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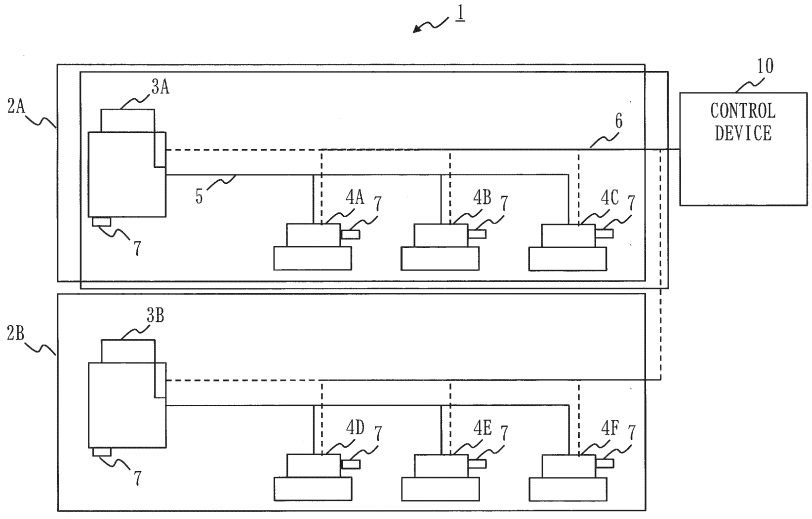
(54) **CONTROL DEVICE, CONTROL METHOD, AND AIR CONDITIONING SYSTEM**

(57) A control device (10) refers to power fluctuation information in which change in a power consumption relative to change in a setting temperature is defined for each indoor unit, and specifies a relaxation amount of the setting temperature at which the total power consumption of a plurality of indoor units (4A through 4F) is reduced by a target power-saving amount or more. The control device (10) changes the setting temperature of each of the plurality of indoor units (4A through 4F) by the relaxation amount specified. In this manner, it is possible to realize power saving by the target power-saving amount or more without excessively deteriorating comfortableness of a user in a part of a space.

Fig. 1



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Description

Technical Field

[0001] The present disclosure relates to a power-saving technique of an air conditioning system.

Background Art

[0002] In terms of an air conditioning system, electric power is saved by changing a setting temperature.

[0003] Patent Literature 1 describes saving electric power in the following manner. A model to calculate a power consumption of an air conditioning unit is created based on the mean value of outside air temperatures and the mean value of room temperatures. By using this model, it is decided whether the load is high. When the load is high, the setting temperature is changed.

Citation List

Patent Literature

[0004] Patent Literature 1: JP 2007-120889 A

Summary of Invention

Technical Problem

[0005] In Patent Literature 1, for each air conditioning unit, whether the load is high is decided, and when the load is high, the setting temperature is changed. Therefore, when looking at a building as a whole, for example, the setting temperature may be excessively changed, and the comfortableness of users may be deteriorated beyond necessity.

[0006] The present disclosure is aimed at making it possible to realize power saving by the target power-saving amount or more while restraining deterioration of comfortableness of a user beyond necessity.

Solution to Problem

[0007] A control device according to the present disclosure is a control device to perform control of an air conditioning system including a plurality of indoor units, the control device including

a relaxation amount specification unit to refer to power fluctuation information in which change in a power consumption relative to change in a temperature difference between an inside and an outside of a room is defined for each of the plurality of indoor units, and to specify a relaxation amount of a setting temperature at which a total power consumption related to the plurality of indoor units is reduced by a target power-saving amount or more, and
a setting change unit to change the setting temperature of each of the plurality of indoor units by the relaxation amount specified by the relaxation amount specification unit.

Advantageous Effects of Invention

[0008] In the present disclosure, a relaxation amount of a setting temperature is specified from the total power consumption related to a plurality of indoor units and a target power-saving amount. In this manner, the setting temperature is changed as necessary with respect to the target power-saving amount. Therefore, it is possible to realize power saving by the target power-saving amount or more while restraining deterioration of comfortableness of a user beyond necessity.

Brief Description of Drawings

[0009]

Fig. 1 is a configuration diagram of an air conditioning system 1 according to a first embodiment;
Fig. 2 is a configuration diagram of a control device 10 according to the first embodiment;
Fig. 3 is a flowchart of a preliminary process according to the first embodiment;
Fig. 4 is an explanatory drawing of a learning process according to the first embodiment;
Fig. 5 is an explanatory drawing of a distribution process according to the first embodiment;
Fig. 6 is a flowchart of a power-saving control process according to the first embodiment;
Fig. 7 is an explanatory drawing of the power-saving control process according to the first embodiment;
Fig. 8 is a configuration diagram of a control device 10 according to a second embodiment;
Fig. 9 is an explanatory drawing of a display control unit 26 according to the second embodiment;
Fig. 10 is a configuration diagram of an air conditioning system 1 according to a third embodiment;
Fig. 11 is a configuration diagram of a control device 10 according to the third embodiment;
Fig. 12 is an explanatory drawing of an airflow generation unit 27 according to the third embodiment;
Fig. 13 is a configuration diagram of a control device 10 according to a fourth embodiment; and
Fig. 14 is a flowchart of a power-saving control process according to the fourth embodiment.

Description of Embodiments

[0010] First Embodiment

Description of Configuration

[0011] Description will be made on a configuration of an air conditioning system 1 according to a first embodiment with reference to Fig. 1.

[0012] The air conditioning system 1 includes one or more air conditioning units 2 and a control device 10. The air conditioning unit 2 is configured by connecting one outdoor unit 3 and one or more indoor units 4 with a refrigerant pipe 5. The air conditioning system 1 includes a plurality of indoor units 4 as a whole irrespective of the number of the air conditioning units 2 and the number of the indoor units 4 included in the air conditioning units 2.

[0013] In Fig. 1, the air conditioning system 1 includes two air conditioning units 2 of an air conditioning unit 2A and an air conditioning unit 2B. The air conditioning unit 2A includes an outdoor unit 3A, and three indoor units 4 of an indoor unit 4A through an indoor unit 4C. The air conditioning unit 2B includes an outdoor unit 3B, and three indoor units 4 of an indoor unit 4D through an indoor unit 4F. Hereinafter, the configuration of Fig. 1 will be described as an example.

[0014] The control device 10 is connected to each outdoor unit 3 and each indoor unit 4 by a network 6. The control device 10 is capable of obtaining information from each outdoor unit 3 and each indoor unit 4 via the network 6. Further, the control device 10 is capable of transmitting control signals to each outdoor unit 3 and each indoor unit 4 via the network 6.

[0015] A temperature sensor 7 is provided in each outdoor unit 3 and each indoor unit 4. In this manner, it is possible to detect an outdoor air temperature where each outdoor unit 3 is installed, and an indoor temperature where each indoor unit 4 is installed.

[0016] Description will be made on a configuration of the control device 10 according to First Embodiment with reference to Fig. 2.

[0017] The control device 10 is a computer.

[0018] The control device 10 includes hardware components of a processor 11, a memory unit 12, a storage unit 13 and a communication interface 14. The processor 11 is connected to the other hardware components via a signal line, and controls these other hardware components.

[0019] The processor 11 is an IC to perform processing. IC is an abbreviation for Integrated Circuit. The processor 11 is, for example, a CPU, a DSP or a GPU. CPU is an abbreviation for Central Processing Unit. DSP is an abbreviation for Digital Signal Processor. GPU is an abbreviation for Graphics Processing Unit.

[0020] The memory unit 12 is a storage device to temporarily store data. The memory unit 12 is, for example, an SRAM or a DRAM. SRAM is an abbreviation for Static Random Access Memory. DRAM is an abbreviation for Dynamic Random Access Memory.

[0021] The storage unit 13 is a storage device to store data. The storage unit 13 is, for example, an HDD. HDD is an abbreviation for Hard Disk Drive. Further, the storage unit 13 may be a portable recording medium such as an SD (registered trademark) memory card, a CompactFlash (registered trademark), a NAND Flash memory, a flexible disk, an optical disk, a compact disk, a Blue-ray (registered trademark) disk, a DVD or the like. SD is an abbreviation for Secure Digital. DVD is an abbreviation for Digital Versatile Disk.

[0022] The communication interface 14 is an interface to communicate with an external device. The communication interface 14 is, for example, a port of an Ethernet (registered trademark), a USB or an HDMI (registered trademark). USB is an abbreviation for Universal Serial Bus. HDMI is an abbreviation for High-Definition Multimedia Interface.

[0023] The control device 10 is connected to each outdoor unit 3 and each indoor unit 4 by the network 6 via the communication interface 14.

[0024] The control device 10 includes a power consumption measurement unit 21, a learning unit 22, a setting unit 23, a relaxation amount specification unit 24 and a setting change unit 25, as functional components. The functions of each functional component of the control device 10 are realized by software.

[0025] The storage unit 13 stores programs to realize the functions of each functional component of the control device 10. These programs are read into the memory unit 12 by the processor 11, and executed by the processor 11. In this manner, the functions of each functional component of the control device 10 are realized.

[0026] In Fig. 1, only one processor 11 is illustrated. However, there may be a plurality of the processors 11, and the plurality of processors 11 may execute the programs to realize each function in cooperation.

Description of Operation

[0027] Description will be made on the operation of the control device 10 according to First Embodiment with reference to Fig. 3 through Fig. 7.

[0028] The operation procedure of the control device 10 according to First Embodiment corresponds to a control method of the air conditioning system 1 according to First Embodiment. Further, the programs to realize the operation of the control device 10 according to First Embodiment correspond to a control program of the air conditioning system 1 according to First Embodiment.

[0029] The operation of the control device 10 includes a preliminary process and a power-saving control process.

[0030] The preliminary process is a process to specify change in power consumption relative to change in temperature difference between the inside and the outside of a room for each indoor unit, and to generate power fluctuation information. The power-saving control process is a process to refer to the power fluctuation information, specifies a relaxation amount of a setting temperature required for each indoor unit, and to save electric power.

[0031] Description will be made on the preliminary process according to First Embodiment with reference to Fig. 3.

(Step S11: Power Consumption Measurement Process)

[0032] The power consumption measurement unit 21 measures power consumption of each air conditioning unit 2 during operation of the air conditioning system 1. In this case, the power consumption measurement unit 21 measures the temperature of the outside of the room where the outdoor unit 3 is installed by the temperature sensor 7 provided in the outdoor unit 3. Further, the power consumption measurement unit 21 measures the temperature of the inside of the room where the indoor unit 4 is installed by the temperature sensor 7 provided in the indoor unit 4. The power consumption measurement unit 21 writes a power consumption, an outdoor temperature and an indoor temperature measured at the same timing as a set in the memory unit 12.

[0033] The power consumption measurement unit 21 proceeds with the procedure to Step S12 when measurement for a fixed period of time is finished.

(Step S12: Learning Process)

[0034] The learning unit 22 sets each air conditioning unit 2 as a target air conditioning unit 2. Then, the learning unit 22 specifies a relation between the change in temperature difference between the inside and the outside of a room, and the change in power consumption of the target air conditioning unit 2.

[0035] Specifically, the learning unit 22 reads a plurality of sets of the power consumption, the outdoor temperature and the indoor temperature measured in Step S11 with respect to the target air conditioning unit 2 from the memory unit 12. Then, as illustrated in Fig. 4, the learning unit 22 specifies the relation between the change in temperature difference between the inside and the outside of the room, and the change in power consumption of the target air conditioning unit 2 from the power consumption, and the temperature difference between the outdoor temperature and the indoor temperature in each set, with respect to the target air conditioning unit 2.

[0036] For example, the learning unit 22 specifies a formula representing the relation between the change in temperature difference and the change in power consumption of the target air conditioning unit 2 using a least-squares method. The method is not limited to this, and the relation between the change in temperature difference and the change in power consumption of the target air conditioning unit 2 may be specified by machine learning using a neural network, or the like.

(Step S13: Distribution Process)

[0037] The learning unit 22 sets each air conditioning unit 2 as the target air conditioning unit 2. Then, the learning unit 22 distributes the power consumption of the target air conditioning unit 2 to each indoor unit 4 included in the target air conditioning unit 2. In this manner, the relation between the change in temperature difference and the change in power consumption of the target air conditioning unit 2 specified in Step S12 is converted into a relation between the change in temperature difference and the change in power consumption related to each indoor unit 4, as illustrated in Fig. 5.

[0038] In this case, the learning unit 22 distributes the power consumption by weighting the power consumption with capacities of the indoor units 4. Specifically, the learning unit 22 distributes the power consumption of the target air conditioning unit 2 to each indoor unit 4 included in the target air conditioning unit 2, by Formula 1. In Formula 1, an indoor unit j is any indoor unit 4 included in the target air conditioning unit 2.

(Formula 1)

[0039] power consumption Win_j of Indoor unit j = (capacity of indoor unit j / sum of capacities of all indoor units 4 included in target air conditioning unit 2) $\times$ power consumption Wout_i of target air conditioning unit 2

[0040] The power consumption distributed to each indoor unit 4 is a power consumption related to the indoor unit 4. That is, the power consumption related to the indoor unit 4 includes not only the electric power consumed by the indoor unit 4, but also the electric power consumed by the outdoor unit 3 related to the indoor unit 4.

(Step S14: Power Fluctuation Information Generation Process)

[0041] The learning unit 22 sets each indoor unit 4 included in each air conditioning unit 2 as the target indoor unit 4. As illustrated in Fig. 5, the learning unit 22 specifies an amount of change in power consumption when the temperature difference changes by a unit quantity (for example, 1K (Kelvin)) with respect to the target indoor unit 4 from the relation between the change in temperature difference and the change in power consumption related to each indoor unit 4 obtained in Step S13.

[0042] The learning unit 22 writes the amount of change in power consumption specified with respect to each indoor unit 4 as the power fluctuation information in the memory unit 12. That is, the power fluctuation information is information to indicate the amount of change in power consumption relative to the amount of change in temperature difference for each indoor unit 4.

[0043] Description is made herein by assuming that the amount of change in power consumption at the time when the temperature difference has changed by the unit quantity is constant. However, technically, even if the amounts of change in temperature difference are the same, the amount of change in power consumption varies depending on from what degree to what degree the temperature difference has changed. It is because there is an influence of operating efficiency of the air conditioning unit 2, or the like. Therefore, the learning

unit 22 may specify the amount of change in power consumption at the time when the temperature difference has changed by the unit quantity for each temperature.

[0044] Description will be made on a power-saving control process according to First Embodiment with reference to Fig. 6.

(Step S21: Setting Process)

[0045] The setting unit 23 sets a target power-saving amount, and a relaxation allowable amount with respect to each indoor unit 4. The target power-saving amount is a target value of the power-saving amount. The relaxation allowable amount is an upper limit to moderate the setting temperature. To moderate the setting temperature is to raise the setting temperature when the air conditioning system 1 performs cooling operation. In addition, to moderate the setting temperature is to lower the setting temperature when the air conditioning system 1 performs heating operation.

[0046] Specifically, the setting unit 23 accepts input of the target power-saving amount, and the relaxation allowable amount with respect to each indoor unit 4, from a manager of the air conditioning system 1. The setting unit 23 writes the target power-saving amount and the relaxation allowable amount accepted in the memory unit 12. The relaxation allowable amount with respect to an indoor unit j being the indoor unit 4 is denoted as ΔdTlim_j.

[0047] The relaxation allowable amount is set depending on a use state of an area where the indoor unit 4 is installed, or the like. For example, a large value is set to the relaxation allowable amount for an indoor unit 4 installed in an area which is not used so often. Further, a small value is set to the relaxation allowable amount for an indoor unit 4 installed in an area used by a customer. Setting a large value to the relaxation allowable amount means that the setting temperature may be largely moderated. That is, there is a possibility that the degree of discomfort becomes high.

(Step S22: First Relaxation Amount Specification Process)

[0048] The relaxation amount specification unit 24 refers to the power fluctuation information, and specifies a relaxation amount of a setting temperature at which the total power consumption related to a plurality of indoor units 4 included in the air conditioning system 1 is decreased by the target power-saving amount or more. The relaxation amount of the setting temperature is an amount to moderate the setting temperature. That is, the relaxation amount is an amount to raise the setting temperature when the air conditioning system 1 performs cooling operation. The relaxation amount is an amount to lower the setting temperature when the air conditioning system 1 performs heating operation. The relaxation amount for an indoor unit j being the indoor unit 4 is denoted as ΔdT_j.

[0049] Specifically, the relaxation amount specification unit 24 sets the same relaxation amount for all the indoor units 4. In this case, the relaxation amount specification unit 24 specifies a smallest relaxation amount at which the total power consumption is decreased by the target power-saving amount or more. For example, when the air conditioning system 1 performs cooling operation, the total power consumption is assumed to be decreased by the target power-saving amount or more, by raising the setting temperature by 2 degrees or more. In this case, the relaxation amount of the setting temperature is specified to be 2 degrees.

[0050] In this case, the indoor temperature is assumed to reach the setting temperature. Therefore, with respect to each indoor unit 4, an amount of change in power consumption related to the indoor unit 4 in a case where the setting temperature is changed by 1K is an amount of change in power consumption related to the indoor unit 4 in a case where a temperature difference is changed by 1K indicated by the power fluctuation information.

(Step S23: Allowable Amount Decision Process)

[0051] The relaxation amount specification unit 24 decides whether an excess indoor unit being an indoor unit whereof the relaxation amount exceeds the relaxation allowable amount exists.

[0052] Specifically, the relaxation amount specification unit 24 sets each indoor unit 4 included in the air conditioning system 1 as the target indoor unit 4. Then, when the target indoor unit 4 is an indoor unit j, whether the indoor unit j is an excess indoor unit with ΔdT_j>ΔdTlim_j is decided. In this manner, the relaxation amount specification unit 24 decides whether an excess indoor unit exists.

[0053] When the excess indoor unit exists, the relaxation amount specification unit 24 proceeds with the process to Step S24. Meanwhile, when the excess indoor unit does not exist, the relaxation amount specification unit 24 proceeds with the process to Step S26.

(Step S24: Upper Limit Setting Process)

[0054] The relaxation amount specification unit 24 sets each of one or more excess indoor units as a target excess indoor unit. The relaxation amount specification unit 24 sets a relaxation allowable amount with respect to the target excess indoor unit as a relaxation amount of the target excess indoor unit. That is, when the target excess indoor unit is an indoor unit j, the relaxation amount specification unit 24 sets ΔdTlim_j to ΔdT_j.

(Step S25: Second Relaxation Amount Specification Process)

[0055] The relaxation amount specification unit 24 specifies the relaxation amount again with respect to the remaining non-excess indoor unit other than the

excess indoor unit.

[0056] By setting the relaxation allowable amount with respect to the excess indoor unit as a relaxation amount, an entire power-saving amount of the plurality of indoor units 4 included in the air conditioning system 1 is decreased. Then, the relaxation amount specification unit 24 specifies again a relaxation amount at which the total power consumption related to the plurality of indoor units 4 is reduced by the target power-saving amount or more when the relaxation allowable amount is set as the relaxation amount with respect to the excess indoor unit. Then, the process is returned to Step S23.

Specifically as follows.

[0057] First, the relaxation amount specification unit 24 sets, as a remaining power-saving amount, a value obtained by subtracting a total reduction amount of a power consumption related to the excess indoor unit in a case where the relaxation allowable amount with respect to the excess indoor unit is set as the relaxation amount, from the target power-saving amount. That is, the relaxation amount specification unit 24 sets each of one or more excess indoor units as the target excess indoor unit. The relaxation amount specification unit 24 refers to the power fluctuation information, and specifies a power consumption to be reduced in a case where the relaxation allowable amount is set as the relaxation amount with respect to the target excess indoor unit. The relaxation amount specification unit 24 sums up the reduced power consumption specified for each of one or more excess indoor units, to obtain a power-saving amount of the excess indoor units. Then, the relaxation amount specification unit 24 sets a value obtained by subtracting the power-saving amount of the excess indoor units from the target power-saving amount as the remaining power-saving amount.

[0058] Next, the relaxation amount specification unit 24 refers to the power fluctuation information, and specifies a relaxation amount with respect to the non-excess indoor units at which a total power consumption related to the non-excess indoor units is reduced by the remaining power-saving amount or more.

[0059] Specifically, the relaxation amount specification unit 24 sets the same relaxation amount to all the non-excess indoor units. In this case, the relaxation amount specification unit 24 specifies a smallest relaxation amount at which the total power consumption related to the non-excess indoor units is reduced by the remaining power-saving amount or more.

(Step S26: Setting Change Process)

[0060] The setting change unit 25 changes a setting temperature with respect to each of the plurality of indoor units 4 included in the air conditioning system 1 by the relaxation amount.

[0061] Specifically, the setting change unit 25 sets each of the plurality of indoor units 4 included in the air conditioning system 1 as the target indoor unit 4. The setting change unit 25 transmits an instruction to change the setting temperature of the target indoor unit 4 by the relaxation amount with respect to the target indoor unit 4 to the target indoor unit 4 via the network 6. When the air conditioning system 1 performs cooling operation, the setting change unit 25 raises the setting temperature by the relaxation amount. Meanwhile, when the air conditioning system 1 performs heating operation, the setting change unit 25 lowers the setting temperature by the relaxation amount.

[0062] That is, the setting temperature is changed as follows. The target indoor unit 4 is assumed to be an indoor unit j. An original setting temperature is assumed to be Tset_j. The setting temperature to save electric power is assumed to be Tmset_j. Then, during cooling operation, $Tmset\_j = Tset\_j + \Delta dT\_j$. During heating operation, $Tmset\_j = Tset\_j - \Delta dT\_j$.

[0063] Then, each of the plurality of indoor units 4 operates in accordance with the setting temperature changed by the setting change unit 25.

[0064] As described above, the relaxation amount specification unit 24 temporarily specifies the relaxation amount of each indoor unit 4 regardless of the relaxation allowable amount. Then, the relaxation amount specification unit 24 adjusts the relaxation amount with respect to each of the plurality of indoor units 4 so that the relaxation allowable amount determined for each indoor unit 4 does not exceed the relaxation amount.

[0065] For example, as illustrated in Fig. 7, it is assumed that a relaxation allowable amount is determined for each indoor unit 4. First, the relaxation amount specification unit 24 temporarily specifies the relaxation amount of each indoor unit 4 as 2K regardless of the relaxation allowable amount. 2K exceeds 1K being a relaxation allowable amount of an indoor unit 4A. Therefore, as for the indoor unit 4A, 1K being the relaxation allowable amount is set as the relaxation amount. Then, the relaxation amounts of the remaining indoor units 4B through 4F are changed from 2K to 3K, so that the target power-saving amount can be attained as a whole.

[0066] There may be a case where it is impossible to attain power saving not less than the target power-saving amount even by setting the relaxation allowable amount as the relaxation amount with respect to all the indoor units 4. In this case, the relaxation amount specification unit 24 may evenly increase the relaxation allowable amount of each indoor unit 4 by a fixed amount. On that basis, the relaxation amount specification unit 24 may repeat the process from Step S22 again.

Effect of First Embodiment

[0067] As described above, the control device 10 according to First Embodiment specifies the relaxation amount of the setting temperature from the total power consumption related to the plurality of indoor units 4 and

the targe power-saving amount. In this manner, the setting temperature is changed as much as necessary for the target power-saving amount. Therefore, it is possible to save electric power by the target power-saving amount or more while restraining deterioration of comfortableness of a user beyond necessity.

[0068] Further, the control device 10 according to First Embodiment sets the relaxation allowable amount for each indoor unit 4. In this manner, an upper limit of discomfort degree during a power-saving time is set for each indoor unit 4. Therefore, when there is an area in which it is undesirable to cause a sense of discomfort for a user, it is possible to make the setting of the area so as to suppress the degree of discomfort.

Other Configurations

<First Variation>

[0069] In First Embodiment, the relaxation amount specification unit 24 specifies the same relaxation amount for each indoor unit 4 in Step S22 of Fig. 6. Similarly, the relaxation amount specification unit 24 specifies the same relaxation amount for each non-excess indoor unit in Step S25 of Fig. 6.

[0070] However, the relaxation amount specification unit 24 may specify the relaxation amount in accordance with the indoor unit 4 (or non-excess indoor unit) based on a rule determined beforehand. For example, it may be possible to set a weight for each indoor unit 4, and to specify the relaxation amount in accordance with the weight. That is, the relaxation amount specification unit 24 may specify the relaxation amounts in such a manner that the heavier the weight for the indoor unit 4 is, the larger the relaxation amount is.

<Second Variation>

[0071] In First Embodiment, each functional component is realized by software. However, as Second Variation, each functional component may be realized by hardware components. Description will be made for Second Variation on points different from those in First Embodiment.

[0072] When each functional component is realized by hardware components, the control device 10 includes an electronic circuit instead of the processor 11, the memory unit 12 and the storage unit 13. The electronic circuit is a dedicated circuit to realize each functional component, and the functions of the memory unit 12 and the storage unit 13.

[0073] As the electronic circuit, a single circuit, a composite circuit, a processor made into a program, a processor made into a parallel program, a logic IC, a GA, an ASIC or an FPGA is supposed. GA is an abbreviation for "Gate Array". ASIC is an abbreviation for "Application Specific Integrated Circuit". FPGA is an abbreviation for "Field Programmable Gate Array".

[0074] Each functional component may be realized by one electronic circuit, or may be realized by a plurality of electronic circuits dispersedly.

<Third Variation>

[0075] As Third Variation, a part of each functional component may be realized by hardware components, and another part of each functional component may be realized by software.

[0076] The processor 11, the memory unit 12, the storage unit 13 and electronic circuits are called processing circuitry. That is, the functions of each functional component are realized by processing circuitry.

Second Embodiment

[0077] Second Embodiment is different from First Embodiment in that a setting temperature after changed is notified. In Second Embodiment, description will be made on this different part, and description on the same parts will be omitted.

Description of Configuration

[0078] Description will be made on a configuration of the control device 10 according to Second Embodiment with reference to Fig. 8.

[0079] The control device 10 is different from the control device 10 illustrated in Fig. 2 in that it includes a display control unit 26 as a functional component. The function of the display control unit 26 is realized by software or hardware components.

Description of Operation

[0080] Description will be made on a power-saving control process according to Second Embodiment with reference to Fig. 6.

[0081] The process from Step S21 through Step S25 is the same as that in First Embodiment.

(Step S26: Setting Change Process)

[0082] The setting change unit 25 changes a setting temperature for each of the plurality of indoor units 4 included in the air conditioning system 1 by a relaxation amount, as in First Embodiment. Then, as illustrated in Fig. 9, the display control unit 26 displays the setting temperature after changed. For example, the display control unit 26 displays a setting temperature on a display device installed inside or near a room where any of the indoor units 4 is installed. Further, the display control unit 26 may display the setting temperature on a smartphone, a tablet terminal or the like of a user.

[0083] In this case, the display control unit 26 may show a display to guide an area whereof the relaxation amount is small. For example, when it is possible to

specify a room where a user is present, the display control unit 26 may guide a room whereof the relaxation amount is smaller than that of the room where the user is present.

Effect of Second Embodiment

[0084] As described above, the control device 10 according to Second Embodiment notifies of the setting temperature after changed. In this manner, it is possible for the user to recognize that the room temperature will be changed. Therefore, it is possible for the user to take measures to relieve the sense of discomfort, such as to move to another area, and so on.

Third Embodiment

[0085] Third Embodiment is different from First and Second Embodiments in that an airflow is generated during cooling operation. In third Embodiment, description will be made on this different point, and description on the same points will be omitted.

[0086] In Third Embodiment, description will be made on a case where a change is made to First Embodiment. However, it is possible to make a change to Second Embodiment.

Description of Configuration

[0087] Description will made on a configuration of the air conditioning system 1 according to Third Embodiment with reference to Fig. 10.

[0088] The air conditioning system 1 is different from the air conditioning system 1 illustrated in Fig. 1 in that it includes an airflow generation device 8 to generate an airflow for a space where each of the plurality of indoor units 4 is installed. The airflow generation device 8 is an electric fan or the like.

[0089] Description will be made on a configuration of the control device 10 according to Third Embodiment with reference to Fig. 11.

[0090] The control device 10 is different from the control device 10 illustrated in Fig. 2 in that it includes an airflow generation unit 27 as a functional component. The function of the airflow generation unit 27 is realized by software or a hardware component.

Description of Operation

[0091] Description will be made on a power-saving control process according to Third Embodiment with reference to Fig. 6.

[0092] The process from Step S21 through Step S25 is the same as that in First Embodiment.

(Step S26: Setting Change Process)

[0093] The setting change unit 25 changes a setting temperature with respect to each of the plurality of indoor units 4 included in the air conditioning system 1 by a relaxation amount, as in First Embodiment. During cooling operation, the airflow generation unit 27 activates the airflow generation devices 8, and generates airflows in areas where the indoor units 4 are installed. In this case, it may be possible for the airflow generation unit 27 to make airflows be generated only in areas where indoor units 4 whereof the relaxation amounts are larger than a standard are installed, as illustrated in Fig. 12. Otherwise, it is possible for the airflow generation unit 27 to make airflows be generated in such a manner that the larger the relaxation amount is, the stronger the airflow is.

Effect of Third Embodiment

[0094] As described above, the control device 10 according to Third Embodiment generates an airflow when the setting temperature is changed during cooling operation. In this manner, it is possible to relieve the sense of discomfort due to change in the setting temperature.

Fourth Embodiment

[0095] Fourth Embodiment is different from First through Third Embodiments in that a relaxation amount is changed depending on whether a person is present. In Fourth Embodiment, description will be made on this different point, and description on the same points will be omitted.

[0096] In Fourth Embodiment, description will be made on a case where a change is made to First Embodiment. However, it is possible to make a change to Second and Third Embodiments.

Description of Configuration

[0097] Description will be made on a configuration of the control device 10 according to Fourth Embodiment with reference to Fig. 13.

[0098] The control device 10 is different from the control device 10 illustrated in Fig. 2 in that it includes a person decision unit 28 as a functional configuration. The function of the person decision unit 28 is realized by software or a hardware component.

Description of Operation

[0099] Description will be made on a power-saving control process according to Fourth Embodiment with reference to Fig. 14.

(Step S31: Setting Process)

[0100] The setting unit 23 sets a target power-saving amount, and a relaxation allowable amount and an absence allowable amount with respect to each indoor unit 4. The absence allowable amount is a relaxation amount

adopted when there is no person in an area where an indoor unit 4 is installed. As the absence allowable amount, a value larger than the relaxation allowable amount is set.

[0101] Specifically, the setting unit 23 accepts input of the target power-saving amount, and the relaxation allowable amount and the absence allowable amount with respect to each indoor unit 4, from the manager of the air conditioning system 1. The setting unit 23 writes the target power-saving amount, the relaxation allowable amount and the absence allowable amount accepted in the memory unit 12. An absence allowable amount of an indoor unit j being the indoor unit 4 is denoted as ΔdTlim2_j.

(Step S32: Person Decision Process)

[0102] The person decision unit 28 decides whether a person is present in an area where each indoor unit 4 is installed.

[0103] Specifically, the person decision unit 28 detects a person existing in the area by using a camera, an infrared sensor or the like provided in the area. When a person is detected, the person decision unit 28 decides that the person is present. Otherwise, when a person is not detected, the person decision unit 28 decides that no one is present. The means to detect a person may be arbitrary.

(Step S33: Absence Allowable Amount Setting Process)

[0104] The relaxation amount specification unit 24 sets an indoor unit 4 installed in an absence space where it is decided that no one is present in Step S32 as an absence indoor unit. As for the absence indoor unit, the relaxation amount specification unit 24 sets an absence allowable amount determined for the absence indoor unit as a relaxation amount.

(Step S34: First Relaxation Amount Specification Process)

[0105] The relaxation amount specification unit 24 sets a remaining indoor unit 4 other than the absence indoor unit as a presence indoor unit. As for the presence indoor unit, the relaxation amount specification unit 24 specifies a relaxation amount of the setting temperature at which the total power consumption related to the plurality of indoor units 4 is decreased by the target power-saving amount or more when the absence allowable amount is set as the relaxation amount with respect to the absence indoor unit.

Specifically as follows.

[0106] First, the relaxation amount specification unit 24 sets a value obtained by subtracting a total reduction amount of a power consumption related to an absence indoor unit in a case where the absence allowable amount is set as a relaxation amount with respect to the absence indoor unit, from the target power-saving amount, as a remaining power-saving amount. That is, the relaxation amount specification unit 24 sets each of one or more absence indoor units as the target absence indoor unit. The relaxation amount specification unit 24 refers to the power fluctuation information, and specifies a power consumption reduced in a case where an absence allowable amount is set as a relaxation amount with respect to the target absence indoor unit. The relaxation amount specification unit 24 sums up the reduced power consumptions specified for each of one or more absence indoor units, to obtain a power-saving amount of the absence indoor units. Then, the relaxation amount specification unit 24 sets a value obtained by subtracting the power-saving amount of the absence indoor units from the target power-saving amount as the remaining power-saving amount.

[0107] Then, the relaxation amount specification unit 24 refers to the power fluctuation information, and specifies a relaxation amount with respect to an absence indoor unit at which a total power consumption related to the absence indoor unit is reduced by the remaining power-saving amount or more.

[0108] Specifically, the relaxation amount specification unit 24 sets the same relaxation amounts for all the absence indoor units. In this case, the relaxation amount specification unit 24 specifies a smallest relaxation amount at which the total power consumption related to the absence indoor units is reduced by the target power-saving amount or more.

[0109] The process from Step S35 through Step 38 is the same as the process from Step S23 through Step S26 in Fig. 6.

Effect of Fourth Embodiment

[0110] As described above, the control device 10 according to Fourth Embodiment changes the relaxation amount depending on whether a person is present. In this manner, it is possible to increase the relaxation amount of an area where no one is present, and to decrease the relaxation amount of an area where a person is present instead. As a result, it is possible to restrain deterioration of comfortableness of a user.

[0111] "Unit" in the description above may be replaced with replaced with "circuit", "step", "procedure", "process" or "processing circuitry".

[0112] In the above, description has been made on embodiments and variations of the present disclosure. Some of these embodiments and variations may be combined and performed. Otherwise, any or some may be partially performed. The present disclosure is not limited to the embodiments and the variations described above, and various modifications can be added as needed.

Reference Signs List

[0113] 1: air conditioning system; 2: air conditioning unit; 3: outdoor unit; 4: indoor unit; 5: refrigerant pipe; 6: network; 7: temperature sensor; 8: airflow generation device; 10: control device; 11: processor; 12: memory unit; 13: storage unit; 14: communication interface; 21: power consumption measurement unit; 22: learning unit; 23: setting unit; 24: relaxation amount specification unit; 25: setting change unit; 26: display control unit; 27: airflow generation unit; 28: person decision unit

Claims

1. A control device to perform control of an air conditioning system including a plurality of indoor units, the control device comprising

a relaxation amount specification unit to refer to power fluctuation information in which change in a power consumption relative to change in a temperature difference between an inside and an outside of a room is defined for each of the plurality of indoor units, and to specify a relaxation amount of a setting temperature at which a total power consumption related to the plurality of indoor units is reduced by a target power-saving amount or more, and
a setting change unit to change the setting temperature of each of the plurality of indoor units by the relaxation amount specified by the relaxation amount specification unit.

2. The control device as defined in claim 1, wherein the relaxation amount specification unit adjusts the relaxation amount with respect to each of the plurality of indoor units so that the relaxation amount does not exceed a relaxation allowable amount determined for each of the plurality of indoor units.

3. The control device as defined in claim 2, wherein

the relaxation amount specification unit temporarily specifies the relaxation amount regardless of the relaxation allowable amount, and
when an excess indoor unit being an indoor unit whereof the relaxation amount specified exceeds the relaxation allowable amount exists, adjusts the relaxation amount by setting, with respect to the excess indoor unit, the relaxation allowable amount regarding the excess indoor unit as the relaxation amount, and by specifying again, with respect to a remaining non-excess indoor unit other than the excess indoor unit, the relaxation amount at which the total power consumption related to the plurality of indoor units is reduced by the target power-saving amount or more in a case where the relaxation allowable amount is set as the relaxation amount with respect to the excess indoor unit.

4. The control device as defined in claim 3, wherein the relaxation amount specification unit specifies again the relaxation amount of the setting temperature with respect to the non-excess indoor unit, by specifying the relaxation amount with respect to the non-excess indoor unit at which a total power consumption related to the non-excess indoor unit is reduced by a remaining power-saving amount or more, when a value obtained by subtracting, from the target power-saving amount, a total reduction amount of a power consumption related to the excess indoor unit in the case where the relaxation allowable amount is set as the relaxation amount with respect to the excess indoor unit is regarded as the remaining power-saving amount.

5. The control device as defined in any one of claim 1 through claim 4, further comprising
a display control unit to display the setting temperature changed by the setting change unit.

6. The control device as defined in any one of claim 1 through claim 5, wherein the air conditioning system includes an airflow generation device to generate an airflow for a space in which each of the plurality of indoor units is installed,

the control device further comprising
an airflow generation unit to control the airflow generation device in accordance with the relaxation amount and generate an airflow.

7. The control device as defined in any one of claim 1 through claim 6, further comprising

a person decision unit to decide whether a person is present in an area in which each of the plurality of indoor units is installed, wherein
the relaxation amount specification unit
sets, with respect to an absence indoor unit being an indoor unit installed in an absence space in which no one is decided to present by the person decision unit, an absence allowable amount determined for the absence indoor unit among the absence allowable amount determined for each of the plurality of indoor units, as the relaxation amount, and
specifies, with respect to a remaining presence indoor unit other than the absence indoor unit, a relaxation amount of a setting temperature at which the total power consumption related to the plurality of indoor units is reduced by the target power-saving amount or more in a case where the absence allowable amount is set as the

relaxation amount with respect to the absence indoor unit.

8. A control method of an air conditioning system including a plurality of indoor units, the control method comprising

referring to power fluctuation information in which change in a power consumption relative to change in a temperature difference between an inside and an outside of a room is defined for each of the plurality of indoor units, and specifying a relaxation amount of a setting temperature at which a total power consumption related to the plurality of indoor units is reduced by a target power-saving amount or more, and
changing the setting temperature of each of the plurality of indoor units by the relaxation amount.

9. An air conditioning system including a plurality of indoor units and a control device, wherein

the control device includes
a relaxation amount specification unit to refer to power fluctuation information in which change in a power consumption relative to change in a temperature difference between an inside and an outside of a room is defined for each of the plurality of indoor units, and to specify a relaxation amount of a setting temperature at which a total power consumption related to the plurality of indoor units is reduced by a target power-saving amount or more, and
a setting change unit to change the setting temperature of each of the plurality of indoor units by the relaxation amount specified by the relaxation amount specification unit, and wherein
each of the plurality of indoor units operates in accordance with the setting temperature changed by the setting change unit.

Fig. 1

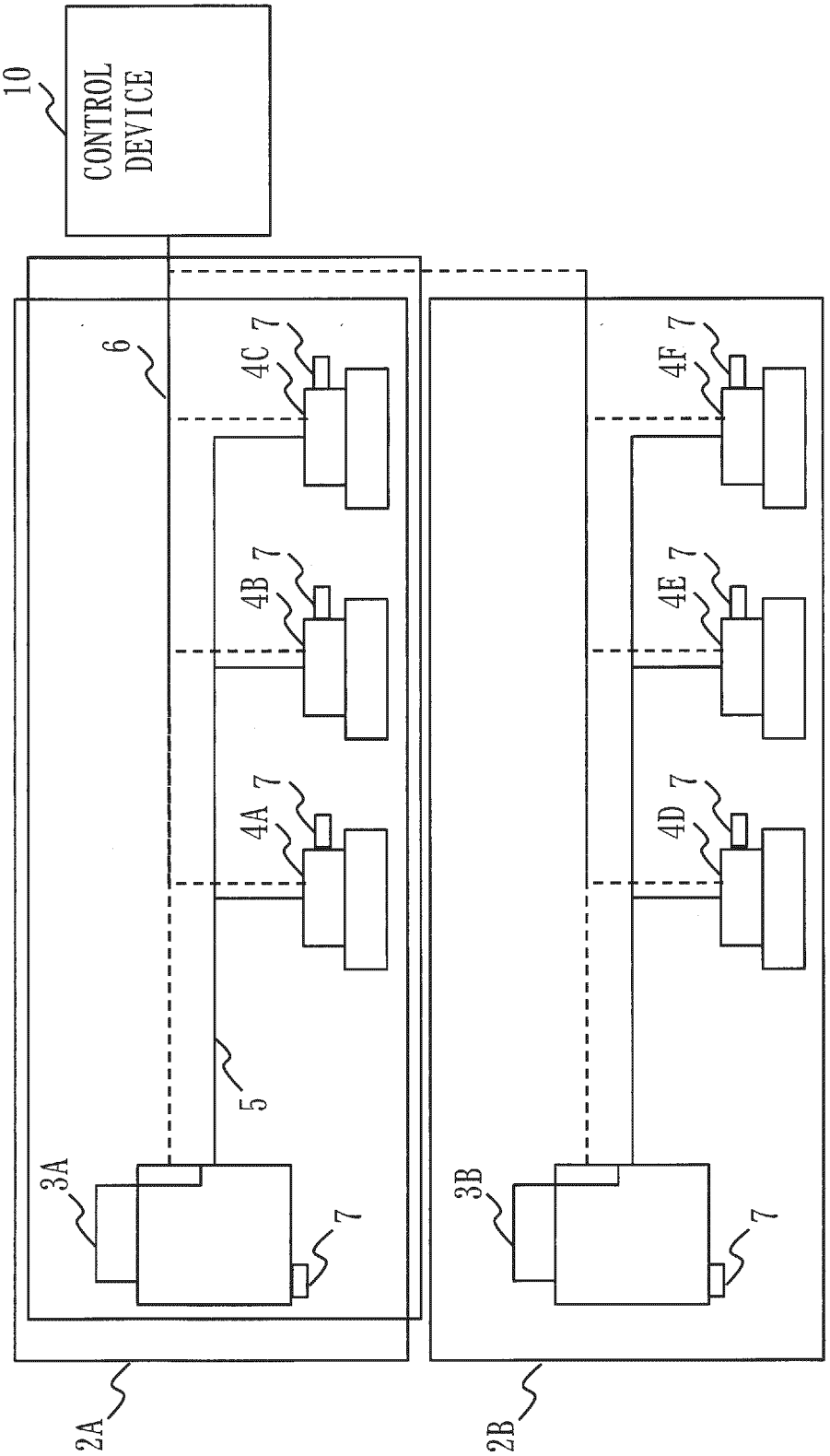
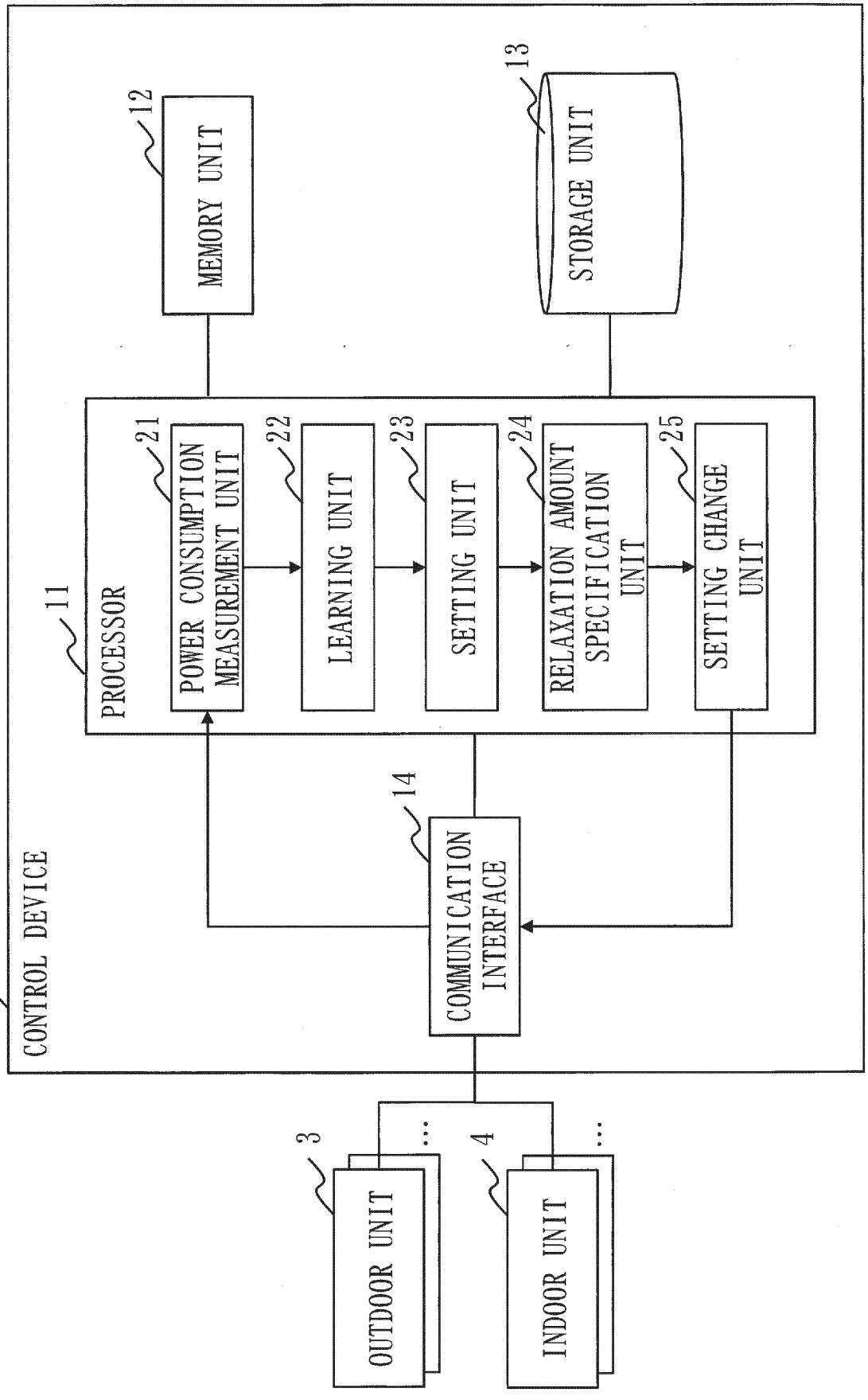


Fig. 2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CONTROL DEVICE
11
PROCESSOR
12
MEMORY UNIT
13
STORAGE UNIT
21
POWER CONSUMPTION MEASUREMENT UNIT
22
LEARNING UNIT
23
SETTING UNIT
24
RELAXATION AMOUNT SPECIFICATION UNIT
25
SETTING CHANGE UNIT
14
COMMUNICATION INTERFACE
3
OUTDOOR UNIT
4
INDOOR UNIT

Fig. 3

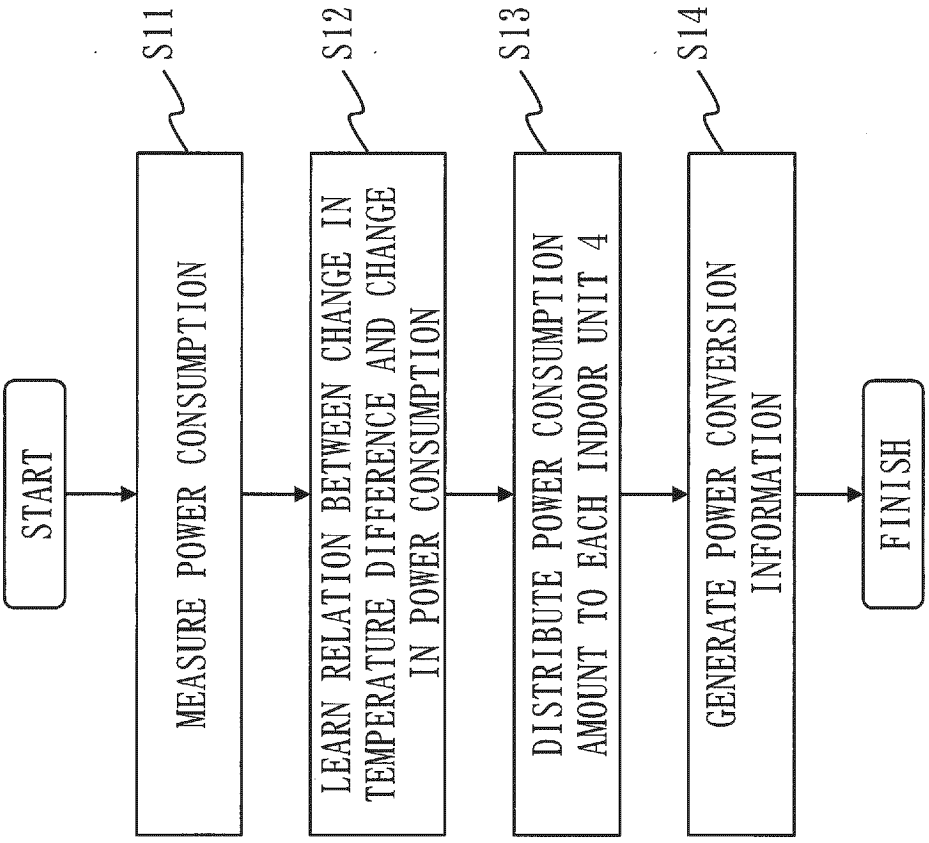

START
S11
MEASURE POWER CONSUMPTION
S12
LEARN RELATION BETWEEN CHANGE IN TEMPERATURE DIFFERENCE AND CHANGE IN POWER CONSUMPTION
S13
DISTRIBUTE POWER CONSUMPTION AMOUNT TO EACH INDOOR UNIT 4
S14
GENERATE POWER CONVERSION INFORMATION
FINISH

Fig. 4

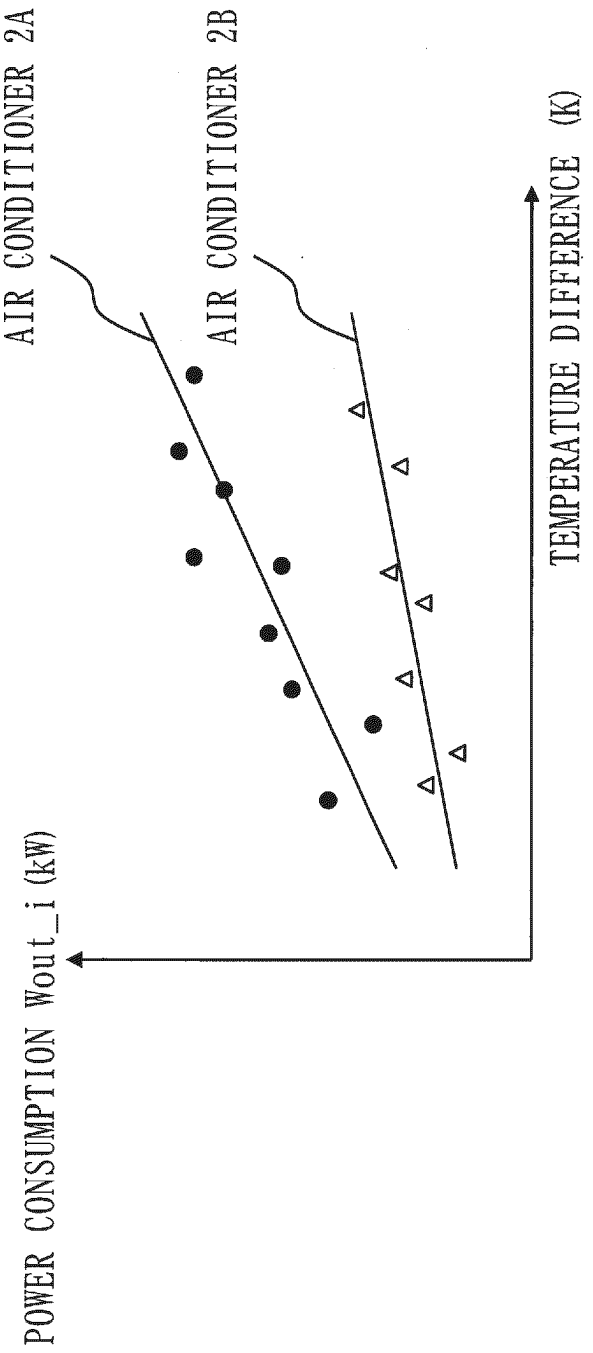

AIR CONDITIONER 2A
AIR CONDITIONER 2B
POWER CONSUMPTION Wout_i (kW)
TEMPERATURE DIFFERENCE (K)

Fig. 5

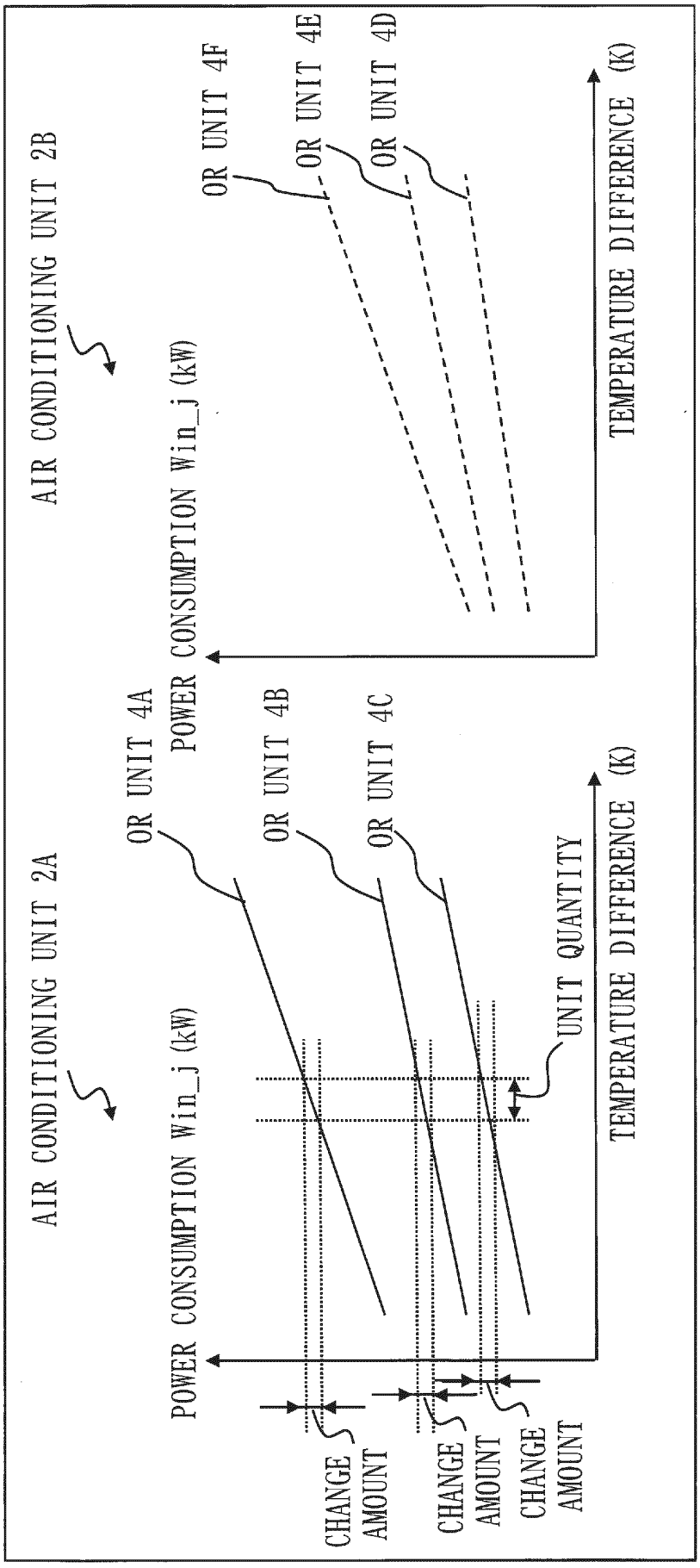

AIR CONDITIONING UNIT 2A
POWER CONSUMPTION Win_j (kW)
OR UNIT 4A
OR UNIT 4B
OR UNIT 4C
UNIT QUANTITY
TEMPERATURE DIFFERENCE (K)
CHANGE AMOUNT
CHANGE AMOUNT
CHANGE AMOUNT
AIR CONDITIONING UNIT 2B
POWER CONSUMPTION Win_j (kW)
OR UNIT 4F
OR UNIT 4E
OR UNIT 4D
TEMPERATURE DIFFERENCE (K)

Fig. 6

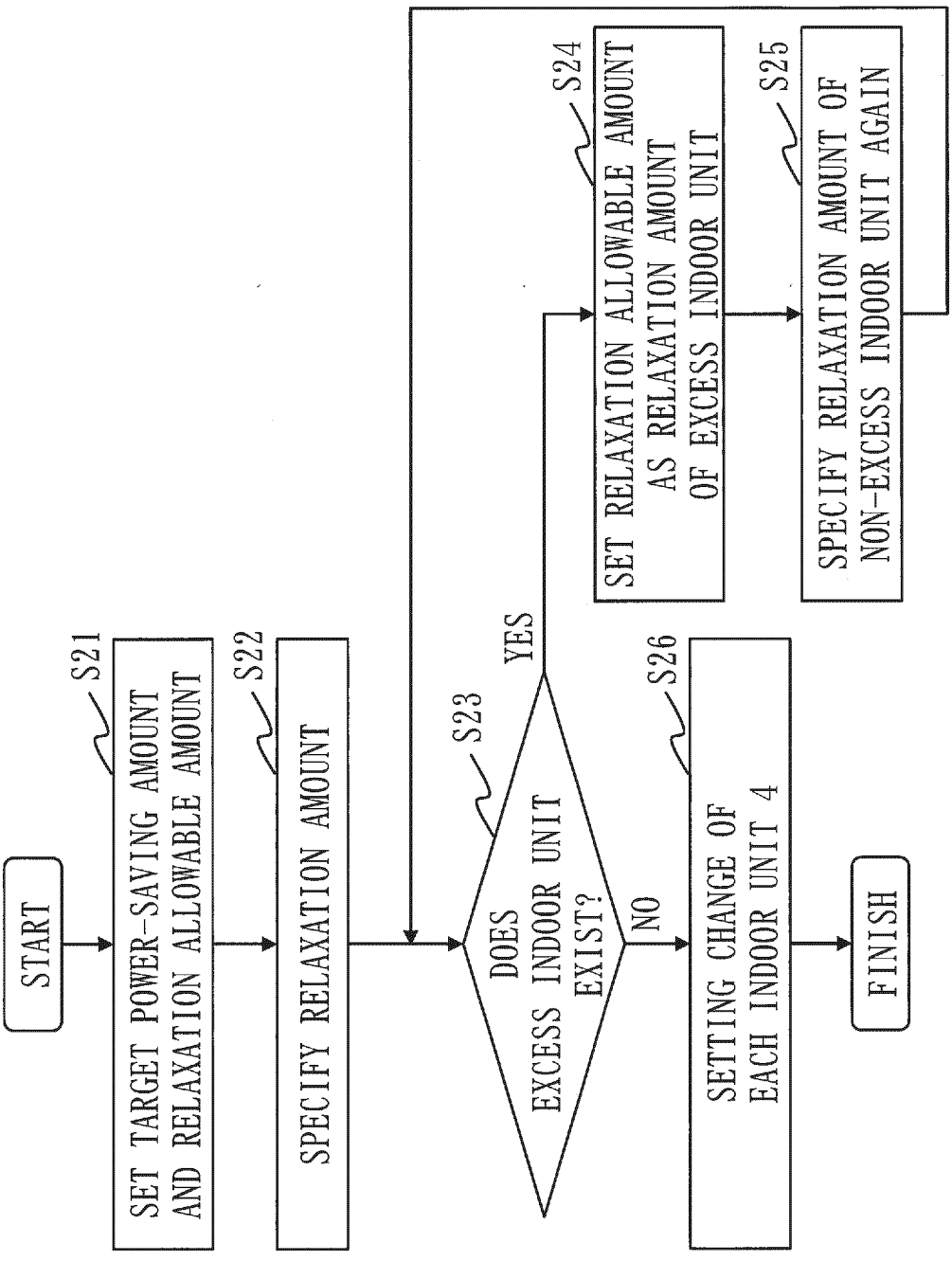

START
S21
SET TARGET POWER-SAVING AMOUNT AND RELAXATION ALLOWABLE AMOUNT
S22
SPECIFY RELAXATION AMOUNT
S23
DOES EXCESS INDOOR UNIT EXIST?
YES
NO
S24
SET RELAXATION ALLOWABLE AMOUNT AS RELAXATION AMOUNT OF EXCESS INDOOR UNIT
S25
SPECIFY RELAXATION AMOUNT OF NON-EXCESS INDOOR UNIT AGAIN
S26
SETTING CHANGE OF EACH INDOOR UNIT 4
FINISH

Fig. 7

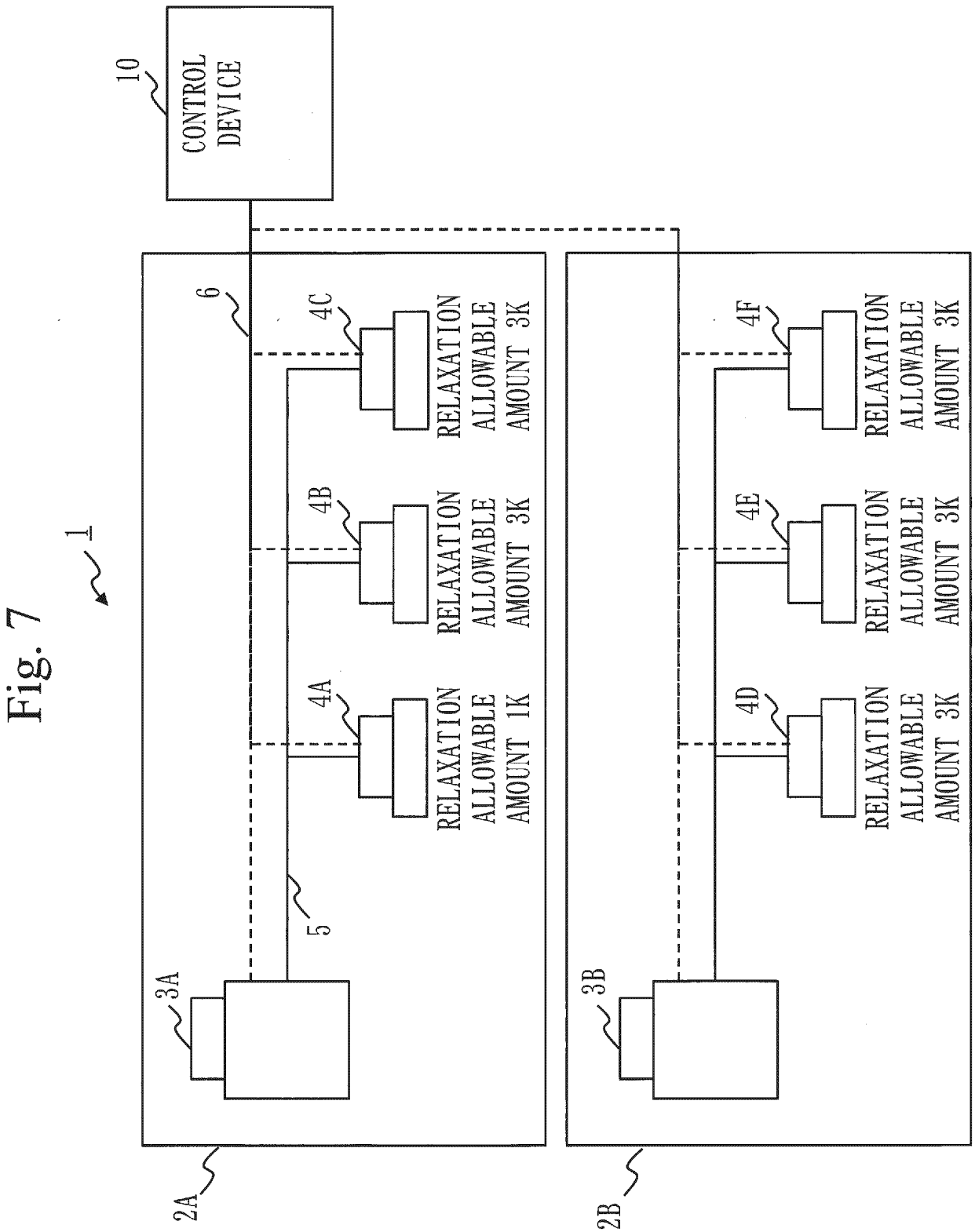

1
10
CONTROL DEVICE
6
2A
2B
3A
3B
4A
4B
4C
4D
4E
4F
5
RELAXATION ALLOWABLE AMOUNT 1K
RELAXATION ALLOWABLE AMOUNT 3K

Fig. 8

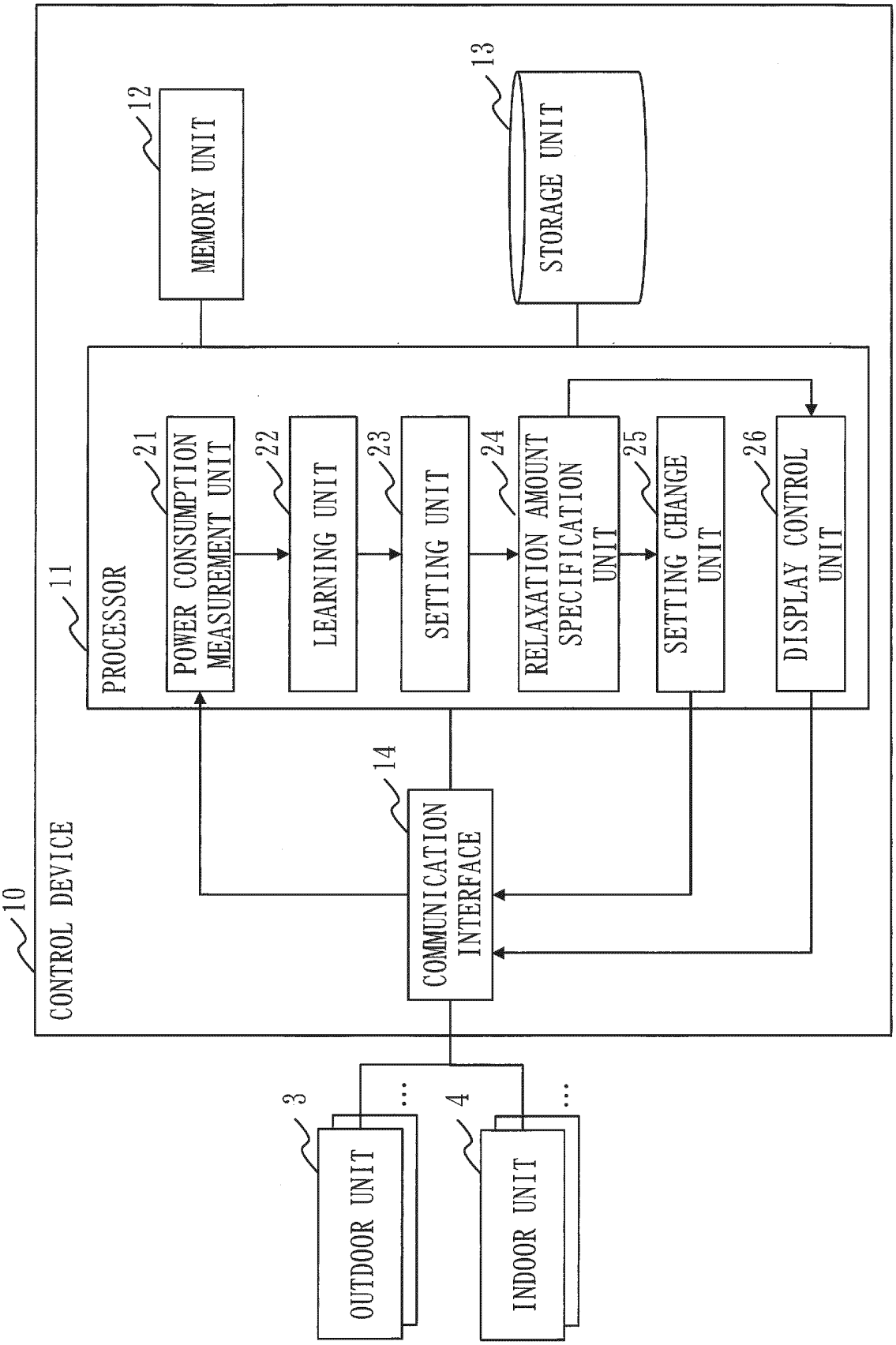

10
CONTROL DEVICE
11
PROCESSOR
12
MEMORY UNIT
13
STORAGE UNIT
21
POWER CONSUMPTION MEASUREMENT UNIT
22
LEARNING UNIT
23
SETTING UNIT
24
RELAXATION AMOUNT SPECIFICATION UNIT
25
SETTING CHANGE UNIT
26
DISPLAY CONTROL UNIT
14
COMMUNICATION INTERFACE
3
OUTDOOR UNIT
4
INDOOR UNIT

Fig. 9

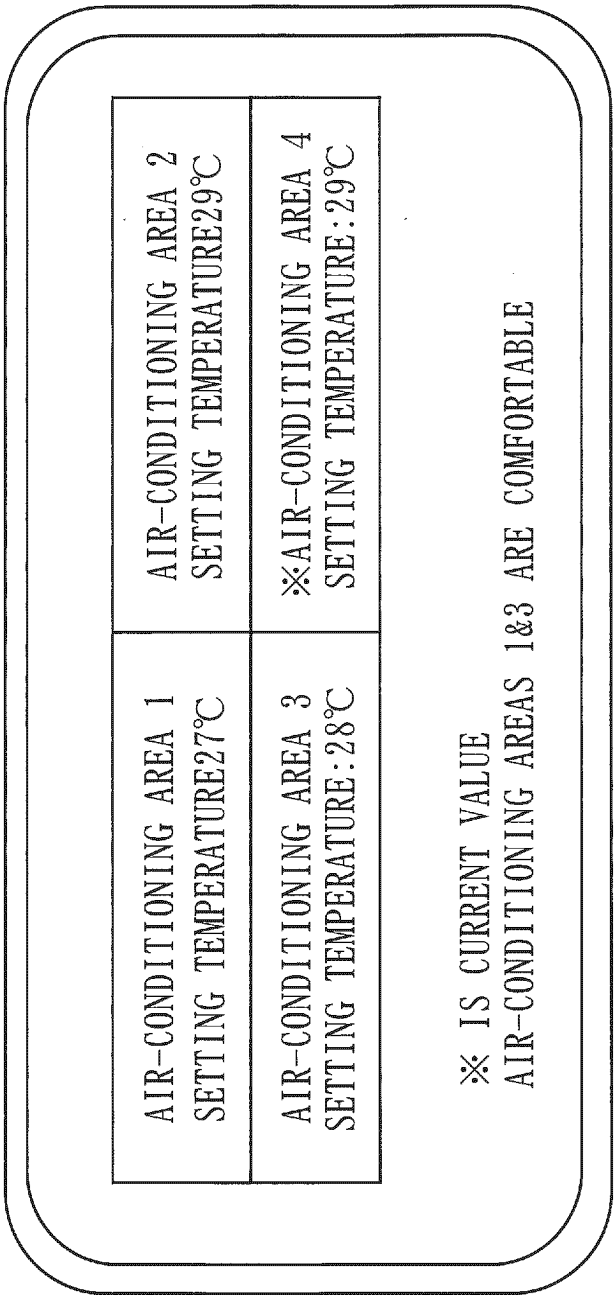

AIR-CONDITIONING AREA 1
SETTING TEMPERATURE27℃
AIR-CONDITIONING AREA 2
SETTING TEMPERATURE29℃
AIR-CONDITIONING AREA 3
SETTING TEMPERATURE:28℃
※AIR-CONDITIONING AREA 4
SETTING TEMPERATURE:29℃
※ IS CURRENT VALUE
AIR-CONDITIONING AREAS 1&3 ARE COMFORTABLE

Fig. 10

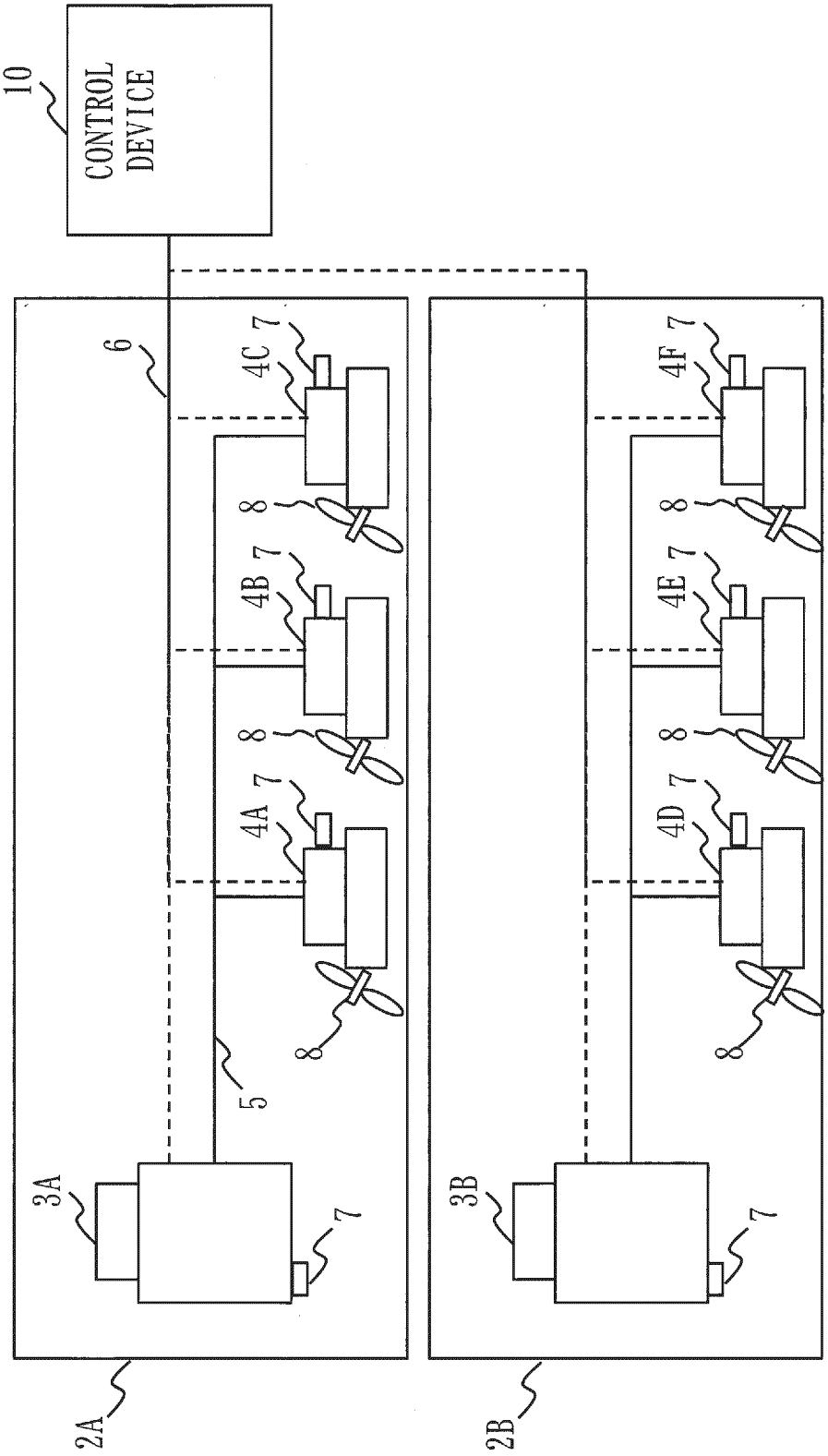


Fig. 11

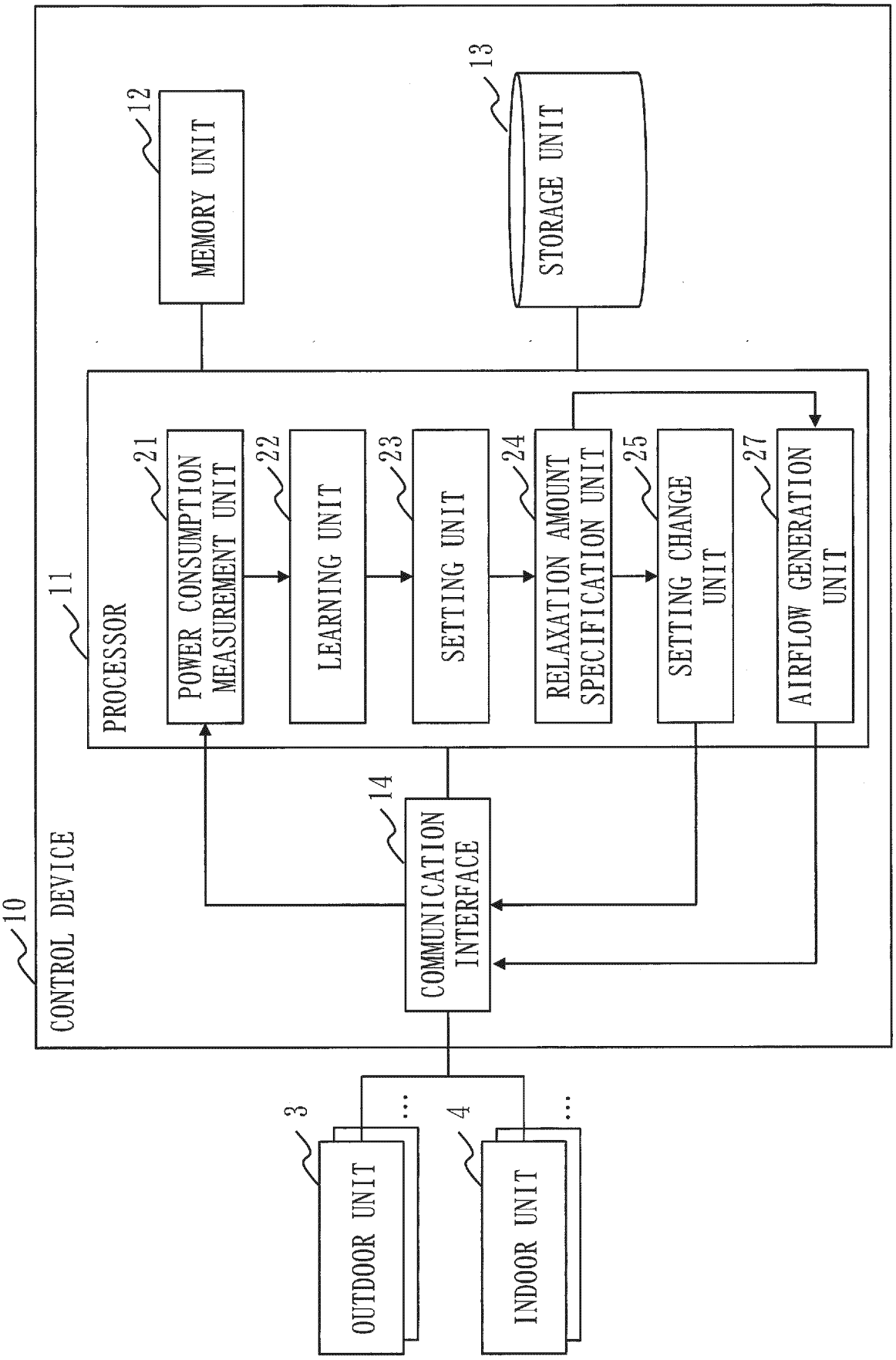

10
CONTROL DEVICE
11
PROCESSOR
12
MEMORY UNIT
13
STORAGE UNIT
14
COMMUNICATION INTERFACE
21
POWER CONSUMPTION MEASUREMENT UNIT
22
LEARNING UNIT
23
SETTING UNIT
24
RELAXATION AMOUNT SPECIFICATION UNIT
25
SETTING CHANGE UNIT
27
AIRFLOW GENERATION UNIT
3
OUTDOOR UNIT
4
INDOOR UNIT

Fig. 12

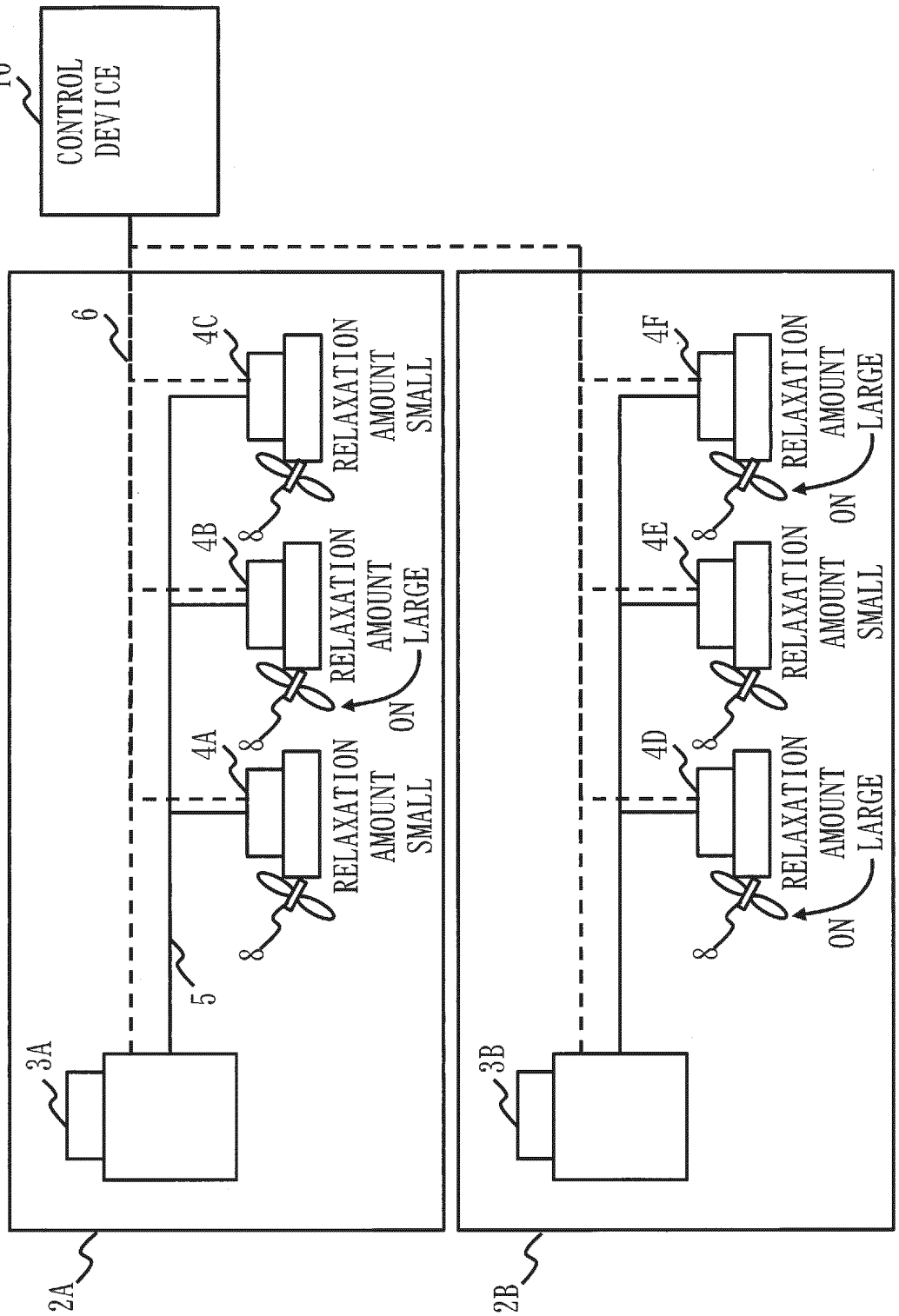

10
CONTROL DEVICE
1
6
4C
RELAXATION AMOUNT SMALL
4B
RELAXATION AMOUNT LARGE
ON
4A
RELAXATION AMOUNT SMALL
8
5
3A
2A
4F
RELAXATION AMOUNT LARGE
ON
4E
RELAXATION AMOUNT SMALL
4D
RELAXATION AMOUNT LARGE
ON
3B
2B

Fig. 13

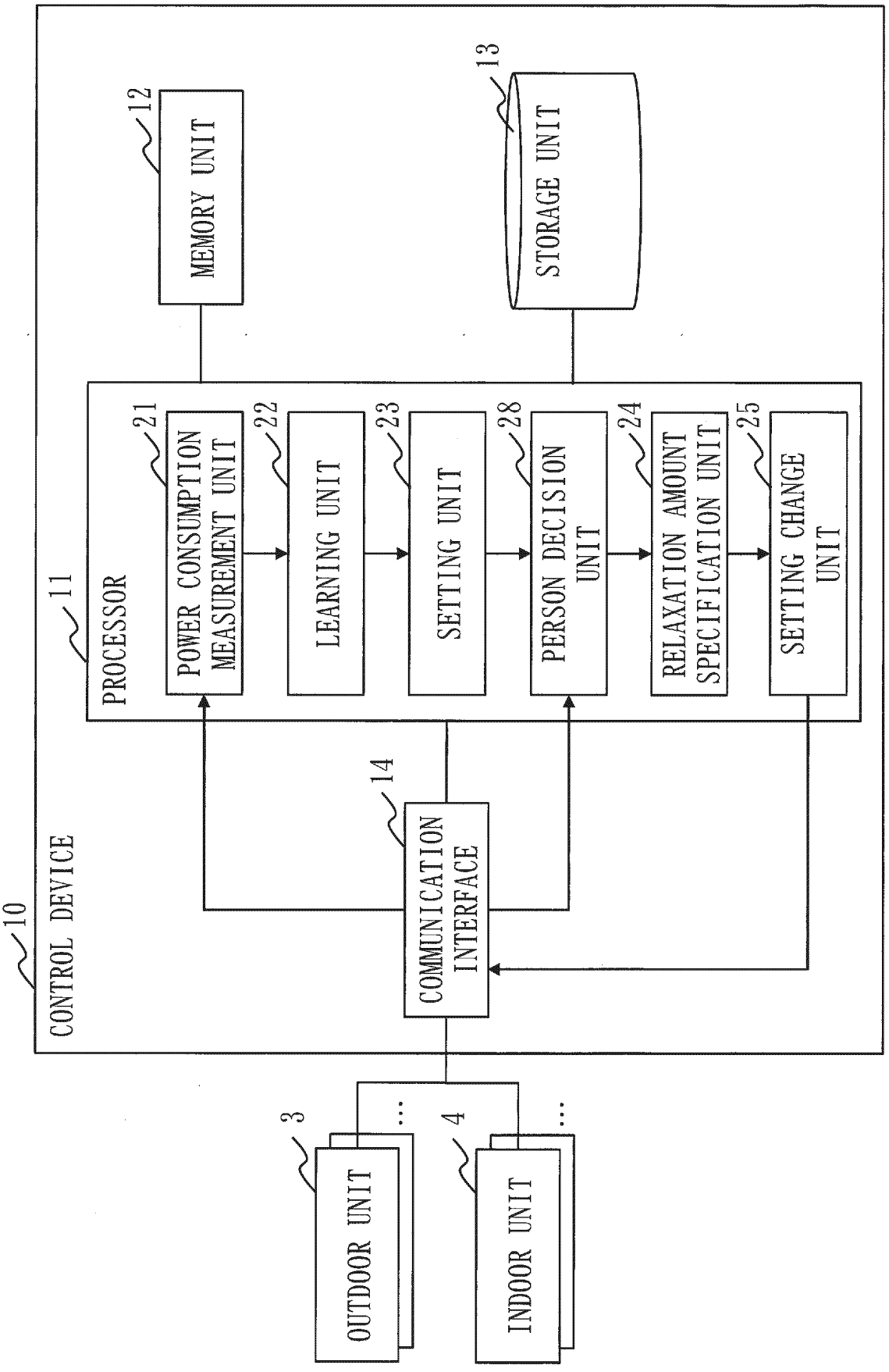
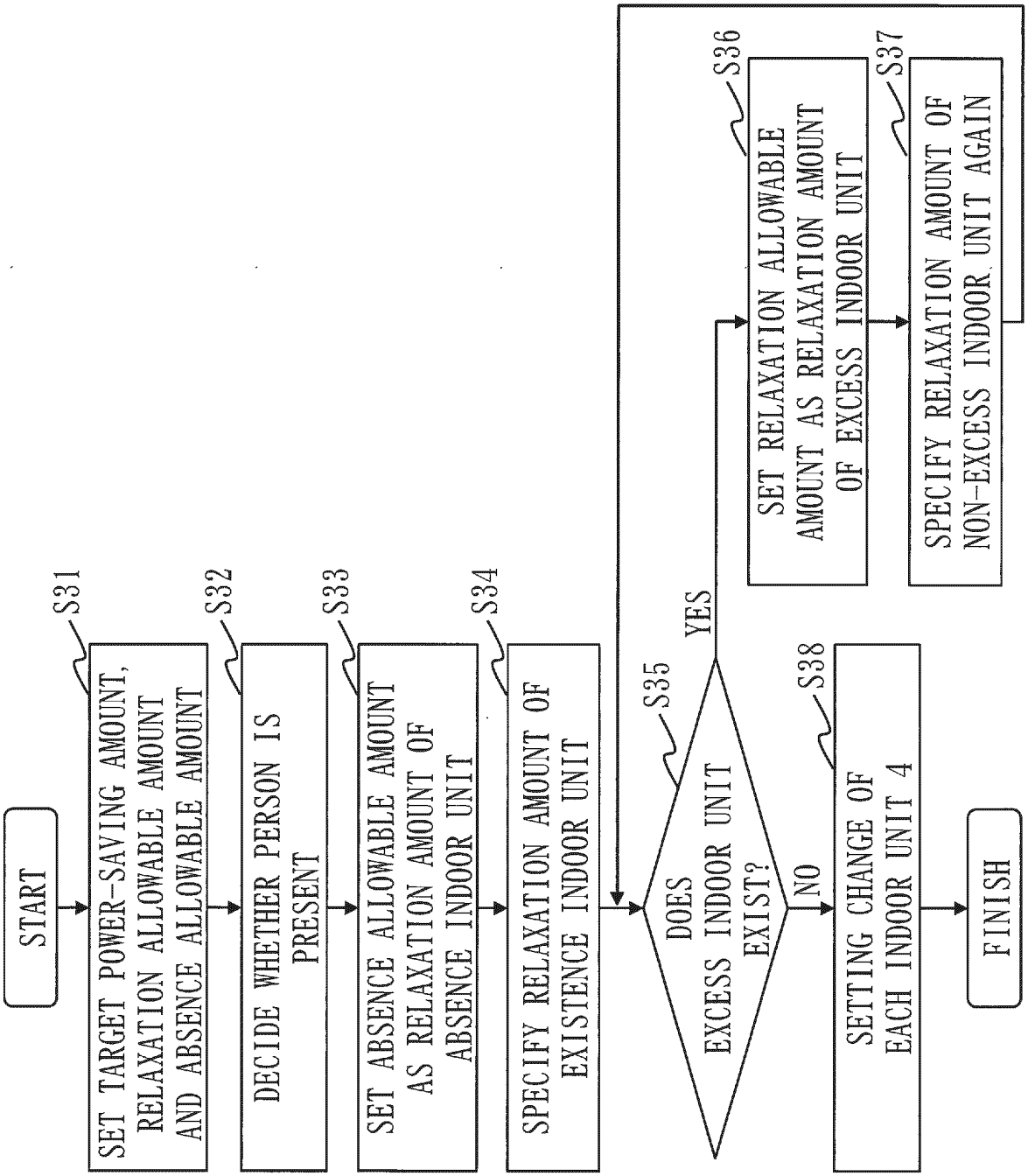

CONTROL DEVICE
10
PROCESSOR
11
MEMORY UNIT
12
STORAGE UNIT
13
COMMUNICATION INTERFACE
14
POWER CONSUMPTION MEASUREMENT UNIT
21
LEARNING UNIT
22
SETTING UNIT
23
PERSON DECISION UNIT
28
RELAXATION AMOUNT SPECIFICATION UNIT
24
SETTING CHANGE UNIT
25
OUTDOOR UNIT
3
INDOOR UNIT
4

Fig. 14


START
S31
SET TARGET POWER-SAVING AMOUNT, RELAXATION ALLOWABLE AMOUNT AND ABSENCE ALLOWABLE AMOUNT
S32
DECIDE WHETHER PERSON IS PRESENT
S33
SET ABSENCE ALLOWABLE AMOUNT AS RELAXATION AMOUNT OF ABSENCE INDOOR UNIT
S34
SPECIFY RELAXATION AMOUNT OF EXISTENCE INDOOR UNIT
S35
DOES EXCESS INDOOR UNIT EXIST?
YES
S36
SET RELAXATION ALLOWABLE AMOUNT AS RELAXATION AMOUNT OF EXCESS INDOOR UNIT
S37
SPECIFY RELAXATION AMOUNT OF NON-EXCESS INDOOR UNIT AGAIN
NO
S38
SETTING CHANGE OF EACH INDOOR UNIT 4
FINISH

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2022/002552

A. CLASSIFICATION OF SUBJECT MATTER

F24F 11/46(2018.01)i; ***F24F 11/54***(2018.01)i; ***F24F 11/63***(2018.01)i
FI: F24F11/46; F24F11/54; F24F11/63

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)

F24F11/46; F24F11/54; F24F11/63

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 1971-2022
Registered utility model specifications of Japan 1996-2022
Published registered utility model applications of Japan 1994-2022

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.
X	JP 2017-135824 A (SUMITOMO ELECTRIC INDUSTRIES, LTD.) 03 August 2017 (2017-08-03) paragraphs [0020]-[0210], fig. 1-16	1, 8-9
Y		2-7
Y	JP 06-002916 A (KABUSHIKI KAISHA TOSHIBA) 11 January 1994 (1994-01-11) paragraphs [0016]-[0028], fig. 1-5	2-7
A	JP 2008-241150 A (MATSUSHITA ELECTRIC WORKS LTD.) 09 October 2008 (2008-10-09) paragraphs [0019]-[0050], fig. 1-11	1-9
A	JP 2012-172924 A (PANASONIC CORP.) 10 September 2012 (2012-09-10) paragraphs [0017]-[0068], fig. 1-11	1-9
A	JP 2013-225166 A (UBITEQ INC.) 31 October 2013 (2013-10-31) paragraphs [0014]-[0134], fig. 1-15	1-9
A	JP 2014-185832 A (PANASONIC CORP.) 02 October 2014 (2014-10-02) paragraphs [0012]-[0040], fig. 1-4	1-9

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"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
07 March 2022	**22 March 2022**

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

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2022/002552

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2020-098049 A (MITSUBISHI HEAVY INDUSTRIES THERMAL SYSTEMS LTD.) 25 June 2020 (2020-06-25) paragraphs [0026]-[0068], fig. 1-4	1-9

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2022/002552

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 2017-135824 A	03 August 2017	(Family: none)	
JP 06-002916 A	11 January 1994	(Family: none)	
JP 2008-241150 A	09 October 2008	(Family: none)	
JP 2012-172924 A	10 September 2012	(Family: none)	
JP 2013-225166 A	31 October 2013	US 2014/0088782 A1 paragraphs [0028]-[0150], fig. 1-15	
JP 2014-185832 A	02 October 2014	(Family: none)	
JP 2020-098049 A	25 June 2020	(Family: none)	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2007120889 A **[0004]**