



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

(43) Date of publication:
29.09.2010 Bulletin 2010/39

(51) Int Cl.:
F24F 11/02 (2006.01)

(21) Application number: **08854193.3**

(86) International application number:
PCT/JP2008/071192

(22) Date of filing: **21.11.2008**

(87) International publication number:
WO 2009/069539 (04.06.2009 Gazette 2009/23)

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

(72) Inventor: **MATSUBARA, Atsushi**
Kusatsu-shi
Shiga 525-8526 (JP)

(74) Representative: **HOFFMANN EITLE**
Patent- und Rechtsanwälte
Arabellastrasse 4
81925 München (DE)

(30) Priority: **28.11.2007 JP 2007307467**

(71) Applicant: **Daikin Industries, Ltd.**
Osaka 530-8323 (JP)

(54) **AIR CONDITIONING APPARATUS**

(57) The present invention provides an air conditioner for achieving comfortable room environment after activation of the air conditioner at an earliest possible stage. An air conditioner (1) of the present invention is an air conditioner configured to execute automatic control of an energy-saving operation. The air conditioner (1) includes a determining unit (8c) and a regulating unit (8d). The determining unit (8c) is configured to determine whether or not indoor temperature and indoor humidity respectively reach target temperature and target humidity, both of which are target values for achieving comfortableness. The regulating unit (8d) is configured to execute a first regulation processing and/or a second regulation processing. In the first regulation processing, the target temperature is regulated to be regulated target temperature roughly equal to the target temperature based on a relation between the indoor humidity and the target humidity. In the second regulation processing, the target humidity is regulated to be regulated target humidity roughly equal to the target humidity based on a relation between the indoor temperature and the target temperature.

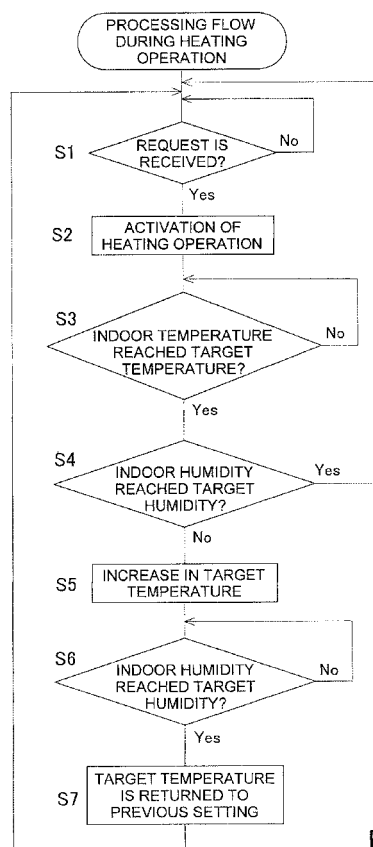


FIG. 6A

Description

TECHNICAL FIELD

[0001] The present invention generally relates to air conditioners.

BACKGROUND ART

[0002] Air conditioners, configured to control room conditions (e.g., temperature and humidity), have been produced for maintaining more comfortable indoor air-conditioning environment (see e.g., Patent Document 1).

<Patent Document 1>

[0003] Japan Laid-open Patent Application Publication No. JP-A-H04-320750

DISCLOSURE OF THE INVENTION

<Technical Problem>

[0004] When the foregoing air conditioners are used for achieving desired air-conditioning environment including desired temperature and humidity, it is difficult to reach both temperature and humidity to predetermined target values immediately after activation of the air conditioners, which takes considerable time for users to feel comfortableness in the rooms.

[0005] In view of the above, an object of the present invention is to provide an air conditioner for achieving physical comfortableness of a user based on both temperature and humidity at an earliest possible stage.

<Solution to Problem>

[0006] An air conditioner according to a first aspect of the present invention is configured to execute automatic control of an energy-saving operation. The air conditioner includes a determining unit and a regulating unit. The determining unit is configured to determine whether or not indoor temperature reaches target temperature and whether or not indoor humidity reaches target humidity. The target temperature and the target humidity are target values for achieving comfortableness. The regulating unit is configured to execute a first regulation processing and/or a second regulation processing. In the first regulation processing, the target temperature is regulated to be regulated target temperature roughly equal to the target temperature based on a relation between the indoor humidity and the target humidity. In the second regulation processing the target humidity is regulated to be regulated target humidity roughly equal to the target humidity based on a relation between the indoor temperature and the target temperature.

[0007] According to the air conditioner of the first aspect of the present invention, the target temperature is

regulated to be the regulated target temperature roughly equal to the target temperature when the indoor humidity does not reach the target humidity. On the other hand, the target humidity is regulated to be the regulated target humidity roughly equal to the target humidity when the indoor temperature does not reach the target temperature. The following is an example case for "regulation of the target temperature to be regulated target temperature roughly equal to the target temperature". When the target temperature is assumed to be 22.0 degrees Celsius, the target temperature is regulated to be temperature of roughly 22.0 degrees Celsius (e.g., 21.0 degrees Celsius or 23.0 degrees Celsius). Similarly, the following is an example case for "regulation of the target humidity to be regulated target humidity roughly equal to the target humidity". When the target humidity is assumed to be 50%, the target humidity is regulated to be humidity of roughly 50% (e.g., 45% or 55%).

[0008] The foregoing configuration makes it possible to achieve physical comfortableness based on both temperature and humidity at earliest possible stage even when temperature does not reach the target temperature or humidity does not reach the target humidity.

[0009] An air conditioner according to a second aspect of the present invention is the air conditioner according to the first aspect of the present invention, wherein, when one of the indoor temperature and the indoor humidity reaches its target value (i.e., the target temperature or the target humidity) but the other of the indoor temperature and the indoor humidity does not reach its target value (i.e., the target temperature or the target humidity), the regulating unit of the air conditioner is configured to temporarily set one of the indoor temperature and the indoor humidity, reaching the target value (i.e., the target temperature or the target humidity), to be an excessive target value as a value exceeding the target value.

[0010] According to the air conditioner of the second aspect of the present invention, when one of the indoor temperature and the indoor humidity reaches the target value (i.e., the target temperature or the target humidity) and the other of the indoor temperature and the indoor humidity does not reach the target value (i.e., the target temperature or the target humidity), one of the indoor temperature and the indoor humidity, reaching the target value (i.e., the target temperature or the target humidity), is temporarily set to be the excessive target value. For example, when the indoor temperature reaches the target indoor temperature but the indoor humidity does not reach the target humidity, setting of the target temperature is temporarily changed to be a value exceeding the target indoor temperature. On the other hand, when the indoor humidity reaches the target humidity but the indoor temperature does not reach the target temperature, setting of the target humidity is temporarily changed to be a value exceeding the target humidity.

[0011] Accordingly, it is possible to achieve comfortable room environment in consideration of either temperature or humidity that does not reach the target value.

[0012] An air conditioner according to a third aspect of the present invention is the air conditioner according to the second aspect of the present invention, wherein the regulating unit is configured to set the target temperature to be excessive temperature when the indoor humidity does not reach the target humidity in the first regulation processing. Subsequently, the regulating unit is configured to return the excessive temperature to the previous target temperature when the indoor humidity reaches the target humidity. The excessive temperature herein refers to a target value exceeding the target temperature.

[0013] According to the air conditioner of the third aspect of the present invention, the indoor temperature is set to be the excessive temperature exceeding the target temperature when humidity does not reach the target humidity. Subsequently, the excessive temperature is returned to the previous target temperature when indoor humidity reaches the target humidity.

[0014] Accordingly, setting of the target temperature is returned to the original setting when the indoor humidity reaches the target humidity. Therefore, it is possible to achieve an energy-saving effect.

[0015] An air conditioner according to a fourth aspect of the present invention is the air conditioner according to one of the first to third aspects of the present invention, wherein the energy-saving operation includes plural operation modes. The target humidity and the target temperature are determined based on a selected one of the operation modes.

[0016] The air conditioner of the fourth aspect of the present invention is controlled with the target temperature and the target humidity depending on a selected one of the operation modes.

[0017] Accordingly, it is possible to achieve comfortable air-conditioning environment in each of the operation modes.

[0018] An air conditioner according to a fifth aspect of the present invention is the air conditioner according to one of the first to fourth aspects of the present invention further including an indoor humidity detecting unit. The indoor humidity detecting unit is configured to detect indoor humidity.

[0019] According to the air conditioner of the fifth aspect of the present invention, comparison is made between humidity detected by the indoor humidity detecting unit and the target humidity. In this case, the indoor humidity detecting unit is, for instance, a humidity sensor or a unit configured to estimate humidity based on temperature of an indoor heat exchanger.

[0020] Accordingly, it is possible to achieve comfortable air-conditioning environment by regulating humidity based on the detected humidity.

[0021] An air conditioner according to a sixth aspect of the present invention is the air conditioner according to one of the first to fourth aspects of the present invention further including a compressor, an outdoor heat exchanger, an indoor heat exchanger, a temperature detecting unit, and an estimating unit. The temperature detecting

unit is configured to detect temperature of the indoor heat exchanger. The estimating unit is configured to estimate indoor humidity. Specifically, the estimating unit is configured to estimate indoor humidity based on temperature of the indoor heat exchanger detected by the temperature detecting unit when either a cooling operation mode or a dehumidifying operation mode is selected.

[0022] According to the air conditioner of the sixth aspect of the present invention, comparison is made between humidity estimated based on temperature of the indoor heat exchanger and the target humidity.

[0023] Accordingly, it is possible to achieve comfortable air-conditioning environment in consideration of humidity even if the air conditioner is not provided with a humidity sensor.

<Advantageous Effects of Invention>

[0024] According to the air conditioner of the first aspect of the present invention, it is possible to achieve physical comfortableness based on both temperature and indoor humidity, at earliest possible stage, even when temperature does not reach the target temperature or indoor humidity does not reach the target humidity.

[0025] According to the air conditioner of the second aspect of the present invention, it is possible to achieve comfortable room environment in consideration of either the indoor temperature or the indoor humidity that does not reach the target value.

[0026] According to the air conditioner of the third aspect of the present invention, it is possible to achieve an energy-saving effect because setting of the target temperature is returned to the original setting when the indoor humidity reaches the target humidity.

[0027] According to the air conditioner of the fourth aspect of the present invention, it is possible to achieve comfortable air-conditioning environment in each of the operation modes.

[0028] According to the air conditioner of the fifth aspect of the present invention, it is possible to achieve comfortable air-conditioning environment by regulating the indoor humidity based on the detected humidity.

[0029] According to the air conditioner of the sixth aspect of the present invention, it is possible to achieve comfortable air-conditioning environment in consideration of indoor humidity even if the air conditioner is not provided with a humidity sensor.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030]

FIG. 1 is an external view of an entire air conditioner according to an exemplary embodiment.

FIG. 2 is a diagram for illustrating configuration of a refrigerant circuit formed by an indoor unit and an outdoor air-conditioning unit, configuration of a humidity unit, and airflow, according to the exemplary

embodiment of the present invention.

FIG.3 is a control block diagram of the air conditioner according to the exemplary embodiment of the present invention.

FIG.4 is a chart for showing mode determination to be executed while an energy-saving automatic operation mode is selected.

FIG.5A is a chart for showing a relation between humidity and temperature during a heating operation.

FIG.5B is a chart for showing a relation between humidity and temperature during a cooling/dehumidifying operation.

FIG.6A is a flowchart for showing a series of processing steps to be executed during a heating operation in the energy saving automatic operation mode.

FIG.6B is a flowchart for showing a series of processing steps to be executed during a cooling operation in the energy saving automatic operation mode.

EXPLANATION OF THE REFERENCE NUMERALS

[0031]

- 1 Air conditioner
- 2 Indoor unit
- 3 Outdoor unit
- 4 Humidifier unit
- 5 Outdoor air-conditioning unit
- 6 Air supply duct
- 31,32 Refrigerant pipe

BEST MODE FOR CARRYING OUT THE INVENTION

(I) Schematic Configuration of Air Conditioner 1

[0032] FIG. 1 illustrates an external view of an air conditioner 1 according to an exemplary embodiment of the present invention. The air conditioner 1 is mainly composed of an indoor unit 2 and an outdoor unit 3. The indoor unit 2 is attached to a wall of a room. The outdoor unit 3 is installed outside of the room. The indoor unit 2 and the outdoor unit 3 send/receive a signal through a communication line exclusively for the signal transmission.

[0033] The outdoor unit 3 is composed of an outdoor air-conditioning unit 5 and a humidifier unit 4. The outdoor air-conditioning unit 5 is connected to the indoor unit 2 through refrigerant pipes 31, 32. The outdoor air-conditioning unit 5 and the indoor unit 2 form a refrigerant circuit to be described. The humidifier unit 4 is connected to the indoor unit 2 through an air supply duct 6. Outdoor air, inhaled by the humidifier unit 4, is transferred to the indoor unit 2 through the air supply duct 6.

[0034] The air conditioner 1 is provided with various operation modes such as a cooling operation mode, a heating operation mode, a dehumidifying operation mode, and an energy-saving automatic operation mode. The air conditioner 1 is configured to execute the foregoing

modes for producing comfortable room environment in response to a request from a user. In the present exemplary embodiment, the energy-saving automatic operation mode refers to a mode that various conditions, including e.g., target temperature, target humidity, air directions, and air flow amount, are preliminarily set for fully achieving comfortableness and for executing a control with good energy-saving efficacy. In the energy-saving automatic operation mode, the air conditioner 1 is configured to be controlled based on the conditions (e.g., the target temperature and the target humidity) preliminarily set for cooling and heating periods separately. Specifically, a dehumidifying operation or a cooling operation (dehumidifying cooling operation) is configured to be executed in the cooling period, whereas a heating operation (i.e., humidifying heating operation) is configured to be executed in the heating period.

(1-1) Indoor Unit 2 and Outdoor Air-Conditioning Unit 5

[0035] FIG.2 shows a refrigerant circuit formed by the indoor unit 2 and the outdoor air-conditioning unit 5. Structures and configurations of the indoor unit 2 and the outdoor air-conditioning unit 5 will be hereinafter described with reference to FIGS.2 and 3.

(i) Indoor Unit 2

[0036] The indoor unit 2 mainly includes an indoor heat exchanger 21, a cross-flow fan 22, and an indoor fan motor 23. The indoor heat exchanger 21 is composed of a heat-transfer pipe and plural fins. The heat-transfer pipe is bent plural times between its longitudinal ends. The heat-transfer pipe passes through the fins. The indoor heat exchanger 21 is configured to exchange heat with air that it makes contact. In the cooling operation, the indoor heat exchanger 21 functions as an evaporator for decreasing temperature of indoor heat that it makes contact. Moisture, contained in the air making contact with the indoor heat exchanger 21, changes into water drops, and the water drops fall onto a drain pan (not illustrated in the figure) disposed beneath the indoor heat exchanger 21. Accordingly, humidity of the air to be discharged into the indoor space is also decreased. In the heating operation, on the other hand, the indoor heat exchanger 21 functions as a condenser. The air, making contact with the indoor heat exchanger 21, is thereby heated and supplied into the indoor space. The cross-flow fan 22 is formed in a cylindrical shape. The cross-flow fan 22 has plural blades on its outer peripheral surface. The cross-flow fan 22 is configured to generate air-flow in perpendicular directions to its rotation shaft. Accordingly, the cross-flow fan 22 inhales the indoor air into the indoor unit 2, and simultaneously blows out the air, heat-exchanged with the indoor heat exchanger 21, into the indoor space. The cross-flow fan 22 is driven and rotated by the indoor fan motor 23. The indoor fan motor 23 is connected to a control unit 8 described below. The

indoor fan motor 23 is configured to be actuated in response to a control signal from the control unit 8.

[0037] Note the indoor unit 2 includes various sensors attached thereto. For example, the sensors include an inhalation temperature sensor 25 and an indoor humidity sensor 26. The inhalation temperature sensor 25 detects temperature of the indoor air to be inhaled into the indoor unit 2, whereas the indoor humidity sensor 26 detects humidity of the indoor space. Humidity, detected herein by the indoor humidity sensor 26, is relative humidity. As shown in FIG.3, the inhalation temperature sensor 25 and the indoor humidity sensor 26 are respectively connected to the control unit 8. Values (i.e., temperature and humidity), respectively detected by the inhalation temperature sensor 25 and the indoor humidity sensor 26, are thereby transmitted to the control unit 8.

(ii) Outdoor Air-Conditioning Unit 5

[0038] The Outdoor air-conditioning unit 5 mainly includes a compressor 51, a propeller fan 52, an outdoor fan motor 53, an outdoor heat exchanger 54, a four-way switch valve 55, an electric valve 56, a liquid closing valve 57, and a gas closing valve 58. The compressor 51 is a machine configured to regulate its capacity through an inverter control. The compressor 51 is configured to inhale low-pressure gas refrigerant, compress the inhaled low-pressure gas refrigerant, and discharge high-pressure gas refrigerant changed from the low-pressure gas refrigerant. The propeller fan 52 is driven and rotated by the outdoor fan motor 53. The propeller fan 52 is configured to inhale the outdoor air into a casing of the outdoor air-conditioning unit 5.

[0039] The outdoor heat exchanger 54 is configured to exchange heat between the refrigerant flowing through the interior of the outdoor heat exchanger 54 and the outdoor air inhaled into the outdoor air-conditioning unit 5 by means of the propeller fan 52. One end of the Outdoor heat exchanger 54 is connected to the four-way switch valve 55, whereas the other end thereof is connected to the electric valve 56. The four-way switch valve 55 is configured to switch a refrigerant circuit based on the cooling/heating mode. The refrigerant, flowing through the outdoor heat exchanger 54, discharges heat in the cooling operation mode (i.e., when the four-way switch valve 55 is in state of a solid line), but absorbs heat in the heating operation mode (i.e., when the four-way switch valve 55 is in state of a dashed line). The electric valve 56 is configured to change its valve opening degree for controlling the amount of the refrigerant flowing into the outdoor heat exchanger 54. The liquid closing valve 57 and the gas closing valve 58 are configured to open/close the refrigerant circuit. As shown in FIG.3, components, including e.g., the outdoor fan motor 53, the compressor 51, the four-way switch valve 55, the electric valve 56, the liquid closing valve 57, and the gas closing valve 58, are connected to the control unit 8. Accordingly, these components are configured to be actuated in response to a control signal from the control unit 8.

ated in response to a control signal from the control unit 8.

[0040] The outdoor air-conditioning unit 5 is further provided with various sensors such as an outdoor temperature sensor 59 shown in FIG.3. The outdoor temperature sensor 59 is configured to detect outdoor temperature. The outdoor temperature sensor 59 is connected to the control unit 8 described below. A value detected by the outdoor temperature sensor 59 is transmitted to the control unit 8.

(1-2) Humidifier Unit 4

[0041] Next, structure and configuration of the humidifier unit 4 will be hereinafter described. The humidifier unit 4 is configured to humidify inhaled outdoor air and supply humidified air into the indoor space. As shown in FIG.2, the humidifier unit 4 mainly includes an inhalation humidifier rotor 41, a rotor drive motor 42, a heater 43, a radial fan 44, a radial fan motor 45, an adsorption fan 46, and an adsorption fan motor 47.

[0042] The inhalation humidifier rotor 41 is a roughly disc-shaped ceramic rotor with a honeycomb structure for allowing air to easily pass through. The inhalation humidifier rotor 41 carries adsorption agent such as zeolite, silica gel or alumina. The inhalation humidifier rotor 41 is configured to adsorb moisture contained in the air that it makes contact and dehumidify the adsorbed moisture by means of heating. The inhalation humidifier rotor 41 is driven and rotated by the rotor drive motor 42. The heater 43 is configured to heat the inhaled outdoor air to be transferred to the inhalation humidifier rotor 41 in humidification. The radial fan 44 is disposed lateral to the inhalation humidifier rotor 41. The radial fan 44 is driven by the radial fan motor 45. The radial fan 44 is configured to introduce the outdoor air into the humidifier unit 4 and generate flow of the air to be blown out to the indoor space (see A1 in FIG.2). Specifically, the radial fan 44 generates the following airflow. That is, the outdoor air is introduced into the humidifier unit 4 through an air supply port 40a, then passes through the inhalation humidifier 41, and is transferred to the indoor unit 2 through the air supply duct 6. The adsorption fan 46 is driven and rotated by the adsorption fan motor 47. The adsorption fan 46 generates airflow for discharging the outdoor air, inhaled into the casing of the humidifier unit 4 through an inhalation port 40b, out of the casing through a blowout port 40c (see A2 in FIG.2). The inhalation humidifier rotor 41 adsorbs moisture contained in the air inhaled through the inhalation portion 40b for a moisture-adsorption objective. After the moisture adsorption, the air is discharged to the outdoor space through the blowout port 40c.

[0043] As shown in FIG.3, components, including e.g., the rotor drive motor 42, the heater 43, the radial fan motor 45, and the adsorption fan motor 47, are connected to the control unit 8 described below. These components are configured to be actuated in response to a control signal from the control unit 8. In short, when humidifica-

tion is required, the heater 43 is turned on for heating the air inhaled through the air supply port 40a. After heated by the heater, the air is transferred to the air supply duct 6 while containing the moisture separated in the inhalation humidifier rotor 41.

(1-3) Control unit 8

[0044] Next, the control unit 8, configured to control the air conditioner 1, will be hereinafter described with reference to FIG.3.

[0045] The control unit 8 is a microcomputer composed of a CPU and a memory. The control unit 8 is divided into plural units, and the units are separately mounted in and shared by the indoor unit 2, an electric equipment box disposed in the humidifier unit 4 and the outdoor air-conditioning unit 5 included in the outdoor unit 3, and the like. Devices, included in the indoor unit 2, the outdoor air-conditioning unit 5, and the humidifier unit 4, are connected to the control unit 8. The control unit 8 is configured to send/receive a signal to/from the devices.

[0046] The control unit 8 mainly includes a receiving unit 8a, a regulating unit 8b, a detecting unit 8c, and a determining unit 8d. The receiving unit 8a is configured to receive a user request received by a signal receiver 24 illustrated in FIG.1. Specifically, the receiving unit 8a is configured to receive a user request set by a remote controller (not illustrated in the figure) through the signal receiver 24. The user request herein includes an operation mode, temperature, humidity, airflow direction, and airflow amount.

[0047] The regulating unit 8b is configured to regulate temperature, humidity, airflow direction, and airflow amount in response to the user request received by the receiving unit 8a. Specifically, the regulating unit 8b is configured to set target values based on the set conditions including an operation mode, temperature, humidity, airflow direction, and airflow amount. For example, when the receiving unit 8a receives any one of the operation modes: the heating operation mode; the cooling operation mode; and the dehumidifying operation mode, the air conditioner 1 is controlled based on the user's desired conditions (i.e., temperature, humidity, airflow direction, and airflow amount) as the target values. In other words, various conditions, including e.g., frequency of the compressor 51 mounted in the outdoor air-conditioning unit 5, opening degree of the electric valve 56, angle of a flap (not illustrated in the figure), and revolution of the indoor fan motor 23, are changed in accordance with the target values set by the regulating unit 8b. Further, various controls are executed, including e.g., activation/deactivation control (i.e., ON/OFF control) of the heater 43 mounted in the humidifier unit 4 and control of the rotor drive motor 42. The air conditioner 1 is thus controlled by regulating temperature, humidity, airflow direction, and airflow amount for achieving the desired indoor environment (e.g., temperature) set by a user. On the other hand, when the receiving unit 8a receives the en-

ergy-saving automatic operation mode, the regulating unit 8b is configured to set predetermined conditions (i.e., temperature, humidity, airflow direction, airflow amount, and the like) as the target values for reliably achieving both energy saving and comfortableness. The target values are herein separately set for the heating period and the cooling period. As shown in FIG.4, it is determined which one of the heating and cooling operations should be executed based on indoor temperature detected by the inhalation temperature sensor 25 and outdoor temperature detected by the outdoor temperature sensor 59. It should be noted that the control unit 8 is provided with a timer (not illustrated in the figure). The control unit 8 is configured to cause the sensors 25, 59 to detect the indoor temperature and the outdoor temperature at predetermined time intervals measured by the timer. Based on the detected indoor and outdoor temperatures, the control unit 8 is configured to again determine which one of the heating and cooling operations should be executed in the energy-saving automatic operation mode.

[0048] In the present exemplary embodiment, the regulating unit 8b is configured to set PMV-based temperature as target temperature for reliably achieving comfortableness. Specifically, PMV is a thermal sensation index for indicating comfortableness, and the target temperature satisfies a condition where a value of PMV is approximately zero. A value of PMV is normally determined with parameters such as indoor temperature, relative humidity, mean radiant temperature, wearing amount, activity amount, and airflow amount. However, the parameters, excluding temperature and humidity, are set to be predetermined standard values for controlling the air conditioner 1 in the present exemplary embodiment. For reliably executing an energy-saving operation, the regulating unit 8b is further configured to correct the PMV-based temperature for obtaining target temperature. Specifically, 0.5 degrees Celsius is subtracted from the PMV-based temperature in the heating operation, whereas 0.5 degrees Celsius is added to the PMV-based target temperature in the cooling operation.

[0049] For more detailed explanation, the following example case will be provided. According to PMV, best comfortableness is achieved at indoor temperature of 22.5 degrees Celsius and humidity of 50% during the heating operation in the energy-saving automatic operation mode. In this case, the regulating unit 8b of the air conditioner 1 of the present exemplary embodiment is configured to set 22.0 degrees Celsius as the target indoor temperature and set 50% as the target humidity. On the other hand, according to PMV, best comfortableness is achieved at indoor temperature of 27.5 degrees Celsius and humidity of 50% during the cooling operation in the energy-saving automatic operation mode. In this case, the regulating unit 8b of the air conditioner 1 of the present exemplary embodiment is configured to set 28.0 degrees Celsius as the target indoor temperature and set 50% as the target humidity. When the regulating unit 8b sets the target values, the control unit 8 is configured

to output a control signal to the respective devices in the indoor unit 2, the outdoor air-conditioning unit 5, and the humidifier unit 4. Accordingly, the respective devices are actuated in accordance with the target values.

[0050] Further, the regulating unit 8b is configured to change the target temperature based on a result of determination by the determining unit 8d described below. Detailed explanation thereof will be hereinafter provided together with explanation of the determining unit 8d.

[0051] The detecting unit 8c is configured to detect values measured by the inhalation temperature sensor 25 and the indoor humidity sensor 26.

[0052] The determining unit 8d is configured to determine whether or not the values detected by the detecting unit 8c reach the target temperature and the target humidity. Under the energy-saving automatic operation mode, the regulating unit 8b is configured to correct the target temperature by 1 degree Celsius when the determining unit 8d determines that indoor humidity, measured by the indoor humidity sensor 26 and then detected by the detecting unit 8c, does not reach the target humidity even though temperature, measured by the inhalation temperature sensor 25 and then detected by the detecting unit 8c, reaches the target temperature. Specifically, the regulating unit 8b is configured to add 1 degree Celsius to the target temperature in the heating operation. On the other hand, the regulating unit 8b is configured to subtract 1 degree Celsius from the target temperature in the cooling operation. The regulating unit 8b thus obtains new (corrected) target temperature (corresponding to "excessive temperature"). More specifically, the regulating unit 8b is configured to correct the target temperature of 22.0 degrees Celsius to be the new (corrected) target temperature of 23.0 degrees Celsius in the heating operation. On the other hand, the regulating unit 8b is configured to correct the target temperature of 28.0 degrees Celsius to be the new (corrected) target temperature of 27.0 degrees Celsius in the cooling operation. Here, humidity changes in accordance with the correction of the target temperature, and comfortableness can be reliably achieved in the indoor environment at an earliest possible stage.

[0053] Next, correction of the target temperature herein executed by the regulating unit 8b, and change in humidity in accordance with the correction of the target temperature will be hereinafter explained with reference to FIGS.5A and 5B. FIGS.5A and 5B respectively show temperature shifting for obtaining recommended humidity. In FIG. 5A, each of "DHA_W1" and "DHA_W2" indicates determination baseline humidity in a humidity zone recommended in the heating operation. In FIG.5B, each of "DHA_C1" and "DHA_C2" indicates determination baseline humidity in a humidity zone recommended in the cooling operation. Further, each "DDH" in FIGS.5A and 5B indicates humidity-zone deviation. As to the heating operation (see FIG.5A), the following example will be provided. When the heating operation is activated, indoor humidity is assumed to correspond to the position of the

solid line of DHA_W2. In this case, humidity is increased to the position of the solid line of DHA_W1 by correcting the target temperature by 1.0 degree Celsius. On the other hand, when humidity is decreased from the position of the solid line of DHA_W1 to the position of the solid line of DHA_W2, humidification is executed through the activation of the humidifier unit 4 for increasing the target temperature by 1.0 degree Celsius. As to the cooling operation (See Fig.5B), the following example will be provided. When the cooling operation is activated, indoor humidity is assumed to correspond to the position of the solid line of DHA_C2. In this case, humidity is decreased to the position of the solid line of DHA_C1 by correcting the target temperature by 1.0 degree Celsius. On the other hand, when humidity is increased from the position of the solid line of DHA_C1 to the position of the solid line of DHA_C2, the target temperature is decreased by 1 degree Celsius. The recommended humidity is thus obtained by shifting temperature.

[0054] When the determining unit 8d subsequently determines that humidity detected by the detecting unit 8c reaches the target humidity, the regulating unit 8b is configured to return the new (corrected) target temperature to the previous target temperature. Specifically, during the heating operation in the energy-saving automatic operation mode, the regulating unit 8b returns the new (corrected) target temperature of 23.0 degrees Celsius to the previous target temperature of 22.0 degrees Celsius. On the other hand, during the cooling operation in the energy-saving automatic operation mode, the regulating unit 8b returns the new (corrected) target temperature of 27.0 degrees Celsius to the previous target temperature of 28.0 degrees Celsius.

<Flow of Processing>

[0055] Next, an explanation will be hereinafter provided with reference to FIG.6 for a series of steps of control processing to be executed by the air conditioner 1 of the present exemplary embodiment in the energy-saving automatic operation mode. First, details will be explained for a series of steps of control processing to be executed during the heating operation in the energy saving automatic operation mode.

[0056] When the receiving unit 8a receives a user request of the energy-saving automatic operation (Step S1), the heating operation is activated based on temperatures that are measured by the inhalation temperature sensor 25 and the outdoor temperature sensor 59 and then detected by the detecting unit 8c (Step S2). In this case, the regulating unit 8b sets preliminarily-set temperature and preliminarily-set humidity as target temperature and target humidity, respectively. Devices, including e.g., the compressor 51 of the outdoor air-conditioning unit 5 and the radial fan motor 45 of the humidifier unit 4, are actuated based on the foregoing target values. Accordingly, the heating operation (i.e., humidifying heating operation) is executed. The determining unit 8d sub-

sequently determines whether or not the temperature, measured by the inhalation temperature sensor 25 and then detected by the detecting unit 8c, reaches the target temperature (Step S3). When determining that the temperature, measured by the inhalation temperature sensor 25 and then detected by the detecting unit 8c, reaches the target temperature, the determining unit 8d further determines whether or not the humidity, measured by the indoor humidity sensor 26 and then detected by the detecting unit 8c, reaches the target humidity (Step S4). When the determining unit 8d determines that the humidity, measured by the indoor humidity sensor 26 and then detected by the detecting unit 8c, does not reach the target humidity, the regulating unit 8b corrects/increases the target temperature by 1 degree Celsius (Step S5). When the determining unit 8d subsequently determines that the humidity, measured by the indoor humidity sensor 26 and then detected by the detecting unit 8c, reaches the target humidity (Step S6), the regulating unit 8b returns the new (corrected) target temperature to the previous target temperature (Step S7).

[0057] Next, details will be explained for a series of steps of control processing to be executed during the cooling operation in the energy-saving automatic operation mode.

[0058] When the receiving unit 8a receives a user request of the energy-saving automatic operation (Step S11), the cooling operation is activated based on temperatures that are measured by the inhalation temperature sensor 25 and the outdoor temperature sensor 59 and then detected by the detecting unit 8c (Step S12). In this case, the regulating unit 8b sets the preliminarily-set temperature and the preliminarily-set humidity as target temperature and target humidity, respectively. Devices, including e.g., the compressor 51 of the outdoor air-conditioning unit 5, are actuated based on the foregoing target values. Accordingly, the cooling operation (i.e., dehumidifying cooling operation) is executed. Then, the determining unit 8d determines whether or not the temperature, measured by the inhalation temperature sensor 25 and then detected by the detecting unit 8c, reaches the target temperature (Step S13). When determining that temperature, measured by the inhalation temperature sensor 25 and then detected by the detecting unit 8c, reaches the target temperature, the determining unit 8d further determines whether or not humidity, measured by the indoor humidity sensor 26 and then detected by the detecting unit 8c, reaches the target humidity (Step S14). When the determining unit 8d determines that the humidity, measured by the indoor humidity sensor 26 and then detected by the detecting unit 8c, does not reach the target humidity, the regulating unit 8b corrects/decreases the target temperature by 1 degree Celsius (Step S 15). When the determining unit 8d subsequently determines that the humidity, measured by the indoor humidity sensor 26 and then detected by the detecting unit 8c, reaches the target humidity (Step S16), the regulating unit 8b returns the new (corrected) target temperature to

the previous target temperature (Step S17).

<Features>

5 [0059]

(1) The air conditioner 1 according to the present exemplary embodiment is provided with plural operation modes. When the energy-saving automatic operation mode is selected from the operation modes, temperature, humidity, airflow amount, and air direction are automatically selected in consideration of energy saving and comfortableness. Accordingly, room environment will be comfortable for a user after operational activation at an earliest possible stage. Further, according to the air conditioner 1 of the present exemplary embodiment, the current target temperature is corrected until humidity reaches the target humidity in view of the fact that a period of time necessary for the indoor humidity to reach given target humidity is generally longer than that necessary for the indoor temperature to reach given target temperature. Therefore, room environment can be comfortable for a user at an earliest possible stage. Further, in consideration of energy saving, the new (corrected) target temperature is returned to the previous target temperature when the indoor humidity reaches the target humidity. Therefore, both comfortableness and energy saving can be satisfied during execution of the control.

[0060] It should be noted that the air conditioner 1 according to the present exemplary embodiment is configured not to set the PMV-based room temperature, satisfying the condition where a value of PMV is equal to zero, as the target temperature in both of the cooling and heating operations in order to achieve an energy-saving effect. Specifically, in the cooling operation, the air conditioner 1 is controlled with the target temperature obtained by adding 0.5 degrees Celsius to the PMV-based room temperature satisfying the condition where a value of PMV is equal to zero. In the heating operation, on the other hand, the air conditioner 1 is controlled with the target temperature obtained by subtracting 0.5 degrees Celsius from the PMV-based room temperature satisfying the condition where a value of PMV is equal to zero. Therefore, it is desirable to return the new (corrected) target temperature to the previous target temperature as early as possible when humidity reaches desired humidity in terms of pursuit of both energy saving and comfortableness.

(2) The air conditioner 1 according to the present exemplary embodiment can execute an operation in consideration of comfortableness and energy saving only by selecting the foregoing energy-saving automatic operation mode through a user operation of a remote controller (not illustrated in the figure).

<Exemplary Modifications>

[0061]

(1) In the foregoing exemplary embodiment, the outdoor unit 3 is composed of the outdoor air-conditioning unit 5 and the humidifier unit 4. However, an air-supply humidifying unit may be installed instead of the humidifier unit 4. When actually installed, the air-supply humidifying unit is configured to execute an air-supplying operation and a humidifying operation. In the air-supplying operation, inhaled outdoor air is supplied to the indoor space without humidifying it. In the humidifying operation, on the other hand, the inhaled outdoor air is humidified and then supplied to the indoor space. When the humidification-free air-supplying operation is herein executed, the heater 43 is deactivated/turned off and the air inhaled through the air supply port 40a is supplied to the air supply duct 6 without processing the inhaled air. In this case, it is possible to achieve the same advantageous effects as those achieved by the air conditioner 1 according to the foregoing exemplary embodiment.

(2) In the foregoing exemplary embodiment, it is determined which of the heating and cooling operations should be executed based on temperatures measured by the inhalation temperature sensor 25 and the outdoor temperature sensor 59 when the energy saving-automatic operation mode is selected. However, the foregoing determination may be executed based on only one of the temperatures measured by the inhalation temperature sensor 25 and the outdoor temperature sensor 59.

(3) In a series of steps of control processing to be executed in the energy-saving automatic operation mode according to the foregoing exemplary embodiment, it is determined whether or not the indoor temperature reaches the target temperature in Step S3 (and Step S13). Subsequently, it is determined whether or not the indoor humidity reaches the target humidity in Step S4 (and Step S14). Thus, this assumes a case that the indoor humidity does not reach the target humidity even through the indoor temperature reaches the target temperature. However, when the air conditioner 1 is installed in a room where indoor temperature is less variable than humidity, contents of Steps S3 and S4 (and Steps S13 and S14) may be exchanged. In this case, it may be determined whether or not the indoor humidity reaches the target humidity in Step S3 (and Step S13). When the indoor humidity reaches the target humidity, it may be determined whether or not the indoor temperature reaches the target temperature in Step S4 (and Step S14). When the indoor temperature does not reach the target temperature, humidity may be changed in Step S5 (and Step S15) for achieving comfortable indoor environment.

[0062] Further, when the air conditioner 1 is installed in a room where temperature is less variable, comfortableness may be reliably achieved by controlling airflow (e.g., airflow direction and airflow amount).

(4) In the energy-saving automatic operation mode according to the foregoing exemplary embodiment, target values of temperature and humidity have been preliminarily set based on PMV in order to achieve comfortableness. However, the target values may be set based on other indices in order to achieve comfortableness. For example, the target values may be set based on SET (Standard Effective Temperature) and/or the like.

(5) In the foregoing exemplary embodiment, comparison is made between humidity actually measured by the indoor humidity sensor 26 and the target humidity. In the cooling/dehumidifying operation, estimated humidity may be used instead of the humidity actually measured by the indoor humidity sensor 26. In this case, the estimated humidity is obtained by an estimating unit configured to estimate indoor humidity. Japan Laid-open Patent Application Publication No. JP-A-2003-139371 exemplifies an air conditioner of the configuration. Specifically, the air conditioner is not provided with any indoor humidity sensor, but a predetermined sensor is used for detecting temperature of an indoor heat exchanger and indoor humidity is estimated based on the detected temperature of the indoor heat exchanger. Even without the indoor humidity sensor 26, the air conditioner 1 according to the present invention can be thus controlled. Consequently, it is possible to achieve comfortable air-conditioning environment in consideration of humidity.

(6) The indoor unit 2 according to the foregoing exemplary embodiment may be further provided with a radiant sensor. In this case, the radiant sensor is configured to detect body surface temperature of a user. Based on the detected body surface temperature, controls of temperature, humidity, and airflow in a room can be executed in consideration of conditions including e.g., radiant temperature, activity amount of a user, and wearing amount. Consequently, it is possible to achieve more comfortable room environment.

(7) In the foregoing exemplary embodiment, the air conditioner 1 is controlled with relative humidity. However, the air conditioner 1 may be controlled with absolute humidity.

(8) In the foregoing exemplary embodiment, the preliminarily-set target temperature and the preliminarily-set target humidity are used in the energy-saving automatic operation mode. However, controls of temperature, humidity, and airflow in a room may be executed in consideration of the impact of radiant temperature to be estimated based on the outdoor

temperature.

(9) The indoor unit 2 according to the present exemplary embodiment may further have a function of setting physical room conditions (e.g., room's thermal insulation property, area of a window, and the number of doors). In this case, radiant temperature can be estimated based on the outdoor temperature and the physical room conditions. Therefore, controls of temperature, humidity, and airflow in a room can be executed in consideration of the impact of the radiant temperature. Consequently, it is possible to achieve more comfortable room environment.

(10) In the present exemplary embodiment, the exemplified air conditioner is configured to regulate indoor temperature and humidity. However, the air conditioner may not be provided with a function of regulating humidity. In this case, the air conditioner may be configured to correct temperature in accordance with detected humidity.

INDUSTRIAL APPLICABILITY

[0063] The present invention is useful as an air conditioner for achieving physical comfortableness based on both temperature and humidity at an earliest possible stage.

Claims

1. An air conditioner (1) which is configured to execute automatic control of an energy-saving operation, comprising:

a determining unit configured to determine whether or not indoor temperature reaches target temperature which is a target value for achieving comfortableness and whether or not indoor humidity reaches target humidity which is a target value for achieving comfortableness, and

a regulating unit configured to execute a first regulation processing in which the target temperature is regulated to be regulated target temperature roughly equal to the target temperature based on a relation between the indoor humidity and the target humidity and/or a second regulation processing in which the target humidity is regulated to be regulated target humidity roughly equal to the target humidity based on a relation between the indoor temperature and the target temperature.

2. The air conditioner according to claim 1, wherein the regulating unit is configured to temporarily set one of the indoor temperature and the indoor humidity, reaching the target value to be an excessive target value as a value exceeding the tar-

get value when one of the indoor temperature and the indoor humidity reaches its target value but the other of the indoor temperature and the indoor humidity does not reach its target value.

3. The air conditioner according to claim 2, wherein the regulating unit is configured to set the target temperature to be excessive temperature referring to a target value exceeding the target temperature when the indoor humidity does not reach the target humidity in the first regulation processing, and configured to return the excessive temperature to the previous target temperature when the indoor humidity reaches the target humidity.
4. The air conditioner according to one of claims 1 to 3, wherein the energy-saving operation includes plural operation modes, and the target humidity and the target temperature are determined based on a selected one of the operation modes.
5. The air conditioner according to one of claims 1 to 4, further comprising:

an indoor humidity detecting unit (26) configured to detect the indoor humidity.

6. The air conditioner according to one of claims 1 to 4, further comprising:

a compressor;
an outdoor heat exchanger;
an indoor heat exchanger;
a temperature detecting unit configured to detect temperature of the indoor heat exchanger; and
an estimating unit configured to estimate the indoor humidity, and
wherein the estimating unit is configured to estimate the indoor humidity based on temperature of the indoor heat exchanger detected by the temperature detecting unit when either a cooling operation mode or a dehumidifying operation mode is selected.

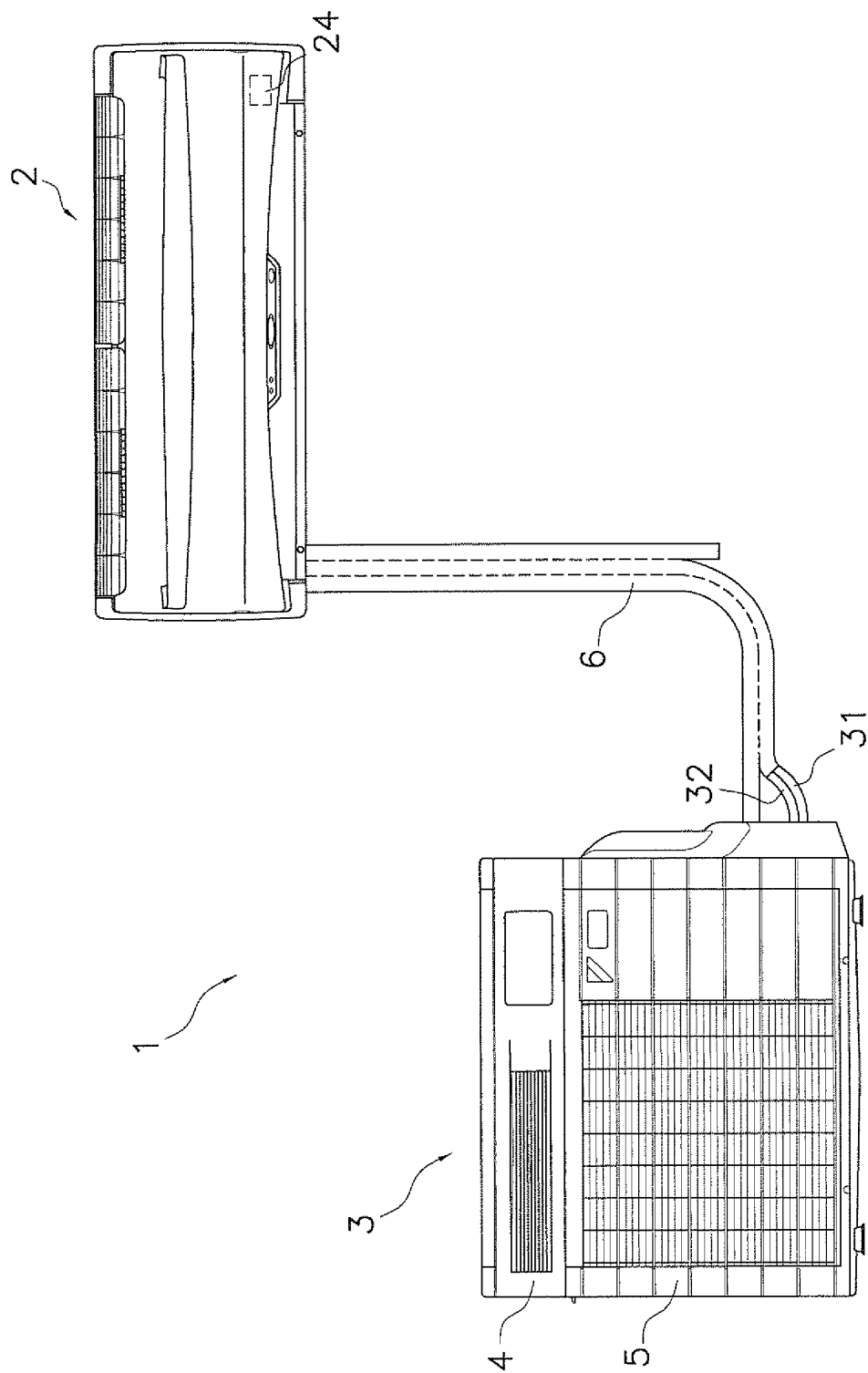


FIG. 1

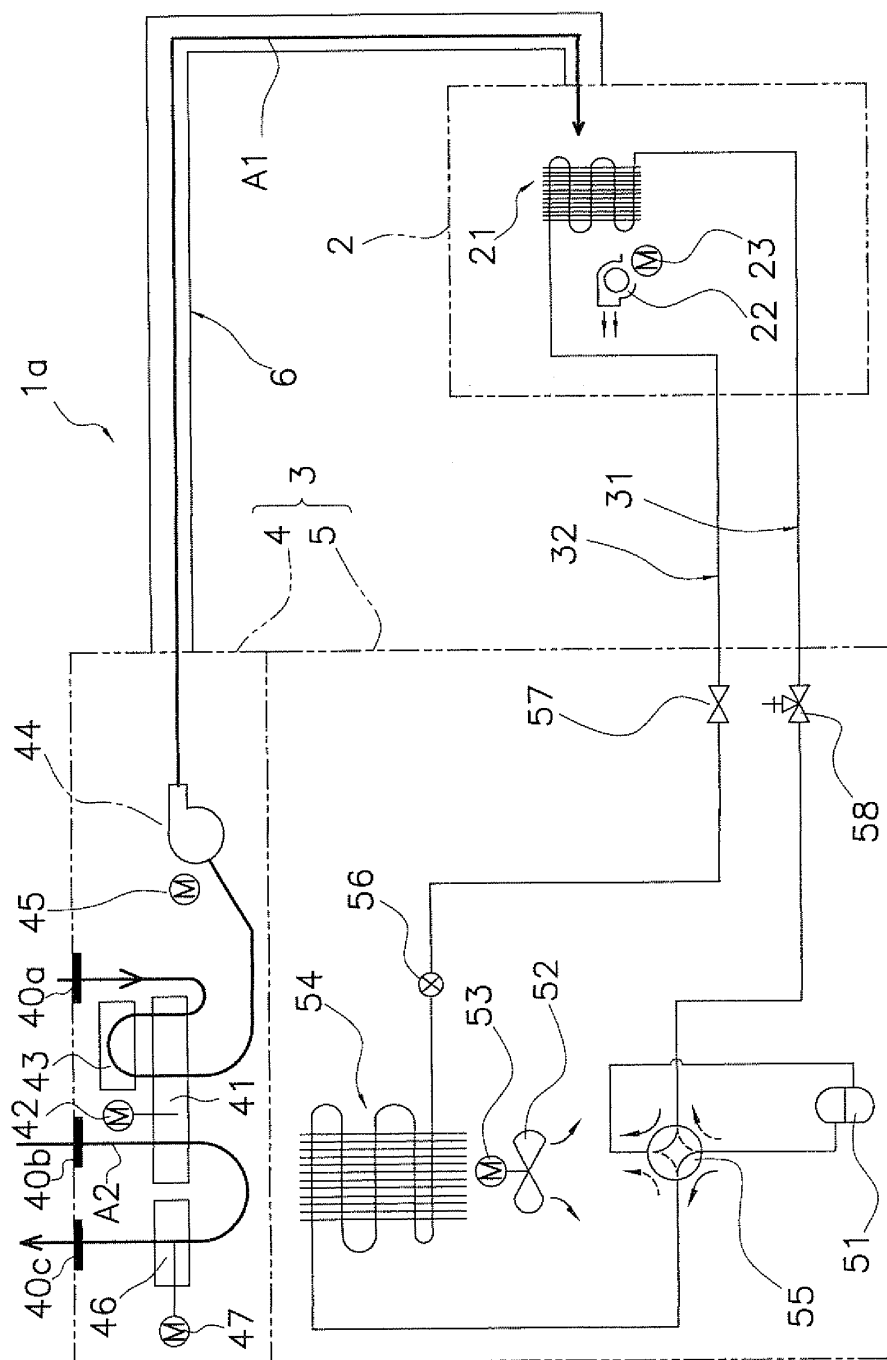


FIG. 2

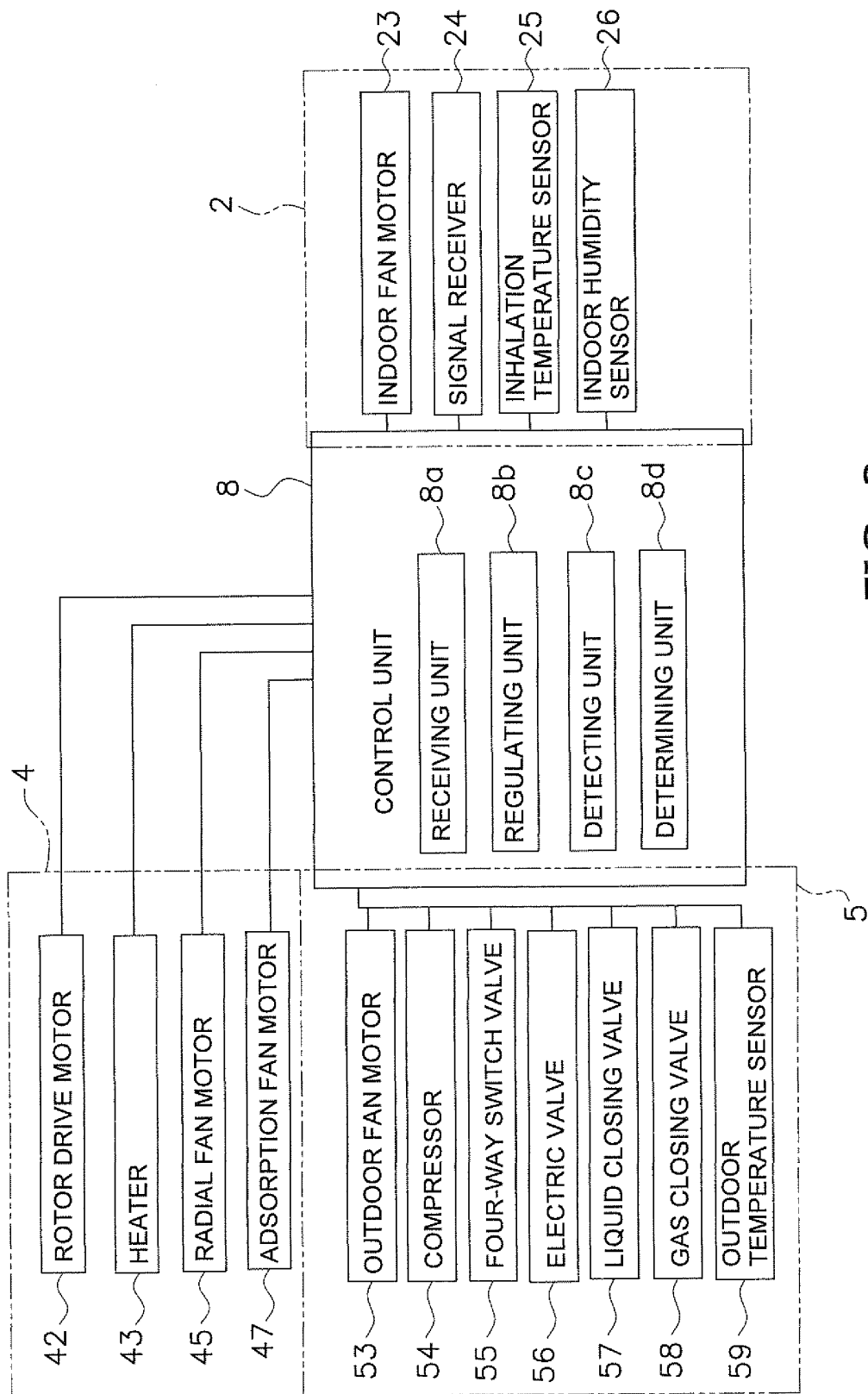


FIG. 3

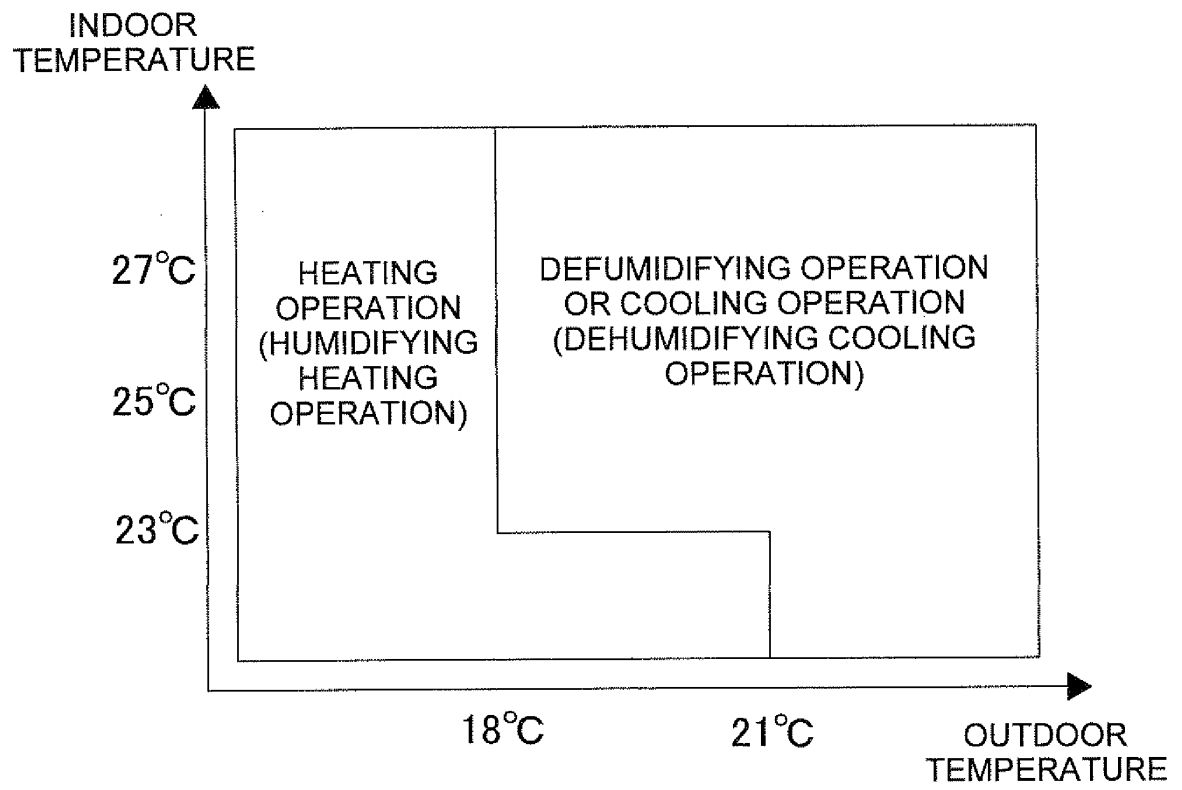


FIG. 4

DURING HEATING OPERATION

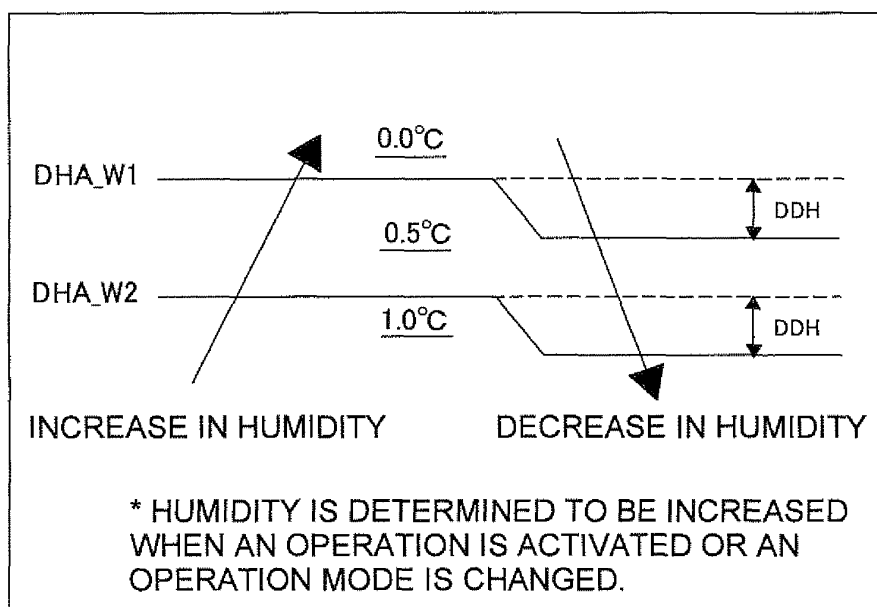


FIG. 5A

DURING COOLING/DEHUMIDIFYING OPERATION

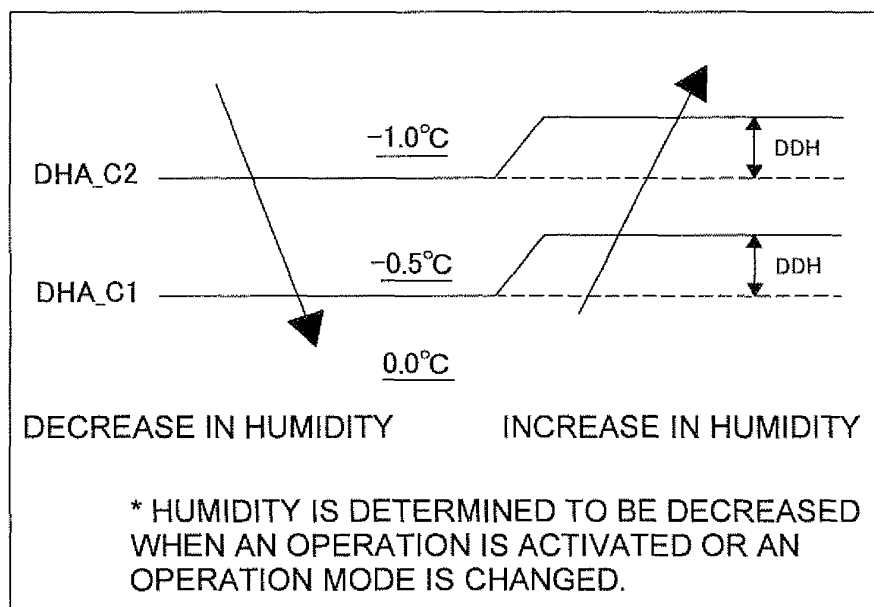


FIG. 5B

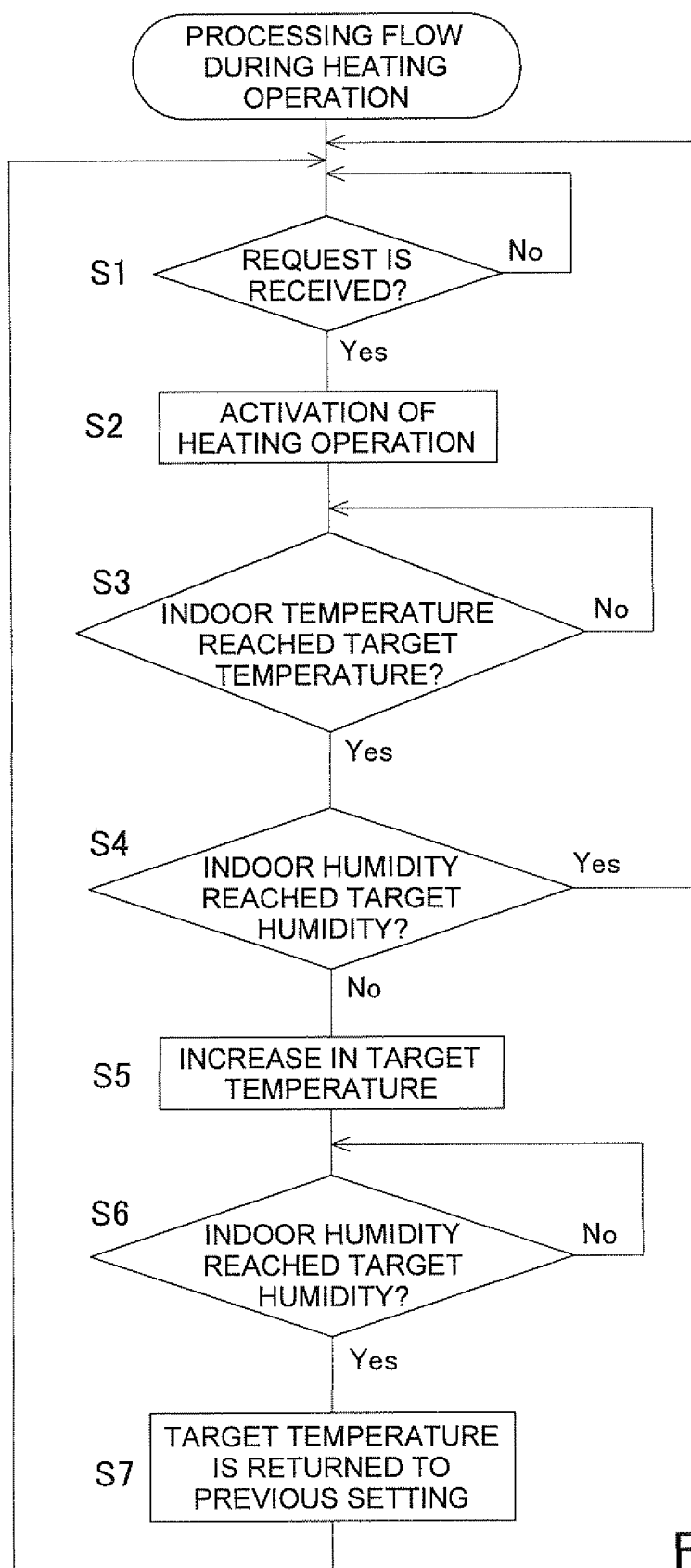


FIG. 6A

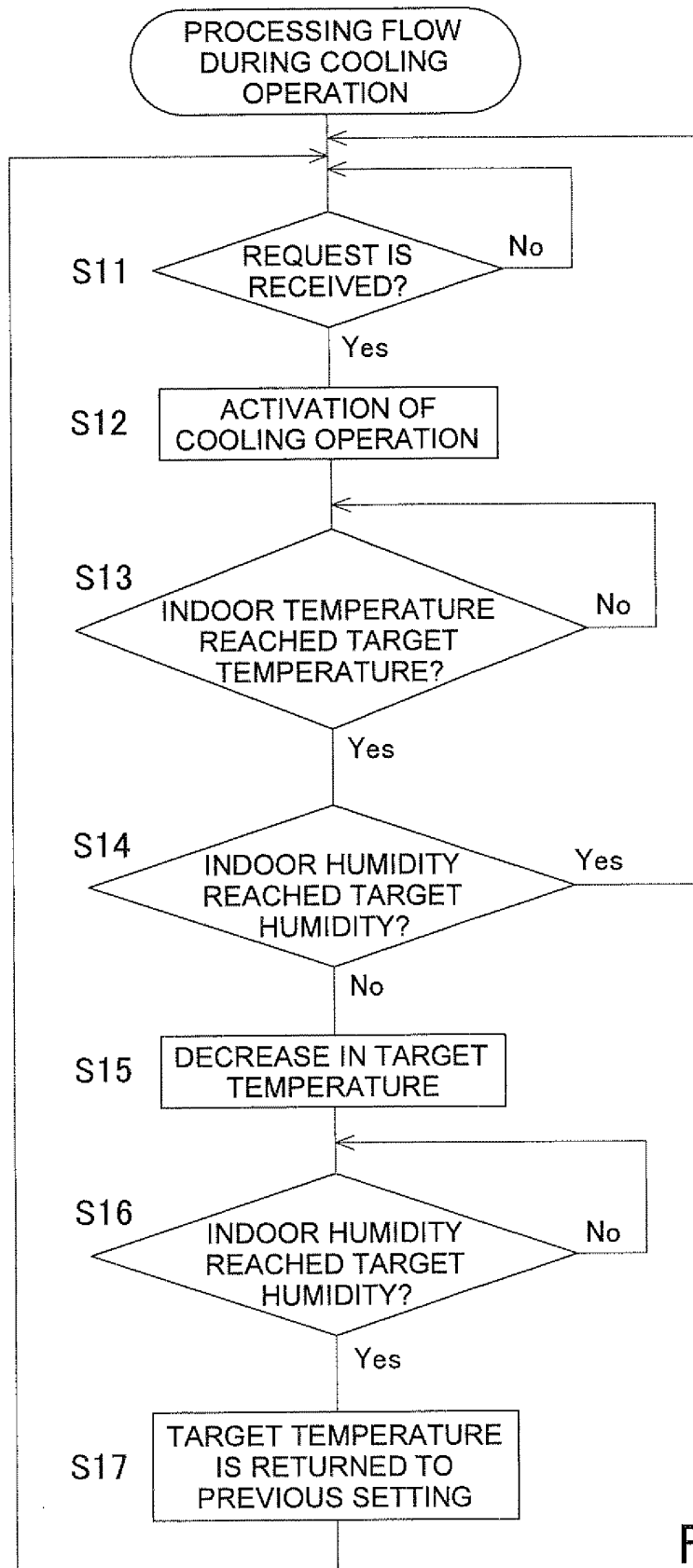


FIG. 6B

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2008/071192

A. CLASSIFICATION OF SUBJECT MATTER F24F11/02 (2006.01) i		
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) F24F11/02		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2009 Kokai Jitsuyo Shinan Koho 1971-2009 Toroku Jitsuyo Shinan Koho 1994-2009		
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	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 22877/1982 (Laid-open No. 126629/1983)	1-3
Y	(Hitachi, Ltd.), 27 August, 1983 (27.08.83), Page 3, line 14 to page 5, line 6; Figs. 2, 3 (Family: none)	4-6
Y	JP 1-208643 A (Toshiba Netsukigu Kabushiki Kaisha), 22 August, 1989 (22.08.89), Claims (Family: none)	4-6
☒ 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 12 February, 2009 (12.02.09)		Date of mailing of the international search report 24 February, 2009 (24.02.09)
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer
Facsimile No.		Telephone No.

Form PCT/ISA/210 (second sheet) (April 2007)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2008/071192

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2001-99458 A (Mitsubishi Electric Corp.), 13 April, 2001 (13.04.01), Claim 7; Par. No. [0035]; Fig. 6 (Family: none)	4-6
Y	JP 2002-130769 A (Funai Electric Co., Ltd.), 09 May, 2002 (09.05.02), Par. Nos. [0004] to [0006] (Family: none)	5,6

Form PCT/ISA/210 (continuation of second sheet) (April 2007)

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP H04320750 A [0003]
- JP 2003139371 A [0062]