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

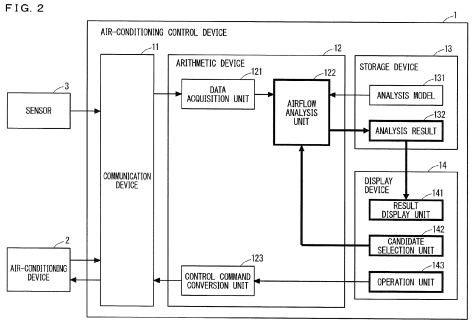
(72) Inventors:
- **SAWADA, Masae**
  Tokyo 100-8310 (JP)
- **TAMURA, Asako**
  Tokyo 100-8310 (JP)
- **MOTODANI, Mio**
  Tokyo 100-8310 (JP)
- **UDAKA, Ryoma**
  Tokyo 100-8310 (JP)

(74) Representative: **Meissner Bolte Partnerschaft mbB**
Patentanwälte Rechtsanwälte
Postfach 86 06 24
81633 München (DE)

(54) **AIR-CONDITIONING CONTROL DEVICE**

(57) An object is to provide an air-conditioning control device capable of operating appropriate air-conditioning setting for a user. An air-conditioning control device (1) is the air-conditioning control device (1) that controls an air-conditioning device (2) that performs air conditioning indoor. The air-conditioning control device (1) includes an arithmetic device (12) and a display device (14). The arithmetic device (12) includes an airflow analysis unit (122) configured to perform airflow analysis based on at least one air-conditioning setting candidates selected by a user. The display device (14) includes a result display unit (141) and an operation unit (143). The result display unit (141) displays an analysis result (132) obtained by the airflow analysis unit (122). The operation unit (143) receives an operation related to an air-conditioning setting of the air-conditioning device (2) that the user performs based on the analysis result (132) displayed on the result display unit (141).

FIG. 2



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Description

TECHNICAL FIELD

[0001] The present disclosure relates to an air-conditioning control device that controls an air conditioner.

BACKGROUND ART

[0002] In conventional control of an air conditioner, a user commonly operates the air conditioner by selecting one of several options for air-conditioning settings such as airflow directions and target temperatures using a remote controller or the like. However, the actual indoor environment is actually formed by the selected air-conditioning setting cannot be known by the user, which has remained a difficulty in selection of the appropriate air-conditioning setting for the user.

[0003] For example, Patent Document 1 discloses an air conditioner that captures an image of a room in which an indoor unit is installed, performs image processing that synthesizes the captured image and airflow information in the room, and displays image information that has undergone the image processing. With this, the user can grasp the indoor air current information, which enables to operate optimal air-conditioning settings according to the indoor environment.

PRIOR ART DOCUMENTS

PATENT DOCUMENT(S)

[0004] [Patent Document 1] Japanese Patent Application Laid-Open No. 2011-257071

SUMMARY

PROBLEM TO BE SOLVED BY THE INVENTION

[0005] In the air conditioner described in Patent Document 1, a temperature distribution is displayed based on thermal images illustrating measured surface temperatures of objects such as walls, or the blowing temperature from the indoor unit. However, the temperature distribution displayed in the air conditioner described in Patent Document 1 is the current temperature distribution, and the user cannot grasp the temperature distribution in advance after setting the air conditioning.

[0006] For example, in a case where a user returns to an office where a plurality of indoor units are installed and intends to lower the temperature, adjusting the airflow direction of one of the air outlets closest to the workspace of the user toward the workspace of the user alone lowers the temperature around the workspace of the user and creates the desired environment. However, it is common for the indoor units including the indoor unit near the workspace of the user to lower a target temperature. Such a case occurs because of a lack of grasp of what kind of temperature distribution is formed in a room with the selection of the air-conditioning settings. Thus, appropriate air-conditioning setting has been difficult for a user to operate.

[0007] Accordingly, an object of the present disclosure is to provide an air-conditioning control device capable of operating appropriate air-conditioning setting for a user.

MEANS TO SOLVE THE PROBLEM

[0008] An air-conditioning control device according to the present disclosure is the air-conditioning control device configured to control an air-conditioning device configured to perform air conditioning indoor, that includes an arithmetic device including an airflow analysis unit configured to perform airflow analysis based on at least one air-conditioning setting candidates selected by a user, and a display device including a result display unit configured to display an airflow analysis result obtained by the airflow analysis unit, and an operation unit configured to receive operation regarding an air-conditioning setting for the air-conditioning device that the user performs based on the airflow analysis result displayed on the result display unit.

EFFECTS OF THE INVENTION

[0009] According to the present disclosure, before performing operation related to the air-conditioning settings for the air-conditioning device, a user can grasp the indoor environment after the air-conditioning setting in advance based on the analysis result; therefore, appropriate air-conditioning settings for the user can be operated.

[0010] The objects, features, aspects, and advantages of the present disclosure will become more apparent from the

following detailed description and the accompanying drawings.

BRIEF DESCRIPTION OF DRAWINGS

[0011]

[FIG. 1] A block diagram illustrating a configuration an air-conditioning system including an air-conditioning control device according to Embodiment.
[FIG. 2] A block diagram illustrating a functional configuration of the air-conditioning control device according to Embodiment, and the connection relationship between an air-conditioning device and a sensor.
[FIG. 3] A table illustrating items stored as device information in Embodiment.
[FIG. 4] A diagram illustrating room shape information used for airflow analysis in Embodiment.
[FIG. 5] An image diagram of a screen displayed on a display device included in the air-conditioning control device according to Embodiment.
[FIG. 6] A flow chart illustrating operation by a user with a display device included in the air-conditioning control device according to Embodiment, and a process of the air-conditioning control device executed by the operation by the user.
[FIG. 7] A diagram illustrating an example of a configuration of a processing circuit included in an arithmetic device.
[FIG. 8] A diagram illustrating an example of a configuration of an other processing circuit included in an arithmetic device.

DESCRIPTION OF EMBODIMENT(S)

<Embodiment>

<Configuration of Air-Conditioning System>

[0012] Embodiment will be described below with reference to the drawings. FIG. 1 is a block diagram illustrating a configuration an air-conditioning system including an air-conditioning control device 1 according to Embodiment.

[0013] As illustrated in FIG. 1, the air-conditioning system includes the air-conditioning control device 1, an air-conditioning device 2, a sensor 3, and a control network 4.

[0014] The air-conditioning control device 1 is connected to the air-conditioning device 2 and the sensor 3 via the control network 4. Also, the air-conditioning control device 1 is a device that controls the air-conditioning device 2.

[0015] The air-conditioning device 2 is an air conditioner that performs indoor air conditioning. The air-conditioning device 2 includes an outdoor unit 21, an indoor unit 22, and a controller 23.

[0016] The outdoor unit 21 cools or heats a heat medium such as refrigerant and water. The indoor unit 22 performs heat exchange between the heat medium and indoor and outdoor air to adjust the indoor temperature. The controller 23 is a device for a user or an administrator to manually change settings of ON/OFF, target temperatures, air volumes, airflow directions, and the like of the indoor unit 22. The air-conditioning device 2 may include a ventilation unit or an outside air-conditioning unit installed for the purpose of introducing outside air into the room, in addition to a device for heating or cooling the indoor air.

[0017] In an air-conditioning system for residential use, one indoor unit 22 is typically installed in one room. A room air conditioner is a representative example of the air-conditioning device 2, for example. However, the air-conditioning device 2 may be a room air conditioner in which a plurality of indoor units 22 are connected to one outdoor unit. Also, the air-conditioning device 2 may be a multi-air conditioner designed for use in structures such as office buildings. Further, the air-conditioning device 2 may be a central air-conditioning system used for centralized air conditioning in a great building. These are only examples, and the types of air-conditioning device 2 are not limited thereto. Also, the air-conditioning target spaces are not limited thereto.

[0018] The sensor 3 is a sensor that measures a physical quantity, includes one or a plurality of sensors 31, 32, etc., and detects indoor and outdoor environmental conditions. The sensor 3 is, for example, a sensor that measures temperature, humidity, radiation temperature, thermal image, air velocity, or the like. If the sensor 3 is built in the air-conditioning device 2, the sensor 3 incorporated in the air-conditioning device 2 may be used.

[0019] Further, when the outdoor temperature is detected, the sensor 3 incorporated in the outdoor unit 21 of the air-conditioning device 2 may be used.

[0020] The control network 4 is a network for communication that connects the air-conditioning control device 1, the air-conditioning device 2, and the sensors 3. For the control network 4, the type of cable, communication protocol, etc. are not particularly limited. That is, the control network 4 may be the one corresponding to wired communication such as LAN or wireless communication. Also, the control network 4 may be the one corresponding to a general-purpose

protocol that is open to the public. Further, the control network 4 may the one corresponding to a dedicated line and a dedicated protocol provided by the manufacturer of the air-conditioning device 2.

<Configuration of Air-Conditioning Control Device>

[0021] Next, a configuration of the air-conditioning control device 1 will be described with reference to FIGS. 1 and 2. FIG. 2 is a block diagram illustrating a functional configuration of the air-conditioning control device 1 according to Embodiment, and the connection relationship between the air-conditioning device 2 and a sensor.

[0022] As illustrated in FIGS. 1 and 2, the air-conditioning control device 1 controls the air-conditioning device 2, and includes a communication device 11, an arithmetic device 12, a storage device 13, and a display device 14.

[0023] The communication device 11 is a device that acquires measurement data from the sensor 3, acquires operation data from the air-conditioning device 2, and transmits control commands to the air-conditioning device 2. The operation data from the air-conditioning device 2 and the measurement data from the sensor 3 are continuously acquired at predetermined time intervals (for example, five minutes). The intervals for those data acquisition may be different from each other.

[0024] The storage device 13 stores an analysis model 131 that includes equipment information, analysis conditions, and room shape information, and an analysis result 132.

[0025] The equipment information includes configuration information such as positions and a number of the air outlets and air inlets of the indoor unit 22 installed in the subject room, as well as information regarding the capabilities, efficiency, adjustable air outlet temperature, air volume, and airflow direction of each indoor unit 22. The configuration information includes the correspondence relationship between the actual shapes of the air outlet and the air inlet of the indoor unit 22 and the shapes of the air outlet and the air inlet of the indoor unit 22 included in the room shape information, and information for identifying the air outlet and the air inlet of the indoor unit 22.

[0026] Next, the details of the device information will be described with reference to FIG. 3. FIG. 3 is a table illustrating items stored as the device information in Embodiment. In FIG. 3, the indoor unit 22 is assumed to be a four-direction cassette type indoor unit having four air outlets and one air inlet for each unit, and it is assumed that four indoor units 22 are installed in the subject room.

[0027] In the air-conditioning control device 1, information on the adjustable airflow speed, vertical airflow direction, and horizontal airflow direction is obtained in advance by referring to the model information of the air-conditioning device 2. Also, the names of an air outlet surface and an inlet surface of each room model are created so as to correspond to the room shape information. These pieces of information are examples, and the information included in the device information is not limited thereto.

[0028] The analysis conditions are various setting conditions in the airflow analysis. For example, the setting includes the type of algorithm used for calculation, the time interval for unsteady calculation, and the calculation target time.

[0029] The room shape information is shape data of 3D CAD or the like used for airflow analysis, and is created in advance as data reproducing the shape for each room into which the air-conditioning control device 1 is installed. In terms of the method of creating room shape information, there are methods in which the room shape information is created by extracting only the necessary shapes for airflow analysis from Building Information Modeling (BIM) data, and by extracting only the surfaces required for airflow analysis from point cloud data obtained by the 3D measurement using visual imaging, laser measurement, or distance sensors or the like.

[0030] Also, a vendor of the air-conditioning control device 1 may provide model creation software with a GUI that can be operated with ease, and a user, an equipment installer, or a maintenance and management operator may operate the software to arrange a utensil such as a set of furniture and create the room shape information. These are mere examples, and the method of creating room shape information is not limited thereto.

[0031] Next, the room shape information will be described with reference to FIG. 4. FIG. 4 is a diagram illustrating the room shape information used for airflow analysis in Embodiment. Specifically, FIG. 4 is a diagram illustrating the room shape information when four cassette type indoor units 22 are installed each of which having air outlets in four directions on the ceiling surface.

[0032] A name is set for identifying the air outlets and the air inlet of each indoor unit. Further, as illustrated in FIG. 4, furniture such as desks, a chair, and book cases may be added to the room shape information in addition to the room shape.

[0033] The analysis result 132 is the calculation result in the airflow analysis unit 122, that is, an airflow analysis result obtained by the airflow analysis unit 122, and consists of values such as the temperature and airflow speed of each mesh in the airflow analysis model.

[0034] Next, the details of the arithmetic device 12 will be described. As illustrated in FIG. 2, the arithmetic device 12 includes a data acquisition unit 121, the airflow analysis unit 122, and a control command conversion unit 123.

[0035] The data acquisition unit 121 acquires measurement data from the sensor 3 through the communication device 11 and acquires operation data from the air-conditioning device 2.

[0036] The airflow analysis unit 122 performs airflow analysis based on at least one air-conditioning setting candidate

selected by the user. Specifically, the airflow analysis unit 122 calculates data indicating the indoor environment after a certain period of time has passed as airflow analysis. Here, the data indicating the indoor environment represents distribution of at least one of the temperature, the airflow speed, the humidity, the CO_2 concentration, and the particle concentration.

[0037] The airflow analysis model to be analyzed is created by acquiring an analysis model 131 composed of device information, analysis conditions, and room shape information from the storage device 13, and using the measurement data from the sensor 3 and the operation data from the air-conditioning device 2. As an airflow analysis model, for example, a Computational Fluid Dynamics (CFD) analysis method is adopted.

[0038] The process of creating an airflow analysis model includes a mesh creation step that divides the indoor space into a number of minute spaces based on the room shape information, a step of setting values corresponding to the shapes of the window and the air-conditioning device 2 included in the room shape information as a wall surface boundary condition, an inflow boundary condition, and an outflow boundary condition for performing the airflow analysis, and a step of setting the initial temperature in the room.

[0039] The value set as a boundary condition is acquired by the following method, for example. For the wall surface boundary condition for each wall surface such as walls, windows, a ceiling, and a floor in the room shape information, the airflow analysis unit 122 acquires the temperature of each corresponding wall surface from the thermal image acquired by the sensor 3, which is an infrared sensor.

[0040] In terms of the inflow boundary condition and the outflow boundary condition of the air-conditioning device 2, first, the airflow analysis unit 122 acquires the model number of the air-conditioning device 2 installed in the subject room from the device information, and obtains the information on the air volume. When the subject model has a plurality of air volume notches, the air volume of the air volume notch selected by the user is used.

[0041] Next, the airflow analysis unit 122 acquires the number of air outlets from the device information, and divides the blowing air volume by the number of air outlets to obtain the blowing air volume per air outlet. Similarly, for the air inlets, the air volume per air inlet can be obtained by acquiring the number of air inlets from the device information and dividing the air volume by the number of air inlets.

[0042] In terms of the outlet temperature of the inflow boundary condition, he airflow analysis unit 122 acquires the temperature of each wall surface from the thermal image, estimates an indoor load from the difference between the temperature of each wall surface and the target temperature selected by the user, and obtains an outlet temperature required to handle the estimated load from the air volume selected by the user and the target temperature by calculation. After the current room temperature acquired from the measurement data or operation data, the initial value of the air outlet temperature in the room is set based on the current room temperature. For example, the governing equation of the fluid used for CFD analysis is illustrated as follows.

[Expression 1]

$$\nabla \cdot \mathbf{u} = 0 \qquad \cdots (1)$$

[Expression 2]

$$\rho\left(\frac{\partial \mathbf{u}}{\partial t} + (\mathbf{u}\cdot\nabla\mathbf{u})\right) = -\nabla p + \nabla\cdot(\mu\nabla\mathbf{u}) + (\rho - \rho_0)\mathbf{g} \quad \cdots (2)$$

[Expression 3]

$$C_p\left(\frac{\partial T}{\partial t} + (\mathbf{u}\cdot\nabla T)\right) = \nabla\cdot(k\nabla T) + Q \qquad \cdots (3)$$

[0043] Here, u represents the velocity vector in three dimensions, t represents time, p represents pressure, ρ represents density, μ represents viscosity coefficient, ρ_0 represents reference density, g represents gravitational acceleration, C_p represents specific heat at constant pressure, T represents temperature, k represents thermal conductivity, and Q represents internal heat generation.

[0044] Expression (1) is a continuity equation that expresses the conservation of mass in a fluid. Expression (2) is the incompressible Navier-Stokes equation representing conservation of momentum. Expression (3) is an energy equation. The airflow analysis unit 122 calculates the temperature, airflow speed, etc. of each divided region by solving Expressions (1) to (3) under the set initial values and boundary conditions. In addition to these, humidity, CO_2 concentration, or particle concentration may also be calculated.

[0045] In addition, airflow analysis requires a large computational load, and if taking computational time may a problem, cloud computing through a network may be utilized. Also, data obtained by performing airflow analysis in advance for a plurality of combination patterns including airflow speed, air volume, and airflow direction in the air-conditioning device 2 may be stored as the analysis result 132 and used.

[0046] The control command conversion unit 123 converts an operation related to air-conditioning settings for the air-conditioning device 2 operated by the user on the operation unit 143 of the display device 14 (to be described later) into a control command for controlling the air-conditioning device 2.

[0047] Next, the display device 14 will be described. As illustrated in FIG. 2, the display device 14 includes a result display unit 141, a candidate selection unit 142, and an operation unit 143, and is a display equipped with a touch panel. The display device 14 may be a smart phone or a tablet. Also, in addition to the display equipped with a touch panel, the display device 14 may be the one to which external input devices such as a mouse and a keyboard are combined.

[0048] The result display unit 141 displays the analysis result 132 stored in the storage device 13 on a result display screen 144 (see FIG. 5). The analysis result 132 is displayed, for example, as a contour diagram of scalar values of the temperature in the room and the absolute value of the airflow speed. In terms of displaying the flow of the airflow, the three components of the airflow speed with respect to a section with a horizontal or vertical plane or the two components with respect to a projection plane may be displayed in a vector diagram, or the flow from the outlet position may be displayed three-dimensionally by particle or vector animation. The viewpoint position for displaying the contour diagram and the vector diagram may be changed by operating a touch panel, for example, so that the user can freely select the desired position. Further, the position in the cross section to be displayed may be set so that the cross section that the user wishes to see can be displayed using a slide bar or the like.

[0049] The candidate selection unit 142 displays a plurality of air-conditioning setting candidates on a selection operation screen 145 (see FIG. 5), and makes the user select at least one of the air-conditioning setting candidates. The selection of air-conditioning setting candidates is performed to make the user check the indoor environment formed after a certain period of time has passed based on the air-conditioning setting candidates selected by the user before the user actually performs an operation related to the air-conditioning setting for the air-conditioning device 2.

[0050] As the candidates for the air-conditioning settings, it may be selected from the airflow speed, the airflow direction, and the target temperature of the settings for the air-conditioning device 2, or may be selected from some of setting patterns consisting of the airflow speed, the airflow direction and the target temperature of the settings for the air-conditioning device 2. Alternatively, it may also be selected from among several control modes that the air-conditioning device 2 automatically performs to achieve the purpose of the user, such as shortening the start-up time, suppressing temperature unevenness in the room, or prevention of direct airflow. Further, not only one candidate, but also a plurality of candidates may be selected for the air-conditioning setting candidates. For items that can be set for the air-conditioning device 2, the user can easily select from options displayed by, for example, a pull-down list.

[0051] After the user confirms the indoor environment formed after a certain period of time has passed on the result display screen 144 (see FIG. 5), the operation unit 143 receives operation regarding the air-conditioning settings for the air-conditioning device 2 that the user operates on the selection operation screen 145 (see FIG. 5).

[0052] FIG. 5 is an image diagram of a screen displayed on the display device 14 included in the air-conditioning control device 1 according to Embodiment. FIG. 5 illustrates a case where four indoor units 22 of the four-way outlet type are installed in the room. A specific example of the relationship between the screen and each part of the display device 14 will be described below. Note that the screen configuration is merely an example, and the configuration is not necessarily limited to this configuration.

[0053] As illustrated in FIG. 5, the result display screen 144 that implements the function of the result display unit 141 is displayed in the left frame of the screen, and the selection operation screen 145 that implements the function of the candidate selection unit 142 and the function of the operation unit 143 is displayed in the right frame.

[0054] A temperature button and an airflow button on the result display screen 144 are used to designate display items, and when the buttons are pressed, the analysis results 132 of the corresponding items are displayed. Also, the slide bar on the left side is for changing the display height. When any of the 10 minutes later button, the 20 minutes later button, and the 30 minutes later button in the upper part of the frame is pressed, the analysis result 132 after the corresponding time has passed is displayed. The user can confirm changes in the indoor environment after a certain period of time has passed for each of the selected air-conditioning setting candidates. Although in the above description, the analysis results 132 at three points in time are displayed on the result display screen 144, the analysis results 132 at two points, four points or more points may be displayed.

[0055] Further, when the user selects a plurality of air-conditioning setting candidates, the result display unit 141 may switch and display a plurality of analysis results 132 respectively corresponding to the plurality of air-conditioning setting candidates selected by the user.

[0056] On the selection operation unit 145, the setting items of the indoor unit 22 selected by the user from among the indoor units 22 displayed on the result display screen 144 are displayed. Although the setting items differ depending on the air-conditioning devices 2, the selectable items here are supposed to be the operation mode, the target temperature,

the airflow speed, the horizontal airflow direction, and the vertical airflow direction. Further, each indoor unit 22 has four air outlets in each of which, the horizontal airflow direction and the vertical airflow direction are selectable, and the air outlet subjected to changing of setting is selectable in the selection operation screen 145.

[0057] When the user presses the environment prediction button displayed at the lower part of the selection operation screen 145 after selecting the setting to be changed, the analysis result 132 based on the setting selected by the user is displayed on the result display screen 144. After the user confirms the analysis result 132 and decides that the indoor environment is what the user wishes, pressing the enter button displayed at the lower part of the selection operation screen 145 makes the air-conditioning setting for the air-conditioning device 2 effective..

<Process of Air-Conditioning Control Device>

[0058] Next, with reference to FIG. 6, the process of the air-conditioning control device 1 executed by the operation by the user will be described. FIG. 6 is a flow chart illustrating the operation by the user with the display device 14 included in the air-conditioning control device 1 according to Embodiment, and a process of the air-conditioning control device 1 executed by the operation by the user.

[0059] As illustrated in FIG. 6, in Step S1, the user selects an indoor unit 22 that the user wishes to change the settings from among the four indoor units 22 displayed on the result display screen 144, and for the selected indoor unit 22, the user selects items such as the operation mode, the target temperature, the airflow speed, the horizontal airflow direction, and the vertical airflow direction. In a case where the user operates setting on the individual specific air outlets in terms of the four air outlets provided in one indoor unit 22, the user displays a simplified diagram of the indoor unit and selects the desired air outlet and then selects the desired airflow speed and airflow direction.

[0060] In Step S2, the user presses an environment prediction button in order to confirm the indoor environment to be formed after a certain period of time has passed, based on the air-conditioning setting candidate selected in Step S1. When the environment prediction button is pressed, a series of airflow analysis processing steps are executed, and the process proceeds to Step S11.

[0061] In Step S11, the airflow analysis unit 122 acquires the measurement data and the operation data that serve as boundary conditions for airflow analysis via the data acquisition unit 121, and reads the analysis model 131 including the device information, the analysis conditions, and the room shape information from the storage device 13.

[0062] In Step S12, the airflow analysis unit 122 creates the airflow analysis model based on the measurement data and the operation data acquired in Step S11 and the analysis model 131.

[0063] In Step S13, the airflow analysis unit 122 executes the airflow analysis by executing the calculation of the airflow analysis model created in Step S12.

[0064] In Step S14, the result display unit 141 displays the calculated analysis result 132 on the result display screen 144, and the process proceeds to the operation on the user side.

[0065] In Step S3, the user confirms the analysis result 132 displayed on the result display screen 144 and determines whether the indoor environment satisfies the user's wish. Here, if the user decides that the user's wish is satisfied, the process proceeds to Step S4, and if the user decides that the user's wish is not satisfied, the process returns to Step S 1.

[0066] In Step S4, when the user presses the enter button, the process proceeds to Step S15 on the air-conditioning control device 1 side.

[0067] In Step S15, the control command conversion unit 123 converts the air-conditioning setting selected by the user into a control command, and the process ends after transmitting the control command to the air-conditioning device 2.

[0068] In the above, the description has been made on the configuration in which, when a plurality of indoor units 22 are installed in the room, the plurality of indoor units 22 are displayed in the image diagram of the room shape displayed on the result display screen 144, and the user selects the indoor unit 22 the user wishes to operate the air-conditioning setting on the result display screen 144. Meanwhile, when a single indoor unit 22 is installed in the room, the procedure for selecting the indoor unit 22 subjected to the air-conditioning setting is eliminated. The selection screen for the air-conditioning settings may be displayed on the selection operation screen 145 without selecting an indoor unit.

[0069] Further, even a case of a single indoor unit 22 being installed indoors, the indoor unit 22 illustrated in the image diagram of the room shape may be selected, and the selection screen for air-conditioning setting may be displayed on the selection operation screen 145 only when it is selected as in the case where multiple indoor units 22 are installed. Further, when the display area of the display device 14 is small, such as a screen of a smartphone, the result display screen 144 and the selection operation screen 145 may not be displayed at the same time, and may be displayed by switching.

<Processing Circuit>

[0070] FIG. 7 is a diagram illustrating an example of a configuration of a processing circuit 90 included in the arithmetic device 12.Each function of the data acquisition unit 121, the airflow analysis unit 122, and the control command conversion

unit 123 is implemented by the processing circuit 90. That is, the processing circuit 90 includes the data acquisition unit 121, the airflow analysis unit 122, and the control command conversion unit 123.

[0071] When the dedicated hardware is applied to the processing circuit 90, a processing circuit 90 corresponds, for example, to a single circuit, a composite circuit, a programmed processor, a parallel programmed processor, an Application Specific Integrated Circuit (ASIC), or a Field-Programmable Gate Array (FPGA), or the combination thereof. Each function of the data acquisition unit 121, the airflow analysis unit 122, and the control command conversion unit 123 may be individually implemented by a plurality of processing circuits, or may be implemented by one processing circuit with the functions being integrated.

[0072] FIG. 8 is a diagram illustrating an example of a configuration of an other processing circuit included in the arithmetic device 12. The processing circuit includes a processor 91 and a memory 92. By the processor 91 executing a program stored in the memory 92, each function of the data acquisition unit 121, the airflow analysis unit 122, and the control command conversion unit 123 is implemented. For example, each function is implemented by software or firmware written as a program being executed by the processor 91. That is, the arithmetic device 12 includes the memory 92 that stores the program and the processor 91 that executes the program.

[0073] In the program, the functions of the data acquisition unit 121, the airflow analysis unit 122, and the control command conversion unit 123 are written. Also, the program causes a computer to execute the procedures or methods of the data acquisition unit 121, the airflow analysis unit 122, and the control command conversion unit 123.

[0074] The processor 91 is, for example, a central processing unit, a processing unit, an arithmetic unit, a microprocessor, a microcomputer, or a digital signal processor (DSP). The memory 92 is, for example, a non-volatile or volatile semiconductor memory, such as a random access memory (RAM), a read only memory (ROM), a flash memory, an erasable programmable read only memory (EPROM), an electrically erasable programmable read only memory (EEPROM), or the like. Also, the memory 92 may be a magnetic disk, a flexible disk, an optical disk, a compact disk, a mini disk, a DVD or the like, or any storage medium to be used in the future. The storage device 13 described above may be the memory 92.

[0075] Each function of the data acquisition unit 121, the airflow analysis unit 122, and the control command conversion unit 123 may be partly implemented by dedicated hardware and partly implemented by software or firmware. In this manner, the processing circuit implements each function described above through hardware, software, firmware, or a combination thereof.

[0076] Also, each function of the result display unit 141, the candidate selection unit 142, and the operation unit 143 included in the display device 14 are implemented by the processing circuit 90 illustrated in FIGS. 7 and 8 and the description thereof is omitted since the process thereof is as much the same as the arithmetic unit 12.

<Effect>

[0077] As described above, the air-conditioning control device 1 according to Embodiment is the air-conditioning control device 1 that controls the air-conditioning device 2 that performs indoor air conditioning, that includes the display device 14 including the arithmetic device 12 including the airflow analysis unit 122 that performs the airflow analysis based on at least one air-conditioning setting candidate selected by the user, the result display unit 141 that displays the analysis result 132 obtained by the airflow analysis unit 122, and the operation unit 143 that receives an operation related to the air-conditioning setting of the air-conditioning device 2 that the user operates based on the analysis result 132 displayed on the result display unit 141.

[0078] Therefore, before performing operation related to the air-conditioning settings for the air-conditioning device 2, the user can grasp the indoor environment after the air-conditioning setting in advance based on the analysis result 132; therefore, appropriate air-conditioning settings for the user can be operated.

[0079] Also, if the air-conditioning setting is found excessive for the user from the analysis result 132, the user can select an appropriate air-conditioning setting. Consequently, the reduction in the amount of energy consumed by the air-conditioning device 2 is ensured, thereby improving comfort and wasting less energy.

[0080] Also, the airflow analysis unit 122 calculates data indicating the indoor environment after a certain period of time has passed as airflow analysis. Therefore, the user can appropriately operate the air-conditioning setting based on the indoor environment after a certain period of time has passed.

[0081] Further, the data indicating the indoor environment represents distribution of at least one of the temperature, the airflow speed, the humidity, the CO_2 concentration, and the particle concentration. Therefore, the user can appropriately operate the air-conditioning setting based on the spatial distribution of indices relating to the thermal environment and air quality as the indoor environment.

[0082] Further, the air-conditioning control device 1 is connected to the sensor 3 that detects indoor or outdoor environmental conditions via the control network 4, the arithmetic device 12 further has the data acquisition unit 121 that acquires the environmental conditions detected by the sensor 3, and the airflow analysis unit 122 performs airflow analysis using the environmental conditions acquired by the data acquisition unit 121 as boundary conditions. Therefore,

the airflow analysis unit 122 can perform highly accurate airflow analysis using the measurement data.

[0083] Further, the sensor 3 is an infrared sensor that acquires a thermal image of the room, and the environmental condition is the surface temperature of an object in the room detected from the thermal image. Therefore, the airflow analysis unit 122 can perform highly accurate airflow analysis with the different temperatures for each wall surface in the room taken into account.

[0084] Further, the result display unit 141 switches and displays a plurality of analysis results 132 respectively corresponding to a plurality of air-conditioning setting candidates selected by the user. Therefore, the user can compare a plurality of indoor environments corresponding to a plurality of air-conditioning settings, allowing the user to operate more suitable air-conditioning settings.

[0085] Also, the result display section 141 displays the analysis results 132 at least at two points in time. Therefore, the user can confirm in chronological order how the indoor space is going to be formed with the passage of time.

<Modification>

[0086] In the above description, the temperature of each corresponding wall surface is obtained from the thermal image obtained by the infrared sensor included in the sensor 3, and the airflow analysis is performed using the obtained temperature of each wall surface as a boundary condition, however, the airflow analysis may be performed using the surface temperature of an object after a certain period of time has passed, which is predicted using weather data and weather forecast data, as a boundary condition.

[0087] The data acquisition unit 121 has a function of acquiring the weather data such as weather forecasts and the weather forecast data via the Internet. The airflow analysis unit 122 learns the relationship between the weather data and the surface temperature of the object, and performs airflow analysis using the surface temperature of the object after a certain period of time has passed, which is predicted based on the learned relationship and weather prediction data, as a boundary condition.

[0088] Consequently, highly accurate airflow analysis can be performed in consideration of changes in boundary conditions over time.

[0089] Further, when the air-conditioning device 2 includes a ventilation device installed for the purpose of introducing outside air into the room, the air flow analysis unit 122 may calculate the air age from the air outlet through which the outside air is introduced into the room by the ventilation device to an exhaust port through which the indoor air is exhausted to the outside, and the obtained air age may be added to the airflow analysis. The air age $T_{air}(x)$ at position x is expressed by the following equation.

[Expression 4]

$$T_{air}(x) = \frac{c'_x(x)}{c_s} \quad \cdots (4)$$

[0090] Here, c's represents the instantaneous uniform diffusion concentration [kg/m^3], cx'(x) represents the concentration distribution when the total amount of pollutant q is generated in the room, and is the stationary solution of the advection equation for the following concentration.

[Expression 5]

$$\frac{\partial c'_x}{\partial t} + \sum_{j=1}^{3} \frac{\partial c'_x U_j}{\partial x_j} = \frac{q}{V} \quad \cdots (5)$$

where V represents the room volume, q represents the amount of pollutants generated from the pollution source, and Q represents the amount of ventilation.

[0091] By adding the air age to the airflow analysis, the user can confirm whether there will be any areas where the outside air does not reach the room when setting the air volume of the ventilation device, thereby ensuring appropriate air volume setting for the ventilation device.

[0092] Further, a person detection sensor that detects the number of people in the room may be adopted as the sensor 3, and airflow analysis may be performed based on information acquired from the number of people in the room.

[0093] The environmental condition is set to the number of people in the room, the airflow analysis unit 122 calculates at least one value among the amount of heat generated, the amount of water generated, the amount of CO_2 generated, and the amount of generated droplets corresponding to the number of people in the room, based on the amount of heat generated, the amount of water generated, the amount of CO_2 generated, and the amount of generated droplets for the

predetermined per person in the room, and performs airflow analysis using the obtained value as a boundary condition. Note that the amount of heat generated, the amount of water generated, the amount of CO_2 generated, and the amount of generated droplets per person in the room are stored in the storage device 13, for example.

[0094] By performing the airflow analysis based on the information obtained from the number of people in the room, the airflow analysis unit 122 can perform highly accurate airflow analysis with the number of people in the room taken into account.

[0095] Although the present disclosure has been described in detail, the foregoing description is, in all aspects, illustrative and not restrictive, and not intended to limit the present disclosure. It is therefore understood that numerous modification examples can be devised.

[0096] Embodiment can be appropriately modified.

EXPLANATION OF REFERENCE SIGNS

[0097] 1 air-conditioning control device, 2 air-conditioning device 3 sensor, 4 control network, 1 arithmetic device, 14 display device, 121 data acquisition unit, 122 airflow analysis unit, 141 result display unit, 143 operation unit

Claims

1. An air-conditioning control device configured to control an air-conditioning device configured to perform air conditioning indoor, comprising:

   an arithmetic device including an airflow analysis unit configured to perform airflow analysis based on at least one air-conditioning setting candidates selected by a user; and
   a display device including a result display unit configured to display an airflow analysis result obtained by the airflow analysis unit, and an operation unit configured to receive operation regarding an air-conditioning setting for the air-conditioning device that the user performs based on the airflow analysis result displayed on the result display unit.

2. The air-conditioning control device according to claim 1, wherein
   the airflow analysis unit is configured to calculate data indicating an indoor environment after a certain period of time has passed as the airflow analysis.

3. The air-conditioning control device according to claim 2, wherein
   the data indicating the indoor environment represents distributions of at least one of a temperature, an airflow speed, a humidity, a CO_2 concentration, and a particle concentration.

4. The air-conditioning control device according to claim 1, wherein

   the air-conditioning control device is connected to a sensor configured to detect an environmental condition of the indoor or outdoor via a control network,
   the arithmetic device further includes a data acquisition unit configured to acquire the environmental condition detected by the sensor, and
   the airflow analysis unit is configured to perform the airflow analysis using the environmental condition acquired by the data acquisition unit as a boundary condition.

5. The air-conditioning control device according to claim 4, wherein

   the sensor is an infrared sensor configured to acquire a thermal image of the indoor, and
   the environmental condition is a surface temperature of an object in the indoor detected from the thermal image.

6. The air-conditioning control device according to claim 5, wherein

   the data acquisition unit has a function of acquiring weather data and weather forecast data via the Internet, and
   the airflow analysis unit is configured to learn a relationship between the weather data and the surface temperature of the object, and perform the airflow analysis using the surface temperature of the object after a certain period of time has passed, which is predicted using the learned relationship and the weather forecast data, as the boundary condition.

7. The air-conditioning control device according to claim 1, wherein
the result display unit is configured to switch and display a plurality of the airflow analysis results respectively corresponding to a plurality of the air-conditioning setting candidates selected by the user.

8. The air-conditioning control device according to claim 1, wherein

the airflow analysis unit is configured to perform the airflow analysis at least at two points in time from a present time until after a certain period of time has passed, and
the result display unit is configured to display the airflow analysis results at the at least two points in time.

9. The air-conditioning control device according to claim 1, wherein

the air-conditioning device includes a ventilation device configured to exchange air in the indoor and outside air, and
the airflow analysis unit is configured to calculate an air age from an air outlet through which outside air is introduced into the indoor by the ventilation device to an exhaust port through which the indoor air is exhausted to the outdoor, and add the obtained air age in the airflow analysis.

10. The air-conditioning control device according to claim 4, wherein

the sensor is a person detection sensor configured to detect the number of people in the indoor,
the environmental condition is the number of people in the indoor, and
the airflow analysis unit is configured to calculate at least one value among an amount of heat generated, an amount of water generated, an amount of CO_2 generated, and an amount of generated droplets corresponding to the number of people in the indoor, based on an amount of heat generated, an amount of water generated, an amount of CO_2 generated, and an amount of generated droplets corresponding to a predetermined per person, and perform the airflow analysis using the obtained value as the boundary condition.

FIG. 1

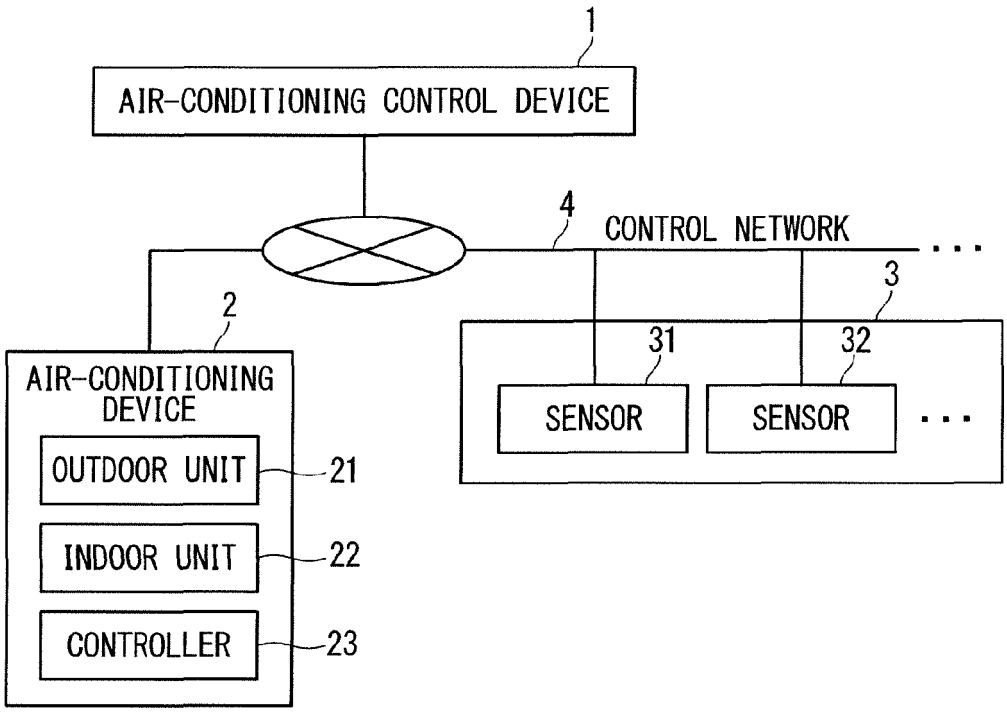

1
AIR-CONDITIONING CONTROL DEVICE
4
CONTROL NETWORK
3
2
31
32
AIR-CONDITIONING DEVICE
SENSOR
SENSOR
OUTDOOR UNIT
21
INDOOR UNIT
22
CONTROLLER
23

FIG. 2

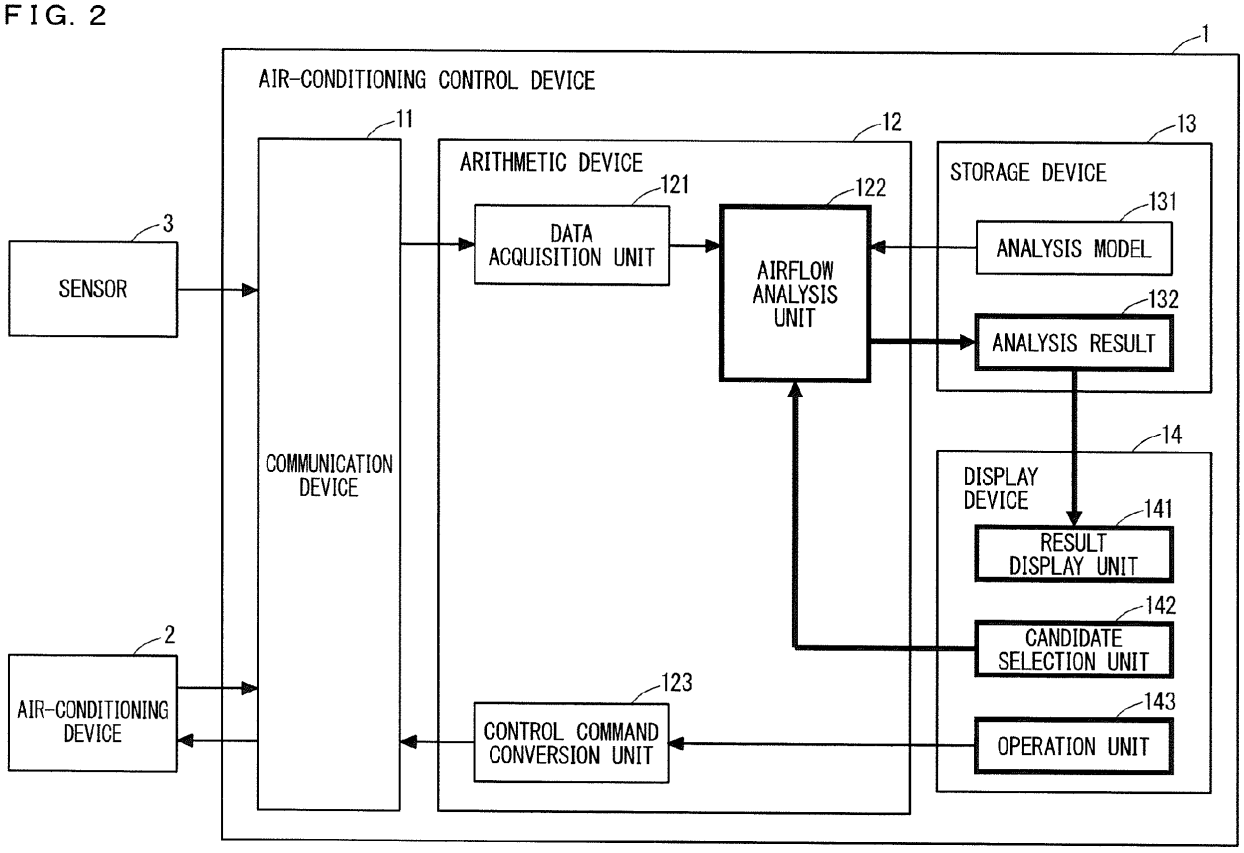

1
AIR-CONDITIONING CONTROL DEVICE
11
12
13
ARITHMETIC DEVICE
STORAGE DEVICE
121
122
131
3
SENSOR
DATA ACQUISITION UNIT
AIRFLOW ANALYSIS UNIT
ANALYSIS MODEL
132
ANALYSIS RESULT
14
COMMUNICATION DEVICE
DISPLAY DEVICE
141
RESULT DISPLAY UNIT
142
CANDIDATE SELECTION UNIT
2
AIR-CONDITIONING DEVICE
123
CONTROL COMMAND CONVERSION UNIT
143
OPERATION UNIT

FIG. 3

INDOOR UNIT NAME	INDOOR UNIT 1	INDOOR UNIT 2	INDOOR UNIT 3	INDOOR UNIT 4
AIRFLOW SPEED LEVEL 1[m^3/min]	17	17	17	17
AIRFLOW SPEED LEVEL 4[m^3/min]	16	16	16	16
...	...	...	...	...
VERTICAL AIRFLOW DIRECTION 1[°]	37	37	37	37
VERTICAL AIRFLOW DIRECTION 2[°]	37	37	37	37
...	...	...	...	...
HORIZONTAL AIRFLOW DIRECTION 1[°]	-45	-45	-45	-45
HORIZONTAL AIRFLOW DIRECTION 2[°]	-22.5	-22.5	-22.5	-22.5
...	...	...	...	...
NAME OF ROOM MODEL AIR OUTLET SURFACE 1	IC1_outlet1	IC2_outlet1	IC3_outlet1	IC4_outlet1
NAME OF ROOM MODEL AIR OUTLET SURFACE 2	IC1_outlet2	IC2_outlet2	IC3_outlet2	IC4_outlet2
NAME OF ROOM MODEL AIR OUTLET SURFACE 3	IC1_outlet3	IC2_outlet3	IC3_outlet3	IC4_outlet3
NAME OF ROOM MODEL AIR OUTLET SURFACE 4	IC1_outlet4	IC2_outlet4	IC3_outlet4	IC4_outlet4
NAME OF ROOM MODEL AIR INLET SURFACE	IC1_inlet	IC2_inlet	IC3_inlet	IC4_inlet

FIG. 4

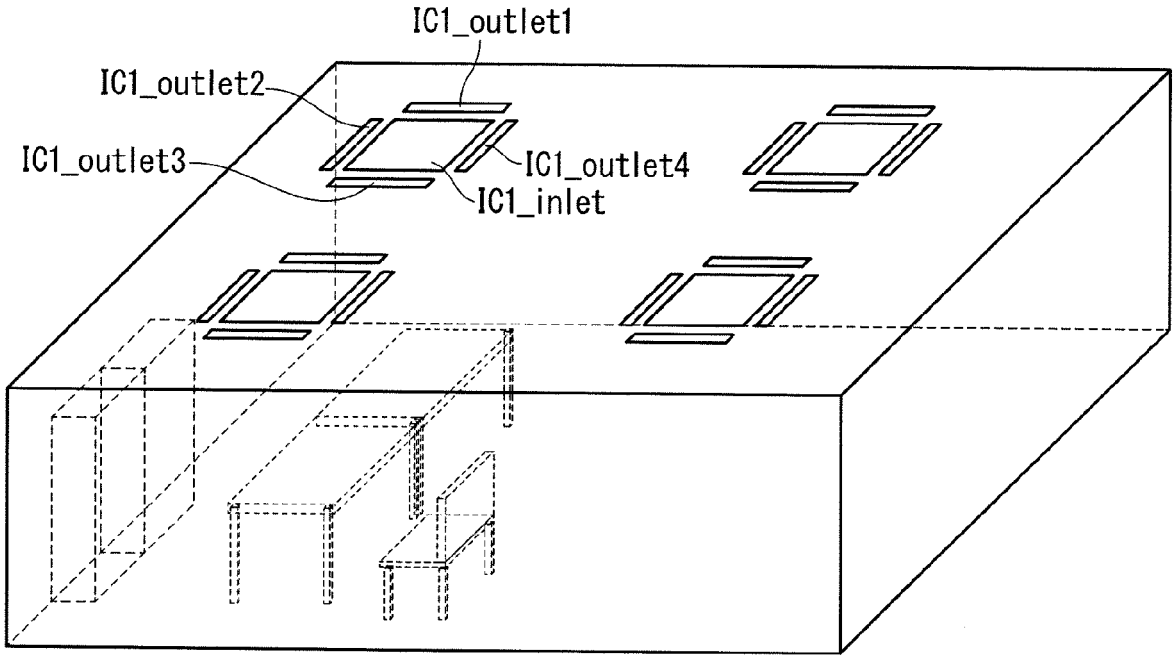


FIG. 5

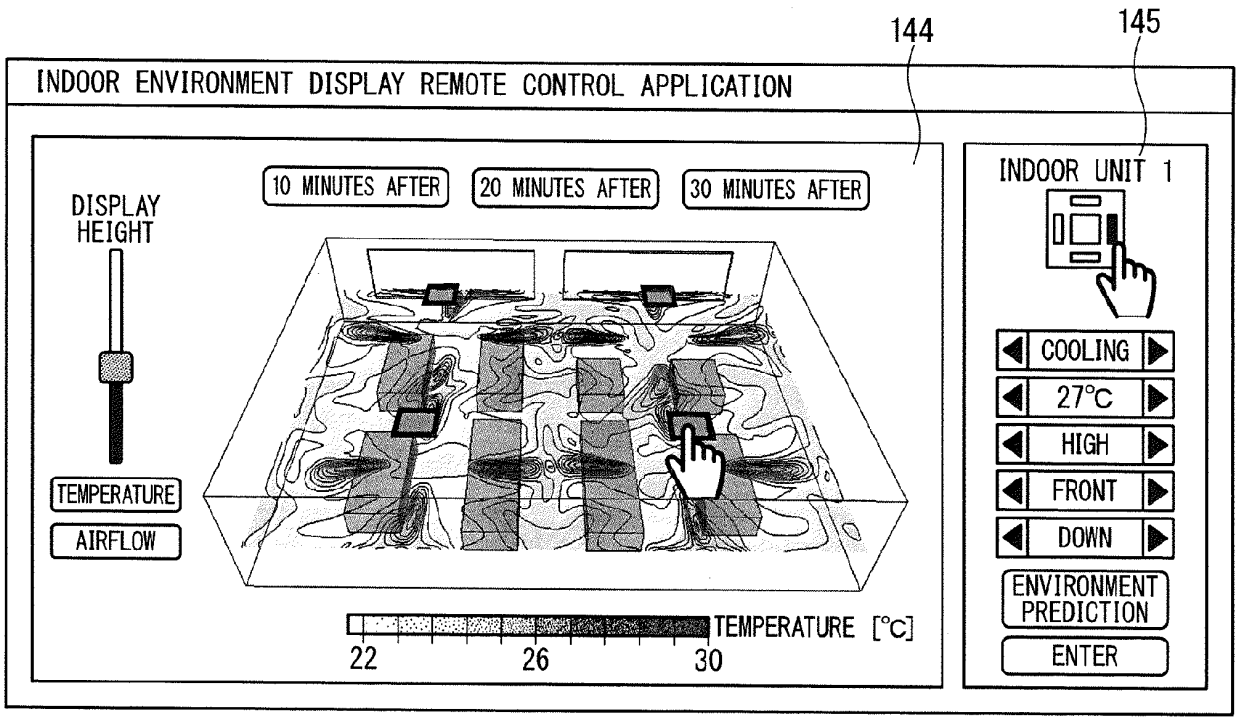

144
145
INDOOR ENVIRONMENT DISPLAY REMOTE CONTROL APPLICATION
DISPLAY HEIGHT
10 MINUTES AFTER
20 MINUTES AFTER
30 MINUTES AFTER
TEMPERATURE
AIRFLOW
TEMPERATURE [°C]
22
26
30
INDOOR UNIT 1
COOLING
27°C
HIGH
FRONT
DOWN
ENVIRONMENT PREDICTION
ENTER

FIG. 6

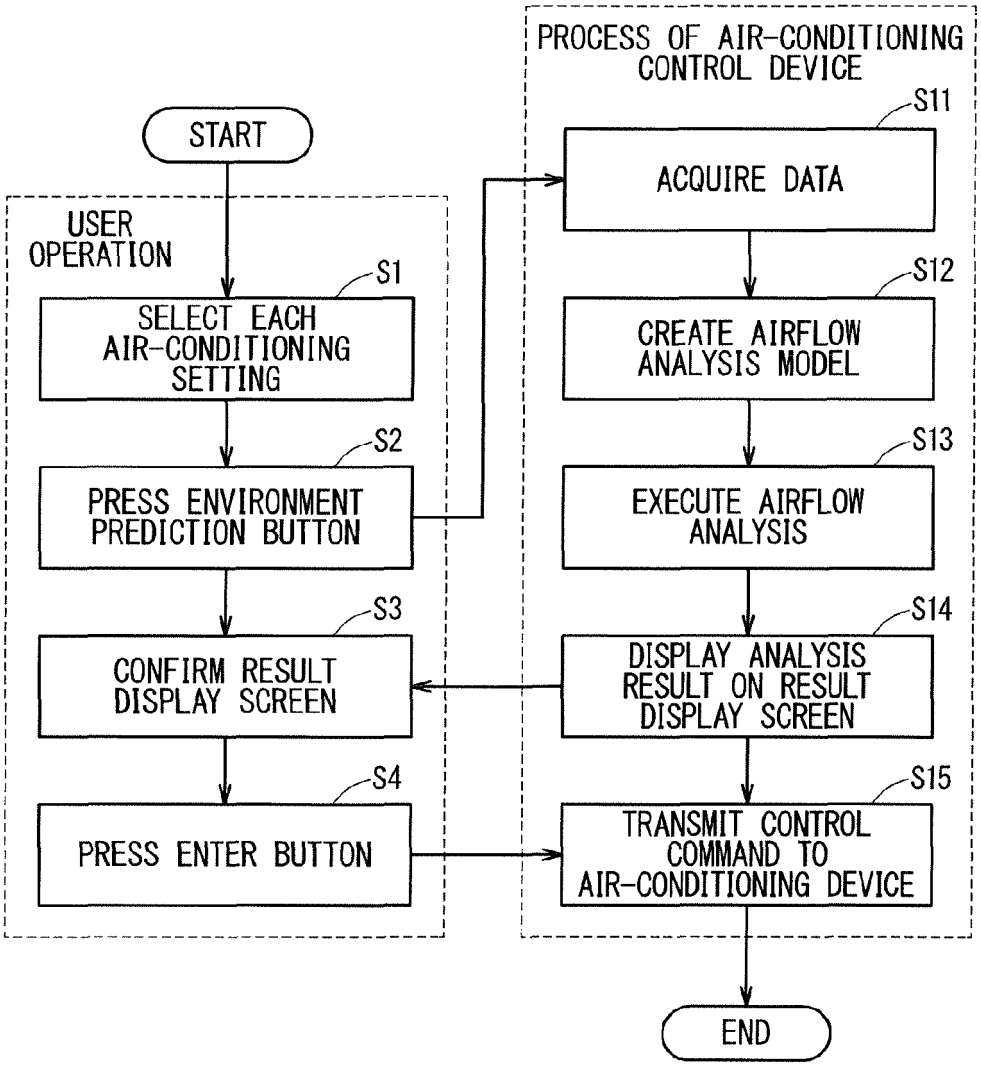

PROCESS OF AIR-CONDITIONING CONTROL DEVICE
START
USER OPERATION
S1
SELECT EACH AIR-CONDITIONING SETTING
S2
PRESS ENVIRONMENT PREDICTION BUTTON
S3
CONFIRM RESULT DISPLAY SCREEN
S4
PRESS ENTER BUTTON
S11
ACQUIRE DATA
S12
CREATE AIRFLOW ANALYSIS MODEL
S13
EXECUTE AIRFLOW ANALYSIS
S14
DISPLAY ANALYSIS RESULT ON RESULT DISPLAY SCREEN
S15
TRANSMIT CONTROL COMMAND TO AIR-CONDITIONING DEVICE
END

FIG. 7

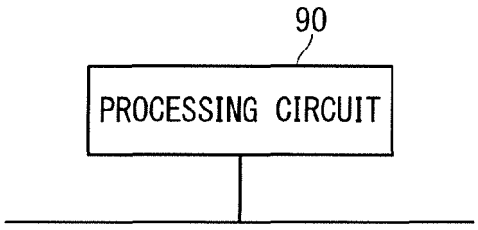
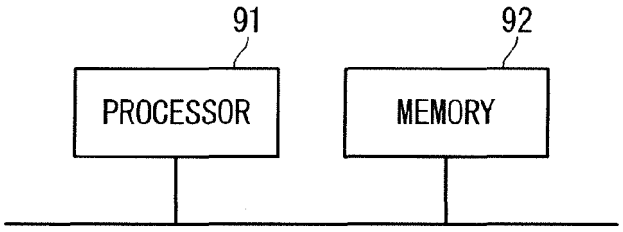


FIG. 8



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2021/017331

A. CLASSIFICATION OF SUBJECT MATTER

F24F 11/48(2018.01)i; F24F 11/52(2018.01)i; F24F 11/523(2018.01)i; F24F 11/62(2018.01)i; F24F 11/64(2018.01)i; F24F 110/10(2018.01)n; F24F 110/20(2018.01)n; F24F 110/30(2018.01)n; F24F 110/64(2018.01)n; F24F 110/70(2018.01)n; F24F 130/10(2018.01)n

FI: F24F11/48; F24F11/523; F24F11/62; F24F11/64; F24F11/52; F24F130:10; F24F110:30; F24F110:20; F24F110:70; F24F110:64; F24F110:10

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)

F24F11/48; F24F11/52; F24F11/523; F24F11/62; F24F11/64; F24F110/10; F24F110/20; F24F110/30; F24F110/64; F24F110/70; F24Fl30/10

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2021
Registered utility model specifications of Japan	1996-2021
Published registered utility model applications of Japan	1994-2021

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	JP 2012-225590 A (FUJI ELECTRIC CO LTD) 15 November 2012 (2012-11-15) paragraphs [0041]-[0173], fig. 1-9	1-3, 8 1-5, 7-10 6
Y	JP 2001-99462 A (MATSUSHITA ELECTRIC IND CO LTD) 13 April 2001 (2001-04-13) paragraphs [0012]-[0047], fig. 1-8	1-5, 7-10
Y	JP 2012-63055 A (TAISEI CORP) 29 March 2012 (2012-03-29) paragraphs [0033]-[0059], fig. 1-8	4, 5, 10
Y	JP 2008-82597 A (DAIKIN IND LTD) 10 April 2008 (2008-04-10) paragraphs [0020]-[0071], fig. 1-5	7

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

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"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 July 2021 (06.07.2021)	20 July 2021 (20.07.2021)

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

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

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2021/017331

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 2005-331209 A (SHARP CORP) 02 December 2005 (2005-12-02) paragraphs [0008]-[0128], fig. 1-24	9
Y	JP 2015-148410 A (TOSHIBA CORP) 20 August 2015 (2015-08-20) paragraphs [0008]-[0041], fig. 1-16	10

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

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2021/017331

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
JP 2012-225590 A	15 Nov. 2012	(Family: none)	
JP 2001-99462 A	13 Apr. 2001	(Family: none)	
JP 2012-63055 A	29 Mar. 2012	(Family: none)	
JP 2008-82597 A	10 Apr. 2008	(Family: none)	
JP 2005-331209 A	02 Dec. 2005	US 2008/0133147 A1 paragraphs [0010]-[0160], fig. 1-24 EP 1767876 A1	
JP 2015-148410 A	20 Aug. 2015	(Family: none)	

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

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2011257071 A **[0004]**