(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 4 053 467 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
07.09.2022 Bulletin 2022/36

(21) Application number: **19950756.7**

(22) Date of filing: **28.10.2019**

(51) International Patent Classification (IPC):
F24F 11/46 *(2018.01)* ***F24F 7/08*** *(2006.01)*
F24F 110/10 *(2018.01)* ***F24F 110/20*** *(2018.01)*
F24F 140/60 *(2018.01)*

(52) Cooperative Patent Classification (CPC):
F24F 11/46; F24F 7/08

(86) International application number:
PCT/JP2019/042106

(87) International publication number:
WO 2021/084568 (06.05.2021 Gazette 2021/18)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

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

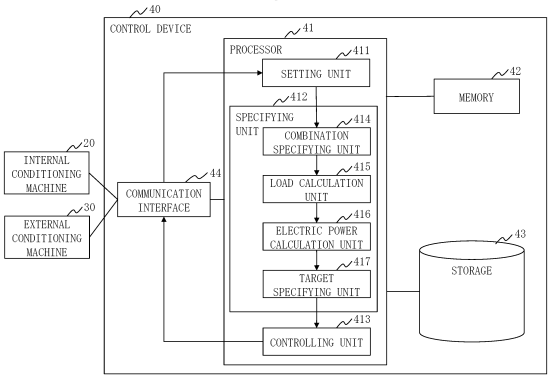
(72) Inventors:
- **HASHIKAWA, Takahiro**
  Tokyo 100-8310 (JP)
- **HAMADA, Mamoru**
  Tokyo 100-8310 (JP)

(74) Representative: **Studio Torta S.p.A.**
Via Viotti, 9
10121 Torino (IT)

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

(57) A control apparatus (40) controls an air conditioning system including: an internal conditioning machine which takes in air from inside of a target space, adjusts temperature of the air, and then outputs the air to the target space; and an external conditioning machine which takes in air from outside of the target space, adjusts temperature of the air, and then outputs the air to the target space. A setting unit (411) receives input of information regarding comfortability in the target space, and sets a target value for the comfortability. A controlling unit (413) controls both the internal conditioning machine and the external conditioning machine based on the target value set by the setting unit (411).

Fig. 5



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Description

Technical Field

[0001] This invention relates to control of an air conditioning system.

Background Art

[0002] There is an air conditioning system which has a configuration of including: an internal conditioning machine that takes in indoor air, adjusts temperature of the air, and then outputs the air into a room; and an external conditioning machine that takes in outdoor air, adjusts temperature of the air, and then outputs the air into the room for ventilation (see Patent Literature 1).

[0003] As a method of controlling the air conditioning system which has this configuration, there is latent heat and sensible heat separating air conditioning in which the internal conditioning machine mainly has a role in temperature adjustment and the external conditioning machine mainly has a role in humidity adjustment. The latent heat and sensible heat separating air conditioning aims for energy saving operation.

[0004] In the latent heat and sensible heat separating air conditioning, set temperature which is temperature to be targeted is given to the internal conditioning machine, and set humidity which is humidity to be targeted is given to the external conditioning machine. Then, the air temperature and the air humidity which are desired by a user are realized in such a manner that the internal conditioning machine operates so that the set temperature is realized and the external conditioning machine operates so that the set humidity is realized.

[0005] The air conditioning system is for improving comfortability in an indoor space. There is Predicted Mean Vote (PMV) as an index for evaluating the comfortability in the indoor space. The PMV is an index calculated from six elements that affect thermal comfort. The six elements are room temperature, average radiation temperature, relative humidity, average wind speed, metabolic amount and the number of put-on clothes.

Citation List

Patent Literature

[0006] Patent Literature 1: JP2019-078501A

Summary of Invention

Technical Problem

[0007] Conventionally, each of the internal conditioning machine and the external conditioning machine has been controlled independently. Therefore, there is a risk that proper control is not performed based on the comfortability.

[0008] This invention aims to enable proper control based on comfortability.

Solution to Problem

[0009] A control apparatus according to the present invention controlling an air conditioning system including: an internal conditioning machine which takes in air from inside of a target space, adjusts temperature of the air, and then outputs the air to the target space; and an external conditioning machine which takes in air from outside of the target space, adjusts temperature of the air, and then outputs the air to the target space, includes:

a setting unit to receive input of information regarding comfortability in the target space, and set a target value for the comfortability; and

a controlling unit to control both the internal conditioning machine and the external conditioning machine based on the target value set by the setting unit.

Advantageous Effects of Invention

[0010] In the present invention, a target value for comfortability is set, and both an internal conditioning machine and an external conditioning machine are controlled based on the target value. Since both the internal conditioning machine and the external conditioning machine are controlled, proper control based on the comfortability is possible.

Brief Description of Drawings

[0011]

Fig. 1 is a configuration diagram of an air conditioning system 10 according to a first embodiment.

Fig. 2 is a configuration diagram of an internal conditioning machine 20 according to the first embodiment.

Fig. 3 is a configuration diagram of an external conditioning machine 30 according to the first embodiment.

Fig. 4 is a configuration diagram of an outside-air supply unit 32 according to the first embodiment.

Fig. 5 is a configuration diagram of a control apparatus 40 according to the first embodiment.

Fig. 6 is a flowchart illustrating whole operation of the control apparatus 40 according to the first embodiment.

Fig. 7 is a flowchart of a specifying process according to the first embodiment.

Fig. 8 is an explanatory diagram of a combination of temperature and humidity when a target PMV is lowered.

Fig. 9 is an explanatory diagram of a combination of temperature and humidity when the target PMV is

raised.

Fig. 10 is an explanatory diagram of a combination specifying process according to the first embodiment.

Fig. 11 is an explanatory diagram of a target specifying process according to the first embodiment.

Description of Embodiments

First Embodiment.

*** Description of Configuration ***

[0012] With reference to Fig. 1, a configuration of an air conditioning system 10 according to a first embodiment will be described.

[0013] The air conditioning system 10 includes an internal conditioning machine 20, an external conditioning machine 30, and a control apparatus 40. The internal conditioning machine 20 takes in air from the inside of a target space 50, adjusts temperature of the air, and then outputs the air into a target space. The external conditioning machine 30 takes in air from the outside of the target space 50, adjusts temperature of the air, and then outputs the air into the target space 50. The control apparatus 40 controls the internal conditioning machine 20 and the external conditioning machine 30.

[0014] With reference to Figs. 1 and 2, a configuration of the internal conditioning machine 20 according to the first embodiment will be described.

[0015] The internal conditioning machine 20 includes an outdoor unit 21 and one or more indoor units 22. In Figs. 1 and 2, the internal conditioning machine 20 includes two indoor units 22. The outdoor unit 21 is installed outdoors, and each indoor unit 22 is installed above a ceiling or the like of a room constituting an indoor space which is the target space 50. The outdoor unit 21 and each indoor unit 22 are connected via a refrigerant pipe 23. A temperature detection device 24 that detects temperature of the outside air is installed in the outdoor unit 21. A temperature detection device 25 that detects temperature in the indoor space which is the target space 50 is installed in each indoor unit 22.

[0016] The outdoor unit 21 includes a compressor 211, a four-way valve 212, an outdoor heat-exchanger 213, and an outdoor fan 214. The compressor 211, the four-way valve 212, and the outdoor heat-exchanger 213 are connected sequentially via a refrigerant pipe 215. Each indoor unit 22 includes an indoor heat-exchanger 221, an expansion valve 222, and an indoor fan 223. The indoor heat-exchanger 221 and the expansion valve 222 are connected sequentially via a refrigerant pipe 224. Further, an edge of one side of the refrigerant pipe 215 of the outdoor unit 21 and an edge of one side of the refrigerant pipe 224 of each indoor unit 22 are connected via the refrigerant pipe 23. Further, an edge of the other side of the refrigerant pipe 215 of the outdoor unit 21 and an edge of the other side of the refrigerant pipe 224 of each indoor unit 22 are connected via the refrigerant pipe 23. Thereby, an internal conditioning structure is constituted.

[0017] With reference to Figs 1 and 3, a configuration of the external conditioning machine 30 according to the first embodiment will be described.

[0018] The external conditioning machine 30 includes an outdoor unit 31 and an outside-air supply unit 32. The outdoor unit 31 is installed outdoors, and the outside-air supply unit 32 is installed above the ceiling or the like of the room constituting the indoor space which is the target space 50. The outdoor unit 31 and the outside-air supply unit 32 are connected via a refrigerant pipe 33. A humidity detection device 34 that detects humidity of the outside air is installed in the outdoor unit 31. A humidity detection device 35 that detects humidity in the indoor space which is the target space 50 is installed in the outside-air supply unit 32.

[0019] The outdoor unit 31 includes a compressor 311, a four-way valve 312, an outdoor heat-exchanger 313, and an outdoor fan 314. The compressor 311, the four-way valve 312, and the outdoor heat-exchanger 313 are connected sequentially via a refrigerant pipe 315. The outside-air supply unit 32 includes a heat exchanger 321 and an expansion valve 322. The heat exchanger 321 and the expansion valve 322 are connected sequentially via a refrigerant pipe 323. Further, an edge of one side of the refrigerant pipe 315 of the outdoor unit 31 and an edge of one side of the refrigerant pipe 323 of the outside-air supply unit 32 are connected via the refrigerant pipe 33. Further, an edge of the other side of the refrigerant pipe 315 of the outdoor unit 31 and an edge of the other side of the refrigerant pipe 323 of the outside-air supply unit 32 are connected via the refrigerant pipe 33. Thereby, an external conditioning structure is constituted.

[0020] With reference to Fig. 4, a configuration of the outside-air supply unit 32 according to the first embodiment will be described.

[0021] The outside-air supply unit 32 includes, in addition to the heat exchanger 321 and the expansion valve 322 illustrated in Fig. 3, an air-supply-purpose blower 324, an air-exhaustion-purpose blower 325, and a heat exchanger 326. The air-supply-purpose blower 324 is a blower for supplying the outside air to the inside of the room. The air-exhaustion-purpose blower 325 is a blower for exhausting the indoor air to the outside of the room. The heat exchanger 326 is a device for heat-exchanging the outside air taken in by the air-supply-purpose blower 324 for the indoor air exhausted by the air-exhaustion-purpose blower 325.

[0022] With reference to Fig. 5, a configuration of the control apparatus 40 according to the first embodiment will be described.

[0023] The control apparatus 40 is a computer.

[0024] The control apparatus 40 includes pieces of hardware such as a processor 41, a memory 42, a storage 43, and a communication interface 44. The processor 41 is connected to the other pieces of hardware via

signal lines, and controls these other pieces of hardware.

[0025] The processor 41 is an Integrated Circuit (IC) that performs processing. The processor 41 is, as a specific example, a Central Processing Unit (CPU). The memory 42 is a storing device that stores data temporally. The memory 42 is, as a specific example, a Static Random Access Memory (SRAM) or a Dynamic Random Access Memory (DRAM). The storage 43 is a storing device that stores data. The storage 43 is, as a specific example, a Hard Disk Drive (HDD). The communication interface 44 is an interface for communicating with an external device. The communication interface 44 is, as a specific example, a port for Ethernet (registered trademark) or a Universal Serial Bus (USB).

[0026] The control apparatus 40 includes a setting unit 411, a specifying unit 412, and a controlling unit 413 as functional configuration elements. The specifying unit 412 includes a combination specifying unit 414, a load calculation unit 415, an electric power calculation unit 416, and a target specifying unit 417 as functional configuration elements. A function of each functional configuration element of the control apparatus 40 is realized by software.

[0027] The storage 43 stores a program that realizes a function of each functional configuration element of the control apparatus 40. This program is read into the memory 42 by the processor 41, and executed by the processor 41. Thereby, the function of each functional configuration element of the control apparatus 40 is realized.

[0028] In Fig. 5, each functional configuration element of the control apparatus 40 is realized by software. However, each functional configuration element of the control apparatus 40 may be realized by hardware. When each functional configuration element is realized by the hardware, the control apparatus 40 includes an electronic circuit instead of a processor 11, a memory 12, and a storage 13. The electronic circuit is a dedicated circuit that realizes functions of each functional configuration element, the memory 12, and the storage 13.

[0029] A single circuit, a composite circuit, a programmed processor, a parallel-programmed processor, a logic IC, a Gate Array (GA), an Application Specific Integrated Circuit (ASIC), or a Field-Programmable Gate Array (FPGA) is assumed as the electronic circuit. Each functional configuration element may be realized by one electronic circuit, or each functional configuration element may be distributed to a plurality of electronic circuits and realized.

*** Description of Operation ***

[0030] With reference to Figs. 6 to 11, operation of the control apparatus 40 according to the first embodiment will be described.

[0031] Operation procedure of the control apparatus 40 according to the first embodiment corresponds to a control method of the air conditioning system 10 according to the first embodiment. Further, a program that realizes the operation of the control apparatus 40 according to the first embodiment corresponds to a control program of the air conditioning system 10 according to the first embodiment.

[0032] With reference to Fig. 6, whole operation of the control apparatus 40 according to the first embodiment will be described.

(step S11: setting process)

[0033] The setting unit 411 receives input of information regarding the comfortability in the target space 50, and sets the target value regarding the comfortability in the target space 50. The comfortability is specified based on at least the temperature and the humidity. In the first embodiment, it is assumed that the PMV is used as an index for the comfortability.

[0034] Specifically, a controller of the air conditioning system 10 is operated by a user, and the information regarding the comfortability in the target space 50 such as "hot" or "cold" is input. Then, the setting unit 411 sets the target value regarding the comfortability according to the information regarding the input comfortability. For example, when the information which is "hot" is input, the setting unit 411 sets as a value of a target PMV which is the target value, a value lower than the target PMV which is currently set. Further, for example, when the information which is "cold" is input, the setting unit 411 sets as the value of the target PMV which is the target value, a value higher than the target PMV which is currently set.

(step S12: specifying process)

[0035] The specifying unit 412 specifies one combination from a plurality of combinations of temperature and humidity which satisfy the target value set in step S11.

[0036] In the first embodiment, the specifying unit 412 specifies from among the plurality of combinations of temperature and humidity which satisfy the target value set in step S11, a combination where a total electric power, which is a total of an electric power consumption of the internal conditioning machine 20 and an electric power consumption of the external conditioning machine 30 and is required for controlling the temperature and the humidity in the target space 50 to be the temperature and the humidity in the combinations, is small.

(step S13: control process)

[0037] The controlling unit 413 controls the internal conditioning machine 20 and the external conditioning machine 30 so that the temperature and the humidity in the target space 50 become the temperature and the humidity in the combination specified in step S12.

[0038] Specifically, the controlling unit 413 controls the internal conditioning machine 20 so that the temperature in the target space 50 becomes temperature in the combination specified in step S12. Further, the controlling

unit 413 controls the external conditioning machine 30 so that the humidity in the target space 50 becomes the humidity in the combination specified in step S12.

[0039] With reference to Fig. 7, the specifying process (step S12 in Fig. 6) according to the first embodiment will be described.

(step S21: combination specifying process)

[0040] The combination specifying unit 414 specifies a plurality of combinations of temperature and humidity that satisfy the target PMV which is the target value.

[0041] Note that, for a parameter other than the temperature and the humidity when the PMV is calculated, a fixed value may be used, or a value approximated from information which is obtained from a sensor may be used. Further, when there is a constraint on the temperature and the humidity which can be set as the target value, the combination does not need to be a combination of temperature and humidity which exactly match the target PMV. In other words, the target PMV may be widen to some extent.

[0042] With reference to Figs. 8 to 10, the specifying process will be specifically described.

[0043] When the target PMV is updated to a value lower than the current target PMV, as a combination of temperature and humidity which satisfy the target value, there are

[0044] (A) a case where the temperature is lowered and the absolute humidity is raised, (B) a case where the temperature and the absolute humidity are lowered, and (C) a case where the temperature is raised and the absolute humidity is lowered.

[0045] As illustrated in Fig. 8, it is assumed that the target PMV currently set is 0 and the temperature and the humidity in the target space 50 are values indicated by a point X. Then, it is assumed that the information which is "hot" is input in step S11, and the target PMV is newly set to - 0.3. A dash-dotted line L1 indicates a combination of temperature and humidity where the PMV is - 0.3. That is, with the temperature and the humidity which are indicated by a point on the dash-dotted line L1, the PMV is - 0.3. Then, the dash-dotted line L1 includes a range equivalent to the above-described cases (A), (B), and (C) relative to the temperature and the humidity which are indicated by the point X.

[0046] When the target PMV is updated to a value higher than the current target PMV, as a combination of temperature and humidity which satisfy the target value, there are

[0047] (A) a case where the temperature is lowered and the absolute humidity is raised, (B') a case where the temperature and the absolute humidity are raised, and (C) the temperature is raised and the absolute humidity is lowered.

[0048] As illustrated in Fig. 9, it is assumed that the current set target PMV is 0 and the temperature and the humidity in the target space 50 are values indicated by a point X. Then, it is assumed that the information which is "cold" is input in step S11 and the target PMV is newly set to + 0.3. A dash-dotted line L2 indicates a combination of temperature and humidity where the PMV is + 0.3. That is, with the temperature and the humidity which are indicated by a point on the dash-dotted line L2, the PMV is + 0.3. Then, the dash-dotted line L2 includes a range equivalent to the above-described cases (A), (B'), and (C) relative to the temperature and the humidity which are indicated by the point X.

[0049] As illustrated in Fig. 10, the combination specifying unit 414 specifies a plurality of combinations of temperature and humidity which satisfy the target value by extracting a plurality of points on a straight line L3 indicating the target PMV set in step S11.

[0050] Specifically, the combination specifying unit 414 extracts the plurality of points by extracting points at an arbitrary interval from a line segment of a range of temperature and humidity which can be obtained, among a straight line L3 indicating the target PMV. In Fig. 10, the combination specifying unit 414 specifies, by extracting four points, four combinations which are a combination of temperature 25.0 °C and humidity 70 %, a combination of temperature 25.5 °C and humidity 60 %, a combination of temperature 26.0 °C and humidity 50 %, and a combination of temperature 26.5 °C and humidity 40 %.

[0051] Note that, the interval to extract the points from the line segment is arbitrary. Therefore, it is acceptable if not only four points but also more points are extracted.

[0052] Note that, there is a case where one of the temperature and the absolute humidity is changed and the other one is not changed. In this case, control in which the only one to be changed is considered, is performed. That is, when the temperature is changed and the absolute humidity is not changed, it is sufficient if only the internal conditioning machine 20 is controlled in consideration of the temperature. On the other hand, when the absolute humidity is changed and the temperature is not changed, it is sufficient if only the external conditioning machine 30 is controlled in consideration of the absolute humidity.

[0053] A point on a boundary line B 1 between a range in the case of (A) and a range in the case of (B) in Fig. 8 and a point on a boundary line B3 between a range in the case of (B') and a range in the case of (C) in Fig. 9 are a combination in the case where the temperature is changed and the absolute humidity is not changed. Further, a point on a boundary line B2 between a range in the case of (B) and a range in the case of (C) in Fig. 8 and a point on a boundary line B4 between a range in the case of (A) and a range in the case of (B') in Fig. 9 are a combination in the case where the absolute humidity is changed and the temperature is not changed.

(step S22: a load calculation process)

[0054] The load calculation unit 415 calculates, by tar-

geting each of the plurality of combinations specified in step S21, a sensible heat load and a latent heat load which are for changing the temperature and the humidity in the target space 50 to the temperature and the humidity in the target combinations. A method of calculating the sensible heat load and the latent heat load may be any method.

[0055] For example, the load calculation unit 415 calculates the sensible heat load and the latent heat load by plugging into a theoretical formula, pieces of information such as outside-air temperature and outside-air humidity, and the temperature and the humidity in the target combination. Note that, the load calculation unit 415 can acquire the outside-air temperature by the temperature detection device 24 and acquire the outside-air humidity by the humidity detection device 34.

[0056] Further, for example, the load calculation unit 415 generates a first correlation equation between: a difference ΔT between the outside-air temperature and the temperature in the target combination; and the sensible heat load. Further, the load calculation unit 415 generates a second correlation equation between: a difference Δx between the outside-air humidity and the humidity in the target combination; and the latent heat load. Then, the load calculation unit 415 calculates the sensible heat load by plugging the difference ΔT into the first correlation equation. Further, the load calculation unit 415 calculates the sensible heat load by plugging the difference Δx into the second correlation equation.

[0057] Further, for example, the load calculation unit 415 generates, by using machine learning or the like, a model for calculating the sensible heat load and the latent heat load based on pieces of information such as the outside-air temperature, the outside-air humidity, and the temperature and the humidity in the target combination. Then, the load calculation unit 415 calculates the sensible heat load and the latent heat load by inputting into the model, pieces of information such as the outside-air temperature and the outside-air humidity, and the temperature and the humidity in the target combination.

(step S23: electric power calculation process)

[0058] The electric power calculation unit 416 calculates, by targeting each of the plurality of combinations specified in step S21, a total electric power required for controlling the temperature and the humidity in the target space 50 to be the temperature and the humidity in the target combination based on the sensible heat load and the latent heat load which are calculated in step S22 for the target combination.

[0059] Specifically, the electric power calculation unit 416 simulates an operation state of the internal conditioning machine 20 in a case of processing the sensible heat load calculated for the target combination, and calculates the electric power consumption of the internal conditioning machine 20. Further, the electric power calculation unit 416 simulates an operation state of the external conditioning machine 30 in a case of processing the latent heat load calculated for the target combination, and calculates the electric power consumption of the external conditioning machine 30. Then, the electric power calculation unit 416 calculates a total electric power by totaling the electric power consumption of the internal conditioning machine 20 and the electric power consumption of the external conditioning machine 30.

[0060] Note that, the electric power consumptions calculated here are things that are used for comparison between combinations. Consequently, it is important that a magnitude relation between the calculated electric power consumptions is correct, and accuracy of an absolute value of the electric power consumption is unimportant.

(step S24: target specifying process)

[0061] The target specifying unit 417 specifies a combination where the calculated total electric power is small among the plurality of combinations specified in step S21.

[0062] For example, as illustrated in Fig. 11, it is assumed that the sensible heat load and the latent heat load are calculated for the four points illustrated in Fig. 10, and further, the total electric power is calculated. In this case, the target specifying unit 417 specifies the combination of temperature 26.0 °C and humidity 50 °C where the total electric power is smallest.

[0063] A control process (step S13 in Fig. 6) according to the first embodiment will be described.

[0064] As the combination of temperature and humidity which satisfy the target value, there are (A) a case where the temperature is lowered and the absolute humidity is raised, (B) the temperature and the absolute humidity are lowered, (C) the temperature is raised and the absolute humidity is lowered, and (B') the temperature and the absolute humidity are raised.

[0065] In the case of (A), at a time of cooling and dehumidifying operation, the controlling unit 413 raises sensible-heat cooling ability and lowers latent-heat cooling ability by raising ability of the internal conditioning machine 20 and lowering ability of the external conditioning machine 30. At a time of heating and humidifying operation, the controlling unit 413 lowers sensible-heat heating ability and raises latent-heat heating ability by lowering the ability of the internal conditioning machine 20 and raising the ability of the external conditioning machine 30. For example, at a time of the cooling and dehumidifying operation, the controlling unit 413 lowers refrigerant evaporating temperature of the internal conditioning machine 20, raises sensible-heat ability, raises the refrigerant evaporating temperature of the external conditioning machine 30, and lowers latent-heat ability.

[0066] In the case of (B), at a time of the cooling and dehumidifying operation, the controlling unit 413 raises the sensible-heat cooling ability and the latent-heat cooling ability by raising the ability of the internal conditioning machine 20 and raising the ability of the external conditioning machine 30. At a time of the heating and humid-

ifying operation, the controlling unit 413 lowers the sensible-heat heating ability and the latent-heat heating ability by lowering the ability of the internal conditioning machine 20 and lowering the ability of the external conditioning machine 30. For example, at a time of the cooling and dehumidifying operation, the controlling unit 413 lowers the refrigerant evaporating temperature of the internal conditioning machine 20 and the external conditioning machine 30, and raises the sensible-heat ability and the latent-heat ability.

[0067] In the case of (C), at a time of the cooling and dehumidifying operation, the controlling unit 413 lowers the sensible-heat colling ability and raises the latent-heat cooling ability by lowering the ability of the internal conditioning machine 20 and raising the ability of the external conditioning machine 30. At a time of the heating and humidifying operation, the controlling unit 413 raises the sensible-heat heating ability and lowers the latent-heat heating ability by raising the ability of the internal conditioning machine 20 and lowering the ability of the external conditioning machine 30. For example, at a time of the cooling and dehumidifying operation, the controlling unit 413 raises the refrigerant evaporating temperature of the internal conditioning machine 20, lowers the sensible-heat ability, lowers the refrigerant evaporating temperature of the external conditioning machine 30, and raises the latent-heat ability.

[0068] In the case of (B'), at a time of the cooling and dehumidifying operation, the controlling unit 413 lowers the sensible-heat cooling ability and the latent-heat cooling ability by lowering the ability of the internal conditioning machine 20 and lowering the ability of the external conditioning machine 30. At a time of the heating and humidifying operation, the controlling unit 413 raises the sensible-heat heating ability and the latent-heat heating ability by raising the ability of the internal conditioning machine 20 and raising the ability of the external conditioning machine 30. For example, at a time of the cooling and dehumidifying operation, the controlling unit 413 raises the refrigerant evaporating temperature of the internal conditioning machine 20 and the external conditioning machine 30, and lowers the sensible-heat ability and the latent-heat ability.

*** Effect of First Embodiment ***

[0069] As described above, in the air conditioning system 10 according to the first embodiment, the control apparatus 40 sets the target value for the comfortability, and controls both the internal conditioning machine 20 and the external conditioning machine 30 based on the target value. Both the internal conditioning machine 20 and the external conditioning machine 30 are controlled, proper control based on the comfortability is possible.

[0070] Further, in the air conditioning system 10 according to the first embodiment, the control apparatus 40 specifies a combination where the total electric power is small, from among a plurality of combinations of temperature and humidity which satisfy the target value for the comfortability. Then, the control apparatus 40 controls the internal conditioning machine 20 and the external conditioning machine 30 so that the temperature and the humidity in the target space 50 become the temperature and the humidity in the specified combination. Therefore, it is possible to realize control of the air conditioning system which lowers the electric power consumption.

[0071] The temperature and the humidity in the indoor space are elements that give influence on the comfortability in the indoor space. When the PMV is used as an index, there are a plurality of combinations of temperature and humidity which have the same PMV. Depending on the combination of temperature and humidity, values of the sensible heat load and the latent heat load are changed. For example, at a time of cooling operation, if set temperature is lowered and set humidity is raised, the sensible heat load is raised and the latent heat load is lowered. Further, at a time of cooling operation, if the set temperature is raised and the set humidity is lowered, the sensible heat load is lowered and the latent heat load is raised.

[0072] That is, in latent heat and sensible heat separating air conditioning, depending on the combination of set temperature and set humidity, load required for processing each of the internal conditioning machine and the external conditioning machine is changed. For this reason, depending on the combination of set temperature and set humidity, electric power consumption for a whole air conditioning system 10 is changed. Therefore, when the temperature and the humidity are decided by a user, there is a possibility that the electric power consumption is higher compared to a case where another combination of temperature and humidity where the same comfortability is obtained is set.

*** Other Configurations ***

< First Modification Example >

[0073] In the first embodiment, the specifying unit 412 specifies the plurality of combinations of temperature and humidity which satisfy the target value for the comfortability, calculates the total electric power for each of all combinations, and specifies the combination where the total electric power is small.

[0074] As a first modification example, by using an optimizing method, the specifying unit 412 may specify the combination where the target value for the comfortability is satisfied and the total electric power is small. Specifically, the specifying unit 412 specifies a combination where the total electric power is small, by the optimizing method by using as an objective function, a function which minimizes the total electric power, and using as a constraint condition, the combination of temperature and humidity satisfying the target value.

< Second Modification Example >

[0075] In the first embodiment, the PMV is used as the index for the comfortability. However, the index for the comfortability is not limited to the PMV. As the index for the comfortability, another index may be used as long as the index is calculated from at least the temperature and the humidity.

< Third Modification Example >

[0076] In the first embodiment, the internal conditioning machine 20 and the external conditioning machine 30 are a configuration of a direct expansion form. However, at least one of the internal conditioning machine 20 and the external conditioning machine 30 does not need to be a configuration of the direct expansion form as long as the configuration is a form where the air conditioning ability is adjustable.

Second Embodiment.

[0077] A second embodiment is different from the first embodiment in that: in an electric power calculation process, an operation point for the internal conditioning machine 20 and the external conditioning machine 30 where the electric power consumption is small, is specified; the total electric power is calculated by using an electric power consumption in the specified operation point; and in a control process, the internal conditioning machine 20 and the external conditioning machine 30 are controlled in the specified operation point. In the second embodiment, these different matters will be described, and descriptions of the same matters will be omitted.

*** Description of Operation ***

[0078] With reference to Fig. 7, a specifying process (step S12 in Fig. 6) according to the second embodiment will be described.

[0079] A process of step S23 is different from the first embodiment.

[0080] In step S23, the electric power calculation unit 416 calculates, by targeting each of the plurality of combinations specified in step S21, a total electric power required for controlling the temperature and the humidity in the target space to be the temperature and the humidity in the target combination. At this time, the electric power calculation unit 416 calculates a total electric power required when an ability setting where the electric power consumption is small is adopted, from among ability settings of each of the internal conditioning machine 20 and the external conditioning machine 30 for controlling the temperature and the humidity in the target space 50 to be the temperature and the humidity in the target combination.

[0081] Specifically, the internal conditioning machine 20 and the external conditioning machine 30 can change an ability setting such as refrigerant evaporating temperature. The electric power calculation unit 416 specifies an operation point of the ability setting such as the refrigerant evaporating temperature of the internal conditioning machine 20 where the electric power consumption is small, when a sensible heat load calculated for the target combination is processed. The electric power calculation unit 416 calculates the electric power consumption of the internal conditioning machine 20 required when the specified ability setting of the operation point is adopted. Further, the electric power calculation unit 416 specifies an operation point of the ability setting such as the refrigerant evaporating temperature of the external conditioning machine 30 where the electric power consumption is small, when the latent heat load calculated for the target combination is processed. The electric power calculation unit 416 calculates a power electric consumption of the external conditioning machine 30 required when the specified ability setting of the operation point is adopted. Then, the electric power calculation unit 416 calculates a total electric power by totaling the electric power consumption of the internal conditioning machine 20 and the electric power consumption of the external conditioning machine 30.

[0082] A control process (step S13 in Fig. 6) according to the second embodiment will be described.

[0083] The controlling unit 413 controls the internal conditioning machine 20 in the ability setting adopted when the electric power consumption of the internal conditioning machine 20 is calculated in step S23. Further, the controlling unit 413 controls the external conditioning machine 30 in the ability setting adopted when the electric power consumption of the external conditioning machine 30 is calculated in step S23.

*** Effect of Second Embodiment ***

[0084] As described above, in the air conditioning system 10 according to the second embodiment, the control apparatus 40 specifies a combination of the temperature and the humidity based on the electric power consumption in the ability setting where the electric power consumption is small. Then, the control apparatus 40 causes the internal conditioning machine 20 and the external conditioning machine 30 to operate in the ability setting where the electric power consumption is small. Therefore, it is possible to obtain effect of energy saving assumed when the combination of temperature and humidity is specified.

[0085] In the first embodiment, the controlling unit 413 controls the internal conditioning machine 20 and the external conditioning machine 30 based on: the combination of temperature and humidity; and an environment condition when the internal conditioning machine 20 and the external conditioning machine 30 are controlled. Thus, for a reason that the environment condition is different from a time when the combination of temperature and humidity is specified, there is a possibility that the

effect of the energy saving assumed when the combination of temperature and humidity is specified, cannot be obtained.

[0086] Compared to this, in the second embodiment, even if the environment condition is different from a time when the combination of temperature and humidity is specified, the internal conditioning machine 20 and the external conditioning machine 30 are controlled in the ability setting, where the electric consumption is small, adopted when the electric power consumption is calculated. Therefore, it is possible to obtain the effect of the energy saving assumed when the combination of temperature and humidity is specified.

[0087] Note that, for a reason that the environment condition is different from a time when the combination of temperature and humidity is specified, even if the control process (step S13 in Fig. 6) is performed, there is a possibility that the temperature and the humidity in the target space 50 deviate largely from the temperature and the humidity in the combination. If this happens, the controlling unit 413 may control and switch the internal conditioning machine 20 and the external conditioning machine 30 according to the temperature and the humidity in the combination as with the first embodiment.

Third Embodiment.

[0088] A third embodiment is different from the first and second embodiments in that conditions regarding the comfortability other than the temperature and the humidity are considered. In the third embodiment, this different matter will be described, and descriptions of the same matters will be omitted.

[0089] In the third embodiment, a case of adding modification to the first embodiment will be described. However, it is possible to add modification to the second embodiment.

*** Description of Operation ***

[0090] In the third embodiment, a case of considering average wind speed in the target space 50 as a condition regarding the comfortability other than the temperature and the humidity, will be described. Note that, the average wind speed may be called an average wind volume. The average wind speed is included as a parameter used when the PMV is calculated. Therefore, if the average wind speed is changed, the PMV is also changed.

[0091] With reference to Fig. 6, whole operation of the control apparatus 40 according to the third embodiment will be described.

[0092] Processes of step S12 and step S13 are different from the first embodiment.

[0093] In step S12, the specifying unit 412 specifies one combination among a plurality of combinations of temperature, humidity, and wind speed which satisfy the targe value set in step S11. In the third embodiment, the specifying unit 412 specifies from among a plurality of combinations of the temperature, the humidity, and the wind speed which satisfy the target value, a combination where a total electric power, which is a total of the electric power consumption of the internal conditioning machine 20 and the electric power consumption of the external conditioning machine 30 and is required for controlling the temperature, the humidity, and the wind speed in the target space 50 to be the temperature, the humidity, and the wind speed in the combinations, is small.

[0094] The controlling unit 413 controls the internal conditioning machine 20 and the external conditioning machine 30 so that the temperature, the humidity, and the wind speed in the target space 50 become the temperature, the humidity, and the wind speed in the combination specified in step S12.

[0095] For example, the controlling unit 413 specifies, by a method such as actual measurement or simulation, a change in the average wind speed in the target space 50 in a case of changing at least one of conditions of blowing air wind-speed and wind direction of the internal conditioning machine 20 or the external conditioning machine 30. With reference to the change in the average wind speed corresponding to the change in the condition, the controlling unit 413 changes at least one of the blowing air wind-speed and the wind direction of the internal conditioning machine 20 or the external conditioning machine 30 so that the wind speed in the target space 50 becomes the wind speed in the combination specified in step S12.

[0096] With reference to Fig. 7, a specifying process (step S12 in Fig. 6) according to the third embodiment will be described.

[0097] Processes of step S21 and step S23 are different from the first embodiment.

[0098] In step S21, the combination specifying unit 414 specifies a plurality of combinations of temperature, humidity, and wind speed which satisfy a target PMV which is the target value.

[0099] In step S23, the electric power calculation unit 416 calculates, by targeting each of the plurality of combinations specified in step S21, a total electric power required for controlling the temperature, the humidity, and the wind speed in the target space to be the temperature, the humidity, and the wind speed in the target combination.

[0100] The electric power calculation unit 416 calculates an electric power consumption required when at least one of the blowing air-wind speed and the wind direction is changed, for at least one of the internal conditioning machine 20 and the external conditioning machine 30 so that the wind speed becomes the wind speed in the target combination. Then, the electric power calculation unit 416 calculates the total electric power in consideration of the electric power consumption required when at least one of the blowing air wind-speed and the wind direction is changed.

*** Effect of Third Embodiment ***

[0101] As described above, in the air conditioning system 10 according to the third embodiment, the control apparatus 40 considers the conditions regarding the comfortability other than the temperature and the humidity. As a result, the more proper control than control based on the comfortability is possible.

[0102] The embodiments and the modification examples of the present invention have been described above. Some of these embodiments and the modification examples may be combined and implemented. Further, any one or some may be partially implemented. Note that, the present invention is not limited to the above embodiments and modification examples, and various types of modifications can be made as necessary.

Reference Signs List

[0103] 10: air conditioning system, 20: internal conditioning machine, 21: outdoor unit, 22: indoor unit, 23: refrigerant pipe, 24: temperature detection device, 25: temperature detection device, 211: compressor, 212: four-way valve, 213: outdoor heat-exchanger, 214: outdoor fan, 215: refrigerant pipe, 221: indoor heat-exchanger, 222: expansion valve, 223: indoor fan, 224: refrigerant pipe, 30: external conditioning machine, 31: outdoor unit, 32: outside-air supply unit, 33: refrigerant pipe, 34: humidity detection device, 35: humidity detection device, 311: compressor, 312: four-way valve, 313: outdoor heat-exchanger, 314: outdoor fan, 315: refrigerant pipe, 321: heat exchanger, 322: expansion valve, 323: refrigerant pipe, 324: air-supply-purpose blower, 325: air-exhaustion-purpose blower, 326: heat exchanger, 40: control apparatus, 41: processor, 42: memory, 43: storage, 44: communication interface, 411: setting unit, 412: specifying unit, 413: controlling unit, 414: combination specifying unit, 415: load calculation unit, 416: electric power calculation unit, 417: target specifying unit, 50: target space.

Claims

1. A control apparatus controlling an air conditioning system including: an internal conditioning machine which takes in air from inside of a target space, adjusts temperature of the air, and then outputs the air to the target space; and an external conditioning machine which takes in air from outside of the target space, adjusts temperature of the air, and then outputs the air to the target space, comprising:

   a setting unit to receive input of information regarding comfortability in the target space, and set a target value for the comfortability; and
   a controlling unit to control both the internal conditioning machine and the external conditioning machine based on the target value set by the setting unit.

2. The control apparatus according to claim 1,

   wherein the comfortability is specified based on at least temperature and humidity,
   wherein the control apparatus further comprises a specifying unit to specify from among a plurality of combinations of temperature and humidity which satisfy the target value for the comfortability set by the setting unit, a combination where a total electric power, which is a total of electric power of the internal conditioning machine and electric power of the external conditioning machine and is required for controlling temperature and humidity in the target space to be the temperature and the humidity in the combinations, is small, and
   wherein the controlling unit controls the internal conditioning machine and the external conditioning machine so that temperature and the humidity in the target space become the temperature and the humidity in the combination specified by the specifying unit.

3. The control apparatus according to claim 2, wherein the specifying unit comprises:

   a combination specifying unit to specify the plurality of combinations of temperature and humidity which satisfy the target value;
   a load calculation unit to calculate a sensible heat load and a latent heat load which are required for changing, by targeting each of the plurality of combinations specified by the combination specifying unit, the temperature and the humidity in the target space to temperature and humidity in the target combination;
   an electric power calculation unit to calculate, by targeting each of the plurality of combinations, the total electric power required for controlling the temperature and the humidity in the target space to be the temperature and the humidity in the target combination, based on the sensible heat load and the latent heat load which are calculated by the load calculation unit for the target combination; and
   a target specifying unit to specify a combination where the total electric power calculated by the electric power calculation unit is small, and
   wherein the controlling unit controls the internal conditioning machine and the external conditioning machine so that the temperature and the humidity in the target space become the temperature and the humidity in the combination specified by the target specifying unit.

4. The control apparatus according to claim 3,

wherein the electric power calculation unit calculates the total electric power when ability setting where an electric power consumption is small is adopted from among ability settings of each of the internal conditioning machine and the external conditioning machine for controlling the temperature and the humidity in the target space to be the temperature and the humidity in the target combination, and
wherein the controlling unit controls the internal conditioning machine and the external conditioning machine in the ability setting adopted when the total electric power is calculated.

5. The control apparatus according to claim 2,

wherein the comfortability is specified based on temperature, humidity, and other conditions,
wherein the control apparatus further comprises a specifying unit to specify from among a plurality of combinations of temperature, humidity, and the other conditions which satisfy the target value for the comfortability set by the setting unit, a combination where a total electric power, which is a total of an electric power consumption of the internal conditioning machine and an electric power consumption of the external conditioning machine and is required for controlling temperature, humidity, and other conditions in the target space to be temperature, humidity, and other conditions in the combinations, is small, and
wherein the controlling unit controls the internal conditioning machine and the external conditioning machine so that the temperature, the humidity, and the other conditions in the target space become the temperature, the humidity, and the other conditions in the combination specified by the specifying unit.

6. The control apparatus according to claim 2,
wherein the specifying unit specifies the combination where the total electric power is small, by an optimizing method by using as an objective function, a function which minimizes the total electric power, and using as a constraint condition, the combination of temperature and humidity satisfying the target value.

7. The control apparatus according to any one of claims 1 to 6,
wherein the controlling unit, if the temperature and the humidity which realize the specified target value, as compared to the temperature and the humidity in the target space, have:

lower temperature and higher humidity, raises ability of the internal conditioning machine and lowers ability of the external conditioning machine at a time of cooling and dehumidifying operation, and lowers the ability of the internal conditioning machine and raises the ability of the external conditioning machine at a time of heating and humidifying operation;
lower temperature and lower humidity, raises the ability of the internal conditioning machine and raises the ability of the external conditioning machine at a time of the cooling and dehumidifying operation, and lowers the ability of the internal conditioning machine and lowers the ability of the external conditioning machine at a time of the heating and humidifying operation;
higher temperature and lower humidity, lowers the ability of the internal conditioning machine and raises the ability of the external conditioning machine at a time of the cooling and dehumidifying operation, and raises the ability of the internal conditioning machine and lowers the ability of the external conditioning machine at a time of the heating and humidifying operation; and
higher temperature and higher humidity, lowers the ability of the internal conditioning machine and lowers the ability of the external conditioning machine, and raises the ability of the internal conditioning machine and raises the ability of the external conditioning machine at a time of the heating and humidifying operation.

8. An air conditioning system including: an internal conditioning machine which takes in air from inside of a target space, adjusts temperature of the air, and then outputs the air to the target space; an external conditioning machine which takes in air from outside of the target space, adjusts temperature of the air, and then outputs the air to the target space; and a control apparatus, the control apparatus comprising:

a setting unit to receive input of information regarding comfortability in the target space, and set a target value for the comfortability; and
a controlling unit to control both the internal conditioning machine and the external conditioning machine based on the target value set by the setting unit.

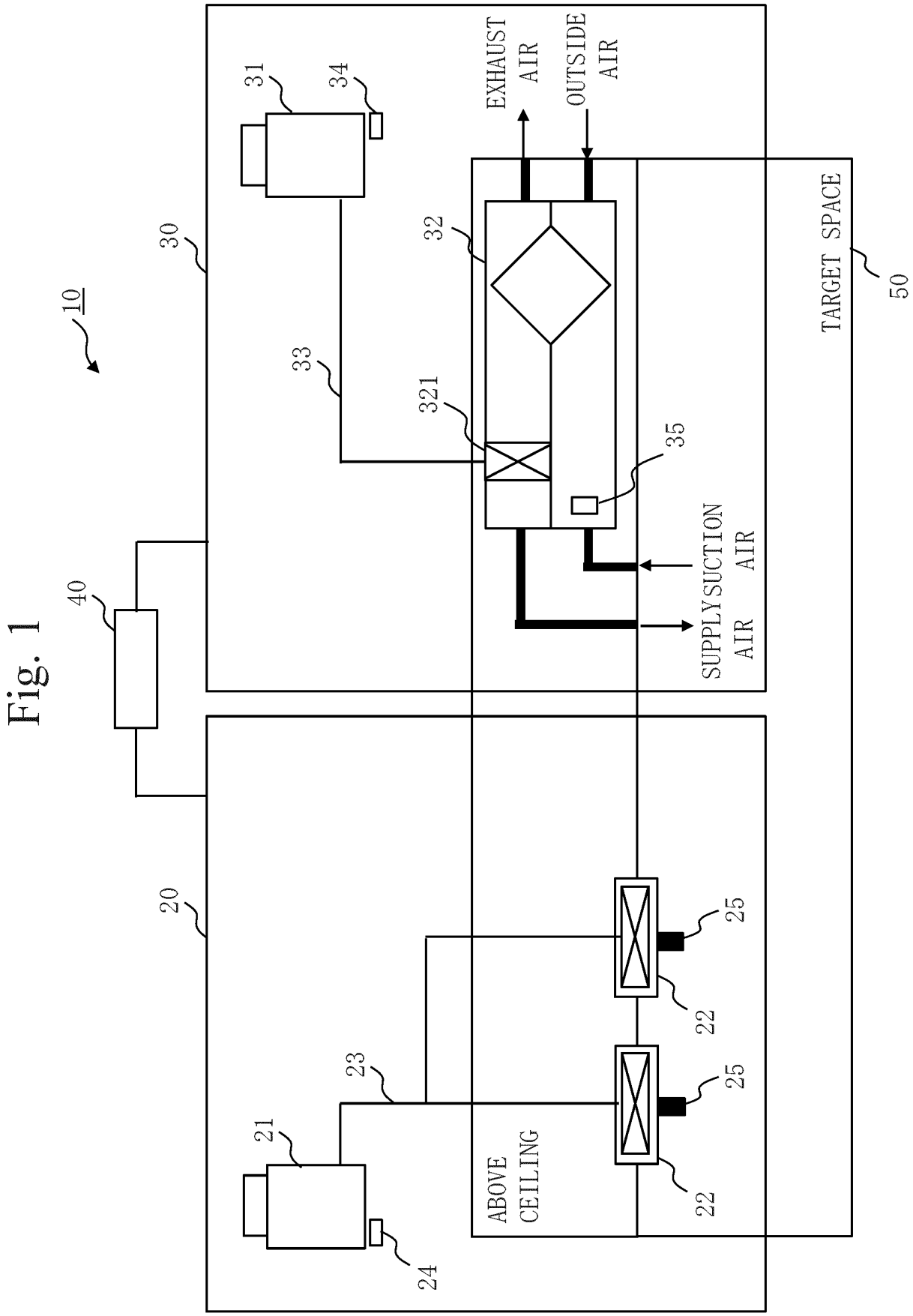
9. A control method of an air conditioning system including: an internal conditioning machine which takes in air from inside of a target space, adjusts temperature of the air, and then outputs the air to the target space; and an external conditioning machine which takes in air from outside of the target space, adjusts temperature of the air, and then outputs the air to the target space, comprising:

receiving, by a control apparatus, input of information regarding comfortability in the target

space, and setting a target value for the comfortability; and

controlling, by the control apparatus, both the internal conditioning machine and the external conditioning machine based on the set target value.

Fig. 1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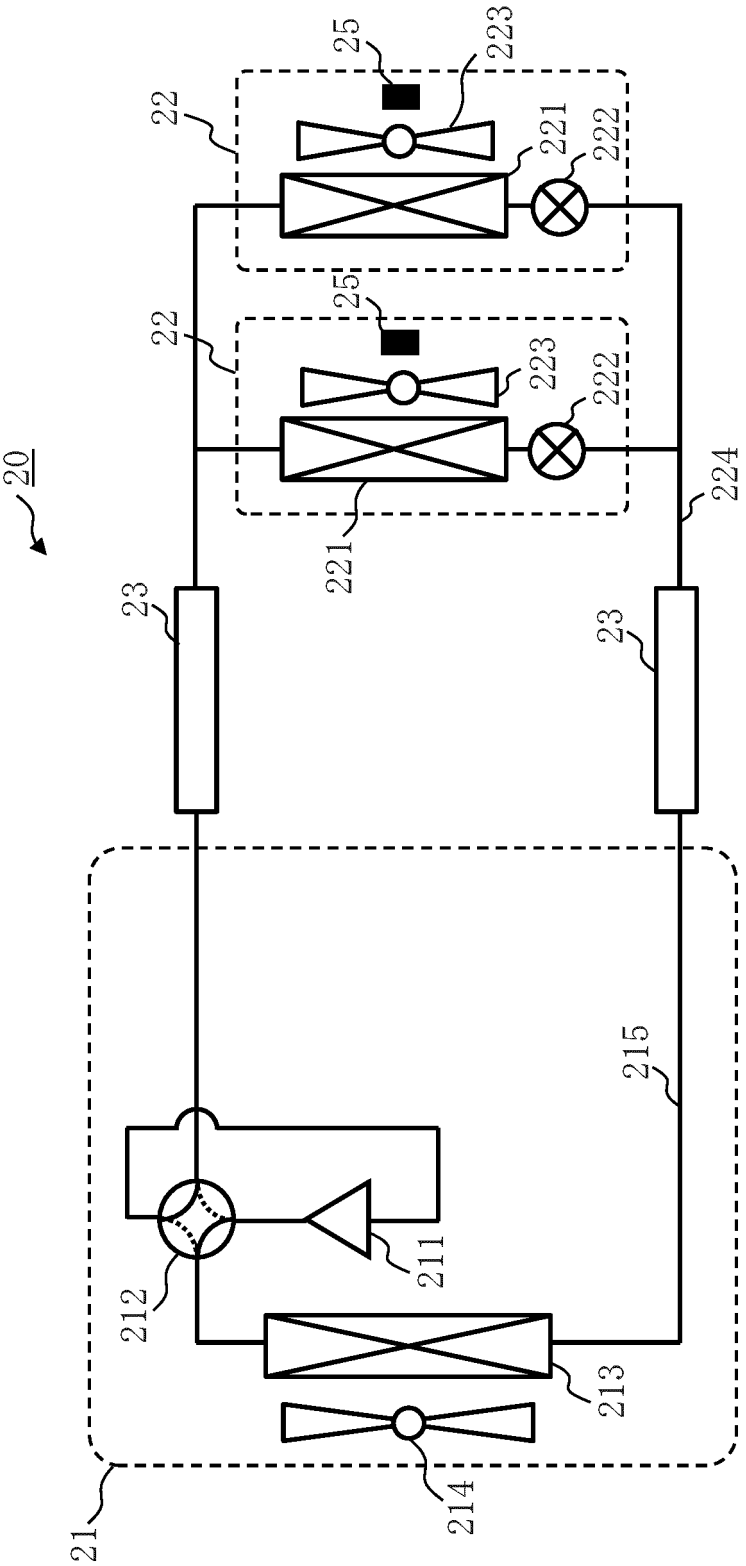
50
321
EXHAUST AIR
OUTSIDE AIR
SUPPLY AIR
SUCTION AIR
TARGET SPACE
ABOVE CEILING

Fig. 2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223
223

Fig. 3

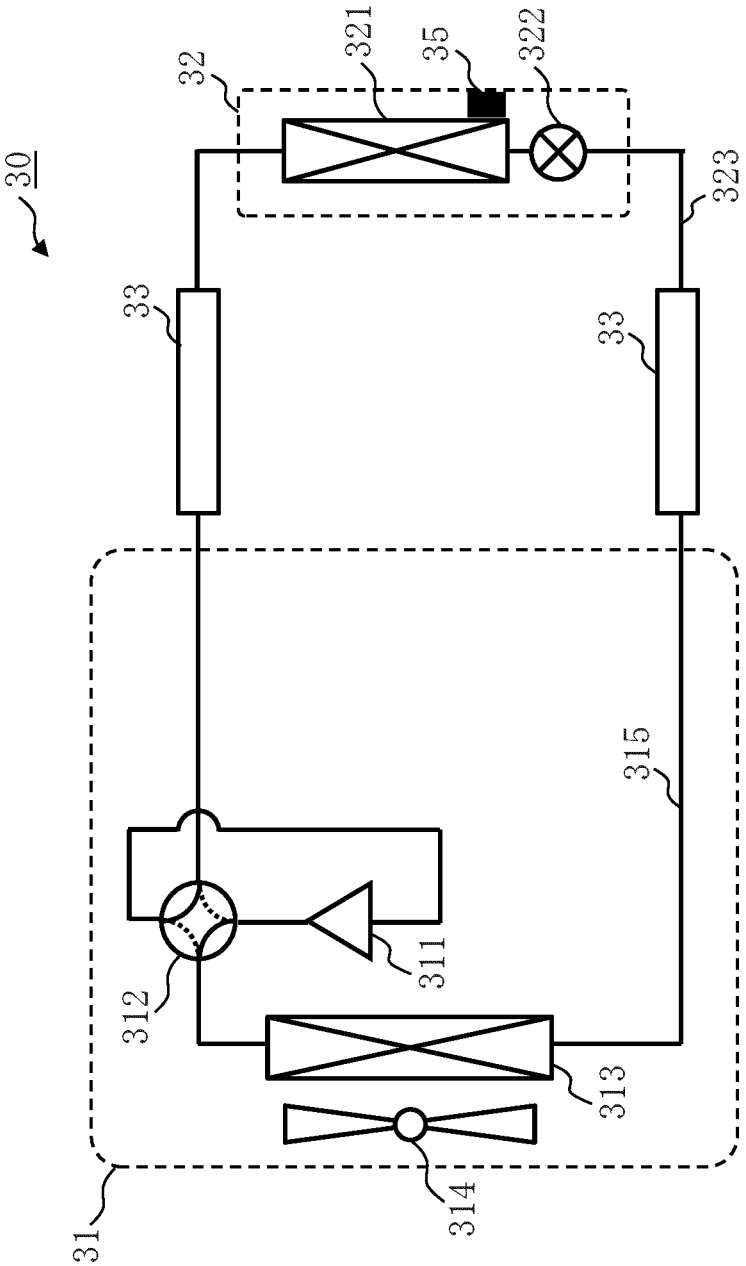


Fig. 4

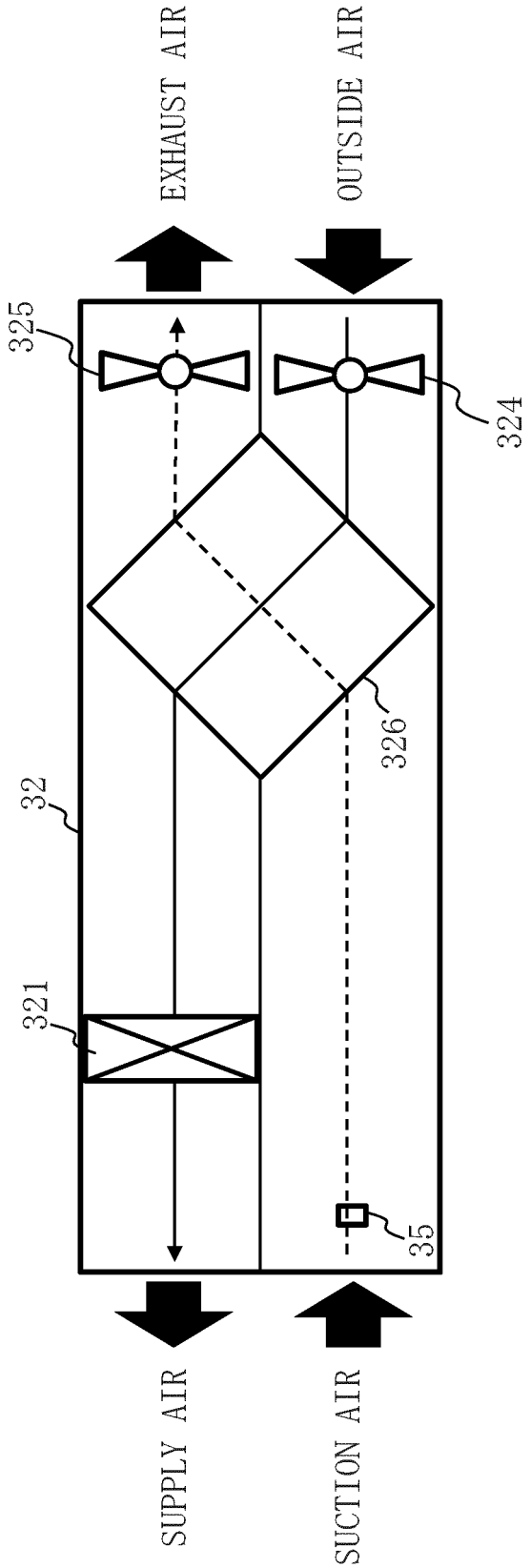

EXHAUST AIR
OUTSIDE AIR
325
324
326
32
321
35
SUPPLY AIR
SUCTION AIR

Fig. 5

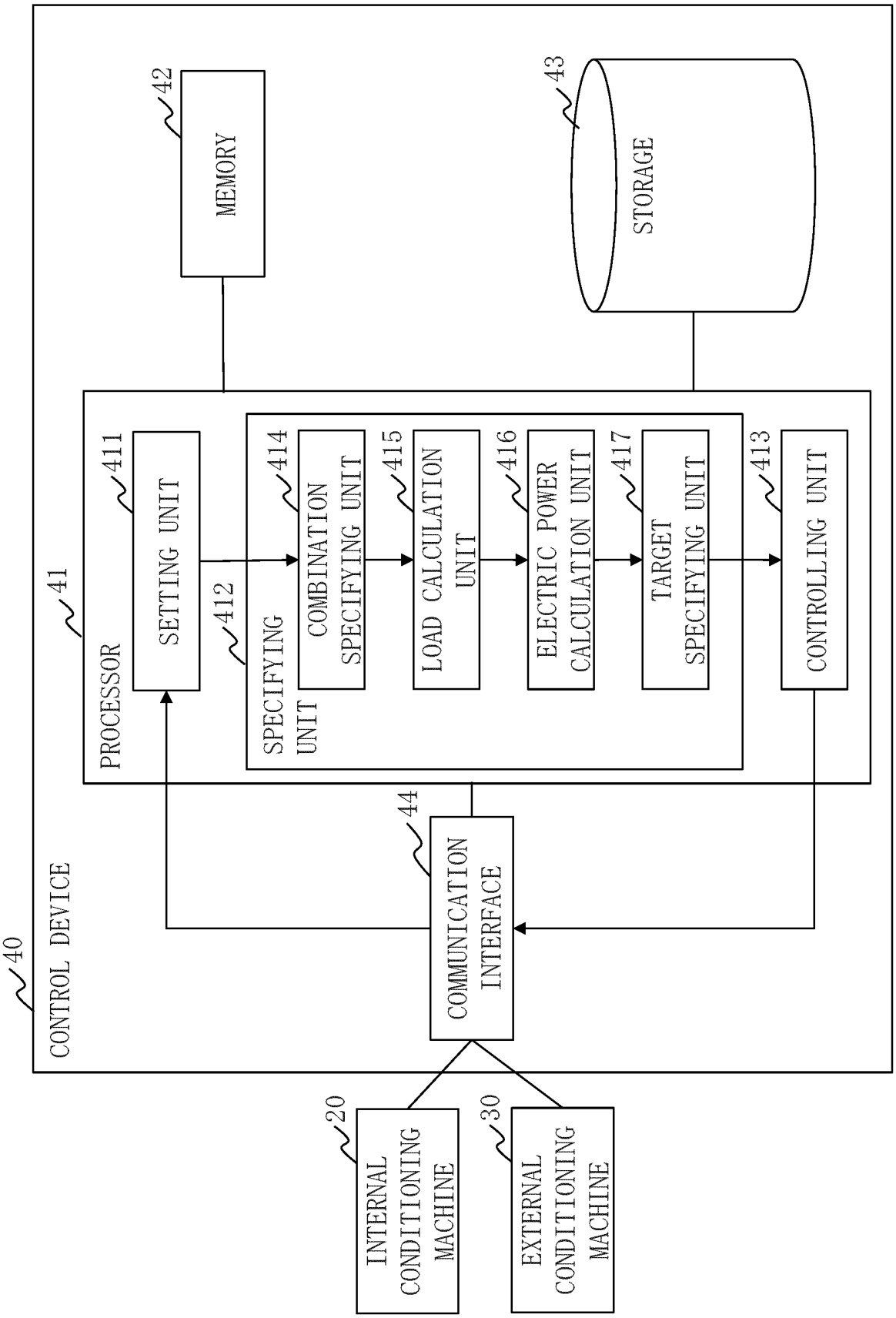

40
CONTROL DEVICE
41
PROCESSOR
411
SETTING UNIT
412
SPECIFYING UNIT
414
COMBINATION SPECIFYING UNIT
415
LOAD CALCULATION UNIT
416
ELECTRIC POWER CALCULATION UNIT
417
TARGET SPECIFYING UNIT
413
CONTROLLING UNIT
42
MEMORY
43
STORAGE
44
COMMUNICATION INTERFACE
20
INTERNAL CONDITIONING MACHINE
30
EXTERNAL CONDITIONING MACHINE

Fig. 6

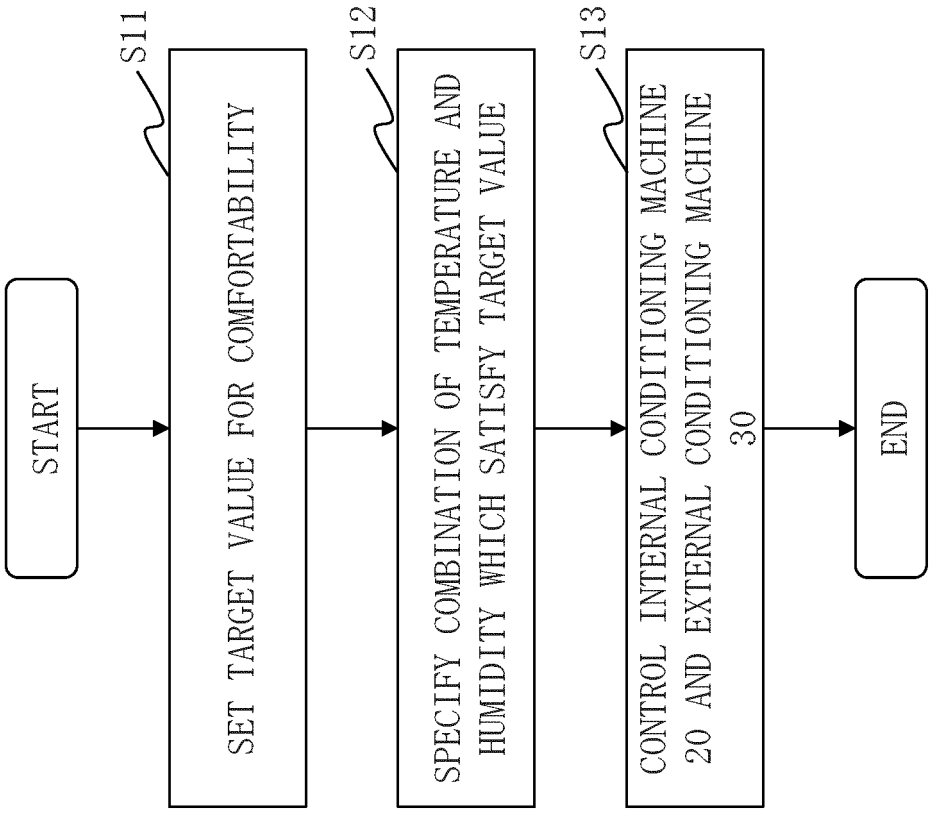

START
S11
SET TARGET VALUE FOR COMFORTABILITY
S12
SPECIFY COMBINATION OF TEMPERATURE AND HUMIDITY WHICH SATISFY TARGET VALUE
S13
CONTROL INTERNAL CONDITIONING MACHINE 20 AND EXTERNAL CONDITIONING MACHINE 30
END

Fig. 7

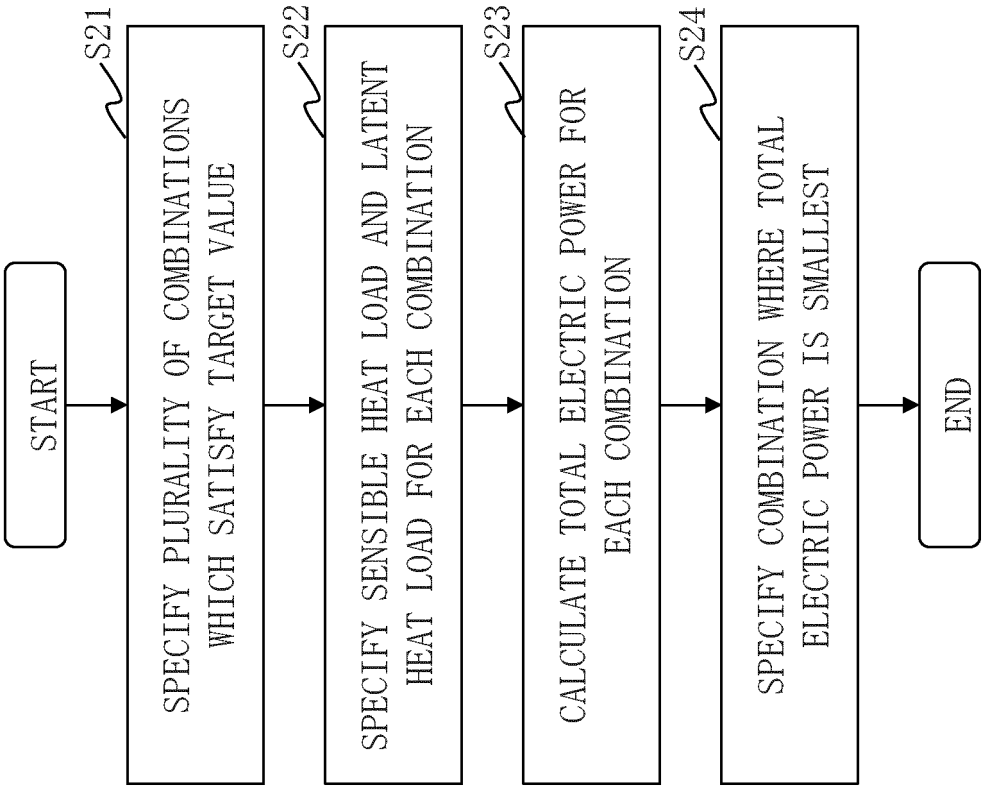

START
S21
SPECIFY PLURALITY OF COMBINATIONS WHICH SATISFY TARGET VALUE
S22
SPECIFY SENSIBLE HEAT LOAD AND LATENT HEAT LOAD FOR EACH COMBINATION
S23
CALCULATE TOTAL ELECTRIC POWER FOR EACH COMBINATION
S24
SPECIFY COMBINATION WHERE TOTAL ELECTRIC POWER IS SMALLEST
END

Fig. 8

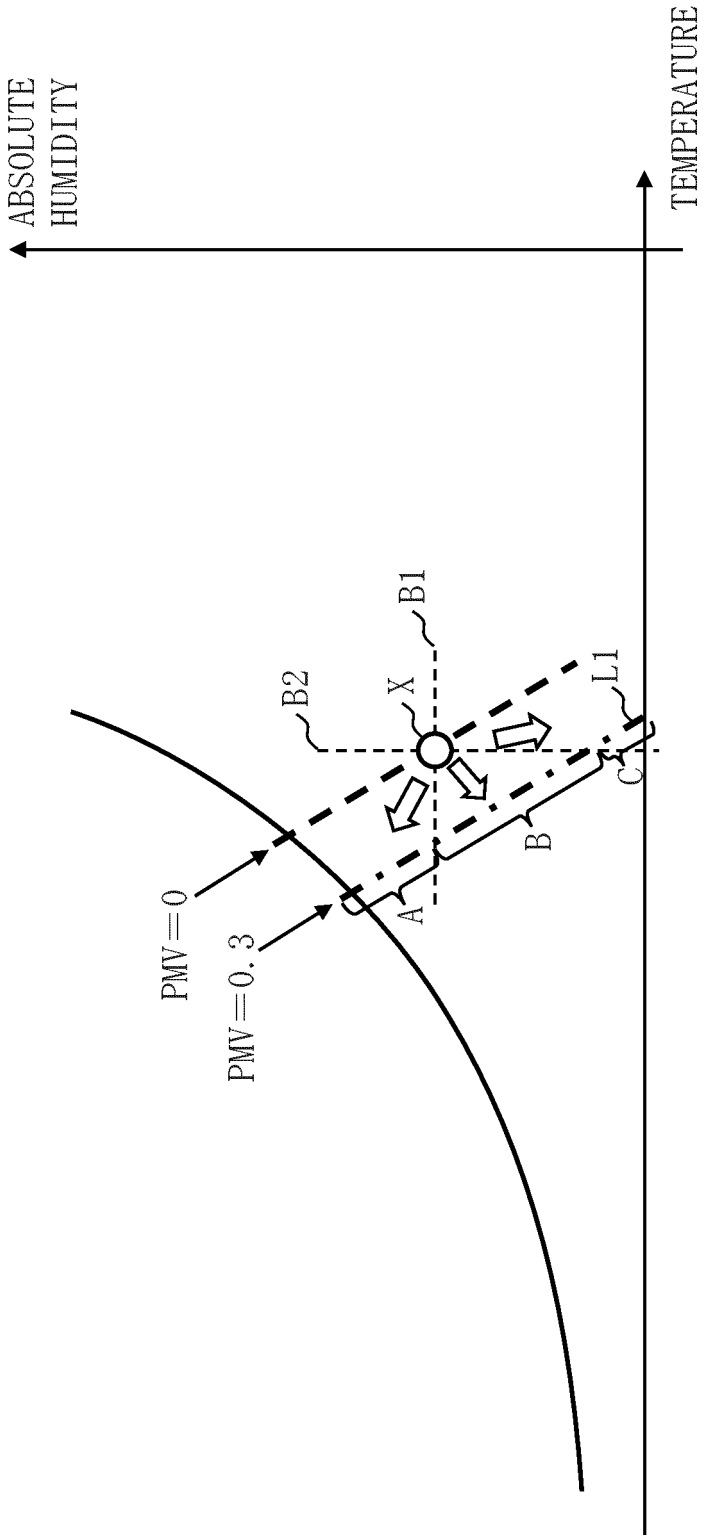


Fig. 9

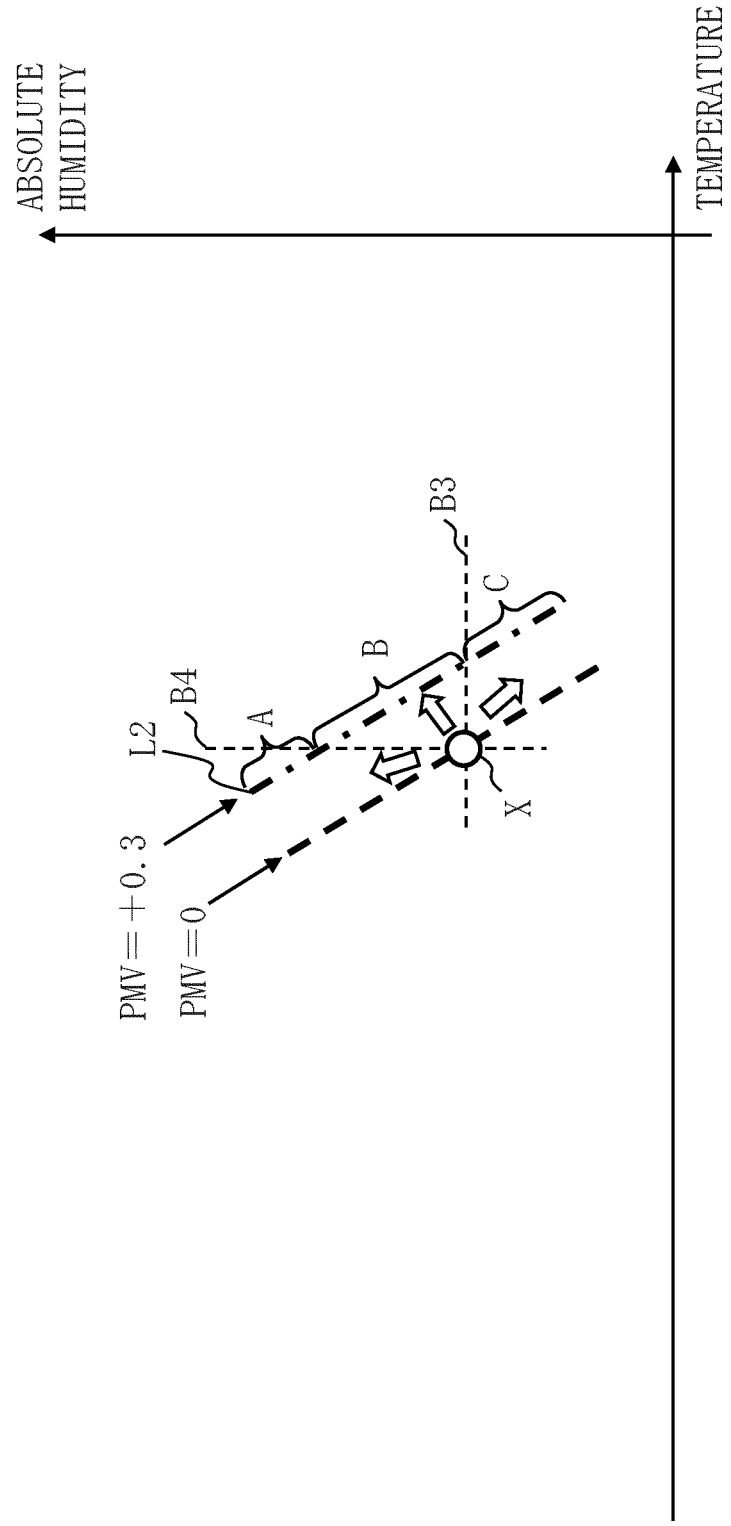


Fig. 10

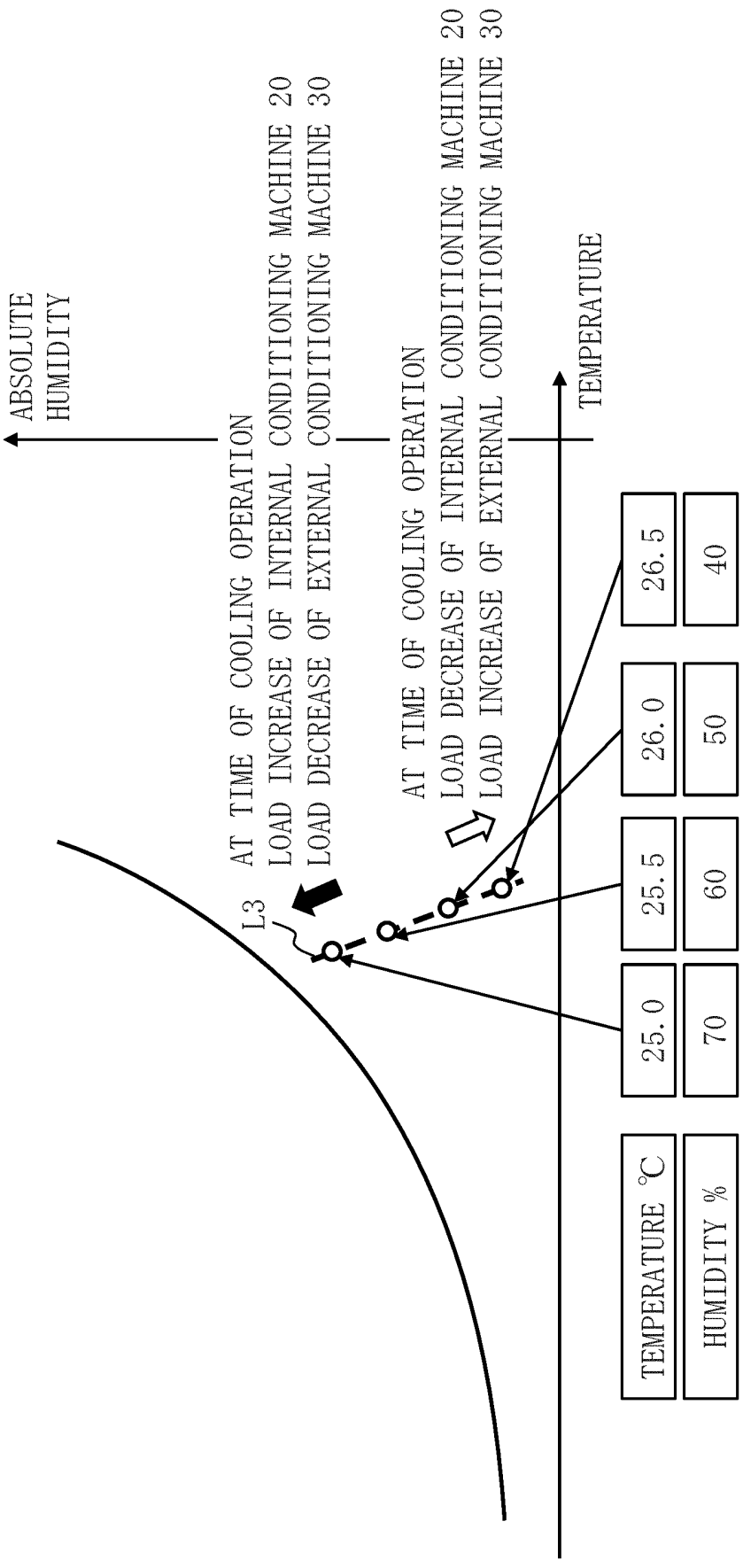
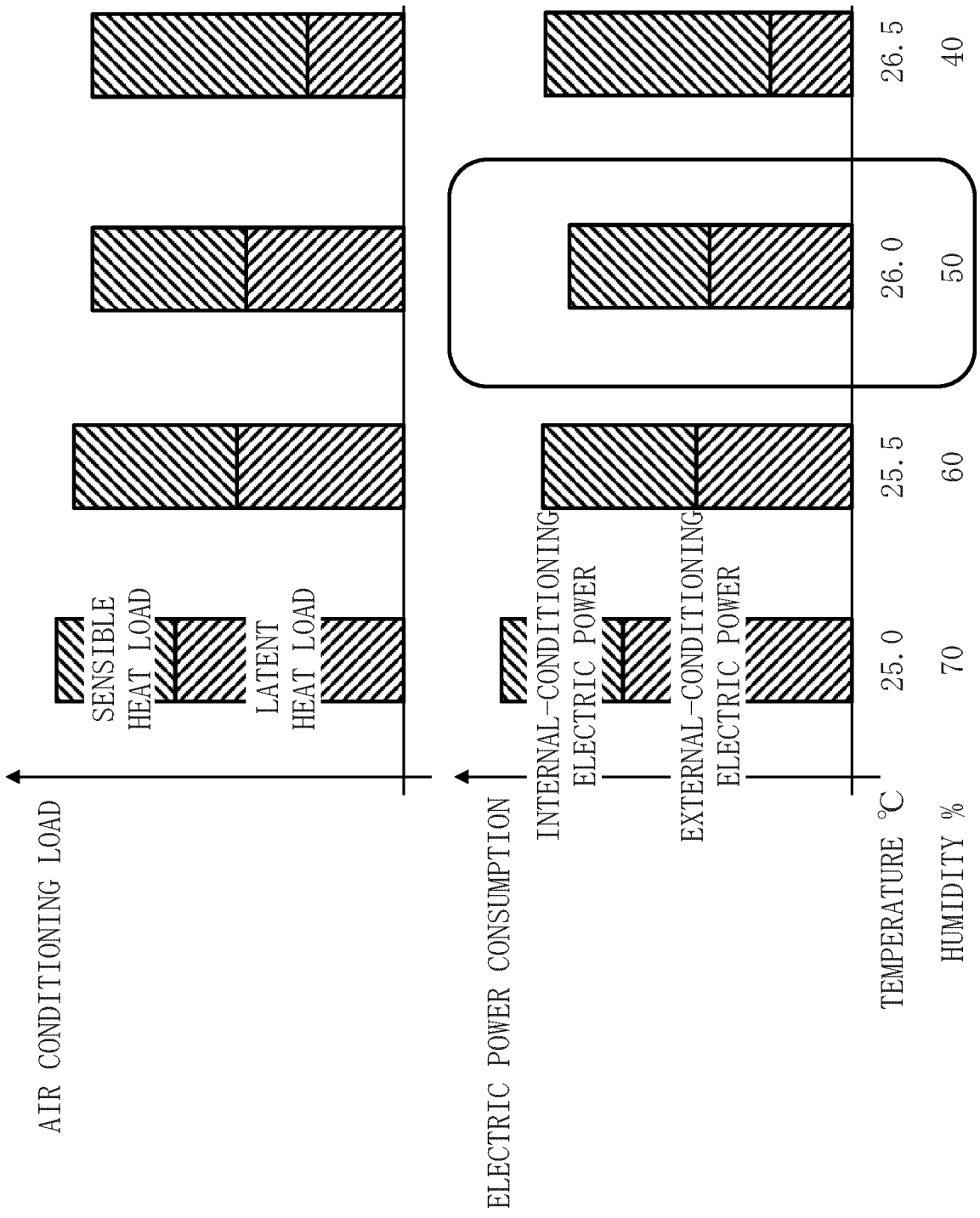

ABSOLUTE HUMIDITY
TEMPERATURE
AT TIME OF COOLING OPERATION
LOAD INCREASE OF INTERNAL CONDITIONING MACHINE 20
LOAD DECREASE OF EXTERNAL CONDITIONING MACHINE 30
AT TIME OF COOLING OPERATION
LOAD DECREASE OF INTERNAL CONDITIONING MACHINE 20
LOAD INCREASE OF EXTERNAL CONDITIONING MACHINE 30
L3
TEMPERATURE ℃
HUMIDITY %
25.0
70
25.5
60
26.0
50
26.5
40

Fig. 11


AIR CONDITIONING LOAD
SENSIBLE HEAT LOAD
LATENT HEAT LOAD
ELECTRIC POWER CONSUMPTION
INTERNAL-CONDITIONING ELECTRIC POWER
EXTERNAL-CONDITIONING ELECTRIC POWER
TEMPERATURE ℃
HUMIDITY %
25.0
70
25.5
60
26.0
50
26.5
40

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2019/042106

A. CLASSIFICATION OF SUBJECT MATTER
Int. Cl. F24F11/46(2018.01)i, F24F7/08(2006.01)n, F24F110/10(2018.01)n, F24F110/20(2018.01)n, F24F140/60(2018.01)n

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int. Cl. F24F11/00-F24F11/89

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 1971-2019
Registered utility model specifications of Japan 1996-2019
Published registered utility model applications of Japan 1994-2019

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	WO 2014/136330 A1 (TOSHIBA CORP.) 12 September 2014, paragraphs [0010]-[0053], fig. 1, 2 & US 2016/0290667 A1, paragraphs [0014]-[0090], fig. 1, 2 & EP 2966372 A1 & CN 104160217 A	1-2, 5-6, 8-9 3-4, 7
Y	WO 2017/081820 A1 (MITSUBISHI ELECTRIC CORP.) 18 May 2017, paragraphs [0013], [0074], [0113], [0148]-[0159] (Family: none)	3-4, 7
A	KR 10-1256781 B1 (SAE HAN GONG JO LTD.) 25 April 2013, entire text, all drawings (Family: none)	1-9

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
06.12.2019	17.12.2019
Name and mailing address of the ISA/ Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Authorized officer Telephone No.

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

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2019/042106

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2019/193639 A1 (MITSUBISHI ELECTRIC CORP.) 10 October 2019, entire text, all drawings (Family: none)	1-9

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

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2019078501 A **[0006]**