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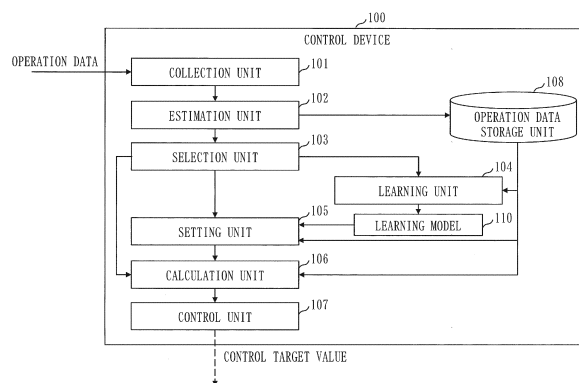
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(54) CONTROL DEVICE AND CONTROL METHOD

(57) A selection unit (130) selects, from among a plurality of indoor units to each of which an air-conditioned space to be air-conditioned is assigned, an indoor unit to represent the plurality of indoor units, as a representative indoor unit, based on a required air-conditioning capacity being an air conditioning capacity required for each indoor unit. A setting unit (105) sets a target temperature of either an evaporating temperature or a condensing temperature which enables an air conditioning capacity of the representative indoor unit to conform to the required air-conditioning capacity of the representative indoor unit, using a learning model (110) obtained by machine learning. A calculation unit (106) calculates, for each indoor unit of the plurality of indoor units other than the representative indoor unit, either a superheat degree or a supercooling degree at which an air conditioning capacity of each indoor unit conforms to the required air-conditioning capacity of the each indoor unit when either an evaporating temperature or a condensing temperature in each indoor unit is made to conform to the target temperature.

Fig. 2



Description**Technical Field**

5 [0001] The present disclosure relates to control over an air conditioner.

Background Art

10 [0002] As a technique related to the present disclosure, there is a technique disclosed in Patent Literature 1. Patent Literature 1 discloses an air conditioner wherein a plurality of outdoor units are connected to one indoor unit.

[0003] Further, Patent Literature 1 discloses a configuration that realizes both energy saving effect and comfortable-
ness. Specifically, in Patent Literature 1, an air conditioning capacity (hereinafter referred to as a required air-conditioning
capacity) required for each indoor unit is obtained. Then, in accordance with the highest required air-conditioning capacity
among the required air-conditioning capacities obtained, a target evaporating temperature and a target superheat degree
15 are set. Additionally, when a cooling temperature (indoor temperature) is lowered from a target cooling temperature
(target indoor temperature) by a specified value or more, by an indoor unit other than the indoor unit with the highest
required air-conditioning capacity, the target superheat degree of the referenced indoor unit is changed.

Citation List

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Patent Literature

[0004] Patent Literature 1: JP 2018-138841 A

25 **Summary of Invention**

Technical Problem

30 [0005] In the technique of Patent Literature 1, a search for the target evaporating temperature is started after each indoor unit is activated. Therefore, a search for the target evaporating temperature is performed when each indoor unit is operated. Thus, in the technique of Patent Literature 1, it takes time before setting of the target evaporating temperature. Then, when a required air-conditioning capacity of any of the indoor units is changed during the search for the target evaporating temperature, there is a problem that an intermittent operation occurs, and the operating efficiency is degraded, in the referenced indoor unit.

35 [0006] Further, in the technique of Patent Literature 1, the target superheat degree of an indoor unit is changed in accordance with a decrease in cooling temperature (indoor temperature). Therefore, it is difficult to make the air conditioning capacity of the indoor unit conform to the required air-conditioning capacity. Therefore, in the technique of Patent Literature 1, there is a problem that an intermittent operation occurs, and the operating efficiency is degraded, in any of the indoor units.

40 [0007] One of the major aims of the present disclosure is to solve the problems as described above. Specifically, the present disclosure is mainly aimed at preventing an intermittence operation from occurring, and an operating efficiency from being degraded, in each indoor unit.

Solution to Problem

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[0008] A control device according to the present disclosure, includes:

a selection unit to select from among a plurality of indoor units to each of which an air-conditioned space to be air-
conditioned is assigned, an indoor unit to represent the plurality of indoor units, as a representative indoor unit,
50 based on a required air-conditioning capacity being an air conditioning capacity required for each indoor unit;
a setting unit to set a target temperature of either an evaporating temperature or a condensing temperature which
enables an air conditioning capacity of the representative indoor unit to conform to the required air-conditioning
capacity of the representative indoor unit, using a learning model obtained by machine learning, and
a calculation unit to calculate, for each indoor unit of the plurality of indoor units other than the representative indoor
unit, either a superheat degree or a supercooling degree at which an air conditioning capacity of the each indoor
55 unit conforms to the required air-conditioning capacity of the each indoor unit when either an evaporating temperature
or a condensing temperature in the each indoor unit is made to conform to the target temperature.

Advantageous Effects of Invention

[0009] According to the present disclosure, a suitable target temperature (evaporating temperature or condensing temperature) is set early by using a learning model. Further, in the present disclosure, a superheat degree and a supercooling degree in each indoor unit at which an air conditioning capacity of each indoor unit conforms to a required air-conditioning capacity of each indoor unit are calculated based on the target temperature set. That is, in the present disclosure, a suitable superheat degree or a suitable supercooling degree which does not generate an intermittent operation in each indoor unit is calculated for each indoor unit.

[0010] Therefore, according to the present disclosure, it is possible to prevent an intermittent operation from occurring, and an operating efficiency from being degraded, in each indoor unit.

Brief Description of Drawings

[0011]

Fig. 1 is a diagram of a configuration example of an air conditioning system according to a first embodiment;
Fig. 2 is a diagram illustrating an example of a functional configuration of a control device according to the first embodiment;

Fig. 3 is a diagram illustrating an example of a hardware configuration of the control device according to the first embodiment;

Fig. 4 is a flowchart illustrating an operation example of the control device in an operation phase (during a cooling operation) according to the first embodiment;

Fig. 5 is a flowchart illustrating an operation example of the control device in the operation phase (during a heating operation) according to the first embodiment;

Fig. 6 is a flowchart illustrating an operation example of the control device in a learning phase (during the cooling operation) according to the first embodiment;

Fig. 7 is a flowchart illustrating an operation example of the control device in the learning phase (during the heating operation) according to the first embodiment;

Fig. 8 is a flowchart illustrating an operation example of the control device in the operation phase (during the cooling operation) according to a second embodiment;

Fig. 9 is a flowchart illustrating an operation example of the control device in the operation phase (during the heating operation) according to the second embodiment;

Fig. 10 is a flowchart illustrating an operation example of the control device in the learning phase (during the cooling operation) according to the second embodiment; and

Fig. 11 is a flowchart illustrating an operation example of the control device in the learning phase (during the heating phase) according to the second embodiment.

Description of Embodiments

[0012] Hereinafter, description will be made on embodiments with reference to diagrams. In the following description and diagrams of the embodiments, same elements or corresponding elements are denoted by same reference numerals.

First Embodiment

Description of Configuration

[0013] Fig. 1 illustrates a configuration example of an air conditioning system 500 according to the present embodiment.

[0014] The air conditioning system 500 according to the present embodiment includes a control device 100 and an air conditioning unit 400.

[0015] The air conditioning unit 400 is constituted by one outdoor unit 200 and a plurality of indoor units 300. The plurality of indoor units 300 are connected to the outdoor unit 200. In Fig. 1, three indoor units 300 are connected to the outdoor unit 200; however, there may be less or more than three indoor units 300.

[0016] The outdoor unit 200 is installed outside a building.

[0017] Each indoor unit 300 is installed inside the building. To each indoor unit 300, a space (for example, a room) to be air-conditioned is individually assigned. The space to be air-conditioned which is assigned to each indoor unit 300 is hereinafter called an air-conditioned space.

[0018] The control device 100 controls the outdoor unit 200 and the plurality of indoor units 300.

[0019] The control device 100 has a learning phase and an operation phase, as action phases.

[0020] The control device 100 performs machine learning in the learning phase. Further, in the operation phase, the control device 100 controls the outdoor unit 200 and the plurality of indoor units 300, using the result of machine learning.

[0021] In the learning phase, the control device 100 collects operation data from the outdoor unit 200 and the plurality of indoor units 300. Then, the control device 100 performs machine learning using the operation data collected, and generates a learning model reflecting the result of machine learning.

[0022] Also in the operation phase, the control device 100 collects the operation data from the outdoor unit 200 and the plurality of indoor units 300. Further, the control device 100 applies the operation data to the learning model, and generates a control target value to control operation of the outdoor unit 200 and the plurality of indoor units 300. Then, the control device 100 outputs the control target value to the outdoor unit 200 and each indoor unit 300, and controls operation of the outdoor unit 200 and each indoor unit 300. In Fig. 1, the operation data is indicated by solid line arrows. Further, the control target values are indicated by broken line arrows.

[0023] Details of the operation data and the control target values will be described below. Further, details of a method of machine learning and an application method of the learning model will be described below.

[0024] The operation procedure of the control device 100 corresponds to a control method.

[0025] Fig. 2 illustrates an example of a functional configuration of the control device 100. Fig. 3 illustrates an example of a hardware configuration of the control device 100.

[0026] First, description will be made on the example of the hardware configuration of the control device 100 with reference to Fig. 3.

[0027] The control device 100 according to the present embodiment is a computer.

[0028] The control device 100 includes a processor 901, a main storage device 902, an auxiliary storage device 903, a communication device 904 and an input and output device 905, as hardware components.

[0029] As illustrated in Fig. 2, the control device 100 includes a collection unit 101, an estimation unit 102, a selection unit 103, a learning unit 104, a setting unit 105, a calculation unit 106, a control unit 107 and an operation data storage unit 108, as a functional configuration.

[0030] The functions of the collection unit 101, the estimation unit 102, the selection unit 103, the learning unit 104, the setting unit 105, the calculation unit 106 and the control unit 107 are realized by programs, for example.

[0031] The auxiliary storage device 903 stores the programs to realize the functions of the collection unit 101, the estimation unit 102, the selection unit 103, the learning unit 104, the setting unit 105, the calculation unit 106 and the control unit 107.

[0032] These programs are loaded into the main storage device 902 from the auxiliary storage device 903. Then, the processor 901 executes these programs, and performs operations of the collection unit 101, the estimation unit 102, the selection unit 103, the learning unit 104, the setting unit 105, the calculation unit 106 and the control unit 107 as described below.

[0033] Fig. 3 schematically represents a state wherein the processor 901 executes the programs to realize the functions of the collection unit 101, the estimation unit 102, the selection unit 103, the learning unit 104, the setting unit 105, the calculation unit 106 and the control unit 107.

[0034] The operation data storage unit 108 is realized by the auxiliary storage device 903, for example.

[0035] Next, description will be made on an example of a functional configuration of the control device 100 with reference to Fig. 2.

[0036] The collection unit 101 collects operation data from the outdoor unit 200 and each indoor unit 300, using the communication device 904.

[0037] When the air conditioning unit 400 performs a cooling operation, the collection unit 101 obtains an outdoor air temperature, a set temperature of each air-conditioned space, a measured temperature measured in each air-conditioned space, an evaporating temperature in each indoor unit 300, a superheat degree in each indoor unit 300 and an operation state value of each indoor unit 300, as operation data.

[0038] Meanwhile, when the air conditioning unit 400 performs a heating operation, the collection unit 101 obtains an outdoor air temperature, a measured temperature measured in each air-conditioned space, a condensing temperature in each indoor unit 300, a supercooling degree in each indoor unit 300 and an operation state value of each indoor unit 300, as operation data.

[0039] Hereinafter, the measured temperature in each indoor unit 300 is also called a room temperature. Further, the evaporating temperature is also called ET. The superheat degree is also called SH. The condensing temperature is also called CT. Further, the supercooling degree is also called SC.

[0040] The operation state value is a value indicating an operation state of each indoor unit 300 during a predetermined time (for example, 10 minutes; hereinafter the same applies). The operation state value is a value between 0 and 1.0. The operation state value is the ratio of a time during which the indoor unit 300 is operating to the predetermined time. When the indoor unit 300 is continuously operating during the predetermined time (when an intermittent operation does not occur), the operation state value is 1.0. When the indoor unit 300 is continuously suspended during the predetermined time, the operation state value is 0. When an intermittent operation occurs in the indoor unit 300 during the predetermined

time, and the time during which the indoor unit 300 is operating is half as long as the predetermined time, the operation state value is 0.5.

[0041] The intermittent operation is an operating state where the indoor unit 300 intermittently repeats operation and suspension.

[0042] The operation state value is also called TheremoON/OFF.

[0043] The collection unit 101 outputs the operation data collected to the estimation unit 102.

[0044] The estimation unit 102 estimates a required air-conditioning capacity of each indoor unit 300, using the operation data. The required air-conditioning capacity is an air-conditioning capacity required for each indoor unit 300. That is, the required air-conditioning capacity is an air conditioning capacity required in the air-conditioned space of each indoor unit 300. In other words, the required air-conditioning capacity is an air conditioning capacity necessary for making the indoor temperature in the air-conditioned space of each indoor unit 300 conform to the set temperature. The required air-conditioning capacity is also called a load.

[0045] When the air conditioning unit 400 performs the cooling operation, the required air-conditioning capacity is a cooling capacity (hereinafter called a required cooling capacity) required for each indoor unit 300. Meanwhile, when the air conditioning unit 400 performs the heating operation, the required air-conditioning capacity is a heating capacity (hereinafter called a required heating capacity) required for each indoor unit 300.

[0046] Details of an estimation method of the required air-conditioning capacity will be described below.

[0047] The estimation unit 102 notifies the selection unit 103 of the required air-conditioning capacity of each indoor unit 300.

[0048] Further, the estimation unit 102 stores the operation data in the operation data storage unit 108.

[0049] The selection unit 103 selects an indoor unit 300 with the highest required air-conditioning capacity from among the plurality of indoor units 300, as an indoor unit-for-learning or a representative indoor unit.

[0050] In the learning phase, the selection unit 103 selects an indoor unit 300 with the highest required air-conditioning capacity as the indoor unit-for-learning. Meanwhile, in the operation phase, the selection unit 103 selects an indoor unit 300 with the highest required air-conditioning capacity as the representative indoor unit.

[0051] The indoor unit-for-learning is an indoor unit 300 representing the plurality of indoor units 300 in the learning phase. The indoor unit-for-learning is the indoor unit 300 used in machine learning in the learning unit 104 to be described below.

[0052] The representative indoor unit is an indoor unit 300 representing the plurality of indoor units 300 in the operation phase. The representative indoor unit is the indoor unit 300 used for setting a target temperature in the setting unit 105 to be described below.

[0053] In the learning phase, the selection unit 103 notifies the learning unit 104 of the indoor unit 300 selected as the indoor unit-for-learning. Meanwhile, in the operation phase, the selection unit 103 notifies the setting unit 105 of the indoor unit 300 selected as the representative indoor unit. Further, the selection unit 103 notifies the calculation unit 106 of a required cooling capacity of an indoor unit 300 other than the representative indoor unit.

[0054] The learning unit 104 obtains the operation data of the indoor unit-for-learning from the operation data storage unit 108.

[0055] Then, the learning unit 104 performs machine learning using the operation data of the indoor unit-for-learning, and generates the learning model 110 wherein the result of machine learning is reflected.

[0056] The learning unit 104 learns an evaporating temperature or a condensing temperature that does not make an intermittent operation occur in the indoor unit-for-learning during the predetermined time. That is, the learning unit 104 learns the evaporating temperature or the condensing temperature which enables the air conditioning capacity of the indoor unit-for-learning to conform to the required air-conditioning capacity of the indoor unit-for-learning. When the air conditioning unit 400 performs the cooling operation, the learning unit 104 learns the evaporating temperature which enables the cooling capacity of the indoor unit-for-learning to conform to the required cooling capacity of the indoor unit-for-learning. When the air conditioning unit 400 performs the heating operation, the learning unit 104 learns the condensing temperature which enables the heating capacity of the indoor unit-for-learning to conform to the required heating capacity of the indoor unit-for-learning.

[0057] When the air conditioning unit 400 performs a cooling operation, the learning unit 104 learns a relation between the cooling capacity of the indoor unit-for-learning and a set temperature of the air-conditioned space of the indoor unit-for-learning, a measured temperature measured in the air-conditioned space of the indoor unit-for-learning, an operation state value of the indoor unit-for-learning, an evaporating temperature measured at the indoor unit-for-learning, an outdoor air temperature and a superheat degree measured at the indoor unit-for-learning. More specifically, the learning unit 104 calculates a correlating equation between an output (the cooling capacity of the indoor unit-for-learning) and an input (the set temperature, the measured temperature, the operation state value, the evaporating temperature, the outdoor air temperature and the superheat degree), using the operation data of the indoor unit-for-learning. Then, the learning unit 104 accumulates the correlating equations calculated, in the learning model 110.

[0058] When a required cooling capacity of the representative indoor unit is given, the setting unit 105 is capable of

deriving a target evaporating temperature which enables the cooling capacity of the representative indoor unit to conform to the required cooling capacity by applying the measured temperature, the set temperature, the operation state value, the evaporating temperature, the outdoor air temperature, the superheat degree and the required cooling capacity of the representative indoor unit to the learning model 110 (correlation equation), as described below.

[0059] Further, when the air conditioning unit 400 performs a heating operation, the learning unit 104 learns a relation between the heating capacity of the indoor unit-for-learning and the set temperature of the air-conditioned space of the indoor unit-for-learning, the measured temperature measured in the air-conditioned space of the indoor unit-for-learning, the operation state value of the indoor unit-for-learning, a condensing temperature measured at the indoor unit-for-learning, the outdoor air temperature and a supercooling degree measured at the indoor unit-for-learning. More specifically, the learning unit 104 calculates correlation equations between an output (the heating capacity of the indoor unit-for-learning) and an input (the set temperature, the measured temperature, the operation state value, the condensing temperature, the outdoor air temperature and the supercooling degree), using the operation data of the indoor unit-for-learning. Then, the learning unit 104 accumulates the correlation equations calculated, in the learning model 110.

[0060] When a required heating capacity of the representative indoor unit is given, the setting unit 105 is capable of deriving a target condensing temperature which enables the heating capacity of the representative indoor unit to conform to the required heating capacity by applying the measured temperature, the set temperature, the operation state value, the condensing temperature, the outdoor air temperature, the supercooling degree and the required heating capacity of the representative indoor unit to the learning model 110 (correlation equation), as described below.

[0061] The setting unit 105 obtains the operation data of the representative indoor unit from the operation data storage unit 108.

[0062] Then, the setting unit 105 applies the operation data of the representative indoor unit to the learning model 110, and sets a target temperature.

[0063] When the air conditioning unit 400 performs the cooling operation, the setting unit 105 sets the target evaporating temperature as the target temperature. The setting unit 105 sets a target temperature of the evaporating temperature at which an intermittent operation does not occur in the representative indoor unit during a predetermined time, as the target evaporating temperature, using the learning model 110. That is, the setting unit 105 sets, as the target evaporating temperature, the target temperature of the evaporating temperature which enables the cooling capacity of the representative indoor unit to conform to the required cooling capacity of the representative indoor unit during the predetermined time, by using the learning model 110. More specifically, the setting unit 105 applies the set temperature of the air-conditioned space of the representative indoor unit, the measured temperature measured in the air-conditioned space of the representative indoor unit, the operation state value, the evaporating temperature measured at the representative indoor unit, the outdoor air temperature, the superheat degree being a fixed value, and the required cooling capacity of the representative indoor unit to the learning model 110 (correlation equation), and obtains the target evaporating temperature.

[0064] Meanwhile, when the air conditioning unit 400 performs the heating operation, the setting unit 105 sets a target condensing temperature as the target temperature. The setting unit 105 sets the target temperature of the condensing temperature at which an intermittent operation does not occur in the representative indoor unit during a predetermined time, as the target condensing temperature, by using the learning model 110. That is, the setting unit 105 sets, as the target condensing temperature, the target temperature of the condensing temperature which enables the heating capacity of the representative indoor unit of the representative indoor unit to conform to the required heating capacity of the representative indoor unit during the predetermined time, by using the learning model 110. More specifically, the setting unit 105 applies the set temperature of the air-conditioned space of the representative indoor unit, the measured temperature measured in the air-conditioned space of the representative indoor unit, the operation state value of the representative indoor unit, the condensing temperature measured at the representative indoor unit, the outdoor air temperature, the supercooling degree being a fixed value and the required cooling capacity of the representative indoor unit to the learning model 110, and obtains the target condensing temperature.

[0065] The setting unit 105 notifies the calculation unit 106 of the target temperature (target evaporating temperature or target condensing temperature) set, and the superheat degree being the fixed value (in the case of cooling operation) or the supercooling degree being the fixed value (in the case of heating operation).

[0066] The calculation unit 106 sets the superheat degree (in the case of cooling operation) or the supercooling degree (in the case of heating operation) of the representative indoor unit to the superheat degree being the fixed value or the supercooling degree being the fixed value that has been used for setting of the target temperature.

[0067] Further, the calculation unit 106 calculates a superheat degree (in the case of cooling operation) or a supercooling degree (in the case of heating operation) of each indoor unit 300 other than the representative indoor unit based on the target temperature (target evaporating temperature or target condensing temperature). More specifically, in the case where the air conditioning unit 400 performs the cooling operation, the calculation unit 106 calculates, for each indoor unit 300, a superheat degree at which the cooling capacity of each indoor unit 300 conforms to the required cooling capacity of each indoor unit 300 during the predetermined time, when the evaporating temperature in each indoor

unit 300 is made to conform to the target evaporating temperature for each indoor unit 300. That is, the calculation unit 106 calculates the superheat degree in each indoor unit 300 at which an intermittent operation does not occur in each indoor unit 300. Further, in the case where the air conditioning unit 400 performs the heating operation, the calculation unit 106 calculates, for each indoor unit 300, a supercooling degree at which the heating capacity of each indoor unit 300 conforms to the required heating capacity of each indoor unit 300 during the predetermined time, when the condensing temperature in each indoor unit 300 is made to conform to the target condensing temperature for each indoor unit 300. That is, the calculation unit 106 calculates the supercooling degree in each indoor unit 300 at which an intermittent operation does not occur in each indoor unit 300.

[0068] When the air conditioning unit 400 performs the cooling operation, the control unit 107 generates a control target value based on the target evaporating temperature and the superheat degree in each indoor unit 300. Then, the control unit 107 outputs the control target value generated to the outdoor unit 200 and each indoor unit 300.

[0069] Further, when the air conditioning unit 400 performs the heating operation, the control unit 107 generates a control target value based on the target condensing temperature and the supercooling degree in each indoor unit 300. Then, the control unit 107 outputs the control target value generated to the outdoor unit 200 and each indoor unit 300.

[0070] The control unit 107 controls operations of the outdoor unit 200 and each indoor unit 300 by outputting the control target value.

Description of Operation

[0071] Next, description will be made on an operation example of the control device 100 according to the present embodiment.

[0072] First, description will be made on an operation example of the control device 100 in the operation phase, with reference to Fig. 4 and Fig. 5.

[0073] It is supposed that the learning model 110 has been generated at the start of the flows in Fig. 4 and Fig. 5.

[0074] Fig. 4 illustrates an operation example of the control device 100 when the air conditioning unit 400 performs the cooling operation.

[0075] Fig. 5 illustrates an operation example of the control device 100 when the air conditioning unit 400 performs the heating operation.

[0076] First, description will be made on the operation of the control device 100 at the time of cooling operation, with reference to Fig. 4.

[0077] In Fig. 4, the collection unit 101 first collects operation data in Step S101.

[0078] The collection unit 101 obtains, as the operation data, an outdoor air temperature, a set temperature of each air-conditioned space, a measured temperature in each air-conditioned space, an evaporating temperature in each indoor unit 300, a superheat degree in each indoor unit 300 and an operation state value of each indoor unit 300. The collection unit 101 obtains the set temperature, the measured temperature, the superheat degree and the operation state value from each indoor unit 300. The evaporating temperatures are collectively managed in the outdoor unit 200. Therefore, the collection unit 101 obtains the evaporating temperatures from the outdoor unit 200. Further, the collection unit 101 also obtains the outdoor air temperature from the outdoor unit 200.

[0079] The collection unit 101 outputs the operation data collected to the estimation unit 102.

[0080] Next, the estimation unit 102 estimates a required cooling capacity of each indoor unit 300 in Step S102.

[0081] The estimation unit 102 estimates a required cooling capacity L1 [kW] of each indoor unit 300 in accordance with, for example, Formula (1) as follows.

$$L1 = (\text{Measured Temperature} - ET - SH) \times \text{Thermo} \quad \text{Formula (1)}$$

[0082] ET is an evaporating temperature. SH is a superheat degree. Thermo is an operation state value.

[0083] The estimation unit 102 notifies the selection unit 103 of the required cooling capacity L1 of each indoor unit 300.

[0084] Next, in Step S103, the selection unit 103 selects a representative indoor unit.

[0085] Specifically, the selection unit 103 selects an indoor unit 300 with the highest required cooling capacity L1 as the representative indoor unit.

[0086] The selection unit 103 notifies the setting unit 105 of the representative indoor unit selected, and the required cooling capacity L1 of the representative indoor unit.

[0087] Further, the selection unit 103 notifies the calculation unit 106 of the required cooling capacities L1 of the indoor units 300 other than the representative indoor unit.

[0088] Next, the setting unit 105 sets a target evaporating temperature in Step S104.

[0089] The setting unit 105 obtains the operation data of the representative indoor unit from the operation data storage unit 108. Specifically, the setting unit 105 obtains the measured temperature, the set temperature, the operation state

value, the outdoor air temperature and the evaporating temperature in the representative indoor unit, from the operation data storage unit 108.

[0090] Then, the setting unit 105 applies the measured temperature, the set temperature, the operation state value, the outdoor air temperature and the evaporating temperature in the representative indoor unit obtained from the operation data storage unit 108, the superheat degree being the fixed value and the required cooling capacity L1 of the representative indoor unit to the learning model 110, and sets the target evaporating temperature.

[0091] The setting unit 105 applies, as the superheat degree being the fixed value, the smallest value (for example, SH = 2K) that is allowed as a superheat degree.

[0092] The target evaporating temperature set by the setting unit 105 is the highest evaporating temperature at which an intermittent operation does not occur in the representative indoor unit during the predetermined time, i.e., the highest evaporating temperature at which the cooling capacity of the representative indoor unit is enough for the required cooling capacity L1. That is, the target evaporating temperature is the highest evaporating temperature among evaporating temperatures which enable the cooling capacity of the representative indoor unit to conform to the required cooling capacity L1. "Enabling the cooling capacity of the representative indoor unit to conform to the required cooling capacity L1" means that the measured temperature in the air-conditioned space of the representative indoor unit is made to conform to the set temperature of the air-conditioned space of the representative indoor unit.

[0093] The setting unit 105 specifies the highest evaporating temperature among the evaporating temperatures which enable the cooling capacity of the representative indoor unit to conform to the required cooling capacity L1, using the correlation equations of the learning model 110, and sets the evaporating temperature specified to the target evaporating temperature.

[0094] The setting unit 105 notifies the calculation unit 106 of the target evaporating temperature and the superheat degree (for example, SH = 2K) being the fixed value.

[0095] Next, in Step S105, the calculation unit 106 sets the target superheat degree of the representative indoor unit.

[0096] Specifically, the calculation unit 106 sets the superheat degree being the fixed value notified from the setting unit 105 to the target superheat degree of the representative indoor unit.

[0097] Next, in Step S106, the calculation unit 106 calculates a superheat degree in each indoor unit 300 other than the representative indoor unit in accordance with Formula (1) stated above.

[0098] Specifically, the calculation unit 106 sets the required cooling capacity L1 of each indoor unit 300 notified from the selection unit 103 to L1 in Formula (1). Further, the calculation unit 106 sets the measured temperature measured in the air-conditioned space of each indoor unit 300 to the measured temperature in Formula (1). Additionally, the calculation unit 106 sets the target evaporating temperature notified from the setting unit 105 to ET in Formula (1). Furthermore, the calculation unit 106 sets a value 1 (Thermo = 1) commonly to each indoor unit 300, to Thermo in Formula (1). Then, the calculation unit 106 calculates an SH that makes the right side and the left side of Formula (1) conform to each other, as the target superheat degree. The calculation unit 106 obtains the measured temperature of each indoor unit 300 from the operation data storage unit 108.

[0099] The target superheat degree calculated by the calculation unit 106 is a superheat degree at which an intermittent operation does not occur in each indoor unit 300 during the predetermined time, when the evaporating temperature in each indoor unit 300 is made to conform to the target evaporating temperature, i.e., a superheat degree which enables the cooling capacity of each indoor unit 300 to conform to the required cooling capacity L1 of each indoor unit 300. "Enabling the cooling capacity of each indoor unit to conform to the required cooling capacity L1 of each indoor unit 300" means that the measured temperature in the air-conditioned space of each indoor unit 300 is made to conform to the set temperature of the air-conditioned space of each indoor unit 300.

[0100] The calculation unit 106 notifies the control unit 107 of the target evaporating temperature and the target superheat degree of each indoor unit 300 including the representative indoor unit.

[0101] Next, in Step S107, the control unit 107 generates a control instruction.

[0102] The control unit 107 decides an operation rotational frequency of a compressor based on the target evaporating temperature. The operation rotational frequency of the compressor is adjusted by the outdoor unit 200.

[0103] Further, the control unit 107 decides, for each indoor unit 300, an opening degree of an indoor expansion valve based on the target superheat degree of each indoor unit 300. The opening degrees of the indoor expansion valves are values that differ for each indoor unit 300. The opening degree of the indoor expansion valve is adjusted in each indoor unit 300.

[0104] The control unit 107 generates a control instruction to the outdoor unit 200, which indicates the operation rotational frequency of the compressor decided. Further, the control unit 107 generates a control instruction to each indoor unit 300, which indicates the opening degree of the indoor expansion valve decided.

[0105] Next, the control unit 107 outputs each control instruction to the outdoor unit 200 and each indoor unit 300.

[0106] By the outdoor unit 200 and each indoor unit 300 being made to operate in accordance with the control instructions, the operations of the outdoor unit 200 and the plurality of indoor units 300 are controlled.

[0107] That is, by outputting the control instructions, the control unit 107 is capable of conforming the cooling capacity

of each indoor unit 300 to the required cooling capacity of each indoor unit 300, and preventing an intermittent operation from occurring in each indoor unit 300.

[0108] Next, description will be made on an operation of the control device 100 at the time of heating operation, with reference to Fig. 5.

[0109] In Fig. 5, the collection unit 101 first collects operation data in Step S201.

[0110] The collection unit 101 obtains, as the operation data, an outdoor air temperature, a set temperature of each air-conditioned space, a measured temperature in each air-conditioned space, a condensing temperature in each indoor unit 300, a supercooling degree in each indoor unit 300 and an operation state value of each indoor unit 300. The collection unit 101 obtains the set temperature, the measured temperature, the supercooling degree and the operation state value from each indoor unit 300. The condensing temperatures are collectively managed in the outdoor unit 200. Therefore, the collection unit 101 obtains the condensing temperatures from the outdoor unit 200. Further, the collection unit 101 also obtains the outdoor air temperature from the outdoor unit 200.

[0111] The collection unit 101 outputs the operation data collected to the estimation unit 102.

[0112] Next, the estimation unit 102 estimates a required heating capacity of each indoor unit 300 in Step S202.

[0113] The estimation unit 102 estimates a required heating capacity L2 [kw] of each indoor unit 300 in accordance with, for example, Formula (2) as follows.

$$L2 = (CT - SC - \text{Indoor Air Temperature}) \times \text{Thermo} \quad \text{Formula (2)}$$

[0114] CT is a condensing temperature. SC is a supercooling degree. Thermo is an operation state value.

[0115] The estimation unit 102 notifies the selection unit 103 of the required heating capacity L2 of each indoor unit 300.

[0116] Next, in Step S203, the selection unit 103 selects a representative indoor unit.

[0117] Specifically, the selection unit 103 selects an indoor unit 300 with the highest required heating capacity L2, as the representative indoor unit.

[0118] The selection unit 103 notifies the setting unit 105 of the representative indoor unit selected, and the required heating capacity L2 of the representative indoor unit.

[0119] Further, the selection unit 103 notifies the calculation unit 106 of required heating capacities L2 of the indoor units 300 other than the representative indoor unit.

[0120] Next, in Step S204, the setting unit 105 sets a target condensing temperature.

[0121] The setting unit 105 obtains the operation data of the representative indoor unit from the operation data storage unit 108. Specifically, the setting unit 105 obtains the measured temperature, the set temperature, the operation state value, the outdoor air temperature and the condensing temperature in the representative indoor unit, from the operation data storage unit 108.

[0122] Then, the setting unit 105 applies the measured temperature, the set temperature, the operation state value, the outdoor air temperature and the condensing temperature in the representative indoor unit obtained from the operation data storage unit 108, the supercooling degree being the fixed value and the required heating capacity L2 of the representative indoor unit to the learning model 110, and sets the target condensing temperature.

[0123] The setting unit 105 applies, as the supercooling degree being the fixed value, the smallest value (for example, SC = 5K) that is allowed as the supercooling degree.

[0124] The target condensing temperature set by the setting unit 105 is the lowest condensing temperature at which an intermittent operation does not occur in the representative indoor unit during the predetermined time, i.e., the lowest condensing temperature at which the heating capacity of the representative indoor unit is enough for the required heating capacity L2. That is, the target condensing temperature is the lowest condensing temperature among the condensing temperatures which enable the heating capacity of the representative indoor unit to conform to the required heating capacity L2. "Enabling the heating capacity of the representative indoor unit to conform to the required heating capacity L2" means that the measured temperature in the air-conditioned space of the representative indoor unit is made to conform to the set temperature of the air-conditioned space of the representative indoor unit.

[0125] The setting unit 105 specifies the lowest condensing temperature among the condensing temperatures which enable the heating capacity of the representative indoor unit to conform to the required heating capacity L2, using the correlation equations of the learning model 110, and sets the condensing temperature specified to the target condensing temperature.

[0126] The setting unit 105 notifies the calculation unit 106 of the target condensing temperature, and the supercooling degree (for example, SC = 5K) being the fixed value.

[0127] Next, in Step S205, the calculation unit 106 sets the target supercooling degree of the representative indoor unit.

[0128] Specifically, the calculation unit 106 sets the supercooling degree being the fixed value notified from the setting unit 105 to the target supercooling degree of the representative indoor unit.

[0129] Next, in Step S206, the calculation unit 106 calculates a supercooling degree in each indoor unit 300 other

than the representative indoor unit in accordance with Formula (2) stated above.

[0130] Specifically, the calculation unit 106 sets the required heating capacity L2 of each indoor unit 300 notified from the selection unit 103 to L2 in Formula (2). Further, the calculation unit 106 sets the measured temperature measured in the air-conditioned space of each indoor unit 300 to the measured temperature in Formula (2). Furthermore, the calculation unit 106 sets the target condensing temperature notified from the setting unit 105 to CT in Formula (2). Additionally, the calculation unit 106 sets a value 1 (Thermo = 1) commonly to each indoor unit 300, to Thermo in Formula (2). Then, the calculation unit 106 calculates an SC that makes the right side and the left side of Formula (2) conform to each other, as the target supercooling degree. The calculation unit 106 obtains the measured temperature of each indoor unit 300 from the operation data storage unit 108.

[0131] The target supercooling degree calculated by the calculation unit 106 is a supercooling degree at which an intermittent operation does not occur in each indoor unit 300 during the predetermined time, when the condensing temperature in each indoor unit 300 is made to conform to the target condensing temperature, i.e., a supercooling degree which enables the heating capacity of each indoor unit 300 to conform to the required heating capacity L2 of each indoor unit 300. "Enabling the heating capacity of each indoor unit 300 to conform to the required heating capacity L2 of each indoor unit 300" means that the measured temperature in the air-conditioned space of each indoor unit 300 is made to conform to the set temperature of the air-conditioned space of each indoor unit 300.

[0132] The calculation unit 106 notifies the control unit 107 of the target condensing temperature and the target supercooling degree of each indoor unit 300 including the representative indoor unit.

[0133] Next, in Step S207, the control unit 107 generates a control instruction.

[0134] The control unit 107 decides an operation rotational frequency of the compressor based on the target evaporating temperature. The operation rotational frequency of the compressor is adjusted in the outdoor unit 200.

[0135] Further, the control unit 107 decides, for each indoor unit 300, an opening degree of the indoor expansion valve based on the target supercooling degree of each indoor unit 300. The opening degrees of the indoor expansion valves are values differ for each indoor unit 300. The opening degree of the indoor expansion valve is adjusted in each indoor unit 300.

[0136] The control unit 107 generates a control instruction to the outdoor unit 200, which indicates the operation rotational frequency of the compressor decided. Further, the control unit 107 generates a control instruction to each indoor unit 300, which indicates the opening degree of the indoor expansion valve decided.

[0137] Next, the control unit 107 outputs each control instruction to the outdoor unit 200 and each indoor unit 300.

[0138] By the outdoor unit 200 and each indoor unit 300 being made to operate in accordance with the control instructions, the operations of the outdoor unit 200 and the plurality of indoor units 300 are controlled.

[0139] That is, by outputting the control instructions, the control unit 107 is capable of conforming the heating capacity of each indoor unit 300 to the required heating capacity of each indoor unit 300, and preventing an intermittent operation from occurring in each indoor unit 300.

[0140] Next, description will be made on an operation example of the control device 100 in the learning phase.

[0141] The control device 100 repeats the flows in Fig. 6 or Fig. 7 for one month, treating one month as a period of time of learning phase, for example.

[0142] Fig. 6 illustrates an operation example of the control device 100 when the air conditioning unit 400 performs the cooling operation.

[0143] Fig. 7 illustrates an operation example of the control device 100 when the air conditioning unit 400 performs the heating operation.

[0144] First, description will be made on an operation of the control device 100 at the time of cooling operation, with reference to Fig. 6.

[0145] In Fig. 6, the collection unit 101 first collects operation data in Step S301.

[0146] The collection unit 101 obtains, as the operation data, an outdoor air temperature, a set temperature of each air-conditioned space, a measured temperature in each air-conditioned space, an evaporating temperature in each indoor unit 300, a superheat degree in each indoor unit 300, and an operation state value of each indoor unit 300.

[0147] In the learning phase, the outdoor unit 200 randomly changes the evaporating temperature. Further, in each indoor unit 300, the superheat degree is fixed at the smallest value (for example, SH = 2K).

[0148] The collection unit 101 outputs the operation data collected to the estimation unit 102.

[0149] Next, in Step S302, the estimation unit 102 estimates the required cooling capacity of each indoor unit 300.

[0150] The estimation unit 102 estimates the required cooling capacity L1 of each indoor unit 300 in accordance with Formula (1) as stated above.

[0151] As described above, since the outdoor unit 200 randomly changes the evaporating temperature in the learning phase, the estimation unit 102 estimates the required cooling capacity L1 of each indoor unit 300 in accordance with Formula (1) for each evaporating temperature.

[0152] The estimation unit 102 notifies the selection unit 103 of the required cooling capacity L1 of each indoor unit 300 for each evaporating temperature.

[0153] Next, in Step S303, the selection unit 103 selects the indoor unit-for-learning.

[0154] Specifically, the selection unit 103 selects the indoor unit 300 with the highest required cooling capacity L1 among the required cooling capacities L1 notified from the estimation unit 102, as the indoor unit-for-learning.

[0155] The selection unit 103 notifies the learning unit 104 of the indoor unit-for-learning selected.

[0156] Next, in Step S304, the learning unit 104 sets the superheat degree being the fixed value.

[0157] Specifically, the learning unit 104 sets the smallest superheat degree (for example, SH = 2K).

[0158] Next, in Step S305, the learning unit 104 performs machine learning.

[0159] The learning unit 104 learns the highest evaporating temperature at which an intermittent operation does not occur in the indoor unit-for-learning, i.e., the highest evaporating temperature among the evaporating temperatures which enable the cooling capacity of the indoor unit-for-learning to conform to the highest required cooling capacity L1, by using the operation data of the indoor unit-for-learning and the superheat degree being the fixed value set in Step S304. "Enabling the cooling capacity of the indoor unit-for-learning to conform to the highest required cooling capacity L1" means that the measured temperature in the air-conditioned space of the indoor unit-for-learning is made to conform to the set temperature of the air-conditioned space of the indoor unit-for-learning when the indoor unit-for-learning is operated with the highest required cooling capacity L1.

[0160] As described above, the learning unit 104 calculates the correlation equation between the input (the set temperature, the measured temperature, the operation state value, the evaporating temperature, the outdoor air temperature and the superheat degree) and the output (cooling capacity of the indoor unit-for-learning), using the operation data of the indoor unit-for-learning, as machine learning.

[0161] The learning unit 104 may perform either supervised learning or unsupervised learning.

[0162] Lastly, in Step S306, the learning unit 104 generates the learning model 110 wherein the result of machine learning performed in Step S305 is reflected.

[0163] Next, description will be made on the operation of the control device 100 at the time of heating operation, with reference to Fig. 7.

[0164] In Fig. 7, the collection unit 101 first collects operation data in Step S401.

[0165] The collection unit 101 obtains, as the operation data, an outdoor air temperature, a set temperature of each air-conditioned space, a measured temperature in each air-conditioned space, a condensing temperature in each indoor unit 300, a supercooling degree in each indoor unit 300, and an operation state value of each indoor unit 300.

[0166] In the learning phase, the outdoor unit 200 randomly changes the condensing temperature. Further, in each indoor unit 300, the supercooling degree is fixed at the smallest value (for example, SC = 5K).

[0167] The collection unit 101 outputs the operation data collected to the estimation unit 102.

[0168] Next, in Step S402, the estimation unit 102 estimates the required heating capacity of each indoor unit 300.

[0169] The estimation unit 102 estimates the required heating capacity L2 of each indoor unit 300 in accordance with Formula (2) stated above.

[0170] As described above, since the outdoor unit 200 randomly changes the condensing temperature in the learning phase, the estimation unit 102 estimates the required heating capacity L2 of each indoor unit 300 in accordance with Formula (2), for each condensing temperature.

[0171] The estimation unit 102 notifies the selection unit 103 of the required heating capacity L2 of each indoor unit 300 for each condensing temperature.

[0172] Next, in Step S403, the selection unit 103 selects the indoor unit-for-learning.

[0173] Specifically, the selection unit 103 selects the indoor unit 300 with the highest required heating capacity L2 among the required heating capacities L2 notified from the estimation unit 102, as the indoor unit-for-learning.

[0174] The selection unit 103 notifies the learning unit 104 of the indoor unit-for-learning selected.

[0175] Next, in Step S404, the learning unit 104 sets the supercooling degree being the fixed value.

[0176] Specifically, the learning unit 104 sets the smallest supercooling degree (for example, SC = 5K).

[0177] Next, in Step S405, the learning unit 104 performs machine learning.

[0178] The learning unit 104 learns the lowest condensing temperature at which an intermittent operation does not occur in the indoor unit-for-learning, i.e., the lowest condensing temperature among the condensing temperatures which enable the heating capacity of the indoor unit-for-learning to conform to the highest required heating capacity L2, by using the operation data of the indoor unit-for-learning and the supercooling degree being the fixed value set in Step S404. "Enabling the heating capacity of the indoor unit-for-learning to conform to the highest required heating capacity L2" means that the measured temperature in the air-conditioned space of the indoor unit-for-learning is made to conform to the set temperature of the air-conditioned space of the indoor unit-for-learning when the indoor unit-for-learning is operated with the highest required heating capacity L2.

[0179] As described above, the learning unit 104 calculates the correlation equation between the input (the set temperature, the measured temperature, the operation state value, the condensing temperature, the outdoor air temperature and the supercooling degree) and the output (the heating capacity of the indoor unit-for-learning), using the operation data of the indoor unit-for-learning, as machine learning.

[0180] The learning unit 104 may perform either supervised learning or unsupervised learning.

[0181] Lastly, in Step S406, the learning unit 104 generates a learning model 110 wherein the result of machine learning performed in Step S405 is reflected.

Description of Effect of Embodiment

[0182] As described above, in the present embodiment, a suitable target temperature (evaporating temperature or condensing temperature) is set early by using the learning model. Further, in the present embodiment, a suitable superheat degree or supercooling degree at which an intermittent operation does not occur in each indoor unit is calculated for each indoor unit.

[0183] Therefore, according to the present embodiment, it is possible to prevent an intermittent operation from occurring in each indoor unit, and to prevent the operating efficiency from being degraded. Further, since an intermittent operation is prevented from occurring in each indoor unit, fluctuation of an indoor air temperature is suppressed, and comfortability is enhanced.

[0184] Furthermore, according to the present embodiment, it is possible to make the indoor units operate at appropriate evaporating temperatures preventing insufficiency of cooling capacity from occurring.

[0185] Similarly, according to the present embodiment, it is possible to make the indoor units operate at appropriate condensing temperatures preventing insufficiency of heating capacity from occurring.

[0186] Therefore, according to the present embodiment, it is possible to realize energy saving while maintaining comfortability.

[0187] Further, in the present embodiment, machine learning is performed using only parameters of the indoor unit-for-learning being the indoor unit with the highest required cooling capacity or the highest required heating capacity. Therefore, according to the present embodiment, it is possible to finish machine learning in a short period of time.

Second Embodiment

[0188] In First Embodiment, the setting unit 105 applies the superheat degree being the fixed value (for example, SH = 2K) to the learning model 110, and sets the target evaporating temperature. Then, the calculation unit 106 sets the superheat degree being the fixed value to the target superheat degree of the representative indoor unit. Further, in First Embodiment, the setting unit 105 applies the supercooling degree being the fixed value (for example, SC = 5K) to the learning model 110, and sets the target condensing temperature. Then, the calculation unit 106 sets the supercooling degree being the fixed value to the target cooling degree of the representative indoor unit.

[0189] In the present embodiment, description will be made on an example wherein the setting unit 105 derives a suitable superheat degree as the target superheat degree of the representative indoor unit as well as the target evaporating temperature, using the learning model 110. Further, in the present embodiment, description will be made on an example wherein the setting unit 105 derives a suitable supercooling degree as the target supercooling degree of the representative indoor unit as well as the target condensing temperature, using the learning model 110.

[0190] In the present embodiment, description will be made mainly on the difference from First Embodiment.

[0191] The items not described hereinafter are similar to those in First Embodiment.

Description of Configuration

[0192] The configuration example of the air conditioning system 500 according to the present embodiment is as illustrated in Fig. 1.

[0193] Further, the example of the functional configuration of the control device 100 according to the present embodiment is as illustrated in Fig. 2. However, as described below, the operations of the learning unit 104, the setting unit 105 and the calculation unit 106 are different from those in First Embodiment.

[0194] The example of the hardware configuration of the control device 100 according to the present embodiment is as illustrated in Fig. 3.

Description of Operation

[0195] Fig. 8 and Fig. 9 illustrate operation examples in the operation phase of the control device 100 according to the present embodiment.

[0196] Fig. 8 illustrates the operation example of the control device 100 when the air conditioning unit 400 performs the cooling operation. Fig. 8 corresponds to Fig. 4 described in First Embodiment.

[0197] Fig. 9 illustrates the operation example of the control device 100 when the air conditioning unit 400 performs the heating operation. Fig. 9 corresponds to Fig. 5 described in First Embodiment.

[0198] First, description will be made on the operation of the control device 100 at the time of cooling operation, with reference to Fig. 8.

[0199] In Fig. 8, Step S101 through Step S103 are the same as those illustrated in Fig. 4. Therefore, the description is omitted.

[0200] In Step S115, the setting unit 105 sets the target evaporating temperature and the target superheat degree of the representative indoor unit.

[0201] The setting unit 105 obtains operation data of the representative indoor unit from the operation data storage unit 108. Specifically, the learning unit 104 obtains a measured temperature, a set temperature, an operation status value, an outdoor air temperature and an evaporating temperature of the representative indoor unit from the operation data storage unit 108.

[0202] Then, the setting unit 105 applies the measured temperature, the set temperature, the operation status value, the outdoor air temperature and the evaporating temperature of the representative indoor unit obtained from the operation data storage unit 108, and the required cooling capacity L1 of the representative indoor unit to the learning model 110, and sets the target evaporating temperature, and the target superheat degree of the representative indoor unit.

[0203] The target evaporating temperature and the target superheat degree set in Step S115 are a combination of the most suitable evaporating temperature and superheat degree among evaporating temperatures and superheat degrees which enable the cooling capacity of the representative indoor unit to conform to the required cooling capacity L1 during the predetermined time, and which enable the electric power consumption of the representative indoor unit to be minimized. That is, the target evaporating temperature and the target superheat degree set in Step S115 are a combination of the highest evaporating temperature and the highest superheat degree that fulfills this condition.

[0204] The setting unit 105 notifies the calculation unit 106 of the target evaporating temperature and the target superheat degree of the representative indoor unit that have been set.

[0205] Step S106 through Step S108 are the same as those illustrated in Fig. 4. Therefore, the description is omitted.

[0206] Next, description will be made on the operation of the control device 100 at the time of heating operation, with reference to Fig. 9.

[0207] In Fig. 9, Step S201 through Step S203 are the same as those illustrated in Fig. 5. Therefore, the description is omitted.

[0208] In Step S215, the setting unit 105 sets a target condensing temperature and a target supercooling degree of the representative indoor unit.

[0209] The setting unit 105 obtains operation data of the representative indoor unit from the operation data storage unit 108. Specifically, the learning unit 104 obtains a measured temperature, a set temperature, an operation state value, an outdoor air temperature and a condensing temperature of the representative indoor unit from the operation data storage unit 108.

[0210] Then, the setting unit 105 applies the measured temperature, the set temperature, the operation state value, the outdoor air temperature and the condensing temperature of the representative indoor unit obtained from the operation data storage unit 108, and the required heating capacity L2 of the representative indoor unit to the learning model 110, and sets the target condensing temperature, and the target supercooling degree of the representative indoor unit.

[0211] The target condensing temperature and the target supercooling degree set in Step S215 are a combination of the most suitable condensing temperature and supercooling degree among condensing temperatures and supercooling degrees which enable the heating capacity of the representative indoor unit to conform to the required heating capacity L2 during the predetermined time, and which enable the electric power consumption of the representative indoor unit to be minimized. That is, the target condensing temperature and the target supercooling degree set in Step S215 are a combination of the highest condensing temperature and the highest supercooling degree that fulfill this condition.

[0212] The setting unit 105 notifies the calculation unit 106 of the target condensing temperature and the target supercooling degree of the representative indoor unit that have been set.

[0213] Step S206 through Step S208 are the same as those illustrated in Fig. 5. Therefore, the description is omitted.

[0214] Next, description will be made on an operation example in the learning phase of the control device 100 according to the present embodiment, with reference to Fig. 10 and Fig. 11.

[0215] In the present embodiment as well, the control device 100 repeats the flows in Fig. 10 and Fig. 11 for one month, treating one month as a period of time of learning phase, for example.

[0216] Fig. 10 illustrates an operation example of the control device 10 when the air conditioning unit 400 performs the cooling operation.

[0217] Fig. 11 illustrates an operation example of the control device 10 when the air conditioning unit 400 performs the heating operation.

[0218] First, description will be made on the operation of the control device 100 at the time of cooling operation, with reference to Fig. 10.

[0219] In Fig. 10, the collection unit 101 collects operation data in Step S311.

[0220] The collection unit 101 obtains, as operation data, an outdoor air temperature, a set temperature of each air-

conditioned space, a measured temperature in each air-conditioned space, an evaporating temperature in each indoor unit 300, a superheat degree in each indoor unit 300, an operation state value of each indoor unit 300, and a power consumption value of each indoor unit 300.

[0221] Unlike Step S301 in Fig. 6, in Step S311, the collection unit 101 also obtains the power consumption value of each indoor unit 300.

[0222] Further, in Step S311, the outdoor unit 200 randomly changes the evaporating temperature, and each indoor unit 300 randomly changes the superheat degree. In Step S301 in Fig. 6, each indoor unit 300 fixes the superheat degree at the smallest value (for example, $SH = 2K$); however, in Step S311, each indoor unit 300 randomly changes the superheat degree.

[0223] The collection unit 101 outputs the operation data collected to the estimation unit 102.

[0224] Next, in Step S312, the estimation unit 102 estimates the required cooling capacity of each indoor unit 300.

[0225] The estimation unit 102 estimates the required cooling capacity L1 of each indoor unit 300 in accordance with Formula (1) stated above.

[0226] As described above, in the learning phase, since the outdoor unit 200 randomly changes the evaporating temperature, and each indoor unit 300 randomly changes the superheat degree, the estimation unit 102 estimates the required cooling capacity L1 of each indoor unit 300 for each combination of the evaporating temperature and the superheat degree.

[0227] The estimation unit 102 notifies the selection unit 103 of the required cooling capacity L1 of each indoor unit 300 for each combination of the evaporating temperature and the superheat degree.

[0228] Step S303 is the same as that illustrated in Fig. 6. Therefore, the description is omitted.

[0229] Next, in Step S315, the learning unit 104 performs machine learning.

[0230] The learning unit 104 learns a combination of the most suitable evaporating temperature and superheat degree among evaporating temperatures and superheat degrees which enable the cooling capacity of the indoor unit-for-learning to conform to the highest required cooling capacity L1, and which enable the electric power consumption of the indoor unit-for-learning to be minimized, by using the operation data of the indoor unit-for-learning. That is, the learning unit 104 learns the combination of the highest evaporating temperature and the highest superheat degree that fulfills this condition.

[0231] The learning unit 104 may perform either supervised learning or unsupervised learning.

[0232] Step S306 is the same as that illustrated in Fig. 6. Therefore, the description is omitted.

[0233] Next, description will be made on the operation of the control device 100 at the time of heating operation, with reference to Fig. 10.

[0234] In Fig. 11, the collection unit 101 collects the operation data in Step S411.

[0235] The collection unit 101 obtains, as the operation data, an outdoor air temperature, a set temperature of each air-conditioned space, a measured temperature in each air-conditioned space, a condensing temperature in each indoor unit 300, a supercooling degree in each indoor unit 300, an operation state value of each indoor unit 300, and a power consumption value of each indoor unit 300.

[0236] Unlike Step S401 in Fig. 7, in Step S411, the collection unit 101 also obtains the power consumption value of each indoor unit 300.

[0237] Further, in Step S411, the outdoor unit 200 randomly changes the condensing temperature, and each indoor unit 300 randomly changes the supercooling degree. In Step S401 in Fig. 7, each indoor unit 300 fixes the supercooling degree at the smallest value (for example, $SC = 5K$); however, in Step S411, each indoor unit 300 randomly changes the supercooling degree.

[0238] The collection unit 101 outputs the operation data collected to the estimation unit 102.

[0239] Next, in Step S412, the estimation unit 102 estimates the required heating capacity of each indoor unit 300.

[0240] The estimation unit 102 estimates the required heating capacity L2 of each indoor unit 300 in accordance with Formula (2) stated above.

[0241] As described above, in the learning phase, since the outdoor unit 200 randomly changes the condensing temperature, and each indoor unit 300 randomly changes the supercooling degree, the estimation unit 102 estimates the required heating capacity L2 of each indoor unit 300 for each combination of the condensing temperature and the supercooling degree.

[0242] The estimation unit 102 notifies the selection unit 103 of the required heating capacity L2 of each indoor unit 300 for each combination of the condensing temperature and the supercooling degree.

[0243] Step S403 is the same as that illustrated in Fig. 7. Therefore, the description is omitted.

[0244] Next, in Step S415, the learning unit 104 performs machine learning.

[0245] The learning unit 104 learns a combination of the most suitable condensing temperature and supercooling degree among condensing temperatures and supercooling degrees which enable the heating capacity of the indoor unit-for-learning to conform to the highest required heating capacity L2, and which enable the electric power consumption of the indoor unit-for-learning to be minimized, by using the operation data of the indoor unit-for-learning. That is, the

learning unit 104 learns the combination of the highest condensing temperature and the highest supercooling degree that fulfill this condition.

[0246] The learning unit 104 may perform either supervised learning or unsupervised learning.

[0247] Step S406 is the same as that illustrated in Fig. 7. Therefore, the description is omitted.

Description of Effect of Embodiment

[0248] According to the present embodiment, it is possible to set the target superheat degree of the representative indoor unit to the suitable superheat degree. Similarly, according to the present embodiment, it is possible to set the target supercooling degree of the representative indoor unit to the suitable supercooling degree.

[0249] Further, according to the present embodiment, it is possible to suppress the electric power consumption of each indoor unit.

Third Embodiment

[0250] In First Embodiment and Second Embodiment, description has been made on the examples wherein the required cooling capacity L1 is calculated in accordance with Formula (1). Further, in First Embodiment and Second Embodiment, description has been made on the examples wherein the required heating capacity L2 is calculated in accordance with Formula (2).

[0251] However, it may be possible to calculate the required cooling capacity L1 by using another formula instead of Formula (1). Further, it may be possible to calculate the required heating capacity L2 by using another formula instead of Formula (2).

[0252] In the present embodiment, description will be made on an example using formulas other than Formula (1) and Formula (2).

[0253] In the present embodiment, description will be made mainly on the difference from First Embodiment.

[0254] The items not described hereinafter are similar to those in First Embodiment.

Description of Configuration

[0255] The configuration example of the air conditioning system 500 according to the present embodiment is as illustrated in Fig. 1.

[0256] Further, the example of the functional configuration of the control device 100 according to the present embodiment is as illustrated in Fig. 2. However, as described hereinafter, the operations of the estimation unit 102, the learning unit 104 and the calculation unit 106 are different from those in First Embodiment.

[0257] The example of the hardware configuration of the control device 100 according to the present embodiment is as illustrated in Fig. 3.

Description of Operation

[0258] In the present embodiment as well, the control device 100 performs the operations illustrated in Fig. 4 and Fig. 5 as the operation in the operation phase.

[0259] First, description will be made on the operation of the control device 100 at the time of cooling operation, with reference to Fig. 4.

[0260] In Step S101, the collection unit 101 collects operation data. In the present embodiment, the collection unit 101 collects values to be described below in addition to the values collected in First Embodiment.

[0261] Further, in the present embodiment, the estimation unit 102 estimates the required cooling capacity L1 [kW] of each indoor unit 300 in accordance with Formula (3) and Formula (4) as follows, in Step S102.

$$L1 = (heo - hei) \times Gr \quad \text{Formula (3)}$$

$$Gr = 7.59 \times 10^{-4} \times Cv \times ((Ph - Ps) \times pl \times 1000)^{0.5} \quad \text{Formula (4)}$$

[0262] Here, hei [kJ/kg] in Formula (3) is an enthalpy at an inlet of an evaporator of an indoor unit 300. Further, heo [kJ/kg] in Formula (3) is an enthalpy at an outlet of the evaporator of the indoor unit 300. hei is decided from an outlet temperature of a condenser of the outdoor unit 200. heo is decided from the outlet temperature of the condenser of the outdoor unit 200 and Ps.

[0263] Further, Gr [kg/s] in Formula (3) is an amount of a refrigerant that flows in the indoor unit 300. Gr can be calculated by Formula (4).

[0264] In Formula (4), Ph [MPa] is a high pressure value (discharge pressure value of a refrigerant in a compressor). Ps [MPa] is a low pressure value (suction pressure value of the refrigerant in the compressor). Cv is an index that expresses an easiness with which a fluid can flow. Cv can be calculated from an indoor unit expansion valve opening degree Li [Pulse]. The relation between Li and Cv is decided by the expansion valve. The control device 100 shall retain data indicating the relation between Li and Cv beforehand as a database.

[0265] ρ_l in Formula (4) is density of a refrigerant at an inlet of the expansion valve. ρ_l is decided from the outlet temperature of the condenser of the outdoor unit 200.

[0266] The collection unit 101 collects Ph, Ps, Li and the output temperature of the condenser as operation data in addition to the values indicated in First Embodiment.

[0267] The estimation unit 102 calculates hei in Formula (3) from the outlet temperature of the condenser obtained as the operation data. Further, the estimation unit 102 calculates heo from the outlet temperature of the condenser and Ps obtained as the operation data. Furthermore, the estimation unit 102 calculates Cv in Formula (4), using Li obtained as the operation data and data in the database. Additionally, the estimation unit 102 calculates ρ_l in Formula (4) from the outlet temperature of the condenser obtained as the operation data.

[0268] Then, the estimation unit 102 calculates Gr in accordance with Formula (4). Further, the estimation unit 102 calculates the required cooling capacity L1 in accordance with Formula (3), from Gr, hei and heo calculated.

[0269] Step S103 through Step S105 in Fig. 4 are similar to those indicated in First Embodiment. Therefore, the description is omitted.

[0270] In Step S106, the calculation unit 106 calculates a superheat degree in each indoor unit 300 other than the representative indoor unit in accordance with Formula (1) indicated in First Embodiment.

[0271] In the present embodiment, the value set to L1 in Formula (1) is the value of L1 calculated in accordance with Formula (3) in Step S102.

[0272] The other values in Formula (1) are the same as those indicated in First Embodiment.

[0273] Step S107 and Step S108 in Fig. 4 are similar to those indicated in First Embodiment. Therefore, the description is omitted.

[0274] Next, description will be made on the operation of the control device 100 at the time of heating operation, with reference to Fig. 5.

[0275] In Step S201, the collection unit 101 collects operation data. In the present embodiment, the collection unit 101 collects values to be described below in addition to the values collected in First Embodiment.

[0276] Further, in the present embodiment, the estimation unit 102 estimates the required heating capacity L2 [kW] of each indoor unit 300 in accordance with Formula (5) and Formula (6) as follows, in Step S202.

$$L2 = (hco - hci) \times Gr \quad \text{Formula (5)}$$

$$Gr = 7.59 \times 10^{-4} \times Cv \times ((Ph - Ps) \times \rho_l \times 1000)^{0.5} \quad \text{Formula (6)}$$

[0277] hci [kJ/kg] in Formula (5) is an enthalpy at the inlet of the condenser of the indoor unit 300. Further, hco [kJ/kg] in Formula (5) is an enthalpy at the outlet of the condenser of the indoor unit 300. hci is decided from an inlet temperature of the evaporator of the outdoor unit 200 and Ph. hco is decided from the inlet temperature of the evaporator of the outdoor unit 200.

[0278] Further, Gr [kg/s] is an amount of a refrigerant that flows in an indoor unit 300. Gr can be calculated from Formula (6). ρ_l in Formula (6) is decided from the inlet temperature of the evaporator of the outdoor unit 200. The other values in Formula (6) are the same as those in Formula (4).

[0279] The collection unit 101 collects Ph, Ps, Li and the inlet temperature of the evaporator in addition to the values indicated in First Embodiment, as the operation data.

[0280] The estimation unit 102 calculates hci in Formula (5) from the inlet temperature of the evaporator and Ph obtained as the operation data. Further, the estimation unit 102 calculates hco from the inlet temperature of the evaporator obtained as the operation data. Furthermore, the estimation unit 102 calculates Cv in Formula (6) by using Li obtained as the operation data, and data in the database. Additionally, the estimation unit 102 calculates ρ_l in Formula (6) from the inlet temperature of the evaporator obtained as the operation data.

[0281] Then, the estimation unit 102 calculates Gr in accordance with Formula (6). Further, the estimation unit 102 calculates the required heating capacity L2 in accordance with Formula (5) from Gr, hci and hco calculated.

[0282] Step S203 through Step S205 in Fig. 5 are the same as those indicated in First Embodiment. Therefore, the description is omitted.

[0283] In Step S206, the calculation unit 106 calculates the supercooling degree in each indoor unit 300 other than the representative indoor unit, in accordance with Formula (2) indicated in First Embodiment.

[0284] In the present embodiment, the value set to L2 in Formula (2) is the value of L2 calculated in accordance with Formula (5) in Step S202.

[0285] The other values in Formula (2) are the same as those indicated in First Embodiment.

[0286] Step S207 and Step S208 in Fig. 5 are similar to those indicated in First Embodiment. Therefore, the description is omitted.

[0287] In the present embodiment as well, the control device 100 performs operations illustrated in Fig. 6 and Fig. 7, as the operations in the learning phase.

[0288] First, description will be made on the operation of the control device 100 at the time of cooling operation, with reference to Fig. 6.

[0289] In Step S301, the collection unit 101 collects operation data. The collection unit 101 collects the same operation data as that collected in Step S101 in the present embodiment.

[0290] Further, in Step S302, the estimation unit 102 estimates the required cooling capacity L1 of each indoor unit 300 in accordance with Formula (3), for each evaporating temperature.

[0291] The operations in and after Step S303 are the same as those indicated in First Embodiment. Therefore, the description is omitted.

[0292] Next, description will be made on the operation of the control device 100 at the time of heating operation, with reference to Fig. 7.

[0293] In Step S401, the collection unit 101 collects operation data. The collection unit 101 collects the same operation data as that collected in Step S201 in the present embodiment.

[0294] Further, in Step S402, the estimation unit 102 estimates the required heating capacity L2 of each indoor unit 300 in accordance with Formula (2), for each condensing temperature.

[0295] The operations in and after Step S403 are the same as those indicated in First Embodiment. Therefore, the description is omitted.

Description of Effect of Embodiment

[0296] In the present embodiment, the required cooling capacity L1 is calculated by using Formula (3) and Formula (4) instead of Formula (1). By using Formula (3) and Formula (4), it is possible to calculate the required cooling capacity L1 more correctly than in the case of using Formula (1). Similarly, in the present embodiment, the required heating capacity L2 is calculated by using Formula (5) and Formula (6) instead of Formula (2). By using Formula (5) and Formula (6), it is possible to calculate the required heating capacity L2 more correctly than in the case of using Formula (2).

[0297] Therefore, according to the present embodiment, it is possible to control each indoor unit 300 more precisely than in First Embodiment.

[0298] In the above, First Embodiment through Third Embodiment have been described; however, two or more of these embodiments may be combined and performed.

[0299] Otherwise, one of these embodiments may be partially performed.

[0300] Meanwhile, two or more of these embodiments may be partially combined and performed.

[0301] Further, the configurations and procedures described in these embodiments may be changed as needed.

Supplementary Description of Hardware Configuration

[0302] Lastly, supplementary description will be made on the hardware configuration of the control device 100.

[0303] The processor 901 illustrated in Fig. 3 is an IC (Integrated Circuit) to perform processing.

[0304] The processor 901 is a CPU (Central Processing Unit), a DSP (Digital Signal Processor) or the like.

[0305] The main storage device 902 illustrated in Fig. 3 is a RAM (Random Access Memory).

[0306] The auxiliary storage device 903 illustrated in Fig. 3 is an ROM (Read Only Memory), a flash memory, an HDD (Hard Disk Drive) or the like.

[0307] The communication device 904 illustrated in Fig. 3 is an electronic circuit to perform communication processing of data.

[0308] The communication device 904 is a communication chip or an NIC (Network Interface Card), for example.

[0309] The input and output device 905 is a keyboard, a mouse, a display or the like.

[0310] Further, the auxiliary storage device 903 also stores an OS (Operating System).

[0311] In addition, at least a part of the OS is executed by the processor 901.

[0312] The processor 901 executes programs to realize the functions of the collection unit 101, the estimation unit 102, the selection unit 103, the learning unit 104, the setting unit 105, the calculation unit 106 and the control unit 107 while executing at least a part of the OS.

[0313] By executing the OS by the processor 901, task management, memory management, file management, communication control and the like are performed.

[0314] Further, at least any of information, data, signal values and variable values indicating results of processing by the collection unit 101, the estimation unit 102, the selection unit 103, the learning unit 104, the setting unit 105, the calculation unit 106 and the control unit 107 is stored in at least any of the main storage device 902, the auxiliary storage device 903, and a register and cache memory inside the processor 901.

[0315] Further, the programs to realize the functions of the collection unit 101, the estimation unit 102, the selection unit 103, the learning unit 104, the setting unit 105, the calculation unit 106 and the control unit 107 may be stored in a portable recording medium such as a magnetic disk, a flexible disk, an optical disk, a compact disk, a Blue-ray (registered trademark) disk, a DVD or the like. Additionally, it may be possible to distribute the portable recording medium wherein the programs to realize the functions of the collection unit 101, the estimation unit 102, the selection unit 103, the learning unit 104, the setting unit 105, the calculation unit 106 and the control unit 107 are stored.

[0316] Further, "unit" of the collection unit 101, the estimation unit 102, the selection unit 103, the learning unit 104, the setting unit 105, the calculation unit 106 and the control unit 107 may be replaced with "circuit", "step", "procedure", "process" or "circuitry".

[0317] In addition, the control device 100 may be realized by a processing circuit. The processing circuit is, for example, a logic IC (Integrated Circuit), a GA (Gate Array), an ASIC (Application Specific Integrated Circuit) or an FPGA (Field-Programmable Gate Array).

[0318] In this case, the collection unit 101, the estimation unit 102, the selection unit 103, the learning unit 104, the setting unit 105, the calculation unit 106 and the control unit 107 are each realized as a part of the processing circuit.

[0319] In the present specification, a superordinate concept of the processor and the processing circuit is called "processing circuitry".

[0320] That is, each of the processor and the processing circuit is a concrete example of "processing circuitry".

Reference Signs List

[0321] 100: control device; 101: collection unit; 102: estimation unit; 103: selection unit; 104: learning unit; 105: setting unit; 106: calculation unit; 107: control unit; 108: operation data storage unit; 110: learning model; 200: outdoor unit; 300: indoor unit; 400: air conditioning unit; 500: air conditioning system; 901: processor; 902: main storage device; 903: auxiliary storage device; 904: communication device; 905: input and output device

Claims

1. A control device comprising:

a selection unit to select from among a plurality of indoor units to each of which an air-conditioned space to be air-conditioned is assigned, an indoor unit to represent the plurality of indoor units, as a representative indoor unit, based on a required air-conditioning capacity being an air conditioning capacity required for each indoor unit; a setting unit to set a target temperature of either an evaporating temperature or a condensing temperature which enables an air conditioning capacity of the representative indoor unit to conform to the required air-conditioning capacity of the representative indoor unit, using a learning model obtained by machine learning, and a calculation unit to calculate, for each indoor unit of the plurality of indoor units other than the representative indoor unit, either a superheat degree or a supercooling degree at which an air conditioning capacity of the each indoor unit conforms to the required air-conditioning capacity of the each indoor unit when either an evaporating temperature or a condensing temperature in the each indoor unit is made to conform to the target temperature.

2. The control device as defined in claim 1, further comprising

an estimation unit to estimate the required air-conditioning capacity of each indoor unit of the plurality of indoor units, wherein the selection unit selects an indoor unit with a highest required air-conditioning capacity from among the plurality of indoor units, as the representative indoor unit.

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

the setting unit sets the target temperature, using a learning model obtained in a learning phase by learning either an evaporating temperature or a condensing temperature which enables an air-conditioning capacity of an indoor

unit-for-learning being an indoor unit with a highest required air-conditioning capacity among the plurality of indoor units to conform to the required air-conditioning capacity of the indoor unit-for-learning.

4. The control device as defined in claim 1, further comprising

a collection unit to collect a measured temperature which is measured in the air-conditioned space of each indoor unit, and
 an estimation unit to estimate the required air-conditioning capacity of each indoor unit, wherein
 the calculation unit calculates, for each indoor unit of the plurality of indoor units other than the representative indoor unit, either a superheat degree or a supercooling degree in the each indoor unit, using the required air-conditioning capacity of the each indoor unit, the measured temperature in the air-conditioned space of the each indoor unit, and the target temperature.

5. The control device as defined in claim 1, wherein

the setting unit sets the target temperature by applying to the learning model, a set temperature of an air-conditioned space of the representative indoor unit, a measured temperature which is measured in the air-conditioned space of the representative indoor unit, an operation state value which indicates an operation state of the representative indoor unit, either an evaporating temperature or a condensing temperature which is measured in the representative indoor unit, an outdoor air temperature, and either a superheat degree being a fixed value or a supercooling degree being a fixed value.

6. The control device as defined in claim 5, further comprising

a control unit to control the representative indoor unit, using the target temperature and either the superheat degree being the fixed value or the supercooling degree being the fixed value, and to control, for each indoor unit of the plurality of indoor units other than the representative indoor unit, the each indoor unit, using the target temperature and either a superheat degree or a supercooling degree calculated for the each indoor unit.

7. The control device as defined in claim 1, wherein

the setting unit sets a target temperature of either an evaporating temperature or a condensing temperature which enables the air conditioning capacity of the representative indoor unit to conform to the required air-conditioning capacity of the representative indoor unit, and which enables an electric power consumption of the representative indoor unit to be minimized, using the learning model.

8. The control device as defined in claim 7, wherein

the setting unit
 derives a combination of an evaporating temperature and a superheat degree, and a combination of a condensing temperature and a supercooling degree which enable the air conditioning capacity of the representative indoor unit to conform to the required air-conditioning capacity of the representative indoor unit, and which enable the electric power consumption of the representative indoor unit to be minimized, using a learning model obtained in a learning phase by learning either a combination of an evaporating temperature and a superheat degree or a combination of a condensing temperature and a supercooling degree which enables an air conditioning capacity of an indoor unit-for-learning being an indoor unit with a highest required air-conditioning capacity among the plurality of indoor units to conform to a required air-conditioning capacity of the indoor unit-for-learning, and which enables an electric power consumption of the indoor unit-for-learning to be minimized, and sets either the evaporating temperature or the condensing temperature derived, as the target temperature.

9. The control device as defined in claim 8, further comprising

a control unit to control the representative indoor unit, using the target temperature, and either a superheat degree or a supercooling degree derived from the learning model, and to control for each indoor unit of the plurality of indoor units other than the representative indoor unit, the each indoor unit, using the target temperature, and either a superheat degree or a supercooling degree calculated for the each indoor unit.

10. The control device as defined in claim 1, wherein

when the plurality of indoor units perform a cooling operation for air conditioning of each air-conditioned space, the setting unit sets a target temperature of an evaporating temperature which enables a cooling capacity of the representative indoor unit to conform to a cooling capacity required for the representative indoor unit,

when the plurality of indoor units perform a heating operation for air conditioning of each air-conditioned space, the setting unit sets a target temperature of a condensing temperature which enables a heating capacity of the representative indoor unit to conform to a heating capacity required for the representative indoor unit,
when the plurality of indoor units perform a cooling operation for air conditioning of each air-conditioned space, the calculation unit calculates a superheat degree at which a cooling capacity of each indoor unit of the plurality of indoor units other than the representative indoor unit conforms to a cooling capacity required for the each indoor unit when an evaporating temperature in the each indoor unit is made to conform to the target temperature for the each indoor unit, and
when the plurality of indoor units perform a heating operation for air conditioning of each air-conditioned space, the calculation unit calculates a supercooling degree at which a heating capacity of each indoor unit of the plurality of indoor units other than the representative indoor unit conforms to a heating capacity required for the each indoor unit when a condensing temperature in the each indoor unit is made to conform to the target temperature for the each indoor unit.

11. A control method comprising:

by a computer, selecting, from among a plurality of indoor units to each of which an air-conditioned space to be air-conditioned is assigned, an indoor unit to represent the plurality of indoor units, as a representative indoor unit, based on a required air-conditioning capacity being an air conditioning capacity required for each indoor unit; by the computer, setting a target temperature of either an evaporating temperature or a condensing temperature which enables an air conditioning capacity of the representative indoor unit to conform to the required air-conditioning capacity of the representative indoor unit, using a learning model obtained by machine learning, and by the computer, calculating, for each indoor unit of the plurality of indoor units other than the representative indoor unit, either a superheat degree or a supercooling degree at which an air conditioning capacity of the each indoor unit conforms to the required air-conditioning capacity of the each indoor unit when either an evaporating temperature or a condensing temperature in the each indoor unit is made to conform to the target temperature.

Fig. 1

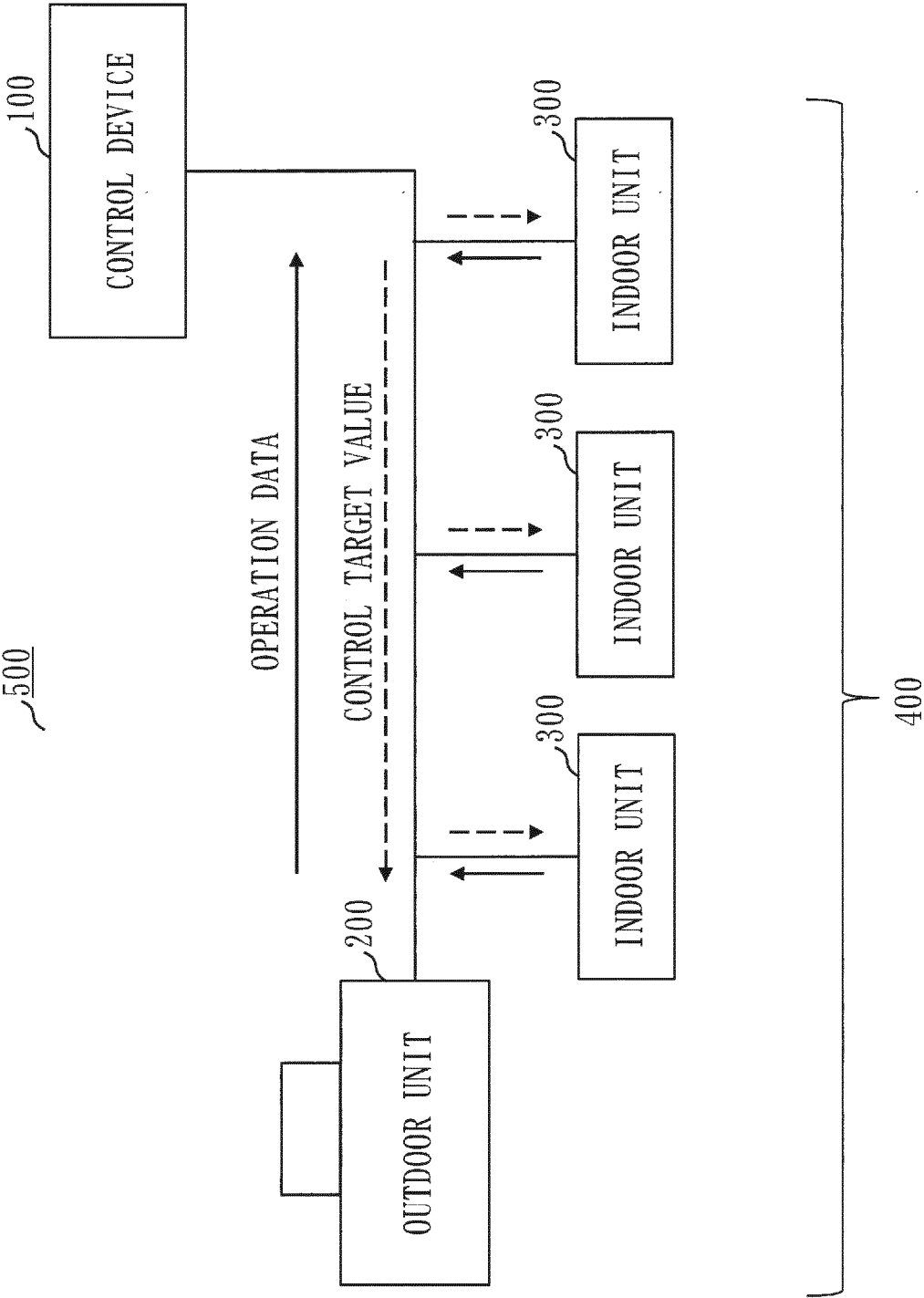


Fig. 2

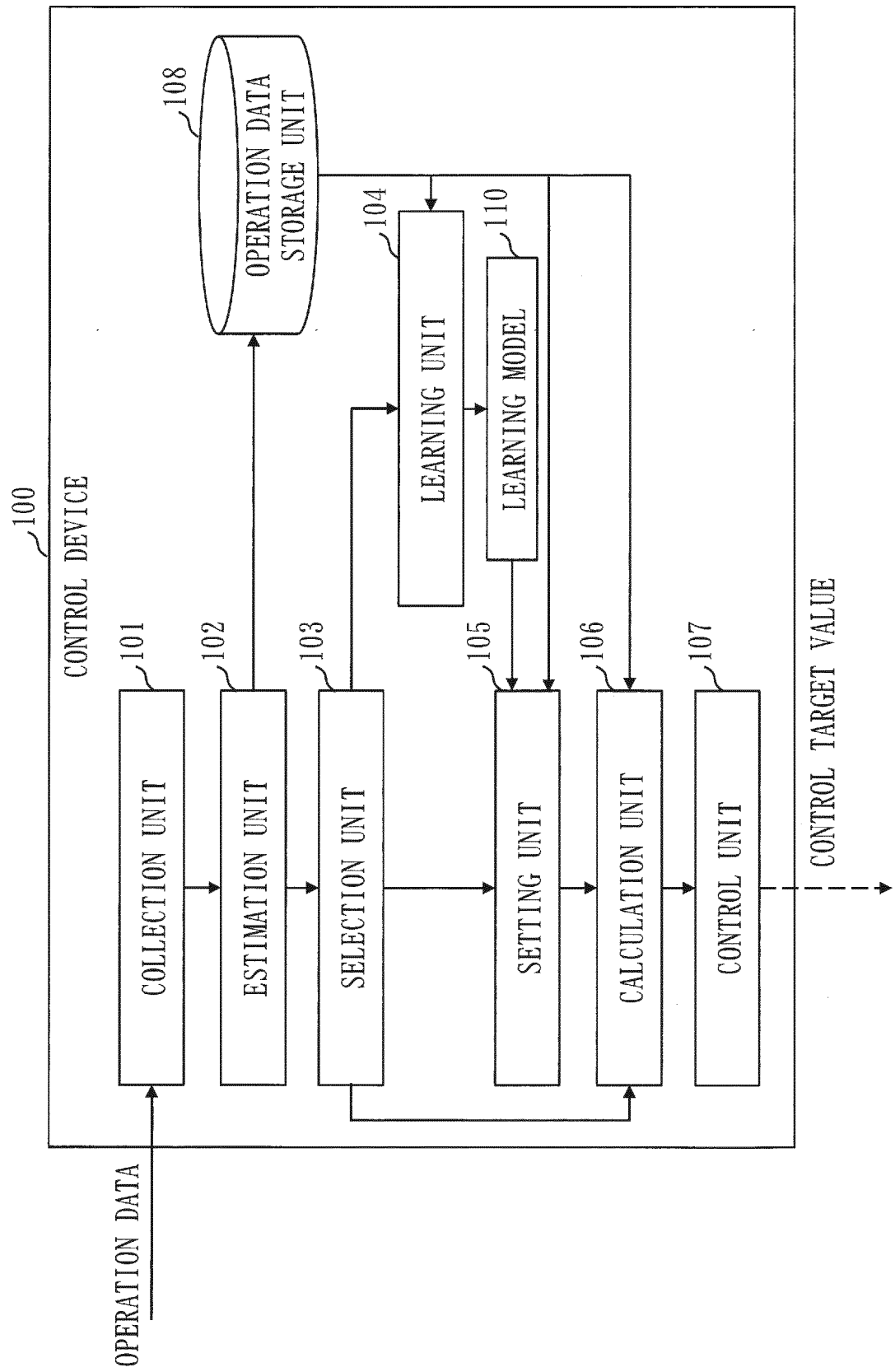


Fig. 3

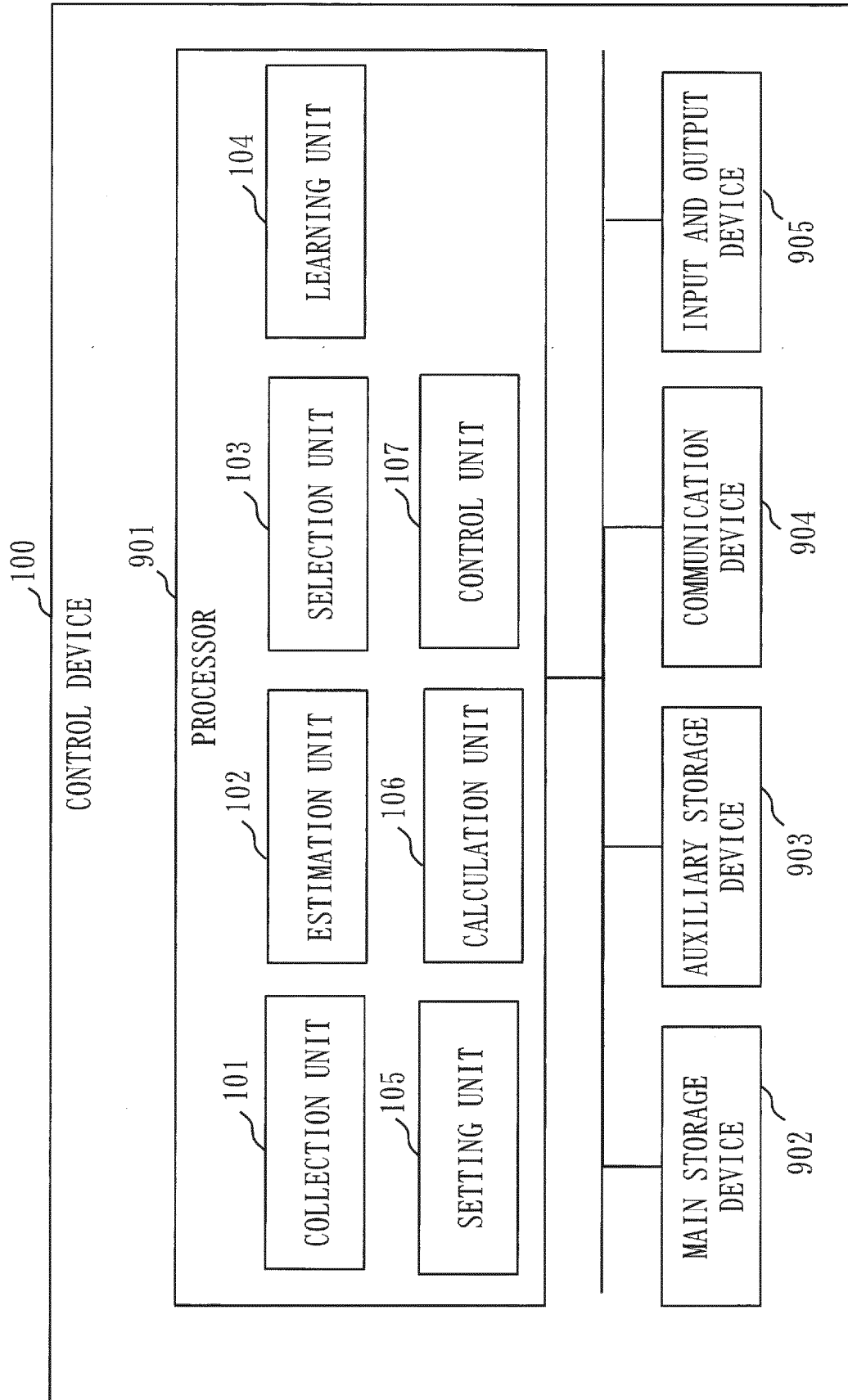


Fig. 4

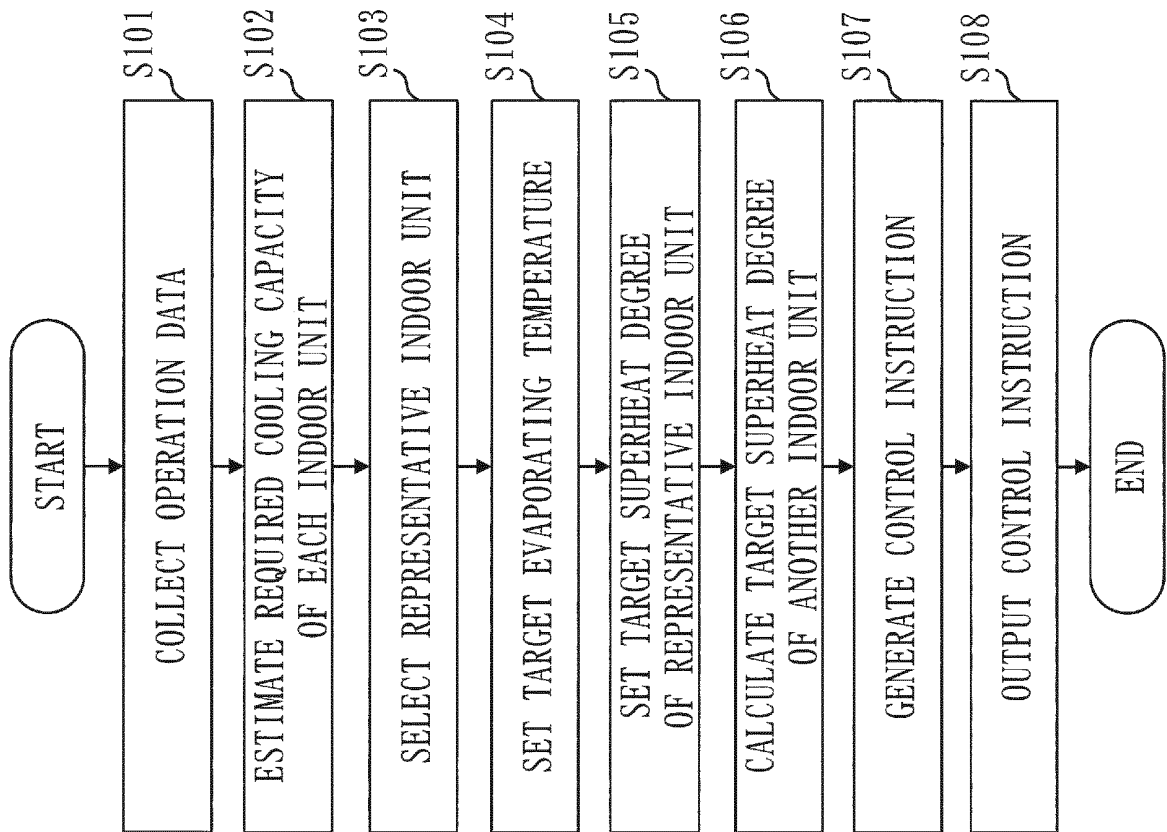


Fig. 5

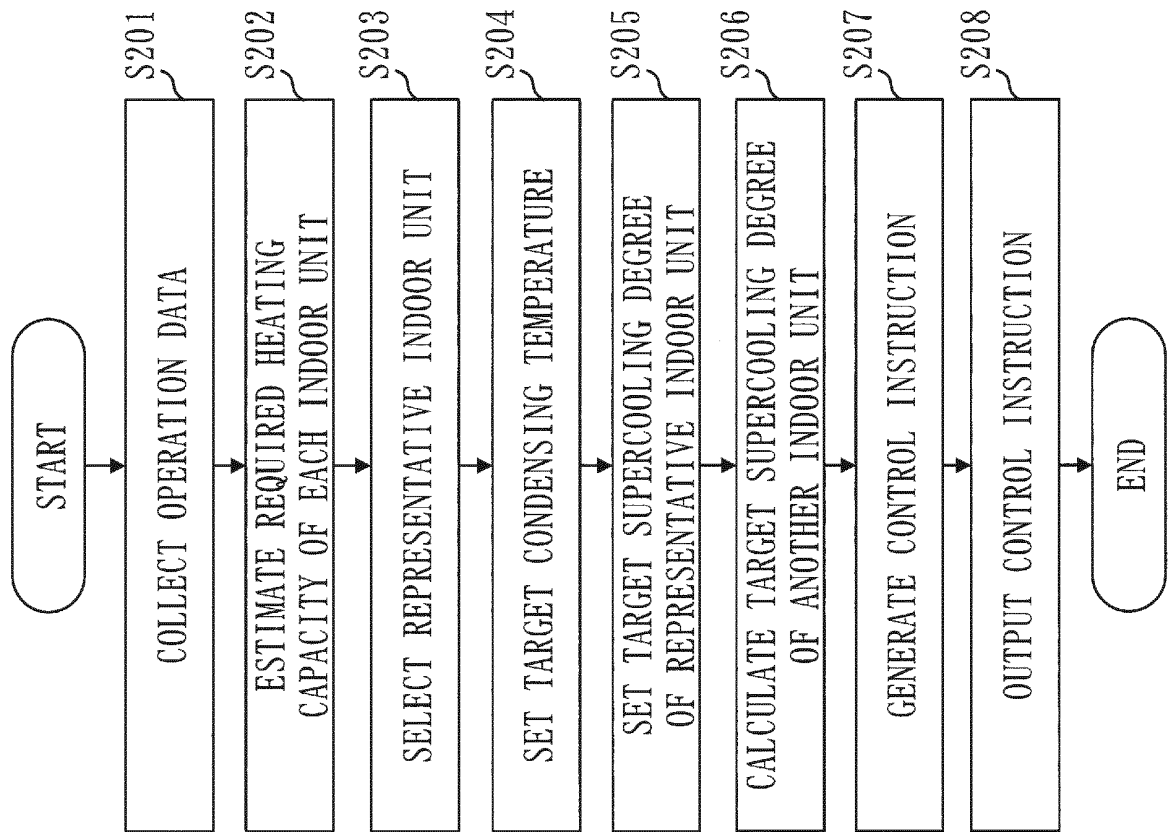


Fig. 6

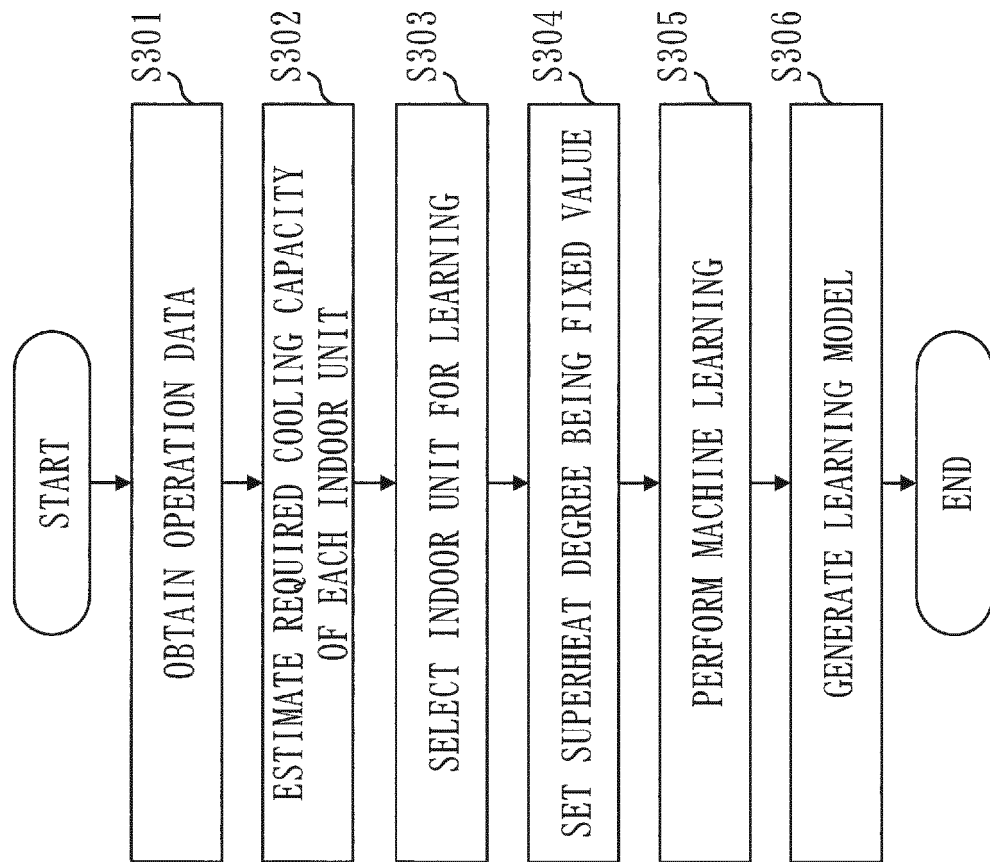


Fig. 7

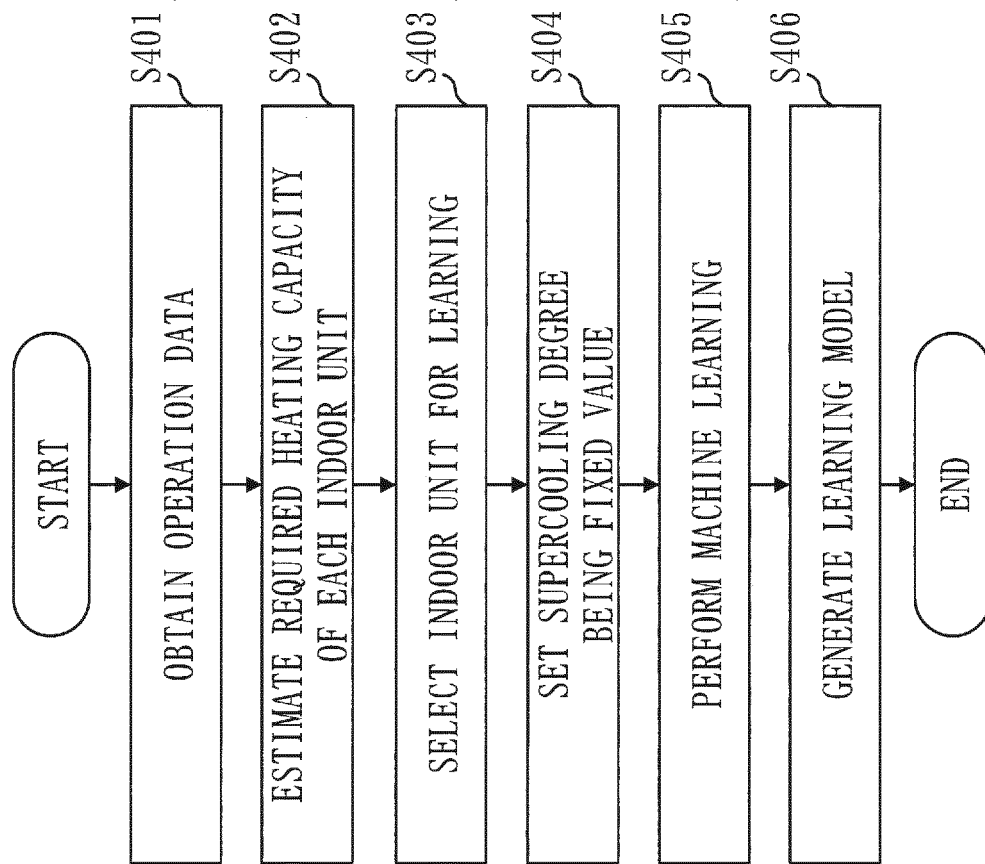


Fig. 8

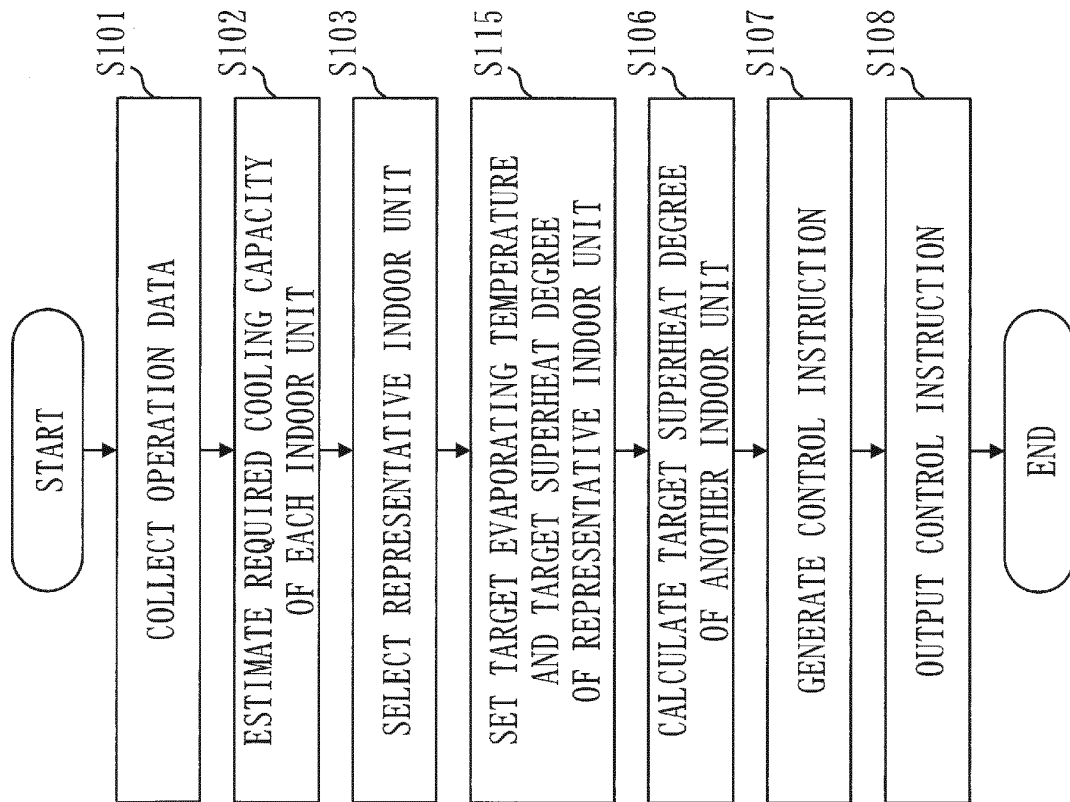


Fig. 9

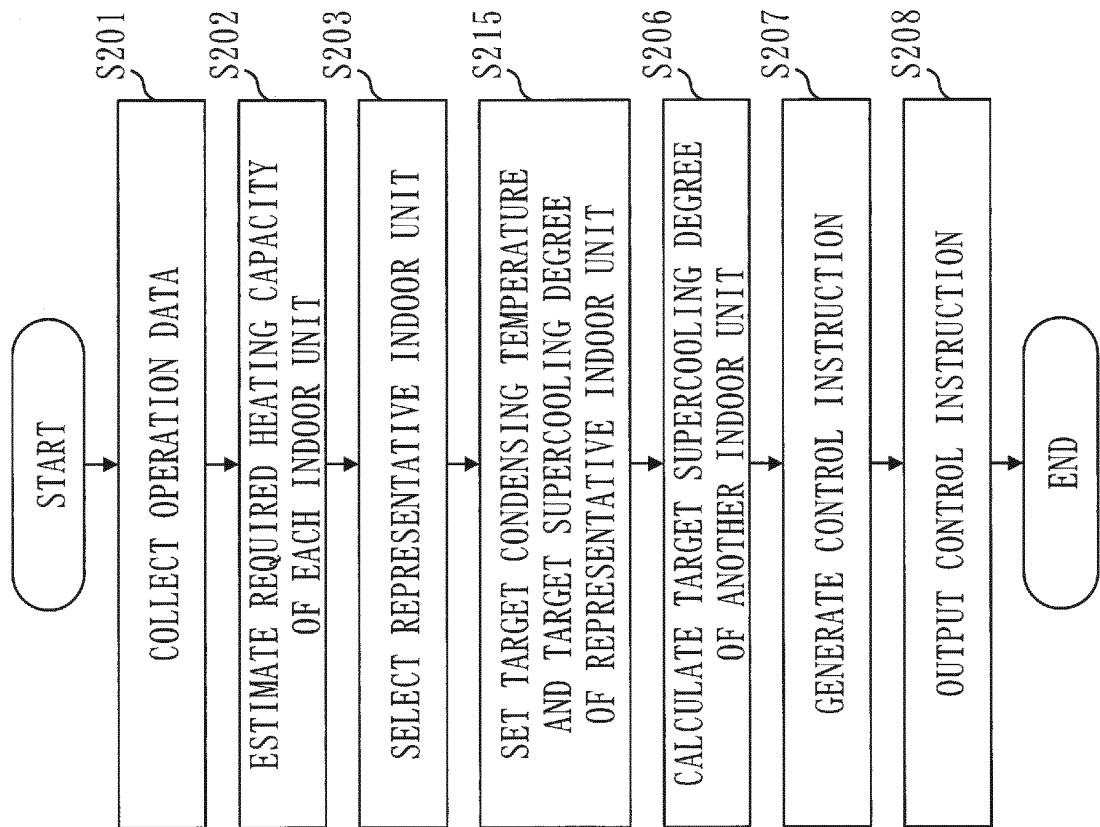


Fig. 10

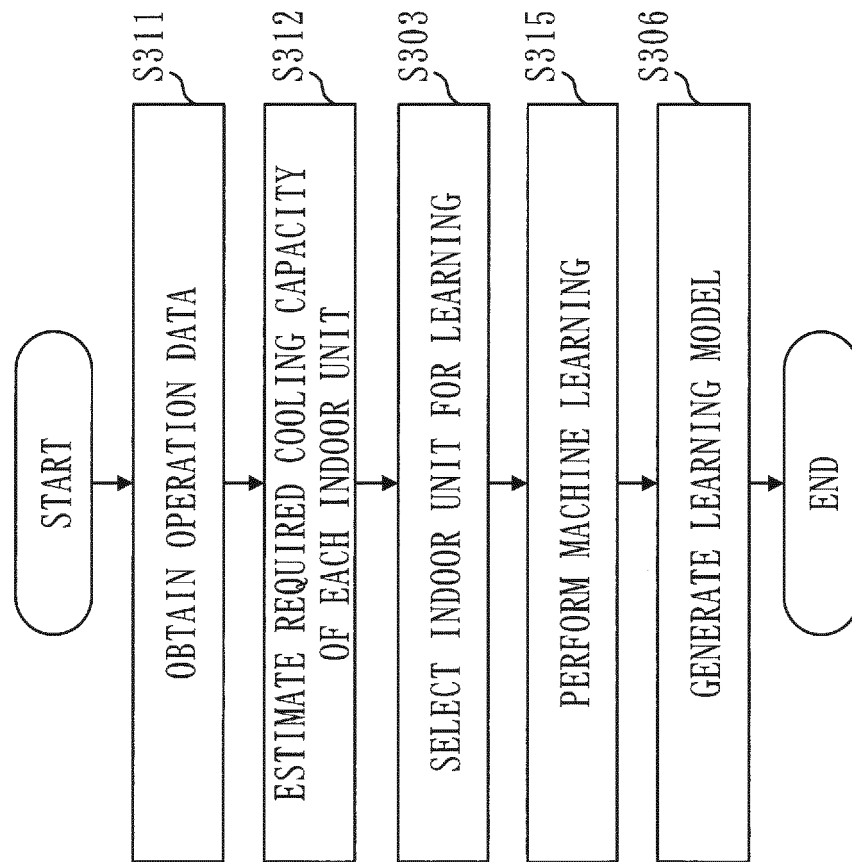
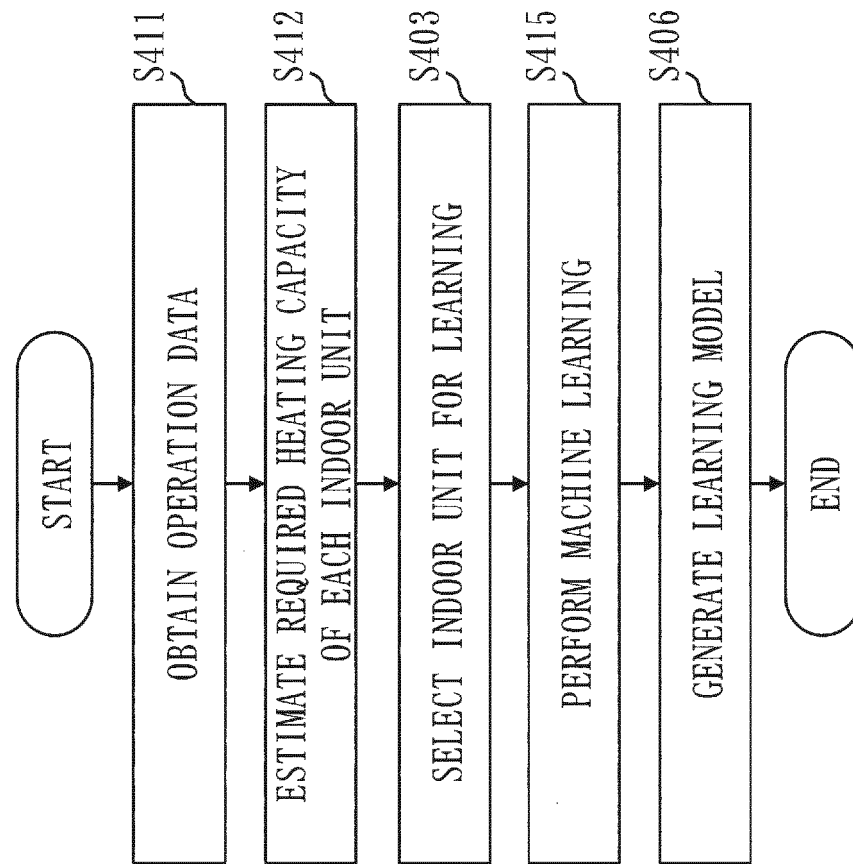


Fig. 11



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2021/041210

A. CLASSIFICATION OF SUBJECT MATTER

F24F 11/46(2018.01)i; **F24F 11/64**(2018.01)i
FI: F24F11/64; F24F11/46

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; F24F11/64

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 1971-2021
Registered utility model specifications of Japan 1996-2021
Published registered utility model applications of Japan 1994-2021

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 2019-163907 A (MITSUBISHI ELECTRIC CORP.) 26 September 2019 (2019-09-26) paragraphs [0009]-[0099], fig. 1-11	1-2, 4, 7, 10-11
A		3, 5-6, 8-9
Y	JP 2002-327949 A (DAIKIN IND., LTD.) 15 November 2002 (2002-11-15) paragraphs [0034]-[0083], fig. 1-9	1-2, 4, 7, 10-11
A		3, 5-6, 8-9
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A		3, 5-6, 8-9
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A	WO 2020/022123 A1 (NIPPON TELEGRAPH AND TELEPHONE CORP.) 30 January 2020 (2020-01-30) paragraphs [0029]-[0188], fig. 1-21	1-11

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

* Special categories of cited documents:	"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
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"E" earlier application or patent but published on or after the international filing date	"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
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"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	

Date of the actual completion of the international search

16 December 2021

Date of mailing of the international search report

28 December 2021

Name and mailing address of the ISA/JP

Japan Patent Office (ISA/JP)
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Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/JP2021/041210

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Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP	2019-163907	A	26 September 2019	(Family: none)	
JP	2002-327949	A	15 November 2002	(Family: none)	
JP	2002-327950	A	15 November 2002	(Family: none)	
WO	2020/203977	A1	08 October 2020	(Family: none)	
WO	2020/022123	A1	30 January 2020	US 2021/0140670 A1 paragraphs [0050]-[0238], fig. 1-21	
				EP 3832556 A1	
				CN 112400179 A	

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

REFERENCES CITED IN THE DESCRIPTION

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