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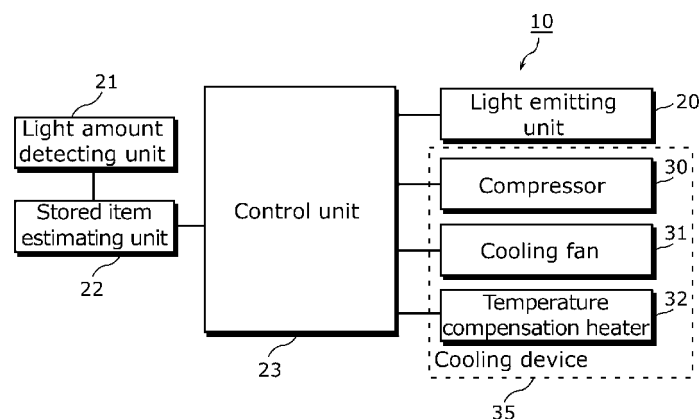
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(54) **REFRIGERATOR**

(57) A refrigerator (10) capable of keeping the freshness of stored items at a high level irrespective of the storage state of the stored items in the refrigerator (10) and reducing power consumption. The refrigerator (10) includes: a refrigerator main body (11) in which a storage compartment (12) is formed; a cooling device (35) which

cools the storage compartment (12); a stored item estimating unit (22) which estimates the total amount or the positions of the stored items (33) in the storage compartment (12); and a control unit (23) which controls the cooling of the storage compartment (12) by the cooling device (35), according to the result of the estimation by the stored item estimating unit (22).

FIG. 4



Description

[Technical Field]

5 **[0001]** The present invention relates to refrigerators, and in particular to a refrigerator capable of controlling an interior temperature of the refrigerator.

[Background Art]

10 **[0002]** In general, a recent home-use refrigerator employs an indirect cooling system using a fan for circulating cool air in the refrigerator. A conventional refrigerator detects an interior temperature of the refrigerator, adjusts the interior temperature according to the detection result, and keeps a suitable interior temperature.

[0003] An example of such a refrigerator which keeps a uniform interior temperature is a refrigerator having a movable cool air discharge device (see Patent Literature 1).

15 **[0004]** FIG. 14 is a front view of the conventional refrigerator disclosed in Patent Literature 1.

[0005] As shown in the illustration, in the conventional refrigerator, a movable cool air discharge device 102 provided in a refrigerator compartment 101 supplies cool air in a horizontal direction to uniform the interior temperature.

[Citation List]

20

[Patent Literature]

[PTL 1]

25 **[0006]** Japanese Unexamined Patent Application Publication No 8-247608

[Summary of Invention]

[Technical Problem]

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[0007] However, stored items do not always have a suitable temperature even when the interior temperature is uniform. This is because the refrigerator detects and controls an interior ambient temperature using a thermistor, and does not have any means to directly detect the temperature of the stored items. Thus, there is a difference between the interior ambient temperature and the actual temperature of the stored items.

35 **[0008]** For example, depending on the amount of the stored items, a temperature difference is made between the temperature detected by the temperature detecting unit disposed in the refrigerator and the temperature of the stored items. Such a difference is made in a transition period that starts, for example, after the interior temperature of the refrigerator increases and ends when the inside of the refrigerator is cooled to reach a preset temperature. Examples of such a transition period include a period immediately after storage of an item, a period after a door of the refrigerator is opened for a long time and is closed, and a period immediately after a defrost operation. For this reason, time required to reach the optimum storage temperature varies depending on a storage amount. More specifically, in general, cooling time is short when the storage amount is small while cooling time is long when the storage amount is large. Especially when the storage amount is small, excess cooling operation may be performed and storage items may be "overcooled".

40 **[0009]** When sufficient time has elapsed after the stored items are stored, and the temperature of the stored items become stable, the stored items keep their temperature due to the heat capacity thereof and thus become more likely to be cooled as the storage amount is larger. For this reason, according to the conventional cooling control, the stored items are "overcooled", and it is impossible to cool the stored items using an optimum temperature. In addition, the refrigerator performs the cooling operation by consuming power wastefully.

45 **[0010]** The present invention has been made to solve the aforementioned problems, with an aim to provide a refrigerator which is capable of (i) keeping the freshness of stored items at a high level by storing the items using an expected temperature irrespective of the storage state in the refrigerator, and (ii) reducing power consumption by preventing the stored items from being "overcooled".

50 [Solution to Problem]

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[0011] In order to solve the aforementioned problems, a refrigerator according to an aspect of the present invention includes: a refrigerator main body in which a storage compartment is formed; a cooling device which cools the storage compartment; a stored item estimating unit configured to estimate an amount or a position of an item stored in the storage

compartment; and a control unit configured to control the cooling of the storage compartment by the cooling device, according to a result of the estimation by the stored item estimating unit.

[Advantageous Effects of Invention]

[0012] A refrigerator according to the present invention detects a storage state in advance and controls an operation statue of the refrigerator based on the information resulting from the detection, and thereby stores items at an expected temperature irrespective of the storage state in the refrigerator. Therefore, the refrigerator is capable of keeping the freshness of the stored items at a high level, and suppressing power consumption by preventing the stored items from being "overcooled".

[Brief Description of Drawings]

[0013]

[FIG. 1]

FIG. 1 is a front view of a refrigerator according to Embodiment 1 of the present invention.

[FIG. 2]

FIG. 2 is a cross-sectional view of the refrigerator according to Embodiment 1 of the present invention, in the case of cutting the refrigerator along a B-B line in FIG. 1.

[FIG. 3]

FIG. 3 is an illustration for explaining operations performed by a light emitting unit and a light amount detecting unit according to Embodiment 1 of the present invention.

[FIG. 4]

FIG. 4 is a control block diagram of the refrigerator according to Embodiment 1 of the present invention.

[FIG. 5A]

FIG. 5A is a graph for explaining control operations performed, in a transition period, by a control unit according to Embodiment 1 of the present invention.

[FIG. 5B]

FIG. 5B is a graph for explaining control operations performed, in a transition period, by the control unit according to Embodiment 1 of the present invention.

[FIG. 5C]

FIG. 5C is a graph for explaining control operations performed, in a transition period, by the control unit according to Embodiment 1 of the present invention.

[FIG. 6]

FIG. 6 is a flowchart for explaining control operations performed, in a transition period, by the control unit according to Embodiment 1 of the present invention.

[FIG. 7A]

FIG. 7A is a graph for explaining control operations performed, in a stable period, by the control unit according to Embodiment 1 of the present invention.

[FIG. 7B]

FIG. 7B is a graph for explaining control operations performed, in a stable period, by the control unit according to Embodiment 1 of the present invention.

[FIG. 7C]

FIG. 7C is a graph for explaining control operations performed, in a stable period, by the control unit according to Embodiment 1 of the present invention.

[FIG. 8]

FIG. 8 is a flowchart for explaining control operations performed, in a stable period, by the control unit according to Embodiment 1 of the present invention.

[FIG. 9]

FIG. 9 is a control block diagram of a refrigerator according to Embodiment 2 of the present invention.

[FIG. 10]

FIG. 10 is a front view of a refrigerator according to Embodiment 3 of the present invention.

[FIG. 11]

FIG. 11 is a front view of the refrigerator according to Embodiment 3 of the present invention.

[FIG. 12]

FIG. 12 is a front view of a refrigerator according to Embodiment 4 of the present invention.

[FIG. 13]

FIG. 13 is a control block diagram of the refrigerator according to Embodiment 4 of the present invention.

[FIG. 14

FIG. 14 is a front view of a conventional refrigerator.

5 [Description of Embodiments]

[0014] A refrigerator according to a first aspect of the present invention includes: a refrigerator main body in which a storage compartment is formed; a cooling device which cools the storage compartment; a stored item estimating unit configured to estimate an amount or a position of an item stored in the storage compartment; and a control unit configured to control the cooling of the storage compartment by the cooling device, according to a result of the estimation by the stored item estimating unit.

[0015] With this, the refrigerator compensates a difference between (i) an interior temperature that is of the refrigerator, detected by a thermistor, and changing according to the amount or positions of stored items and the temperature of the stored items. Therefore, the temperature of the stored items is always kept at an optimum temperature. For this reason, since the stored items are kept at an expected temperature irrespective of the storage state in the refrigerator, it is possible to keep the freshness of the stored items at a high level, and to suppress the power consumption by preventing the stored items from being "overcooled".

[0016] Preferably, a refrigerator according to a second aspect of the present invention further includes: a light emitting unit that includes a light source which emits light onto the stored item in the storage compartment; and a light amount detecting unit disposed in the storage compartment, and configured to detect an amount of the light emitted by the light emitting unit, via the stored item and a structural component in the storage compartment, wherein the stored item estimating unit is configured to estimate the amount or the position of the stored item, according to a result of the detection of the light amount by the light amount detecting unit.

[0017] In this way, the light amount detecting unit receives the light emitted from the light source such as an LED. Thus, with the simple structure, it is possible to estimate the amount or the position of the stored item.

[0018] Preferably, in a refrigerator according to a third aspect of the present invention, the control unit is configured to select an operation pattern according to a result of the estimation of the amount or the position of the stored item by the stored item estimating unit, and to control the cooling device so that the refrigerator attains an interior temperature that is preset according to the operation pattern.

[0019] In this way, it is possible to store the item under approximately the same condition (interior temperature of the refrigerator) irrespective of the amount or the position of the stored item by performing adaptive control based on the amount or the position of the stored item. Therefore, it is possible to provide the refrigerator that achieves a high freshness keeping effect and also achieves a high power saving effect by preventing overcooling.

[0020] Preferably, a refrigerator according to a fourth aspect of the present invention further includes a door open or close detecting unit configured to detect an opened state or a closed state of a door of the refrigerator, the door being provided in front of the storage compartment, wherein in a period in which the door open or close detecting unit detects a closed state of the door of the refrigerator, the light emitting unit, the light amount detecting unit, the stored item estimating unit, and the control unit start a sequence of operations.

[0021] In this way, the light amount is detected without being affected by background light that is ambient light. Therefore, it is possible to control the refrigerator with detection accuracy higher than conventional. In this way, it is possible to provide the refrigerator that is capable of storing the stored item under approximately the same storage condition irrespective of the amount or the position of the stored item and achieving a high freshness keeping effect and a high power saving effect.

[0022] Preferably, in a refrigerator according to a fifth aspect of the present invention, the light emitting unit is a lighting unit provided in the storage compartment.

[0023] In this way, the light emitting unit can be configured simply without any additional special light emitting unit.

[0024] Preferably, in a refrigerator according to a sixth aspect of the present invention, the light emitting unit includes a plurality of light sources, and is configured to turn on the light sources sequentially, the light amount detecting unit is configured to detect the amount of the light emitted by the light emitting unit, and the stored item estimating unit is configured to estimate the amount or the position of the stored item, according to a result of the detection of the light amount by the light amount detecting unit.

[0025] In this way, the light sources are turned on sequentially. Therefore, it is possible to estimate the stored items exactly. For this reason, it is also possible to detect the stored item disposed even at a small place in a large storage compartment. Therefore, it is possible to increase the accuracy in the estimation of the amount or the position of the stored item.

[0026] Preferably, a refrigerator according to a seventh aspect of the present invention further includes a space detecting unit configured to detect an available space in a storage space of the storage compartment in a non-contact manner, wherein the space detecting unit is configured to detect a volume of a space surrounding at least a cool air

discharge port, and the stored item estimating unit is configured to estimate the amount or the position of the stored item, according to a result of the detection by the space detecting unit.

[0027] This makes it easier to estimate the position of an available space and to store foods from outside, and to thereby save energy. Furthermore, it is possible to provide a refrigerator which is capable of facilitating optimum food arrangement that is effective against power consumption increase due to overstuffing of foods or storing foods around a cool air discharge port and realizing a power saving operation.

[0028] In other words, it is possible to detect, in a non-contact manner, the ratio of the volume of the foods with respect to the storage space. Here, the volume includes the heights of the foods. In this way, it is possible to detect the state of an available space in a comparatively accurate manner. This makes it easier to recognize which part of the storage space in the refrigerator compartment is available, and thus makes it possible to store the foods immediately with a reduction in the time duration during which a door of the refrigerator is open. Accordingly, it is possible to suppress increase in the interior temperature of the refrigerator due to the opening of the door, and to thereby save energy.

[0029] In the case where foods are placed around the cool air discharge port, the amount of discharged cool air is small even when there is a sufficient storage space, and a longer time is required to cool the foods. In this case, the cooling effect inside the refrigerator decreases, with increase in the energy consumption. In addition, a large amount of cool air flowing on the foods around the cool air discharge port may dry or overcool the foods and thereby deteriorate the quality of the foods. However, according to the present invention, it is possible to facilitate storage of foods by, for example, preferentially informing another storage space, and to thereby suppress such a deterioration in the quality of the foods to a minimum. Likewise, it is possible to facilitate a power saving operation that is effective against power consumption increase caused in the case where the amount of stored foods is too much or foods are stored around the cool air discharge port.

[0030] Preferably, in a refrigerator according to an eighth aspect of the present invention, the space detecting unit and the light emitting unit are arranged on opposite sides of the storage space in which the stored item is stored.

[0031] With this, since the light from the light emitting unit enters the space detecting unit via foods, the change in the amount of the light passing through highly depends on the change in the volume of the stored foods. Accordingly, the accuracy of detecting an available space is further increased.

[0032] Preferably, in a refrigerator according to a ninth aspect of the present invention, the light emitting unit is disposed at a front part of the storage compartment, and the space detecting unit is disposed at a back wall side of the storage compartment.

[0033] In this way, it is possible to detect an available space even when the door of the storage compartment is not closed completely, in other words, ambient light enters the storage compartment, and thus the accuracy of detecting the available space is further increased.

[0034] Preferably, a refrigerator according to a tenth aspect of the present invention further includes an informing unit configured to display information about the available space in the storage space detected by the space detecting unit, on an outer surface of the door provided in front of the storage compartment.

[0035] This makes it easier to understand the available space and store foods from outside. This also makes it possible to have a rough idea of a possible food storage place before opening the door, and to thereby further reduce the time duration during which the door is open.

[0036] Preferably, in a refrigerator according to a tenth aspect of the present invention, the informing unit is configured to display, as the information about the available space, an alarm screen for informing a user that a high-power consuming operation is performed.

[0037] In this way, it is possible to inform the user that a high-power consuming operation is currently being performed due to overstuffing of foods or storing foods around the cool air discharge port.

[0038] Hereinafter, embodiments of the present invention are described with reference to the drawings. It is to be noted that these embodiments should not be interpreted to limit the present invention.

[Embodiment 1]

[0039] Hereinafter, Embodiment 1 of the present invention is described with reference to FIG. 1 to FIG. 8.

[0040] FIG. 1 is a front view of a refrigerator according to Embodiment 1 of the present invention, and FIG. 2 is a cross-sectional view of the refrigerator according to Embodiment 1 of the present invention, in the case of cutting the refrigerator along a B-B line in FIG. 1.

[0041] The refrigerator 10 in each of these illustrations includes a refrigerator main body 11 that is a heat insulating body. The refrigerator main body 11 includes an outer casing mainly made from steel plates, an inner casing formed with a resin such as ABS, and a heat insulating item between the outer casing and the inner casing, and thus is free from surrounding heat.

[0042] The refrigerator main body 11 has a plurality of storage compartments which are separated from each other and heat-insulated. The storage compartments are arranged such that a refrigerator compartment 12 is disposed at the

uppermost part, an ice making compartment 13 and a switching compartment 14 are arranged side-by-side below the refrigerator compartment 12, a freezer compartment 15 is disposed below the ice making compartment 13 and the switching compartment 14, and a vegetable compartment 16 is disposed at the lowermost part. In addition, a door is provided for each of the storage compartments in order to prevent external air such that the door is in front of a front opening part of the refrigerator main body 11. In addition, an operating unit 17 for setting an interior temperature of each compartment and setting ice making or fast cooling is disposed around the center portion of a refrigerator compartment door 12a of the refrigerator compartment 12.

[0043] The refrigerator compartment 12 includes a plurality of storage shelves 18 some of them are configured to be movable horizontally.

[0044] The refrigerator compartment 12 further includes lighting units 19, light emitting units 20, and a light amount detecting unit 21.

[0045] The lighting units 19 are disposed upright at a left side wall and a right side wall that are located ahead of the front ends of the storage shelves 18 and short of the halfway point of the depth of the interior of the refrigerator when seen from the front surface of the refrigerator 10 at which the refrigerator door is opened.

[0046] The light emitting units 20 are disposed at positions adjacent to the lighting units 19 provided for the right and left side walls of the refrigerator, and each includes light sources which emit light onto items stored in the refrigerator compartment 12.

[0047] The light amount detecting unit 21 is disposed at a position behind the refrigerator compartment 12, and detects the amount of the light emitted by the light emitting unit 20 via the stored items and structural components in the refrigerator compartment 12.

[0048] The light amount detecting unit 21 may be disposed at any position in the refrigerator as long as it is disposed at a position on which the light is emitted by the light emitting unit 20 via the stored items and structural components in the refrigerator compartment 12.

[0049] In addition, the refrigerator compartment 12 includes a mechanical compartment formed in a rear area of the uppermost part thereof. The mechanical component includes a compressor 30 and structural components such as a dryer for removing water which are used as components at a high-pressure side in a freezing cycle.

[0050] The freezer compartment 15 includes a cooling compartment for generating cool air on a back wall thereof. The cooling compartment includes a cooler and a cooling fan that sends air cooled by the cooler to the refrigerator compartment 12, the switching compartment 14, the ice making compartment 13, the vegetable compartment 16, and the freezer compartment 15. The freezer further includes a radiant heater, a drain pan, a drain tube evaporation dish, etc. that are used to remove frost and ice attached to the cooler and the surrounding portion.

[0051] The refrigerator compartment 12 is set to have a temperature that is normally within a range from 1 to 5 degrees Celsius that is the lower limit for cooling storage without freezing, while the vegetable compartment 16 located at the lowermost part is set to have a temperature that is within a range from 2 to 7 degrees Celsius that is slightly higher than or equivalent to the temperature range for the refrigerator compartment 12. In addition, the freezer compartment 15 is set to have a temperature that is normally within a freezing temperature range from -22 to -15 degrees Celsius for freezing storage. However, with an aim to improve the freezing storage state, the temperature range may be set to, for example, a lower range from -30 to -25 degrees Celsius.

[0052] The ice making compartment 13 includes, in an upper portion thereof, an automatic ice making machine (not shown) that makes ice from water forwarded from a water storage tank (not shown) inside the refrigerator compartment 12, and stores the ice in an ice storage container (not shown) disposed in a lower portion thereof.

[0053] The switching compartment 14 can switch between the temperature ranges that are the cooling temperature range from 1 to 5 degrees Celsius, the vegetable temperature range from 2 to 7 degrees Celsius, and the freezing temperature range from -22 to -15 degrees Celsius, and can also switch to a temperature range that is preset between the cooling temperature range and the freezing temperature range. The switching compartment 14 is a storage compartment that includes an independent door and is provided in parallel to the ice making compartment 13. The door is highly likely to be a drawer door.

[0054] In this embodiment, the switching compartment 14 is assumed to be a storage compartment having a temperature range including the cooling temperature range and the freezing temperature range. Alternatively, it is possible to assume the switching compartment 14 to be a storage compartment that has a temperature only within the aforementioned temperature range that is a middle temperature range between the cooling temperature range and the freezing temperature range, by separately setting the cooling temperature range to the refrigerator compartment 12 and the vegetable compartment 16 and setting the freezing temperature range to the freezer compartment 15. With a recent increase in the demands for frozen foods, it is also possible to assume the switching compartment to be a storage compartment having a particular temperature range such as a fixed freezing temperature range.

[0055] In addition, the aforementioned details of the important parts of the present invention that are described in this embodiments may be applied to a refrigerator 10 that includes a compressor 30 in a mechanical compartment in a rear area of a storage compartment that is located, as known generally in the conventional art, at the lowermost part of a

heat insulating main body.

[0056] Hereinafter, the refrigerator configured as described above is further explained in terms of operations and effects performed and provided by the refrigerator.

[0057] Here, operations performed by the light emitting unit 20 and the light amount detecting unit 21 are described in detail with reference to FIG. 3. FIG. 3 is an illustration for explaining operations performed by the light emitting unit 20 and the light amount detecting unit 21 according to Embodiment 1 of the present invention.

[0058] As shown in the diagram, the light output from the light emitting unit 20 disposed at each of the right and left side walls of the refrigerator is emitted on the inside of the refrigerator compartment 12 and stored items 33 stored in the refrigerator compartment 12. In addition, some part of the light output from the light emitting unit 20 enters the light amount detecting unit 21 disposed in the refrigerator compartment 12.

[0059] This diagram shows the inside of the refrigerator compartment 12 in the case where the stored items 33 are stored therein. In the refrigerator compartment 12, the following areas are present: Area A in which the emitted light 34a from the light emitting unit 20 at each of the right and left side walls is shielded due to the presence of the stored items 33; Area B in which the emitted light 34a from the light emitting unit 20 at one of the right and left side walls is shielded due to the presence of the stored items 33; and Area C in which the emitted light 34a from the light emitting unit 20 at each of the right and left side walls is not shielded.

[0060] In this case, the light amount detecting unit 21 is present in Area B in which the emitted light 34a from the light emitting unit 20 at one of the right and left side walls is shielded, and thus a corresponding light amount is detected and output. In addition, in the case where the amount of the stored items 33 is large, the size of Area A in which the emitted light 34a is shielded increases, and thus the amount of the light detected by the light amount detecting unit 21 decreases. In addition, in the case where the amount of the stored items 33 is small, the size of Area C in which the emitted light 34a is not shielded increases, and thus the amount of the light detected by the light amount detecting unit 21 increases.

[0061] In this way, the light amount detecting unit 21 detects a light amount change due to the presence of the stored items 33 and/or a difference in the amount or the positions of the stored items 33. This light amount detection result is used to make a determination based on a predetermined threshold value that is set in advance, so as to classify the amount (large or small) or the positions of the stored items 33 in the refrigerator. This is described in detail later.

[0062] Here, the light emitting units 20 may be the lighting units 19 normally provided in the refrigerator 10. With this simple structure, it is possible to estimate the storage state without any additional light sources. In other words, it is possible to estimate the amount or the positions of the stored items 33 by using the lighting units 19 provided in the refrigerator compartment 12 as the light emitting units 20.

[0063] Next, with reference to a control block diagram shown in FIG. 4, control operations are described. FIG. 4 is a control block diagram of the refrigerator 10 according to Embodiment 1 of the present invention.

[0064] As shown in the diagram, the refrigerator 10 according to Embodiment 1 of the present invention includes a stored item estimating unit 22 and a control unit 23, in addition to the light emitting units 20 and the light amount detecting unit 21 described above.

[0065] The stored item estimating unit 22 estimates the amount or the positions of the stored items in the refrigerator compartment 12, and outputs the estimation result to the control unit 23. More specifically, the stored item estimating unit 22 estimates the amount or the positions of the stored items according to the detection result of the light amount by the light amount detecting unit 21.

[0066] According to the result of the estimation by the stored item estimating unit 22, the control unit 23 controls the cooling of the refrigerator compartment 12 by the cooling device 35 which is provided in the refrigerator 10 and cools the refrigerator compartment 12. More specifically, the control unit 23 selects an operation pattern according to the result of the estimation of the amount or the positions of the stored items by the stored item estimating unit 22, and controls the cooling device 35 so as to realize a preset interior temperature of the refrigerator according to the operation pattern. Here, the cooling device 35 includes a compressor 30, a cooling fan 31, and a temperature compensation heater 32. The control unit 23 automatically changes operations by the devices.

[0067] An example is provided. In a transition period, the light emitting units 20 emit light at predetermined timings. When the result of the detection by the light amount detecting unit 21 is larger than a predetermined value, the stored item estimating unit 22 estimates that the amount of the stored items is small, and the control unit 23 automatically causes a power saving operation that is for example, an operation for reducing the number of revolutions of the compressor 30 or an operation for preventing overcooling, or the like.

[0068] On the other hand, when the result of the detection by the light amount detecting unit 21 is smaller than or equal to the predetermined value, the stored item estimating unit 22 estimates that the amount of the stored items is large, and the control unit 23 automatically causes, by increasing the number of revolutions of the compressor 30, a normal operation involving revolutions of the compressor 30 that is larger in number than the revolutions of the compressor 30 in the power saving operation, so that the preset temperature is reached within a predetermined time duration.

[0069] Otherwise, instead of changing the number of the revolutions of the compressor, the control unit 23 adjusts the interior temperature by controlling the amount of cool wind. More specifically, using an open or close mechanism, the

control unit 23 selectively closes or opens a path for forwarding cool air to each of the storage compartments in the case of the power saving operation or the normal operation.

[0070] Hereinafter, an example is described in which the stored item estimating unit 22 estimates the amount of the stored items, the control unit 23 controls the cooling device 35 according to the amount of the stored items estimated by the stored item estimating unit 22. This example is similar to an example in which the stored item estimating unit 22 estimates the positions of the stored items, the control unit 23 controls the cooling device 35 according to the positions of the stored items estimated by the stored item estimating unit 22.

[0071] Hereinafter, with reference to FIG. 5A to 5C, descriptions are given of operations performed by the control unit 23 of the refrigerator in transition periods. Each of FIG. 5A to FIG. 5C is a graph for explaining control operations performed, in a corresponding one of the transition periods, by the control unit 23 according to Embodiment 1 of the present invention.

[0072] Here, each of the transition periods is, for example, a period that starts after the interior temperature of the refrigerator 10 increases and ends when the inside is cooled to reach a preset temperature. Examples of the transition periods include a period immediately after storage of an item, a period after a door of the refrigerator is opened for a long time and is closed, and a period immediately after a defrost operation. In general, the interior temperature change in such a transition period is greater than a preset temperature by more than ± 3 degrees Celsius.

[0073] More specifically, FIG. 5A shows operations performed by the control unit 23 that performs temperature control similar to conventional temperature control in the case of a normal storage amount (hereinafter, Normal). FIG. 5B shows operations performed by the control unit 23 in the case of a large storage amount (hereinafter, Large), and FIG. 5C shows operations performed by the control unit 23 in the case of a small storage amount (hereinafter, Small). For simplicity, the items stored in each case are assumed to be of a similar type.

[0074] In each of FIG. 5B and FIG. 5C, a solid line shows a detected temperature of the stored items in the refrigerator in this embodiment, and a broken line shows time dependency of the detected temperature of the stored items in the case where conventional control is performed. Here, K0 is a storage temperature preset for the stored items 33. In the case of a storage amount Larger or Smaller than Normal, the control unit 23 switches operation states of the cooling device 35, based on the result of the estimation of the storage amount by the stored item estimating unit 22.

[0075] FIG. 5A shows change in the temperature of the stored items in the case of the Normal storage amount and an interior storage rate of $50\% \pm 10\%$. In this embodiment, control is performed using this temperature change as reference. It is to be noted that, determination standards of "Normal, Large, and Small" regarding storage amounts vary depending on the sizes, the configurations, and the control schemes of refrigerators. Thus, determination standards are not limited to the determination standards shown here.

[0076] When the stored items 33 of the similar kind are stored and the amount thereof is larger than Normal, the amount of the light detected by the light amount detecting unit 21 decreases. Based on the decrease in the detected light amount, the stored item estimating unit 22 estimates that the interior storage amount is Large.

[0077] In this case, as shown in FIG. 5B, the conventional cooling operation (the broken line) requires a long time to cool the stored items to the preset temperature. Therefore, the control unit 23 increases the number of revolutions of the compressor 30 or increases the amount of circulating cool air so as to automatically switch to a fast cooling operation with an aim to cool the stored items down to the preset temperature within the predetermined time duration. In this way, it is possible to realize the storage temperature within the period equivalent to the period in the case of FIG. 5A without depending on the amount of the stored items 33, and to thereby keep the freshness of the stored items 33 without depending on the amount of the stored items 33.

[0078] When the stored items 33 are stored and the amount thereof is smaller than Normal, the amount of the light detected by the light amount detecting unit 21 increases. Based on the increase in the detected light amount, the stored item estimating unit 22 estimates that the interior storage amount is Small.

[0079] In this case, as shown in FIG. 5C, the conventional cooling operation (the broken line) cools the stored item down to the preset temperature in a short period of time. Thus, the cooling operation may consume electric power more than required. Thus, the control unit 23 reduces the number of revolutions of the compressor 30 or reduces the amount of circulating cool air so as to automatically switch to the power saving operation, with an aim to cool the stored item down to the preset temperature within the predetermined time duration. This operation slows the interior temperature change, and thereby achieves a power saving effect, and reduces noise by reducing the revolution speed of the cooling fan 31.

[0080] These operations are described in detail with reference to the control flowchart in FIG. 6. FIG. 6 is a flowchart for explaining control operations performed, in a transition period, by the control unit 23 according to Embodiment 1 of the present invention.

[0081] As shown in the flowchart, the control unit 23 determines whether or not a current period is a transition period, based on an interior temperature (Step S102). When determining that the current period is the transition period (Y in Step 102), the control unit 23 performs the following control.

[0082] First, the control unit 23 turns on the light emitting unit 20 so as to perform a stored item detection operation

(Step S103). Next, the light amount detecting unit 21 detects the amount of light attenuated by the stored items (Step S104).

[0083] The stored item estimating unit 22 estimates the level of the storage amount by comparing the light amount detected by the light amount detecting unit 21 with the predetermined threshold value (Step S105).

[0084] The stored item estimating unit 22 estimates whether the storage amount is Large or not (Step S106). When the stored item estimating unit 22 estimates that the storage amount is Large (Y in Step S106), the control unit 23 causes the cooling device 35 to perform the fast operation until the stored items are cooled down to the preset temperature (Step S107).

[0085] When the stored item estimating unit 22 estimates that the storage amount is not Large (N in Step S106), the stored item estimating unit 22 estimates whether or not the storage amount is Small or not (Step S108). When the stored item estimating unit 22 estimates that the storage amount is Small (Y in Step S108), the control unit 23 causes the cooling device 35 to perform the power saving operation until the stored items are cooled down to the preset temperature (Step S109).

[0086] When the stored item estimating unit 22 estimates that the storage amount is not Small (N in Step S108), the control unit 23 determines that the stored amount is Normal (Step S110), and causes the cooling device 35 to perform the normal cooling operation (Step S111).

[0087] Next, with reference to FIG. 7A to FIG. 7C, descriptions are given of operations performed by the control unit 23 of the refrigerator in the case where sufficient time has elapsed after the items are stored, and the temperature of the stored items becomes stable. Each of FIG. 7A to FIG. 7C is a graph for explaining control operations performed, in a corresponding one of stable periods, by the control unit 23 according to Embodiment 1 of the present invention.

[0088] Here, each of the stable periods is a period that starts when the temperature of the stored items reaches the preset temperature and lasts while the temperature of the stored items is kept constant by, for example, turning ON/OFF a cooling operation. In general, the interior temperature in a stable period changes approximately within a range of ± 3 degrees Celsius.

[0089] More specifically, FIG. 7A shows operations performed by the control unit 23 that performs temperature control similar to conventional temperature control in the case of a normal storage amount (hereinafter, Normal). FIG. 7B shows operations performed by the control unit 23 in the case of a large storage amount (hereinafter, Large), and FIG. 7C shows operations performed by the control unit 23 in the case of a small storage amount (hereinafter, Small). Here, in a stable period, cooling is performed by repeating, in a cycle T, a cooling period and a rest period.

[0090] When the stored items 33 of the similar kind are stored and the amount thereof is larger than Normal, the amount of the light detected by the light amount detecting unit 21 decreases. Based on the decrease in the detected light amount, the stored item estimating unit 22 estimates that the interior storage amount is Large.

[0091] In this case, the heat capacity of each of the stored items is summed up to be a large total interior heat capacity of the stored items in the refrigerator, the cooling performance is increased, and increase in the temperature is slowed. Accordingly, as shown in FIG. 7B, each of the cooling period and the rest period is long, and thus the cycle T is longer than a cycle T in the case of the Normal storage amount.

[0092] In this case, the total heat capacity of the cooled stored items keeps the interior temperature at a low temperature, and thus an average temperature K1 of the stored items is lower than the preset temperature K0, resulting in what is called "overcooling".

[0093] Accordingly, in this case, the control unit 23 controls the cooling device 35 such that a temperature K2 higher than K0 by 1 to 2 degrees Celsius is set as a new preset temperature. In this way, overcooling of the stored items is suppressed, and the cooling operation is suppressed to keep the temperature of the stored items at a temperature approximately the same as the previous preset temperature K0. Therefore, it is possible to reduce power consumption while keeping the quality of the stored items.

[0094] It is desirable that the preset temperature K2 be increased from K0 by a temperature obtained according to " $K0 - K1$ ". Here, it is possible to prevent decrease in the quality of the stored items due to a dramatic temperature increase, by setting a temperature higher by 1 to 2 degrees Celsius as a temperature range predetermined as described above.

[0095] When the amount of the stored items is smaller than Normal, the amount of the light detected by the light amount detecting unit 21 increases. Based on the increase in the detected light amount, the stored item estimating unit 22 estimates that the interior storage amount is Small.

[0096] In this case, since the amount of the stored items is smaller, the heat capacity of each of the stored items is summed up to be a small total interior heat capacity of the stored items in the refrigerator. Thus, it is likely that the cooling performance is decreased, and that the temperature is increased fast. In addition, since the total interior heat capacity is small, the temperature of the stored items decreases fast with cooling.

[0097] Accordingly, as shown in FIG. 7C, each of the cooling period and the rest period is short, and thus a cycle T is shorter than a cycle T in the case of the Normal storage amount. However, it is likely that the temperature of the stored items is kept to be approximately the same as the preset temperature.

[0098] When cooling control similar to cooling control performed in the case of the Normal amount is performed in this case, as shown in FIG. 7C, each of the cooling period and the rest period is short, and thus wind path control must be performed frequently, resulting in a loss of energy. For this reason, with an aim to save energy more, the control unit 23 performs control so that the cooling period and the rest period become equivalent to those in the case of the normal operation by, for example, reducing the cooling amount to suppress cooling.

[0099] The control unit 23 reduces the cooling amount by, for example, reducing the number of revolutions of the cooling fan 31 or stopping the cooling fan 31, by reducing the wind amount, or reducing the number of operational revolutions or the operation rate of the compressor 30.

[0100] In this way, it is possible to realize the cooling period and the rest period equivalent to those in the normal operation, and to reduce the electric power consumption by performing such a power saving operation.

[0101] These operations are described in detail with reference to the control flowchart in FIG. 8. FIG. 8 is a flowchart for explaining control operations performed, in a stable period, by the control unit 23 according to Embodiment 1 of the present invention.

[0102] As shown in the flowchart, the control unit 23 determines whether or not a current period is a stable period, based on an interior temperature (Step S202). When determining that the current period is the stable period (Y in Step S202), the control unit 23 performs the following control.

[0103] First, the control unit 23 turns on the light emitting units 20 so as to perform an operation for detecting stored items (Step S203). Next, the light amount detecting unit 21 detects the amount of light attenuated by the stored items (Step S204).

[0104] The stored item estimating unit 22 estimates the level of the storage amount by comparing the light amount detected by the light amount detecting unit 21 with the predetermined threshold value (Step S205).

[0105] The stored item estimating unit 22 estimates whether or not the storage amount is Large (Step S206). When the stored item estimating unit 22 estimates that the storage amount is Large (Y in Step S206), the control unit 23 controls the cooling device 35 so as to increase the preset temperature up to K2 that is a temperature higher than K0 (Step S207).

[0106] When the stored item estimating unit 22 estimates that the storage amount is not Large (N in Step S206), the stored item estimating unit 22 estimates that the storage amount is Normal or Small (Step S208). The control unit 23 controls the cooling device 35 so as to perform the normal operation or the power saving operation for reducing the cooling amount (Step S209).

[0107] As described above, the refrigerator 10 according to this embodiment includes: the refrigerator main body 11; the cooling device 35 which cools the inside of the refrigerator 10; the light emitting units 20 which are arranged at predetermined positions in the refrigerator 10 and each of which includes at least one light source which emits the inside of the refrigerator 10 and the stored items 33 in the refrigerator 10; the light amount detecting unit 21 which is disposed in the refrigerator 10, and detects the amount of the light emitted by the light emitting units 20, via the stored items and the structural components in the refrigerator 10; the stored item estimating unit 22 which estimates the amount or the positions of the stored items, based on the result of the detection by the light amount detecting unit 21; and the control unit 23 which controls the cooling device 35 according to the result of the estimation of the amount or the positions of the stored items by the stored item estimating unit 22, and controls the interior temperature of the refrigerator 10 according to the predetermined temperature setting.

[0108] With this structure, the amount or the positions of the stored items 33 is estimated based on the result of the estimation by the light amount detecting unit 21, and control adapted to the amount or the positions is performed in the refrigerator 10. This adaptive control makes it possible to store the stored items 33 under approximately the same storage condition irrespective of the amount or the positions of the stored items 33. Thus, the refrigerator 10 is capable of providing a high freshness keeping effect and a high power saving effect.

[0109] In other words, since the stored items are kept at an expected temperature irrespective of the storage state of the stored items in the refrigerator, it is possible to keep the freshness of the stored items at a high level, and to suppress the power consumption by preventing the stored items 33 from being "overcooled". In this way, the light amount detecting unit 21 receives the light emitted from the light sources such as LEDs. Thus, with the simple structure, it is possible to estimate the amount or the positions of the stored items 33.

[0110] Furthermore, in the case of a Small storage amount, it is possible to provide an energy saving effect and reduce noise in a transition period, by slowing interior temperature change. On the other hand, although overcooling of the stored items is likely to occur in a stable period in the case of a Large storage amount, it is possible to increase the preset cooling temperature of the refrigerator so as to perform the power saving operation, and to thereby provide a power saving effect.

[0111] Although the stored item estimating unit 22 is provided in the refrigerator compartment 12 in this embodiment, the stored item estimating unit 22 may be provided in any one of the ice making compartment 13, the switching compartment 14, the freezer compartment 15, or the vegetable compartment 16.

[Embodiment 2]

[0112] Next, a refrigerator according to Embodiment 2 of the present invention is described.

[0113] FIG. 9 is a control block diagram of the refrigerator 10a according to Embodiment 2 of the present invention.

[0114] As shown in the diagram, the refrigerator 10a according to Embodiment 2 further includes a door open or close detecting unit 25 which detects an opened state or a closed state of a door of the refrigerator, in addition to the respective structural elements of the refrigerator 10 according to Embodiment 1 shown in FIG. 4.

[0115] The door open or close detecting unit 25 detects an opened state or a closed state of the refrigerator door disposed at a front surface of the storage compartment. In other words, the door open or close detecting unit 25 detects an opened state or a closed state of the refrigerator compartment door 12a.

[0116] In a period during which the door open or close detecting unit 25 detects a closed state of the refrigerator compartment door 12a, a light emitting unit 20, a light amount detecting unit 21, a stored item estimating unit 22, and a control unit 23 start a sequence of operations.

[0117] In this way, an opened state or a closed state of the refrigerator compartment door 12a is detected, and the light emitting unit 20 and the light amount detecting unit 21 are operated while the door is in a closed state. These operations make it easier to prevent the influence of background light.

[0118] In addition, a change in the amount or the positions of the stored items is always followed by a sequence of user operations that are opening the door, storing or extracting foods, and closing the door lastly. Accordingly, it is only necessary that the amount or the positions of the stored items is detected only after the door is opened or closed. In other words, with the door open or close detecting unit 25, it is possible to reduce the detection operation to the minimum, and to reduce electric power that is consumed by the light emitting units 20 etc.

[0119] In addition, each of home-use refrigerators turns ON or OFF lighting units provided in the refrigerator when a door provided therein is opened or closed, because the detection of the opening or closing of the door is associated with turning-ON or -OFF of the door.

[Embodiment 3]

[0120] Next, a refrigerator according to Embodiment 3 of the present invention is described.

[0121] Each of FIG. 10 and FIG. 11 is an illustration showing a structure of a refrigerator 10b according to Embodiment 3.

[0122] Embodiment 3 includes the same structural elements as the structural elements of the refrigerators according to Embodiments 1 and 2 and also includes parts to which the same technical ideas are applicable. Accordingly, no detailed descriptions are repeated for the structural elements and the parts. In addition, any of the structural elements in Embodiments 1 and 2 can be combined with Embodiment 3 and executed.

[0123] As shown in FIG. 10, the refrigerator 10b includes, as light emitting units, lighting units 19 each of which includes a plurality of light sources 20a to 20d. In this way, the light emitting units can be simply configured without any special light emitting units.

[0124] The lighting units 19 are disposed upright at a left side wall and a right side wall that are located ahead of the front ends of the storage shelves 18 and short of the halfway point of the depth of the interior of the refrigerator when seen from the front surface of the refrigerator 10b at which the refrigerator door is opened. The light sources 20a to 20d in each of the lighting units 19 are arranged at an equal interval, and can emit light evenly onto all parts located at the top to bottom inside the refrigerator compartment 12.

[0125] Furthermore, light amount detecting units 21a to 21d are arranged at rear positions in the refrigerator compartment 12, and each of the light amount detecting units 21a to 21d mainly detects attenuation in the light amount of emitted light 34b that is transformed from emitted light 34a when the emitted light 34a is blocked by stored items 33.

[0126] In addition, a light amount detecting unit 21e is disposed at a point that is (i) on a ceiling surface at the side of the door of the refrigerator compartment 12 and (ii) short of the halfway point of the depth of the interior of the refrigerator. This light amount detecting unit 21e detects mainly attenuation in the light amount of emitted light 34c that is transformed from emitted light 34a when the emitted light 34a is blocked by the stored items 33 located at the front side, that is, the door side.

[0127] In other words, each of the lighting units 19 sequentially turns on the plurality of light sources 20a to 20d, the light amount detecting unit 21 detects the amount of the light emitted by the lighting unit 19, and the stored item estimating unit 22 estimates the amount or the positions of the stored items according to the result of the light amount detection by the light amount detecting unit 21. In this way, the light sources are sequentially turned on. Therefore, it is possible to estimate the stored items exactly. For this reason, it is also possible to detect the stored items disposed even at a small place in a large storage compartment. Therefore, it is possible to increase the accuracy in the determination of the amount or the positions of the stored items.

[0128] It is to be noted that, as the light amount detecting units 21a to 21e, it is possible to use light amount detecting devices or chromaticity sensors capable of identifying RGB in addition to illuminance.

[0129] In addition, as shown in FIG. 11, it is possible to detect the amount or the positions of the stored items accurately by providing, in addition to the lighting units 19, a light source 20e which is a light emitting unit located on the ceiling surface in the refrigerator and providing a light amount detecting unit 21f at a lower part of the refrigerator.

[0130] The light source 20e on the ceiling surface is located short of the halfway point of the depth of the interior of the refrigerator when seen from the side of the door that opens at the refrigerator compartment 12. In addition, in this embodiment, the light source 20e is located at a position that is (i) at the door side with respect to the front ends of storage shelves 18 and (ii) at the depth side with respect to door shelves 24a to 24c attached to the refrigerator compartment door 12a. For this reason, in this arrangement, there is no possibility that light that is emitted from the light source 20e on the ceiling surface toward the light amount detecting unit 21f is blocked by the stored items placed on the storage shelves 18 and the door shelves 24a to 24c.

[0131] For the same reason, the light amount detecting unit 21f at the lower part is located at a position that is (i) at the door side with respect to the front ends of the storage shelves 18, (ii) at the depth side with respect to the door shelves 24a to 24c attached to the refrigerator compartment door 12a, and (iii) a position lower than the lowermost storage shelf 18.

[0132] The light amount detecting unit 21f may be placed on any one of surfaces such as a side or bottom surface of the refrigerator. Alternatively, it is possible to inverse the positional relationship between the light source 20e on the ceiling surface and the light amount detecting unit 21f at the lower part. Alternatively, a plurality of light detecting units may be provided instead.

[0133] In this way, light is emitted from the ceiling surface in the refrigerator, and the amount of the light is detected at the lower part. This light is spread toward the storage shelves 18 and the door shelves 24a to 24c. Accordingly, it is possible to detect the amount or the positions of the stored items accurately.

[0134] Here, in the case of a storage compartment having a long height such as a refrigerator compartment, light from the light source 20e on the ceiling surface is less likely to reach stored items at the lower part. In this case, it is desirable that a light emitting unit located at the lower part such as a light source 20d be also used to emit the inside of the refrigerator uniformly.

[0135] The light amount detecting units 21a to 21f may be placed at any positions in the refrigerator as long as the positions are positions at which the light amount detecting units 21a to 21f receive the light emitted from the light sources 20a to 20e via the stored items and structural components in the refrigerator. In the case of not requiring highly-precise estimation of the amount or the positions of stored items, there is no need to provide a plurality of light detecting units, and a single light detecting unit may be provided instead.

[Embodiment 4]

[0136] Next, a refrigerator according to Embodiment 4 of the present invention is described.

[0137] FIG. 12 is a front view of a refrigerator 10c according to Embodiment 4 of the present invention.

[0138] As shown in the illustration, the refrigerator 10c includes a refrigerator main body 11 including an inner casing 11a and an outer casing 11b. The inner casing 11a is provided via a heat insulating wall, includes a refrigerator compartment 12, an ice making compartment 13, a freezer compartment 15, and a vegetable compartment 16 from top to bottom in this sequential order, and also includes a switching compartment 14 that is provided adjacent to the ice making compartment 13 and is capable of switching between interior temperatures of the refrigerator.

[0139] The refrigerator compartment 12 that has the largest storage capacity and the highest use frequency of storing and extracting stored items is provided with a refrigerator compartment door 12a that is composed of biparting doors each of which pivots about hinges and is for closing the front surface opening. Each of the ice making compartment 13, the switching compartment 14, the vegetable compartment 16, and the freezer compartment 15 is provided with a drawer door.

[0140] The inside of the refrigerator compartment 12 is kept at a cooling temperature and is horizontally divided by a plurality of shelves 18a to 18c provided at a suitable interval. The refrigerator compartment 12 includes, at the bottom part, a water supplying tank for supplying water for ice making and a low-temperature compartment 12b for keeping stored items at a chilling temperature.

[0141] More specifically, the space above each of the storage shelves 18a to 18c is a space for storing items such as foods. In this embodiment, the storage shelf 18a is for mounting items to be stored in the storage space formed at the uppermost stage, the storage shelf 18b is for mounting items to be stored in the storage space formed at the second uppermost stage, and the storage shelf 18c is for mounting items to be stored in the storage space formed immediately below the storage shelf 18b. The storage segment at the lowermost stage below the storage shelf 18c includes the water supplying tank for supplying water for ice making and the low-temperature compartment 12b for keeping stored items at a chilling temperature.

[0142] In addition, the refrigerator compartment 12 includes lighting units 19 provided one-to-one in front parts of right and left side walls of the storage compartment. Each of the lighting units 19 includes a plurality of LEDs arranged vertically

at an equal interval. In addition, the refrigerator compartment 12 includes, at the back wall side, space detecting units 26 each including a light amount detecting unit. Here, each of the space detecting units 26 has a function similar to the function of the light amount detecting unit 21 according to Embodiments 1 to 3.

[0143] More specifically, the space detecting unit 26a that is a light amount detecting unit is provided on the back wall that is located (i) above the storage shelf 18a for mounting items in the uppermost storage space and (ii) below the inner casing 11a at the ceiling surface side. In addition, the space detecting unit 26b that is a light amount detecting unit is provided on the back wall that is located (i) above the storage shelf 18b for mounting items in the second uppermost storage space and (ii) below the storage shelf 18a.

[0144] This embodiment shows a state in which stored items 33 are placed on the storage shelf 18b. In other words, the space detecting unit 26b and each of the lighting units 19 are located at positions between which one of the stored items 33 is placed.

[0145] In addition, cool air discharge ports 4 are provided one-to-one above the space detecting units 26. More specifically, the cool air discharge port 4a is provided in the upper proximity of the upper-side space detecting unit 26a, and the cool air discharge port 4b is provided in the upper proximity of the lower-side space detecting unit 26b.

[0146] Next, a description is given of a functional structure of a refrigerator 10c according to Embodiment 4 of the present invention.

[0147] FIG. 13 is a control block diagram of the refrigerator 10c according to Embodiment 4 of the present invention.

[0148] As described above, the refrigerator 10c according to Embodiment 4 further includes: a space detecting unit 26 instead of the light amount detecting unit 21 of the refrigerator 10 according to Embodiment 11 shown in FIG. 4; and an informing unit 27.

[0149] The space detecting unit 26 detects, in a non-contact manner, an available space in the storage space in the refrigerator compartment 12. More specifically, the space detecting unit 26 detects a space volume of a space at least around the cool air discharge port 4 by detecting the amounts of the light emitted by the lighting units 19 via the stored items 33 and structural components in the refrigerator compartment 12.

[0150] In other words, as shown in FIG. 12, the space detecting unit 26 is composed of a space detecting unit 26a and a space detecting unit 26b. The space detecting unit 26a detects the size of the space volume at least around the cool air discharge port 4a, and the space detecting unit 26b detects the size of the space volume at least around the cool air discharge port 4b.

[0151] The stored item estimating unit 22 estimates the amount or the positions of the stored items 33, according to the result of the detection by the space detecting unit 26.

[0152] The informing unit 27 displays information about the available space in the storage space detected by the space detecting unit 26, on an outer surface of the door provided in a front surface of the refrigerator compartment 12. For example, the informing unit 27 displays, as the information about the available space, an alarm screen for informing a user of the fact that a high-power consuming operation is currently being performed.

[0153] Hereinafter, a description is given of operations performed by the refrigerator 10c configured as described above.

[0154] First, the lighting units 19 are turned on when the door 108 is closed. In the upper stage above the storage shelf 18a, the light from the lighting units 19 reaches the space detecting unit 26a which detects illuminance in the storage space at the uppermost stage.

[0155] In the middle stage between the storage shelf 18a and the storage shelf 18b, a part of the light from the lighting units 19 passes through a space between the stored items 33 and reaches the space detecting unit 26b which detects illuminance in the storage space at the second uppermost stage. The other part of the light from the lighting units 19 reaches the stored items 33. A part of the other part is reflected by the stored items 33 and is dispersed, and the other part of the other part is absorbed by the stored items 33. Accordingly, a shadow of the stored items 33 is formed in a space that is opposite to the lighting units 19 with respect to the stored items 33, in other words, that is at the back wall side behind the stored items 33. Since the space includes a small amount of light due to the shadow, the space is dark.

[0156] As known from this, the light from the lighting units 19 is blocked more significantly resulting in a greater reduction in the amount of the light that reaches the space detecting unit 26b located behind the stored items 33, as the stored items are higher or the amount of the stored items is larger.

[0157] In this way, the space detecting units 26a and 26b detect the amount of the light, and a fact that there is an available space at the upper stage above the storage shelf 18a (the upper stage is above the middle stage below the storage shelf 18a) is displayed on a display unit (not shown) provided on the outer surface of the refrigerator compartment door 12a that is a door. In other words, the informing unit 27 informs the user of the states of the stored items in the refrigerator compartment 12 by providing such display on the outer surface of the refrigerator compartment door 12a provided at the front surface side of the refrigerator compartment 112 that is a storage compartment in which the space detecting units 26a and 26b are provided.

[0158] The user can check the display presented by the informing unit 27, open the refrigerator compartment door 12a, smoothly mount items such as foods onto the storage shelf 18a that corresponds to the uppermost storage space displayed as mounting a small amount of stored items, and immediately close the refrigerator compartment door 12a.

[0159] As another example, when stored items 33 are stored in front of the cool air discharge port 4b as shown in FIG. 12 or the amount of the storage items 33 is too much, in other words, when the amount of the light in the proximity of the cool air discharge port 4 and detected by the space detecting unit 26 is smaller than a predetermined value, the informing unit 27 presents an alarm screen for informing that a high-power consuming operation is to be performed because the space detecting unit 26 detects that the storage space is overstuffed with the stored items 33.

[0160] Here, when the amount of the stored items 33 is too much, or when the stored items 33 are placed in the proximity of the cool air discharge port 4, the stored items 33 serve as resistors that block circulation of cool air and thus reduce the amount of circulating cool air per unit time. Accordingly, a long time is required for cooling the stored items 33. In addition, a reduction in the amount of circulating cool air reduces the amount of wind in a converter. This reduces a heat exchange amount, and lowers an evaporating temperature. This also increases the difference between high and low pressures in a freezing cycle, resulting in increase in power input for a compressor. For this reason, in order to maintain cooling time, there are needs to increase the number of revolutions of a fan that circulates cool air and increase the revolutions of the compressor, resulting in increase in power consumption.

[0161] In the actual use of the refrigerator, it is possible to save energy by providing the user an alarm informing that power consumption is on the increase, and to thereby facilitate optimum arrangement of the stored items. Therefore, it is possible to provide consumers refrigerators that save energy more than conventional, and to thereby contribute to CO₂ reduction.

[0162] As described above, it is possible to reduce the time in which the refrigerator compartment door 12a is opened, and to thereby reduce the amount of external air having a high temperature that enters when the refrigerator compartment door 12a is opened, resulting in energy saving. Since it is also possible to suppress temporary increase in the interior temperature of the refrigerator compartment 12, it is possible to suppress increase in the temperature of the stored items, and to thereby reduce degradation in the quality of the stored items.

[0163] Furthermore, it is possible to attract user attention to energy saving operation by the informing unit 27 presenting an alarm informing that high-power consuming operation is to be performed.

[0164] This effect is higher than conventional especially in the case of home-use refrigerators that are likely to store various kinds of foods.

[0165] Although the refrigerator according to the present invention has been described above based on the embodiments, the present invention is not limited to the embodiments.

[0166] In other words, it should be interpreted that the embodiments disclosed herein are exemplary and nonrestrictive in any respect. The scope of the present invention is defined by the Claims, not by the above descriptions. Accordingly, all of possible equivalent modifications are intended to be included within the scope of the present invention.

[Industrial Applicability]

[0167] A refrigerator according to the present invention is applicable to home-use or commercial-use refrigerators each having a function of detecting stored items and performs control for switching to an operation mode such as a power saving operation, based on the result of the detection.

[Reference Signs List]

[0168]

10, 10a, 10b, 10c	Refrigerator
4, 4a, 4b	Cool air discharge port
11	Refrigerator main body
11a	Inner casing
11b	Outer casing
12, 101	Refrigerator compartment
12a	Door of refrigerator compartment
12b	Low-temperature compartment

	13	Ice making compartment
	14	Switching compartment
5	15	Refrigerator compartment
	16	Vegetable compartment
	17	Operating unit
10	18, 18a, 18b, 18c	Storage shelf
	19	Lighting unit
15	20	Light emitting unit
	20a, 20b, 20c, 20d, 20e	Light source
20	21, 21a, 21b, 21c, 21d, 21e, 21f	Light amount detecting unit
	22	Stored item estimating unit
	23	Control unit
25	24a, 24b, 24c	Door shelf
	25	Door open or close detecting unit
30	26, 26a, 26b	Space detecting unit
	27	Informing unit
	30	Compressor
35	31	Cooling fan
	32	Temperature compensation heater
	33	Stored item
40	34a, 34b, 34c	Emitted light
	35	Cooling device
45	102	Cool air discharging device

Claims

- 50 1. A refrigerator comprising:
- a refrigerator main body in which a storage compartment is formed;
- a cooling device which cools the storage compartment;
- 55 a stored item estimating unit configured to estimate an amount or a position of an item stored in the storage compartment; and
- a control unit configured to control the cooling of the storage compartment by the cooling device, according to a result of the estimation by the stored item estimating unit.

2. The refrigerator according to Claim 1, further comprising:

a light emitting unit that includes a light source which emits light onto the stored item in the storage compartment;
and

a light amount detecting unit disposed in the storage compartment, and configured to detect an amount of the light emitted by the light emitting unit, via the stored item and a structural component in the storage compartment, wherein the stored item estimating unit is configured to estimate the amount or the position of the stored item, according to a result of the detection of the light amount by the light amount detecting unit.

3. The refrigerator according to one of Claim 1 and Claim 2, wherein the control unit is configured to select an operation pattern according to a result of the estimation of the amount or the position of the stored item by the stored item estimating unit, and to control the cooling device so that the refrigerator attains an interior temperature that is preset according to the operation pattern.

4. The refrigerator according to one of Claim 2 and Claim 3, further comprising a door open or close detecting unit configured to detect an opened state or a closed state of a door of the refrigerator, the door being provided in front of the storage compartment, wherein in a period in which the door open or close detecting unit detects a closed state of the door of the refrigerator, the light emitting unit, the light amount detecting unit, the stored item estimating unit, and the control unit start a sequence of operations.

5. The refrigerator according to any one of Claims 2 to 4, wherein the light emitting unit is a lighting unit provided in the storage compartment.

6. The refrigerator according to any one of Claims 2 to 5, wherein the light emitting unit includes a plurality of light sources, and is configured to turn on the light sources sequentially, the light amount detecting unit is configured to detect the amount of the light emitted by the light emitting unit, and the stored item estimating unit is configured to estimate the amount or the position of the stored item, according to a result of the detection of the light amount by the light amount detecting unit.

7. The refrigerator according to any one of Claims 1 to 6, further comprising a space detecting unit configured to detect an available space in a storage space of the storage compartment in a non-contact manner, wherein the space detecting unit is configured to detect a volume of a space surrounding at least a cool air discharge port, and the stored item estimating unit is configured to estimate the amount or the position of the stored item, according to a result of the detection by the space detecting unit.

8. The refrigerator according to Claim 7, wherein the space detecting unit and the light emitting unit are arranged on opposite sides of the storage space in which the stored item is stored.

9. The refrigerator according to one of Claim 7 and Claim 8, wherein the light emitting unit is disposed at a front part of the storage compartment, and the space detecting unit is disposed at a back wall side of the storage compartment.

10. The refrigerator according to any one of Claims 7 to 9, further comprising an informing unit configured to display information about the available space in the storage space detected by the space detecting unit, on an outer surface of the door provided in front of the storage compartment.

11. The refrigerator according to Claim 10, wherein the informing unit is configured to display, as the information about the available space, an alarm screen for informing a user that a high-power consuming operation is performed.

FIG. 1

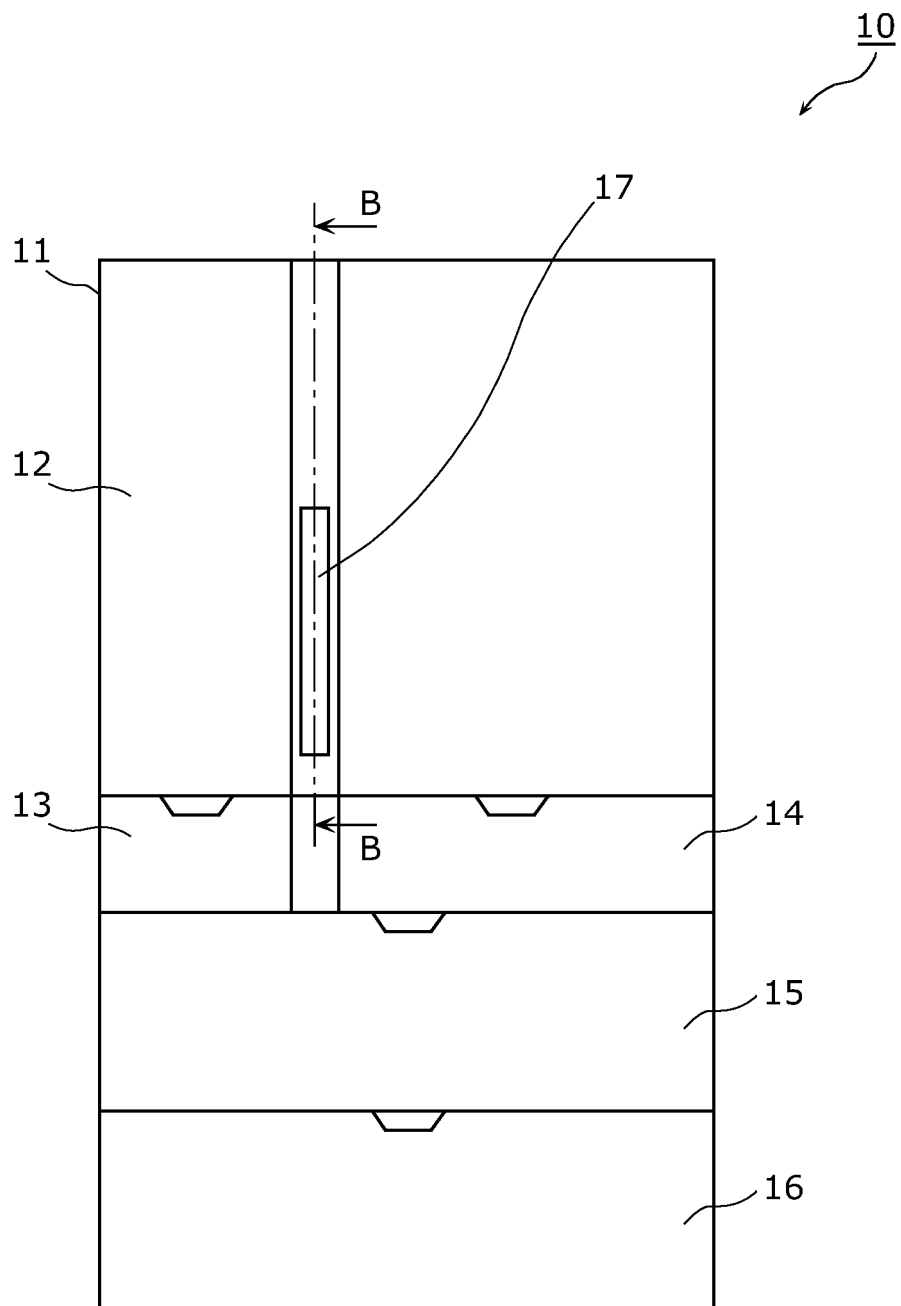


FIG. 2

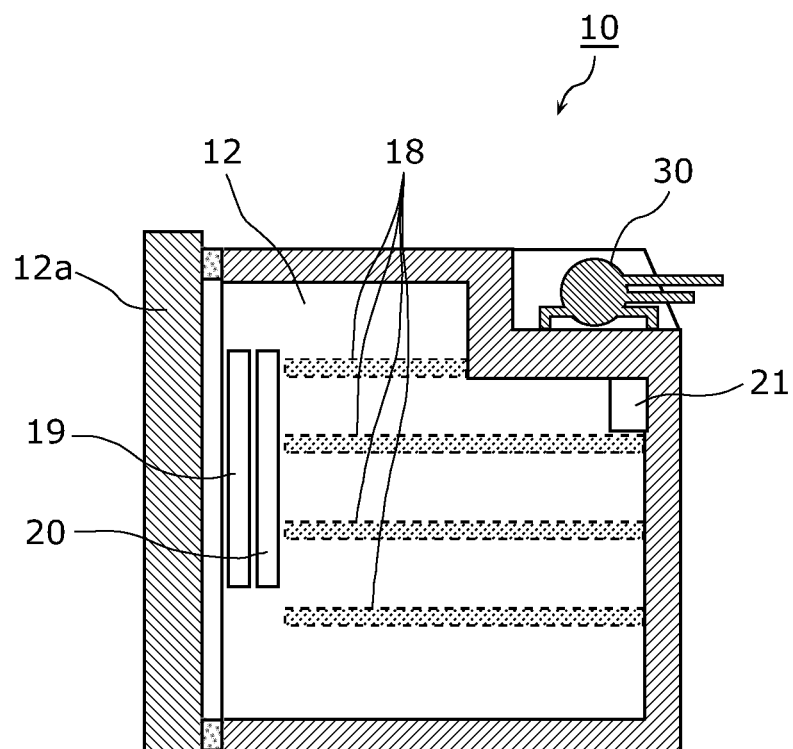


FIG. 3

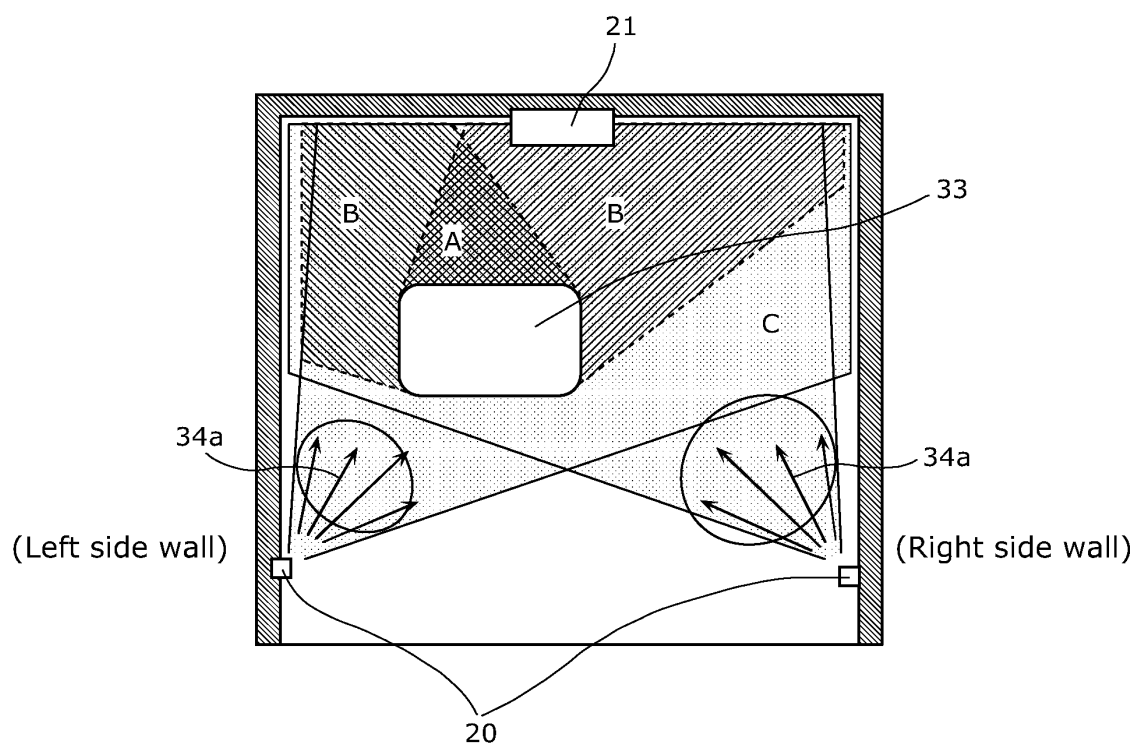


FIG. 4

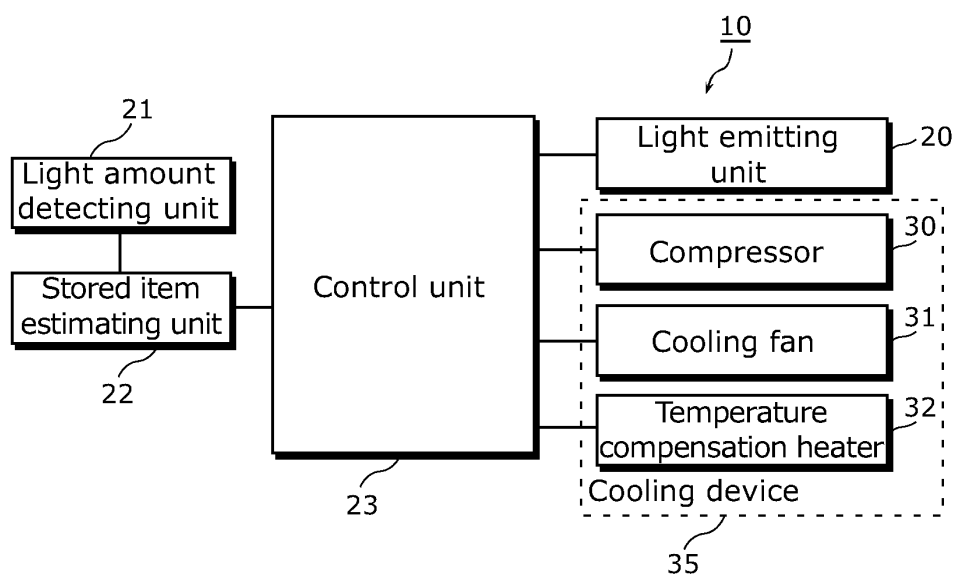


FIG. 5A

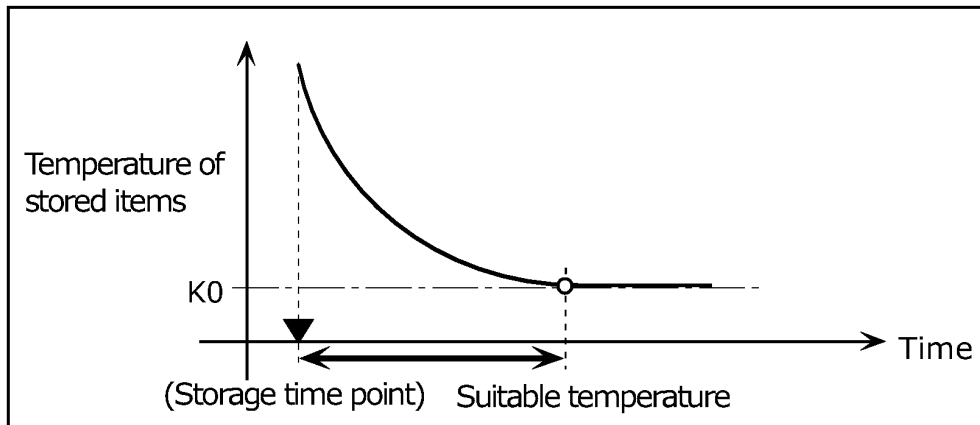


FIG. 5B

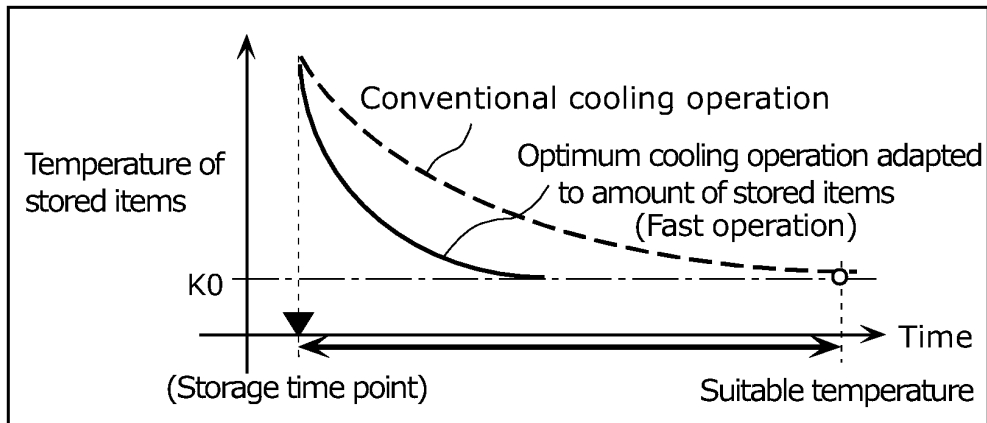


FIG. 5C

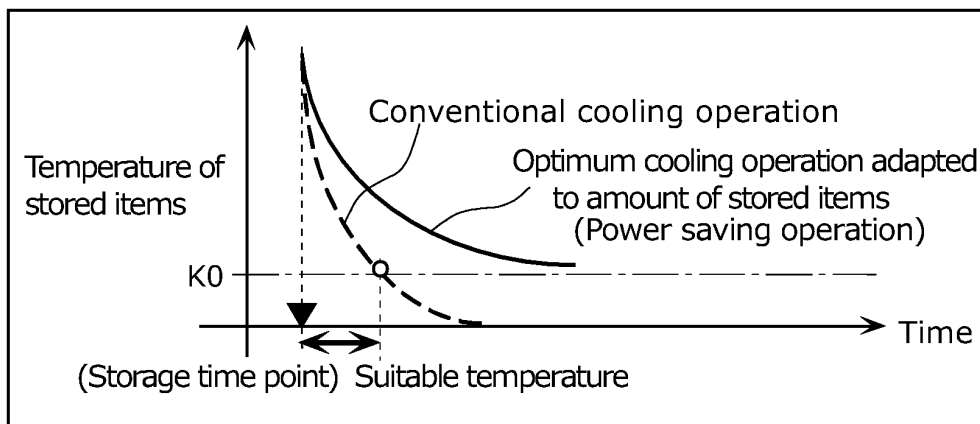


FIG. 6

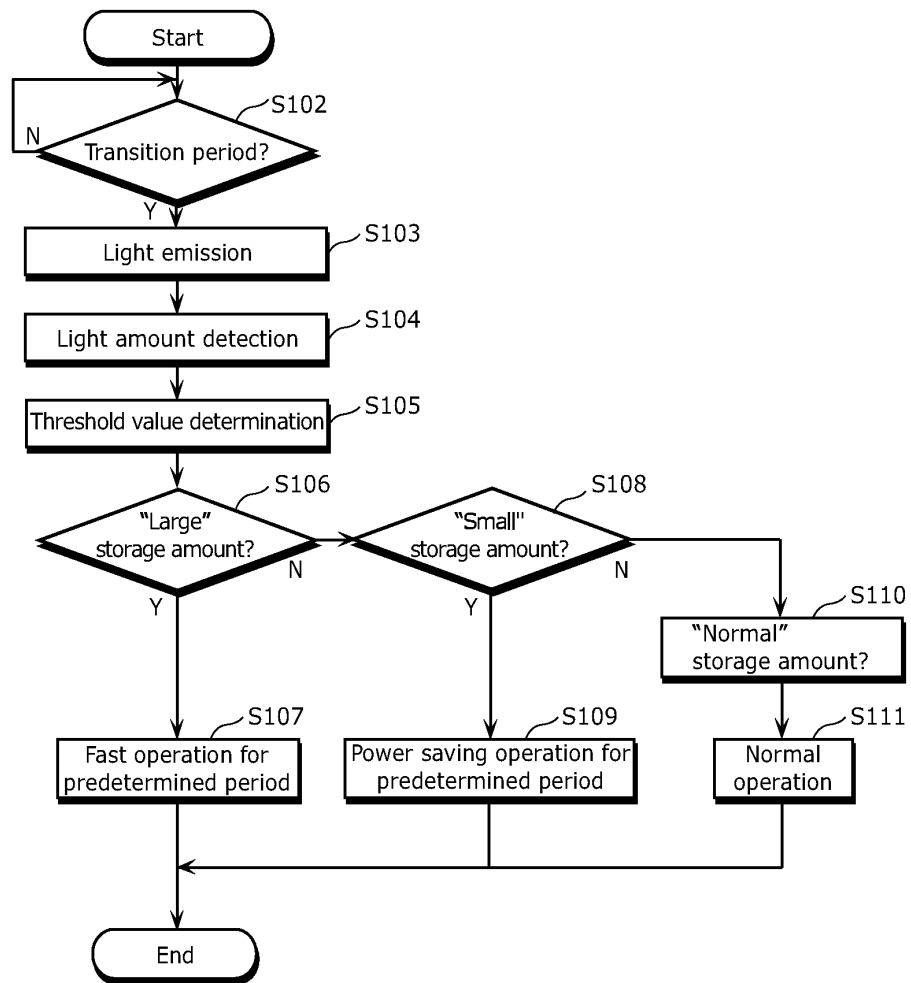


FIG. 7A

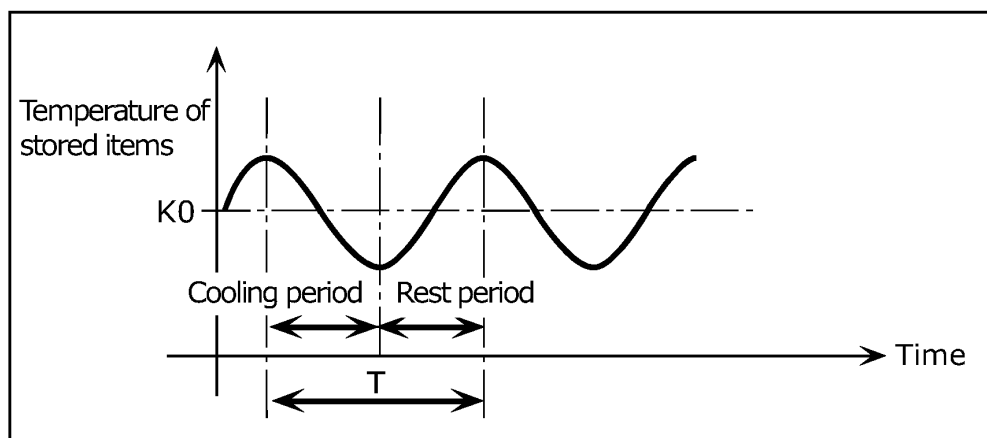


FIG. 7B

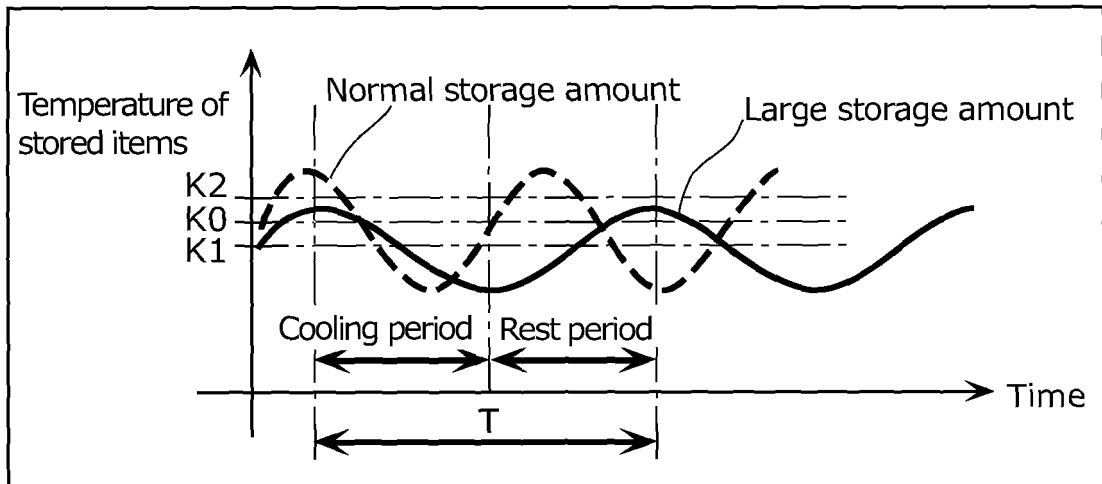


FIG. 7C

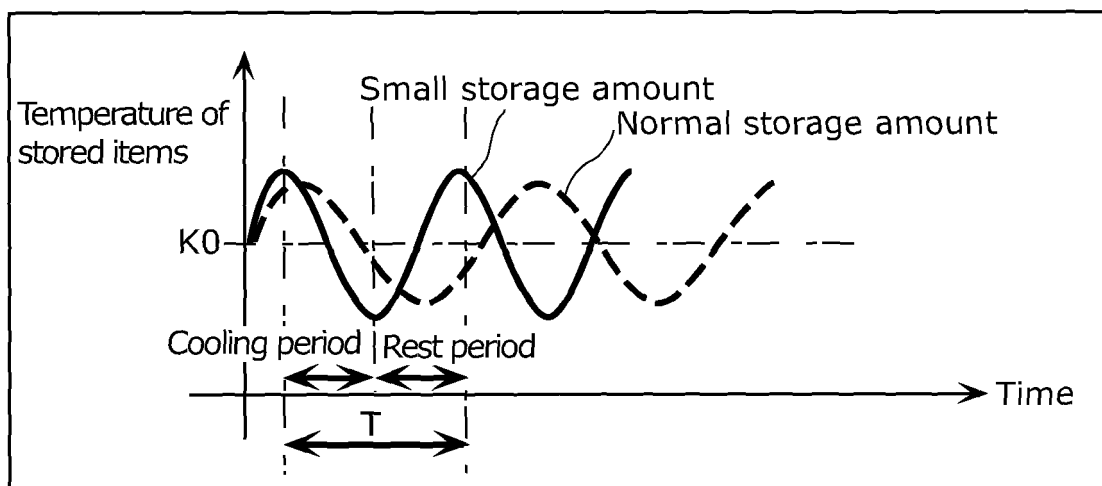


FIG. 8

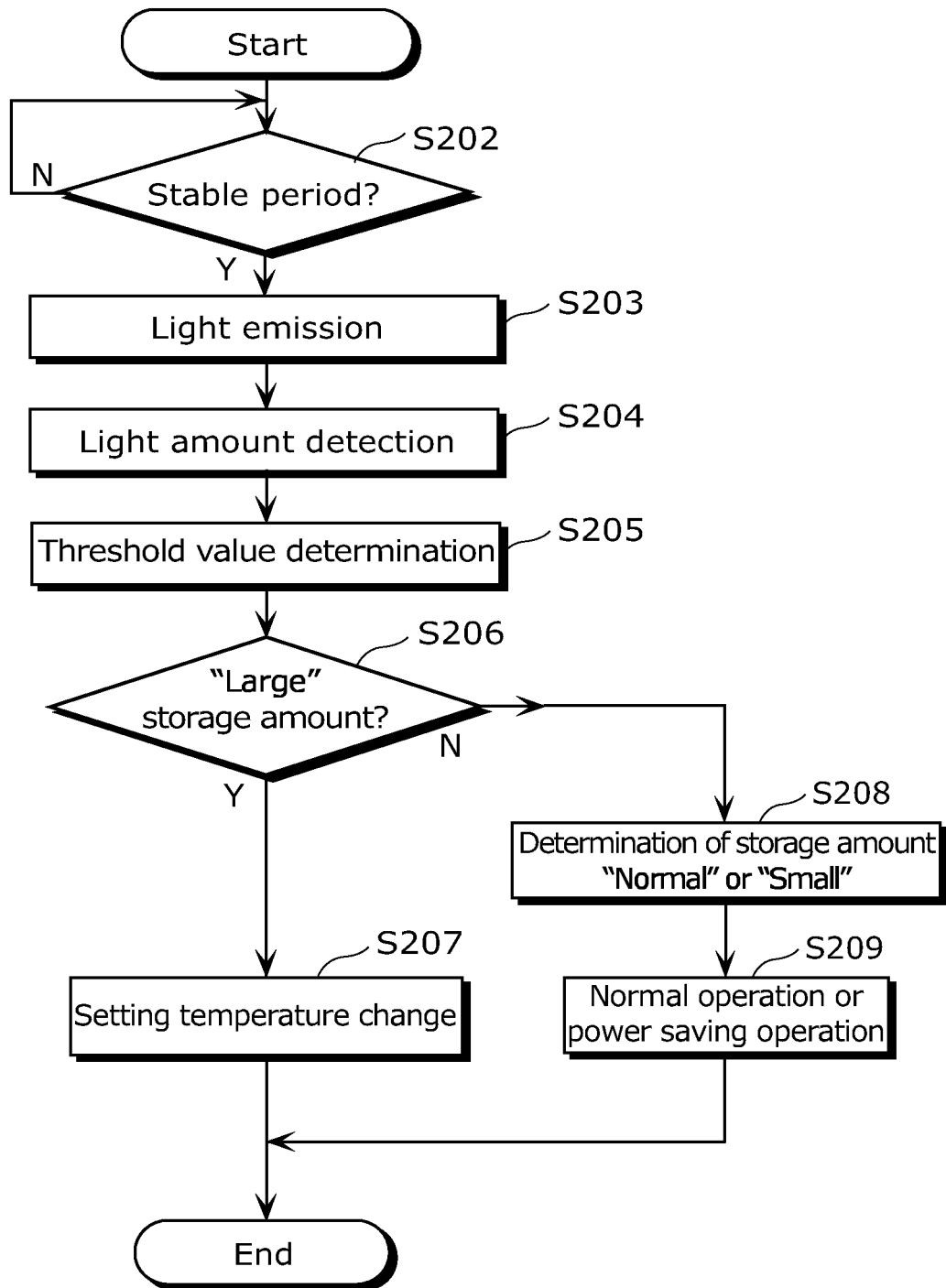


FIG. 9

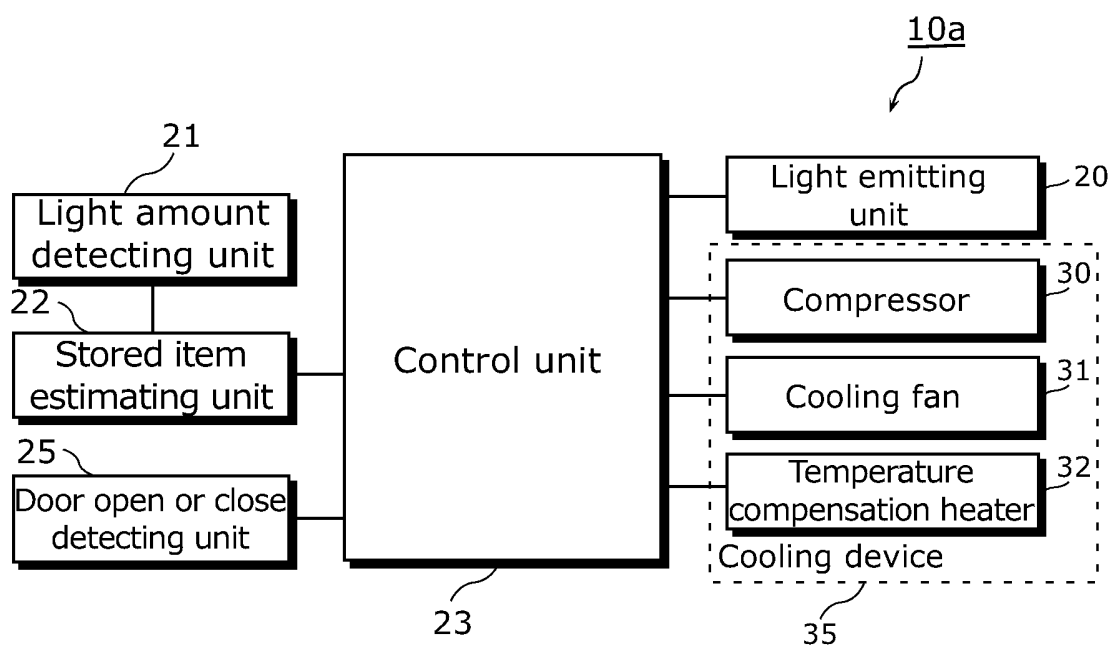


FIG. 10

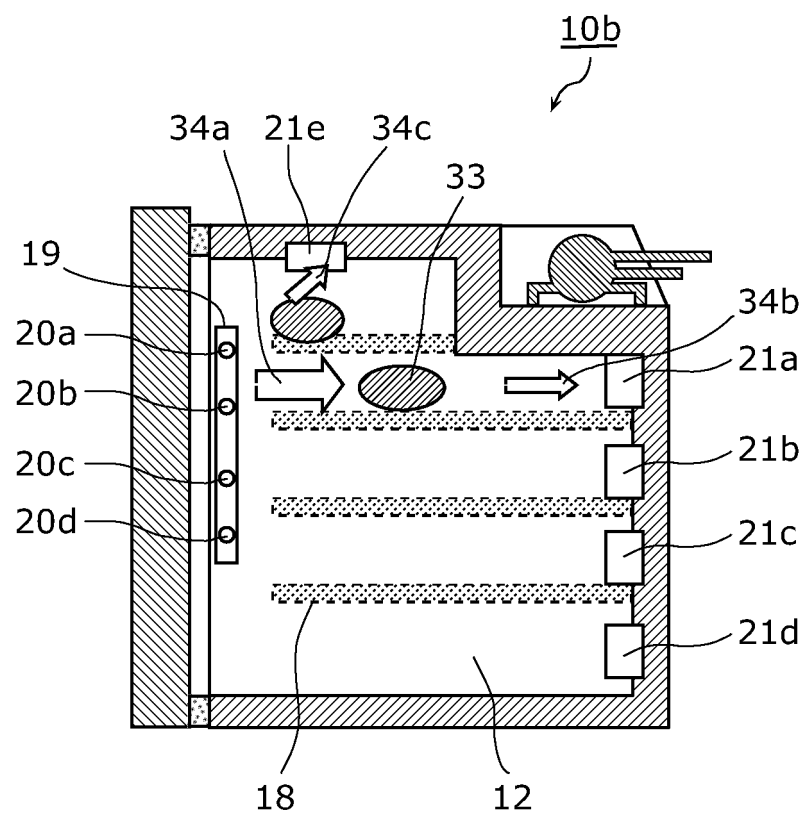


FIG. 11

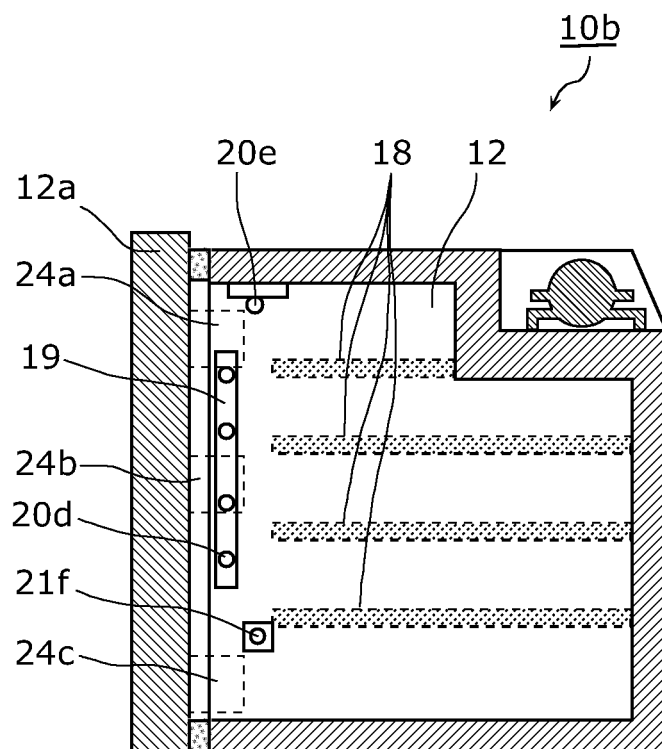


FIG. 12

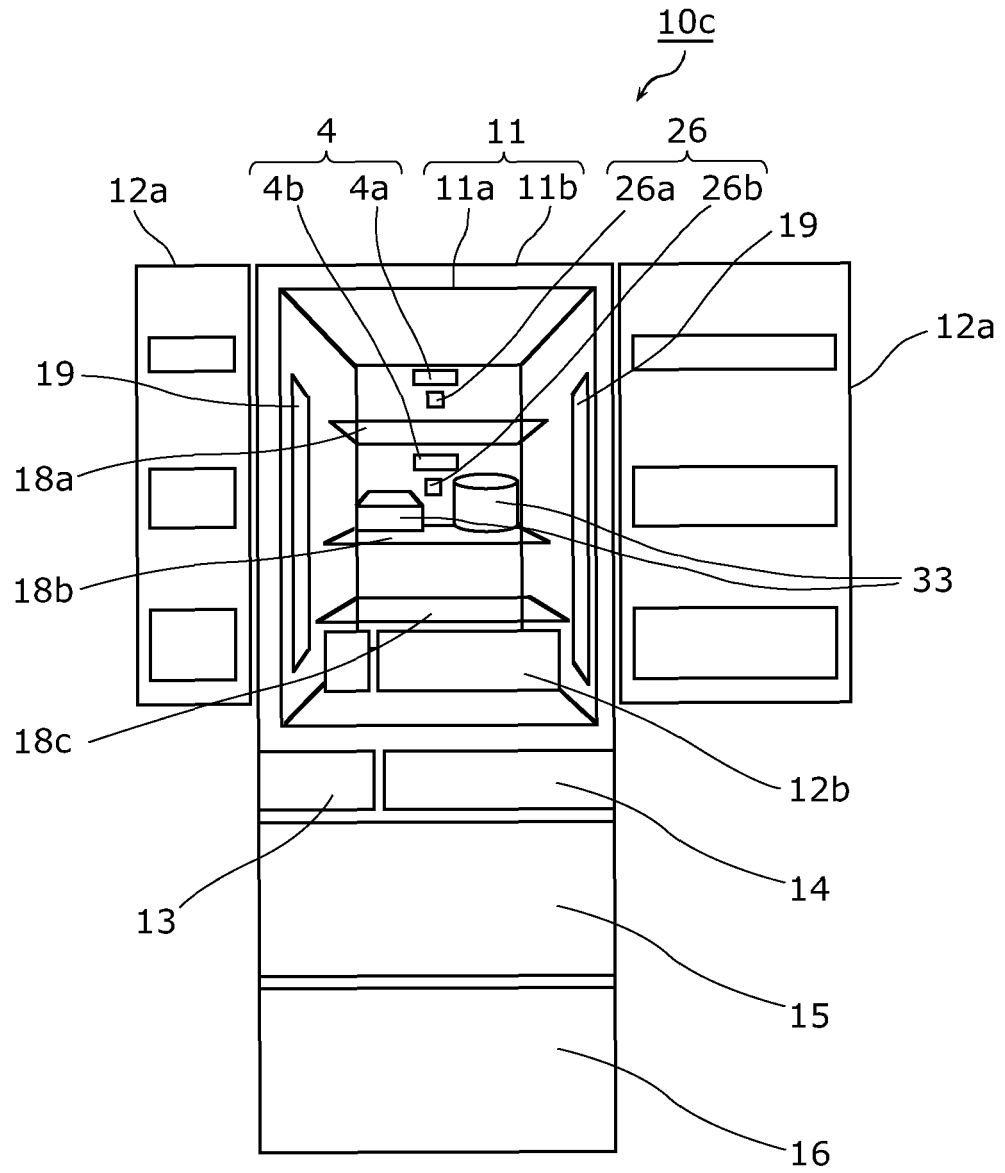


FIG. 13

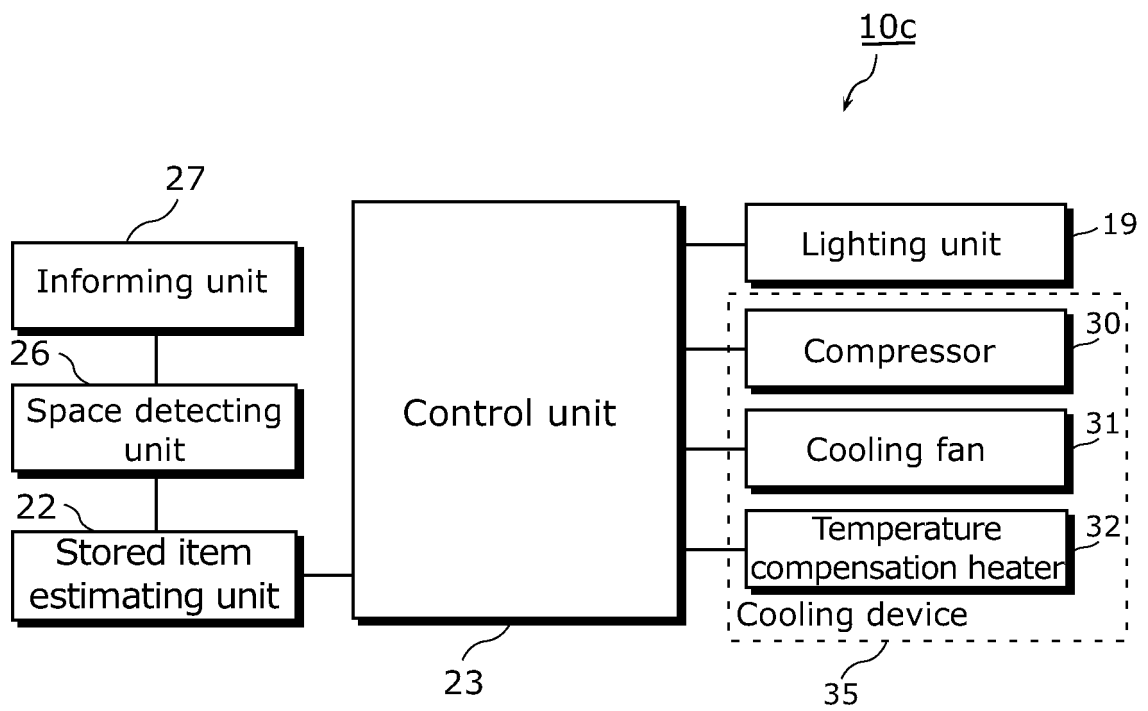
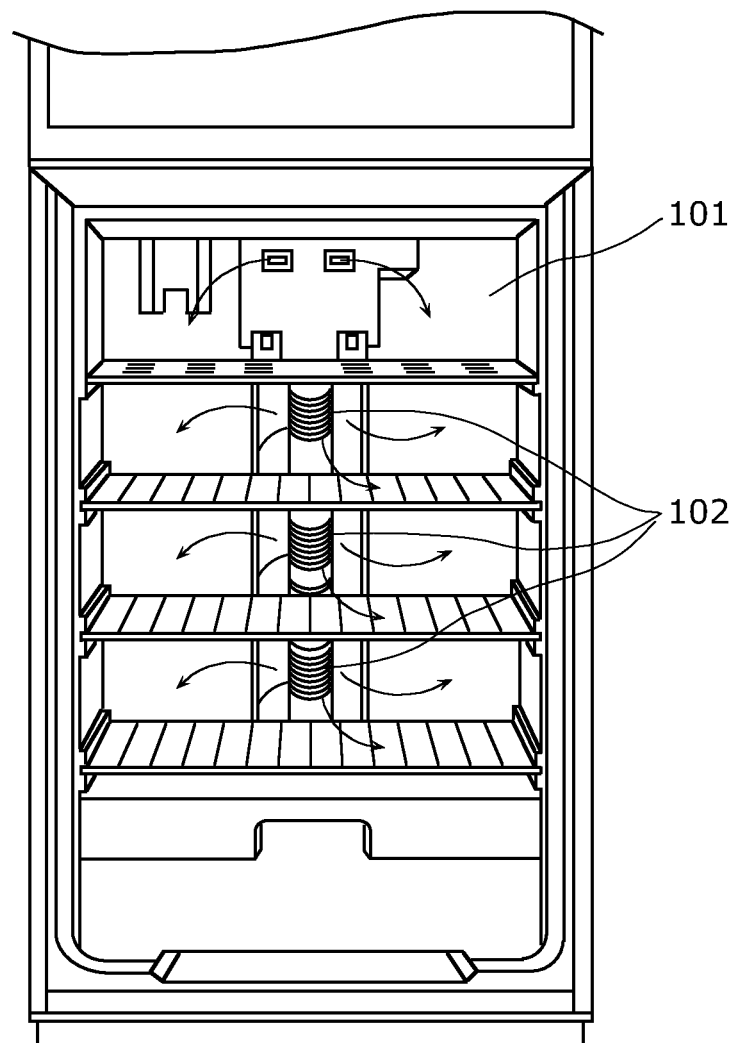


FIG. 14



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2011/001375

A. CLASSIFICATION OF SUBJECT MATTER

F25D11/00 (2006.01) i, F25D23/00 (2006.01) i, F25D29/00 (2006.01) i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F25D11/00, F25D23/00, F25D29/00

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

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2011

Kokai Jitsuyo Shinan Koho 1971-2011 Toroku Jitsuyo Shinan Koho 1994-2011

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2003-185326 A (Matsushita Electric Industrial Co., Ltd.), 03 July 2003 (03.07.2003), claims; paragraphs [0001] to [0108]; fig. 1 to 11	1-11
Y	JP 2003-90661 A (Hitachi, Ltd.), 28 March 2003 (28.03.2003), claims; paragraphs [0001] to [0044]; fig. 1 to 26	1-11
Y	JP 2003-185327 A (Hitachi, Ltd.), 03 July 2003 (03.07.2003), claims; paragraphs [0001] to [0092]; fig. 1 to 30	1-11

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

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"&" document member of the same patent family

Date of the actual completion of the international search
07 June, 2011 (07.06.11)Date of mailing of the international search report
21 June, 2011 (21.06.11)Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

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Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2011/001375

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	JP 2006-329599 A (Toshiba Corp.), 07 December 2006 (07.12.2006), claims; paragraphs [0001] to [0049]; fig. 1 to 4	5-11
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Y	JP 11-294934 A (Matsushita Refrigeration Co.), 29 October 1999 (29.10.1999), claims; paragraphs [0001] to [0098]; fig. 1 to 15	11
A	JP 8-247608 A (Samsung Electronics Co., Ltd.), 27 September 1996 (27.09.1996), entire text; all drawings	1-11

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

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Information on patent family members

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JP 11-294934 A	1999.10.29	(Family: none)	
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REFERENCES CITED IN THE DESCRIPTION

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