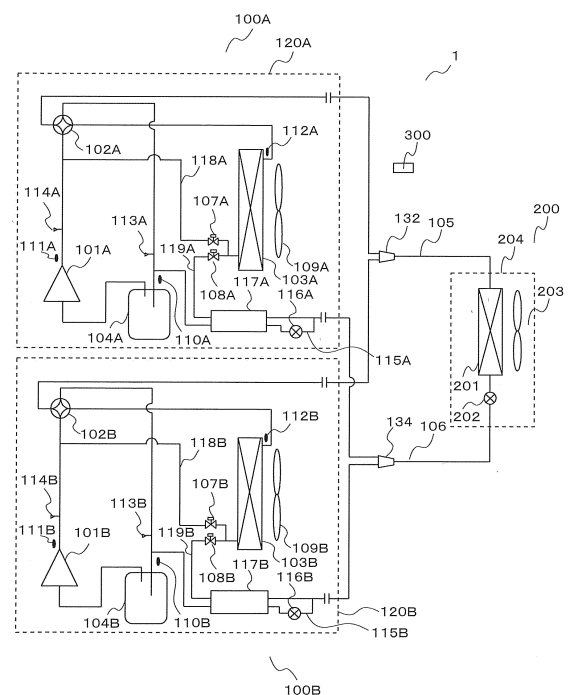
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(54) **AIR CONDITIONING DEVICE**

(57) An air-conditioning apparatus 1 includes at least two outdoor units on each of which a compressor 101 and an outdoor heat exchanger 103 are mounted and at least one indoor unit 200 on which an indoor expansion device and an indoor heat exchanger 201 are mounted, the at least one outdoor unit 100 performs a defrosting operation in which a first expansion device is opened, discharging refrigerant from the compressor 101 is bypassed to the outdoor heat exchanger 103 via a hot-gas bypass pipe 118, a third expansion device is closed, and an opening degree of a second expansion device is regulated while the other outdoor unit 100 is performing a heating operation.

FIG. 1



Description

Technical Field

[0001] The present invention relates to an air-conditioning apparatus for performing air-conditioning and the like by using a refrigeration cycle (heat-pump cycle) and particularly to an air-conditioning apparatus with improved comfort when an indoor unit is performing a heating operation.

Background Art

[0002] In a prior-art air-conditioning apparatus, when a heating operation is performed at a low outside temperature, there is a concern that a frost adheres to a fin surface and refrigerant pipes of an outdoor heat exchanger serving as an evaporator. When the frost adheres to the fin surface and the refrigerant pipes of the outdoor heat exchanger, an air-path pressure loss of the outdoor heat exchanger increases, and a heat transfer performance lowers. Thus, defrosting is needed by regularly performing a defrosting operation of the outdoor unit, but there is a problem that the heating operation should be stopped during the defrosting operation.

[0003] An air-conditioning apparatus including a plurality of outdoor units and performing the heating operation even during the defrosting operation to maintain comfort during the defrosting operation is disclosed (see Patent Literature 1 and Patent Literature 2, for example) to cope with the aforementioned problem.

[0004] In the air-conditioning apparatus (an air-conditioning system having two systems of outdoor units) including a plurality of outdoor units as described in Patent Literature 1 and Patent Literature 2, an intensity of a load of the entire system is determined when the defrosting operation is to be performed, and the defrosting operation is performed when a temperature on an indoor side lowers to result in a sense of discomfort, even if the defrosting operation is performed while the heating operation is continued.

Citation List

Patent Literature

[0005]

Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2008-175410 (see [0030] to [0047], Fig. 3, and Fig. 4, for example)
Patent Literature 2: Japanese Unexamined Patent Application Publication No. 2012-107790 (see [0030] to [0050], Fig. 1 and Fig. 2, for example)

Summary of Invention

Technical Problem

[0006] In an air-conditioning apparatus including a plurality of outdoor units as described in Patent Literature 1 and Patent Literature 2, when the defrosting operation is performed while the heating operation is continued, that is, when at least one outdoor unit performs the defrosting operation when the other outdoor units are performing the heating operation, due to a difference in operation cycles between the outdoor unit performing the heating operation (hereinafter referred to as a heating-operation side outdoor unit) and the outdoor unit performing the defrosting operation (hereinafter referred to as a defrosting-operation side outdoor unit), a refrigerant amount is biased to the heating-operation side outdoor unit.

[0007] Thus, when the defrosting operation is continued for a long time or repeated, the refrigerant amount runs short in the defrosting-operation side outdoor unit, which results in an excessive rise in a compressor discharge temperature or the like, while in the heating-operation side outdoor unit, the refrigerant amount increases and causes a liquid inflow (liquid-back) in a large quantity into the compressor or the like, and there is a problem that stable operation cannot be performed.

[0008] The present invention was made to solve the problems as above and has an object to provide an air-conditioning apparatus including a plurality of outdoor units, which corrects biased refrigerant amounts between outdoor units (between the heating-operation side outdoor unit and the defrosting-operation side outdoor unit) and performing a stable operation when the defrosting operation is performed while the heating operation is continued.

Solution to Problem

[0009] An air-conditioning apparatus according to an embodiment of the present invention includes at least two outdoor units on each of which a compressor and an outdoor heat exchanger are mounted and at least one indoor unit on which an indoor expansion device and an indoor heat exchanger are mounted, the outdoor unit is connected to the indoor unit in parallel, the compressor, the indoor heat exchanger, the indoor expansion device, and the outdoor heat exchanger are sequentially connected by pipes and constitute a refrigerant circuit through which refrigerant is circulated, in which the outdoor unit includes a hot-gas bypass pipe for bypassing discharging refrigerant from the compressor to the outdoor heat exchanger, a first expansion device for controlling a flow rate of the refrigerant flowing through the hot-gas bypass pipe, a liquid bypass pipe branching from a connection pipe for connecting the indoor unit and the outdoor heat exchanger and connected to a suction side of the compressor, a second expansion device for controlling a flow rate of the refrigerant flowing through the

liquid bypass pipe, and a third expansion device for controlling a flow rate of the refrigerant flowing through an outdoor-side connection pipe closer to the outdoor heat exchanger side than a branch point from the liquid bypass pipe in the connection pipe, and the at least one outdoor unit performs a defrosting operation in which the first expansion device is opened, the discharging refrigerant from the compressor is bypassed to the outdoor heat exchanger through the hot-gas bypass pipe, the third expansion device is closed, and an opening degree of the second expansion device is regulated when the other outdoor units are performing the heating operation.

Advantageous Effects of Invention

[0010] With the air-conditioning apparatus according to the embodiment of the present invention, since the at least one outdoor unit performs the defrosting operation in which the first expansion device is opened, the discharging refrigerant from the compressor is bypassed to the outdoor heat exchanger through the hot-gas bypass pipe, the third expansion device is closed, and the opening degree of the second expansion device is regulated when the other outdoor units are performing the heating operation, the bias in the refrigerant amount between the outdoor units can be corrected, and the stable operation can be performed without causing the excessive rise in the discharge temperature of the compressor, the liquid back or the like.

Brief Description of Drawings

[0011]

[Fig. 1] Fig. 1 is a refrigerant circuit diagram showing an example of an air-conditioning apparatus according to an embodiment of the present invention.

[Fig. 2] Fig. 2 is a control flowchart in a defrosting operation of the air-conditioning apparatus according to the embodiment of the present invention. Description of Embodiments

Embodiment.

[0012] Fig. 1 is a refrigerant circuit diagram showing an example of an air-conditioning apparatus 1 according to an embodiment of the present invention.

[0013] Hereinafter, a refrigerant circuit configuration of the air-conditioning apparatus 1 will be described based on Fig. 1. The air-conditioning apparatus 1 is installed in a building, an apartment and the like and capable of a cooling operation and a heating operation at the same time by using a refrigeration cycle (heat-pump cycle) for circulating refrigerant (refrigerant for air-conditioning). Moreover, the air-conditioning apparatus 1 performs a defrosting operation.

[0014] A relationship in size of each of constituent members might be different from the actual constituent

members in the following drawings including Fig. 1 in some cases. Moreover, the present invention is not limited to the embodiment described below.

[0015] The air-conditioning apparatus 1 according to this embodiment includes, as illustrated in Fig. 1, outdoor units (heat-source side units) 100A and 100B, an indoor unit (load side unit) 200, and a controller 300.

[0016] The outdoor units 100A and 100B are connected to the indoor unit 200 in parallel by refrigerant pipes, respectively, and constitute a refrigerant circuit that is an essential part and perform heating or cooling in a target space by causing the refrigerant to be circulated in the refrigerant circuit. The air-conditioning apparatus 1 is constituted such that the two outdoor units 100A and 100B are connected to the single indoor unit 200, however, the configuration is not particularly limited as long as there is a plurality (two units) or more of the outdoor units 100.

[0017] Moreover, in Fig. 1, "A" is added to reference numeral of each device provided in the outdoor unit 100A, while "B" is added to reference numeral of each device provided in the outdoor unit 100B in the drawings. In the following explanation, "A" and "B" after reference numerals might be omitted in some cases, but it is needless to say that each device is provided in the both outdoor unit 100A and outdoor unit 100B.

[0018] The refrigerant pipe includes a gas pipe 105 through which a gas refrigerant (gas refrigerant) flows and a liquid pipe 106 through which a liquid refrigerant (liquid refrigerant or two-phase gas-liquid refrigerant) flows. The refrigerant circulated in the refrigerant circuit is not particularly limited and it is R410A, R404A, HFO (hydro fluoro olefin) or the like that is an HFC-based refrigerant or CO₂, ammonium or the like that is a natural refrigerant.

[0019] The outdoor unit 100A includes a compressor 101 A, a four-way valve 102A, an outdoor heat exchanger (heat-source side heat exchanger) 103A, an accumulator 104A, a first valve 107A, a second valve 108A, a fan 109A, a first temperature sensor 110A, a second temperature sensor 111A, a third temperature sensor 112A, a first pressure sensor 113A, a second pressure sensor 114A, a liquid bypass pipe 115A, a bypass expansion device 116A, a refrigerant heat exchanger 117A, a hot-gas bypass pipe 118A, and an outdoor-side connection pipe 119A and the constitution is accommodated in a main body case 120A.

[0020] The indoor unit 200 includes an indoor heat exchanger (load-side heat exchanger) 201, an expansion unit 202, and a fan 203, and the constitution is accommodated in a housing 204.

[0021] In the refrigerant circuit of the air-conditioning apparatus 1 for the outdoor unit 100A and the indoor unit 200, the compressor 101 A, the four-way valve 102A, the indoor heat exchanger 201, the expansion unit 202, the refrigerant heat exchanger 117A, the outdoor heat exchanger 103A, and the accumulator 104A are sequentially connected by pipes. In the outdoor unit 100A, the

hot-gas bypass pipe 118A for bypassing discharging refrigerant flowing from the compressor 101 A toward the four-way valve 102A to the outdoor heat exchanger 103A so that it flows to the outdoor heat exchanger 103A without passing through the four-way valve 102A is provided. Moreover, the liquid bypass pipe 115A for bypassing low-temperature refrigerant flowing from the indoor unit 200 toward the outdoor heat exchanger 103A to an inlet of the accumulator 104A (suction side of the compressor 101 A) is provided.

[0022] The compressor 101 A compresses to turn the suctioned refrigerant in a high-temperature/high-pressure state. The four-way valve 102A switches a flow of the refrigerant flowing through the refrigerant circuit between a cooling operation and a heating operation.

[0023] The outdoor heat exchanger 103A exchanges heat between ambient air and the refrigerant flowing in the outdoor heat exchanger 103A. The outdoor heat exchanger 103A serves as an evaporator, for example, and evaporates and gasifies the refrigerant. Alternatively, the outdoor heat exchanger 103A serves as a radiator (condenser) and condenses and liquefies the refrigerant.

[0024] In this embodiment, an example in which the outdoor unit 100A includes a single heat exchanger will be described, but it may be constituted including a plurality of heat exchangers.

[0025] The fan 109A is configured to blow air to the outdoor heat exchanger 103A. The accumulator 104A is disposed between the suction side of the compressor 101 A and the four-way valve 102A and stores excess refrigerant. The accumulator 104A is a container for storing the excess refrigerant, for example.

[0026] The bypass expansion device 116A is disposed at a position at which the bypass expansion device 116A can regulate a passage of the liquid bypass pipe 115A. The refrigerant heat exchanger 117A is disposed in a passage of the outdoor-side connection pipe 119A closer to the outdoor heat exchanger 103A side than a branch point to the liquid bypass pipe 115A and in a passage of the liquid bypass pipe 115A in the connection pipes between the expansion unit 202 and the outdoor heat exchanger 103A.

[0027] The bypass expansion device 116A and the refrigerant heat exchanger 117A are devices for exchanging heat between refrigerant in a liquid (liquid refrigerant) (high-temperature, high-pressure) flowing out of the outdoor heat exchanger 103A and refrigerant at a low-temperature low-pressure subjected to flow rate control by the bypass expansion device 116A during the cooling operation and for supercooling the refrigerant to be supplied to the indoor unit 200, for example. The liquid flowing through the bypass expansion device 116A is returned to the accumulator 104A via the liquid bypass pipe 115A.

[0028] A first valve 107A and a second valve 108A are solenoid valves, for example, and control the flow rate of the refrigerant flowing through the refrigerant circuit by regulating the opening degrees thereof. The first valve

107A is disposed at a position at which the first valve 107A can control a passage of the hot-gas bypass pipe 118A. The second valve 108A is disposed at a position at which the second valve 108A can control a passage of the outdoor-side connection pipe 119A.

[0029] The first valve 107A and the second valve 108A may be opening and closing valves. Moreover, it may be so constituted that a three-way valve is provided instead of the first valve 107A and the second valve 108A for switching between the passage of the hot-gas bypass pipe 118A and the passage between a header 134 and the outdoor heat exchanger 103A.

[0030] The first pressure sensor 113A is a sensor for detecting a pressure of the refrigerant and detects a pressure of the refrigerant flowing into the accumulator 104A (or a pressure of the refrigerant on the suction side of the compressor 101 A).

[0031] The first temperature sensor 110A is a thermistor, for example, and detects a temperature of the refrigerant flowing into the accumulator 104A (or a temperature of the refrigerant on the suction side of the compressor 101 A).

[0032] A saturation temperature of the refrigerant flowing into the accumulator 104A is obtained from the pressure of the first pressure sensor 113A, and whether a state of the refrigerant flowing into the accumulator 104A is a superheated gas or not can be determined by comparing the saturation temperature with the temperature of the first temperature sensor 110A.

[0033] The second pressure sensor 114A is a sensor for detecting a pressure of the refrigerant and detects a pressure of the refrigerant discharged from the compressor 101A.

[0034] The second temperature sensor 111A is a thermistor, for example, and detects a temperature of the refrigerant discharged from the compressor 101 A.

[0035] A saturation temperature of the refrigerant discharged from the compressor 101A is obtained from the pressure of the second pressure sensor 114A, and whether a state of the refrigerant discharged from the compressor 101A is a superheated gas or not can be determined by comparing it with the temperature of the second temperature sensor 111A.

[0036] The third temperature sensor 112A is a thermistor, for example, and detects a temperature of the refrigerant flowing through the outdoor heat exchanger 103A. The third temperature sensor 112A is installed between the outdoor heat exchanger 103A and the four-way valve 102A so that the third temperature sensor 112A detects a refrigerant temperature on a refrigerant outflow side in a cooling operation or in a defrosting operation and detects the refrigerant temperature on a refrigerant inflow side in the heating operation. Therefore, based on a detection result of the third temperature sensor 112A, it can be determined whether the outdoor unit 100A is performing a defrosting operation or performing a heating operation.

[0037] The indoor heat exchanger 201 exchanges heat

between ambient air and the refrigerant flowing in the indoor heat exchanger 201. The indoor heat exchanger 201 serves as an evaporator, for example, and evaporates and gasifies the refrigerant. Alternatively, the indoor heat exchanger 201 serves as a radiator (condenser) and condenses and liquefies the refrigerant.

[0038] The expansion unit 202 serves as a pressure reducing valve or an expansion valve, and reduces or expands a pressure of the refrigerant. The expansion unit 202 is an electronic expansion valve capable of variable control of an opening degree, for example, and executes fine flow control by regulating the opening degree. The expansion unit 202 may be inexpensive refrigerant flow control means such as a capillary tube.

[0039] The outdoor unit 100B includes a compressor 101 B, a four-way valve 102B, an outdoor heat exchanger (heat-source side heat exchanger) 103B, an accumulator 104B, a first valve 107B, a second valve 108B, a fan 109B, a first temperature sensor 110B, a second temperature sensor 111 B, a third temperature sensor 112B, a first pressure sensor 113B, a second pressure sensor 114B, a liquid bypass pipe 115B, a bypass expansion device 116B, a refrigerant heat exchanger 117B, and a hot-gas bypass pipe 118B, and these constitutions are accommodated in a main body case 120B.

[0040] For example, the compressor 101 B of the outdoor unit 100B corresponds to the compressor 101A of the outdoor unit 100A. The four-way valve 102B, the outdoor heat exchanger 103B, the accumulator 104B, the first valve 107B, the second valve 108B, the fan 109B, the first temperature sensor 110B, the second temperature sensor 111 B, the third temperature sensor 112B, the first pressure sensor 113B, the second pressure sensor 114B, the liquid bypass pipe 115B, the bypass expansion device 116B, the refrigerant heat exchanger 117B, the hot-gas bypass pipe 118B, and the outdoor-side connection pipe 119B also correspond to each of those with the same reference numerals of the outdoor unit 100A.

[0041] Since the outdoor unit 100B has constitution similar to that of the outdoor unit 100A, detailed description will be omitted. Moreover, since the refrigerant circuit of the air-conditioning apparatus 1 for the outdoor unit 100B and the indoor unit 200 is also similar to the refrigerant circuit of the air-conditioning apparatus 1 for the outdoor unit 100A and the indoor unit 200, the detailed description will be omitted.

[0042] The outdoor unit 100A and the outdoor unit 100B may be disposed in the same housing.

[0043] Moreover, as a unit for switching a flow of the refrigerant flowing through the refrigerant circuit, a two-way valve and a three-way valve may be used in combination instead of the four-way valve 102.

[0044] Moreover, the air-conditioning apparatus 1 according to this embodiment is assumed to perform the cooling operation and the heating operation but it may be so constituted that the cooling operation is not performed and in that case, the four-way valve 102 is not

needed.

[0045] The outdoor units 100A and 100B and the indoor unit 200 are connected by the gas pipe 105 and the liquid pipe 106 via headers 132 and 134. In the heating operation, the refrigerant flowing out of the outdoor units 100A and 100B merges at the header 132, while the refrigerant flowing out of the indoor unit 200 branches at the header 134. Moreover, in the cooling operation, the refrigerant flowing out of the outdoor units 100A and 100B merges at the header 134, while the refrigerant flowing out of the indoor unit 200 branches at the header 132.

[0046] The controller 300 is constituted by a microcomputer or the like, for example, and controls the outdoor units 100 and the indoor unit 200 of the air-conditioning apparatus 1 in accordance with various operations. In this embodiment, the controller 300 controls the bypass expansion device 116 in accordance with each value of the first pressure sensor 113A, the first temperature sensor 110A, the second pressure sensor 114A, and the second temperature sensor 111A.

[0047] The bypass expansion device 116 corresponds to the "second expansion device" of the present invention, the first valve 107 to the "first expansion device" of the present invention, the second valve 108 to the "third expansion device" of the present invention, and the expansion unit 202 to the "indoor expansion device" of the present invention.

[0048] Subsequently, an operation of the air-conditioning apparatus 1 in the heating operation will be described.

[0049] In the following description, a high pressure or a low pressure is assumed to mean a relative relationship of a pressure in the refrigerant circuit. A high temperature or a low temperature is, likewise, assumed to mean a relative relationship of a temperature in the refrigerant circuit. Moreover, a main entity of the operation of the air-conditioning apparatus 1 described below is the controller 300.

[0050] When the heating operation is to be performed in the outdoor units 100A and 100B, the first valves 107A and 107B are closed, and the second valves 108A and 108B are opened.

[0051] The high-temperature/high-pressure gas (gas) refrigerant pressurized in the compressors 101A and 101 B in the outdoor units 100A and 100B flows into the header 132 via the four-way valves 102A and 102B. The gas refrigerant pressurized in the compressor 101 A and the gas refrigerant pressurized in the compressor 101 B merge at the header 132 and flows into the indoor unit 200.

[0052] The gas refrigerant having flowed into the indoor unit 200 passes through the indoor heat exchanger 201, exchanges heat with ambient air and is condensed. Then, the pressure of the refrigerant having flowed out of the indoor heat exchanger 201 is controlled by the expansion unit 202, and the liquid at an intermediate pressure or the refrigerant in the two-phase gas-liquid state branches at the header 134 and flows into the outdoor units 100A and 100B.

[0053] The refrigerant having flowed into the outdoor units 100A and 100B exchanges heat with the ambient air by passing through the outdoor heat exchangers 103A and 103B and is evaporated and becomes gas refrigerant. This gas refrigerant is suctioned into the compressors 101 A and 101 B via the four-way valves 102A and 102B and the accumulators 104A and 104B. The refrigerant having been suctioned into the compressors 101A and 101 B is pressurized again and is discharged.

[0054] Subsequently, an operation of the air-conditioning apparatus 1 according to this embodiment in the defrosting operation will be described.

[0055] In the following description, an example in which the defrosting operation is performed in the outdoor unit 100A will be described. At this time, the heating operation is performed in the outdoor unit 100B. It may be so constituted that the defrosting operation is performed in the outdoor unit 100B, and the heating operation is performed in the outdoor unit 100A.

[0056] As described below, the air-conditioning apparatus 1 performs the defrosting operation while the heating operation is continued by performing the defrosting operation in either one of the outdoor unit 100A and the outdoor unit 100B and by performing the heating operation in the other of the outdoor unit 100A and the outdoor unit 100B.

[0057] When the defrosting operation is to be performed in the outdoor unit 100A, the first valve 107A is opened, and the second valve 108A is closed. As a result, a part of the high-temperature refrigerant discharged from the compressor 101 A passes through the first valve 107A and flows into the outdoor heat exchanger 103A. In the high-temperature refrigerant discharged from the compressor 101 A, a part other than those flowing into the outdoor heat exchanger 103A flows into the header 132 and merges with the refrigerant having flowed out of the outdoor unit 100B at the header 132 and flows into the indoor unit 200.

[0058] When the high-temperature refrigerant flows into the outdoor heat exchanger 103A, heat exchange is performed between the high-temperature gas refrigerant and frost adhered to the outdoor heat exchanger 103A. Specifically, the frost adhered to the outdoor heat exchanger 103A takes away heat of the high-temperature gas refrigerant. As a result, the frost having adhered to the outdoor heat exchanger 103A is melted and flows down. Since the second valve 108A is closed at this time, the low-temperature refrigerant from the liquid pipe 106 does not flow into the outdoor heat exchanger 103A.

[0059] When the defrosting operation is performed in the outdoor unit 100A, the heating operation is performed in the outdoor unit 100B. That is, the high-temperature/high-pressure gas refrigerant pressurized in the compressor 101 B passes through the gas pipe 105 and flows into the indoor unit 200. The gas refrigerant having flowed into the indoor unit 200 passes through the indoor heat exchanger 201 and becomes the liquid at the intermediate pressure or brings into the two-phase gas-liquid

state. The liquid at the intermediate pressure or the refrigerant in the two-phase gas-liquid state passes through the liquid pipe 106 and passes through the outdoor heat exchanger 103B of the outdoor unit 100B and becomes the gas refrigerant. This gas refrigerant is suctioned into the compressor 101 A again and is pressurized and discharged.

[0060] As described above, in the defrosting operation of the air-conditioning apparatus 1 according to this embodiment, in the outdoor unit 100A, a part of the high-temperature refrigerant discharged from the compressor 101A flows into the indoor heat exchanger 201 of the indoor unit 200. However, the low-temperature refrigerant having flowed out of the indoor unit 200 does not flow into the outdoor unit 100A since the second valve 108A is closed and thus, a refrigerant amount is biased to the outdoor unit 100B into which the low-temperature refrigerant flows.

[0061] Thus, during the defrosting operation, the bypass expansion device 116A of the outdoor unit 100A is opened so that the low-temperature refrigerant from the liquid pipe 106 passes through the liquid bypass pipe 115A and is returned also to (the accumulator 104A of) the outdoor unit 100A without passing through the outdoor heat exchanger 103A. As a result, the liquid refrigerant is returned also to the outdoor unit 100A without lowering the defrosting performance of the air-conditioning apparatus 1, and bias in the refrigerant amount between the outdoor units 100 (between the outdoor unit 100A and the outdoor unit 100B) can be prevented.

[0062] The liquid bypass pipe 115A and the bypass expansion device 116A can be used for supercooling the refrigerant to be supplied to the indoor unit 200 in the cooling operation in the refrigerant heat exchanger 117A.

[0063] Fig. 2 is a control flowchart in the defrosting operation of the air-conditioning apparatus 1 according to the embodiment of the present invention.

[0064] Fig. 2 is a flowchart illustrating a control flow relating to opening-degree control of the bypass expansion device 116A for preventing bias in the refrigerant amount between the outdoor units 100 in the defrosting operation. The bias in the refrigerant amount between the outdoor units 100 is determined by a degree of superheat (SH-A) of the refrigerant at the accumulator 104A inlet (or the suction side of the compressor 101 A) of the outdoor unit 100A performing the defrosting operation.

[0065] The degree of superheat (SH-A) of the refrigerant at the accumulator 104A inlet is calculated from a difference between the saturation temperature acquired from a value of the first pressure sensor 113A and a value of the first temperature sensor 110A (STEP11).

[0066] When SH-A acquired from the above is 3 degrees C (a first threshold value determined in advance) or more, it is determined that the liquid refrigerant has not been returned to the outdoor unit 100A, and the bypass expansion device 116A is opened only by a value X determined in advance (the opening degree of the bypass expansion device 116A is set to +X). On the other

hand, when SH-A is less than 3 degrees C, the opening degree of the bypass expansion device 116A is not changed (STEP12).

[0067] Whether excess refrigerant has been returned or not to the outdoor unit 100A is determined by the degree of superheat (TdSH-A) of the refrigerant on a discharge side of the compressor 101 A of the outdoor unit 100A performing the defrosting operation. The degree of superheat (TdSH-A) of the refrigerant on the discharge side of the compressor 101 A is calculated from a difference between the saturation temperature acquired from a value of the second pressure sensor 114A and a value of the second temperature sensor 111 A (STEP13).

[0068] When TdSH-A acquired from the above is less than 20 degrees C (a second threshold value determined in advance), it is determined that the excess liquid refrigerant has been returned to the outdoor unit 100A, and the bypass expansion device 116A is closed only by the value X determined in advance (the opening degree of the bypass expansion device 116A is set to -X). On the other hand, when TdSH-A is 20 degrees C or more, the opening degree of the bypass expansion device 116A is not changed (STEP14).

[0069] By executing processing of the aforementioned STEP11 to STEP14 at certain intervals, the liquid refrigerant flowing into the outdoor unit 100A performing the defrosting operation is controlled, and the bias in the refrigerant amount between the outdoor units 100 can be corrected.

[0070] The refrigerant control illustrated in Fig. 2 is also applied similarly when the outdoor unit 100 performing the defrosting operation is switched or in the case where the number of the outdoor units 100 is three or more.

[0071] As described above, with the air-conditioning apparatus 1 according to this embodiment, when the other outdoor unit 100 is performing the heating operation, at least one unit of the outdoor unit 100 performs the defrosting operation in which the first valve 107 is opened, the discharging refrigerant from the compressor 101 is bypassed to the outdoor heat exchanger 103 via the hot-gas bypass pipe 118, the second valve 108 is closed, and the opening degree of the bypass expansion device 116 is regulated, whereby the bias in the refrigerant amount between the outdoor units 100 can be corrected, and stable operation can be performed without causing the excessive rise in the discharge temperature of the compressor 101, the liquid back or the like.

[0072] Regarding the control of the opening degree of the bypass expansion device 116 in detail, the opening degree of the bypass expansion device 116 is regulated in accordance with the degree of superheat (SH-A) of the refrigerant at the inlet of the accumulator 104 and the degree of superheat (TdSH-A) of the refrigerant on the discharge side of the compressor 101 A. Then, the low-temperature refrigerant from the liquid pipe 106 is returned also to (the accumulator 104 of) the outdoor unit 100 performing the defrosting operation via the liquid bypass pipe 115 without passing through the outdoor heat

exchanger 103. As a result, when the defrosting operation is performed while the heating operation is continued, the bias in the refrigerant amount between the outdoor units 100 can be corrected, and stable operation can be performed without causing the excessive rise in the discharge temperature of the compressor 101, the liquid back or the like.

[0073] The first threshold value and the second threshold value are not limited to the aforementioned values but are determined in accordance with a type of the refrigerant and the like. Moreover, a value at which the bypass expansion device 116A is opened when the value is the first threshold value or more and a value at which the bypass expansion device 116A is closed when the value is less than the second threshold value may be different values.

Reference Signs List

[0074] 1 air-conditioning apparatus, 100A outdoor unit, 100B outdoor unit, 101A compressor, 101 B compressor, 102A four-way valve, 102B four-way valve, 103A outdoor heat exchanger, 103B outdoor heat exchanger, 104A accumulator, 104B accumulator, 105 gas pipe, 106 liquid pipe, 107A first valve, 107B first valve, 108A second valve, 108B second valve, 109A fan, 109B fan, 110A first temperature sensor, 110B first temperature sensor, 111A second temperature sensor, 111 B second temperature sensor, 112A third temperature sensor, 112B third temperature sensor, 113A first pressure sensor, 113B first pressure sensor, 114A second pressure sensor, 114B second pressure sensor, 115A liquid bypass pipe, 115B liquid bypass pipe, 116A bypass expansion device, 116B bypass expansion device, 117A refrigerant heat exchanger, 117B refrigerant heat exchanger, 118A hot-gas bypass pipe, 118B hot-gas bypass pipe, 119A outdoor-side connection pipe, 119B outdoor-side connection pipe, 120A main body case, 120B main body case, 132 header, 134 header, 200 indoor unit, 201 indoor heat exchanger, 202 expansion unit, 203 fan, 204 housing, 300 controller.

Claims

1. An air-conditioning apparatus comprising:

at least two outdoor units on each of which a compressor and an outdoor heat exchanger are mounted; and
at least one indoor unit on which an indoor expansion device and an indoor heat exchanger are mounted,

the outdoor units being connected to the indoor unit in parallel,
the compressor, the indoor heat exchanger, the indoor expansion device, and the outdoor heat exchanger being sequentially connected by pipes and constituting a refrigerant circuit in which refrigerant is circulated,
the outdoor unit including
a hot-gas bypass pipe for bypassing discharging refrigerant from the compressor to the outdoor heat exchanger;
a first expansion device configured to regulate a flow rate of the refrigerant flowing through the hot-gas bypass pipe;
a liquid bypass pipe branching from a connection pipe for connecting the indoor unit and the outdoor heat exchanger and connected to a suction side of the compressor;
a second expansion device configured to regulate a flow rate of the refrigerant flowing through the liquid bypass pipe; and
a third expansion device configured to regulate a flow rate of the refrigerant flowing through an outdoor-side connection pipe arranged on a side of the outdoor heat exchanger with respect to a branch point from the liquid bypass pipe in the connection pipe,
the at least one outdoor unit performing a defrosting operation in which the first expansion device is opened, the discharging refrigerant from the compressor is bypassed to the outdoor heat exchanger through the hot-gas bypass pipe, the third expansion device is closed, and an opening degree of the second expansion device is regulated when the other outdoor units are performing a heating operation.

2. The air-conditioning apparatus of claim 1, wherein in the outdoor unit performing the defrosting operation, an opening degree of the second expansion device is regulated in accordance with a degree of superheat of the refrigerant on the suction side of the compressor and the degree of superheat of the refrigerant on a discharge side of the compressor.
3. The air-conditioning apparatus of claim 2, wherein in the outdoor unit performing the defrosting operation, when the degree of superheat of the refrigerant on the suction side of the compressor is at a first threshold value determined in advance or more, the opening degree of the second expansion device is increased only by a value determined in advance; and
when the degree of superheat of the refrigerant on the discharge side of the compressor is less than a second threshold value determined in advance, the opening degree of the second expansion device is decreased only by a value determined in advance.

4. The air-conditioning apparatus of claim 3, wherein the outdoor unit includes
a first pressure sensor configured to detect a pressure of the refrigerant on the suction side of the compressor,
a first temperature sensor configured to detect a temperature of the refrigerant on the suction side of the compressor,
a second pressure sensor configured to detect a pressure of the refrigerant on the discharge side of the compressor, and
a second temperature sensor configured to detect a temperature of the refrigerant on the discharge side of the compressor,
in the outdoor unit performing the defrosting operation, the degree of superheat of the refrigerant on the suction side of the compressor is calculated from a difference between a saturation temperature acquired from a value of the first pressure sensor and a value of the first temperature sensor; and
a degree of superheat of the refrigerant on the discharge side of the compressor is calculated from a difference between a saturation temperature acquired from a value of the second pressure sensor and a value of the second temperature sensor.
5. The air-conditioning apparatus of any one of claims 1 to 4, wherein
the outdoor unit includes a refrigerant heat exchanger configured to exchange heat between the refrigerant flowing through the outdoor-side connection pipe and the refrigerant flowing through the liquid bypass pipe.

Amended claims under Art. 19.1 PCT

1. An air-conditioning apparatus (1) comprising:
at least two outdoor units (100A, 100B) on each of which a compressor (101A, 101B) and an outdoor heat exchanger (103A, 103B) are mounted; and
at least one indoor unit (200) on which an indoor expansion device (202) and an indoor heat exchanger (201) are mounted,
the outdoor units (100A, 100B) being connected to the indoor unit (200) in parallel,
the compressor (101A, 101B), the indoor heat exchanger (201), the indoor expansion device (202), and the outdoor heat exchanger (103A, 103B) being sequentially connected by pipes and constituting a refrigerant circuit in which refrigerant is circulated,
the outdoor unit (100A, 100B) including
a hot-gas bypass pipe (118A, 118B) for bypassing discharging refrigerant from the compressor (101A, 101B) to the outdoor heat exchanger

(103A, 103B);

a first expansion device (107A, 107B) configured to regulate a flow rate of the refrigerant flowing through the hot-gas bypass pipe (118A, 118B);

a liquid bypass pipe (115a, 115B) branching from a connection pipe for connecting the indoor unit (200) and the outdoor heat exchanger (103A, 103B) and connected to a suction side of the compressor (101A, 101B);

a second expansion device (116) configured to regulate a flow rate of the refrigerant flowing through the liquid bypass pipe (115a, 115B); and a third expansion device (108) configured to regulate a flow rate of the refrigerant flowing through an outdoor-side connection pipe (119A, 119B) arranged on a side of the outdoor heat exchanger (103A, 103B) with respect to a branch point from the liquid bypass pipe (115a, 115B) in the connection pipe,

the at least one outdoor unit (100A, 100B) performing a defrosting operation in which the first expansion device (107A, 107B) is opened, the discharging refrigerant from the compressor (101A, 101B) is bypassed to the outdoor heat exchanger (103A, 103B) through the hot-gas bypass pipe (118A, 118B), the third expansion device (108) is closed, and an opening degree of the second expansion device (116) is regulated when the other outdoor units (100A, 100B) are performing a heating operation.

2. The air-conditioning apparatus (1) of claim 1, wherein

in the outdoor unit (100A, 100B) performing the defrosting operation, an opening degree of the second expansion device (116) is regulated in accordance with a degree of superheat of the refrigerant on the suction side of the compressor (101A, 101B) and the degree of superheat of the refrigerant on a discharge side of the compressor (101A, 101B).

3. The air-conditioning apparatus (1) of claim 2, wherein

in the outdoor unit (100A, 100B) performing the defrosting operation, when the degree of superheat of the refrigerant on the suction side of the compressor (101A, 101B) is at a first threshold value determined in advance or more, the opening degree of the second expansion device (116) is increased only by a value determined in advance; and when the degree of superheat of the refrigerant on the discharge side of the compressor (101A, 101B) is less than a second threshold value determined in advance, the opening degree of the second expansion device (116) is decreased only by a value determined in advance.

4. The air-conditioning apparatus (1) of claim 3, wherein

the outdoor unit (100A, 100B) includes a first pressure sensor (113A, 113B) configured to detect a pressure of the refrigerant on the suction side of the compressor (101A, 101B), a first temperature sensor (110A, 110B) configured to detect a temperature of the refrigerant on the suction side of the compressor (101A, 101B), a second pressure sensor (114A, 114B) configured to detect a pressure of the refrigerant on the discharge side of the compressor (101A, 101B), and a second temperature sensor (111 A, 111 B) configured to detect a temperature of the refrigerant on the discharge side of the compressor (101A, 101B), in the outdoor unit (100A, 100B) performing the defrosting operation, the degree of superheat of the refrigerant on the suction side of the compressor (101A, 101B) is calculated from a difference between a saturation temperature acquired from a value of the first pressure sensor (113A, 113B) and a value of the first temperature sensor (110A, 110B); and a degree of superheat of the refrigerant on the discharge side of the compressor (101A, 101B) is calculated from a difference between a saturation temperature acquired from a value of the second pressure sensor (114A, 114B) and a value of the second temperature sensor (111 A, 111 B).

5. The air-conditioning apparatus (1) of any one of claims 1 to 4, wherein

the outdoor unit (100A, 100B) includes a refrigerant heat exchanger (117A, 117B) configured to exchange heat between the refrigerant flowing through the outdoor-side connection pipe (119A, 119B) and the refrigerant flowing through the liquid bypass pipe (115a, 115B).

FIG. 1

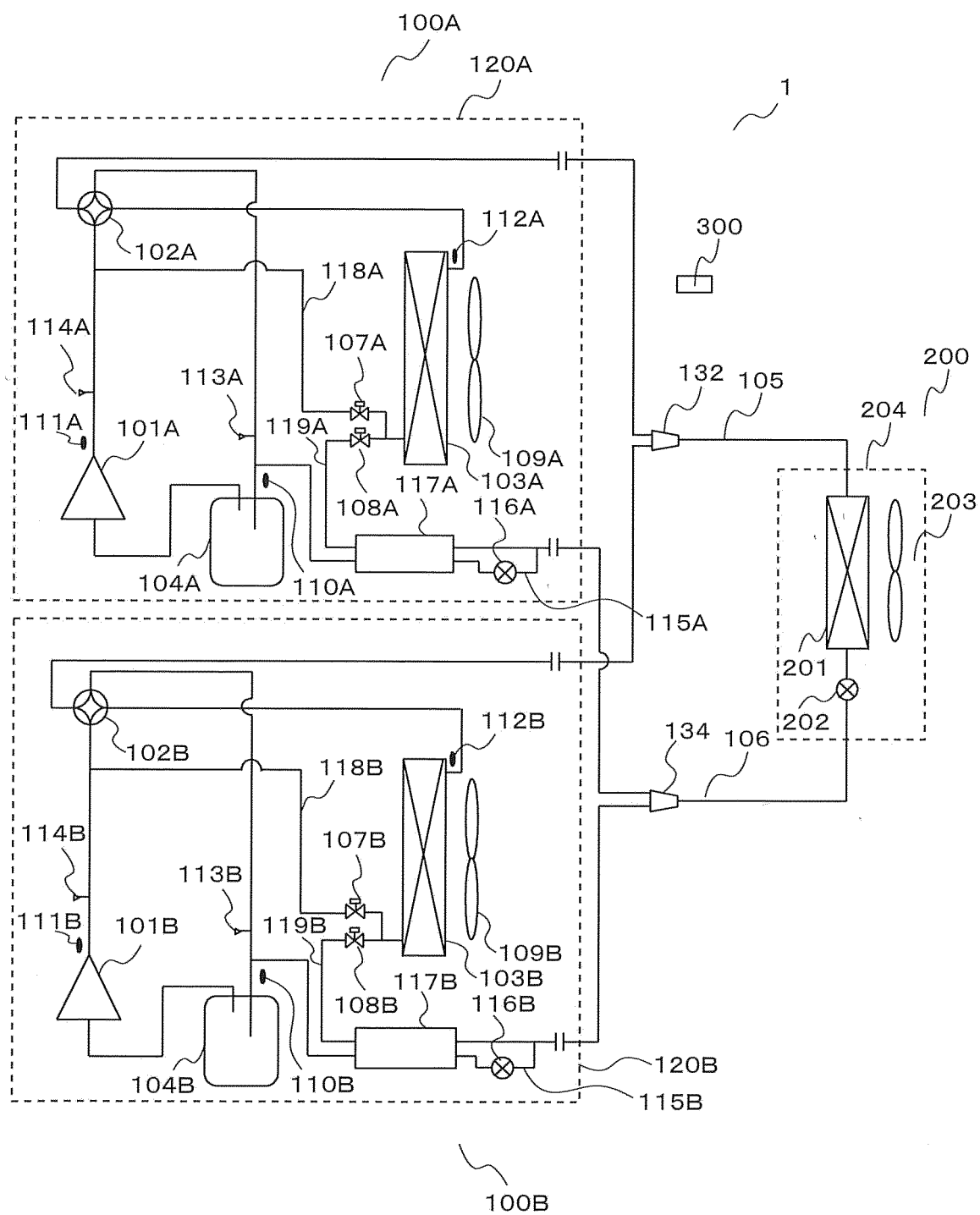
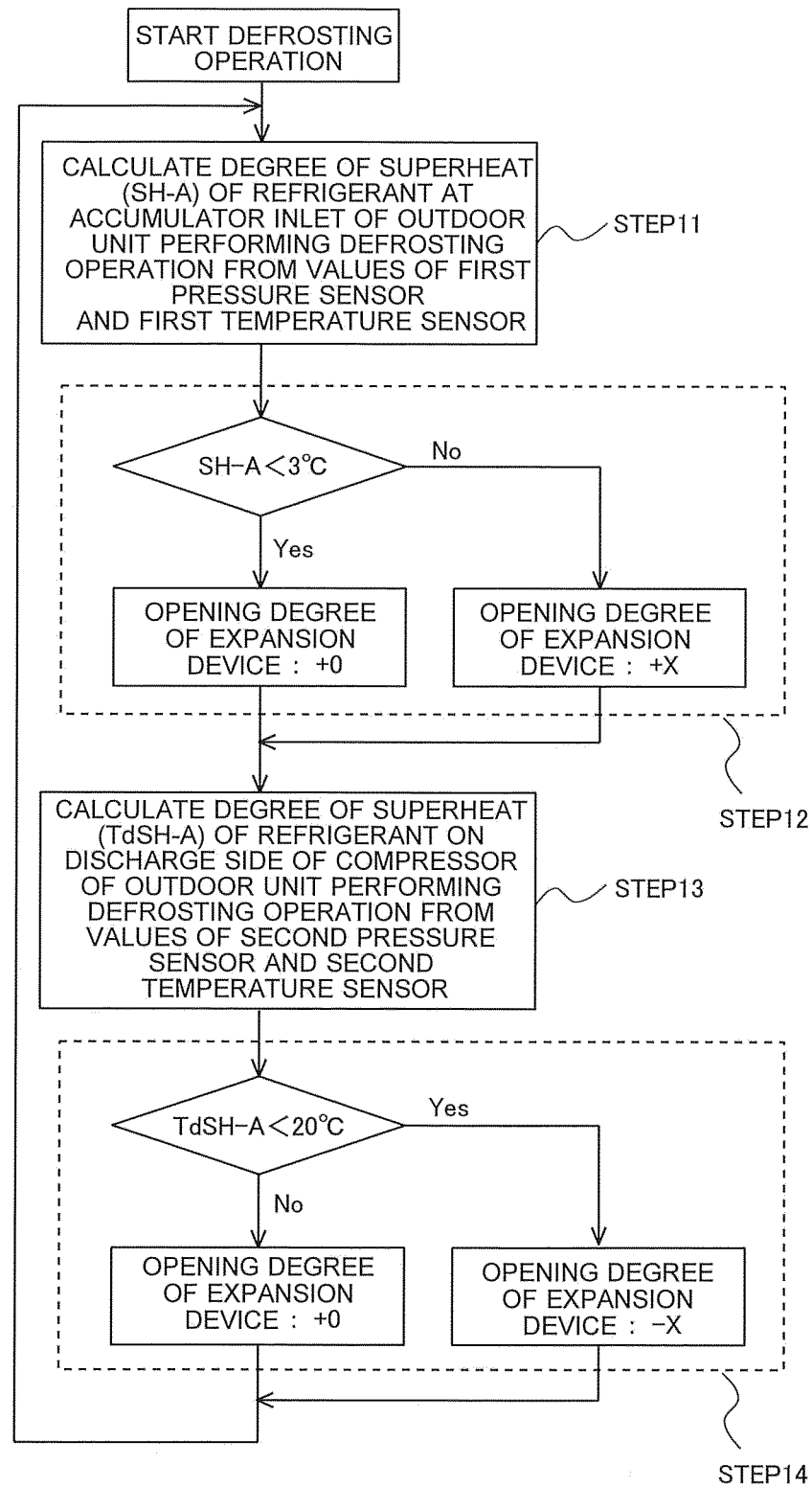


FIG. 2



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2014/083403

A. CLASSIFICATION OF SUBJECT MATTER

F24F11/02(2006.01)i, F25B1/00(2006.01)i, F25B47/02(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)

F24F11/02, F25B1/00, F25B47/02

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

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2015

Kokai Jitsuyo Shinan Koho 1971-2015 Toroku Jitsuyo Shinan Koho 1994-2015

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2002-286273 A (Mitsubishi Electric Corp.), 03 October 2002 (03.10.2002), entire text; all drawings (Family: none)	1-5
A	JP 2014-211251 A (Mitsubishi Electric Corp.), 13 November 2014 (13.11.2014), entire text; all drawings (Family: none)	1-5
A	JP 2010-71544 A (Mitsubishi Electric Corp.), 02 April 2010 (02.04.2010), entire text; all drawings (Family: none)	1-5



Further documents are listed in the continuation of Box C.



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Date of the actual completion of the international search
12 March 2015 (12.03.15)Date of mailing of the international search report
31 March 2015 (31.03.15)Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2014/083403

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2008-175410 A (Mitsubishi Electric Corp.), 31 July 2008 (31.07.2008), entire text; all drawings (Family: none)	1-5
A	JP 2012-107790 A (Mitsubishi Electric Corp.), 07 June 2012 (07.06.2012), entire text; all drawings (Family: none)	1-5

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

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2008175410 A [0005]
- JP 2012107790 A [0005]