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(72) Inventors:
• **OHTA, Yoshihiro**
Tokyo 100-8310 (JP)
• **MINEYUKI, Takuma**
Tokyo 100-8310 (JP)
• **KANEKO, Yosuke**
Tokyo 100-8310 (JP)

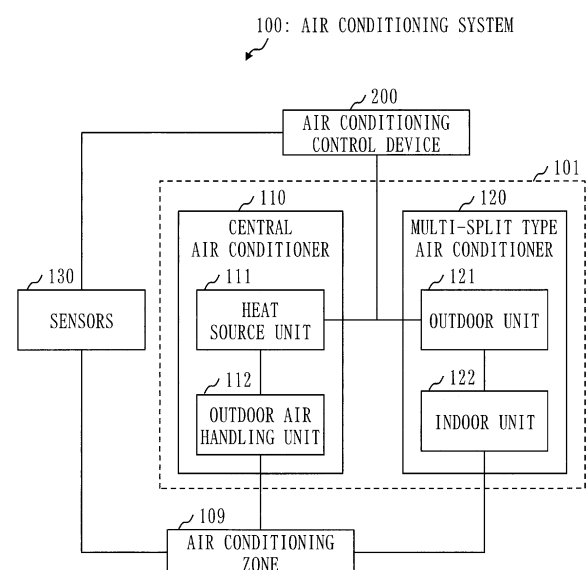
(71) Applicant: **MITSUBISHI ELECTRIC CORPORATION**
Chiyoda-ku
Tokyo 100-8310 (JP)

(74) Representative: **Mewburn Ellis LLP**
Aurora Building
Counterslip
Bristol BS1 6BX (GB)

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

(57) An air conditioning control device (200) calculates one or more estimate values for an air conditioning zone (109) based on zone environment data and operation state data, generates one or more candidates for a setting value group pair based on current setting data, calculates predicted energy consumption and predicted comfort as a predicted balance based on the one or more estimate values for each candidate, and determines a setting value group pair to be set for an air conditioner pair (101) based on the predicted balance of each candidate.

Fig. 1



Description

the present disclosure includes

Technical Field

[0001] The present disclosure relates to control of an air conditioning system.

Background Art

[0002] As air conditioning systems that are excellent in terms of energy saving and comfort, central air conditioners have been adopted in large buildings, and multi-split type air conditioners for buildings have been adopted in small and medium-sized buildings.

[0003] In recent years, in order to improve energy saving, an air conditioning system in which an outdoor air handling unit of a central air conditioner and indoor air handling unit of a multi-split type air conditioner for a building are combined may be adopted also in a large building.

[0004] The outdoor air handling unit and the indoor air handling unit process heat by different methods in terms of capacity and characteristics. Therefore, load coordination control to coordinate and control the outdoor air handling unit and the indoor air handling unit is performed.

[0005] In load coordination control, at least one of the setting value of the outdoor air handling unit and the setting value of the indoor air handling unit is controlled so that the indoor temperature or the indoor humidity approaches a predetermined value and the sum of the power consumption of the central air conditioner and the power consumption of the multi-split type air conditioner for a building is reduced.

Citation List**Patent Literature**

[0006] Patent Literature 1: JP 6414354 B

Summary of Invention**Technical Problem**

[0007] The technology of Patent Literature 1 brings the temperature or humidity closer to a specified setting value, but cannot set a better setting value taking into consideration a balance between power consumption and comfort.

[0008] An object of the present disclosure is to make it possible to determine a setting value for an air conditioning system taking into consideration a balance between energy consumption and comfort.

Solution to Problem

[0009] An air conditioning control device according to

a state estimation unit to calculate an estimate value based on zone environment data that indicates a measurement value of each of one or more types of states of an air conditioning zone in which an air conditioner pair composed of two types of air conditioners is used and operation state data that indicates a state value of each of one or more types of states for each of the air conditioners, the estimate value being an estimate value of each of one or more types of states of the air conditioning zone different from the one or more types of states in the zone environment data;

a candidate generation unit to generate one or more candidates for a setting value group pair for the air conditioner pair based on current setting data that indicates a setting value group pair that is set for the air conditioner pair;

a balance prediction unit to calculate, as a predicted balance, predicted power consumption and predicted comfort in a case where the setting value group pair is set for the air conditioner pair, based on one or more estimate values that have been calculated, for each generated candidate; and
a setting determination unit to determine one candidate as a setting value group pair to be set for the air conditioner pair based on the predicted balance of each candidate.

Advantageous Effects of Invention

[0010] According to the present disclosure, a setting value for an air conditioning system can be determined taking into consideration a balance between energy consumption and comfort.

Brief Description of Drawings

[0011]

Fig. 1 is a configuration diagram of an air conditioning system 100 in Embodiment 1;

Fig. 2 is a configuration diagram of an air conditioning control device 200 in Embodiment 1;

Fig. 3 is a functional configuration diagram of the air conditioning control device 200 in Embodiment 1;

Fig. 4 is a flowchart of an air conditioning control method in Embodiment 1;

Fig. 5 is a figure illustrating generation of a candidate for a setting value group pair (first time) in Embodiment 1;

Fig. 6 is a figure illustrating generation of a candidate for a setting value group pair (second and subsequent times) in Embodiment 1;

Fig. 7 is a figure illustrating a Pareto dominance in Embodiment 1;

Fig. 8 is a figure illustrating the Pareto dominance in

Embodiment 1;

Fig. 9 is a graph illustrating a relationship of setting values, energy consumption, and room temperatures in Embodiment 1;

Fig. 10 is a figure illustrating selection of a candidate for a setting value group pair in Embodiment 1;

Fig. 11 is a configuration diagram of the air conditioning system 100 in Embodiment 2;

Fig. 12 is a functional configuration diagram of the air conditioning control device 200 in Embodiment 3;

Fig. 13 is a flowchart of the air conditioning control method in Embodiment 3;

Fig. 14 is a functional configuration diagram of the air conditioning control device 200 in Embodiment 4;

Fig. 15 is a flowchart of a model learning process in Embodiment 4;

Fig. 16 is a flowchart of the air conditioning control method in Embodiment 4;

Fig. 17 is a functional configuration diagram of the air conditioning control device 200 in Embodiment 5;

Fig. 18 is a flowchart of the air conditioning control method in Embodiment 5;

Fig. 19 is a functional configuration diagram of the air conditioning control device 200 in Embodiment 6;

Fig. 20 is a flowchart of the air conditioning control method in Embodiment 6;

Fig. 21 is a functional configuration diagram of the air conditioning control device 200 in Embodiment 7;

Fig. 22 is a flowchart of the air conditioning control method in Embodiment 7;

Fig. 23 is a figure illustrating selection of a candidate for a setting value group pair in Embodiment 7;

Fig. 24 is a flowchart of the air conditioning control method in Embodiment 8;

Fig. 25 is a figure illustrating an upper limit value of a temperature setting in Embodiment 8;

Fig. 26 is a configuration diagram of the air conditioning system 100 in Embodiment 9;

Fig. 27 is a flowchart of the air conditioning method in Embodiment 9;

Fig. 28 is a figure illustrating selection of a candidate for a setting value group pair in Embodiment 9; and

Fig. 29 is a hardware configuration diagram of the air conditioning control device 200 in the embodiments.

Description of Embodiments

[0012] In the embodiments and drawings, the same elements or corresponding elements are denoted by the same reference sign. Description of an element denoted by the same reference sign as that of an element that has been described will be omitted or simplified as appropriate. Arrows in figures mainly indicate flows of data or flows of processing.

Embodiment 1.

[0013] An air conditioning system 100 will be described

based on Figs. 1 to 10.

*** Description of Configuration ***

5 [0014] Based on Fig. 1, a configuration of the air conditioning system 100 will be described.

[0015] The air conditioning system 100 is a system that conditions air in an air conditioning zone 109.

10 [0016] The air conditioning zone 109 is a zone in which air conditioning is to be performed. Specifically, the air conditioning zone 109 is a specific room.

[0017] The air conditioning system 100 includes an air conditioner pair 101 used for air conditioning in the air conditioning zone 109.

15 [0018] The air conditioner pair 101 includes two types of air conditioners.

[0019] A specific example of two types of air conditioners is a central air conditioner 110 and a multi-split type air conditioner 120.

20 [0020] The central air conditioner 110 includes a heat source unit 111 and an outdoor air handling unit 112. The outdoor air handling unit 112 is also simply called an air conditioner.

25 [0021] The heat source unit 111 produces cold water and hot water.

[0022] The outdoor air handling unit 112 conditions outdoor air using the cold water and the hot water, and supplies it to the air conditioning zone 109.

30 [0023] The multi-split type air conditioner 120 is a multi-split type air conditioner for a building.

[0024] The multi-split type air conditioner 120 includes an outdoor unit 121 and an indoor unit 122. The outdoor unit 121 is connected with the air conditioning zone 109 via a refrigerant pipe. The indoor unit 122 is also called an indoor air conditioner.

35 [0025] The outdoor unit 121 includes a compressor, and compresses and then discharges a refrigerant.

[0026] The indoor unit 122 draws in air from the air conditioning zone 109, conditions the air that has been drawn in, and supplies it to the air conditioning zone 109.

40 [0027] An air conditioning control device 200 includes sensors 130.

45 [0028] The sensors 130 are sensors of one or more types. Each sensor is installed in the air conditioning zone 109, the central air conditioner 110, or the multi-split type air conditioner 120.

[0029] The sensors 130 measure states of the air conditioning zone 109, the central air conditioner 110, and the multi-split type air conditioner 120.

50 [0030] The air conditioning control device 200 controls the central air conditioner 110 and the multi-split type air conditioner 120 based on measurement data obtained by the sensors 130.

55 [0031] Based on Fig. 2, a configuration of the air conditioning control device 200 will be described.

[0032] The air conditioning control device 200 is a computer that includes hardware such as a processor 201, a memory 202, an auxiliary storage device 203, a

communication device 204, and an input/output interface 205. These hardware components are connected with one another through signal lines.

[0033] The processor 201 is an IC that performs operational processing and controls other hardware components. For example, the processor 201 is a CPU.

[0034] IC is an abbreviation for integrated circuit.

[0035] CPU is an abbreviation for central processing unit.

[0036] The memory 202 is a volatile or non-volatile storage device. The memory 202 is also called a main storage device or a main memory. For example, the memory 202 is a RAM. Data stored in the memory 202 is saved in the auxiliary storage device 203 as necessary.

[0037] The auxiliary storage device 203 is a non-volatile storage device. For example, the auxiliary storage device 203 is a ROM, an HDD, a flash memory, or a combination of these. Data stored in the auxiliary storage device 203 is loaded into the memory 202 as necessary.

[0038] ROM is an abbreviation for read only memory.

[0039] HDD is an abbreviation for hard disk drive.

[0040] The communication device 204 is a receiver and a transmitter. For example, the communication device 204 is a communication chip or a NIC. Communication of the air conditioning control device 200 is performed using the communication device 204.

[0041] NIC is an abbreviation for network interface card.

[0042] The input/output interface 205 is a port to which an input device and an output device are connected. For example, the input/output interface 205 is a USB terminal, the input device is a keyboard and a mouse, and the output device is a display. Input to and output from the air conditioning control device 200 are performed using the input/output interface 205.

[0043] USB is an abbreviation for Universal Serial Bus.

[0044] The air conditioning control device 200 is connected with the central air conditioner 110, the multi-split type air conditioner 120, and the sensors 130 via the communication device 204.

[0045] Note that the air conditioning control device 200 may be connected with the central air conditioner 110, the multi-split type air conditioner 120, and the sensors 130 via the input/output interface 205.

[0046] The air conditioning control device 200 includes elements such as a data acquisition unit 211, a state estimation unit 212, a candidate generation unit 213, a balance prediction unit 214, a setting determination unit 215, and a setting output unit 216. These elements are realized by software.

[0047] The auxiliary storage device 203 stores an air conditioning control program to cause a computer to function as the data acquisition unit 211, the state estimation unit 212, the candidate generation unit 213, the balance prediction unit 214, the setting determination unit 215, and the setting output unit 216. The air conditioning control program is loaded into the memory 202 and executed by the processor 201.

[0048] The auxiliary storage device 203 further stores an OS. At least part of the OS is loaded into the memory 202 and executed by the processor 201.

[0049] The processor 201 executes the air conditioning control program while executing the OS.

[0050] OS is an abbreviation for operating system.

[0051] Input data and output data of the air conditioning control program are stored in a storage unit 290.

[0052] The memory 202 functions as the storage unit 290. However, a storage device such as the auxiliary storage device 203, a register in the processor 201, and a cache memory in the processor 201 may function as the storage unit 290 in place of the memory 202 or together with the memory 202.

[0053] The air conditioning control device 200 may include a plurality of processors as an alternative to the processor 201.

[0054] The air conditioning control program can be recorded (stored) in a computer readable format in a non-volatile recording medium such as an optical disc or a flash memory.

[0055] Fig. 3 illustrates a functional configuration of the air conditioning control device 200.

[0056] A zone estimation model 291 and a balance prediction model 292 are stored in the storage unit 290. These models will be described later.

*** Description of Operation ***

[0057] A procedure for the operation of the air conditioning control device 200 is equivalent to an air conditioning control method. The procedure for the operation of the air conditioning control device 200 is also equivalent to a procedure for processing by the air conditioning control program.

[0058] Based on Fig. 4, the air conditioning control method will be described.

[0059] In step S110, the data acquisition unit 211 acquires zone environment data and operation state data from the sensors 130.

[0060] The zone environment data indicates measurement values of one or more types of states of the air conditioning zone 109.

[0061] A measurement value is a value indicating a measured state (state value). Specifically, a measurement value indicates a physical quantity related to a thermal environment.

[0062] Specific examples of a state of the air conditioning zone 109 are a temperature, a humidity, and an air speed.

[0063] The operation state data indicates a state value of each of one or more types of states for each air conditioner.

[0064] In the central air conditioner 110, specific examples of a state of the heat source unit 111 are hot and cold water inlet and outlet temperatures, a compressor frequency, and an air supply fan rotation speed. Specific examples of a state of the outdoor air handling unit 112

are cold and hot water coil inlet and coil outlet temperatures, a cold and hot water coil flow rate, a hot and cold water coil valve opening degree, a supply air temperature, a supply air humidity, a fan rotation speed, a fan air volume, an outdoor air damper opening degree, and a filter differential pressure.

[0065] In the multi-split type air conditioner 120, specific examples of a state of the outdoor unit 121 are a refrigerant condensation temperature, a compressor frequency, compressor power consumption, a fan rotation speed, a supply air volume, an inlet temperature, an outlet temperature, an outdoor air temperature, and an outdoor air humidity. Specific examples of a state of the indoor unit 122 are an inlet temperature, an outlet temperature, a refrigerant evaporation temperature, a refrigerant pressure, a fan rotation speed, and an air flow volume.

[0066] The data acquisition unit 211 also acquires current setting data from the air conditioner pair 101.

[0067] The current setting data indicates a setting value group pair that is set for the air conditioner pair 101. That is, the current setting data indicates a setting value group that is set for the central air conditioner 110 and a setting value group that is set for the multi-split type air conditioner 120. A setting value group is one or more setting values.

[0068] In the central air conditioner 110, a specific example of a setting for the heat source unit 111 is a hot and cold water outlet temperature. Specific examples of a setting for the outdoor air handling unit 112 are a supply air temperature, a supply air humidity, a fan rotation speed, and an outdoor air damper opening degree.

[0069] In the multi-split type air conditioner 120, a specific example of a setting for the outdoor unit 121 is a refrigerant evaporation temperature. Specific examples of a setting for the indoor unit 122 are a inlet temperature and a fan rotation speed.

[0070] In step S 120, the state estimation unit 212 calculates an estimate value of each of one or more types of states of the air conditioning zone 109 based on the zone environment data and the operation state data.

[0071] An estimate value is an estimated state value. Specifically, an estimate value indicates a physical quantity that is difficult to measure directly.

[0072] An estimated state is a state that cannot be measured by the sensors 130 and is different from a state in the zone environment data. Specifically, an estimated state is a state that varies with building-specific parameters, such as an internal heat load, wall insulation, and solar radiation, as well as the time of day.

[0073] Each estimate value is calculated using the zone estimation model 291.

[0074] The zone estimation model 291 is an air conditioner model. The air conditioner model is a model for simulating the operation of each air conditioner.

[0075] The state estimation unit 212 calculates the zone estimation model 291 using as input the zone environment data and the operation state data. As a result,

zone estimate data is obtained. The zone estimate data indicates an estimate value of each of one or more types of states of the air conditioning zone 109.

[0076] Each estimate value may be calculated based on an indoor/outdoor enthalpy difference, the amount of outdoor air introduced, and the heat processing capacity of each air conditioner. For example, each estimate value may be calculated using a state estimator such as a state observer or a Kalman filter.

[0077] In step S130, the candidate generation unit 213 generates one or more candidates for a setting value group pair for the air conditioner pair 101 based on the current setting data.

[0078] In step S130 at the first time, the candidate generation unit 213 generates a candidate by changing a setting value group pair indicated by the current setting data.

[0079] Based on Fig. 5, generation of a candidate at the first time will be described. Fig. 5 indicates the current setting values (solid line) and the setting values of a candidate (dashed line) regarding the temperature. The setting values are indicated as a time series.

(1) The candidate generation unit 213 randomly determines a time period during which the setting value is to be changed (change time period) within a specified period. The specified period is determined in advance.

(2) The candidate generation unit 213 randomly determines a change width of the setting value in the change time period within a setting range. The setting range is determined in advance.

(3) The candidate generation unit 213 changes the setting value in the change time period in the time series of the current setting values by the change width. The changed time series is a candidate for the setting values.

[0080] In step S130 at the second and subsequent times, the candidate generation unit 213 generates a new candidate by changing a candidate at a previous time.

[0081] Based on Fig. 6, generation of a candidate at the second and subsequent times will be described. Fig. 6 indicates the setting values of two existing candidates (solid line (a), dashed line (b)) and the setting values of two new candidates (solid line (A), dashed line (B)) regarding the temperature. The setting values are indicated as a time series.

[0082] (0) The candidate generation unit 213 deletes each candidate with a poor predicted balance than those of other candidates among the candidates at previous times. As a result, only good candidates remain.

[0083] For example, the candidate generation unit 213 retains good candidates by a method called Pareto dominance. The method for retaining good candidates will be described later.

- (1) The candidate generation unit 213 randomly selects two candidates (reference candidates) from the remaining candidates.
- (2) The candidate generation unit 213 randomly determines the change time period.
- (3) As a change value for each of the reference candidates in the change time period, the candidate generation unit 213 adopts the setting value of the other reference candidate. Alternatively, the candidate generation unit 213 may calculate an average of the setting values of the two reference candidates as a change value for each of the reference candidates.
- (4) The candidate generation unit 213 changes the setting value in the change time period to the change value for each of the reference candidates. The changed time series of each of the reference candidates is the setting values of a new candidate.

[0084] Based on Figs. 7 and 8, the Pareto dominance will be described.

[0085] First, the candidate generation unit 213 compares each candidate A with another candidate B using an objective function for energy consumption and an objective function for comfort.

[0086] Next, for each candidate A, the candidate generation unit 213 determines whether there is a candidate B that is better than the candidate A in both energy consumption and comfort.

[0087] Then, if there is a candidate B that is superior to the candidate A in both energy consumption and comfort, the candidate generation unit 213 deletes the candidate A. In Fig. 7, there is a candidate B that is superior to the candidate A, so that the candidate A is deleted.

[0088] If there is no candidate B that is superior to the candidate A in both energy consumption and comfort, the candidate generation unit 213 retains the candidate A. In Fig. 8, there is no candidate B that is superior to the candidate A, so that the candidate A is retained.

[0089] If it is determined for every candidate whether there is a candidate that is superior and only candidates for which there are no other superior candidates and which are in a trade-off relationship are retained, only candidates represented by filled circles remain.

[0090] Note that the candidate generation unit 213 may retain good candidates by a method other than Pareto dominance.

[0091] The candidate generation unit 213 may determine dominated or non-dominated of each candidate of candidates in a trade-off relationship (filled circles in Figs. 7 and 8) using a crowding distance of NSGA-II and retain good candidates based on the determined dominated or non-dominated.

[0092] NSGA is an abbreviation for non-dominated sorting genetic algorithm.

[0093] Step S130 will be supplemented.

[0094] To generate candidates, a generally known multi-purpose optimization method may be used.

[0095] Specific examples of the multi-purpose optimi-

zation method are NSGA-II, NSGA-III, MOPSO, and MOEA/D. A specific example of NSGA-II is SBX.

[0096] MOPSO is an abbreviation for multi-objective particle swarm optimization.

5 **[0097]** MOEA/D is an abbreviation for a multi-objective evolutionary algorithm based on decomposition.

[0098] SBX is an abbreviation for simulated binary crossover.

10 **[0099]** Referring back to Fig. 4, the description will be continued from step S140.

[0100] In step S140, for each generated candidate, the balance prediction unit 214 calculates a predicted balance in a case where the setting value group pair is set for the air conditioner pair 101, based on the one or more calculated estimate values.

15 **[0101]** The predicted balance is predicted energy consumption and predicted comfort. For example, comfort is expressed as a temperature and a humidity. Comfort may be expressed as a comfort index value such as PMV or SET*.

[0102] PMV is an abbreviation for predicted mean vote.

[0103] SET* is an abbreviation for standard new effective temperature.

25 **[0104]** In step S140 at the n-th time, the balance prediction unit 214 calculates a predicted balance based on the estimate state data obtained in step S120 and the setting value group pair obtained in step S130 at the n-th time.

30 **[0105]** The predicted balance is calculated using the balance prediction model 292.

[0106] The balance prediction model 292 is an air conditioner model.

35 **[0107]** The balance prediction unit 214 calculates the balance prediction model 292 using as input the zone estimate data and the setting value group pair. As a result, the predicted balance is obtained.

[0108] Fig. 9 indicates an example of temperature setting values in a time series and energy consumption and comfort (room temperature) calculated by the balance prediction model.

40 **[0109]** The predicted balance is calculated using the values in a specified period in the calculated time series (energy consumption, comfort). For example, an integrated value in the specified period is calculated as the predicted balance for energy consumption, and an average value in the specified period is calculated as the predicted balance for comfort.

[0110] Referring back to Fig. 4, the description will be continued from step S150.

50 **[0111]** In step S150, the setting determination unit 215 determines whether a termination condition for step S130 and step S140 has been satisfied. The termination condition is determined in advance.

55 **[0112]** For example, the termination condition is specified times of repetition or repetition for a specified time period. The termination condition may be a condition such as that the energy consumption, comfort, or predicted balance satisfies a specified condition.

[0113] If the termination condition has been satisfied, processing proceeds to step S160.

[0114] If the termination condition has not been satisfied, processing proceeds to step S130.

[0115] In step S160, the setting determination unit 215 determines one candidate as the setting value group pair to be set for the air conditioner pair 101 based on the predicted balance of each candidate.

[0116] Specifically, the setting determination unit 215 determines a candidate with a predicted balance closest to an ideal balance as the setting value group pair to be set for the air conditioner pair 101.

[0117] Fig. 10 indicates a relationship between the predicted balance of each candidate and the ideal balance. Each candidate point (filled circle or filled square) indicates the predicted balance of each candidate. An ideal point (filled triangle) indicates the ideal balance. The candidate point (filled square) has the shortest distance to the ideal point. Therefore, the candidate of the candidate point (filled square) is selected as the setting value group pair to be set for the air conditioner pair 101.

[0118] Note that the setting value group pair is selected from candidates that satisfy conditions for energy consumption and comfort that need to be satisfied.

[0119] Referring back to Fig. 4, step S170 will be described.

[0120] In step S170, the setting output unit 216 outputs the determined setting value group pair to the air conditioner pair 101. That is, the setting output unit 216 outputs the setting value group for the central air conditioner 110 to the central air conditioner 110, and outputs the setting value group for the multi-split type air conditioner 120 to the multi-split type air conditioner 120.

[0121] As a result, the setting value group pair is set for the air conditioner pair 101. The central air conditioner 110 and the multi-split type air conditioner 120 receive the respective setting value groups, and set the setting value groups.

*** Effects of Embodiment 1 ***

[0122] In the existing technology, a load distribution that minimizes power consumption is determined on condition that the temperature or humidity approaches a desired value, and setting values according to the determined load distribution are set.

[0123] In Embodiment 1, various candidates for setting values are explored through multi-objective optimization, including setting values that allow energy saving even if the temperature and humidity do not approach desired values. Then, setting values that result in a good balance between energy consumption and comfort are selected from the various candidates for setting values. That is, Embodiment 1 allows better setting values to be set.

[0124] In Embodiment 1, a state of a room that is usually difficult to measure is estimated based on the current measurement value, the current operating state, and the air conditioner model, and an optimal setting

value is calculated taking into consideration a transition of the state in a specified period. Therefore, Embodiment 1 can determine setting values for air conditioners more appropriately than the existing technology that uses only current measurement values. Embodiment 1 can determine setting values taking into consideration not only a momentary state of energy consumption after a change but also a transient increase in power consumption associated with the change together with a change in comfort.

[0125] Embodiment 1 has means for automatically extracting one candidate from generated candidates for setting values. Therefore, Embodiment 1 can automatically select ideal setting values under desired conditions, which are usually judged by humans. This allows for continuous control of air conditioners.

Embodiment 2.

[0126] With regard to an embodiment in which the multi-split type air conditioner 120 includes a plurality of indoor units 122, differences from Embodiment 1 will be mainly described based on Fig. 11.

*** Description of Configuration ***

[0127] Based on Fig. 11, a configuration of the air conditioning system 100 will be described.

[0128] In the air conditioning system 100, the multi-split type air conditioner 120 includes a plurality of indoor units 122. That is, the multi-split type air conditioner 120 includes two indoor units 122 or three or more indoor units 122.

[0129] The plurality of indoor units 122 are installed in the same air conditioning zone 109, and the indoor units 122 operate or stop individually.

*** Description of Operation ***

[0130] The procedure for the air conditioning control method is the same as the procedure in Embodiment 1.

[0131] However, in step S110 and step S130, the setting value group for the multi-split type air conditioner 120 in the setting value group pair includes a setting value indicating the number of operating indoor units. The number of operating indoor units is the number of the indoor units 122 that are operating.

*** Effects of Embodiment 2 ***

[0132] Embodiment 2 can optimize a change in the number of operating units. When a plurality of indoor units of a multi-split type air conditioner for a building are placed in the same air conditioning zone, Embodiment 2 can optimize the state (operating, stopped) of each of the indoor units individually.

[0133] For example, when changing the number of operating units can further reduce energy consumption

while maintaining the same indoor thermal environment (for example, when the load is low), Embodiment 2 can reduce energy consumption by changing the number of operating units.

Embodiment 3.

[0134] With regard to an embodiment in which information on the air conditioning zone 109 is utilized, differences from Embodiment 1 will be mainly described based on Figs. 12 and 13.

*** Description of Configuration ***

[0135] Based on Fig. 12, a configuration of the air conditioning control device 200 will be described.

[0136] The air conditioning control device 200 further includes an element called a data acquisition unit 221.

[0137] The air conditioning control program further causes a computer to function as the data acquisition unit 221.

*** Description of Operation ***

[0138] Based on Fig. 13, the air conditioning control method will be described.

[0139] In step S310, the data acquisition unit 211 acquires the zone environment data and the operation state data from the sensors 130.

[0140] The data acquisition unit 211 also acquires the current setting data from the air conditioner pair 101.

[0141] The data acquisition unit 221 further acquires zone information data.

[0142] The zone information data indicates at least one of information on the number of people in the air conditioning zone 109 and thermal information of the air conditioning zone 109.

[0143] The information on the number of people indicates the number of people present in the air conditioning zone 109. For example, the information on the number of people is acquired from an entry and exit control system. The information on the number of people may be acquired based on an image captured of the air conditioning zone 109. For example, a visible light camera is installed (on the ceiling) in the air conditioning zone 109, and captures an image of the air conditioning zone 109 and outputs the image. The data acquisition unit 211 acquires the image, and calculates the number of people by processing the image.

[0144] The thermal information indicates an amount of heat generated in the air conditioning zone 109, a wall temperature in the air conditioning zone 109, and so on. For example, a thermal camera is installed in the air conditioning zone 109 and measures the amount of heat generated, the wall temperature, and so on. The data acquisition unit 211 acquires the thermal information from the thermal camera.

[0145] In step S320, the state estimation unit 212

calculates one or more estimate values based on the zone environment data, the operation state data, and the zone information data.

[0146] After step S320, processing proceeds to step S140.

[0147] The processing in step S140 and the subsequent steps is as described in Embodiment 1.

*** Effects of Embodiment 3 ***

[0148] Embodiment 3 utilizes the number of people present in the room. For example, a count value of the number of people in the room obtained from an entry and exit control system, a count value of the number of people in the room obtained by processing an image from a visible light camera installed on the ceiling, a level of heat generated in the room or a wall temperature measured by a thermal camera, and so on are utilized. Then, Embodiment 3 estimates a state of the air conditioning zone (room state).

[0149] This allows Embodiment 3 to improve the accuracy of estimation of a room state.

Embodiment 4.

[0150] With regard to an embodiment in which an alternative model 293 that replaces the balance prediction model 292 is used, differences from Embodiment 1 will be mainly described based on Figs. 14 to 16.

*** Description of Configuration ***

[0151] Based on Fig. 14, a configuration of the air conditioning control device 200 will be described.

[0152] The air conditioning control device 200 further includes an element called a model learning unit 222.

[0153] The air conditioning control program further causes a computer to function as the model learning unit 222.

[0154] The alternative model 293 is a model that replaces the balance prediction model 292. For example, the alternative model 293 is a learned model obtained by machine learning.

*** Description of Operation ***

[0155] Based on Fig. 15, a model learning unit process will be described. The model learning process is a process to generate the alternative model 293 and is executed by the model learning unit 222.

[0156] In step S401, the model learning unit 222 generates training environment data, training state data, and training setting data based on learning conditions.

[0157] The training environment data is data that is equivalent to the zone environment data.

[0158] The training state data is data that is equivalent to the operation state data.

[0159] The training setting data is data that is equivalent to the current setting data.

lent to the current setting data.

[0160] Specific examples of a learning condition are a range of setting values, a range of state values, the number of samples, a sample interval, weather data, and a learning target date.

[0161] In step S402, the model learning unit 222 calculates an estimate value of each of one or more types of states of the air conditioning zone 109 based on the training environment data and the training state data. The calculation method is the same as the method in step S120 in Embodiment 1.

[0162] Data indicating one or more calculated estimate values will be referred to as training estimate data. The training estimate data is equivalent to the zone estimate data.

[0163] In step S403, the model learning unit 222 generates one or more candidates for the setting value group pair for the air conditioner pair 101 based on the training setting data. The generation method is the same as the method in step S130 in Embodiment 1. However, a candidate that is generated satisfies the learning conditions.

[0164] A generated candidate will be referred to as a training candidate.

[0165] In step S404, for each generated candidate, the model learning unit 222 calculates a predicted balance in a case where the setting value group pair is set for the air conditioner pair 101, based on the one or more calculated estimate values. The calculation method is the same as the method in step S140 in Embodiment 1.

[0166] The calculated predicted balance will be referred to a training balance.

[0167] In step S405, the model learning unit 222 stores the training candidate, the training estimate data, and the training balance as training data.

[0168] In step S406, the model learning unit 222 determines whether a termination condition for acquirement of training data has been satisfied.

[0169] If the termination condition has been satisfied, processing proceeds to step S407.

[0170] If the termination condition has not been satisfied, processing proceeds to step S403.

[0171] In step S407, the model learning unit 222 generates the alternative model 293 by leaning the training data.

[0172] Based on Fig. 16, the air conditioning control method will be described.

[0173] Step S110 to step S130 are as described in Embodiment 1.

[0174] After step S130, processing proceeds to step S440.

[0175] In step S440, for each generated candidate, the balance prediction unit 214 calculates a predicted balance in a case where the setting value group pair is set for the air conditioner pair 101, based on the one or more calculated estimate values.

[0176] Specifically, the balance prediction unit 214 calculates the alternative model 293 using as input the

zone estimate data and the setting value group pair. As a result, the predicted balance is obtained.

[0177] After step S440, processing proceeds to step S150.

5 **[0178]** Step S150 to step S170 are as described in Embodiment 1.

*** Effects of Embodiment 4 ***

10 **[0179]** Embodiment 4 uses the alternative model to speed up prediction calculation. Embodiment 4 learns an input and output relationship of an air conditioner model using a machine learning model or the like while an air conditioner is operating, and uses a learning result to predict energy consumption and comfort.

15 **[0180]** This allows Embodiment 4 to speed up prediction that would take time if the air conditioner model is used.

20 Embodiment 5.

[0181] With regard to an embodiment in which air quality in the air conditioning zone 109 is taken into consideration, differences from Embodiment 1 will be mainly described based on Figs. 17 and 18.

*** Description of Configuration ***

30 **[0182]** The configuration of the air conditioning system 100 is the same as the configuration in Embodiment 1. However, the sensors 130 include an air quality sensor installed in the air conditioning zone 109.

35 **[0183]** The air quality sensor is a sensor that measures air quality. Specific examples of air quality include a carbon dioxide concentration and a particle count. The particle count is the number of particles such as PM10 or PM2.5

[0184] Based on Fig. 17, a configuration of the air conditioning control device 200 will be described.

40 **[0185]** The air conditioning control device 200 further includes a data acquisition unit 223.

[0186] The air conditioning control program further causes a computer to function as the data acquisition unit 223.

45 *** Description of Operation ***

[0187] Based on Fig. 18, the air conditioning control method will be described.

50 **[0188]** In step S510, the data acquisition unit 211 acquires the zone environment data and the operation state data from the sensors 130.

[0189] The data acquisition unit 211 also acquires the current setting data from the air conditioner pair 101.

55 **[0190]** The data acquisition unit 223 further acquires air quality data from the sensors 130.

[0191] The air quality data indicates the air quality in the air conditioning zone 109.

[0192] After step S510, processing proceeds to step S120.

[0193] In step S120, the state estimation unit 212 calculates one or more estimate values based on the zone environment data and the operation state data.

[0194] In step S130, the candidate generation unit 213 generates one or more candidates for the setting value group pair based on the current setting data.

[0195] After step S130, processing proceeds to step S540.

[0196] In step S540, the balance prediction unit 214 calculates a predicted balance for each generated candidate, based on the one or more estimate values and the air quality data.

[0197] Specifically, the balance prediction unit 214 calculates the balance prediction model 292 using as input the zone estimate data, the air quality data, and the setting value group pair. As a result, the predicted balance is obtained.

[0198] The predicted balance is predicted energy consumption, predicted comfort, and predicted air quality.

[0199] After step S540, processing proceeds to step S150.

[0200] Step S150 and the subsequent steps are as described in Embodiment 1.

*** Effects of Embodiment 5 ***

[0201] Embodiment 5 performs optimization taking air quality into consideration. Embodiment 5 explores setting values by three-objective optimization for the energy consumption, the indoor thermal environment, and the air quality environment. As air quality, a CO₂ concentration, a PM₁₀ particle count, a PM_{2.5} particle count, or the like is measured and used.

[0202] As a result, Embodiment 5 makes it possible to derive setting values that result in a good thermal environment and a good air quality environment.

Embodiment 6.

[0203] With regard to an embodiment that takes into consideration a required amount of ventilation, differences from Embodiment 5 will be mainly described based on Figs. 19 and 20.

*** Description of Configuration ***

[0204] Based on Fig. 19, a configuration of the air conditioning control device 200 will be described.

[0205] The air conditioning control device 200 further includes an element called a ventilation amount calculation unit 224.

[0206] The air conditioning control program further causes a computer to function as the ventilation amount calculation unit 224.

*** Description of Operation ***

[0207] Based on Fig. 24, the air conditioning control method will be described.

5 **[0208]** In step S510, the data acquisition unit 211 acquires the zone environment data and the operation state data.

[0209] The data acquisition unit 211 also acquires the current setting data.

10 **[0210]** The data acquisition unit 223 further acquires the air quality data.

[0211] After step S510, processing proceeds to step S610.

15 **[0212]** In step S610, the ventilation amount calculation unit 224 calculates a required amount of ventilation based on the air quality data.

[0213] The required amount of ventilation is the amount of ventilation necessary to make the air quality environment of the air conditioning zone 109 an ideal environment.

[0214] After step S610, processing proceeds to step S120.

25 **[0215]** In step S120, the state estimation unit 212 calculates one or more estimate values based on the zone environment data and the operation state data.

[0216] After step S120, processing proceeds to step S630.

30 **[0217]** In step S630, the candidate generation unit 213 generates one or more candidates based on the current setting data, on condition that an amount of ventilation that is equal to or greater than the required amount of ventilation is secured in the air conditioning zone 109 when each candidate is set as the air conditioner pair.

35 **[0218]** For example, in each candidate, the amount of ventilation calculated based on a setting value related to the amount of ventilation is equal to or greater than the required amount of ventilation.

[0219] After step S630, processing proceeds to step S540.

40 **[0220]** Step S540 and the subsequent steps are as described in Embodiment 5.

*** Effects of Embodiment 6 ***

45 **[0221]** Embodiment 6 calculates the required amount of ventilation. Embodiment 6 calculates the required amount of ventilation for the measured air quality, and obtains setting values that improve energy consumption and result in a good indoor thermal environment within a range in which the required amount of ventilation is secured.

55 **[0222]** As a result, Embodiment 6 allows for energy saving and comfortable operation of air conditioners while satisfying the minimum requirements for good air quality.

Embodiment 7.

[0223] With regard to an embodiment in which a questionnaire result on comfort is taken into consideration, differences from Embodiment 1 will be mainly described based on Figs. 21 to 23.

*** Description of Configuration ***

[0224] Based on Fig. 21, a configuration of the air conditioning control device 200 will be described.

[0225] The air conditioning control device 200 further includes an element called a questionnaire result acquisition unit 225.

[0226] The air conditioning control program further causes a computer to function as the questionnaire result acquisition unit 225.

*** Description of Operation ***

[0227] Based on Fig. 22, the air conditioning control method will be described.

[0228] In step S710, the data acquisition unit 211 acquires the zone environment data and the operation state data from the sensors 130.

[0229] The data acquisition unit 211 also acquires the current setting data from the air conditioner pair 101.

[0230] The questionnaire result acquisition unit 225 further acquires questionnaire result data. For example, the questionnaire result data is input into the air conditioning control device 200. Then, the questionnaire result acquisition unit 225 accepts the input questionnaire result data.

[0231] The questionnaire result data indicates a questionnaire result on comfort. The questionnaire result is obtained from occupants of the room of the air conditioning zone 109, for example.

[0232] After step S710, processing proceeds to step S120.

[0233] Step S120 to step S150 are as described in Embodiment 1.

[0234] After step S150, processing proceeds to step S760.

[0235] In step S760, the setting determination unit 215 determines one candidate as the setting value group pair to be set for the air conditioner pair 101 based on the questionnaire result data and the predicted balance of each candidate.

[0236] Specifically, the setting determination unit 215 determines the ideal balance based on the questionnaire result data. Then, the setting determination unit 215 selects one candidate as the setting value group pair by the same method as the method in step S160 in Embodiment 1.

[0237] Fig. 23 indicates how the ideal balance (ideal point) is changed based on a questionnaire result.

[0238] For example, it is assumed that a candidate corresponding to an indoor environment that is neither

warm nor cold during cooling is selected. As a result of a questionnaire of occupants, it is found out that it is more comfortable for the occupants if the room is not too cold and the room temperature is not too low. In this case, the ideal point is changed to the side that would normally reduce comfort (warmer side). When the ideal point is changed, a selected candidate changes.

*** Effects of Embodiment 7 ***

[0239] In Embodiment 7, a questionnaire result is reflected. That is, Embodiment 7 extracts setting values so that a result of a questionnaire of occupants of the room is reflected. In order to extract setting values, Embodiment 7 changes the ideal balance that has been set, based on the result of the questionnaire. For example, Embodiment 7 moves the ideal point to the side that is deemed comfortable in the result of the questionnaire.

[0240] As a result, Embodiment 7 makes it possible to extract good setting values taking into further consideration comfort of actual occupants.

Embodiment 8.

[0241] With regard to an embodiment in which the characteristics of each air conditioner are taken into consideration, differences from Embodiment 1 will be mainly described based on Figs. 24 and 25.

*** Description of Configuration ***

[0242] The configuration of the air conditioning system 100 is the same as the configuration in Embodiment 1.

*** Description of Operation ***

[0243] Based on Fig. 24, the air conditioning control method will be described.

[0244] Step S110 and step S120 are as described in Embodiment 1.

[0245] After step S120, processing proceeds to step S830.

[0246] In step S830, the candidate generation unit 213 determines a limit range of setting values for the central air conditioner 110 and a limit range of setting values for the multi-split type air conditioner 120 according to the characteristics of the central air conditioner 110 and the multi-split type air conditioner 120. The limit range is a range of values that a setting value can take.

[0247] Then, the candidate generation unit 213 generates one or more candidates for each air conditioner, based on the current setting data and the limit range. In each candidate, each setting value is a value included in the limit range.

[0248] For example, it is assumed that the overall energy consumption in a multi-split type air conditioner for a building can be reduced by processing sensible heat. It is also assumed that the overall energy consump-

tion in a central air conditioner can be reduced by processing latent heat. In this case, in the multi-split type air conditioner for the building, a setting value of the evaporation temperature is limited to a high range so that latent heat is processed. In the central air conditioner, a setting value of the heat source outlet temperature is limited to a low range so that latent heat is processed. Then, candidates for each setting value is generated in the limited range.

[0249] Fig. 25 indicates an upper limit value of temperature settings. The upper limit value is a value obtained by taking efficiency into consideration, and indicates the upper limit of the limit range of temperature settings. Setting values of the temperature are lower than the upper limit value.

*** Effects of Embodiment 8 ***

[0250] Embodiment 8 takes into consideration the characteristics of each air conditioner. Embodiment 8 limits the range of setting values according to the characteristics of each air conditioner, and optimizes setting values within the limited range.

[0251] As a result, Embodiment 8 can efficiently explore more appropriate setting values and shorten the time required for optimization.

Embodiment 9.

[0252] With regard to an embodiment in which air in each of a plurality of air conditioning zones 109 is conditioned, differences from Embodiment 1 will be mainly described based on Figs. 26 to 28.

*** Description of Configuration ***

[0253] Based on Fig. 26, a configuration of the air conditioning system 100 will be described.

[0254] The air conditioning system 100 is a system that conditions air in each of the plurality of air conditioning zones 109.

[0255] In the air conditioning system 100, the multi-split type air conditioner 120 includes a plurality of indoor units 122.

[0256] The plurality of indoor units 122 are used for air conditioning in the air conditioning zones 109 that are mutually different.

*** Description of Operation ***

[0257] Based on Fig. 27, the air conditioning control method will be described.

[0258] In step S910, the data acquisition unit 211 acquires the zone environment data and the operation state data from the sensors 130. The data acquisition unit 211 also acquires the current setting data from the air conditioner pair 101.

[0259] Note that the zone environment data is acquired

individually for each of the air conditioning zones 109.

[0260] In step S920, the state estimation unit 212 calculates an estimate value of each of one or more types of states of the air conditioning zone 109 based on the zone environment data and the operation state data.

[0261] Note that one or more estimate values are calculated individually for each of the air conditioning zones 109.

[0262] In step S930, the candidate generation unit 213 generates one or more candidates for the setting value group pair for the air conditioner pair 101 based on the current setting data.

[0263] Note that one or more candidates are generated on condition that power consumption is small and comfort is good in all the air conditioning zones 109.

[0264] In step S940, for each generated candidate, the balance prediction unit 214 calculates a predicted balance in a case where the setting value group pair is set for the air conditioner pair 101, based on the one or more estimate values of each of the air conditioning zones 109.

[0265] Note that the predicted balance includes comfort of each of the air conditioning zones 109.

[0266] After step S940, processing proceeds to step S150.

[0267] Step S150 and the subsequent steps are as described in Embodiment 1.

[0268] Fig. 28 indicates a relationship between the predicted balance of each candidate and the ideal balance in a case where there are two air conditioning zones 109.

[0269] When there are a first air conditioning zone 109 and a second air conditioning zone 109, a candidate of a candidate point closest to the ideal balance (ideal point) is selected from candidates arranged in three dimensions.

*** Effects of Embodiment 9 ***

[0270] Embodiment 9 can support a plurality of air conditioning zones. In Embodiment 9, when there are two air conditioning zones, the following are predicted: (a) energy consumption of the entire air conditioner, (b) the indoor environment of the first air conditioning zone, and (c) the indoor environment of the second air conditioning zone. Then, Embodiment 9 explores setting values so as to improve all of (a) to (c).

[0271] As a result, in a system that supplies air to a plurality of air conditioning zones, it is possible to calculate setting values that optimize the overall energy consumption of a plurality of air conditioners and the indoor environment of each air conditioning zone.

*** Supplement to the Embodiments ***

[0272] Based on Fig. 29, a hardware configuration of the air conditioning control device 200 will be described.

[0273] The air conditioning control device 200 includes processing circuitry 209.

[0274] The processing circuitry 209 is hardware that

realizes the data acquisition unit 211, the state estimation unit 212, the candidate generation unit 213, the balance prediction unit 214, the setting determination unit 215, and the setting output unit 216. Further, the processing circuitry 209 realizes the data acquisition unit 221, the model learning unit 222, the data acquisition unit 223, the ventilation amount calculation unit 224, and the questionnaire result acquisition unit 225.

[0275] The processing circuitry 209 may be dedicated hardware, or may be the processor 201 that executes programs stored in the memory 202.

[0276] When the processing circuitry 209 is dedicated hardware, the processing circuitry 209 is, for example, a single circuit, a composite circuit, a programmed processor, a parallel-programmed processor, an ASIC, an FPGA, or a combination of these.

[0277] ASIC is an abbreviation for application specific integrated circuit.

[0278] FPGA is an abbreviation for field programmable gate array.

[0279] The air conditioning control device 200 may include a plurality of processing circuits as an alternative to the processing circuitry 209.

[0280] In the processing circuitry 209, some functions may be realized by dedicated hardware and the remaining functions may be realized by software or firmware.

[0281] As described above, the functions of the air conditioning control device 200 can be realized by hardware, software, firmware, or a combination of these.

[0282] Each of the embodiments is an example of a preferred embodiment, and is not intended to limit the technical scope of the present disclosure. Each of the embodiments may be partially implemented or may be implemented in combination with another embodiment. The procedures described using flowcharts or the like may be suitably changed.

[0283] Each "unit" that is an element of the air conditioning control device 200 may be interpreted as "process", "step", "circuit", or "circuitry".

Reference Signs List

[0284] 100: air conditioning system, 101: air conditioner pair, 109: air conditioning zone, 110: central air conditioner, 111: heat source unit, 112: outdoor air handling unit, 120: multi-split type air conditioner, 121: outdoor unit, 122: indoor unit, 130: sensors, 200: air conditioning control device, 201: processor, 202: memory, 203: auxiliary storage device, 204: communication device, 205: input/output interface, 209: processing circuitry, 211: data acquisition unit, 212: state estimation unit, 213: candidate generation unit, 214: balance prediction unit, 215: setting determination unit, 216: setting output unit, 221: data acquisition unit, 222: model learning unit, 223: data acquisition unit, 224: ventilation amount calculation unit, 225: questionnaire result acquisition unit, 290: storage unit, 291: zone estimation model, 292: balance prediction model, 293: alternative model.

Claims

1. An air conditioning control device comprising:

a state estimation unit to calculate an estimate value based on zone environment data that indicates a measurement value of each of one or more types of states of an air conditioning zone in which an air conditioner pair composed of two types of air conditioners is used and operation state data that indicates a state value of each of one or more types of states for each of the air conditioners, the estimate value being an estimate value of each of one or more types of states of the air conditioning zone different from the one or more types of states in the zone environment data;
a candidate generation unit to generate one or more candidates for a setting value group pair for the air conditioner pair based on current setting data that indicates a setting value group pair that is set for the air conditioner pair;
a balance prediction unit to calculate, as a predicted balance, predicted power consumption and predicted comfort in a case where the setting value group pair is set for the air conditioner pair, based on one or more estimate values that have been calculated, for each generated candidate; and
a setting determination unit to determine one candidate as a setting value group pair to be set for the air conditioner pair based on the predicted balance of each candidate.

2. The air conditioning control device according to claim 1,

wherein one air conditioner of the air conditioner pair is a multi-split type air conditioner including a plurality of indoor units, and
wherein a setting value group for the multi-split type air conditioner of the setting value group pair includes a setting value indicating the number of operating indoor units.

3. The air conditioning control device according to claim 1 or claim 2,

wherein the state estimation unit calculates the one or more estimate values based on zone information data, the zone environment data, and the operation state data, and
wherein the zone information data indicates at least one of information on the number of people in the air conditioning zone and thermal information of the air conditioning zone.

4. The air conditioning control device according to any

one of claim 1 to claim 3, further comprising

a model learning unit,
 wherein the model learning unit generates training environment data equivalent to the zone environment data and training state data equivalent to the operation state data, calculates training estimate data equivalent to the one or more estimate values based on the training environment data and the training state data, generates training setting data equivalent to the current setting data, generates one or more training candidates equivalent to the one or more candidates based on the training setting data, calculates a training balance equivalent to the predicted balance in a case where the training candidate is set for the air conditioner pair, based on the training estimate data, for each training candidate, and generates an alternative model for each training candidate by learning the training candidate, the training estimate data, and the training balance, and
 wherein the balance prediction unit calculates the predicted balance for each candidate by calculating the alternative model using as input the one or more estimate values and the candidate.

5. The air conditioning control device according to any one of claim 1 to claim 4,
 wherein based on air quality data that indicates air quality in the air conditioning zone and the one or more estimate values, the balance prediction unit calculates, as the predicted balance, predicted air quality, the predicted energy consumption, and the predicted comfort.

6. The air conditioning control device according to claim 5, further comprising

a ventilation amount calculation unit,
 wherein the ventilation amount calculation unit calculates a required amount of ventilation based on the air quality data, and
 wherein the candidate generation unit generates the one or more candidates based on the current setting data on condition that when each candidate is set for the air conditioner pair, an amount of ventilation equal to or greater than the required amount of ventilation is secured in the air conditioning zone.

7. The air conditioning control device according to any one of claim 1 to claim 6,
 wherein the setting determination unit determines an ideal balance based on questionnaire result data that indicates a result of a questionnaire on comfort, and determines the setting value group pair based on the

ideal balance and the predicted balance of each candidate.

8. The air conditioning control device according to any one of claim 1 to claim 7,
 wherein for each air conditioner of the air conditioners, the candidate generation unit generates a candidate for a setting value for the air conditioner within a limit range determined according to a characteristic of the air conditioner.

9. The air conditioning control device according to any one of claim 1 to claim 8,

wherein there are a plurality of the air conditioning zones,
 wherein the state estimation unit calculates the one or more estimate values for each of the air conditioning zones, and
 wherein the balance prediction unit calculates, as the predicted balance, the predicted energy consumption and the predicted comfort of each of the air conditioning zones based on the one or more estimate values of each of the air conditioning zones.

10. An air conditioning control method comprising:

calculating an estimate value based on zone environment data that indicates a measurement value of each of one or more types of states of an air conditioning zone in which an air conditioner pair composed of two types of air conditioners is used and operation state data that indicates a state value of each of one or more types of states for each of the air conditioners, the estimate value being an estimate value of each of one or more types of states of the air conditioning zone different from the one or more types of states in the zone environment data;
 generating one or more candidates for a setting value group pair for the air conditioner pair based on current setting data that indicates a setting value group pair that is set for the air conditioner pair;
 calculating, as a predicted balance, predicted power consumption and predicted comfort in a case where the setting value group pair is set for the air conditioner pair, based on one or more estimate values that have been calculated, for each generated candidate; and
 determining one candidate as a setting value group pair to be set for the air conditioner pair based on the predicted balance of each candidate.

11. An air conditioning control program to cause a computer to execute:

a state estimation process of calculating estimate value based on zone environment data that indicates a measurement value of each of one or more types of states of an air conditioning zone in which an air conditioner pair composed of two types of air conditioners is used and operation state data that indicates a state value of each of one or more types of states for each of the air conditioners, the estimate value being an estimate value of each of one or more types of states of the air conditioning zone different from the one or more types of states in the zone environment data;

a candidate generation process of generating one or more candidates for a setting value group pair for the air conditioner pair based on current setting data that indicates a setting value group pair that is set for the air conditioner pair;

a balance prediction process of calculating, as a predicted balance, predicted power consumption and predicted comfort in a case where the setting value group pair is set for the air conditioner pair, based on one or more estimate values that have been calculated, for each generated candidate; and

a setting determination process of determining one candidate as a setting value group pair to be set for the air conditioner pair based on the predicted balance of each candidate.

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Fig. 1

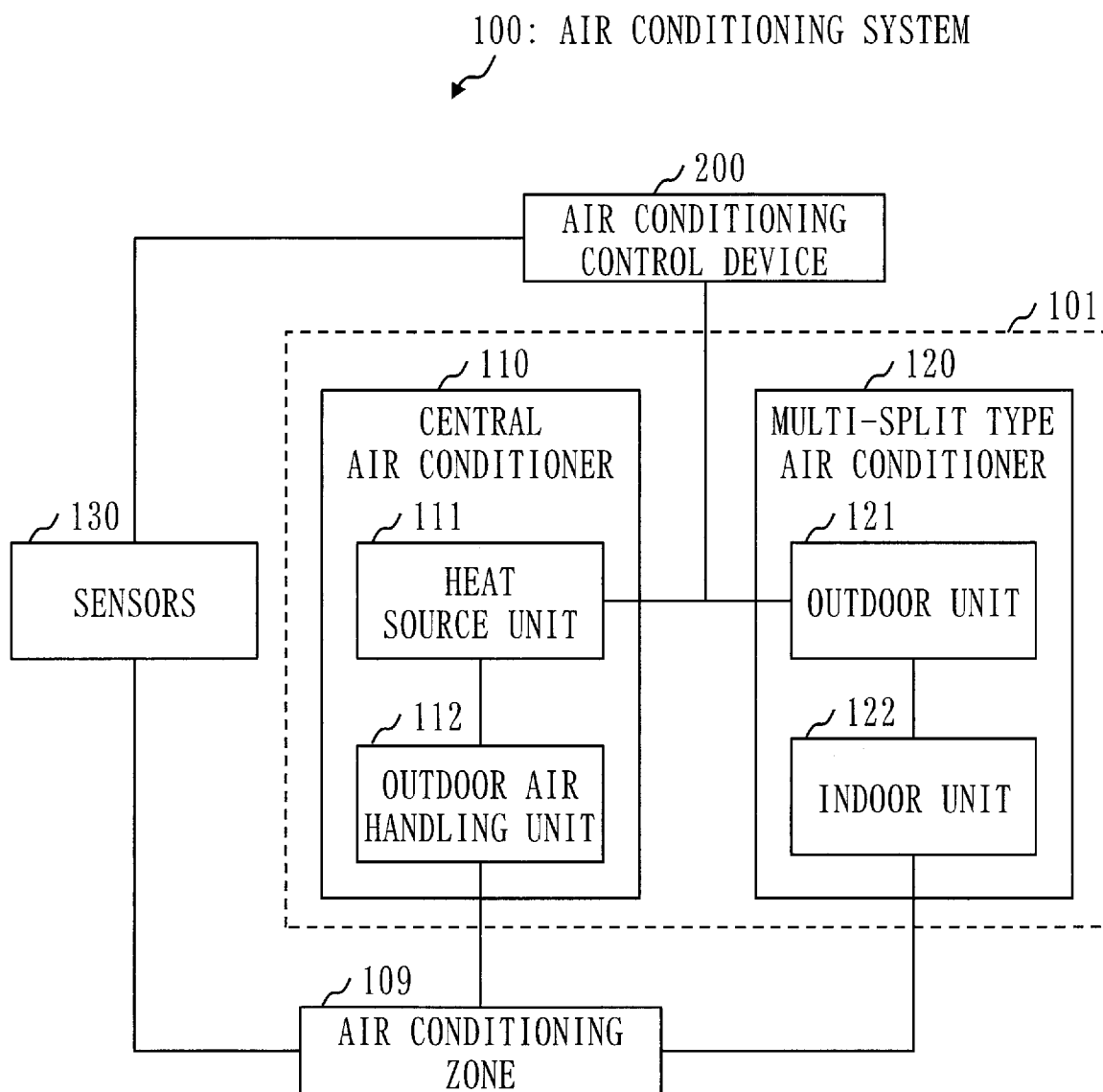


Fig. 2

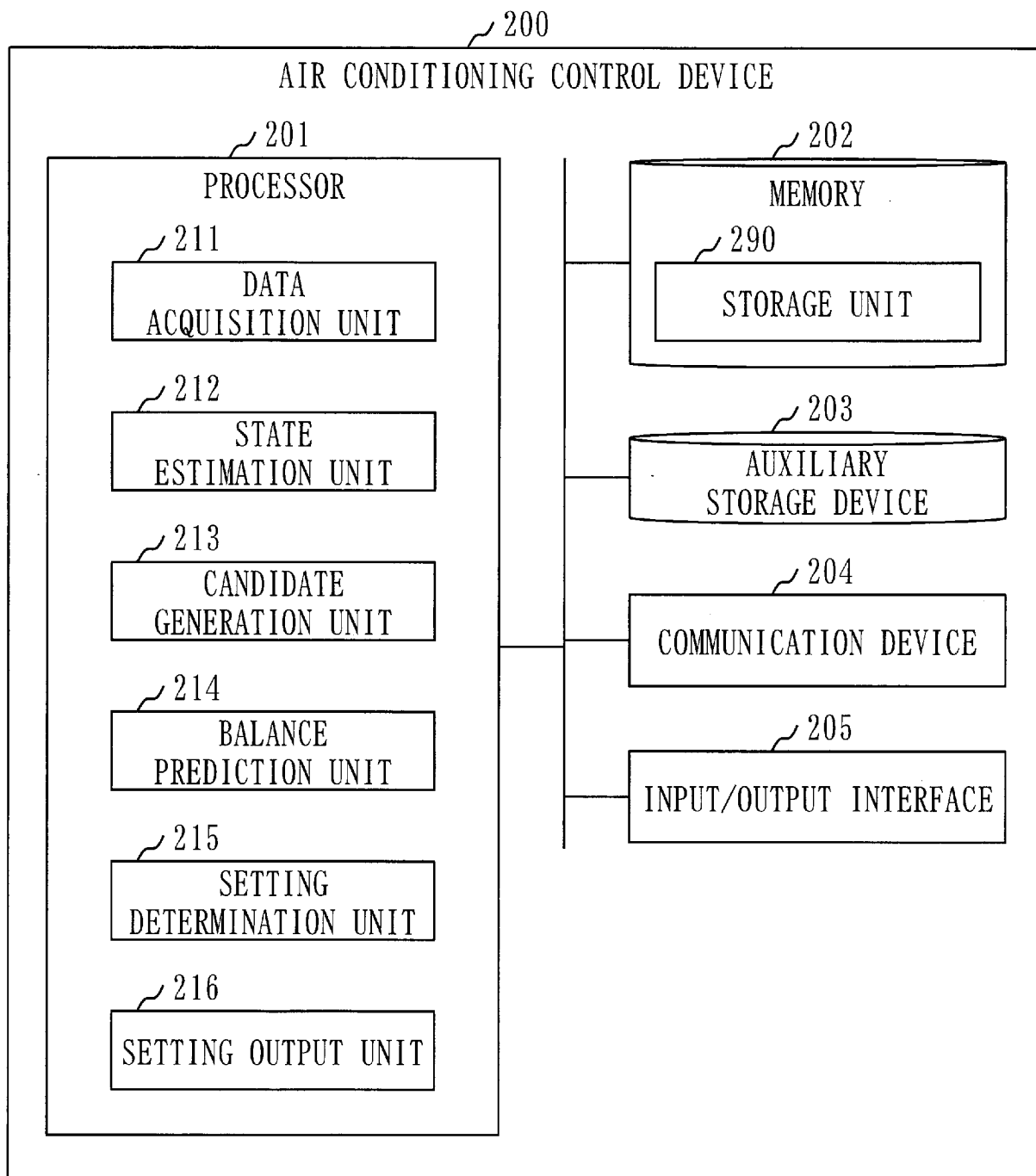


Fig. 3

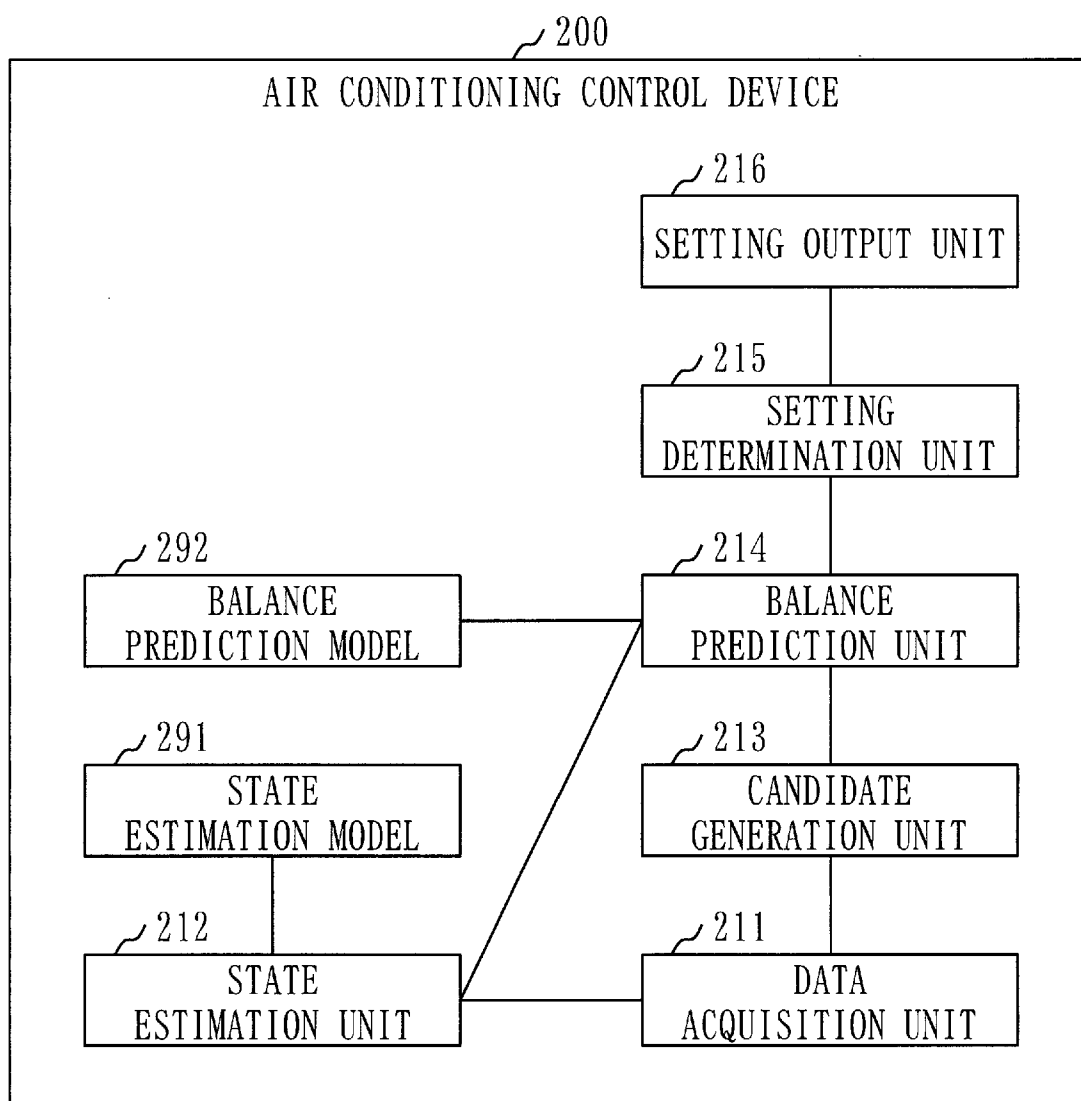


Fig. 4

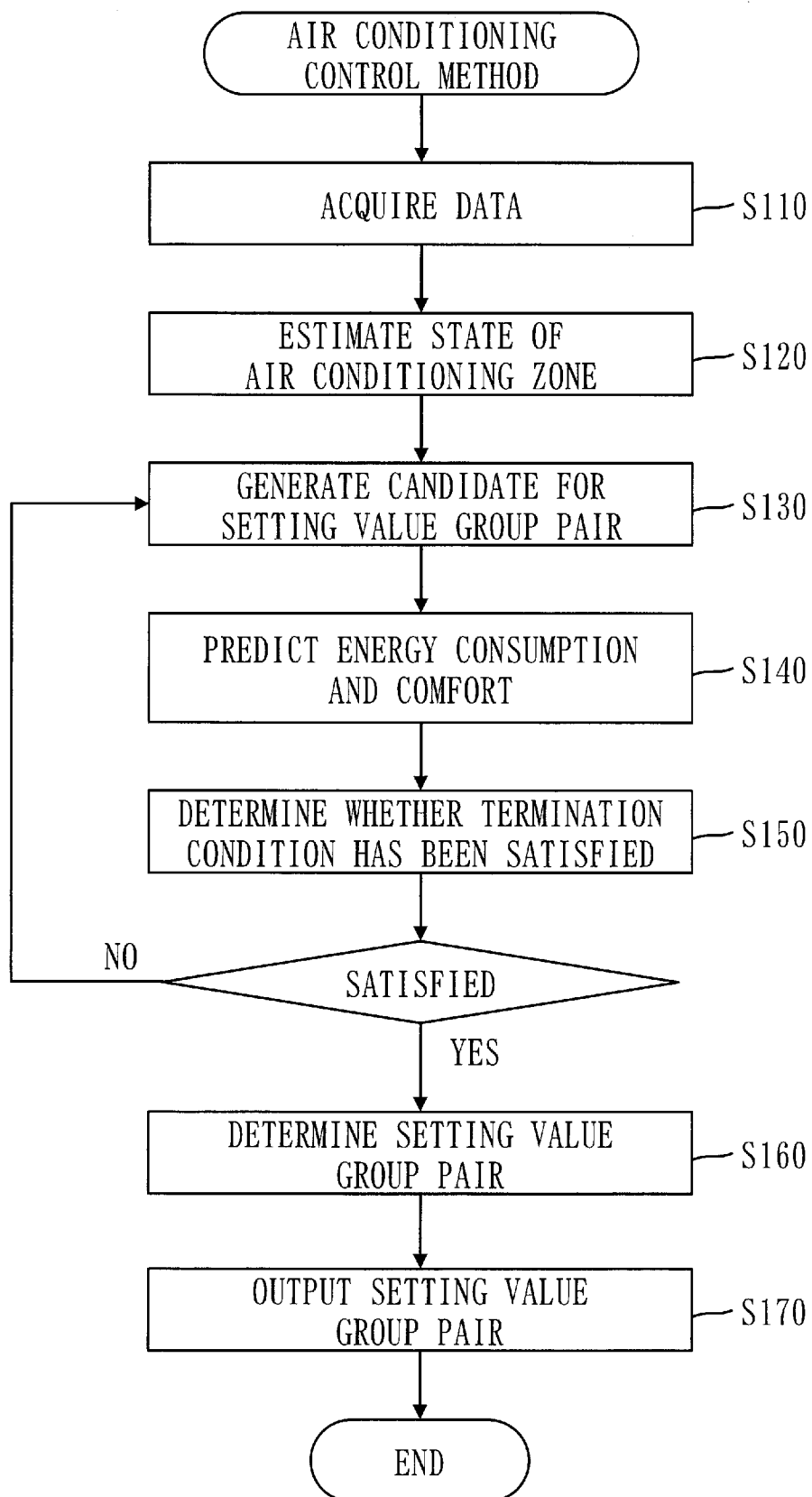


Fig. 5

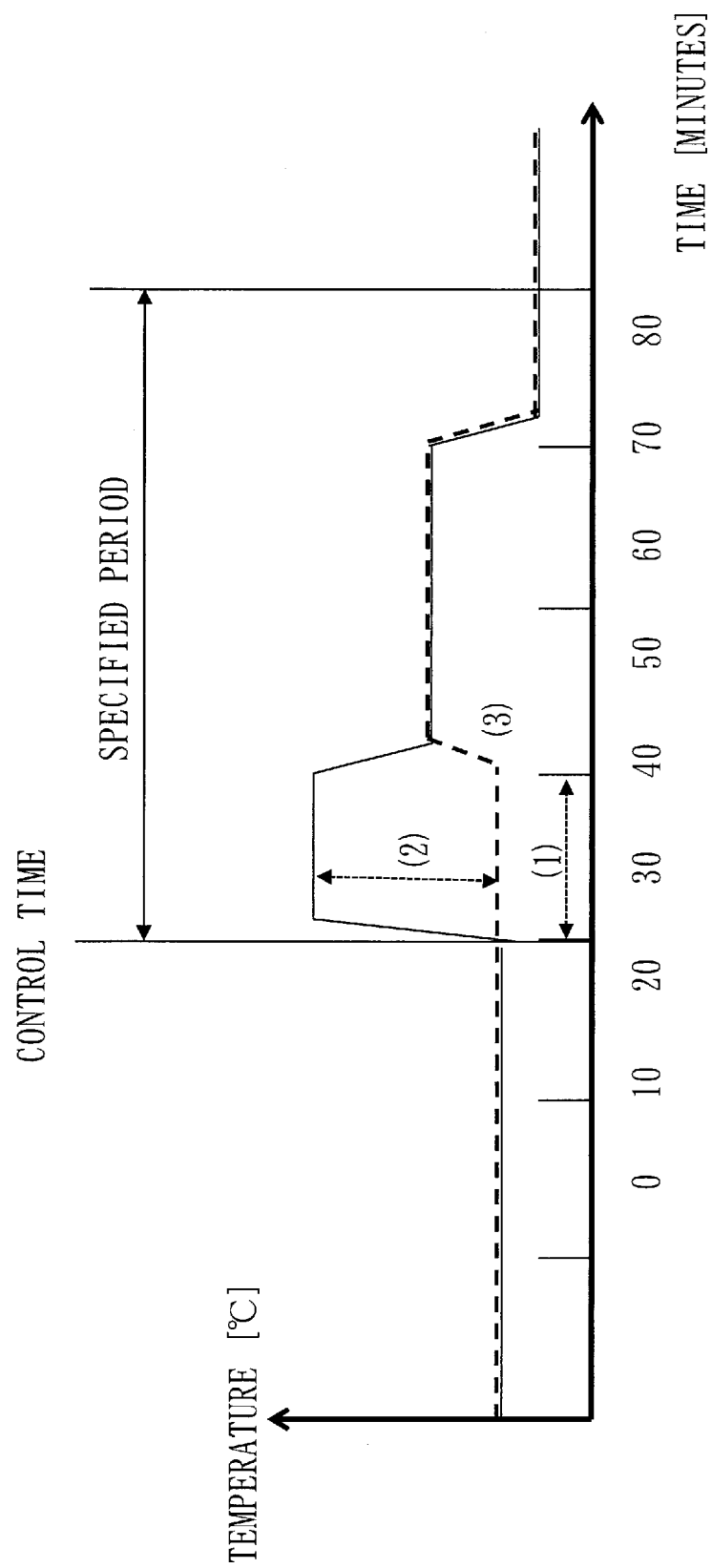


Fig. 6

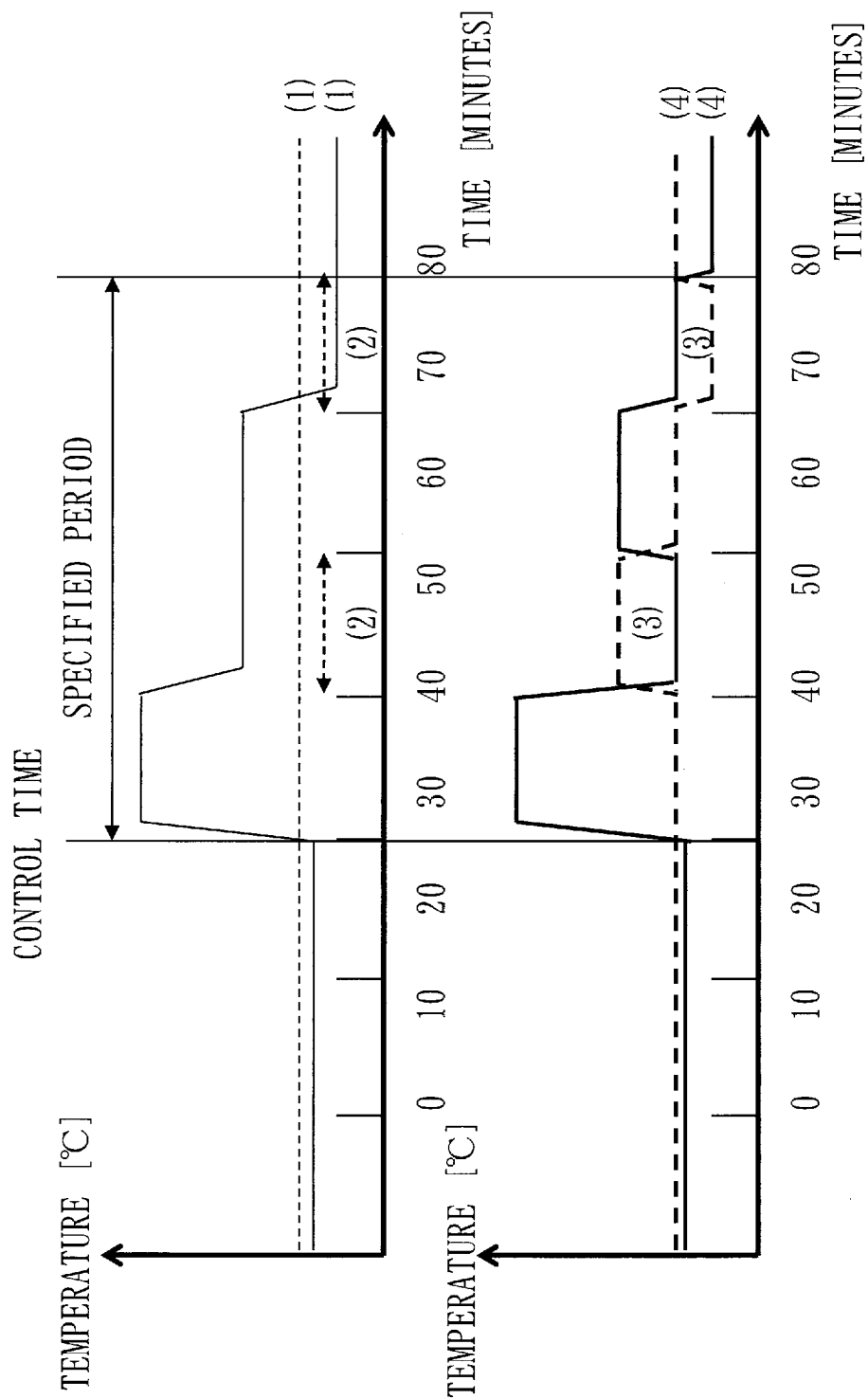


Fig. 7

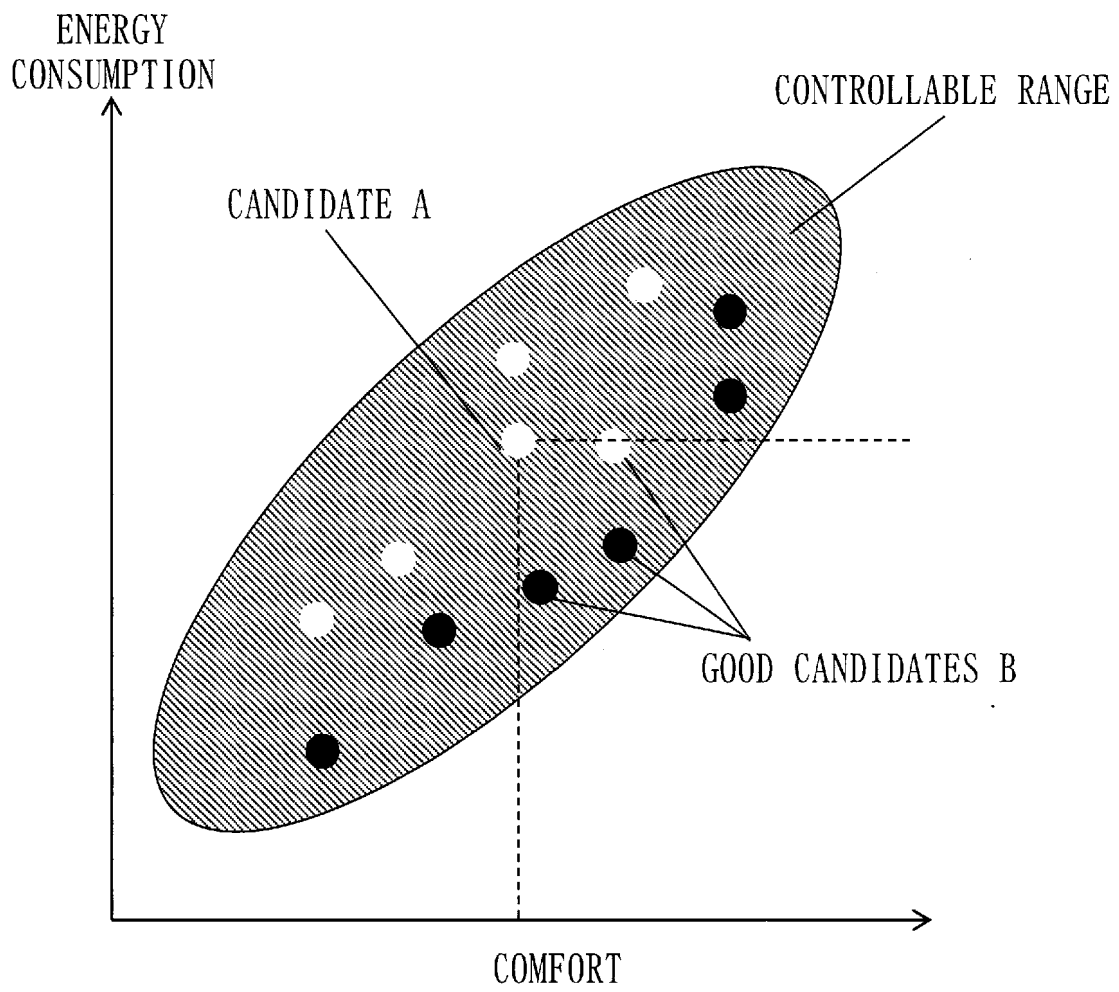


Fig. 8

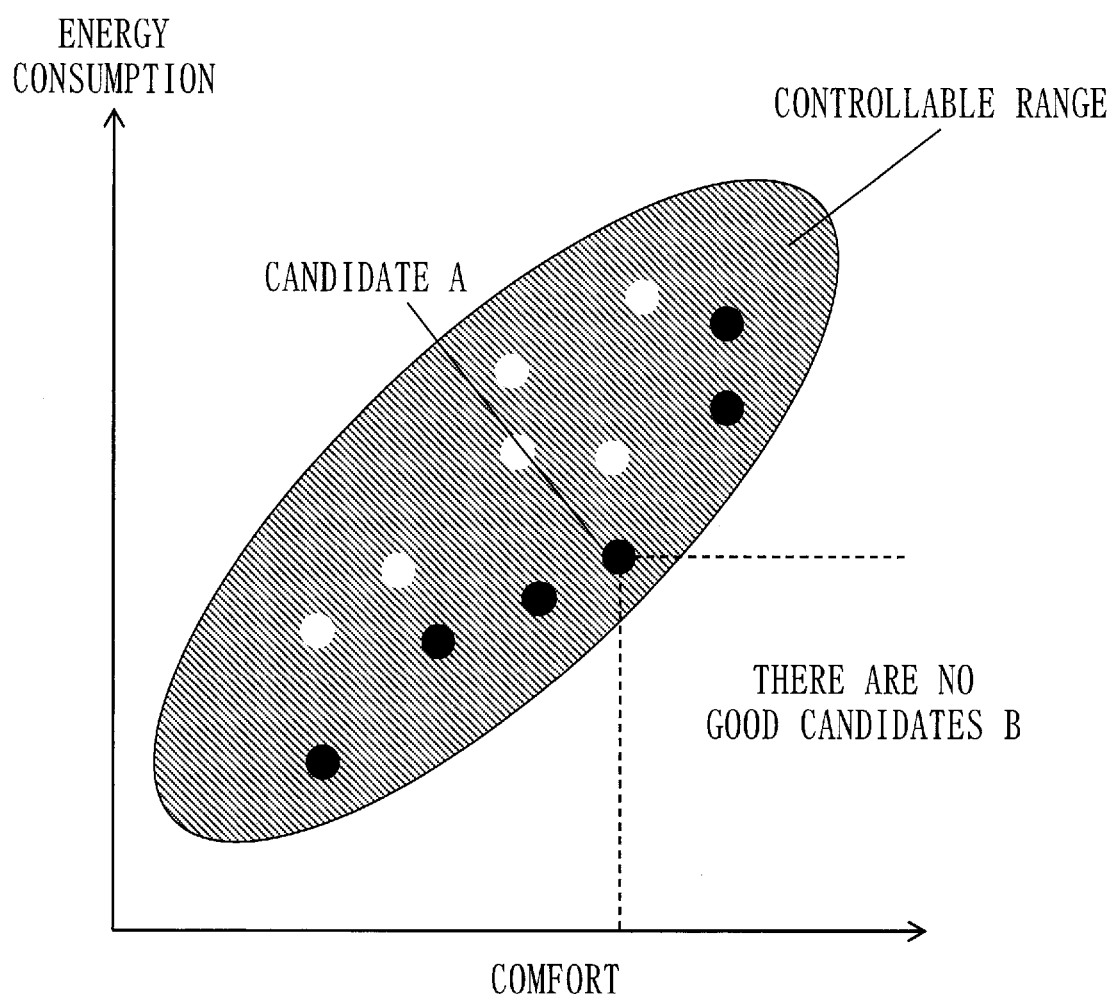


Fig. 9

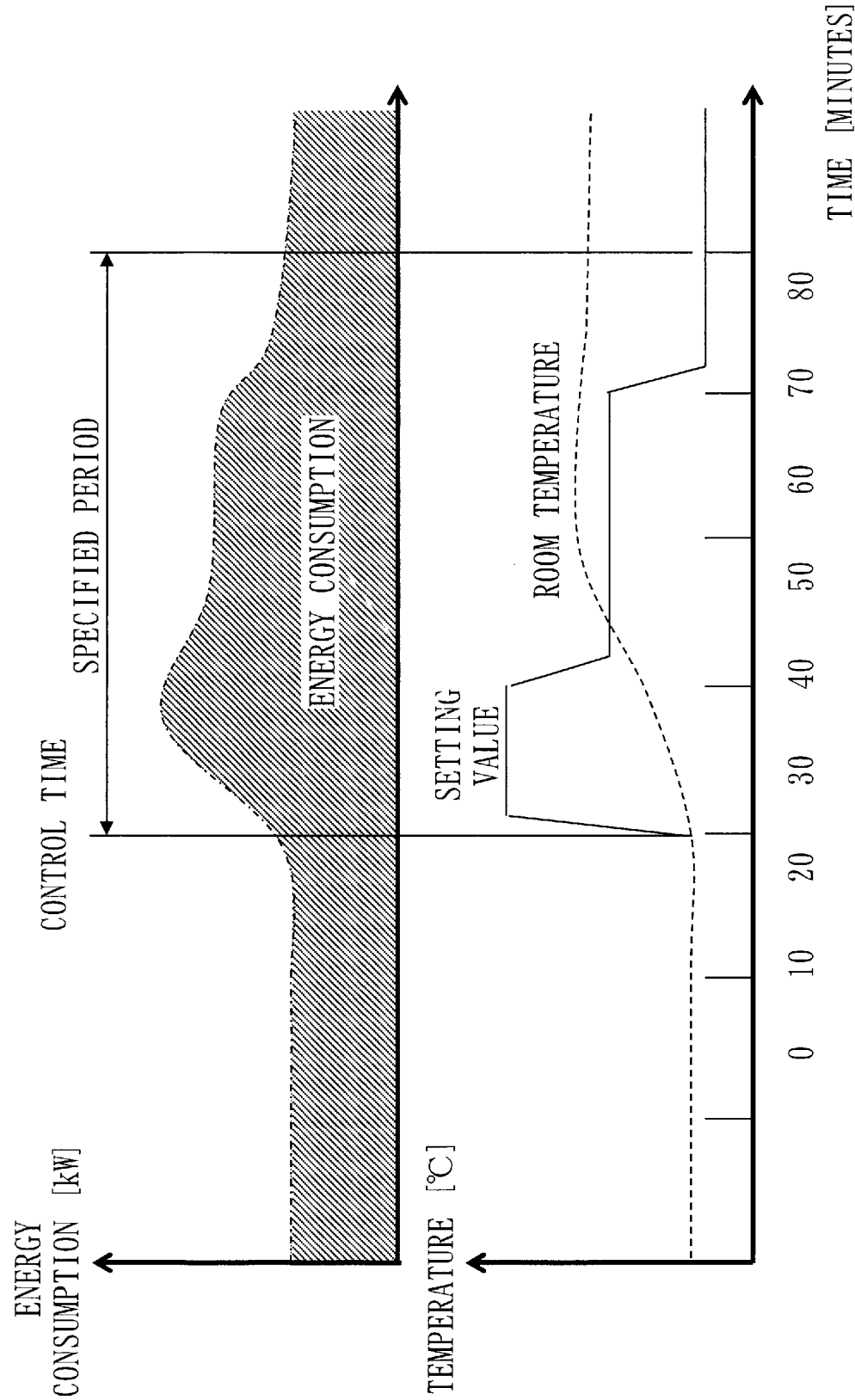


Fig. 10

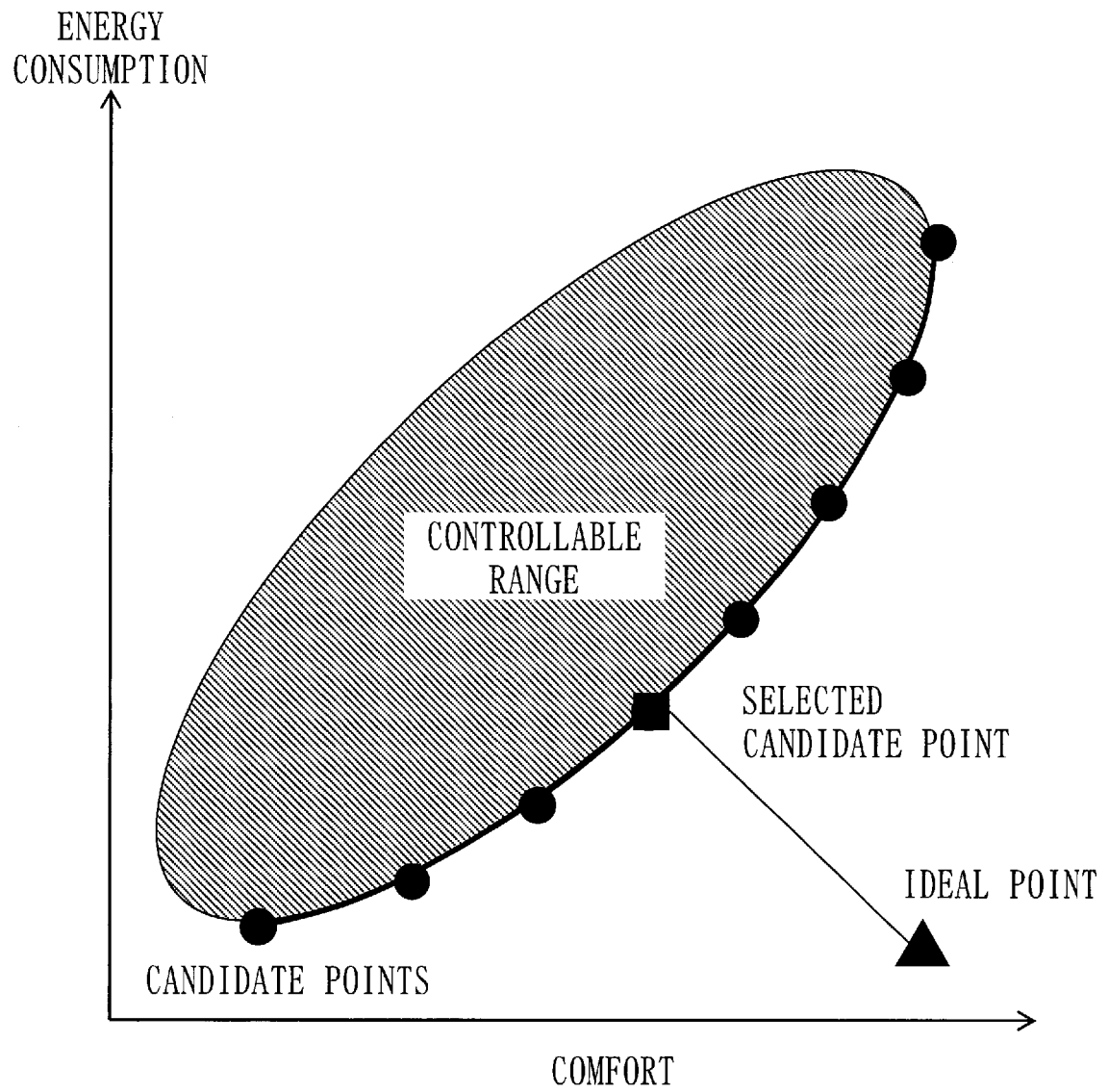


Fig. 11
100: AIR CONDITIONING SYSTEM

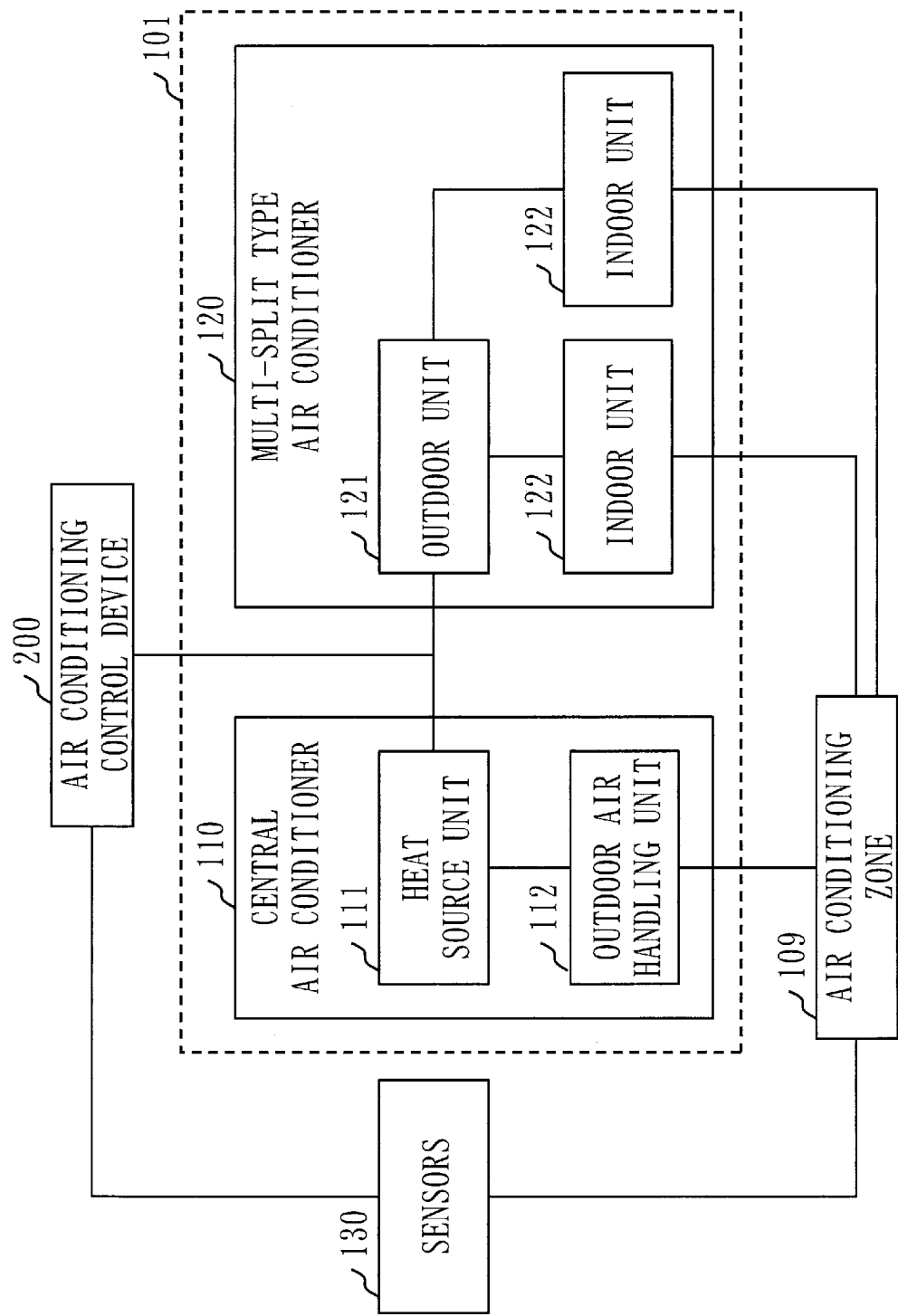


Fig. 12

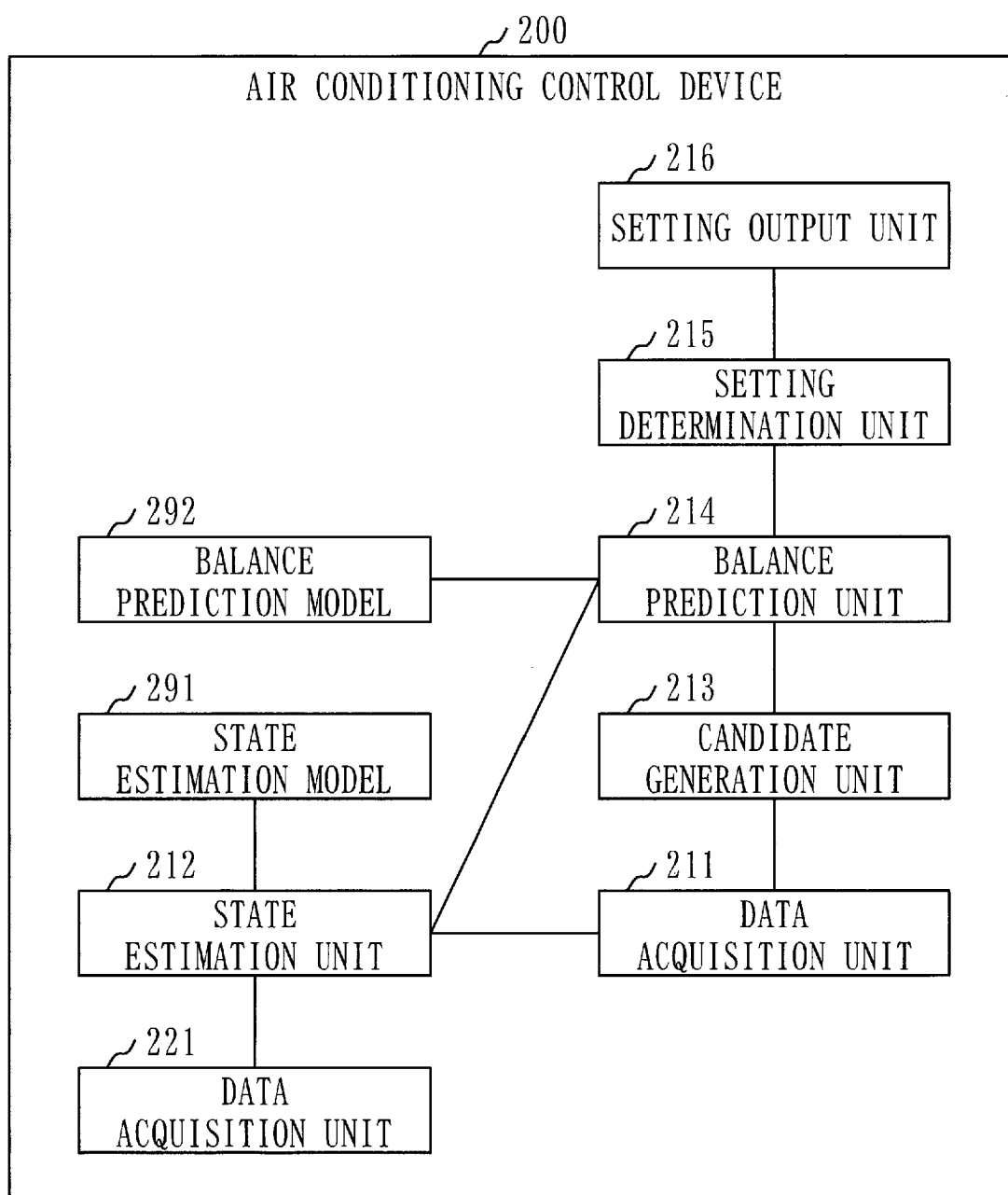


Fig. 13

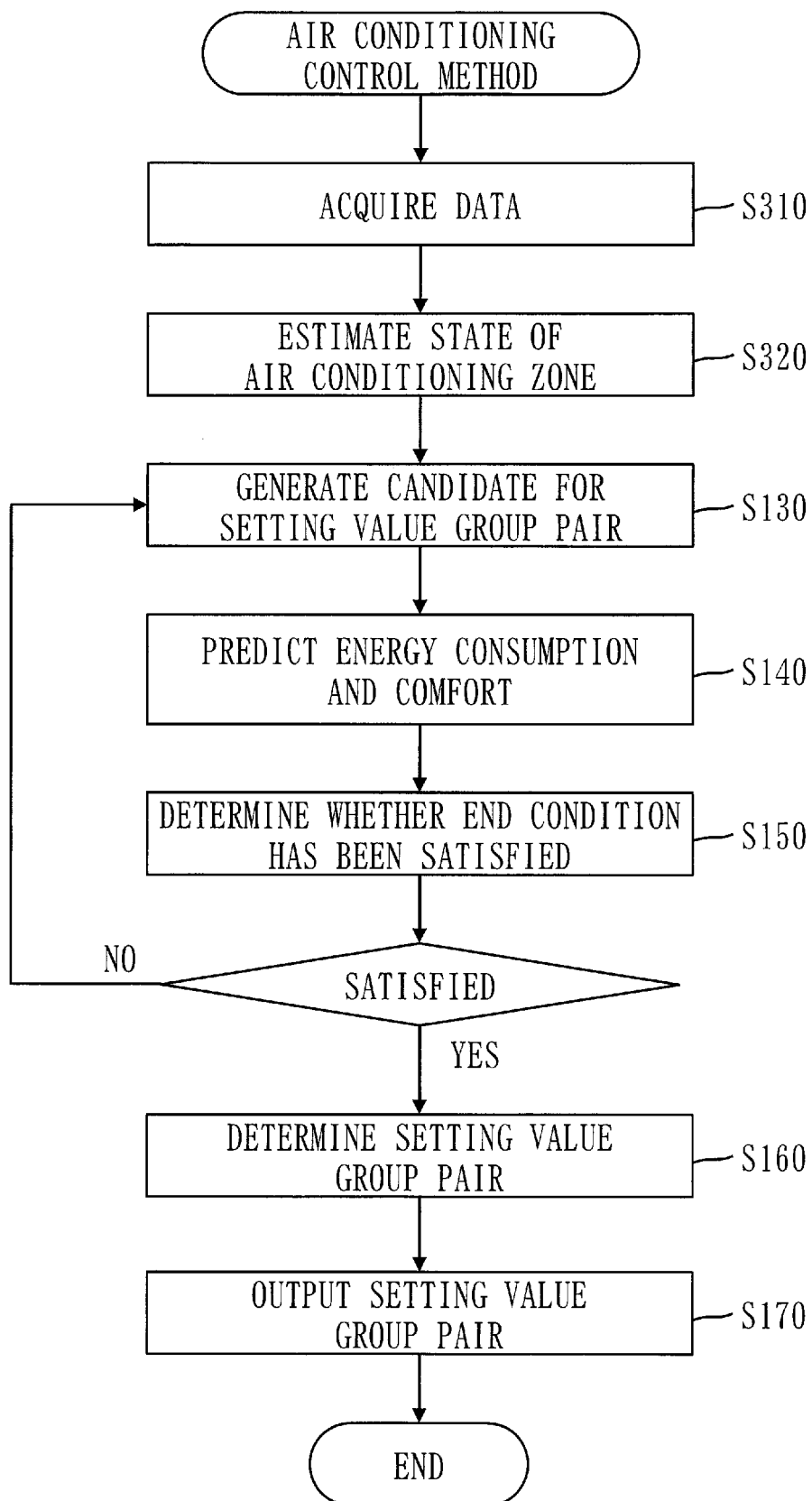


Fig. 14

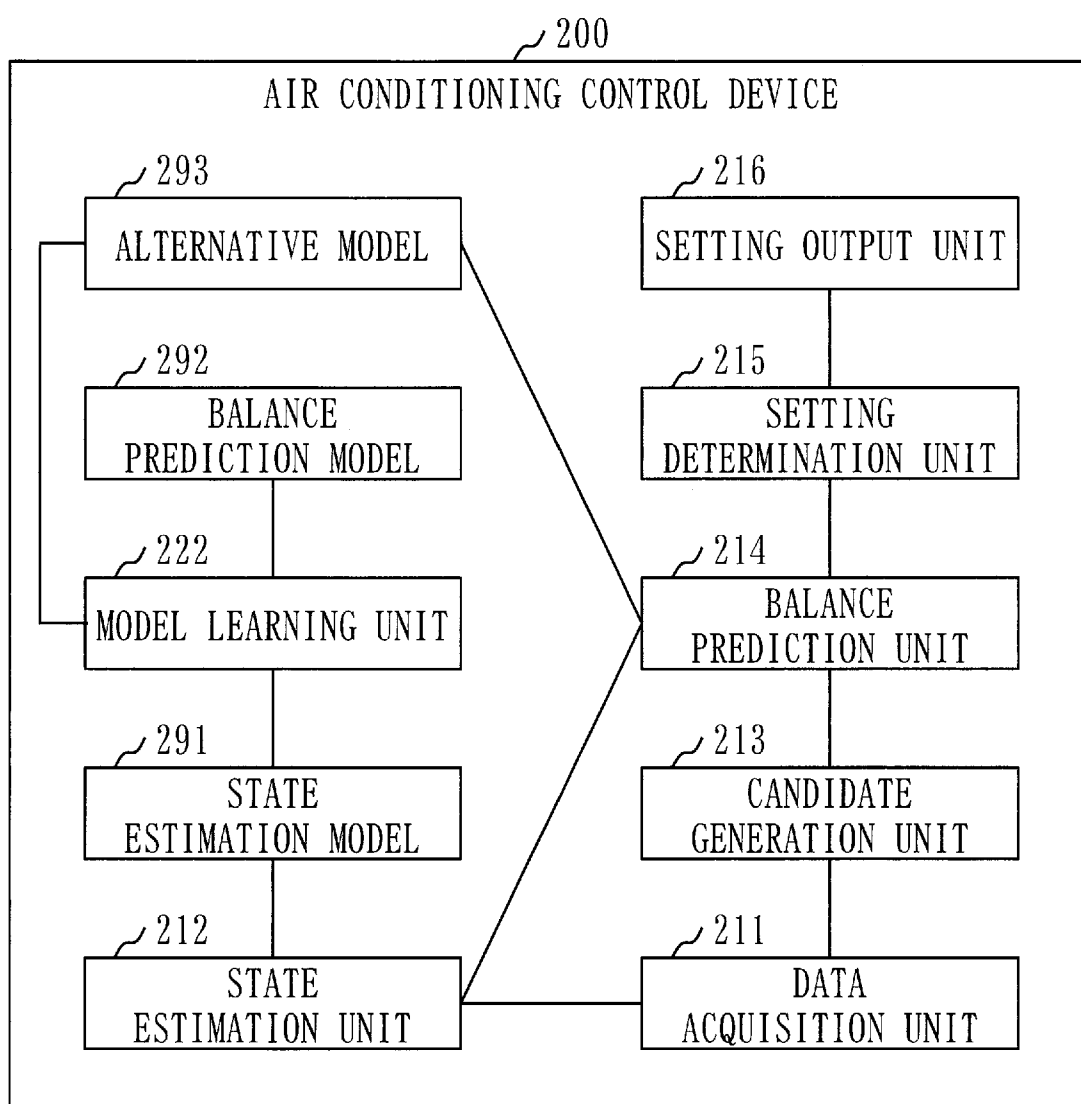


Fig. 15

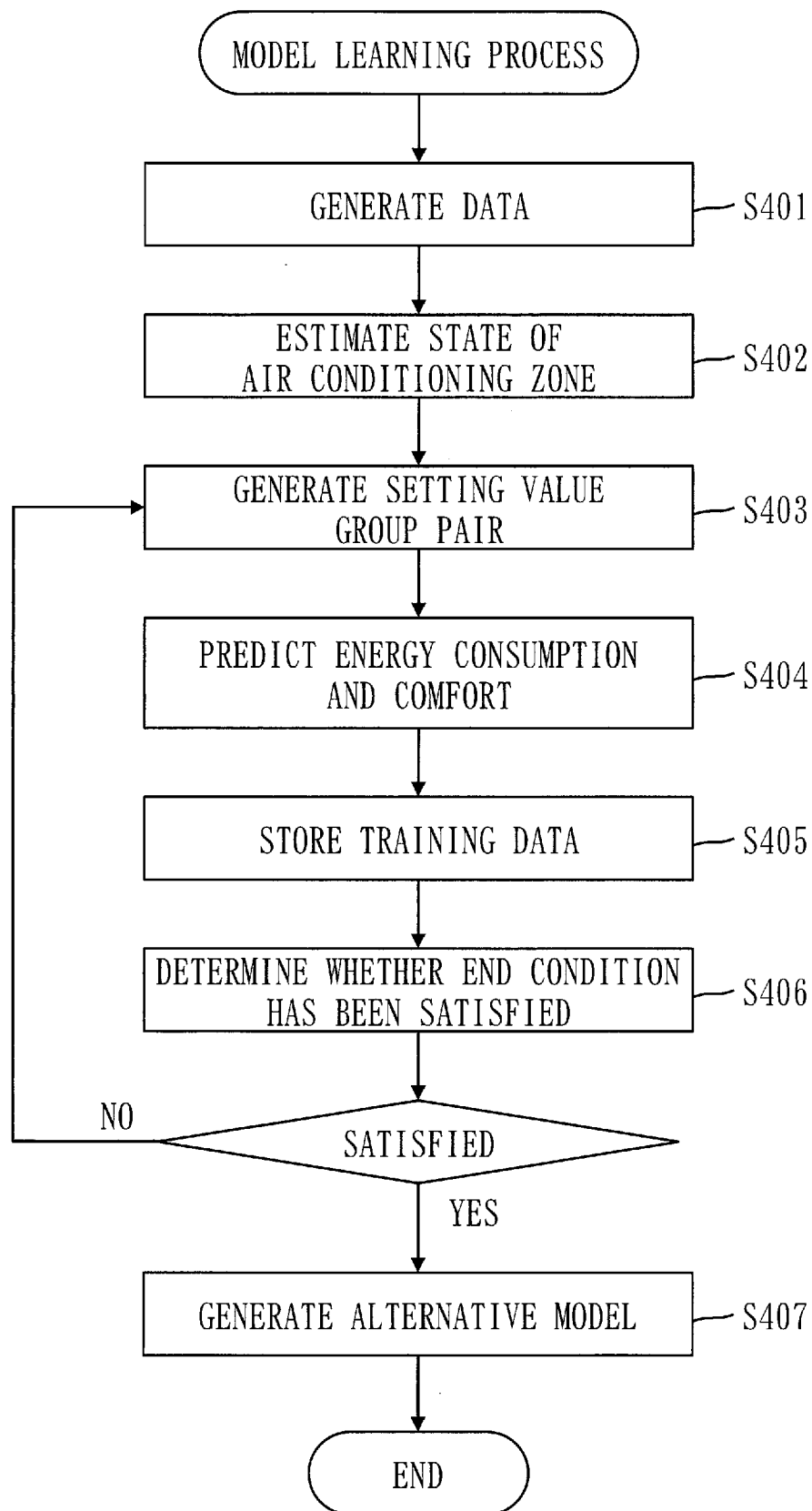


Fig. 16

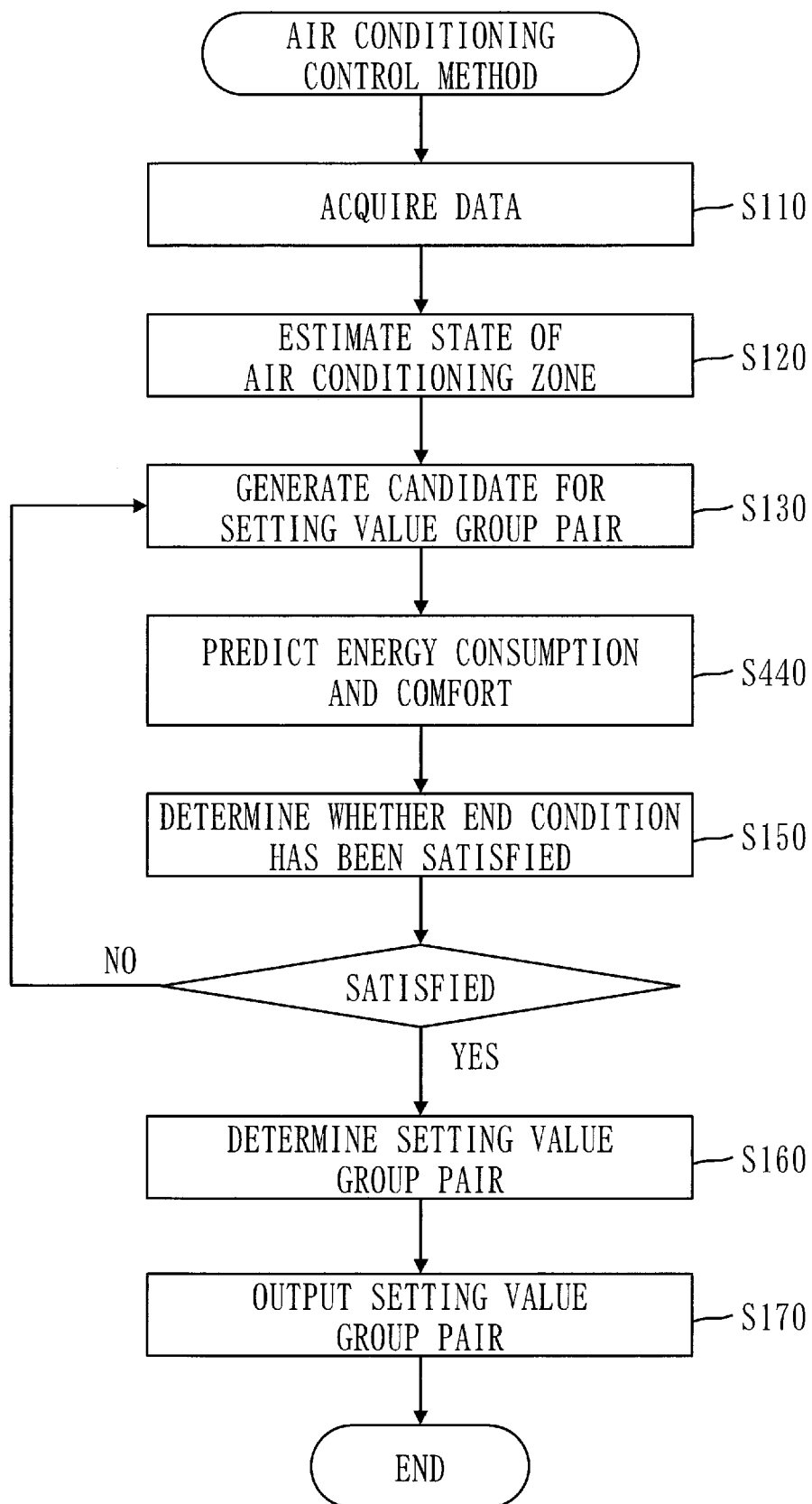


Fig. 17

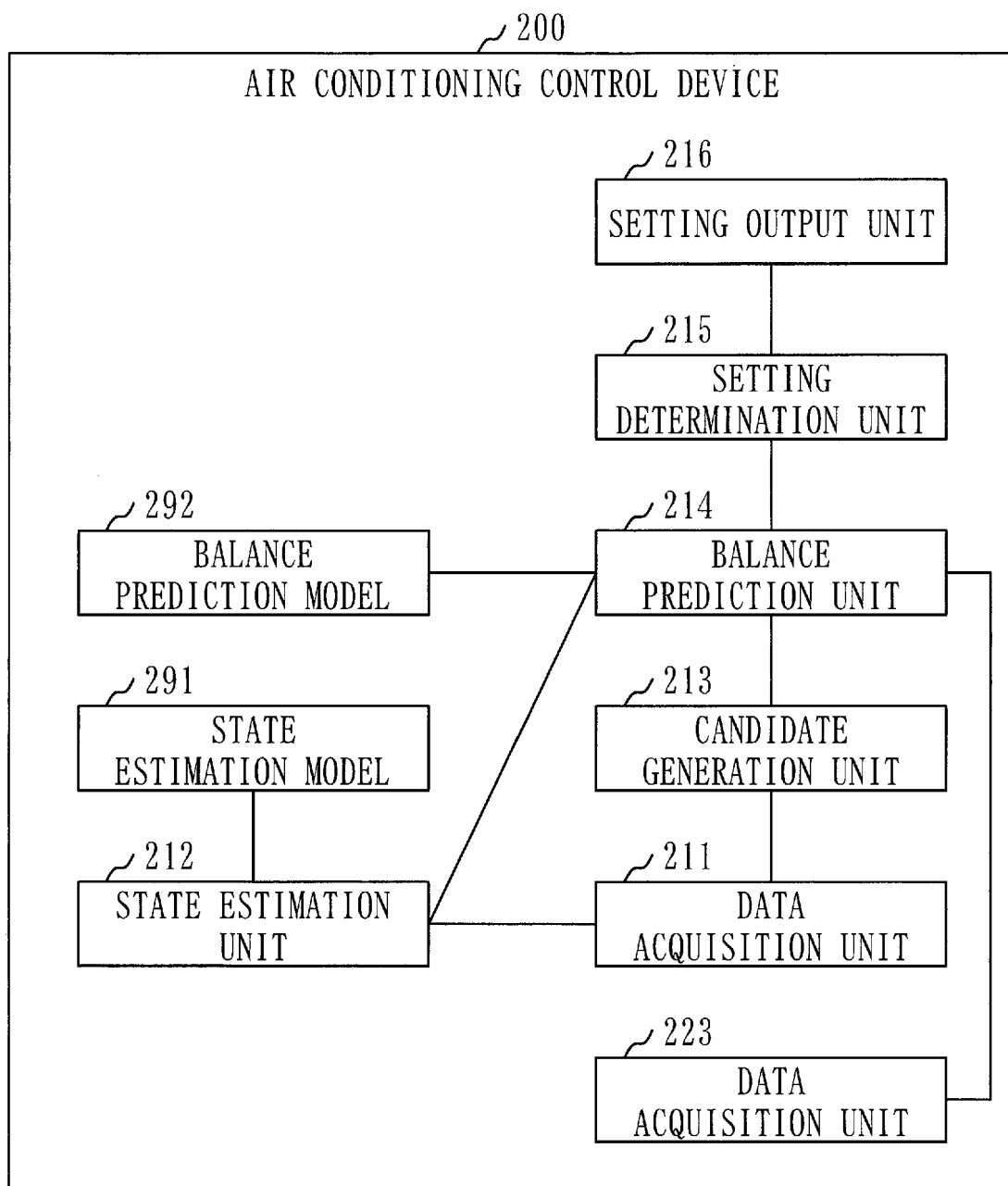


Fig. 18

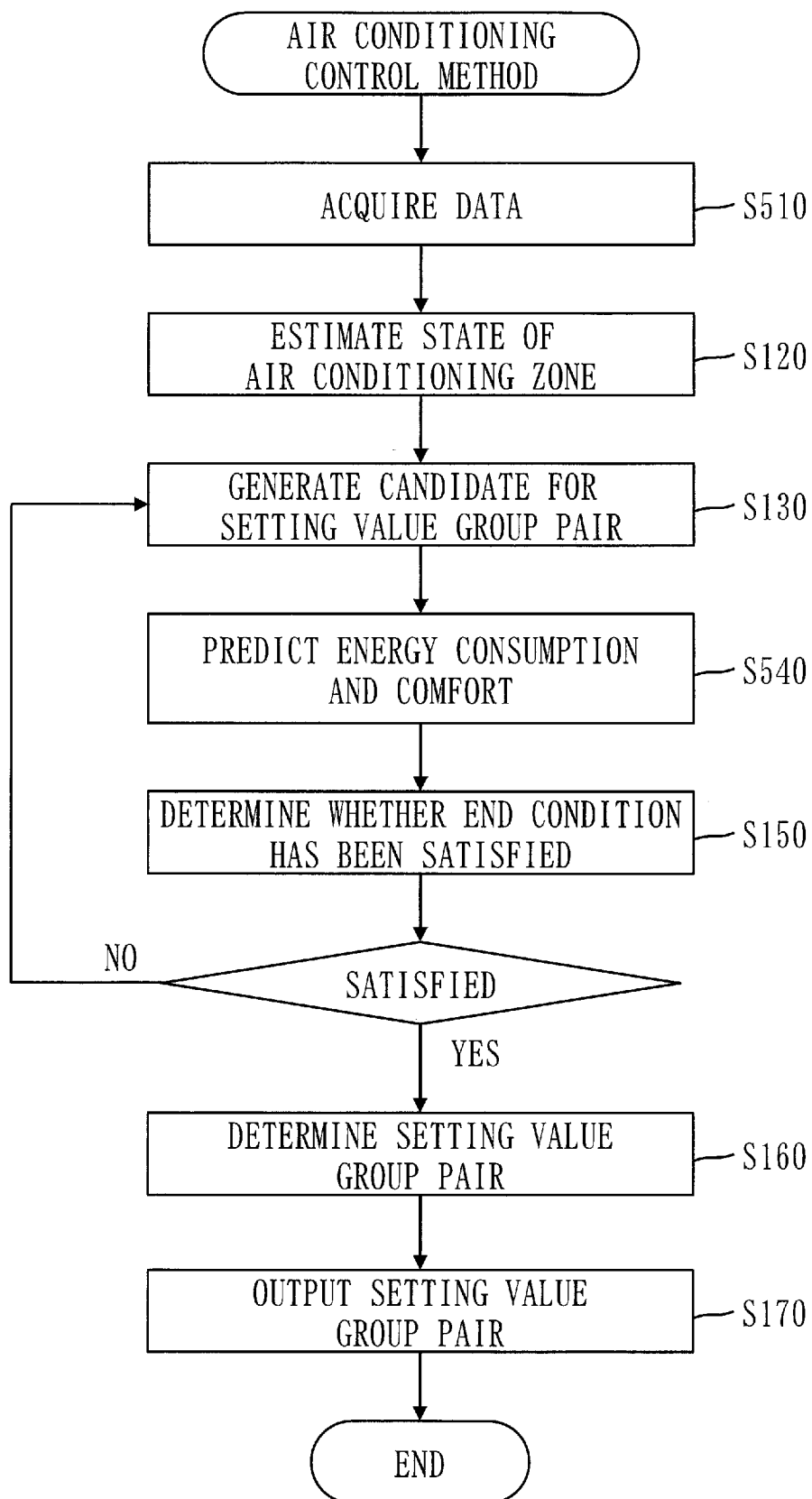


Fig. 19

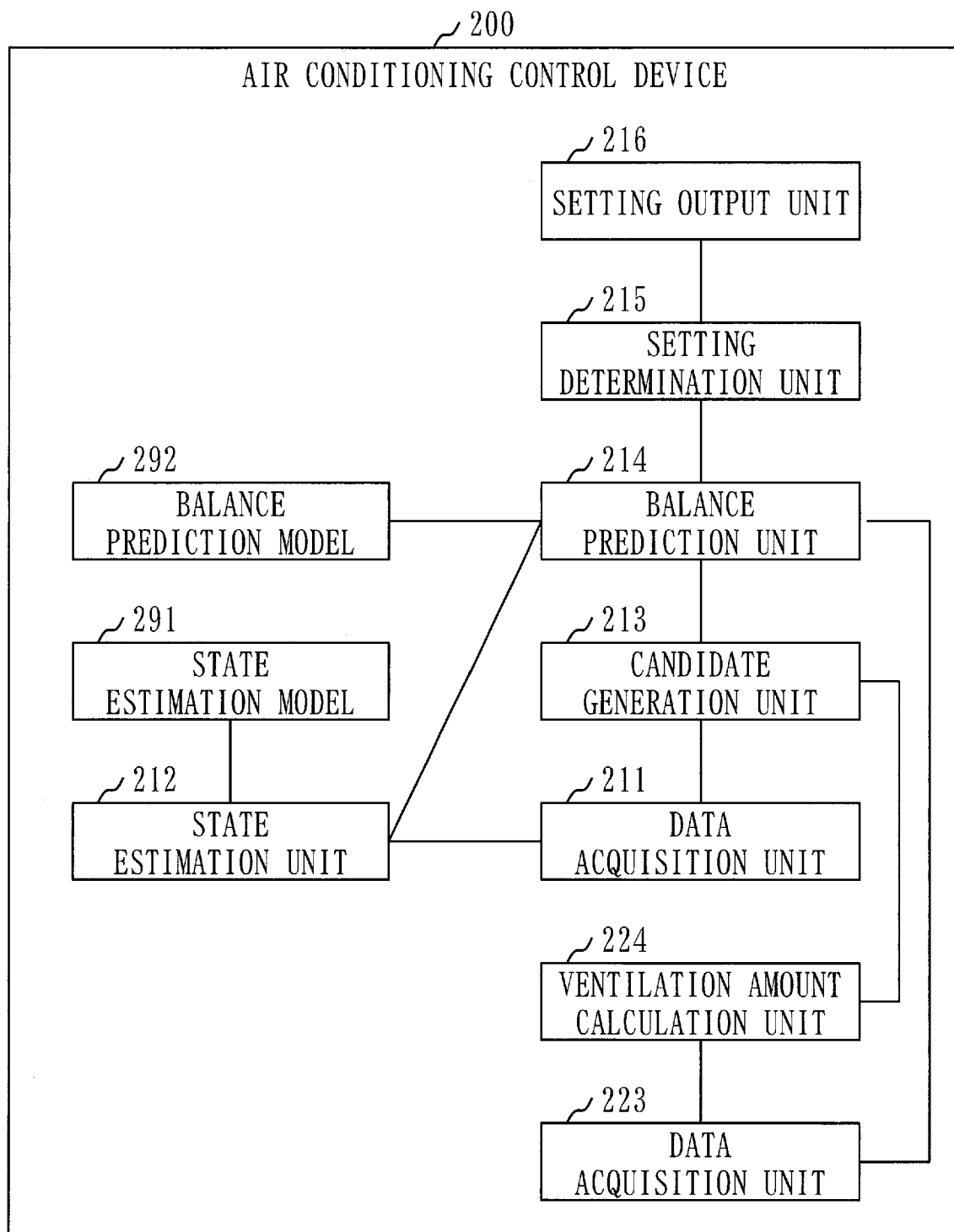


Fig. 20

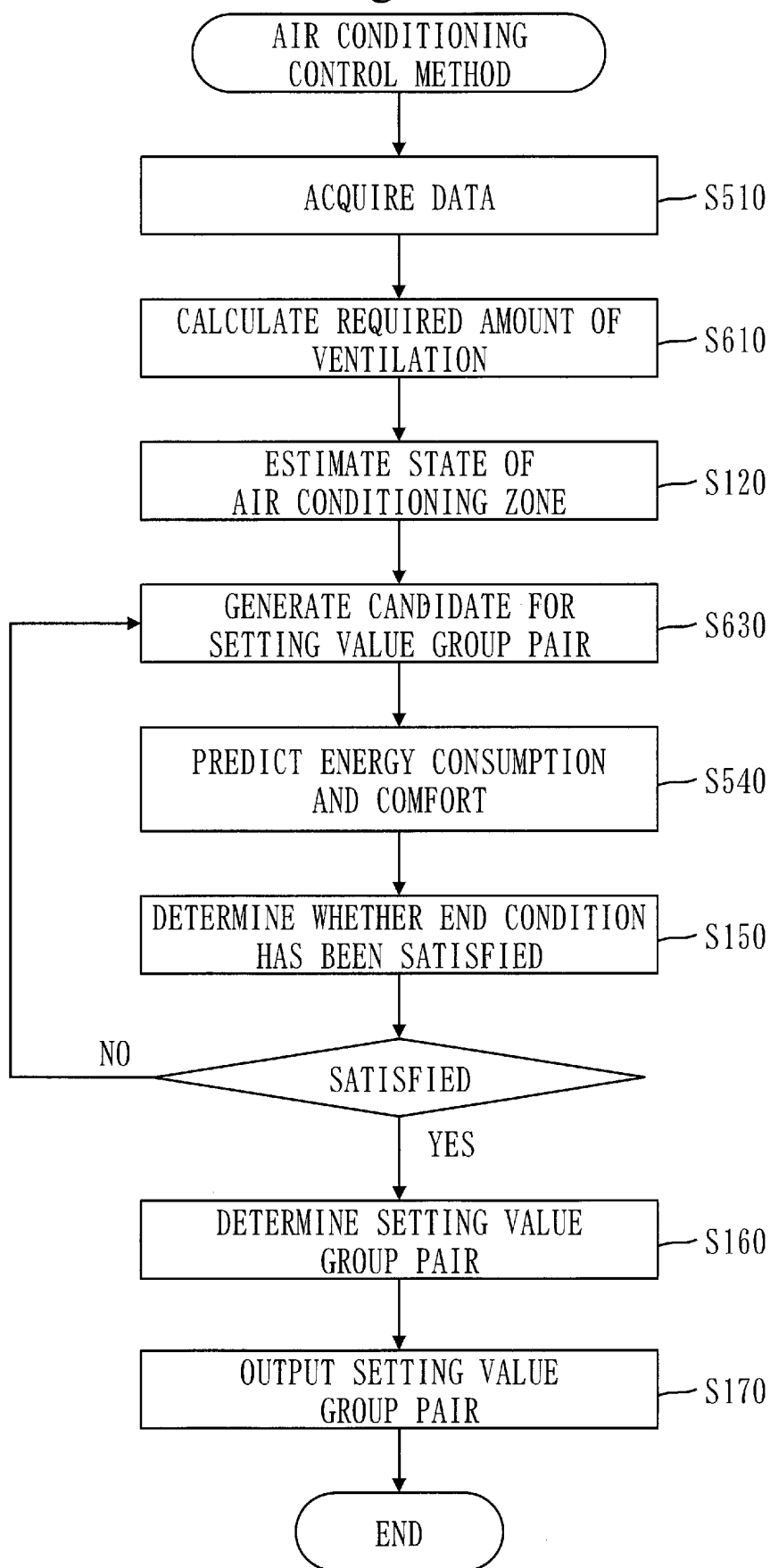


Fig. 21

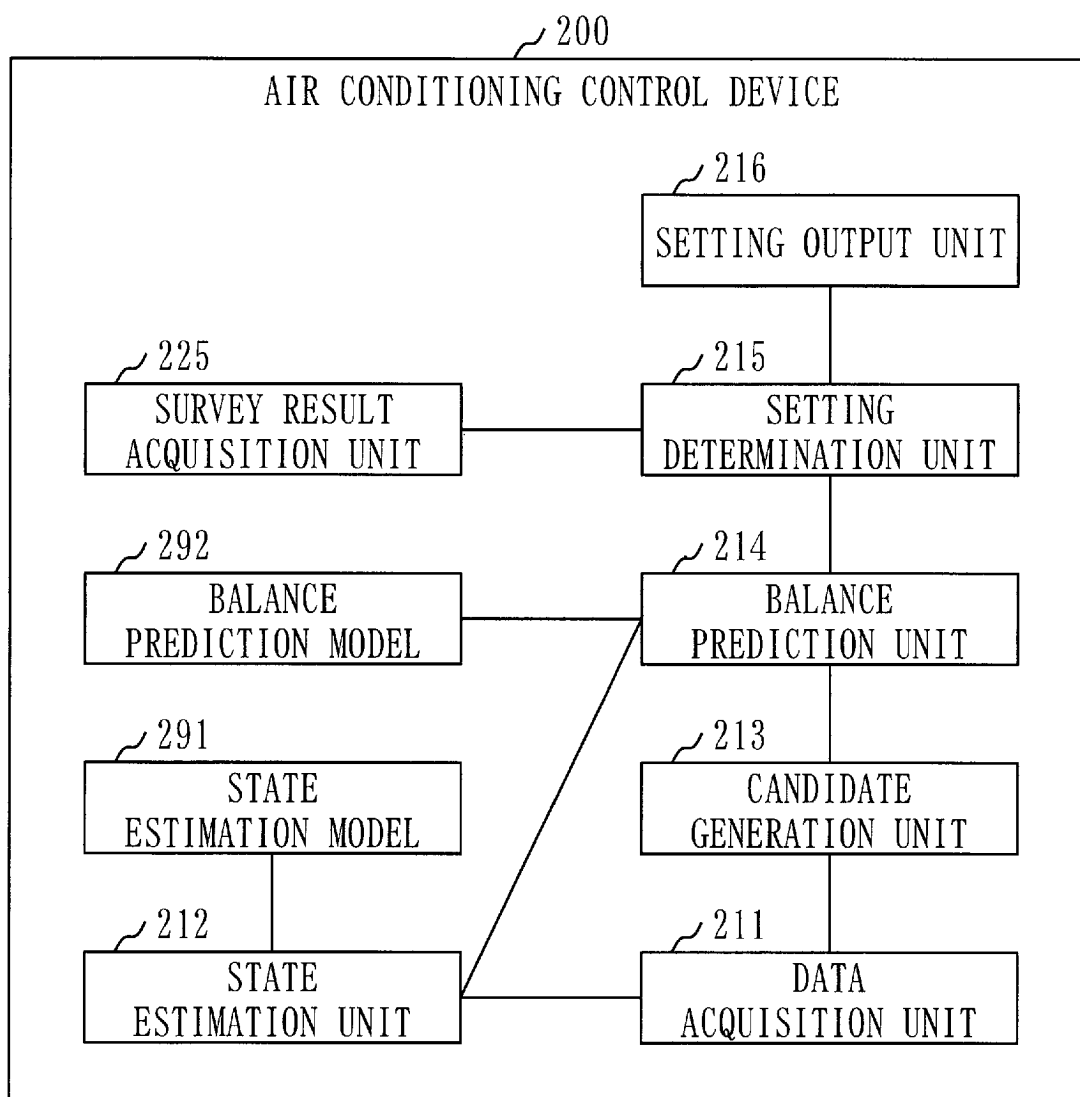


Fig. 22

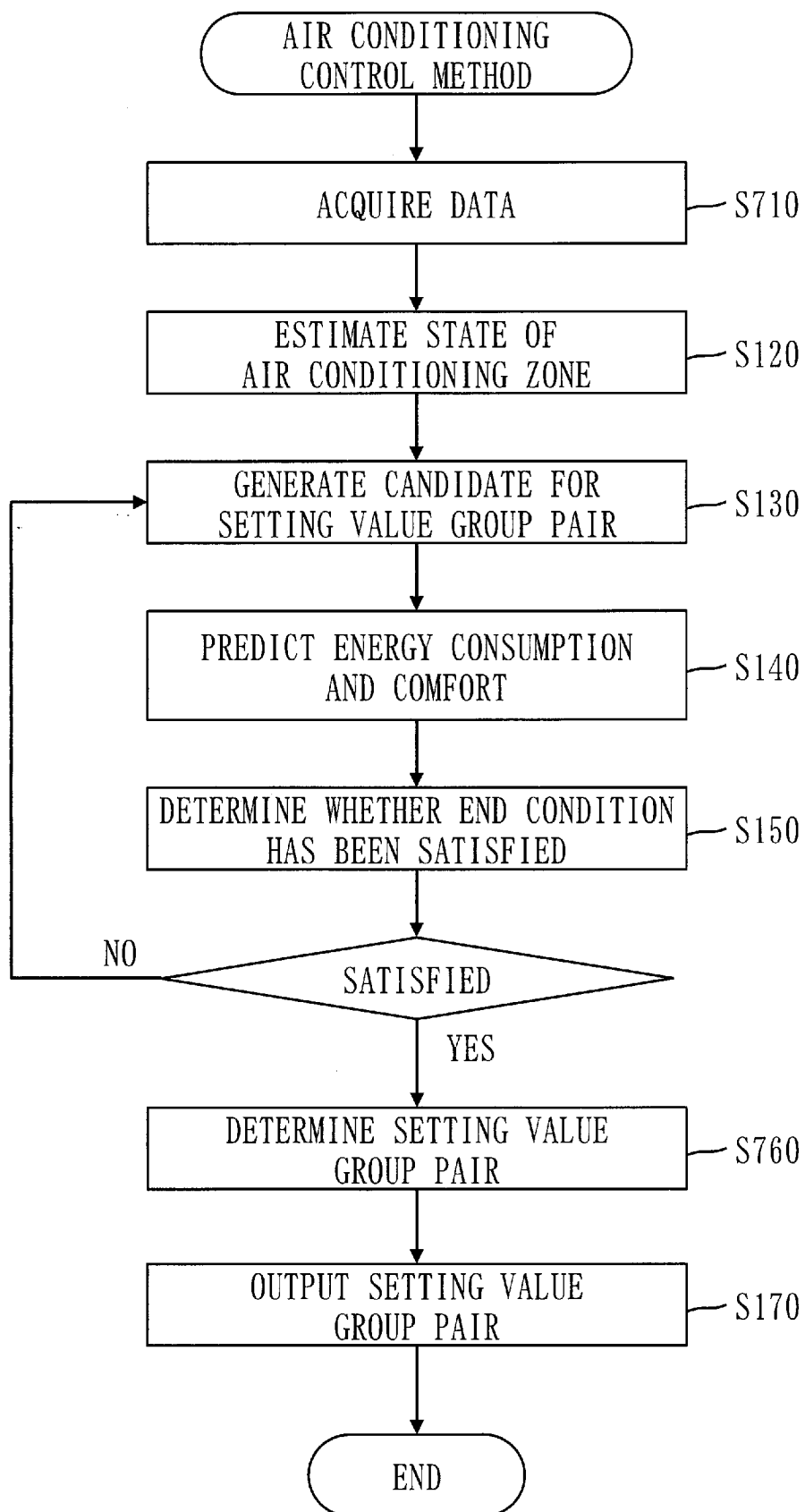


Fig. 23

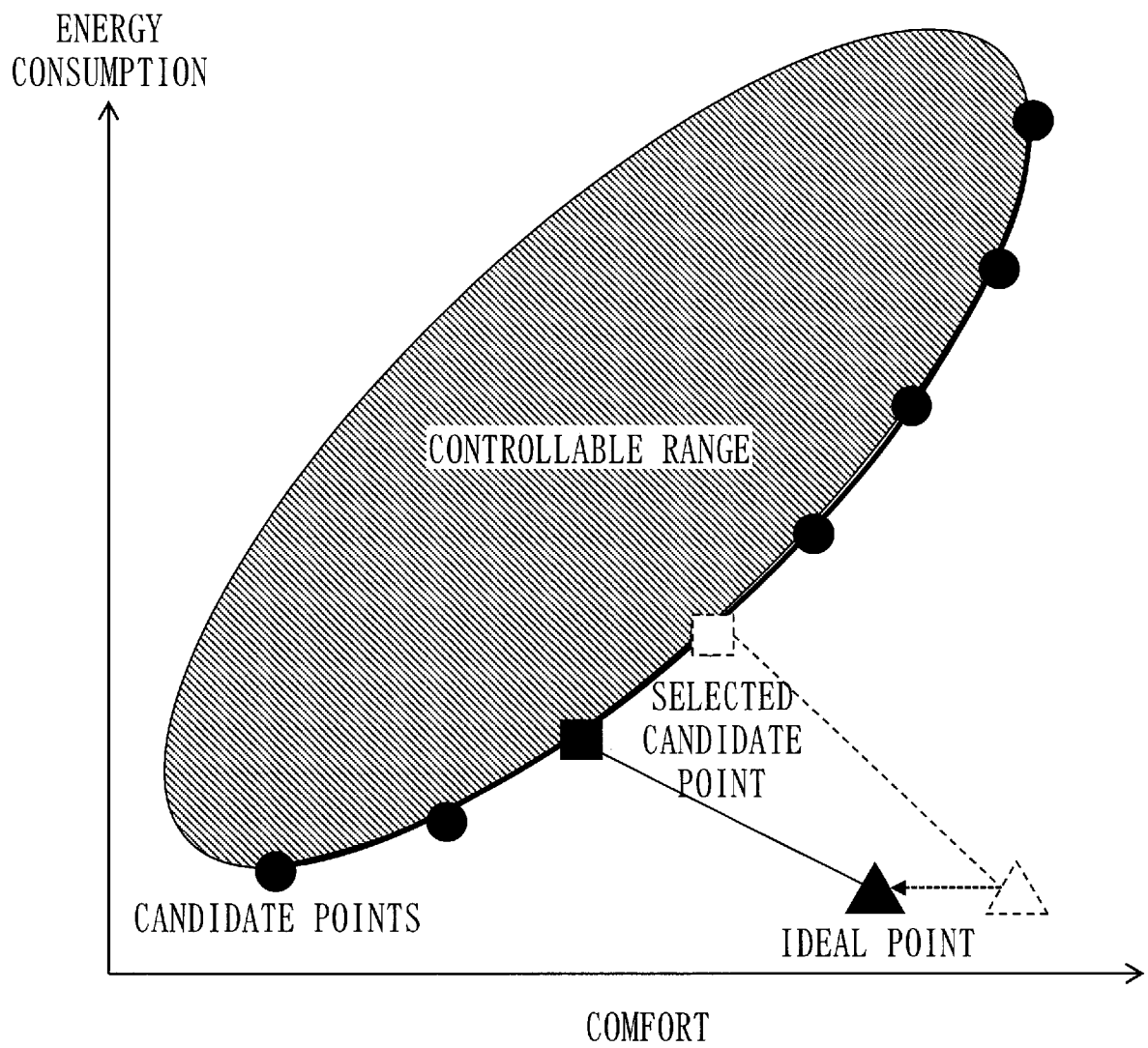


Fig. 24

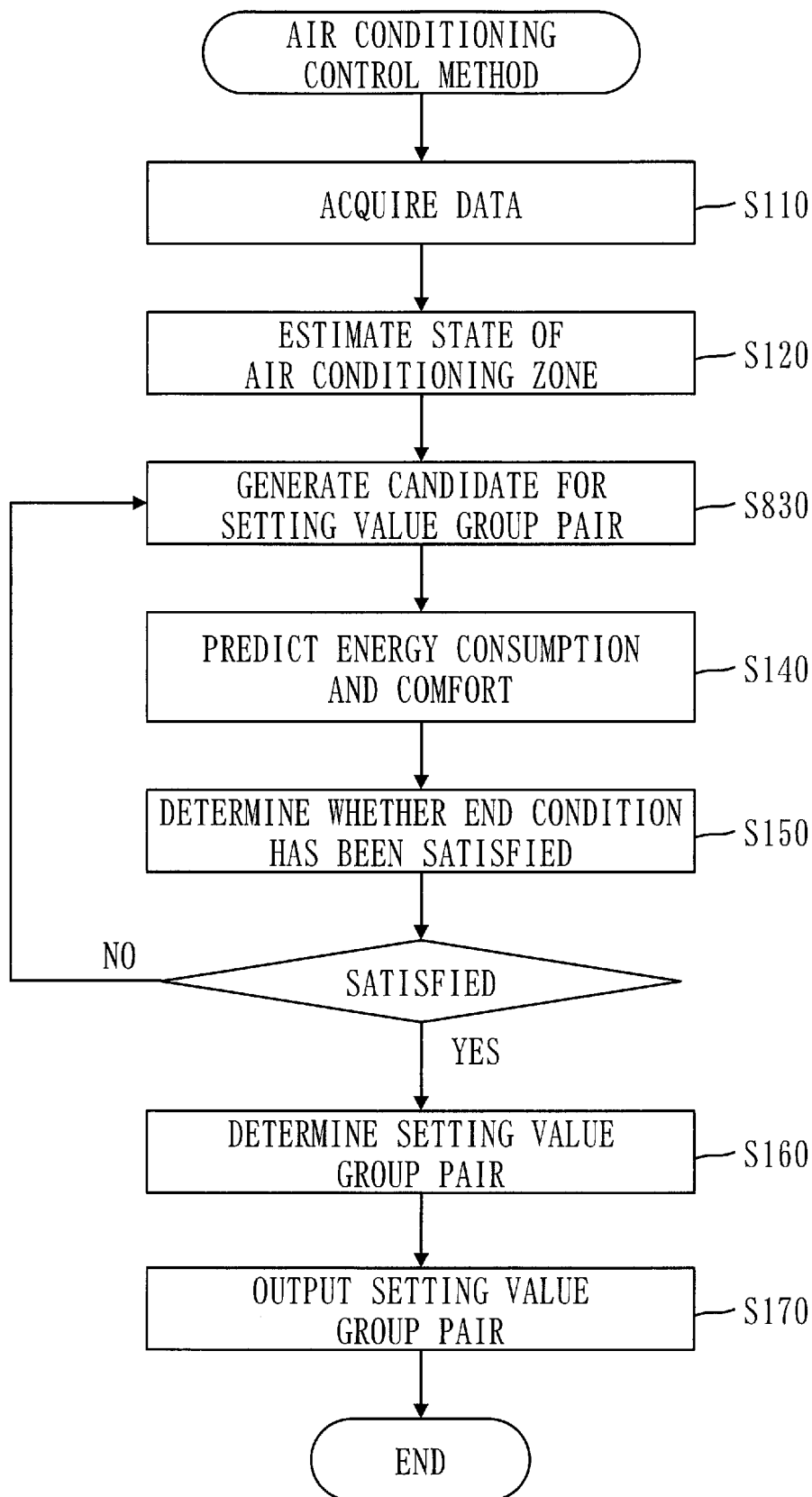
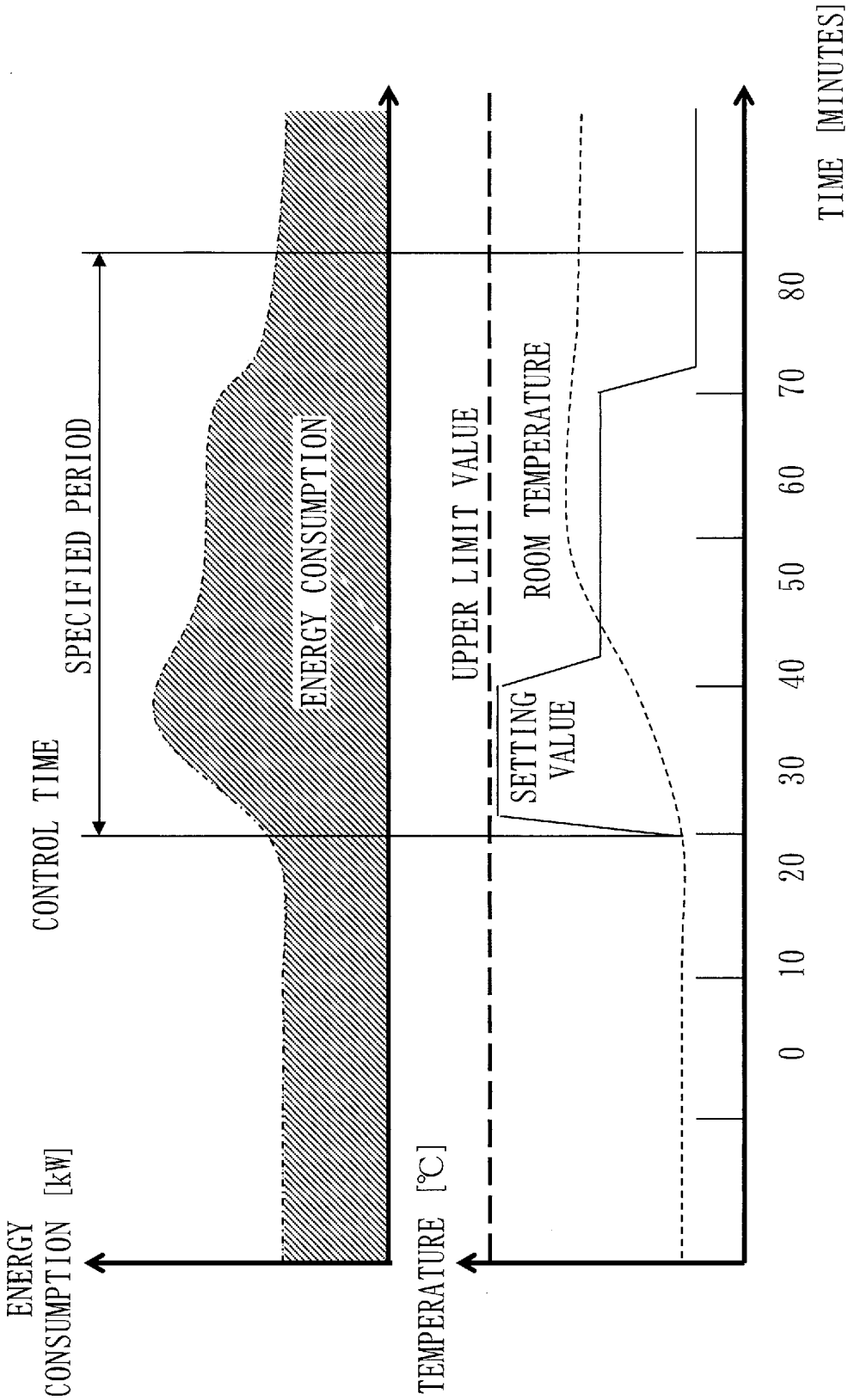


Fig. 25



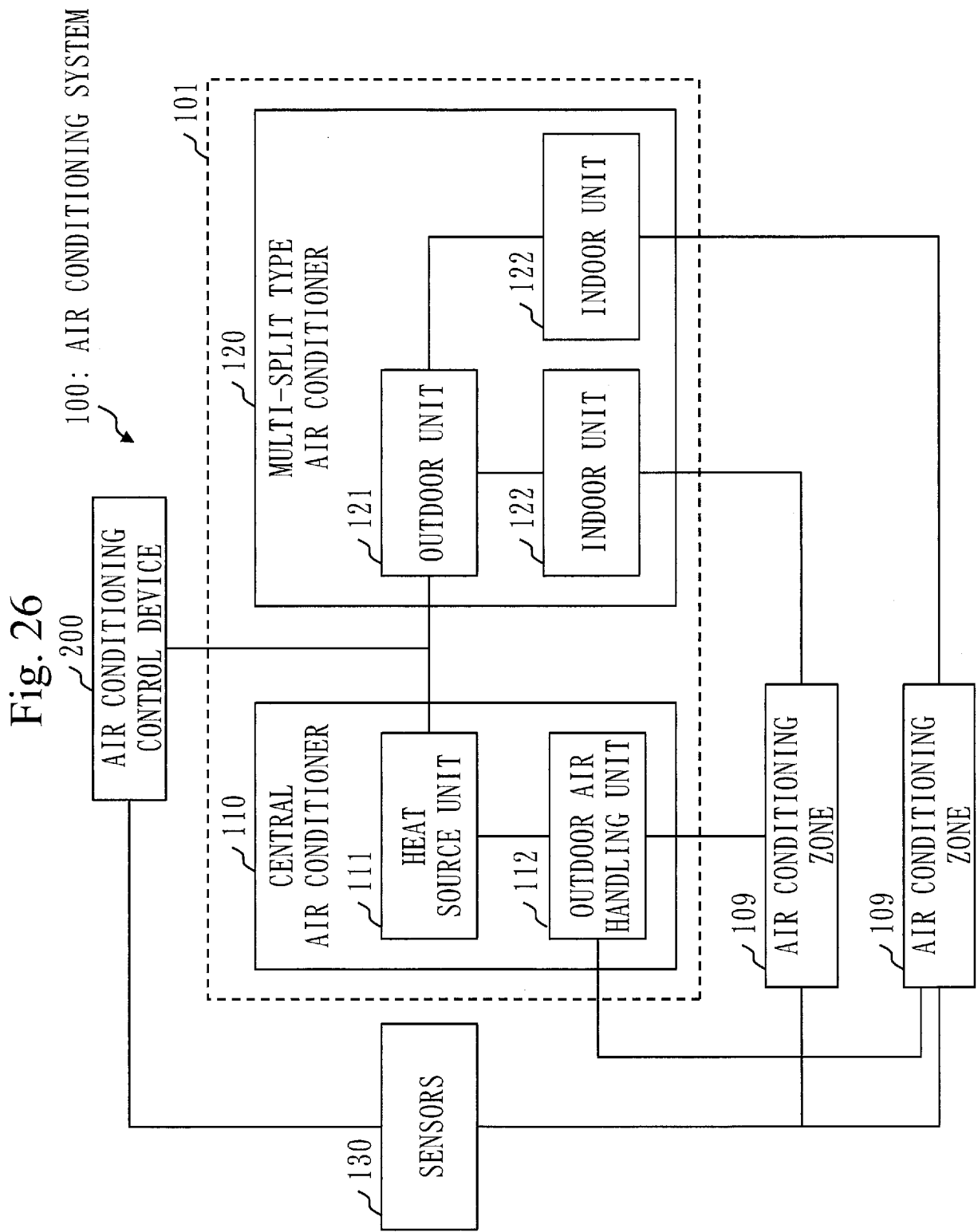


Fig. 27

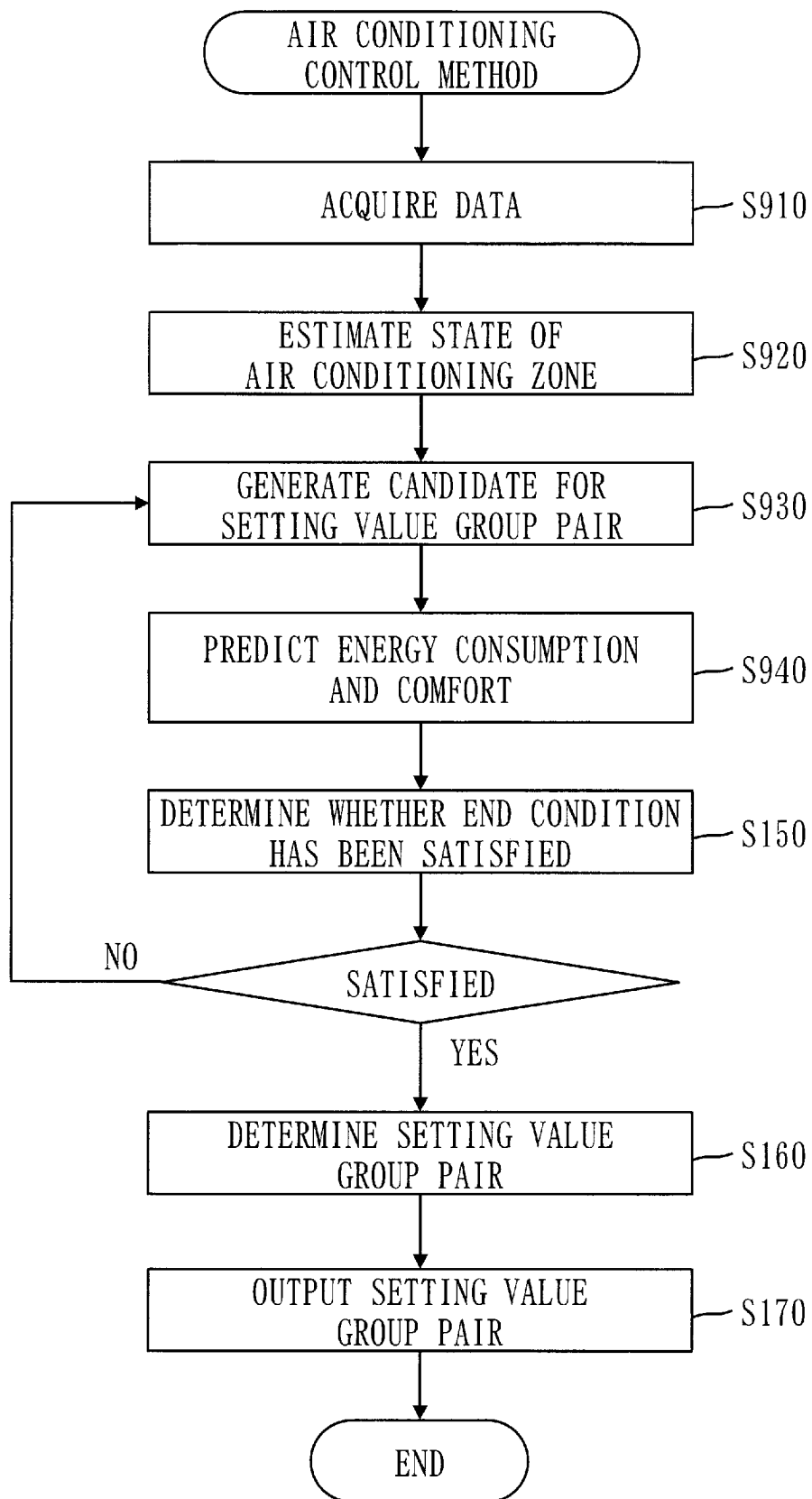


Fig. 28

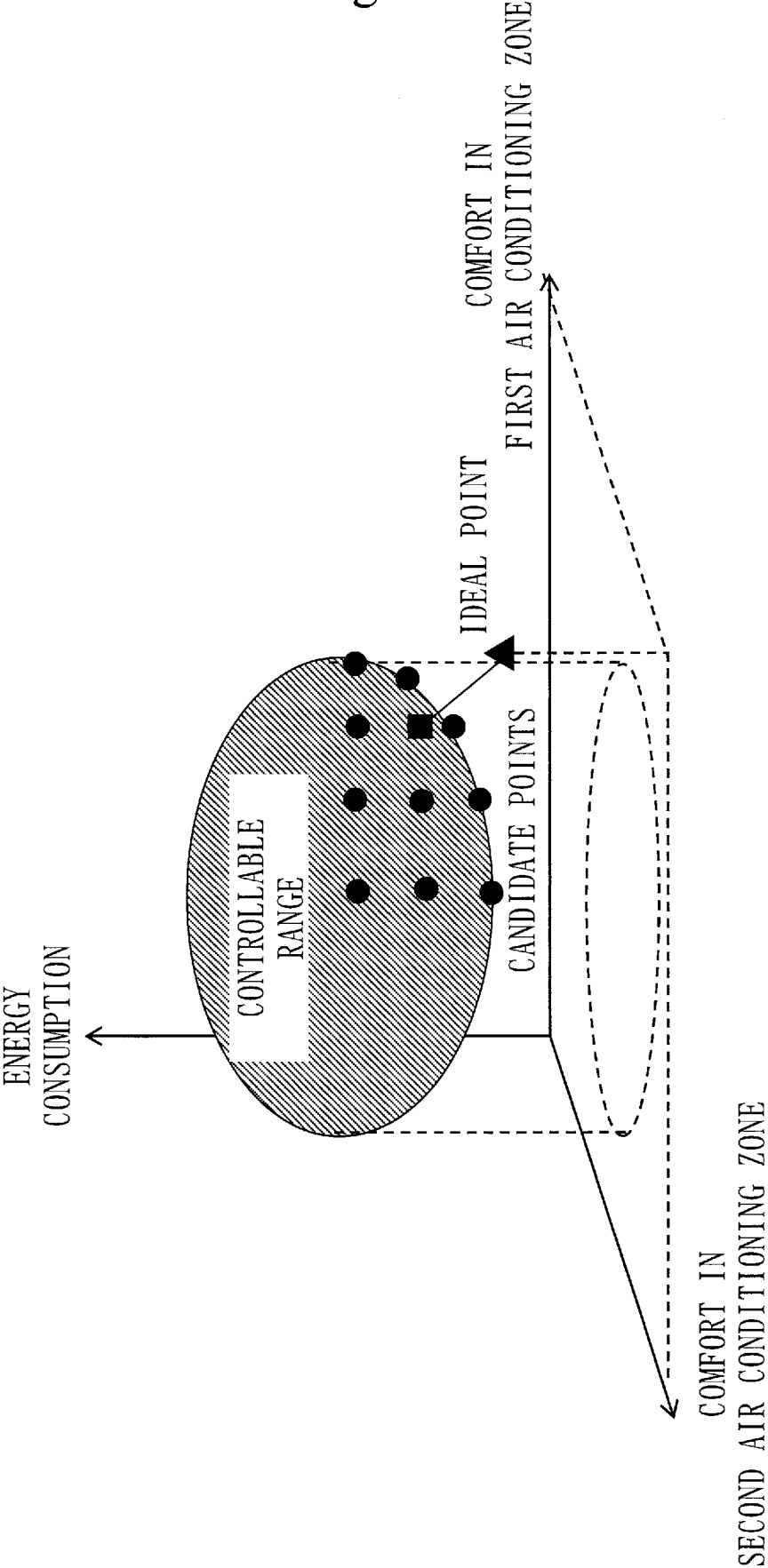
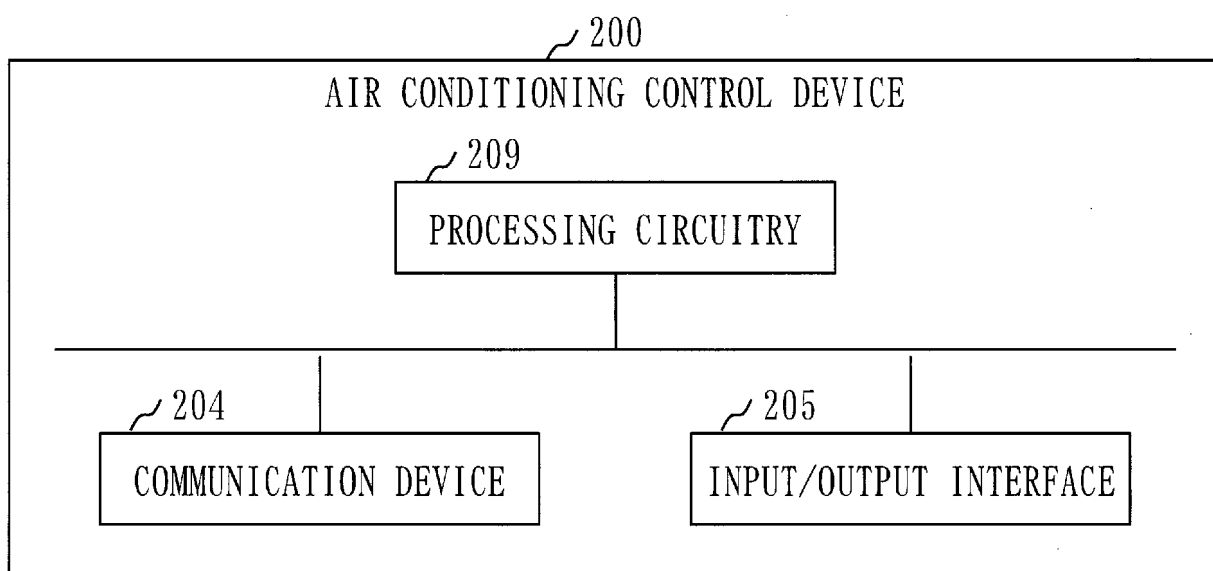


Fig. 29



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2022/020207

A. CLASSIFICATION OF SUBJECT MATTER**F24F 11/64**(2018.01)i

FI: F24F11/64

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)

F24F11/64

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2018-173264 A (DAIKIN IND LTD) 08 November 2018 (2018-11-08) paragraphs [0036]-[0195]	1-3, 7-11
A		4-6
Y	JP 2017-26161 A (TOSHIBA CORP) 02 February 2017 (2017-02-02) paragraphs [0008]-[0050]	1-3, 7-11
Y	JP 2004-324908 A (MATSUSHITA ELECTRIC WORKS LTD) 18 November 2004 (2004-11-18) paragraphs [0022]-[0096]	7-9

☐ 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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"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

27 May 2022

Date of mailing of the international search report

26 July 2022

Name and mailing address of the ISA/JP

Japan Patent Office (ISA/JP)
 3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915
 Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2022/020207

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
JP	2018-173264	A	08 November 2018	US	2020/0080742	A1	
				paragraphs [0067]-[0230]			
				WO	2018/182022	A1	
				EP	3604954	A1	
				CN	110462301	A	
							
JP	2017-26161	A	02 February 2017	(Family: none)			
							
JP	2004-324908	A	18 November 2004	(Family: none)			
							

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 6414354 B [0006]