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(54) CONTROL DEVICE, MULTI-SPLIT AIR CONDITIONING SYSTEM PROVIDED WITH SAME, AND CONTROL METHOD, AND CONTROL PROGRAM

(57) The present invention is provided with: a detection unit (42) that detects whether or not the heating capacity in an indoor unit performing heating operation is deficient; and a control unit (43) that fully closes the indoor expansion valve of a stopped indoor unit that is an indoor unit not in operation, in a case where an indoor unit having deficient heating capacity is detected. In addition, the present invention is provided with a determination unit (41) that determines whether or not a period, in which a first temperature difference between the set temperature for the indoor unit and the indoor temperature in the room in which air conditioning is to be performed by the indoor unit is not less than a first predetermined value, continues for a first predetermined period or longer, or determines whether or not a second temperature difference in refrigerant pipping between two points of an outlet and another point except the outlet in a section to the outlet from the inlet of an indoor heat exchanger provided in the indoor unit, is not more than a second predetermined value. The detection unit (42) detects that the heating capacity is deficient, in a case where the determination result of the determination unit (41) is affirmative.

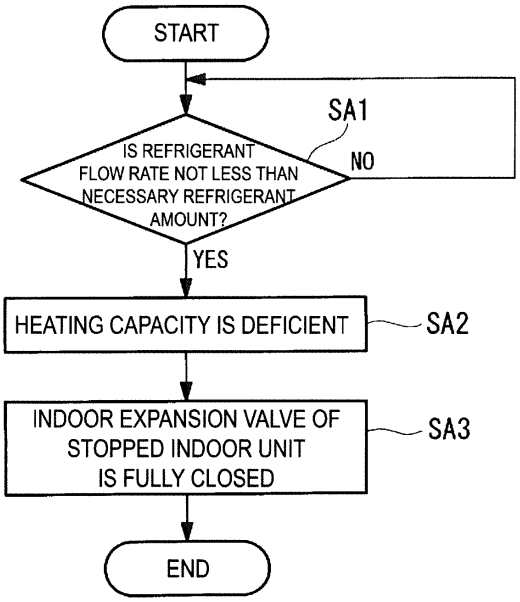

FIG. 3

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Description

Technical Field

[0001] The present disclosure relates to a control device, a multi-split air conditioning system provided with the same, and a control method and a control program.

Background Art

[0002] In an air conditioning system, a necessary refrigerant amount is changed depending on operating conditions such as cooling and heating, air conditions, and the like. Further, in a multi-split air conditioning system, a necessary refrigerant amount varies depending on the number of operating indoor units, in addition to operating state, air conditions, and the like.

[0003] The change in the necessary refrigerant amount corresponds to the refrigerant amount being adjusted a refrigerant amount by system control or receiver. The operating indoor units are controlled to be supplied with the appropriate refrigerant amount.

[0004] Patent Document 1 described below discloses a technique that, in heating operation in which a stop load side unit and an operation load side unit are mixed, determines whether the refrigerant amount in an operation cycle is appropriate at regular time intervals, and when the refrigerant amount is not in an appropriate range, and that appropriately corrects an opening degree of an expansion valve that communicates with the stop load side unit to adjust the refrigerant amount.

[0005] Patent Document 2 described below discloses a technology that, an expansion valve of an indoor unit stopped is fully closed so that a cooling cycle during heating operation is caused not to be a deficient refrigerant state, and noise from a blower of the indoor unit stopped in a quiet environment is reduced, and an indoor unit to be fully closed can be automatically and manually selected.

[0006] Patent Document 3 described below discloses a technology that a stopped indoor unit in which the expansion valve is to be closed is arbitrarily selected in a thermo-off state.

Citation List

Patent Documents

[0007]

Patent Document 1: JP-A-2000-266388
Patent Document 2: JP-A-2005-76954
Patent Document 3: JP-A-2005-49069

Summary of Disclosure

Problem to be Solved by the Disclosure

[0008] By the way, in heating operation, in a case where there is a surplus refrigerant not less than a necessary refrigerant amount, a refrigerant amount is adjusted by accumulating a fraction of refrigerant into a stopped indoor unit in a receiver or a multi-split air conditioning system.

[0009] However, in Patent Document 1 described above, when the refrigerant amount in the air conditioning system is excessive, the refrigerant flow rate may not be adjusted and the refrigerant may not be stored by the receiver or the like even if the opening degree of the expansion valve of the stop load side unit is adjusted. As a result, there is a problem that the refrigerant amount becomes excessive in the operating load side unit, and the heating capacity is deficient. In Patent Documents 2 and 3, the case where the refrigerant amount is excessive is not assumed, thus the problem of heating capacity being deficient due to the excessive refrigerant amount cannot be resolved.

[0010] Further, although an accumulated amount of the refrigerant amount can be increased by increasing a capacity of the receiver, there is a problem that the cost increases.

[0011] In light of the foregoing, a purpose of the present disclosure is to provide a control device that can prevent deficiency of heating capacity without increasing the cost, a multi-split air conditioning system provided with the same, and a control method and a control program.

Solution to Problem

[0012] In order to solve the problem described above, the present disclosure provides the following means.

[0013] A control device according to a first aspect of the present disclosure is a control device configure to control operation of a multi-split air conditioning system in which a plurality of indoor units are connected to an outdoor unit, and refrigerant flow rate that flows through refrigerant piping is adjusted by an opening degree of an expansion valve of the indoor unit, the control device includes a detection unit configured to detect whether deficiency of heating capacity occurs in an indoor unit performing heating operation, and a control unit that fully closes the expansion valve of stopped indoor unit that is an indoor unit not in operation, in a case where the indoor unit having the deficiency of heating capacity is detected.

[0014] According to the present aspect, in a case where deficiency of heating capacity is detected in the indoor unit performing heating operation, by fully closing the expansion valve of a stopped indoor unit that is an indoor unit not in operation, a part of the refrigerant flowing through the refrigerant piping of the indoor unit performing heating operation is stored on a stopped indoor unit side. As a result, the refrigerant flow rate of the indoor

unit performing heating operation can be reduced, even if the deficiency of heating capacity occurs due to excessive refrigerant flow rate, the deficiency of heating capacity can be improved.

[0015] According to the present aspect, it is not necessary to change the receiver capacity, thus the cost is not increased, and the deficiency of heating capacity can be prevented.

[0016] In a site where an air conditioning system is installed, sometimes there is a problem during installation, such as the installer overcharges the refrigerant. By performing the control of this aspect, the existing air conditioning system can be redundant.

[0017] The control device described above may further include a determination unit configured to determine whether a period, in which a first temperature difference between a set temperature of the indoor unit and an indoor temperature of a room in which air conditioning is to be performed by the indoor unit is not less than a first predetermined value, continues for a first predetermined period or longer, or determine whether a second temperature difference in the refrigerant piping between two points of an outlet and another point except the outlet in a section from an inlet to the outlet of an indoor heat exchanger disposed in the indoor unit, is not greater than a second predetermined value. The detection unit may detect that the deficiency of heating capacity has occurred, in a case where a determination result of the determination unit is affirmative.

[0018] In heating operation, it is possible to determine whether the room in which air conditioning is to be performed is not sufficiently warm, whether the refrigerant is accumulated in the indoor units, or the like, and the deficiency of heating capacity has occurred can be detected.

[0019] The determination unit of the control device described above may determine a third temperature difference between an indoor temperature of a room in which air conditioning is to be performed by the indoor unit and a refrigerant temperature at a bend part or an inlet of the refrigerant piping of the indoor heat exchanger disposed in the indoor unit, is not greater than a third predetermined value.

[0020] When the refrigerant is accumulated in the indoor units, the accumulated refrigerant temperature is close to the indoor temperature (suction temperature) of the indoor units. A deficiency of heating capacity may be detected by comparing the indoor temperature and the refrigerant temperature of the bend part or the inlet of the refrigerant piping. According to the present aspect, the temperature sensor disposed on the refrigerant piping at the outlet side of the indoor heat exchanger can be reduced.

[0021] The control unit of the control device described above may fully close the expansion valves of all of the indoor units not in operation or a part of the indoor units not in operation.

[0022] The indoor units in which the expansion valves of the indoor units are fully closed are set as all of the indoor units not in operation or a part of the indoor units not in operation. According to the present aspect, control can be performed according to the excess of the operating indoor unit with respect to the required refrigerant flow rate.

[0023] In a case where the expansion valves of a part of the indoor units not in operation are fully closed, the control unit of the control device described above may select the indoor unit in which the expansion valve is fully closed based on an address preset for the indoor unit.

[0024] According to the present aspect, by selecting the indoor units based on the preset addresses, the indoor units in which the expansion valve is closed can be quickly determined.

[0025] In a case where the expansion valves of a part of the indoor units not in operation are fully closed, the control unit of the control device described above may select the indoor unit in which a period during which the operation is stopped is not less than a second predetermined period.

[0026] The indoor unit in which a period during which the operation is stopped is not less than a second predetermined period is selected as the indoor unit in which the expansion valve is fully closed. According to the present aspect, it is possible to avoid controlling an expansion valve of an indoor unit operated frequently to be fully closed, and is prevented from being different from a normal operation.

[0027] The present disclosure provides a multi-split air conditioning system including the control device according to any one of the aspects described above, an outdoor unit, and a plurality of indoor units connected to the outdoor unit.

[0028] The present disclosure provides a control method for controlling operation of a multi-split air conditioning system in which a plurality of indoor units are connected to an outdoor unit, and refrigerant flow rate that flows through refrigerant piping is adjusted by an opening degree of an expansion valve of the indoor unit, the control method includes, detecting whether deficiency of heating capacity occurs in an indoor unit performing heating operation, and fully closing the expansion valve of a stopped indoor unit that is an indoor unit not in operation, in a case where the indoor unit having the deficiency of heating capacity is detected.

[0029] The present disclosure provides a control program for controlling operation of a multi-split air conditioning system in which a plurality of indoor units are connected to an outdoor unit, and refrigerant flow rate that flows through refrigerant piping is adjusted by an opening degree of an expansion valve of the indoor unit, the control program causes a computer to execute: a process of detecting whether deficiency of heating capacity occurs in an indoor unit performing heating operation, and a process of fully closing the expansion valve of a stopped indoor unit that is an indoor unit not in operation, in a case where the indoor unit having the deficiency of heat-

ing capacity is detected.

Advantageous Effect of Disclosure

[0030] The present disclosure achieves the effect of providing a control device of a multi-split air conditioning system that is capable of preventing deficiency of heating capacity without increasing the cost.

Brief Description of Drawings

[0031]

FIG. 1 is a schematic view of a refrigerant circuit of a multi-split air conditioning system according to the present disclosure.
FIG. 2 is a function block diagram illustrating an electrical configuration of a control device of the multi-split air conditioning system according to the present disclosure.
FIG. 3 is an operation flow of the control device of the multi-split air conditioning system according to the present disclosure.

Description of Embodiments

[0032] Hereinafter, embodiments of a control device, a multi-split air conditioning system provided with the same, and a control method and a control program according to the present disclosure will be described with reference to the drawings.

[0033] An embodiment of the present disclosure will be described with reference to FIG. 1.

[0034] FIG. 1 schematically illustrates a refrigerant circuit of a multi-split air conditioning system 1 according to the present embodiment.

[0035] In the multi-split air conditioning system 1, a plurality of indoor units 3A and 3B are connected in parallel to one outdoor unit 2. The plurality of indoor units 3A and 3B are connected to each other in parallel via branching devices 6 between gas-side piping 4 and liquid-side piping 5 that are connected to the outdoor unit 2. In the present embodiment, an example is given of a case where the plurality of indoor units are two, but the number of indoor units is not particularly limited as long as the number of indoor units is a plurality.

[0036] Note that, the indoor units are referred to as indoor units 3 unless otherwise specified.

[0037] The outdoor unit 2 includes an inverter-driven compressor 10 configured to compress a refrigerant, a four-way selector valve 12 configured to switch the refrigerant circulation direction, an outdoor heat exchanger 13 configured to exchange heat between the refrigerant and outside air, a supercooling coil 14 integrally configured with the outdoor heat exchanger 13, an outdoor expansion valve (EEVH) 15, a receiver 16 that stores a liquid refrigerant, a supercooling heat exchanger 17 configured to supercool the liquid refrigerant, an supercooling expansion valve (EEVSC) 18 that controls the refrigerant amount diverted to the supercooling heat exchanger 17, an accumulator 19 that separates the liquid from a refrigerant gas which is sucked into the compressor 10 and cause only a gas portion to be taken into the compressor 10, a gas-side operation valve 20, and a liquid-side operation valve 21.

[0038] Each of the above-described devices on the outdoor unit 2 side is sequentially connected via refrigerant piping 22, and constitutes an outdoor refrigerant circuit 23 that is known. Further, an outdoor fan 24 configured to blow the outside air to the outdoor heat exchanger 13 is disposed in the outdoor unit 2.

[0039] The gas-side piping 4 and the liquid-side piping 5 are refrigerant piping connected to the gas-side operation valve 20 and the liquid-side operation valve 21 of the outdoor unit 2, and lengths of the gas-side piping 4 and the liquid-side piping 5 are appropriately set according to a distance between the outdoor unit 2 and the plurality of indoor units 3A and 3B connected to the outdoor unit 2 at the time of installation in the field. A plurality of the branching devices 6 are provided midway on the gas-side piping 4 and the liquid-side piping 5, and an appropriate number of the indoor units 3A and 3B are connected via the branching devices 6. As a result, a refrigerating cycle (refrigerant circuit) 7 of one closed system is configured.

[0040] The indoor units 3A and 3B each includes an indoor heat exchanger 30 that causes inside air to exchange heat with the refrigerant for cooling or heating and provide the inside air for an indoor air conditioning, an indoor expansion valve (EEVC) 31, an indoor fan 32 that causes the inside air to circulate via the indoor heat exchanger 30, and an indoor controller 39, wherein the indoor units 3A and 3B are connected to the branching devices 6 via branched gas-side piping 4A, 4B and branched liquid-side piping 5A, 5B on the indoor side.

[0041] Further, the indoor units 3A and 3B each includes a first heat exchange temperature sensor (inlet side temperature sensor during heating) 33, a second heat exchange temperature sensor (outlet side temperature sensor during heating) 35, a third heat exchange temperature sensor (temperature sensor at a bend part) 34, and a suction temperature sensor 36.

[0042] The first heat exchange temperature sensor 33 is disposed on an inlet side of the refrigerant during heating operation of the indoor heat exchanger 30 for the indoor units 3A and 3B. The first heat exchange temperature sensor 33 detects the temperature of the refrigerant flowing into the indoor heat exchanger 30 functioning as a condenser.

[0043] The second heat exchange temperature sensor 35 is disposed on the outlet side of the refrigerant during heating operation of the indoor heat exchanger 30 for the indoor units 3A and 3B. The second heat exchange temperature sensor 35 detects the temperature of the refrigerant that flows out from the indoor heat exchanger 30 functioning as a condenser.

[0044] The third heat exchange temperature sensor 34 is disposed between the inlet side and the outlet side of the indoor heat exchanger 30, for example, in an intermediate part between the inlet side and the outlet side where cooling and heating is curved (bend part). The third heat exchange temperature sensor 34 detects the temperature of the refrigerant between the inlet side and the outlet side of the indoor heat exchanger 30.

[0045] The suction temperature sensor 36 detects the temperature of a suction air sucked from a room in which air conditioning is to be performed by the indoor units 3A and 3B.

[0046] Information of each temperature detected by the first heat exchange temperature sensor 33, the second heat exchange temperature sensor 35, the third heat exchange temperature sensor 34, and the suction temperature sensor 36, is output to the control device 40 (details will be described later) via the indoor controller 39 corresponding to the indoor units 3A and 3B.

[0047] In the multi-split air conditioning system 1 described above, the cooling operation is performed as described below. The flow of refrigerant during cooling operation is indicated by a solid arrow in FIG. 1.

[0048] High-temperature and high-pressure refrigerant gas, which is compressed and discharged by the compressor 10, is circulated toward the outdoor heat exchanger 13 by the four-way selector valve 12, and subjected to heat exchange with the outside air blown by the outdoor fan 24 to be condensed and liquefied in the outdoor heat exchanger 13. After further cooling by the supercooling coil 14, the liquid refrigerant passes through the outdoor expansion valve 15 and is temporarily stored in the receiver 16.

[0049] The liquid refrigerant whose circulation amount has been adjusted in the receiver 16 is partially diverted from the liquid refrigerant piping in the process of flowing through the liquid refrigerant piping side via the supercooling heat exchanger 17, and is subjected to heat exchange with the refrigerant adiabatically expanded by the supercooling expansion valve 18 to impart a degree of supercooling. This liquid refrigerant is introduced from the outdoor unit 2 to the liquid-side piping 5 via the liquid-side operation valve 21, and diverted to the branched liquid-side piping 5A, 5B of the indoor units 3A and 3B via the branching devices 6.

[0050] The liquid refrigerant diverted to the branched liquid-side piping 5A, 5B flows into the indoor units 3A and 3B, is adiabatically expanded by the indoor expansion valve 31 to form a gas-liquid two-phase flow, and is introduced into the indoor heat exchanger 30. In the indoor heat exchanger 30, heat is exchanged between the refrigerant and the inside air circulated by the indoor fan 32, thus the inside air is cooled and provided for indoor cooling. On the other hand, the refrigerant is gasified, flows to the branching device 6 via the branched gas-side piping 4A, 4B, and merges with the refrigerant gas from other indoor units in the gas-side piping 4.

[0051] The refrigerant gas merged in the gas-side piping 4 is returned to the outdoor unit 2 again, through the gas-side operation valve 20 and the four way selector valve 12, merged with the refrigerant gas from the supercooling heat exchanger 17, and then introduced into the accumulator 19. In the accumulator 19, the liquid portion contained in the refrigerant gas is separated, and only the gas portion is suctioned into the compressor 10. This refrigerant is compressed in the compressor 10 again, and the cooling operation is performed by repeating the cycle described above.

[0052] On the other hand, the heating operation is performed as follows. The flow of the refrigerant during heating operation is indicated by a dotted arrow in FIG. 1.

[0053] The high-temperature and high-pressure refrigerant gas compressed and discharged by the compressor 10 is circulated to the gas-side operation valve 20 via the four-way selector valve 12. This high-pressure gas refrigerant is led out from the outdoor unit 2 via the gas-side operation valve 20 and the gas-side piping 4, and introduced into the plurality of indoor units 3A and 3B via the branching devices 6 and the branched gas-side piping 4A, 4B on the indoor side.

[0054] The high-temperature and high-pressure refrigerant gas introduced into the indoor units 3A and 3B is subjected to heat exchange with the inside air circulated via the indoor fan 32 in the indoor heat exchanger 30, thus the inside air heated is blown into the room and used for heating. On the other hand, the refrigerant condensed and liquefied by the indoor heat exchanger 30 flows to the branching device 6 via the indoor expansion valve 31 and the branched liquid-side piping 5A, 5B, is merged with the refrigerant from other indoor units, and is returned to the outdoor unit 2 via the liquid-side piping 5. Note that, during heating, in the indoor units 3A and 3B, the opening degree of the indoor expansion valve 31 is controlled via the indoor controller 39 so that the refrigerant flow rate that flows into the indoor heat exchanger 30 functioning as a condenser becomes a control target value.

[0055] The refrigerant returned to the outdoor unit 2 flows to the supercooling heat exchanger 17 via the liquid-side operation valve 21, and after being subjected to supercooling as in the case of cooling, the refrigerant flows into the receiver 16 and is temporarily stored so that the circulation amount is adjusted. This liquid refrigerant is supplied to the outdoor expansion valve 15 and adiabatically expanded, and then flows into the outdoor heat exchanger 13 via the supercooling coil 14.

[0056] In the outdoor heat exchanger 13, heat is exchanged between the refrigerant and the outside air blown from the outdoor fan 24, and the refrigerant absorbs the heat from the outside air and is evaporated and gasified. This refrigerant passes through the four-way selector valve 12 from the outdoor heat exchanger 13, is merged with the refrigerant gas from the supercooling heat exchanger 17, and is then introduced into the accumulator 19. In the accumulator 19, the liquid portion contained in the refrigerant gas is separated, and only the

gas portion is suctioned into the compressor 10 and once again compressed in the compressor 10. The heating operation is performed by repeating the cycle described above.

[0057] Accordingly, during heating operation, the circulation amount of the refrigerant is adjusted by the control such as the refrigerant is temporarily stored in the receiver 16, however, sometimes adjustment of the refrigerant flow rate at the receiver 16 may not catch up, and the indoor units 3A and 3B may become deficient for heating capacity due to the excessive amount of the refrigerant flow rate.

[0058] Hereinafter, control executed by a control device 10 according to the present embodiment, for preventing excessive refrigerant flow rate during heating operation and preventing the deficiency of heating capacity, will be described.

[0059] The multi-split air conditioning system 1 includes a control device 40.

[0060] FIG. 2 is a block diagram illustrating an electrical configuration of the control device 40 for controlling the multi-split air conditioning system 1 according to the present embodiment.

[0061] The control device 40 includes, for example, a Central Processing Unit (CPU), a Random Access Memory (RAM), a Read Only Memory (ROM), a computer readable storage medium, and the like. Further, for example, a sequence of processing for performing various functions is stored on a storage medium or the like in the form of a program, and the various functions are performed by the CPU loading this program from the storage medium, storing the program into the RAM or the like, and executing information processing and calculation processing. Note that the program may be preinstalled in the ROM or other storage medium, may be provided in the form of being stored in a computer-readable storage medium, or may be distributed through wired or wireless communication means, or the like. Examples of the computer-readable storage medium include a magnetic disk, a magneto-optical disk, a CD-ROM, a DVD-ROM, a semiconductor memory, and the like. Further, the control device 40 is included in the outdoor unit 2.

[0062] Specifically, the control device 40 includes a determination unit 41, a detection unit 42, and a control unit 43.

[0063] The determination unit 41 determines whether the refrigerant flow rate flowing through the refrigerant piping is not less than a required refrigerant flow rate in the indoor units 3A and 3B performing heating operation. The necessary refrigerant amount of the multi-split air conditioning system 1 varies depending on cooling operation, heating operation, or air conditioning of the air conditioning space, the number of indoor units operating, and the like. In the present embodiment, based on the temperature information detected by the various temperature sensors disposed near the indoor heat exchangers 30 of the indoor units 3A and 3B, the determination unit 41 determines whether the refrigerant flow rate that flows through the indoor units 3A and 3B operating is not less than the required refrigerant flow rate.

[0064] Specifically, the determination unit 41 determines whether a period, in which a first temperature difference between a set temperature for each of the indoor units 3A and 3B and an indoor temperature of the room in which air conditioning is to be performed by the indoor units 3A and 3B is not less than the first predetermined value, continues for a first predetermined period or longer, or determines whether a second temperature difference in the refrigerant piping between two points of an outlet and another point except the outlet in a section from the inlet to the outlet of the indoor heat exchanger 30 disposed in each of the indoor units 3A and 3B, is not greater than a second predetermined value.

[0065] The case where the first temperature difference between the set temperature of the indoor units 3A and 3B and the indoor temperature is not less than the first predetermined value continues for the first predetermined period or longer, includes a state in which the room in which air conditioning is to be performed is less likely to warm up.

[0066] The case where the second temperature difference in the refrigerant piping between the two points of the outlet and another point except the outlet in a section from an inlet to the outlet of the indoor heat exchanger 30 is not greater than the second predetermined value, includes a state in which the refrigerant is accumulated in the refrigerant piping of the indoor units 3A and 3B and the temperature difference between the two points of the outlet and another point disappears. The other point except the outlet may be, for example, a bend part that is an intermediate part between the outlet and the inlet, or an inlet part.

[0067] Further, an indoor temperature sensor (not illustrated) for detecting an indoor temperature within a room in which air conditioning is to be performed is provided on the indoor units 3A and 3B side, and in a case where the indoor units 3A and 3B are disposed in a ceiling of a room with a high ceiling, even if it is determined that the indoor temperature and the set temperature have been reduced, sometimes the temperature difference between the indoor temperature in a space where a human or the like exists and the set temperature may be large. In this case, the temperature difference between, as the indoor temperature, an actual indoor temperature experienced by the human or the like and the indoor temperature detected on the indoor units 3A and 3B side becomes large.

[0068] In consideration of such a situation, an indoor temperature sensor that detects the indoor temperature of the room in which air conditioning is to be performed by the indoor units 3A and 3B, is disposed in a remote controller (not illustrated) that operates the indoor units 3A and 3B, thus the remote controller can detect the indoor temperature close to the indoor temperature experienced by a human or the like, and the difference between the set temperature and the indoor temperature

can be determined with good accuracy.

[0069] Accordingly, the determination unit 41 is configured to determine "a case where a period in which a first temperature difference between a set temperature of the indoor units 3A and 3B and an indoor temperature is not less than a first predetermined value continues for a first predetermined value or longer", by limiting to the case where the indoor temperature sensor is disposed in the remote controller, thus the accuracy of determining whether the space in which air conditioning is to be performed is appropriately air conditioned can be improved.

[0070] In a case where the determination unit 41 makes an affirmative determination, the detection unit 42 detects that deficiency of heating capacity has occurred, and outputs to the control unit 43 that the deficiency of heating capacity has occurred.

[0071] In a case where the indoor units 3A and 3B having the deficiency of heating capacity is detected by the control unit 43, the control unit 43 fully closes (closes) the indoor expansion valve 31 of stopped indoor units that are the indoor units 3A and 3B not in operation.

[0072] In the present embodiment, a case where the indoor units are two, one indoor unit is operating, and another one indoor unit is a stopped indoor unit, is given as an example, however, the present disclosure may be applied even if the indoor units are not less than three, and sometimes the stopped indoor units may be not less than two depending on an operating state of the multi-split air conditioning system 1.

[0073] In a case where the stopped indoor units are not less than two, the indoor units 3 in which indoor expansion valve 31 is fully closed may be some of the indoor units 3 or may be all of the indoor units 3.

[0074] In a case where the indoor units 3 in which the indoor expansion valve 31 is fully closed is used as the indoor units 3 of a part of the indoor units, a method of selecting the indoor units 3 to be closed is not particularly limited.

[0075] For example, in a case where an address for identifying each of the indoor units 3A and 3B is assigned, each of the stopped indoor units may be selected based on the address, such as selecting one stopped indoor unit that has a small number indicating the address among the stopped indoor units. Also, for example, one stopped indoor unit may be selected that has not been used for a certain period of time, for which the period in which the operation is stopped is not less than the second predetermined period, that is, one stopped indoor unit used frequently is avoided from being selected. Further, in a case where a plurality of indoor units 3 in which the indoor expansion valves 31 are closed is selected, the indoor expansion valves 31 of the plurality of indoor units 3 may be closed together, or the indoor expansion valves 31 of the plurality of indoor units 3 may be closed sequentially (stepwise).

[0076] The control of selecting some of the indoor units 3 among the stopped indoor units may be performed manually by a user or may be controlled by the control device 40.

[0077] According to the supercooling refrigerant flow rate in the indoor units 3A and 3B performing operation, it can be determined whether setting the indoor unit 3 in which the indoor expansion valve 31 is fully closed to be a part of the stopped indoor units 3 or all of the stopped indoor units 3, or how many indoor units 3 are to be selected in the case where the indoor unit 3 is set to be a part of the indoor units 3.

[0078] This is because, by closing the indoor expansion valve 31 more than necessary, the necessary refrigerant may not flow to the indoor units 3A and 3B performing operation, and the refrigerant flow rate is deficient.

[0079] Hereinafter, operations of the control device according to the present embodiment will be described with reference to FIG. 1 to FIG. 3.

[0080] Here, although a case where the indoor unit 3A performs heating operation and the indoor unit 3B is a stopped indoor unit that stops operation is described as an example, the present disclosure is not limited to this example.

[0081] The indoor unit 3A performs heating operation, and the indoor unit 3B is stopped from operating. To adjust the refrigerant flow rate of the multi-split air conditioning system 1, the opening degree of the indoor expansion valve 31 of the indoor unit 3B not in operation is adjusted to be slightly opened.

[0082] During heating operation, the refrigerant having a temperature about 40°C to 50°C flows into the inlet side of the refrigerant piping of the indoor heat exchanger 30 of the indoor unit 3A. In the case where the refrigerant is accumulated in the indoor units 3 performing operation, the temperature within the refrigerant piping (for example, the bend part) of the indoor heat exchanger 30 is close to the indoor temperature (suction temperature; for example, 20°C), thus, the refrigerant having a temperature about 40°C to 50°C, which has flowed into the inlet of the refrigerant piping, is lowered in temperature by the accumulated refrigerant and further accumulated in the refrigerant piping.

[0083] In the indoor unit 3A performing heating operation, when it is determined that the period in which the first temperature difference between the set temperature and the indoor temperature is not less than the first predetermined value, continues for a first predetermined period or longer, or it is determined that the second temperature difference between the outlet temperature detected by the second heat exchanger temperature sensor 35 of the indoor heat exchanger 30 of the indoor unit 3A and the bend part temperature detected by the third heat exchange temperature sensor 34 is not greater than the second predetermined value (step SA1 in FIG. 3), deficiency of heating capacity is detected as the refrigerant flow rate is not greater than the necessary refrigerant amount in the indoor unit 3A (step SA2 in FIG. 3).

[0084] Further, when a negative determination is made in the determination of step SA1 in FIG. 3, the flow is returned to repeat the determination.

[0085] When the deficiency of heating capacity of the indoor unit 3A is detected, it is assumed that the refrigerant is accumulated in the indoor heat exchanger 30 of the indoor unit 3A, and the indoor expansion valve 3 1 of the indoor unit 3B is controlled to be fully closed (step SA3 in FIG. 3).

[0086] A part of the refrigerant flowing through the refrigerant piping of the indoor unit 3A in heating operation flows to the indoor unit 3B, which is a stopped indoor unit, and is stored in the indoor unit 3B. As a result, by gradually reducing the refrigerant flow rate of the indoor unit 3A in heating operation, the accumulation of the refrigerant in the indoor unit 3A is eliminated, and the deficiency of heating capacity due to the excessive refrigerant flow rate is improved.

[0087] As described above, according to the control device 40, the multi-split air conditioning system 1 provided with the control device 40, and the control method and control program according to the present embodiment, in a case where deficiency of heating capacity is detected in the indoor units 3A and 3B performing heating operation, by fully closing the indoor expansion valves 31 of the stopped indoor unit which are the indoor units 3A and 3B not in operation, a part of the refrigerant flowing through the refrigerant piping of the indoor units 3A and 3B performing heating operation is stored on the stopped indoor unit side. As a result, the refrigerant flow rate of the indoor units 3A and 3B performing heating operation can be reduced, and even if deficiency of heating capacity occurs due to the excessive refrigerant flow rate, the deficiency of heating capacity can be improved.

[0088] According to the present embodiment, it is not necessary to change the receiver capacity and, thus, the deficiency of heating capacity can be prevented without increasing the cost.

[0089] Further, in a site where the multi-split air conditioning system 1 is installed, sometimes there is a problem during installation work, such as the installer overcharges the refrigerant. By performing this control, the existing multi-split air conditioning system 1 can be redundant.

[0090] In addition, in heating operation, it is possible to determine whether the room in which air conditioning is to be performed is not sufficiently warm, whether the refrigerant is accumulated in the indoor unit, or the like, and the deficiency of heating capacity has occurred can be detected.

Modified example

[0091] In the embodiment described above, in a case where the second temperature difference in the refrigerant piping between two points of the outlet of the indoor heat exchanger 30 and another point except the outlet is not greater than the second predetermined value, although it has been described as determining that the refrigerant flow rate is not less than the required refrigerant, the present disclosure is not limited to this.

[0092] For example, in a case where the refrigerant is accumulated in the indoor units 3, the indoor temperature (intake temperature) of the indoor units 3 is close to the temperature of the refrigerant accumulated in the refrigerant piping, and the difference between the indoor temperature and the bend part or inlet temperature may be compared to detect deficiency of heating capacity. By detecting the deficiency of heating capacity by comparing the indoor temperature and the refrigerant temperature of the bend part or inlet of the refrigerant piping, the temperature sensor (the first heat exchange temperature sensor 33) disposed in the refrigerant piping can be reduced.

[0093] Further, the liquid refrigerant tends to be accumulated and a false detection may be caused at the outlet side of the refrigerant piping, thus, it is preferred not to use the outlet temperature to compare with the indoor temperature.

Reference Signs List

[0094]

1	Multi-split air conditioning system
2	Outdoor unit
3A, 3B	Indoor unit
50	Control device
41	Determination unit
42	Detection unit
43	Control unit

Claims

1. A control device configured to control operation of a multi-split air conditioning system in which a plurality of indoor units are connected to an outdoor unit, and refrigerant flow rate that flows through refrigerant piping is adjusted by an opening degree of an expansion valve of the indoor unit, the control device comprising:

   a detection unit configured to detect whether deficiency of heating capacity occurs in an indoor unit performing heating operation; and
   a control unit that fully closes the expansion valve of a stopped indoor unit that is an indoor unit not in operation, in a case where the indoor unit having the deficiency of heating capacity is detected.

2. The control device according to claim 1, further comprising:

   a determination unit configured to determine whether a period, in which a first temperature difference between a set temperature for the indoor unit and an indoor temperature of a room

in which air conditioning is to be performed by the indoor unit is not less than a first predetermined value, continues for a first predetermined period or longer, or determine whether a second temperature difference in the refrigerant piping between two points of an outlet and another point except the outlet in a section from an inlet to the outlet of an indoor heat exchanger disposed in the indoor unit, is not greater than a second predetermined value, wherein
the detection unit detects that the deficiency of heating capacity has occurred, in a case where a determination result of the determination unit is affirmative.

3. The control device according to claim 2, wherein
the determination unit determines whether a third temperature difference between an indoor temperature of a room in which air conditioning is to be performed by the indoor unit and a refrigerant temperature at a bend part or an inlet of the refrigerant piping of the indoor heat exchanger disposed in the indoor unit, is not greater than a third predetermined value.

4. The control device according to any one of claims 1 to 3, wherein
the control unit fully closes the expansion valves of all of the indoor units not in operation or a part of the indoor units not in operation.

5. The control device according to any one of claims 1 to 4, wherein
the control unit selects the indoor unit in which the expansion valve is fully closed based on an address preset for the indoor unit, in a case where the expansion valves of a part of the indoor units not in operation are fully closed.

6. The control device according to any one of claims 1 to 5, wherein
the control unit selects the indoor unit in which a period during which the operation is stopped is not less than a second predetermined period, in a case where the expansion valves of a part of the indoor units not in operation are fully closed.

7. A multi-split air conditioning system comprising:

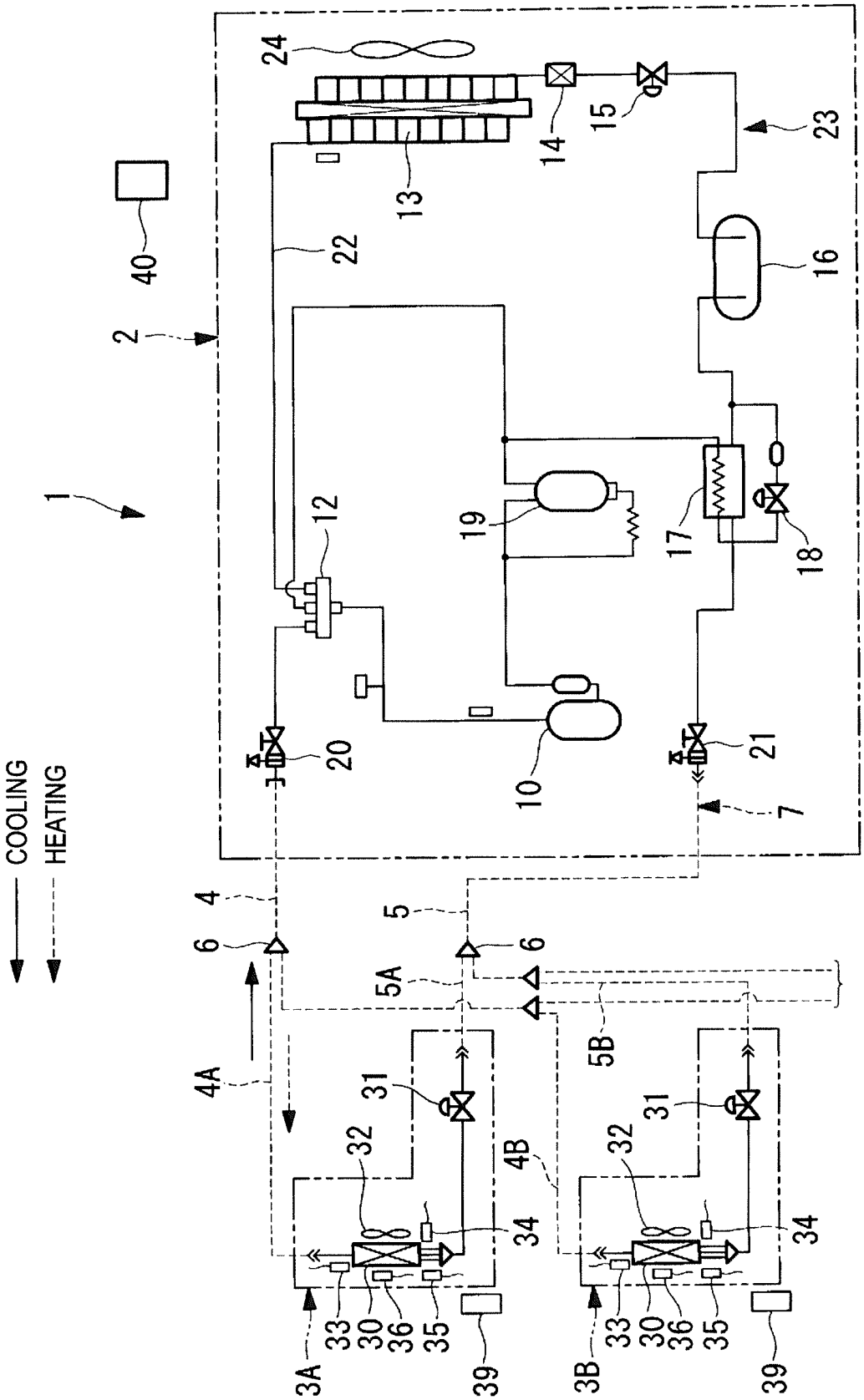
the control device according to any one of claims 1 to 6;
an outdoor unit; and
a plurality of indoor units connected to the outdoor unit.

8. A control method of controlling operation of a multi-split air conditioning system in which a plurality of indoor units are connected to an outdoor unit, and refrigerant flow rate that flows through refrigerant piping is adjusted by an opening degree of an expansion valve of the indoor unit, the control method comprising:

detecting whether deficiency of heating capacity occurs in an indoor unit performing heating operation; and
fully closing the expansion valve of a stopped indoor unit that is an indoor unit not in operation, in a case where the indoor unit having the deficiency of heating capacity is detected.

9. A control program of controlling operation of a multi-split air conditioning system in which a plurality of indoor units are connected to an outdoor unit, and refrigerant flow rate that flows through refrigerant piping is adjusted by an opening degree of an expansion valve of the indoor unit, the control program causes a computer to execute:

a process of detecting whether deficiency of heating capacity occurs in an indoor unit performing heating operation; and
a process of fully closing the expansion valve of a stopped indoor unit that is an indoor unit not in operation, in a case where the indoor unit having the deficiency of heating capacity is detected.


COOLING
HEATING
1
2
40
24
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17
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20
10
21
7
4
6
5
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5A
5B
4A
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4B
34
33
30
36
35
39
3A
3B

FIG. 1

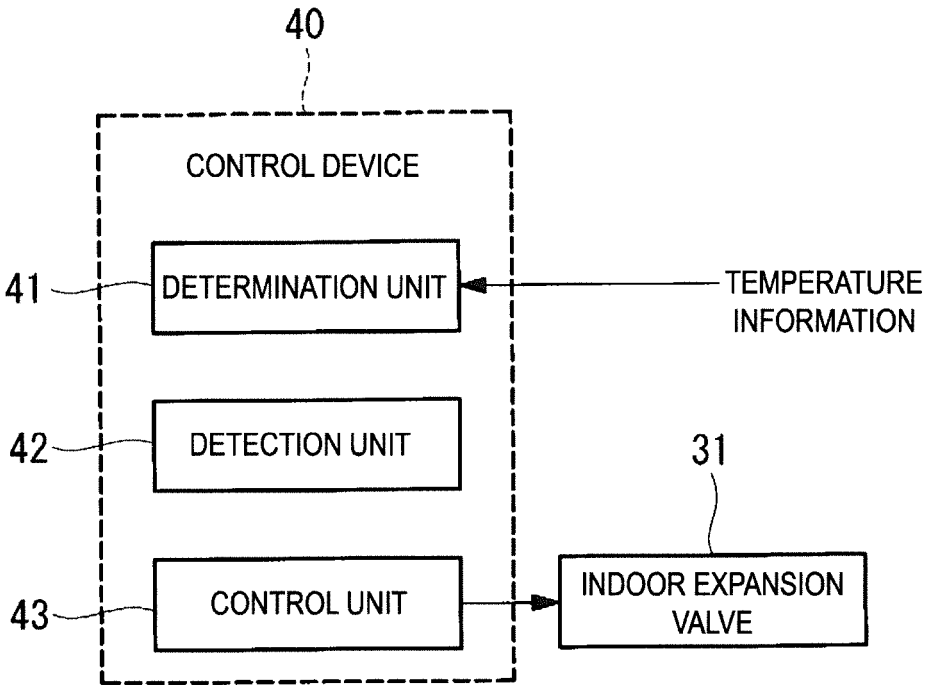
40
CONTROL DEVICE
41
DETERMINATION UNIT
TEMPERATURE INFORMATION
42
DETECTION UNIT
31
43
CONTROL UNIT
INDOOR EXPANSION VALVE

FIG. 2

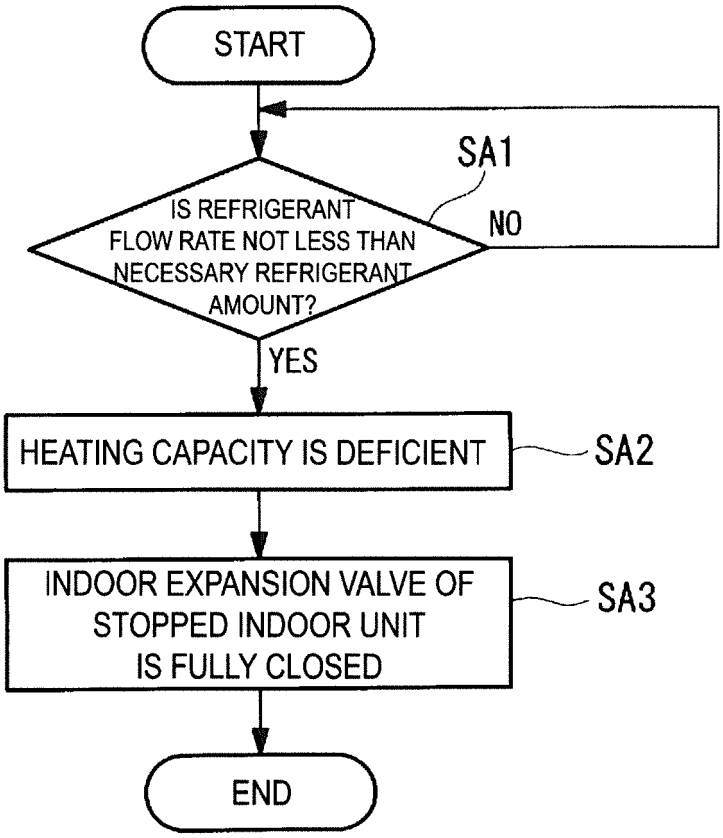
START
SA1
IS REFRIGERANT FLOW RATE NOT LESS THAN NECESSARY REFRIGERANT AMOUNT?
NO
YES
HEATING CAPACITY IS DEFICIENT
SA2
INDOOR EXPANSION VALVE OF STOPPED INDOOR UNIT IS FULLY CLOSED
SA3
END

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2018/016020

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl. F24F11/86(2018.01)i, F24F11/32(2018.01)i, F24F11/61(2018.01)i, F25B13/00(2006.01)i, F24F110/10(2018.01)n

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. F24F11/86, F24F11/32, F24F11/61, F25B13/00, F24F110/10

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	JP 2000-266388 A (MITSUBISHI ELECTRIC CORPORATION) 29 September 2000, paragraphs [0041]-[0043], [0119]-[0130], fig. 16-18 (Family: none)	1-9
Y	JP 9-145191 A (SANYO ELECTRIC CO., LTD.) 06 June 1997, paragraphs [0017]-[0027], fig. 1, 2 (Family: none)	1-9
Y	WO 2011/161720 A1 (MITSUBISHI ELECTRIC CORPORATION) 29 December 2011, paragraphs [0016], [0061]-[0064], fig. 1 & US 2013/0067942 A1, paragraphs [0031], [0078]-[0081], fig. 1	1-9

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

* Special categories of cited documents:
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
06.06.2018	19.06.2018

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2018/016020

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 2011-202833 A (TOSHIBA CARRIER CORPORATION) 13 October 2011, paragraphs [0020]-[0031], [0039], fig. 1, 2 (Family: none)	1-9
Y	JP 2008-134039 A (DAIKIN INDUSTRIES, LTD.) 12 June 2008, paragraphs [0116]-[0132], fig. 12 (Family: none)	2-7
Y	JP 2005-49069 A (MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.) 24 February 2005, paragraphs [0011]-[0019], fig. 1, 2 (Family: none)	5-7
Y	JP 2005-76954 A (MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.) 24 March 2005, paragraphs [0008]-[0011], fig. 1, 2 (Family: none)	6-7

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2000266388 A **[0007]**
- JP 2005076954 A **[0007]**
- JP 2005049069 A **[0007]**