

DESCRIPTION

Title of the Invention: AIR CLEANER

Technical Field

[0001] The present invention relates to an air cleaner.

Background Art

[0002] A conventional air cleaner is disclosed in Patent Document 1. This air cleaner includes a filter and a fan disposed inside a housing. The housing includes an air exhaust chamber formed in an upper part and an air intake chamber formed in a lower part. The air intake chamber has a suction port that opens frontward, and the air exhaust chamber has an exhaust port that opens upward. Further, a blower is disposed in a partition part between the air intake chamber and the air exhaust chamber. In addition, a filter is attached to the suction port in a detachable/attachable manner.

[0003] When the air cleaner having the structure described above starts operation, the blower generates an airflow so that the air enters from the suction port into the air intake chamber. The air entering from the suction port into the air intake chamber enters the air exhaust chamber. Because the filter is attached to the suction port of the air cleaner, dust contained in the entering air is collected by the filter. Then, the clean air from which dust is removed is blown to the outside of housing. In this way, the air is cleaned in the room where the air cleaner is disposed.

[0004] When the filter gets dirty by collecting dust, its pressure loss increases so that airflow amount is decreased, and hence air cleaning ability is decreased. For this reason, in the air cleaner, when the filter gets dirt, it is necessary to clean the filter or to replace the filter. The air cleaner of Patent Document 1 is equipped with a sensor for detecting pressure difference between the outside and the inside of the air cleaner, measures pressure difference between an inlet side and an outlet side of the filter, and informs a user about the dirty condition of the filter (informs that it is necessary to clean or replace the filter) based on the pressure difference.

List of Citations

Patent Literature

[0005] Patent Document 1: JP-A-10-52619

Summary of the Invention

Technical Problem

[0006] However, the air cleaner described in Patent Document 1 needs the pressure sensor for detecting pressure difference between the inside and the outside of the air cleaner, and hence the structure of the air cleaner becomes complicated. In addition, there is an air cleaner that notifies replacement of the filter based on an elapsed time period such as a filter mounted period or an operation period, but it is difficult to accurately notify filter replacement timing because the dirty condition of the filter varies depending on environment of a place where the air cleaner is installed (dirtiness of the air) or airflow amount during operation.

[0007] Therefore, it is an object of the present invention to provide an air cleaner with a simple structure capable of appropriately notifying filter replacement timing.

Means for Solving the Problem

[0008] In order to achieve the above-mentioned object, the present invention provides an air cleaner for cleaning air in an installation space by collecting dust contained in air sucked from a suction opening by a dust collecting unit and blowing out the air after dust collection from a blow-out opening. The air cleaner includes a blower for generating airflow, an informing unit capable of displaying a state of the dust collecting unit, a control unit capable of controlling the blower and the informing unit, and a computing unit capable of communicating with the control unit. The control unit sends to the computing unit a total amount of air that has passed through the dust collecting unit in a predetermined period and a total dust collecting time. The computing unit obtains information of an installation space volume and an amount of dust contained in the installation space, and calculates a total dust collection amount that is a total amount of dust collected by the dust collecting unit, based on the total amount of air that has passed through the dust collecting unit, the total dust collecting time, and the information of the installation space volume and the amount of dust

contained in the installation space. If the total dust collection amount is larger than a threshold value, the computing unit sends a notification instruction to the control unit, and the control unit controls the informing unit to inform a dust collection state of the dust collecting unit, based on reception of the notification instruction.

[0009] With this structure, by obtaining the amount of air that has passed through the dust collecting unit and the total dust collecting time from the air cleaner, the total dust collection amount of the dust collecting unit is calculated. Further, based on the total dust collection amount, a state of the dust collecting unit (e.g. a state of a filter provided to the dust collecting unit) can be notified.

[0010] In this way, without using a member such as a sensor for detecting a dust collection state, a state of the dust collecting unit can be notified to a user. Further, the user can be informed of replacement of the dust collecting unit (mainly a filter).

[0011] In the structure described above, the control unit is capable of communicating with an external apparatus, and the computing unit is disposed in the external apparatus. With this structure, because the computing unit is disposed externally, calculation ability of the air cleaner can be low. In addition, in a structure in which a plurality of air cleaners disposed in different positions send information to the computing unit, it is easy to reconsider a value of a constant used in a calculation equation, based on states of the plurality of air cleaners, i.e. based on maintenance results of the dust collecting units (filter replacement) by users after the calculation result is notified. In this way, the calculation result can become close to a correct value.

[0012] In the structure described above, the computing unit corrects the amount of air that has passed through the dust collecting unit based on a current total dust collection amount of the dust collecting unit, so as to calculate the total dust collection amount of the dust collecting unit. With this structure, dust collection ability of the dust collecting unit varies depending on the dust collection amount. Further, because the variation of the dust collecting ability is reflected on the calculation, it is possible to obtain a correct dust collection amount by the calculation. In this way, maintenance of the dust collecting unit can be performed without too much or too little.

[0013] In order to achieve the object described above, the present invention provides an air cleaner for cleaning air in an installation space by collecting dust contained in air sucked from a suction opening by a dust collecting unit and blowing out the air after

dust collection from a blow-out opening. The air cleaner includes a carbon monoxide detection unit for detecting carbon monoxide concentration in sucked air or blown-out air, a carbon dioxide detection unit for detecting carbon dioxide concentration in the sucked air or the blown-out air, an ozone detection unit for detecting ozone concentration in the sucked air or the blown-out air, and an informing unit for informing each of the carbon monoxide concentration, the carbon dioxide concentration, and the ozone concentration.

[0014] With this structure, the air cleaner can inform a measurement result of the carbon monoxide, the carbon dioxide, and the ozone concentration, and hence the user can be informed of a dust state as well as a contaminated state of the space in which the air cleaner is installed. Further, because the carbon monoxide and the ozone are harmful to human body, by informing concentrations of these gases, the user can be protected from a risk of the gases. In addition, although the carbon dioxide is not harmful to human body, its concentration is increased along with a decrease of oxygen concentration in many cases. By informing the carbon dioxide concentration, the user can recognize that the oxygen concentration is decreased in the space.

[0015] In order to achieve the object described above, the present invention provides an air cleaner for cleaning air in an installation space by collecting dust contained in air sucked from a suction opening by a dust collecting unit and blowing out the air after dust collection from a blow-out opening. The air cleaner includes a carbon monoxide detection unit for detecting carbon monoxide concentration in sucked air or blown-out air, a carbon dioxide detection unit for detecting carbon dioxide concentration in the sucked air or the blown-out air, an ozone detection unit for detecting ozone concentration in the sucked air or the blown-out air, and a control unit. The carbon monoxide detection unit includes a first detection element and a first heater for heating the first detection element. The carbon dioxide detection unit includes a second detection element and a second heater for heating the second detection element. The ozone detection unit includes a third detection element. The control unit shifts timing of turning on the first heater from a carbon dioxide detection period of the second detection element and from an ozone detection period of the third detection element, and shifts timing of turning on the second heater from a carbon monoxide detection period of the first detection element and from the ozone

detection period of the third detection element.

[0016] With this structure, detection accuracy deterioration of the sensor due to a voltage drop when heater drive is started (at a rising edge) can be suppressed. In this way, carbon monoxide concentration, carbon dioxide concentration, and ozone concentration can be accurately notified.

Advantageous Effects of the Invention

[0017] According to the present invention, it is possible to provide an air cleaner with a simple structure capable of appropriately notifying filter replacement timing.

Brief Description of Drawings

[0018] Fig. 1 is a front view of an air cleaner according to the present invention.

Fig. 2 is a rear view of the air cleaner shown in Fig. 1.

Fig. 3 is a cross-sectional view cut in a middle part in an up-down direction of the air cleaner shown in Fig. 1.

Fig. 4 is a cross-sectional view cut in a middle part in a left-right direction of the air cleaner shown in Fig. 1.

Fig. 5 is a plan view of the air cleaner shown in Fig. 1.

Fig. 6 is a schematic view of an interface unit disposed on an upper surface of a housing.

Fig. 7 is a block diagram showing devices connected to a control unit of the air cleaner according to the present invention.

Fig. 8 is a flowchart showing a procedure of notifying replacement of a dust collecting filter of the air cleaner according to the present invention.

Fig. 9 is a block diagram of still another example of the air cleaner according to the present invention.

Fig. 10 is a flowchart showing a procedure of notifying replacement of the dust collecting filter of still another example of the air cleaner according to the present invention.

Fig. 11 is a block diagram of still another example of the air cleaner according to the present invention.

Fig. 12 is a diagram showing an interface unit of the air cleaner shown in Fig. 11.

Fig. 13 is a diagram showing a display example of a display unit that displays concentrations of CO, which is provided to the interface unit shown in Fig. 12.

Fig. 14 is a circuit diagram of a measurement circuit including a CO sensor.

Fig. 15 is a table showing a relationship between a dirt degree and a resistance ratio.

Fig. 16 is a schematic view of a measuring unit and its periphery of the air cleaner according to the present invention.

Fig. 17 is a timing chart showing driving states of the CO sensor, a CO₂ sensor, and an O₃ sensor of the air cleaner according to the present invention.

Description of Embodiments

[0019] Hereinafter, embodiments of the present invention is described with reference to the drawings.

[0020] <First embodiment>

Fig. 1 is a front view of an air cleaner according to the present invention. Fig. 2 is a rear view of the air cleaner shown in Fig. 1. Fig. 3 is a cross-sectional view cut in a middle part in an up-down direction of the air cleaner shown in Fig. 1. Fig. 4 is a cross-sectional view cut in a middle part in a left-right direction of the air cleaner shown in Fig. 1. Fig. 5 is a plan view of the air cleaner shown in Fig. 1.

[0021] Note that, in the following description, otherwise noted, the up-down direction and the left-right direction are defined based on an air cleaner A shown in Fig. 1. In addition, a depth direction of the paper plane of Fig. 1 is a front-rear direction, and a front side of the paper plane is regarded as the front in the description of each unit.

[0022] The air cleaner A includes a housing 10, a dust collecting unit 20, a blower 30, an interface unit 40, a control unit 50, and a computing unit 60. The housing 10 is a rectangular box-shaped member constituting an exterior of the air cleaner A. The housing 10 has a suction opening 11, an air passage 12, and a blow-out opening 13. In the air cleaner A, the suction opening 11, the air passage 12, and the blow-out opening 13 are communicated in this order. Details thereof are described below.

[0023] The suction opening 11 is formed in a lower part on a rear surface of the housing 10. The suction opening 11 has a rectangular shape and is an opening for sucking external air into the housing 10. The air passage 12 is a space for passing an air flow (airflow) generated by driving the blower 30 provided to the dust collecting unit 20 as

described later. The air passage 12 includes a branch part 121 and branch air passages 122. Each of the branch air passages 122 is formed on each of the left and right end sides in the housing 11. The branch part 121 connects the left and right branch air passages 122. The branch part 121 allows the air sucked from the suction opening 11 to branch into the left and right branch air passages 122.

[0024] The blow-out opening 13 is disposed on each of the left and right sides of the front upper part of the housing 10. The left and right blow-out openings 13 are respectively communicated to the left and right branch air passages 122. The air after passing through the branch air passages 122 are blown to the outside from the blow-out openings 13. Further, a grid-like grill 131 is attached to each of the left and right blow-out openings 13. The grill 131 restricts a user's hand or the like from entering the housing 10.

[0025] In the air cleaner A, the dust collecting unit 20 and the blower 30 are disposed inside the air passage 12. In this description, the blower 30 is a centrifugal fan. However, without limiting to this, various fans capable of generating an airflow inside the air passage 12 can be used. The blowers 30 is disposed inside each of the left and right branch air passages 122. The blower 30 includes an impeller 31 and a motor 32. When power is supplied to the blower 30, the motor 32 rotates so that the impeller 31 is driven to rotate. In this way, the airflow is generated inside the air passage 12, which flows from the suction opening 11 to the blow-out opening 13. As shown in Fig. 1, in the air cleaner A, the airflow from a lower part to an upper part is generated in the branch air passage 122.

[0026] When the blower 30 is driven, the air is sucked from the suction opening 11 into the housing 10. The air sucked from the suction opening 11 is divided at the branch part 121 of the air passage 12 into the left and right branch air passages 122. Further, the air flows from the lower part to the upper part in the branch air passage 122 and is blown to the outside of the housing 10 from the blow-out opening 13.

[0027] The dust collecting unit 20 is disposed inside the air passage 12. The dust collecting unit 20 includes a prefilter 21, a dust collecting filter 22, and a dust removing unit 23. The prefilter 21 is a filter that collects dust and the like from the passing air. The prefilter 21 is disposed inside the housing 10 so as to face the suction opening 11. The air entering from the suction opening 11 passes through the prefilter 21.

- [0028] The prefilter 21 includes a frame 211 and a mesh 212. The frame 212 is made of synthetic resin such as ABS resin and has rectangular windows arranged vertically and horizontally in a matrix. The mesh 212 is made of polypropylene or the like and has a lattice structure finer than dust collected by the prefilter 21. The frame 211 and the mesh 212 are fixed to each other by welding. However, without limiting to the welding, they may be glued with adhesive or may be fixed using an additional fixing member. Various methods capable of securely fixing the frame 211 and the mesh 212 can be used.
- [0029] When the air sucked from the suction opening 11 passes through the mesh 212, dust cannot pass through the mesh 212 because it is larger than the pitch of the mesh 212. The dust contained in the air sucked from the suction opening 11 is collected by the mesh 212 when the air passes through the mesh 212. In the air cleaner A, the prefilter 21 collects dust contained in the air sucked from the suction opening 11. When the dust collected by the mesh 212 increases, the mesh 212 is clogged, i.e., clogging occurs so that the airflow is blocked. Therefore, in the air cleaner A, the dust removing unit 23 removes the dust collected by the prefilter 21 (dust removal is performed).
- [0030] As shown in Figs. 1 and 4, the dust removing unit 23 is disposed in an upper space inside the housing 10. The dust removing unit 23 includes a rotation blush 231, a dust box 232, a guide frame 233, and a pinion 234. The dust removing unit 23 moves the prefilter 21 along the guide frame 233. The dust adhered to the prefilter 21 is removed by the rotation blush 231 and collected in the dust box 232.
- [0031] The pinion 234 is engaged with a rack (not shown) formed on each edge of the prefilter 21 on the left and right sides. The pinion 234 is rotated by a motor that is not shown. When the pinion 234 rotates, the prefilter 21 moves in a reciprocating manner between a dust collecting position P1 facing the suction opening 11 and a retreat position P2 retreated to the dust removing unit 23. In this case, the prefilter 21 is guided by the guide frame 233.
- [0032] The dust box 232 is disposed along the guide frame 233 and is detachable from and attachable to the housing 10. An opening 14 for putting in and out the dust box 232 is formed in the rear surface of the housing 10. The opening 14 is formed above the suction opening 11 (see Fig. 2).

[0033] The rotation blush 231 is disposed inside the dust box 232. The rotation blush 231 is driven to rotate by a motor that is not shown. Note that the motor that drives the rotation blush 231 to rotate and the motor that drives the pinion 234 to rotate may be different motors or may be the same motor. The rotation blush 231 includes a rotation shaft and brush bristles disposed on the outer surface of the rotation shaft. The brush bristles are formed to stand radially on the outer surface of the rotation shaft. The rotation blush 231 is rotated so that the moving direction of brush bristle tips is opposite to the moving direction of the prefilter 21 when the prefilter 21 moves from the dust collecting position P1 to the retreat position P2. In this way, when the prefilter 21 moves from the dust collecting position P1 to the retreat position P2, the dust collected on the surface of the prefilter 21 is removed by the brush bristles. The dust removed from the prefilter 21 by the rotation blush 231 is stored in the dust box 232.

[0034] The dust removal from the prefilter 21 by the dust removing unit 23 may be performed regularly, for example, when an elapsed time of the air cleaning operation from the last dust removal reaches a predetermined time. In addition, a sensor may be disposed, and the dust removal may be performed when the prefilter 21 gets dirty to a certain degree. A method of detecting dirt of the prefilter 21 may be a method of directly checking the prefilter 21 or may be a method of detecting amount of air passing through the prefilter 21 so as to detect clogging of the prefilter 21. Note that when the dust removing unit 23 operates, the blowers 30 are stopped.

[0035] As shown in Figs. 1 and 3, the dust collecting filter 22 is disposed at a boundary part between the branch part 121 of the air passage 12 and the branch air passage 122. In other words, the dust collecting filter 22 is disposed on each of the left and right sides so that the air entering the left and right branch air passages 122 passes. As the dust collecting filter 22, there is a HEPA filter, for example, but this is not a limitation. The dust collecting filter 22 includes a filter material 221 and a frame material 222. The filter material 221 collects foreign matter such as dust in the passing air. The frame material 222 is made of resin, and the filter material 221 is fixed to the frame material 222 with hot melt. Note that it is preferred that the filter material 221 be folded like bellows (be pleated). In this way, filtration area of the filter material 221 can be increased.

[0036] The filter material 221 is finer than the mesh 212. In other words, the dust collecting filter 22 is a filter that collects foreign matter finer than the dust collected by the prefilter 21 (e.g. PM2.5 or micro particle matter). The dust collecting filter 22 is disposed on the upstream of each of the left and right blowers 24 in the airflow direction. In the air cleaner A, large foreign matter is collected by the prefilter 21, and fine foreign matter that cannot be collected by the prefilter 21 is collected by the dust collecting filter 22.

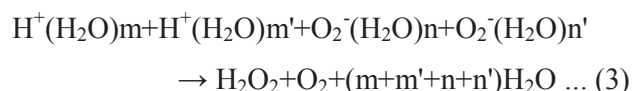
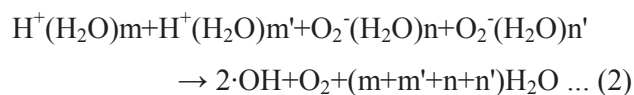
[0037] A deodorizing filter (not shown) containing adsorbent such as activated carbon that absorbs odor components (particles) contained in the air may be disposed between the prefilter 21 and the dust collecting filter 22. In this way, odor components in the air are absorbed by the adsorbent, and the air can be deodorized.

[0038] An ion generator 15 for supplying ions to the airflow is disposed in the air passage 12. The ion generator 15 has an electrode exposed to the inside of the branch air passage 122 in each of the branch air passages 122. In the ion generator 15, a voltage having an AC waveform or a pulse waveform is applied to the electrode so that positive ions and/or negative ions are generated.

[0039] For example, when a positive voltage is applied to the electrode, positive ions mainly containing $H^+(H_2O)_m$ are generated. When a negative voltage is applied, negative ions mainly containing $O_2^-(H_2O)_n$ are generated. Here m and n are integers. $H^+(H_2O)_m$ and $O_2^-(H_2O)_n$ are condensed on surfaces of floating bacteria and odor components in the air and enclose them.

[0040] Further, as shown in formula (1) to (3), $[·OH]$ (hydroxyl radical) and H_2O_2 (hydrogen peroxide) that are active species are condensed and generated by collision on surfaces of microorganisms or the like so that the floating bacteria and the like are killed. Here m' and n' are integers. Therefore the air cleaner A can remove germs and odors in a room by generating positive ions and negative ions and discharging them from the blow-out opening 13.

[0041] $H^+(H_2O)_m + O_2^-(H_2O)_n \rightarrow ·OH + 1/2O_2 + (m+n)H_2O \dots (1)$



- [0042] As shown in Figs. 1 and 4, the air cleaner A has an ion passage 16 and a damper 17. The ion passage 16 connects the branch air passage 122 and the dust removing unit 23. Ions generated in the ion generator 15 pass through the ion passage 16 and are supplied to the dust removing unit 23. The ions after passing through the ion passage 16 are blown to the prefilter 21 moved into the dust removing unit 23, mainly to the mesh 212. By blowing the ions to the prefilter 21, charge stored in the prefilter 21 are neutralized.
- [0043] The damper 17 is disposed on a side wall surface of the branch air passage 122, so as to open and close a connection portion between the branch air passage 122 and the ion passage 16. The damper 17 rotates to open and close, but without limiting to this, it is possible to use various open and close mechanisms capable of connecting or separating the ion passage 16 and the branch air passage 122.
- [0044] The damper 17 is opened when the dust removing unit 23 performs dust removal of the prefilter 21. In this way, ions generated in the ion generator 15 enters from the branch air passage 122 into the ion passage 16, and the ions are blown to the prefilter 21 moved to the dust removing unit 23.
- [0045] In this way, by blowing the ions to the prefilter 21, static electricity of the prefilter 21 and dust is neutralized by the ions. In this way, the dust can be easily separated from the prefilter 21, and the rotation brush 232 can remove much dust collected by the prefilter 21. In addition, because static electricity is neutralized, it is possible to prevent reattachment of the separated dust to the prefilter 21. In addition, the ions entering from the ion passage 16 into the dust removing unit 23 neutralize static electricity of the rotation brush 231, too. In this way, it is possible to prevent the dust from attaching to the rotation brush 231 and being hard to separate from the same.
- [0046] When the air cleaner A operates to collect dust, i.e. when the blower 30 is driven, the damper 17 is closed. In this way, the air flowing in the branch air passage 122 is blown to the outside of the housing 10 from the blow-out opening 13. In addition, it is possible to prevent the dust collected in the dust box 232 from being blown up by the airflow when the airflow enters the ion passage 16. In this way, it is possible to prevent the air to be blown out from the blow-out opening 13 from being dirty with dust.
- [0047] Note that when the dust removing unit 23 is performing the dust removal of the

prefilter 21, the blower 30 is stopped, but this is not a limitation. It is possible to drive the blower 30 so that air enters from the branch air passage 122 into the ion passage 16. In this case, it is preferred that airflow amount by the blower 30 be such that air enters from the damper into the ion passage 16 and be smaller than that in the normal operation. In addition, only one of the left and right blowers 30 may be driven so that air containing ions enters from one of the ion passages 16 while the air is discharged from the other ion passage 16. In this case, it is possible to generate ions from the ion generator 15 on the side on which the blower 30 is driven and to stop the other ion generator 15. Further, when one of the blowers 30 is rotated, always the same blower 30 may be operated or two blowers 30 may be switched to operate when the dust removal is performed.

[0048] In addition, as shown in Fig. 1, in the air cleaner A, the ion passages 16 are disposed to respectively communicate to the branch air passages 122 disposed on the left and right sides, but this is not a limitation. For example, the ion passage 16 may be disposed to communicate to one of the left and right branch air passages 122. In this case, it is preferred to generate ion from the ion generator 15 disposed in the branch air passage 122 to which the ion passage 16 communicate. In addition, the ion generator 15 may be disposed to face the dust removing unit 23.

[0049] As shown in Fig. 5, the interface unit 40 is disposed on an upper surface of the housing 10. The interface unit 40 is connected to the control unit 50, notifies information such as an operation status of the air cleaner A, a setting status, a state of the room in which the air cleaner A is placed, and receives an operation input from the user. Details of the interface unit 40 are described below with reference to the drawings. Fig. 6 is a schematic view of the interface unit disposed on the upper surface of the housing.

[0050] As shown in Fig. 6, the interface unit 40 includes an operation unit 401 for receiving an operation input by the user, and an informing unit 402 for notifying a status of the air cleaner A. Note that the operation unit 401 and the informing unit 402 of the interface unit 40 perform so-called light emission display in which a position or information is notified to the user by transmission of light emitted from an LED (not shown) disposed behind.

[0051] The operation unit 401 includes a plurality of buttons 41a to 41g, and operation setting

of the air cleaner A is performed by user's operation. The buttons 41a to 41g are displayed to the user with related operations by figures (i.e. icons) or character strings. For example, by pressing the button 41a, time displays such as current time and total operating time are switched in display units 42a and 42b. In addition, by continuously pressing the button 41a (hereinafter this operation is referred to as long press), timer setting is performed. Further, by long press of the button 41a, the display unit 42a displays temperature, and the display unit 42b displays humidity.

[0052] By operating the button 41b, the air cleaner A is connected to a network including the Internet via a wireless communication network or the like. Note that, by long press of the button 41b, the mode is switched to the mode for setting network connection. By operation of the button 41c, airflow amount of the blower 30 can be adjusted. By pressing the button 41c, airflow amount of the blower 30 is changed. Note that the adjusted airflow amount is displayed on a display unit 42d described later.

[0053] By operating the button 41d, the dust removal of the prefilter 21 by the dust removing unit 23 is performed. Note that, by pressing the button 41d, based on the above-mentioned condition, the automatic dust removal of the prefilter 21 is switched between the mode in which the automatic dust removal is performed and the mode in which the automatic dust removal is not performed. In addition, by operating the button 41d, the dust removing unit 23 may forcibly perform the dust removal of the prefilter 21.

[0054] By operating the button 41e, notification of replacement timing of the dust collecting filter 22 is reset. The notification that replacement of the dust collecting filter 22 is necessary is made on the display unit 42f. Replacement timing of the dust collecting filter 22 will be described later. The button 41f notifies that it is necessary to dispose dust stored in the dust box 232. Further, by operation of the button 41f, the notification to dispose dust is reset. By operation of the button 41g, supply of power to the air cleaner A is started or stopped. The button 41g is a so-called power supply button.

[0055] Note that the buttons 41a to 41f are luminous buttons having a figure or a button shape that emerges with passing light from the LED disposed on the rear surface. Therefore, the buttons 41a to 41f are not displayed when the power supply of the air cleaner A is turned off. On the other hand, because the button 41g is the power

supply button, it should be recognized by the user regardless of on/off of power supply of the air cleaner A. Therefore, the button 41g is displayed on the surface panel of the interface unit 40. The button 41g may be printed or may be a recess formed on the surface. In this description, it is printed. Note that it is preferred that the button 41g be printed with phosphorescent paint so that it can be seen in a dark ambient.

[0056] In addition, in the air cleaner A, the buttons 41a to 41d of the operation unit 401 are used for inputting volume of the room in which the air cleaner A is placed, i.e. the room in which the air is cleaned by the air cleaner A. Note that in the air cleaner A, floor area and ceiling height of the room are input, and the volume of the room is calculated from the floor area and the ceiling height. The input of the volume of the room may be performed by the user or may be registered in advance at factory shipping in a case where the volume of the installation place such as a hotel, a school, or a hospital is known.

[0057] For example, in order to directly input the number, simultaneous long press of the button 41a and the button 41d may be performed for changing to the input mode. Further, the number is displayed on the display unit 42a and the display unit 42b, and the number is increased using the button 41b or decreased using the button 41c, so as to input the floor area and the ceiling height of the room. This input method is merely one example and is not a limitation. It is possible to select values from given floor areas and ceiling heights, which are nearest to those of the room.

[0058] The informing unit 402 includes the display units 42a to 42f. The display units 42a to 42f display a current status of the air cleaner A, a state of the space in which the air cleaner A is placed, an operation being performed by the user, and the like. The display unit 42a is a so-called 7-segment display unit including seven segments that emit light. The display units 42a and 42b display characters such as a number or an alphabet by switching on/off of light emission of the seven segments. In this description, they are used for displaying (notifying) time when the timer is used, current time, or the like.

[0059] In addition, as described above, the display units 42a and 42b may be used for displaying different information. For example, the display unit 42a displays temperature while the display unit 42b displays humidity. Note that when displaying temperature and humidity on the display units 42a and 42b, the ":" display between the

display units 42a and 42b is turned off, the display unit 42a turns on the "°C" display indicating temperature, and the display unit 42b turns on the "%" display indicating humidity. ":", "°C", and "%" are light emission display.

[0060] The display unit 42c displays "on timer" for turning on the power supply after a predetermined time elapses and "off timer" for turning off the power supply. Only when the "on timer" or the "off timer" is set, the display unit 42c is turned on. The display unit 42d notifies blowing intensity of the blower 30. For example, as the blowing intensity, "automatic", "strong", "medium", "sleep", "pollen", and "quiet" are set, but these are not limitations. For example, like a display unit 42e described later, it is possible to adopt a structure in which a plurality of lamps (hereinafter referred to as indicators) are turned on, and the number of turned-on indicators indicates the airflow amount.

[0061] The display unit 42e notifies a state of ambient air of the air cleaner A. As information to be informed, there are four items of "odor", "dust", "PM2.5", and "air index", but these are not limitations. Further, adjacent to these displays by characters, four indicators are disposed respectively to the displays. The indicator is turned on or off, and a status of each item is notified by the number of turned-on indicators.

[0062] The indicators of the "odor", "dust", and "PM2.5" are turned on in such a manner that the number of turned-on indicators becomes larger as the concentration is higher, for example. In addition, the "air index" is a general index of them all. As the number of turned-on indicators of the "air index" is larger, it indicates that the ambient environment is dirtier. In this description, the characters of the information "odor", "dust", "PM2.5", and "air index" are luminous, but they may be printed. In addition, the indicators may have the same color or may have different colors. For example, the luminous color when the concentration is low may be white or green while the luminous color when the concentration is high may be yellow or red. Note that the color may be changed in all indicators.

[0063] The display unit 42f is turned on when replacement of the dust collecting filter 22 is necessary. After the display unit 42f is turned on, when the dust collecting filter 22 is replaced and the button 41e is operated, the display unit 42f is turned off.

[0064] Next, the control unit 50 and the computing unit 60 of the air cleaner A according to the present invention are described with reference to the drawings. Fig. 7 is a block

diagram showing devices connected to the control unit of the air cleaner according to the present invention.

- [0065] The control unit 50 is a logic circuit (a circuit including an MPU, a CPU, or the like) for integrally controlling the air cleaner A. The control unit 50 is connected to the ion generator 15, the damper 17, the dust removing unit 23, the blower 30, the interface unit 40, the computing unit 60, and a measuring unit 70. In addition, the control unit 50 is connected to a clock unit 51, a storage unit 52, and a communication unit 53.
- [0066] Note that the ion generator 15, the damper 17, the dust removing unit 23, and the blower 30 operate according to a signal from the control unit 50. In addition, the operation unit 401 of the interface unit 40 sends a signal to the control unit 50, and the informing unit 402 notifies information based on a signal from the control unit 50.
- [0067] The measuring unit 70 measures dirt degree of the air in the room (space) in which the air cleaner A is placed. The measuring unit 70 includes an odor sensor (not shown) and a dust sensor (not shown). The odor sensor measures concentration of odor particles contained in the air of the room in which the air cleaner A is placed. In addition, the dust sensor measures concentration of dust contained in the air. In addition, the dust sensor also measures concentration of PM2.5 contained in the air. The concentrations of the odor particles, dust, PM2.5 measured by the measuring unit 70 are sent to the control unit 50. The odor sensor and the dust sensor are conventionally well known, and hence detailed description thereof is omitted. Note that, though not illustrated, the measuring unit 70 is disposed in the air passage 12. Further, as described later, the control unit 50 controls the blower 30 based on concentrations of odor particles, dust, and PM2.5 in the air. Therefore, the measuring unit 70 is disposed on an airflow direction upstream side of a suction side of the collecting filter 22 that collects odor particles, dust, and PM2.5.
- [0068] The control unit 50 performs variable control (e.g. inverter control) of rotational frequency of the motor 32 of the blower 30, so as to control the airflow amount by controlling the rotational frequency of the motor 32. The control unit 50 determines the airflow amount blown out from the blower 30 based on concentrations of odor particles, dust, and PM2.5. In addition, the ion generator 15, the damper 17, and the dust removing unit 23 have structures for performing predetermined operations, and

they operate based on signals (instructions) from the control unit 50.

[0069] The interface unit 40 includes an interface controller 400. The interface controller 400 is connected to each of the buttons 41a to 41g of the operation unit 401 and the display units 42a to 42f of the informing unit 402. The interface controller 400 obtains signals from the buttons 41a to 41g and sends information thereof to the control unit 50. In addition, the interface controller 400 controls on/off of the display units 42a to 42f based on the signal from the control unit 50.

[0070] For example, the control unit 50 sends a signal indicating concentrations of "odor", "dust", and "PM2.5" to the interface controller 400 of the interface unit 40. The interface controller 400 turns on the indicators of the display unit 42e as described later so as to notify concentrations of "odor", "dust", and "PM2.5".

[0071] The clock unit 51 includes a counter for measuring time. The clock unit 51 measures elapsed time from an arbitrary time point. In addition, the clock unit 51 may have current time information. The clock unit 51 stops counting time during measuring the elapsed time. In addition, the clock unit 51 can measure a plurality of times at one time.

[0072] The storage unit 52 is a memory for storing information sent to the control unit 50, information processed by the control unit 50, information given to the control unit 50 in advance, and other information. The communication unit 53 is connected to a network NW. The network NW is a small-scale network for a household or the like and a communication network including the Internet. In the air cleaner A, the communication unit 53 is connected to a wireless communication network (the small-scale network) and then is connected to an external communication network (the Internet) via the wireless communication network.

[0073] Therefore, the communication unit 53 has a structure capable of wireless communication. In addition, it may be a structure for directly communicating with a device (e.g. an information terminal such as a smartphone or a tablet PC) placed close to the air cleaner A. In this case, the communication unit 53 may not be directly connected to the Internet. In addition, it may be a structure for directly connecting to the external network without connecting to the small-scale network (e.g. by using a cellular phone network). In addition, it may be a structure for connecting to the network NW by wire. Further, it may be a structure that does not connect to the

Internet when being capable of working in a network independent of the Internet.

[0074] Note that the clock unit 51, the storage unit 52, and the communication unit 53 are independent of the control unit 50, and the control unit 50 can freely access them. However, this is not a limitation. For example, at least one of the clock unit 51, the storage unit 52, and the communication unit 53 may be included as a circuit block inside the control unit 50.

[0075] The computing unit 60 includes a logic circuit including an MPU, a CPU, or the like. In the air cleaner A, the computing unit 60 has a structure dedicated to computing compared with the control unit 50, i.e. a structure capable of computing at high speed. Note that the computing unit 60 may be formed integrally to the control unit 50. For example, it may be an integrated circuit (LSI) including a control unit as a control block and a computing unit as a computing block inside. Further, the computing unit 60 may be a program that works on a logic circuit of the control unit 50.

[0076] Although details of the computing process in the computing unit 60 will be described later, the computing unit 60 performs the computing process based on information obtained from the control unit 50. Further, the value determined by computing is compared with a reference value. Further, based on the comparison result, if necessary, the comparison result is sent to the control unit 50.

[0077] In the air cleaner A, dust collected by the dust collecting filter 22 is accumulated by continuing the air cleaning operation. Further, in the dust collecting filter 22, when the collected dust increases, clogging occurs, and hence dust collecting ability is lowered. Therefore, in the air cleaner A, when amount of dust collected by the dust collecting filter 22 becomes a certain level, the informing unit 402 (display unit 42f) informs and urges the user to replace the filter. A procedure of calculating a total amount of dust collected by the dust collecting filter 22 in the air cleaner A and notifying replacement of the filter is described below with reference to the drawings.

[0078] Fig. 8 is a flowchart showing a procedure of notifying replacement of the dust collecting filter in the air cleaner according to the present invention. Note that the air cleaner A according to the present invention has a structure in which the blower 30 is stopped depending on an operating mode or an operating condition.

[0079] As shown in Fig. 8, the control unit 50 checks whether or not drive of the blower 30 is started (Step S101). The control unit 50 waits until the drive of the blower 30 is

started (No in Step S101). When confirming that the blower 30 is driven (Yes in Step S101), the control unit 50 checks whether or not an "additionally set time" has elapsed after the blower 30 is driven (Step S102). Note that the "additionally set time" may be a randomly set time or may be a constant time.

[0080] If the additionally set time has not elapsed (No in Step S102), the control unit 50 checks whether or not the blower 30 is stopped (Step S103). If the blower 30 is not stopped (No in Step S103), the process returns to checking whether or not the additionally set time has elapsed (Step S102).

[0081] If the additionally set time has elapsed (Yes in Step S102) or if the blower 30 is stopped (Yes in Step S103), the control unit 30 obtains from the clock unit 51 an elapsed time Δt after the drive of the blower 30 is started (Step S104). In this description, the elapsed time Δt is the same as the "additionally set time" and is a total dust collecting time in a predetermined period.

[0082] Further, based on the control of the blower 30, the control unit 50 obtains total amount of air Q_n that has passed through the dust collecting filter 22 (dust collecting unit) after the drive of the blower 30 is started (Step S105). Note that the total amount of air Q_n that has passed through the filter 22 is calculated from the rotational frequency and the drive time of the blower 30 and a pressure loss of the dust collecting filter 22. However, this is not a limitation. It is possible to adopt a structure in which an airflow amount sensor is used for detecting the amount of air that has passed through the dust collecting filter 22, or a pressure sensor is used for calculating flow amount based on a pressure difference so as to calculate amount of air that has passed through the dust collecting filter 22.

[0083] The control unit 50 is connected to the Internet via the network NW so as to obtain information from external service. The air cleaner A obtains dust concentration C_{out} as information about dirty condition of external air of a site where its installation room (space) is located (Step S106). Note that the control unit 50 regularly obtains information of the dust concentration of the site where the room is located and stores the latest obtained dust concentration in the storage unit 52. Further, the control unit 50 may retrieve the latest stored dust concentration C_{out} . In addition, it is possible to adopt a structure in which the user manually input.

[0084] In addition, when the air cleaner A is installed in the room, the air cleaner A obtains

information of floor area S and ceiling height h of the room, and the information is stored in the storage unit 52. The control unit 50 accesses the storage unit 52 so as to retrieve the floor area S and the ceiling height h of the room (Step S107).

[0085] The control unit 50 sends to the computing unit 60 the elapsed time Δt , the total amount of air Q_n that has passed through the dust collecting filter 22 after the drive of the blower 30 is started, the dust concentration C_{out} , and the floor area S and the ceiling height h of the room. Further, the computing unit 60 calculates from the information a dust collection amount Δm of the dust collecting filter 22 after the drive of the blower 30 is started (Step S108).

[0086] The calculation equations for the dust collection amount Δm of the dust collecting filter 22 after the drive of the blower 30 is started are as follows.

[Equation 1]

$$\Delta m = \frac{K_v \cdot P_p \cdot C_{out} \cdot S \cdot h}{Q + (K_o + K_v) \cdot S \cdot h} \cdot Q \cdot \Delta t$$

[Equation 2]

$$Q = \frac{Q_n}{\Delta t}$$

In these equations, K_v represents the number of ventilation times, K_o represents a natural attenuation rate, and P_p is a penetration rate of dust entering from the outside into the room. K_v , K_o , and P_p are all stored in the storage unit 52 as constants when the air cleaner A is manufactured. However, without limiting to this, they may be changed at installation time. In addition, they may be changed by the user based on a state of the room in use or a state of air in the room. In addition, Q represents amount of air that has passed through the dust collecting filter 22 per unit time after the drive of the blower 30 is started until the present time.

[0087] The storage unit 52 stores total dust collection amount m accumulated on the dust collecting filter 22 until just before the drive of the blower 30 is started. The computing unit 60 obtains the total dust collection amount m stored in the storage unit 52. Note that, to obtain the total dust collection amount m from the storage unit 52, the control unit 50 obtains the total dust collection amount m from the storage unit 52 and sends it to the computing unit 60. However, the computing unit 60 may directly obtain it from the storage unit 52. The computing unit 60 adds the dust collection

amount Δm of the dust collecting filter 22 after the drive of the blower 30 is started, which is calculated in Step S108, to the current total dust collection amount m , so as to update the total dust collection amount m (Step S109). Note that the updated total dust collection amount m is stored in the storage unit 52. In this case, the total dust collection amount m may be overwritten or history data may be saved. In this description, it is overwritten.

[0088] Dust collecting ability of the dust collecting filter 22 is decreased as the dust collection amount increases. In the air cleaner A, when the total dust collection amount m of the dust collecting filter 22 becomes a threshold value m_{th} of the dust collection amount, replacement of the dust collecting filter 22 is recommended. Note that the threshold value m_{th} of the dust collection amount is the total dust collection amount when the dust collecting ability of the dust collecting filter 22 is decreased to a half of that at start of use. The threshold value m_{th} of the dust collection amount is determined based on a result of experiment or simulation. In addition, it may be corrected by an average value of the total dust collection amount when the dust collecting filter 22 is replaced in the past. Note that the total dust collection amount m is reset to "0" when the dust collecting filter 22 is replaced.

[0089] In the air cleaner A, the computing unit 60 checks whether or not the updated total dust collection amount m is more than or equal to the threshold value m_{th} of the dust collection amount (Step S110). If the total dust collection amount m is less than the threshold value m_{th} of the dust collection amount (No in Step S110), the control unit 50 checks whether or not the blower 30 is being driven (Step S111).

[0090] Note that, in case of No in Step S110, the computing unit 60 may send a signal indicating no abnormality to the control unit 50. In this case, after receiving the signal indicating no abnormality from the computing unit 60, the control unit 50 checks drive of the blower 30 (Step S111). In addition, in case of No in Step S110, the computing unit 60 may not do an action for the control unit 50. In this case, the control unit 50 checks drive of the blower 30 if it received no signal from the computing unit 60 when a predetermined time elapses after sending data such as the elapsed time Δt to the computing unit 60 (Step S111). Note that these are examples, and it is possible to adopt various methods that enable the control unit 50 to check that the total dust collection amount m is less than the threshold value m_{th} of the dust

collection amount.

[0091] If the blower 30 is being driven (Yes in Step S111), the control unit 50 returns to checking whether or not the set time has elapsed (Step S102) and repeats the operation described above. In addition, if the blower 30 is stopped (No in Step S111), the control unit 50 waits until the blower 30 is driven (returns to Step S101).

[0092] In addition, if the total dust collection amount m is more than or equal to the threshold value m_{th} of the dust collection amount (Yes in Step S110), the computing unit 60 sends to the control unit 50 a notification instruction that instructs to replace the dust collecting filter 22 (Step S112). When receiving the notification instruction from the computing unit 60, the control unit 50 sends to the interface controller 400 an instruction to display for replacing the dust collecting filter 22. On the basis of the instruction, the interface controller 400 controls the display unit 42f to work for notifying that replacement of the dust collecting filter 22 is necessary (Step S113). After that, the control unit 50 checks whether or not the blower 30 is being driven (moves to Step S111).

[0093] As described above, in the air cleaner A, the dust collection amount of the dust collecting filter 22 in each period is calculated, and the total dust collection amount of the dust collecting filter 22 is calculated. Further, when the total dust collection amount becomes more than a predetermined amount (threshold value), the user or the like is informed that replacement of the dust collecting filter 22 is necessary, i.e. about a state of the dust collecting unit 20, by using the informing unit 402 of the interface unit 40.

[0094] In the air cleaner A, when the total dust collection amount of the dust collecting filter 22 is increased so that the dust collecting ability is decreased, it is informed by the informing unit 402 (the display unit 42f thereof). In this way, the dust collecting ability of the air cleaner A can be maintained at a constant level or higher, and it is easy to maintain clean air in the room.

[0095] In addition, the air cleaner A has a structure in which the total dust collection amount of the dust collecting filter 22 is obtained by calculation, and hence effort and time can be reduced compared with a case in which the dust collection amount of the dust collecting filter 22 is visually checked. Further, because the notification is performed using the informing unit 402, the number of accessing the dust collecting filter 22 by

the user for replacement of the dust collecting filter 22 can be reduced, and hence it is possible to reduce occasions for the user to touch the dust collected by the dust collecting filter 22. In addition, the structure of the air cleaner A can be simplified compared with a case of using a detector for detecting the dust collection amount of the dust collecting filter 22.

[0096] In the structure described above, the air cleaner A drives the blower 30 also after informing to recommend the replacement of the dust collecting filter 22. This is because dust collection efficiency of the dust collecting filter 22 is gradually decreased, and dust collection does not become disabled soon after the total dust collection amount becomes more than a certain amount. In addition, it is possible to adopt a structure in which the blower 30 is stopped when the total dust collection amount of the dust collecting filter 22 becomes more than a certain amount. The blower 30 may be stopped simultaneously with informing to recommend the replacement of the dust collecting filter 22. In addition, the blower 30 may be stopped after a predetermined time elapses or after the total dust collection amount is further increased after informing to recommend the replacement of the dust collecting filter 22.

[0097] Note that, operations of the blower 30 includes a stop operation in this embodiment, but the blower 30 may have a structure without stop operation though the airflow amount thereof is changed. In this case, the step of checking drive of the blower 30 in Fig. 8 is eliminated. In addition, "elapsing of the set time after starting drive of the blower" is replaced with "elapsing of the set time after starting operation of the air cleaner or after the last calculation".

[0098] <Second embodiment>

The pressure loss of the dust collecting filter 22 is increased as the total dust collection amount increases. In other words, in the dust collecting filter 22, an increase in the total dust collection amount causes a decrease in the passing amount of air and a decrease in the dust collecting ability. Therefore, in the air cleaner A according to this embodiment, a variation of the pressure loss of the dust collecting filter 22 due to a variation of the total dust collection amount of the dust collecting filter 22 is taken into account for calculating the total dust collection amount. Note that the air cleaner A according to this embodiment has the same structure as the air cleaner A described above although calculation is different. Therefore, detailed description of the

structure of the air cleaner A is omitted.

[0099] When the total dust collection amount of the dust collecting filter 22 increases, clogging occurs in the dust collecting filter 22, and the pressure loss thereof is increased. When the total dust collection amount of the dust collecting filter 22 is increased, the amount of air passing through the dust collecting filter 22 is decrease. Due to the increase in the total dust collection amount m of the dust collecting filter 22, the pressure loss, i.e. the amount of air passing through the dust collecting filter 22 per unit time should be corrected. A correction coefficient of the amount of air passing through the dust collecting filter 22 is represented by μ , and the correction coefficient μ is expressed as a function of the total dust collection amount m .

[Equation 3]

$$\mu = f(m)$$

[0100] The equation of Equation 3 is described in detail. In the dust collecting filter 22, the amount of air passing per unit time is determined by the total dust collection amount. Just after the dust collecting filter 22 is replaced, i.e. when the total dust collection amount m is zero, the amount of passing air is largest. Further, as the total dust collection amount m increases, the amount of passing air decreases. For example, the lifetime of the dust collecting filter 22 is the time until the dust collecting ability becomes half of that of a new product. In other words, supposing that the amount of passing air is "1" when the dust collecting filter 22 is new, the amount of passing air of the dust collecting filter 22 just before replacement is "1/2".

[0101] On the basis of the description of the first embodiment, the total dust collection amount when the dust collecting filter 22 is replaced is the same as the threshold value m_{th} of the dust collection amount. Supposing that the air passing through the dust collecting filter 22 is linearly decreased due to an increase in the total dust collection amount m of the dust collecting filter 22, the correction coefficient μ is expressed by the following equation.

[Equation 4]

$$\mu = 1 - \frac{1}{2 \cdot m_{th}} \cdot m$$

[0102] Further, using the correction coefficient μ , the dust collection amount Δm of the dust

collecting filter 22 after the drive of the blower 30 is started is expressed by the following equation.

[Equation 5]

$$\Delta m = \frac{K_v \cdot P_p \cdot C_{out} \cdot S \cdot h}{\mu \cdot Q + (K_o + K_v) \cdot S \cdot h} \cdot \mu \cdot Q \cdot \Delta t$$

[0103] In this way, adjustment based on the change (decrease) in the dust collecting ability of the dust collecting filter 22 is added to the calculation of the dust collection amount of the dust collecting filter 22, and hence the total dust collection amount of the dust collecting filter 22 can be correctly obtained. In this way, it is possible to prevent replacement of the dust collecting filter 22 having sufficient dust collecting ability or continuous use of the dust collecting filter 22 that has become lower dust collecting ability than estimated. Note that the correction coefficient μ may be decreased nonlinearly. In that case, the correction coefficient μ can be determined by changing the equation of Equation 4. This equation of Equation 4 may be automatically corrected using the network NW.

[0104] In addition, other features are the same as those of the first embodiment.

[0105] <Third embodiment>

Still another example of the air cleaner according to the present invention is described with reference to the drawings. Fig. 9 is a block diagram of the still another example of the air cleaner according to the present invention. An air cleaner B shown in Fig. 9 includes a computing unit 61 disposed on a server SV that is an external apparatus, and other structures are the same as those of the air cleaner A. Therefore, in the air cleaner B, substantially the same part as in the air cleaner A is denoted by the same numeral or symbol, and detailed description of the same part is omitted.

[0106] As shown in Fig. 9, the server SV as an external apparatus is connected to the network NW to which the air cleaner B is connected. Note that the network NW is the Internet in this description, and the server SV is connected to a plurality of air cleaners B via the network NW.

[0107] The server SV includes the computing unit 61. In the same manner as the computing unit 60 of the air cleaner A, the computing unit 61 calculates the total amount of dust collected by the dust collecting filter 22, i.e. the total dust collection amount based on the information from the control unit 50. The computing unit 61 has a structure

capable of storing information.

- [0108] The clock unit 51 provided to the air cleaner B includes a time counter for counting time. The time counter counts time during a period in which the blower 30 of the air cleaner B is driven. The clock unit 51 stops counting when the blower 30 is stopped. Further, a count number when stopping counting is saved, and when the drive of the blower 30 is restarted, the time count is restarted from the count number. Note that, in the structure in which the blower 30 is not stopped, the time count is continued during a period in which the power supply of the air cleaner B is turned on. In this case, the air cleaner B has a structure capable of saving the count number when the power supply is turned off. In addition, the time counter of the clock unit 51 may reset the count number when the dust collecting filter 22 is replaced. In addition, the count number when the dust collecting filter 22 is replaced may be sent to the control unit 50 so that the time count is continued from the count number.
- [0109] The control unit 50 and the computing unit 61 obtains the count number (time) from the clock unit 51 and holds (stores) the count number. Further, the control unit 50 and the computing unit 61 can obtain the elapsed time from a certain time point to a time point when the count number is obtained next time based on the count number obtained at the certain time and the count number obtained the next time.
- [0110] The control unit 50 uses the clock unit 51 so as to obtain total use time of the current attached dust collecting filter 22. In addition, the control unit 50 uses the clock unit 51 and the blower 30 so as to obtain the total amount of air that has passed through the dust collecting filter 22, i.e. the total amount of air that has passed through the dust collecting filter 22 after the dust collecting filter 22 is newly attached until the present time. Further, the control unit 50 can send the total use time and the total amount of air to the computing unit 61.
- [0111] The computing unit 61 calculates the total dust collection amount of the dust collecting filter 22 based on the information sent from the control unit 50. As described above, the control unit 50 detects the total amount of air that has passed through the dust collecting filter 22 every time when the additionally set time elapses. Further, the detection result is sent to the computing unit 61 together with the time count number. The computing unit 61 performs the calculation every time when receiving the information from the control unit 50.

[0112] A method of calculating the total dust collection amount of the dust collecting filter 22 is described below. The control unit 50 sends the time count number and the total amount of air to the computing unit 61 every time when the additionally set time elapses. For example, supposing that the time count number of s-th time is t_s and the total amount of air is Q_s , then the last time when the control unit 50 sent the total amount of air to the computing unit 61 is (s-1)th time. The time count number of (s-1)th time is t_{s-1} , the total amount of air is Q_{s-1} . The time count number t_{s-1} and the total amount of air Q_{s-1} are stored in the computing unit 61.

[0113] The computing unit 61 calculates time Δt from (s-1)th time to s-th time and the total amount of air Q_n that has passed through the dust collecting filter 22 using the following equations.

[Equation 6]

$$\Delta t = t_s - t_{s-1}$$

[Equation 7]

$$Q_n = Q_s - Q_{s-1}$$

[0114] The computing unit 61 obtains data of the time count number and the total amount of air from the control unit 50 via the network NW. Further, the computing unit 61 does not inform the control unit 50 about that these data are obtained. Therefore, the control unit 50 cannot check whether or not the data sent to the computing unit 61 is received by the computing unit 61. Therefore, the control unit 50 sends the total time count number t_s of the s-th time and the total amount of air Q_s that has passed through the dust collecting filter 22. In this way, for example, even if the latest time count number t_{s-1} and the total amount of air Q_{s-1} are not correctly received by the computing unit 61, the time Δt and the total amount of air Q_n that has passed through the dust collecting filter 22 in the time can be obtained using (s-2)th time that is the time before last and s-th time. In other words, by storing the value that was received last time or obtained by calculation in this way, even if obtaining the data is failed, the total amount of air can be obtained based on the data obtained next time.

[0115] A procedure of informing the replacement timing of the dust collecting filter 22 using the air cleaner B is described with reference to the drawings. Fig. 10 is a flowchart showing a procedure of notifying replacement of the dust collecting filter in still

another example of the air cleaner according to the present invention.

[0116] The flowchart shown in Fig. 10 has substantially the same part as the flowchart shown in Fig. 8. The substantially the same part has substantially the same operation as in Fig. 8, and description thereof is simplified. As shown in Fig. 10, the control unit 50 checks whether or not the drive of the blower 30 is started (Step S201) and waits until the drive of the blower 30 is started (the same operation as in Step S101). When the drive of the blower 30 is confirmed, the control unit 50 starts time count by the clock unit 51 (Step S202).

[0117] The control unit 50 checks whether or not the additionally set time has elapsed after the drive of the blower 30 is started (Step S203). Note that the additionally set time is time that is randomly set that the average thereof becomes a predetermined time. For example, it is time that is randomly set within the range from 8 to 20 minutes so that the average thereof becomes 15 minutes. In this way, because the additionally set time is random, the data sent from a plurality of air cleaners to the computing unit 61 are prevented from being concentrated at one time. Note that, if the computing unit 61 has sufficient processing ability, the additionally set time may be a constant time.

[0118] If the additionally set time has not elapsed (No in Step S203), the control unit 50 checks whether or not the blower 30 is stopped (Step S204). If the blower 30 is not stopped (No in Step S204), the process returns to checking whether or not the additionally set time has elapsed (Step S203). If the blower 30 is stopped (Yes in Step S204), the time count by the clock unit 51 is stopped (Step S205).

[0119] When the additionally set time has elapsed (Yes in Step S203) or after the blower 30 is stopped and the clock unit 51 stops time count (after Step S205), the control unit 30 checks the clock unit 51 and sends the time count number t_s at present to the computing unit 61 of the server SV (Step S206).

[0120] The control unit 50 sends the total amount of air Q_s that has passed through the dust collecting filter 22 at present to the computing unit 61 (Step S207). The control unit 50 gets (calculates) the total amount of air Q_s that has passed through the dust collecting filter 22 based on the drive of the blower 30 as described above.

[0121] The server SV is connected to the Internet via the network NW. Further, the computing unit 61 obtains the dust concentration C_{out} as dirt information of the air

around the room in which the air cleaner B is installed from the Internet service (Step S208). In addition, the computing unit 61 retrieves the floor area S and the ceiling height h of the room that is obtained in advance (Step S209).

[0122] Obtaining of the dust concentration C_{out} and the floor area S and the ceiling height h of the room by the computing unit 61 is described. The connection of the air cleaner B to the network NW is performed when being installed in the room. In this description, the connection is performed manually (by operating the button 41b in Fig. 6). In this case, the control unit 50 accesses the server SV disposed on the network NW, and sends the position information, the floor area S , and the ceiling height h of the room to the computing unit 61. The computing unit 61 controls a storage unit that is disposed in the server SV and is not shown to store the information. The information of the room in which the air cleaner B is installed is sent to the computing unit 61 automatically when use of the air cleaner B is started. In addition, it is possible to adopt a structure in which the information is manually sent.

[0123] The computing unit 61 itself can obtain the dust concentration in the air in a designated area from a service on the network NW. When the computing unit 61 obtains from the control unit 50 the information of the time count number t_s and the total amount of air Q_s that has passed through the dust collecting filter 22, the computing unit 61 obtains from a service (server) providing dust concentration the dust concentration around the room based on room position information.

[0124] When the computing unit 61 obtains from the control unit 50 the time count number t_s and the total amount of air Q_s that has passed through the dust collecting filter 22, the computing unit 61 calculates the dust collection amount of the dust collecting filter 22. The computing unit 61 stores the time count number, the total amount of air that has passed through the dust collecting filter 22, and the total dust collection amount of the dust collecting filter 22 at the last calculation time. The computing unit 61 retrieves the information. Further, the computing unit 61 calculates the dust collection amount Δm of the dust collecting filter 22 after the last calculation time until this calculation time (Step S210). Note that the calculation of the dust collection amount Δm is performed using the equations described above.

[0125] The computing unit 61 updates the total dust collection amount m of the dust collecting filter 22 using the calculated dust collection amount Δm (Step S211).

When updating the total dust collection amount m , the computing unit 61 also updates the time count number t_s and the total amount of air Q_s that has passed through the dust collecting filter 22. Note that the computing unit 61 may rewrite these values or may save them as history data. In this description, the computing unit 61 rewrites these data. When the dust collecting filter 22 is replaced, the control unit 50 sends the information to the computing unit 61. The computing unit 61 receives the information that the dust collecting filter 22 is replaced and then resets the stored total dust collection amount m of the dust collecting filter 22 to "0". In this case, the total amount of air that has passed through the dust collecting filter 22 until the last time is also reset to "0". In addition, the time count number is reset if the clock unit 51 is reset, while it is not reset if the clock unit 51 is not reset.

[0126] The operation of the computing unit 61 for checking whether or not the replacement of the dust collecting filter 22 is necessary is the same as that described above. In other words, the computing unit 60 checks whether or not the updated total dust collection amount m is more than or equal to the threshold value m_{th} of the dust collection amount (Step S212). If the total dust collection amount m is less than the threshold value m_{th} of the dust collection amount (No in Step S212), the control unit 50 checks whether or not the blower 30 is being driven (Step S213).

[0127] If the blower 30 is being driven (Yes in Step S213), the control unit 50 returns to checking whether or not the set time has elapsed (Step S203), and the operation described above is repeated. In addition, if the blower 30 is stopped (No in Step S213), the control unit 50 waits until the blower 30 is driven (returns to Step S201).

[0128] In addition, if the total dust collection amount m is more than or equal to the threshold value m_{th} of the dust collection amount (Yes in Step S212), the computing unit 60 sends to the control unit 50 a notification instruction that instructs to notify the replacement of the dust collecting filter 22 via the network NW (Step S214). When receiving the notification instruction from the computing unit 60, the control unit 50 controls the display unit 42f to work for notifying that the replacement of the dust collecting filter 22 is necessary based on the instruction (Step S215). After that, the control unit 50 checks whether or not the blower 30 is being driven (moves to Step S213).

[0129] In this way, the computing unit 61 is provided to the server SV disposed on the

network NW, and the computing unit 61 calculates the dust collection amount of the dust collecting filter 22, and hence the logic circuit of the air cleaner B installed in the room can be simplified. In this way, cost of the part of the air cleaner B installed in the room can be reduced. In addition, it is possible to manage dust collecting states of the dust collecting filters of a plurality of air cleaners. Further, it is also possible to appropriately change (adjust) coefficients used in the calculation equations by comprehending the dust collecting states. In addition, the server SV may manage a state other than the dust collecting filter 22, for example, total drive time of the blower 30, power consumption, or the like. In addition, because parts of the air cleaner installed in the room can be integrally managed, the replacement of the dust collecting filter, maintenance timing of the blower, or the like may be informed to a user's mobile terminal or the like, as necessary (e.g. responding to a user's request).

[0130] In this embodiment, the external apparatus, in which the computing unit 61 is disposed, outside the housing 10 of the air cleaner B, is the server SV disposed on the network NW, but this is not a limitation. For example, the computing unit 61 may be disposed in a server for home security, an information management apparatus for home use such as a home electronics management controller, a mobile terminal such as a smartphone or a tablet PC, or the like.

[0131] <Fourth embodiment>

Still another example of the air cleaner according to the present invention is described with reference to the drawings. Fig. 11 is a block diagram of still another example of the air cleaner according to the present invention. An air cleaner C shown in Fig. 11 has the same structure as the air cleaner A except that an interface unit 40c and a measuring unit 70c are different. Therefore, a part of the air cleaner C that is substantially the same as that of the air cleaner A is denoted by the same numeral or symbol, and detailed description of the same part is omitted.

[0132] As shown in Fig. 11, the measuring unit 70c of the air cleaner C includes a CO (carbon monoxide) sensor 71, a CO₂ (carbon dioxide) sensor 72, and an O₃ (ozone) sensor 73. The CO sensor 71, the CO₂ sensor 72, and the O₃ sensor 73 are disposed in a vicinity of the suction opening 11 of the air cleaner C so as to measure concentrations of CO, CO₂, and O₃ contained in the air sucked from the suction opening 11. Note that the measuring unit 70c also includes the odor sensor and the

dust sensor that are provided to the measuring unit 70. Note that the dust collecting filter 22 collects micro-substances but does not absorb gas such as CO, CO₂ and O₃. Therefore, the CO sensor 71, the CO₂ sensor 72, and the O₃ sensor 73 may be disposed either on the suction side or on the discharge side of the dust collecting filter 22.

[0133] The CO sensor 71, the CO₂ sensor 72, and the O₃ sensor 73 are connected to the control unit 50. The CO concentration measured by the CO sensor 71, the CO₂ concentration measured by the CO₂ sensor 72, and the O₃ concentration measured by the O₃ sensor 73 are sent to the control unit 50.

[0134] In the air cleaner C, the measuring unit 70c described above measures the CO, CO₂, and O₃ concentrations. Further, in the interface unit 40c of the air cleaner C can inform these gas concentrations. The interface unit 40c is described below with reference to the drawings. Fig. 12 is a diagram showing the interface unit of the air cleaner shown in Fig. 11. Fig. 13 is a diagram showing a display example of a display unit provided to the interface unit shown in Fig. 12 so as to display the CO concentration.

[0135] The interface unit 40c shown in Fig. 12 includes a display unit 42g that displays the CO concentration, a display unit 42h that displays the CO₂ concentration, and a display unit 42i that displays the O₃ concentration. As shown in Figs. 12 and 13, the display unit 42g includes four indicators. Further, the CO concentration is indicated by the number of turned-on indicators. Note that, as the CO concentration in the air is higher, more indicators are turned on.

[0136] As shown in Fig. 13, the control unit 50 classifies the CO concentration into Dirt Degrees 0 to 3 as described later. Further, in Dirt Degree 0, one indicator is turned on. In addition, in Dirt Degree 1, two indicators are turned on. In Dirt Degree 2, three indicators are turned on. In Dirt Degree 3, four indicators are turned on. In this way, by the indication with the number of turned-on indicators of the display unit 42g of the interface unit 40c, the user can recognize by intuition whether the CO concentration is high or low. Note that the indicator may be accompanied with, for example, a display urging ventilation, a display calling attention about an operating state (such as incomplete combustion) of an apparatus around, a warning display, or the like.

- [0137] In the same manner, in each of the display unit 42h that displays CO₂ and the display unit 42i that displays O₃ of the interface unit, indicators are turned on according to the CO₂ concentration (dirt degree) or the O₃ concentration (dirt degree).
- [0138] As described above, the air cleaner C according to the present invention measures concentrations of substances such as CO and O₃ harmful to human body and notifies the concentration. In this way, the user can avoid harm of toxic substances by ventilation of the room or temporary evacuation from the room. In addition, although CO₂ has little harm to human body, most reason for the increase in CO₂ is consumption of oxygen due to flame used in warming or cooking. In other words, if CO₂ is increasing, oxygen is decreasing in many cases. In this case, by notifying the CO₂ concentration, the user can be informed that oxygen in the room is being decreased.
- [0139] Next, details of the CO sensor 71, the CO₂ sensor 72, and the O₃ sensor 73 are described with reference to the drawings. Note that the CO sensor 71, the CO₂ sensor 72, and the O₃ sensor 73 have the same structure though they detect different substances. Therefore, in the following description, a measurement circuit using the CO sensor 71 is exemplified and described as a representative of these sensors.
- [0140] Fig. 14 is a circuit diagram of the measurement circuit including the CO sensor. Note that the circuit shown in Fig. 14 is an equivalent circuit of the measurement circuit for measuring CO, in which details may be different from the actual measurement circuit. A CO measurement circuit 700 includes the CO sensor 71, a load resistor 701, and an A/D converter 702.
- [0141] In the air cleaner C according to this embodiment, the CO sensor 71 is a semiconductor sensor. The CO sensor 71 includes a measurement resistor 711 and a heater 712. The measurement resistor 711 is a semiconductor element having a resistance that varies according to CO concentration.
- [0142] In the measurement resistor 711, accuracy of the measured CO concentration varies depending on temperature. In other words, when temperature of the measurement resistor 711 is low, measurement accuracy is low. Therefore, in the CO sensor 71, in order to suppress accuracy deterioration depending on temperature, the heater 712 is used for heating the measurement resistor 711.
- [0143] In the measurement circuit 700, one terminal of the measurement resistor 711 is

connected to one terminal of the load resistor 701, and the other terminal is connected to a ground. In addition, the other terminal of the load resistor 701 is connected to the control unit 50, and the other terminal of the load resistor 701 is applied with a bias voltage V_b . Further, the measurement circuit 700 obtains a voltage across terminals of the load resistor 701 (output voltage V).

[0144] Supposing that a resistance of the measurement resistor 711 of the CO sensor 71 is R_1 , a resistance of the load resistor 701 is R_2 , the bias voltage is V_b , then the output voltage V is expressed by the following equation.

[Equation 8]

$$V = \frac{R_2 V_b}{R_1 + R_2}$$

[0145] The output voltage V is digitized by the A/D converter 702 and then is input to the control unit 50. In other words, the measurement circuit 700 uses a so-called voltage divider circuit, measures the voltage across terminals of the load resistor 701 connected in series to the measurement resistor 711 as the output voltage V , digitizes the voltage, and outputs the digitized value to the control unit 50. The A/D converter 702 converts a voltage value of the bias voltage into a 10-bit value. In other words, the A/D converter 702 outputs the voltage value as a number of 0 to 1023. Note that, in the following description, the digital value may be used as the output voltage V for description.

[0146] The CO₂ sensor 72 and the O₃ sensor 73 have the same structure as the CO sensor 71. Further, the CO₂ measurement circuit and the O₃ measurement circuit have the same structure as the CO measurement circuit.

[0147] The control unit 50 detects a CO dirt degree of the air based on an output value of the A/D converter 702. The dirt degree is described below. As to the measurement resistor 711 of the CO sensor 71, the resistance R_1 is often varied because of manufacturing reasons or the like. Because the bias voltage V_b is constant, if the resistance R_2 of the load resistor 702 is constant, the output voltage V varies depending on variation of the resistance R_1 . Therefore, in the measurement circuit 700, the resistance R_2 of the load resistor 701 is determined so that a digital value of the output voltage V becomes close to a predetermined value, e.g. 512 as a 10-bit digital value in a predetermined CO concentration environment.

[0148] By setting a 10-bit digital value of the output voltage V to 512, when the output voltage V varies, the output voltage V can be obtained in substantially the same range both in increasing case and in decreasing case.

[0149] <Fifth embodiment>

The control unit 50 stores the resistance R1 of the load resistor 701 and can determine the resistance of the measurement resistor 711 by obtaining the output voltage V. As described above, the resistance of the measurement resistor 711 varies because of manufacturing reasons or the like. Therefore, even if the resistance of the measurement resistor 711 is determined from the output value, it is difficult to evaluate absolute concentration of CO. Therefore, the control unit 50 compares the output value obtained at certain reference timing with the current output value and determines the dirt degree based on the comparison result. Rs represents the current resistance of the measurement resistor 711, and Rb represents the resistance of the measurement resistor 711 at the reference timing. Then, a resistance ratio Y(%) is determined by the following equation.

[Equation 9]

$$Y = \frac{R_s}{R_b} \times 100$$

[0150] Further, the measurement resistor 711 of the CO sensor 71 has characteristics that the resistance thereof becomes smaller as the CO concentration becomes higher. In other words, when the CO concentration does not change with respect to the reference timing, the resistance ratio Y becomes 100. On the contrary, if the CO concentration is increased, the resistance ratio Y becomes close to 0. The air cleaner C utilizes this phenomenon and classifies the dirt degree into four degrees based on the value of the resistance ratio Y.

[0151] Fig. 15 is a table showing a relationship between the dirt degree and the resistance ratio. As shown in Fig. 15, a resistance ratio of 69 or larger corresponds to Dirt Degree 0, a resistance ratio of 50 or more and smaller than 69 corresponds to Dirt Degree 1, a resistance ratio of 40 or more and smaller than 50 corresponds to Dirt Degree 2, and a resistance ratio smaller than 40 corresponds to Dirt Degree 3. Dirt Degree 0 has the lowest CO concentration, while Dirt Degree 3 has the highest CO concentration. Note that, when using the measurement resistor whose resistance

increases as the gas concentration becomes higher, the dirt degree is classified based on a ratio between the resistance R_b at the reference timing and the current resistance R_s which are exchanged.

- [0152] By evaluating the CO concentration based on the ratio between the resistance at the reference timing and the current resistance of the measurement resistor 711 (by relative evaluation), the CO concentration can be evaluated even if the resistance is varied. However, the CO concentration at the reference timing may be high in the room where the air cleaner C is installed. When calculating the resistance ratio Y, the resistance of the measurement resistor 711 at the reference timing of high CO concentration is used as the reference, and hence there may be a case where the CO concentration, which is actually high, is determined to be low.
- [0153] Because CO is a gas that is harmful to human body, if a high CO concentration is displayed as low, the user may be suffered from CO poisoning. Therefore, the control unit 50 of the air cleaner C controls to display Dirt Degree 3 if the current resistance R_s of the measurement resistor 711 is smaller than a predetermined threshold resistance value. By performing this control, if there is a possibility that the CO concentration is high, the state can be informed to the user, and hence the user can take countermeasures such as ventilation or evacuation before being suffered from CO poisoning. Note that it is preferred to use the threshold resistance value that is beyond the variation range of the measurement resistor 711. Note that the same method is used for measuring CO₂ concentration and measuring O₃ concentration, so as to determine the dirt degrees.
- [0154] In addition, in the structure of relative evaluation of the measurement resistor as described above, the resistance of the measurement resistor 711 at the reference timing (hereinafter referred to as a reference resistance) is regularly updated.
- [0155] In many cases, CO is generated by incomplete combustion of a cooking device or a heating appliance. In addition, CO₂ is generated by breathing of human in many cases. O₃ is related to quantity of ultraviolet rays. Each of CO, CO₂, and O₃ is hard to rapidly increase or decrease in a short time.
- [0156] In detection of such gases whose concentration are not expected to change rapidly, if the reference resistance is updated in a short time (e.g. 8 minutes), the reference resistance may be updated before the concentration has changed so that the

concentration and the dirt degree are not relevant to each other. Therefore, in the air cleaner C according to the present invention, the reference resistance of the CO sensor 71 is updated every one hour, and the reference resistances of the CO₂ sensor 72 and the O₃ sensor 73 are updated every three hours. In this way, mild changes of the CO concentration, the CO₂ concentration, and the O₃ concentration can be securely detected.

[0157] In addition, the semiconductor gas sensor has characteristics that an adhered OH radical is hardly detached. Therefore, there is a case where although the air is cleaned in reality, the resistance of the measurement resistor is not restored. If the measurement is continued in the state where the measurement resistor is not restored, the interface unit 40c (the display unit 42g, 42h, or 42i) continues to notify that the air is dirty, though the air is cleaned in reality. Therefore, for correct measurement, the control unit 50 perform a saturation process in which when the indicators of the display unit 42g, 42h, or 42i continues the same turn-on state, the turn-on state is changed to indicate the previous dirt degree.

[0158] If the saturation process is performed in a short time (e.g. 10 minutes), the display may indicate that the dirt degree is decreased although the air is not cleaned in reality. Therefore, the time for performing the saturation process (saturation time) of the CO concentration, the CO₂ concentration, and the O₃ concentration that mildly change is set to one hour for CO or four hours for CO₂ and O₃. By setting the saturation time in this way, the air cleaner C can perform notification corresponding to the CO concentration, the CO₂ concentration, and the O₃ concentration.

[0159] <Sixth embodiment>

Still another example of the air cleaner is described. The air cleaner C measures the gas concentrations (dirt degrees due to the gases) using the CO sensor 71, the CO₂ sensor 72, and the O₃ sensor 73, each of which is an element whose resistance (measurement resistor) changes depending on a change of each gas concentration. The element whose resistance changes depending on a change of the gas concentration changes as time passes (aging). In other words, as time passes, the element shows different resistances when measuring the same concentration. The change of the measurement resistor due to aging is described below. Note that the CO sensor 71 is exemplified as a representative in the following description, but other sensors can use

the same structure.

- [0160] Note that as described above, the output voltage V is digitized into 10-bit values by the A/D converter 702. Therefore, in the following description, the output is expressed by a number from 0 to 1023 for description. In this description, under a constant environment (concentration) R_2 , the output is 512. Note that the output of 512 is a median of 10-bit values and is set so that both the increasing range and the decreasing range can be large. However, other numeric value may be used if increasing or decreasing tendency is known in advance.
- [0161] In the equation of Equation 8, the denominator increases when the resistance R_1 is decreased, and hence the output voltage V is increased. In other words, when the CO concentration is increased, the output voltage V is increased. If operating time is short, no problem occurs in use in this state. However, if the resistance R_1 of the measurement resistor 711 of the CO sensor 71 is changed by aging, the CO concentration varies in the same output voltage V . For example, if the resistance R_1 is decreased by aging, the output voltage V is increased in measurement in the same CO concentration. If the output voltage V is increased, measurable range when the CO concentration is increased is decreased, and hence it becomes difficult to detect resistance corresponding to the CO concentration of the measurement resistor 711.
- [0162] Therefore, in order to support a change by aging of the resistance of the measurement resistor 711, the control unit 50 has a structure capable of changing the load resistor 701. By changing the load resistor 701, the resistance R_1 can be accurately measured even if the resistance R_1 of the measurement resistor 711 changes.
- [0163] For example, if the output voltage V is 900 continuously for a few days, the control unit 50 determines that it is not because of an abrupt increase of the CO concentration but because of a decrease of the resistance R_1 by aging of the measurement resistor 711. Then, the control unit 50 performs control of decreasing the resistance R_2 of the load resistor 701. In addition, on the contrary, if the output voltage V is 100 continuously for a few days, the control unit 50 determines that it is not because of an abrupt decrease of the CO concentration due to ventilation or the like but because of an increase of the resistance R_1 by aging of the measurement resistor 711. Then, the control unit 50 performs control of increasing the resistance R_2 of the load resistor 701.

- [0164] In this way, by changing the resistance R2 of the load resistor 701, the digitized output voltage V can be set to a value close to a median in the detection range (e.g. 512). In this way, in both the increasing and decreasing cases of the output voltage, the detection can be performed in wide range.
- [0165] Each of the CO sensor 71, the CO₂ sensor 72, and the O₃ sensor 73 is not sensitive to substances other than CO, CO₂, or O₃ compared with the odor sensor that is conventionally used for the air cleaner. In other words, the CO sensor 71, the CO₂ sensor 72, and the O₃ sensor 73 can accurately measure CO, CO₂, and O₃, respectively. However, these sensors are sensitive to high concentration alcohol.
- [0166] Further, when high concentration alcohol is adhered to, the CO sensor 71 and the CO₂ sensor 72 respond in a dirty direction while the O₃ sensor 73 responds in a clean direction. The control unit 30 utilizes this phenomenon so as to check whether or not the response of the CO sensor 71, the CO₂ sensor 72, and the O₃ sensor 73 is due to high concentration alcohol.
- [0167] A method of checking whether or not the response is due to high concentration alcohol is described below. The control unit 50 detects averages of the CO concentration, the CO₂ concentration, and the O₃ concentration for a short time (e.g. 1 minute) from the output value of the CO sensor 71, the CO₂ sensor 72, and the O₃ sensor 73. Further, the control unit 50 compares the detection value (or the average value for a short time) of the CO concentration or the CO₂ concentration with a minimum value (a value in the clean direction) of the average value for a short time in a past predetermined time (e.g. 10 minutes). In addition, the control unit 50 compares the detection value (or the average value for a short time) of the O₃ concentration with a maximum value (a value in the dirty direction) of the average value for a short time in the past predetermined time (e.g. 10 minutes).
- [0168] The control unit 50 determines that high concentration alcohol is detected, if the CO and/or CO₂ detection values are changed from the minimum value of the average value for a short time in the past predetermined time in the dirty direction by a predetermined value or more, and if the O₃ detection value is changed from the maximum value of the average value for a short time in the past predetermined time in the clean direction by a predetermined value or more (this condition is referred to as Condition 1).

[0169] When determining that the detected gas is high concentration alcohol, the control unit 50 sets the dirt degree of each of CO, CO₂ and O₃ to Dirt Degree 0 until a predetermined time (e.g. 15 minutes) elapses after Condition 1 becomes not satisfied. Note that if the dirt degree is Dirt Degree 2 or higher just before high concentration alcohol is detected, it is important to notify each gas concentration, and hence the correction to Dirt Degree 0 is not performed. The condition of not performing the correction is not limited to Dirt Degree 2 but may be Dirt Degree 3. Further, the measurement time for the CO concentration, the CO₂ concentration, and the O₃ concentration by the CO sensor 71, the CO₂ sensor 72, and the O₃ sensor 73 are set to be long (e.g. 10 minutes), and the average value is calculated in the set time.

[0170] When high concentration alcohol is detected, the control unit 50 corrects the dirt degrees of CO, CO₂, and O₃ as described above, and thus notification of incorrect information to the user can be prevented even if a misdetection occurs due to high concentration alcohol.

[0171] <Variations>

In the example described above, it is determined whether or not high concentration alcohol is detected in the detection of CO by the CO sensor 71, the detection of CO₂ by the CO₂ sensor 72, and the detection of O₃ by the O₃ sensor 73. In other words, the control unit 50 determines whether or not the detected gas is high concentration alcohol based on whether or not variations of the CO and/or CO₂ detection values are predetermined values or more, and whether or not a variation of the O₃ detection value is a predetermined value or more, and hence the structure thereof is simple.

[0172] On the other hand, in the method described above, although the control unit 50 determines whether or not high concentration alcohol is detected based on the detection result, but the CO sensor 71, the CO₂ sensor 72, and the O₃ sensor 73 are in misoperation due to high concentration alcohol. Therefore, during the period in which the misoperation occurs, the CO, CO₂, and O₃ detection accuracies are deteriorated. Therefore, in order to exclude an influence of high concentration alcohol that causes misoperations of the CO sensor 71, the CO₂ sensor 72, and the O₃ sensor 73, the following structure may be adopted.

[0173] A variation of this embodiment is described with reference to the drawings. Fig. 16 is a schematic view of a measuring unit and its periphery of the air cleaner according

to the present invention. The air cleaner C shown in Fig. 16 has the same structure as the air cleaner C of the fourth embodiment except that an interference filter 25 is disposed. Therefore, description of each structural elements is omitted.

[0174] In the air cleaner C, the measuring unit 70c is disposed between the prefilter 21 and the dust collecting filter 22. Further, the interference filter 25 is disposed on the downstream side of the prefilter 21 in the air passage 12 so that the air after passing through the prefilter 21 passes through the interference filter 25. Note that the measuring unit 70c includes the CO sensor 71, the CO₂ sensor 72, and the O₃ sensor 73, and may be attached to an inner surface of the housing 10 or may be attached to a member protruding from an inner surface of the housing 10.

[0175] An interference gas and the interference filter 25 are described below. The CO sensor 71, the CO₂ sensor 72, and the O₃ sensor 73 included in the measuring unit 70c are sensors that detect CO, CO₂, and O₃, respectively. Each sensor has an element that detects an object (gas). This element is effective for detecting the object gas but may respond to a gas other than the object gas. In other words, the gas other than the object gas interferes with detection of CO, CO₂, and O₃ by the CO sensor 71, the CO₂ sensor 72 and the O₃ sensor 73. Therefore, the gas other than the object gas, to which the sensor (element) responds, is referred to as an interference gas. Further, a filter that removes (absorbs) the interference gas contained in the air is referred to as an interference filter. Note that an example of the interference gas is alcohol, but this is not a limitation. In addition, an example of the interference filter 25 is an activated carbon filter, but this is not a limitation.

[0176] In the air cleaner C, the air sucked from the suction opening 11 passes through the prefilter 21 and passes through the interference filter 25. When the air passes through the interference filter 25, the interference gas contained in the air is absorbed by the interference filter 25. Further, the air after passing through the interference filter 25 contacts with the measuring unit 70c. In this case, the air contacting with the measuring unit 70c contains no or little interference gas. Therefore, an influence of the interference gas to the detection of CO, CO₂, and O₃ by the CO sensor 71, the CO₂ sensor 72, and the O₃ sensor 73 can be excluded or substantially excluded.

[0177] As described above, by disposing the interference filter 25 on the upstream side of the measuring unit 70c in the airflow direction, an influence of the interference gas to the

detection of CO, CO₂, and O₃ by the CO sensor 71, the CO₂ sensor 72, and the O₃ sensor 73 can be excluded or substantially excluded.

[0178] Note that, in this variation, the interference gas (alcohol) that influences the detection of CO, CO₂, and O₃ by the CO sensor 71, the CO₂ sensor 72, and the O₃ sensor 73 included in the measuring unit 70c is exemplified and described, but this is not a limitation. For example, there may be a case where the air contains an interference gas that influences only one of the CO sensor 71, the CO₂ sensor 72, and the O₃ sensor 73. Also in this case, the interference filter 25 can be disposed on the upstream side of the entire measuring unit 70c in the airflow direction. In addition, it is possible to adopt a structure in which among the sensors included in the measuring unit 70c, the sensor that is affected by the interference gas and the sensor that is not affected or not substantially affected by the interference gas are separated from each other, so that the interference filter is disposed on the upstream side of the sensor that is affected by the interference gas and on the downstream side of the sensor that is not affected or not substantially affected.

[0179] Note that the measuring unit 70c may include the odor sensor or the like. The odor sensor includes an element that responds to odor particles. Most odor particles are absorbed by the activated carbon filter. Therefore, if the interference filter 25 is disposed on the upstream side of the odor sensor in the airflow direction, the odor sensor may not be able to correctly detect odor in the air in the room. In this case, the odor sensor may be separated from other sensors in the measuring unit 70c and may be disposed on the upstream side of the interference filter 25 in the airflow direction. In other words, in the measuring unit, a sensor that detects a substance to be absorbed by the interference filter 25 can be separated from other sensor so as to be disposed on the upstream side of the interference filter 25 in the airflow direction. In other words, the sensor that is affected by the interference gas can be disposed on the downstream side of the interference filter 25 in the airflow direction.

[0180] <Seventh embodiment>

Still another example of the air cleaner according to the present invention is described with reference to the drawings. Fig. 17 is a timing chart showing driving states of the CO sensor, the CO₂ sensor, and the O₃ sensor in the air cleaner according to the present invention. The air cleaner C of this embodiment has the same structure as the

air cleaner C of the fourth embodiment except that operation timings of the CO sensor, the CO₂ sensor, and the O₃ sensor are changed. Therefore, description of each structural elements is omitted.

[0181] Each of the measurement resistors used for the CO sensor 71, the CO₂ sensor 72, and the O₃ sensor 73 has guaranteed operating temperature. A heater for heating up to the guaranteed operating temperature is attached to each of the CO sensor 71, the CO₂ sensor 72, and the O₃ sensor 73.

[0182] The heaters of the CO sensor 71 and the CO₂ sensor 72 are pulse controlled so as to repeat on and off, and a voltage drop occurs instantly when the heater is switched from off to on. If the detection of the resistance of the measurement resistor of the CO sensor 71 or the resistance of the measurement resistor of the CO₂ sensor 72 is performed at the timing when the voltage drop occurs, because the bias voltage is unstable, correct voltage value cannot be detected. Note that the heater of the O₃ sensor 73 is controlled to be continuously turned on and does not cause a voltage drop, and hence the heater of the O₃ sensor 73 is omitted.

[0183] Fig. 17 shows timings for driving the heaters of the CO sensor 71 and the CO₂ sensor 72 and measuring the resistances thereof. As shown in Fig. 17, turning on/off of the heater of the CO sensor 71 is repeated at period Cy1. Further, the resistance of the measurement resistor is measured at a timing shifted from the heater-on timing in the end of the period Cy1.

[0184] In addition, as shown in Fig. 17, turning on/off of the heater of the CO₂ sensor 72 is also repeated at the period Cy1. Further, the resistance of the measurement resistor is measured at a timing shifted from the heater-on timing in the end of the period Cy1.

[0185] Further, the heater of the CO sensor 71 is turned on at timing such that the rising edge is shifted from the measurement time (ON period in Fig. 17) of the resistance of the measurement resistor of the CO₂ sensor 72. In addition, the heater of the CO₂ sensor 72 is turned on at timing such that the rising edge is shifted from the measurement time (ON period in Fig. 17) of the resistance of the measurement resistor of the CO sensor 71. In addition, the detection period of the resistance of the measurement resistor of the O₃ sensor 73 is also shifted from the rising edges of the heater of the CO sensor 71 and the heater of the CO₂ sensor.

[0186] By controlling the CO sensor 71, the CO₂ sensor 72, and the O₃ sensor 73 as shown in

Fig. 17, the detection of the resistance of the measurement resistor of the CO sensor 71 is not affected by the voltage drop due to turning on of the heater of the CO sensor 71 or the voltage drop due to turning on of the heater of the CO₂ sensor 72. In addition, in the same manner, the detection of the resistance of the measurement resistor of the CO₂ sensor 72 is not affected by the voltage drop due to turning on of the heater of the CO sensor 71 or the voltage drop due to turning on of the heater of the CO₂ sensor 72. Further, the detection of the resistance of the measurement resistor of the O₃ sensor 73 is not affected by the voltage drop due to turning on of the heater of the CO sensor 71 or the voltage drop due to turning on of the heater of the CO₂ sensor 72. In this way, the CO sensor 71, the CO₂ sensor 72, and the O₃ sensor 73 can correctly measure the CO concentration, the CO₂ concentration, and the O₃ concentration, respectively.

[0187] Note that this embodiment describes that the CO sensor 71 and the CO₂ sensor 72 have the same operation period, but they may have different periods. In case of different periods, in order to prevent overlapping between the rising of the heater and the detection period of the resistance of the measurement resistor, it is preferred that one of the periods be an integral multiplication of the other period.

[0188] Note that if the heater of the O₃ sensor 73 is pulse controlled, the heater of the O₃ sensor is also controlled in the same manner.

[0189] Although the embodiments of the present invention are described above, the present invention is not limited to these embodiments. In addition, the embodiments of the present invention can be modified variously within the scope of the present invention without deviating from the spirit thereof.

List of Reference Signs

[0190] A, B, C air cleaner

10 housing

11 suction opening

12 air passage

121 branch part

122 branch air passage

13 blow-out opening

131 grill
14 opening
15 ion generator
16 ion passage
17 damper
20 dust collector
21 prefilter
211 frame
212 mesh
22 dust collecting filter
221 filter material
222 frame material
23 dust removing unit
231 rotation blush
232 dust box
233 guide frame
234 pinion
30 blower
31 impeller
32 motor
40 interface unit
401 operation unit
402 informing unit
41a-41g button
42a-42i display unit
50 control unit
51 clock unit
52 storage unit
53 communication unit
60 computing unit
61 computing unit
70 measuring unit

70c measuring unit

71 CO sensor

711 measurement resistor (element)

712 heater

700 measurement circuit

701 load resistor

702 A/D converter

CLAIMS

1. An air cleaner for cleaning air in an installation space by collecting dust contained in air sucked from a suction opening by a dust collecting unit and blowing out the air after dust collection from a blow-out opening, the air cleaner comprising:

- a blower for generating airflow;
- an informing unit capable of displaying a state of the dust collecting unit;
- a control unit capable of controlling the blower and the informing unit; and
- a computing unit capable of communicating with the control unit, wherein
 - the control unit sends to the computing unit a total amount of air that has passed through the dust collecting unit in a predetermined period and a total dust collecting time in which dust collection is performed by the dust collecting unit,
 - the computing unit obtains information of an installation space volume and an amount of dust contained in the installation space,
 - the computing unit calculates a total dust collection amount that is a total amount of dust collected by the dust collecting unit, based on the total amount of air that has passed through the dust collecting unit, the total dust collecting time, and the information of the installation space volume and the amount of dust contained in the installation space, and if the total dust collection amount is larger than a threshold value, the computing unit sends an notification instruction to the control unit, and
 - the control unit controls the informing unit to inform a dust collection state of the dust collecting unit, based on reception of the notification instruction.

2. The air cleaner according to claim 1, wherein

- the control unit is capable of communicating with an external apparatus; and
 - the computing unit is disposed in the external apparatus.
3. The air cleaner according to claim 1 or 2, wherein the computing unit corrects the amount of air that has passed through the dust collecting unit based on a current total dust collection amount of the dust collecting unit, so as to calculate the total dust collection amount of the dust collecting unit.
4. An air cleaner for cleaning air in an installation space by collecting dust contained in air

sucked from a suction opening by a dust collecting unit and blowing out the air after dust collection from a blow-out opening, the air cleaner comprising:

- a carbon monoxide detection unit for detecting carbon monoxide concentration in sucked air or blown-out air;

- a carbon dioxide detection unit for detecting carbon dioxide concentration in the sucked air or the blown-out air;

- an ozone detection unit for detecting ozone concentration in the sucked air or the blown-out air; and

- an informing unit for informing each of the carbon monoxide concentration, the carbon dioxide concentration, and the ozone concentration.

5. An air cleaner for cleaning air in an installation space by collecting dust contained in air sucked from a suction opening by a dust collecting unit and blowing out the air after dust collection from a blow-out opening, the air cleaner comprising:

- a carbon monoxide detection unit for detecting carbon monoxide concentration in sucked air or blown-out air;

- a carbon dioxide detection unit for detecting carbon dioxide concentration in the sucked air or the blown-out air;

- an ozone detection unit for detecting ozone concentration in the sucked air or the blown-out air; and

- an control unit, wherein

- the carbon monoxide detection unit includes a first detection element and a first heater for heating the first detection element,

- the carbon dioxide detection unit includes a second detection element and a second heater for heating the second detection element,

- the ozone detection unit includes a third detection element, and

- the control unit shifts timing of turning on the first heater from a carbon dioxide detection period of the second detection element and from an ozone detection period of the third detection element, and shifts timing of turning on the second heater from a carbon monoxide detection period of the first detection element and from the ozone detection period of the third detection element.

6. The air cleaner according to claim 4 or 5, further comprising an interference gas filter for absorbing an interference gas that interferes with at least one of the carbon monoxide detection by the carbon monoxide detection unit, the carbon dioxide detection by the carbon dioxide detection unit, and the ozone detection by the ozone detection unit, wherein

the interference gas filter is disposed between the suction opening and one of the carbon monoxide detection unit, the carbon dioxide detection unit, and the ozone detection unit, whose detection operation is interfered by the interference gas, so that the sucked air passes through the interference gas filter.

7. The air cleaner according to claim 6, wherein the interference gas filter is an activated carbon filter.