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(71) Applicant: **Panasonic Corporation**
Kadoma-shi
Osaka 571-8501 (JP)

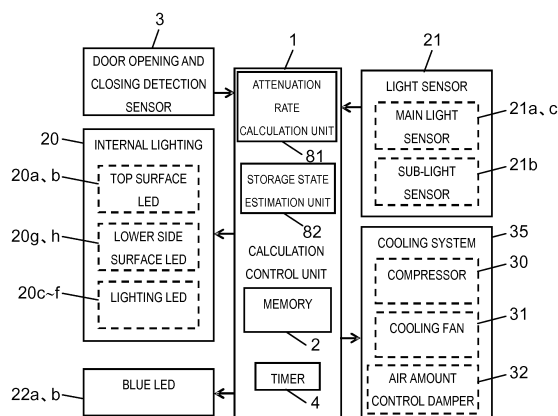
(72) Inventors:
• **MORI, Kiyoshi**
Osaka 540-6207 (JP)
• **KAKITA, Kenichi**
Osaka 540-6207 (JP)
• **KAMISAKO, Toyoshi**
Osaka 540-6207 (JP)
• **NAKAGAWA, Masashi**
Osaka 540-6207 (JP)

(74) Representative: **Eisenführ Speiser**
Patentanwälte Rechtsanwälte PartGmbB
Postfach 31 02 60
80102 München (DE)

(54) **REFRIGERATOR**

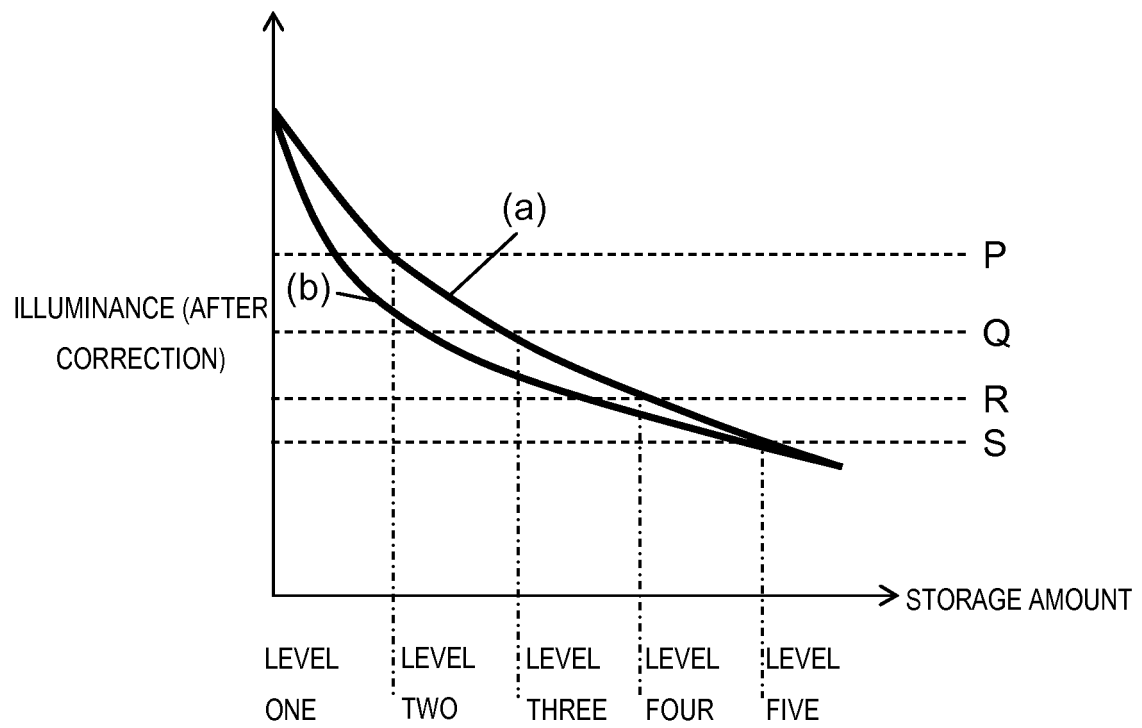
(57) A refrigerator includes a storage room that is divided into sections by a heat insulation wall and a heat insulation door, and stores storage items, a light source that is disposed inside the storage room, a light sensor (21) that detects the illumination light illuminated from the light source, and a calculation control unit (1) that performs a calculation process based on a detection result of the light sensor (21). The calculation control unit (1) includes an attenuation rate calculation unit (81) that calculates an attenuation rate from a reference storage room illuminance in a state that the storage items are stored, based on the reference storage room illuminance in a state that the storage items are not stored in the storage room and a detected illuminance by the light sensor (21), and a storage state estimation unit (82) that estimates a storage amount of the storage items, based on a calculation result of the attenuation rate calculation unit (81).

FIG. 2



100

FIG. 20



Description

TECHNICAL FIELD

[0001] The present invention relates to a refrigerator that is provided with means for detecting a storage state of storage items in the refrigerator.

BACKGROUND ART

[0002] In a household refrigerator in recent years, an indirect cooling system that circulates the cooling air in the refrigerator using a fan is generally used. In a refrigerator in the related art, by adjusting and controlling the temperature according to the detection result of the internal temperature, the internal temperature is maintained at an appropriate temperature.

[0003] For example, as a refrigerator in which the internal temperature is uniformly maintained, a refrigerator provided with a movable cold air discharge device is known (for example, refer to PTL 1).

[0004] Fig. 26 is a front view illustrating an internal structure of refrigerating room 101 of refrigerator 500 in the related art.

[0005] As illustrated in Fig. 26, in refrigerator 500, movable cold air discharge device 102 in refrigerating room 101 supplies cold air to the right and left. As a result, the internal temperature can be uniformly maintained. In refrigerator 500 like this, the temperature is estimated by a thermistor inside.

[0006] However, in such the refrigerator in the related art, a storage state such as the amount and placement of storage items such as stored food, has not been considered.

Citation List

Patent Literature

[0007] PTL 1: Japanese Patent Unexamined Publication No.8-247608

SUMMARY OF THE INVENTION

[0008] The present invention is devised in view of problems in the related art described above, and provides a refrigerator capable of cooling according to a storage state of storage items in the refrigerator.

[0009] A refrigerator in the present invention includes a storage room that is divided into sections by a heat insulation wall and a heat insulation door, and stores storage items, a light source that is disposed inside the storage room, a light sensor that detects the illumination light illuminated from the light source, and a calculation control unit that performs calculation process based on a detection result of the light sensor. The calculation control unit includes an attenuation rate calculation unit that calculates an attenuation rate from a reference storage room

illuminance in a state that the storage items are stored, based on the reference storage room illuminance in a state that the storage items are not stored in the storage room and a detected illuminance by the light sensor, and a storage state estimation unit that estimates a storage amount of the storage items, based on a calculation result of the attenuation rate calculation unit.

BRIEF DESCRIPTION OF DRAWINGS

[0010]

Fig. 1 is a front view of a refrigerator in a first embodiment of the present invention.

Fig. 2 is a block diagram for the control of the refrigerator in the first embodiment of the present invention.

Fig. 3A is a 3A-3A cross-sectional view of the refrigerator in Fig. 1 in the first embodiment of the present invention.

Fig. 3B is a front view of the refrigerator when the refrigerating room door of refrigerating room is opened in the first embodiment of the present invention.

Fig. 4 is a diagram illustrating characteristics between the output current and detected illuminance at a light sensor that is a storage state detection unit of the refrigerator in the first embodiment of the present invention.

Fig. 5 is a characteristics diagram illustrating relations between a storage rate and the detected illuminance at the light sensor for each reflection rate of the wall surface in the refrigerator in the first embodiment of the present invention.

Fig. 6 is a characteristics diagram illustrating relations between a storage rate and the detected illuminance at the light sensor for each transmittance on the storage shelves in the refrigerator in the first embodiment of the present invention.

Fig. 7A is a flow chart illustrating a control flow of an operation for detecting the storage state in the refrigerator in the first embodiment of the present invention.

Fig. 7B is a flow chart illustrating a control flow of an operation for detecting the storage state in the refrigerator in the first embodiment of the present invention.

Fig. 8 is a diagram for explaining an operation for detecting the storage state using a top surface LED in the refrigerator in the first embodiment of the present invention.

Fig. 9 is a diagram illustrating characteristics at the time of detecting the storage state using the top surface LED in the refrigerator in the first embodiment of the present invention.

Fig. 10 is a diagram for explaining an operation for detecting the storage state using a lower side surface LED in the refrigerator in the first embodiment of the

present invention.

Fig. 11 is a diagram illustrating characteristics at the time of detecting the storage state using a lower side surface LED in the refrigerator in the first embodiment of the present invention.

Fig. 12 is a diagram illustrating average characteristics of the characteristics values illustrated in Fig. 9 and Fig. 11 in the refrigerator in the first embodiment of the present invention.

Fig. 13 is a diagram for explaining an example of storage in the vicinity of the main light sensor in the refrigerator in the first embodiment of the present invention.

Fig. 14 is a diagram for explaining an example of error occurrence due to the storage items in the vicinity of the main light sensor in the refrigerator in the first embodiment of the present invention.

Fig. 15 is a diagram illustrating storage state detection characteristics in the vicinity of the main light sensor in the refrigerator in the first embodiment of the present invention.

Fig. 16 is a diagram for explaining a storing example of a reflection object in the vicinity of the main light sensor in the refrigerator in the first embodiment of the present invention.

Fig. 17 is a diagram for explaining an example of error occurrence due to the reflection object in the vicinity of the main light sensor in the refrigerator in the first embodiment of the present invention.

Fig. 18A is a diagram illustrating a relationship between a wavelength and reflection rate of the light in the refrigerator in the first embodiment of the present invention.

Fig. 18B is a diagram illustrating a relationship between a wavelength and reflection rate of the light in the refrigerator in the first embodiment of the present invention.

Fig. 18C is a diagram illustrating a relationship between a wavelength and reflection rate of the light in the refrigerator in the first embodiment of the present invention.

Fig. 19 is a diagram illustrating reflection object detection characteristics in the vicinity of the main light sensor in the refrigerator in the first embodiment of the present invention.

Fig. 20 is a diagram illustrating a storage state detection characteristics after the correction calculation in the first embodiment of the present invention.

Fig. 21 is a cross-sectional view seen from the side of a refrigerator in a second embodiment of the present invention.

Fig. 22 is a diagram for explaining a state in which storage items are stored in the back of the refrigerating room in the refrigerator in the second embodiment of the present invention.

Fig. 23A is a cross-sectional view seen from the top illustrating an example of arranging the light sensors in the refrigerator in the second embodiment of the

present invention.

Fig. 23B is a cross-sectional view seen from the top illustrating an example of arranging the light sensors in the refrigerator in the second embodiment of the present invention.

Fig. 24A is a cross-sectional view seen from the side illustrating an example of arranging the light sensors in the refrigerator in the second embodiment of the present invention.

Fig. 24B is a cross-sectional view seen from the side illustrating an example of arranging the light sensors in the refrigerator in the second embodiment of the present invention.

Fig. 25 is a cross-sectional view seen from the top illustrating an example of arranging the light sensors to the air path in the refrigerator in the second embodiment of the present invention.

Fig. 26 is a front view illustrating the internal structure of the refrigerating room in the refrigerator in the related art.

DESCRIPTION OF EMBODIMENTS

[0011] Hereinafter, embodiments of the present invention will be described with reference to the drawings. The present invention is not limited to the below-described embodiments.

(First Embodiment)

[0012] Hereinafter, the first embodiment of the present invention will be described based on Fig. 1 to Fig. 20.

[0013] Fig. 1 is a front view of refrigerator 100 in the first embodiment of the present invention. Fig. 2 is a block diagram for the control of refrigerator 100. Fig. 3A is a 3A-3A cross-sectional view of refrigerator 100 in Fig. 1. Fig. 3B is a front view of refrigerator 100 when refrigerating room door 12a of refrigerating room 12 is opened.

[0014] As illustrated in Fig. 1, Fig. 3A and Fig. 3B, refrigerator 100 is configured to include refrigerator body 11. Refrigerator body 11 is a heat insulating box body and is configured to include an outer box mainly using a steel plate, an inner box molded by resin such as ABS, and a heat insulating material injected between the outer box and the inner box.

[0015] As illustrated in Fig. 1, refrigerator body 11 is divided into a plurality of storage rooms by heat insulating walls and heat insulating doors. Specifically, at the uppermost part of refrigerator body 11, refrigerating room 12 is disposed. In addition, at lower part of refrigerating room 12, ice making room 13 and temperature switching room 14 are provided side-by-side. At the lower part of ice making room 13 and temperature switching room 14, freezing room 15 is provided. At the lower part of freezing room 15 which is the lowermost part of refrigerator body 11, vegetables room 16 is disposed.

[0016] At the front side of each storage room, heat insulating door for separating from the external air is formed

respectively in the front side opening section of refrigerator body 11. Refrigerating room door 12a is a heat insulating door of refrigerating room 12. In the part near the center of refrigerating room door 12a, display unit 17 is disposed, that can perform the setting of internal temperature in each storage room, ice making and fast cooling and the like, and that displays a detection result of the storage state and an operating status of refrigerator 100.

[0017] As illustrated in Fig. 2, refrigerator 100 includes internal lighting 20 that is a light source disposed inside of refrigerating room 12, light sensor 21 that detects the illumination light illuminated from the light source, calculation control unit 1 that performs the calculation process based on the detection result of light sensor 21. Refrigerator 100 further includes blue LED 22a and 22b.

[0018] Calculation control unit 1 includes attenuation rate calculation unit 81 that calculates the attenuation rate from the reference storage room illuminance in a state that the storage items are stored, based on the reference storage room illuminance in a state that the storage items are not stored in refrigerating room 12 and the detected illuminance by light sensor 21, and storage state estimation unit 82 that estimates the storage amount of the storage items based on the calculation result of attenuation rate calculation unit 81.

[0019] Refrigerator 100 further includes door opening and closing detection sensor 3 which is a door opening and closing detection unit that detects the opening and closing of refrigerating room door 12a.

[0020] Internal lighting 20 includes top surface LEDs 20a and 20b, lighting LEDs 20c to 20f and lower side surface LEDs 20g and 20h.

[0021] Calculation control unit 1 further includes memory 2 and timer 4.

[0022] Light sensor 21 includes main light sensors 21a and 21c, and sub-light sensor 21b.

[0023] Refrigerator 100 includes cooling system 35. Cooling system 35 includes compressor 30, cooling fan 31 and air amount control damper 32.

[0024] As illustrated in Fig. 3A and Fig. 3B, in refrigerating room 12, a plurality of internal storage shelves 18 are provided so that the foods which are storage items can be sorted and stored. At the internal side surface of refrigerating room door 12a, door storage shelves 19 are provided. Internal storage shelves 18 and door storage shelves 19 are formed of material having a high transmittance of light such as glass or transparent resin.

[0025] On the surface of internal storage shelves 18 and door storage shelves 19, processing is performed so that the light is diffused while the constant transmittance is maintained. In this way, the brightness distribution in refrigerating room 12 can be controlled. The transmittance here is preferred to be equal to or higher than 50%, and if the transmittance is lower than 50%, there is a possibility that the accuracy of the storage state detection may be decreased because there may be a place where it is difficult for light to reach in the refrigerator.

Practically, it is preferable to set the transmittance of internal storage shelves 18 and door storage shelves 19 being equal to or higher than 70%. The reason for this will be described below.

[0026] As illustrated in Fig. 2, Fig. 3A and Fig. 3B, in refrigerating room 12, internal lightings 20 are provided in order to brightly illuminate the storage room inside the refrigerator. In this way, the visibility of foods which are the stored storage items is improved.

[0027] As illustrated in Fig. 3A, internal lightings 20 are provided near the door side (front side) than 1/2 (center) position in a depth direction in the refrigerator, seen from the front of the door opening side of refrigerator 100.

[0028] Internal lightings 20, as illustrated in Fig. 3B, are provided on the top surface, left side wall surface and right side wall surface respectively. Specifically, as internal lightings 20, a plurality of LEDs such as; top surface LED 20a and 20b on the top surface, lighting LEDs 20c to 20f on the right and left side wall surface, and lower side surface LEDs 20g and 20h, are used. In this way, light having high luminosity is incident on light sensor 21. Accordingly, it is possible to improve the detection sensitivity of storage state by light sensor 21. In addition, by sequentially lighting the plurality of LEDs provided on the different positions, since the detected value of the light sensor 21 is changed by the storage state and the LEDs turned on, it is possible to estimate the storage state in more detail. The LEDs of internal lightings 20 are provided on the position higher than the position of light sensor 21 in refrigerating room 12.

[0029] On the side wall surface, lighting LEDs 20c to 20f and lower side surface LED 20g are disposed in a vertical direction as illustrated in Fig. 3A and 3B. In this way, it is possible to evenly and entirely illuminate refrigerating room 12 which is longer in height direction than in a width direction.

[0030] On the lower position which is the position near the refrigerating room door 12a side than 1/2 (center) position in the depth direction in the refrigerator, main light sensors 21a and 21c and sub-light sensor 21b that are light sensors 21, are provided. In this way, it is possible to accurately detect the storage state of the storage items such as foods stored near the door where the influence of outside air flown in due to the opening and closing of the door is large, and possible to control so as to maintain an appropriate temperature in the refrigerator.

[0031] As light sensor 21, an illuminance sensor, specifically a sensor which is most sensitive in a peak wavelength of 500 to 600 nm, is used in the present embodiment. The light sensor may be most sensitive in another peak wavelength band. It is determined such that the light emission wavelength or the like of the light sources such as top surface LEDs 20a and 20b, lower side surface LEDs 20g and 20h, and blue LEDs 22a and 22b, can be detected.

[0032] In Fig. 3B, if refrigerating room 12 is assumed to be divided into two sections in the left-to-right direction,

top surface LED 20a and main light sensor 21c are disposed in the right section. In addition, top surface LED 20b, main light sensor 21a and sub-light sensor 21b are disposed in the left section. In addition, if refrigerating room 12 is assumed to be divided into two sections in a vertical direction, top surface LEDs 20a and 20b are disposed in the upper section. Lower side surface LEDs 20g and 20h, main light sensors 21a and 21c, and sub-light sensor 21b are disposed in the lower section. In this way, LEDs and light sensors 21 that configure the storage state detection unit are disposed in the plurality of sections. The detected illuminance at light sensor 21 is a detected illuminance of indirect illumination light, that includes reflection light from the wall surface and the storage items in refrigerating room 12.

[0033] Main light sensors 21a and 21c measure the illuminance in a state where the illumination light of top surface LEDs 20a and 20b, or lower side surface LEDs 20g and 20h repeats the reflection at the wall surface of refrigerating room 12 and the reflection and the attenuation at the storage items, and the brightness distribution in refrigerating room 12 is saturated. Calculation control unit 1, using the measured value of main light sensors 21a and 21c, performs the calculation process and estimates the storage state of the storage items. In the present embodiment, as described above, by disposing the LEDs and light sensors 21 in the plurality of sections, it is possible to detect the storage state with a high accuracy regardless of the arrangement of the storage items.

[0034] It is practically preferable to set the reflection rate of the wall surface in refrigerating room 12 being equal to or higher than 0.5. As described above, it is practically preferable to set the transmittance of internal storage shelf 18 and door storage shelf 19 being equal to or higher than 70%. The reason for this will be described below.

[0035] Fig. 4 is a diagram illustrating characteristics between the output current and detected illuminance at light sensor 21 that configures the storage state detection unit of refrigerator 100 in the first embodiment of the present invention. Fig. 5 is a characteristics diagram illustrating relations between the storage rate and the detected illuminance at light sensor 21 for each reflection rate of the wall surface in same refrigerator 100. Fig. 6 is a characteristics diagram illustrating relations between a storage rate and the detected illuminance at light sensor 21 for each transmittance on internal storage shelves 18 in refrigerator 100. The illuminance of light sensor 21 can be output as a current value or a voltage value (hereinafter, description will be made with the current value, but can be replaced by the voltage value).

[0036] The inner box that configures the inner walls of refrigerating room 12 of refrigerator 100 is formed of vacuum molded white ABS resin, and reflection rate R of the inner wall surfaces in the refrigerator is equal to or higher than 0.5.

[0037] Reflection rate R is defined as a rate of reflecting

light flux on a certain surface with respect to the incident light flux on the same surface, it can be said that the number is larger, it is more reflective. The measuring is can be performed by a commercially buyable spectrophotometer. There is a measuring instrument by which transmittance T can be simultaneously measured as well as reflection rate R. In the Japanese Industrial Standards, the method of measuring and testing of reflection rate R is defined in JIS-K3106 and the like. Reflection rate R also can be estimated by the brightness measured using a luminance meter for the sample in which the reflection rate is already known (grey scale).

[0038] Transmittance T is a proportion of incident light having a specific wavelength passing through a test material, it can be said that the number is larger, it is easier to transmit. Regarding transmittance T, the method of measuring and testing of transmittance T is defined in JIS-K7361-1 and the like. Internal storage shelves 18 disposed inside of refrigerating room 12 of refrigerator 100 are formed of polystyrene or glass, and door storage shelves 19 are formed of polystyrene. Then, transmittance T of internal storage shelves 18 and door storage shelves 19 are respectively equal to or higher than 70%. If the transmittance satisfies above-described relationship, the materials are not limited to the above described examples.

[0039] As illustrated in Fig. 4, the detected illuminance at main light sensors 21a and 21c, and the output current value at that time have a linear relationship. Thus, as the illuminance increases, the output current value also increases. Meanwhile, when the illuminance decreases, the output current value also decreases. When the illuminance is decreased to be equal to or lower than a predetermined value, that is, equal to or lower than 0.5 Lux at the storage state detection unit in the present embodiment, the linear relationship with the output current is lost. The output current value at this time at the storage state detection unit in the present embodiment is 0.1 μ A. However, the relationship between the illuminance and the output current value differs depending on the specification of the storage state detection unit. The accuracy of the sensor which detects the illuminance deteriorates at the illuminance of lower than one Lux. However, light sensor 21 assumed to be used in the present embodiment has a comparatively high performance, the lowest illuminance required is equal to or higher than 0.5 Lux.

[0040] As a result, by estimating the storage rate of the storage items when the illuminance is equal to or higher than the predetermined value (0.5 Lux) in which the detected illuminance at light sensor 21 and the output current value have a linear relationship, calculation control unit 1 can improve the estimation accuracy of the storage rate.

[0041] That is, by not using the illuminance range in which the detected illuminance at light sensor 21 and the output current value do not have a linear relationship in estimating the storage state of the storage items, it is possible to improve the estimation accuracy of the stor-

age rate. In a case where the detected illuminance at light sensor 21 is equal to or lower than the predetermined output value (0.5 Lux), it is also possible to use for fault diagnosis.

[0042] As described above, when the lowest illuminance is converted to the output current value, the output current value is 0.1 μ A. That is, in the present embodiment, the minimum output current of main light sensors 21a and 21c is equal to or higher than 0.1 μ A. As a result, based on the detected illuminance attenuation amount at main light sensors 21a and 21c from the view point of minimum output current, it is possible to improve the estimation accuracy of the storage state of the storage items.

[0043] In addition, as illustrated in Fig. 5, when the light amount from the light source is constant and the storage rate of the storage items in the refrigerator is increased, the detected illuminance at main light sensors 21a and 21c is decreased. Then, as reflection rate R of the wall surface in the refrigerator (in Fig. 5, $R = 0.3, 0.5$ and 0.7) decreases, there is a tendency that the detected illuminance at main light sensors 21a and 21c decreases when the storage rate is same. That is because a part of light from the light source reflects from the wall surface in the refrigerator and reaches the main light sensors 21a and 21c, and as reflection rate R on the wall surface in the refrigerator decreases, the light amount reaches main light sensors 21a and 21c decreases.

[0044] There is a case that a design member having a low reflection rate may be installed on the wall surface in the refrigerator. However, the light amount that reaches main light sensors 21a and 21c depends upon reflection rate R of the wall surface having a wide area in the refrigerator.

[0045] As described above, there is a need for detecting the storage state avoiding a detection accuracy unstable region DNG of light sensor 21. The minimum illuminance at main light sensors 21a and 21c is required to be equal to or higher than 0.5 Lux. Accordingly, from the relation illustrated in Fig. 5, it can be understood that the reflection rate R of the wall surface in the refrigerator being required to be equal to or higher than 0.5.

[0046] Here, in order to increase the receiving light amount at light sensor 21, increasing the light amount from the light source can be considered. However, there are possibilities that the power consumption may increase or increase of the temperature in the refrigerator may occur due to the heat generation of the light source. There is also a possibility that, the user may feel dazzling when the light source is used both for lighting function and the detection of the storage state, and the visibility of the foods may deteriorate. Therefore, recklessly increasing the light amount may not be advantageous. As a result, in the present embodiment, the LEDs in the light source are adjusted such that, when the illuminance is measured in a dark room in a state where the refrigerator is empty and refrigerating room door 12a is opened, the illuminance at the position where the illuminance is the

lowest on internal storage shelf 18, is equal to or lower than 100 Lux. The illuminance value equal to or lower than 100 Lux here is a brightness seen by the user, and specifically is a value measured by a usual illuminance meter with a most sensitive axis of sensing unit thereof being installed in a direction horizontal to internal storage shelf 18 and in a direction toward refrigerating room door 12a side.

[0047] In the present embodiment, as a light source of internal lighting 20, LEDs having luminosity equal to or lower than 20 candela per each LED are used in consideration of the thermal influence in the refrigerator.

[0048] Here, a case is assumed, in which the luminosity of the LEDs for the storage state detection unit is relatively low, like a case in which a dedicated light source is used for the configuration without using the LEDs for both of the storage state detection unit and a lighting function of internal lighting 20. In this case, it is needed to increase reflection rate R in the refrigerator so as to be higher than 0.5.

[0049] As illustrated in Fig. 6, as the transmittance of internal storage shelf 18 and door storage shelf 19 (in Fig. 6, 30%, 60%, and 90%) decreases, there is a tendency that the illuminance of light sensor 21 at the same storage rate decreases. In the present embodiment, by setting the transmittance of internal storage shelf 18 and door storage shelf 19 as equal to or higher than 70%, it is possible to secure the estimation accuracy of the storage state of the storage items based on the detected illuminance attenuation amount at light sensor 21.

[0050] As a method of detecting the object using light sensor 21, for example, as in the photo-interrupter, a method using a phenomenon that the light intensity is severely attenuated by shielding, is generally used. According to this method, the existence of one object can be digitally detected using one light sensor 21, and the existence of a plurality of objects can be detected by using a plurality of light sensors. However, in a case of using such a configuration, the existence of storage items only in the limited position in the storage room can be detected, and it is difficult to grasp the storage state in the entire storage room. However, according to refrigerator 100 in the present embodiment, using a small quantity of LEDs and light sensors 21, the storage state in an entire space in refrigerating room 12 can be grasped in an analog manner. That is, not only the existence of the storage items but also the quantitative amount of the storage items can be grasped. That is, the configuration of refrigerator 100 in the present embodiment is suitable for detecting the entire amount of the storage items in the closed space.

[0051] In the method of detecting the object using light sensor 21, if the vicinity of light sensor 21, that is, the direct front of light sensor 21 is blocked by the storage items, the light level that can be detected is severely decreased and the change rate of the light intensity is also decreased. As a result, it is considered that a complicated process may be required for detecting the storage state.

[0052] However, in the present embodiment, as illustrated in Fig. 3A, top surface LEDs 20a and 20b, lighting LEDs 20c to 20f, lower side surface LEDs 20g and 20h, and main light sensors 21a and 21c are mounted on space α between internal storage shelf 18 and door storage shelf 19. As a result, even in a case where refrigerating room 12 is full of storage items, the possibility that the vicinity of light sensor 21 is blocked by foods is very low. In this way, the possibility that the upper and lower space between the heat insulating door and front end of internal storage shelf 18 is blocked by the storage items is low. Thus, the stable light path from the light source can be secured. Therefore, it is possible to accurately estimate the storage state of the storage items based on the detected illuminance attenuation amount at light sensor 21 due to the existence of the storage items on door storage shelf 19 and internal storage shelf 18.

[0053] Main light sensors 21a and 21b are installed on the front side of the vertical plane including the end portion of the front side of internal storage shelf 18, and the space between the vertical planes including the end portion of the back side of refrigerating room door 12a which is a heat insulating door. Further preferably, main light sensors 21a and 21b are installed on the part α that does not reach to door storage shelf 19, and that is the front side of the vertical plane including the end portion of the front side of internal storage shelf 18, and the space between the vertical plane including the end portion of the back side of refrigerating room door 12a which is a heat insulating door. In this way, since there is a space between internal storage shelf 18 and door storage shelf 19, it is possible to prevent main light sensors 21a and 21c that configure the storage state detection unit from being blocked by the storage items.

[0054] Returning to Fig. 3A, in a machine room formed on the back region of the top of refrigerating room 12, components of the refrigeration cycle such as a dryer for removing water including compressor 30 are accommodated.

[0055] On the back surface of freezing room 15, a cooling room that generates cooling air is provided. In the cooling room, a cooler and cooling fan 31 (refer to Fig. 2) that blows the cooling air which is cooling means cooled by the cooler, to refrigerating room 12, temperature switching room 14, ice making room 13, vegetable room 16 and freezing room 15. Air amount control damper 32 (refer to Fig. 2) that controls air amount from cooling fan 31 is installed in the air path. A radiant heater, an evaporating dish such as a drain pan or a drain tube for removing the frost and ice adhering to and around the cooler, are installed.

[0056] Calculation control unit 1 performs the temperature control for refrigerating room 12, with the non-freezing temperature as a lower limit (usually 1°C to 5°C) for refrigerated storage. Calculation control unit 1 performs the temperature control for vegetable room 16, with setting the temperature similar to that of refrigerating room 12 or slightly higher temperature (for example, 2°C to

7°C). Calculation control unit 1 sets the temperature for freezing room 15 to the freezing temperature zone (usually -22°C to -15°C). However, in order for the improvement of the frozen storage state, in some case, for example, it is set to a low temperature of -30°C or -25°C.

[0057] Ice making room 13 makes ice by an automatic icemaker provided on the upper part of the room using water supplied from a water storage tank in refrigerating room 12, and stores the ice in an ice storage container disposed on the lower part of the room.

[0058] Temperature switching room 14, besides the setting of temperature zone such as 1°C to 5°C (refrigerating), 2°C to 7°C (vegetables) and -22°C to -15°C (freezing), can switch the temperature to the predetermined temperature zone between the refrigerating temperature zone to the freezing temperature zone. Temperature switching room 14 is a storage room provided in parallel with ice making room 13, and has an independent door, for example, a pull-out-type door.

[0059] In the present embodiment, temperature switching room 14 is a storage room capable of controlling the temperature zone including the refrigerating temperature zone to freezing temperature zone. However, temperature switching room 14 is not limited to this configuration, and may be provided as a storage room which is specialized to switch the temperature zone between the refrigerating temperature zone and the freezing temperature zone by entrusting the refrigerating to refrigerating room 12 or vegetable room 16, and entrusting the freezing to freezing room 15 respectively. In addition, temperature switching room 14 may be provided as a storage room that is set to a specific temperature zone, for example, the temperature zone fixed to the freezing temperature according to the fact that the demand for the frozen foods in recent years has been increased.

[0060] The operation and the action of refrigerator 100 configured as described above will be described.

[0061] In the present embodiment, the storage state of the storage items is detected using top surface LEDs 20a and 20b, and lower side surface LEDs 20g and 20h, among internal lightings 20. In addition, in the present embodiment, the storage state is detected using main light sensor 21a and sub-light sensor 21b, among light sensors 21.

[0062] When it is needed to increase the detection accuracy of the storage state of the storage items, it is sufficient to increase the number of LED light sources in use such as using lighting LEDs 20c to 20f as a storage state detection unit. In addition, it is also possible to improve the detection accuracy by increasing the number of light sensor 21 in use such as using main light sensor 21c as a storage state detection unit.

[0063] Hereinafter, the operation of detecting the storage state of the storage items using top surface LEDs 20a and 20b, lower side surface LEDs 20g and 20h, and main light sensor 21a and sub-light sensor 21b, will be described using Fig. 7A to Fig. 12.

[0064] Fig. 7A and Fig. 7B are flow charts illustrating

a control flow of an operation for detecting the storage state in refrigerator 100 in the first embodiment of the present invention. Fig. 8 is a diagram for explaining an operation for detecting the storage state using top surface LEDs 20a and 20b in same refrigerator 100. Fig. 9 is a diagram illustrating characteristics at the time of detecting the storage state using top surface LEDs 20a and 20b in same refrigerator 100. Fig. 10 is a diagram for explaining an operation for detecting the storage state using lower side surface LED 20g in same refrigerator 100. Fig. 11 is a diagram illustrating characteristics at the time of detecting the storage state using a lower side surface LED 20g in same refrigerator 100. Fig. 12 is a diagram illustrating average characteristics of the characteristics values illustrated in Fig. 9 and Fig. 11 in same refrigerator 100.

[0065] In refrigerating room 12, usually the length in a height direction is longer than that in a width direction (vertically long shape). As a result, an example of detecting the storage state by dividing refrigerating room 12 into two sections of upper and lower, will be mainly described.

[0066] As illustrated in Fig. 7A, firstly, the opening and closing of refrigerating room door 12a is detected by door opening and closing detection sensor 3 (S101). In a case where the door is detected to be in the closed state (is closed), calculation control unit 1 determines that there is a possibility that the storage items may be put-in or put-out, and starts the calculation process.

[0067] Calculation control unit 1 can also start the operation for detecting the storage state (operation for acquiring the basic data), after counting a predetermined time from the closing of refrigerating room door 12a by timer 4 (S102). In this case, calculation control unit 1 starts the controlling when the heat insulating door is detected to be closed by door opening and closing detection sensor 3, and after a predetermined time has passed.

[0068] Here, in step S102, the reason for counting the predetermined time period by timer 4 (reason for waiting for predetermined time period) will be described.

[0069] One reason is to prevent the influence on the detection of the storage state due to the minute dew condensation on the surface of internal storage shelf 18 and door storage shelf 19 where is in a low temperature, and change of the transmittance. That is, it is to detect the storage state when the dew condensation is cleared after the predetermined time period.

[0070] One more reason is to prevent the influence on the detection of the storage state due to the decrease of luminosity of LED caused by the heat generation of internal lighting 20 because when refrigerating room door 12a is opened, internal lighting 20 is turned on. That is, it is to detect the storage state after turning off the LED when the door is closed, and when the temperature increase is resolved after the predetermined time passes, then again turning on the LED.

[0071] As described above, to wait for the predetermined time is to stabilize the illuminance in the storage

room.

[0072] As another method for stabilizing the illuminance in the storage room, there is a method in which the LED is turned on for a while even when refrigerating room door 12a is closed and generates the heat, and after a predetermined time, when the temperature increase of the LED is saturated to be constant, then the detection is started. It is also possible to stabilize the luminosity of the LED by this method.

[0073] Calculation control unit 1, when the operation for detecting the storage state is started, firstly turns on the light sources of top surface LEDs 20a and 20b disposed on top surface which is the upper section of refrigerator 100 (S103).

[0074] For example, as illustrated in Fig. 8, a case is assumed in which foods that are storage items 23a are stored on internal storage shelf 18, and storage items 23b are also stored on door storage shelf 19. In this case, light 24a output from top surface LED 20a (component of light is illustrated in Fig. 8 as arrows. A dotted line indicates that the luminosity is attenuated) is reflected at storage items 23a and attenuated, and diffuses to other direction as light 24b and 24c. Then, lights 24b and 24c repeat the reflection at the wall surface of refrigerating room 12 and other foods. Light 24d reflected at storage items 23b on door storage shelf 19 is also attenuated, and diffuses to other direction as light 24e. Then, light 24e further repeats the reflection at the wall surface of refrigerating room 12 and other storage items such as foods. After the repeated reflection like this, the brightness distribution in refrigerating room 12 is saturated to be stabilized.

[0075] In general, the illumination light of the LED is emitted with a predetermined illumination angle. For this reason, light 24a and 24d indicated by arrows in Fig. 8 are a part of component of light emitted from the LED. Hereinafter, the depiction of light is similar to this.

[0076] Optical axis of top surfaces LED 20a and 20b are forwarding the vertically downward direction, and the detecting direction of main light sensors 21a and 21c are forwarding the horizontal direction, thus, both are disposed so as not to face each other. As a result, most of the component of light generated from top surface LEDs 20a and 20b are not directly incident on main light sensors 21a and 21c but the light reflected at the wall surface and the storage items are incident on main light sensors 21a and 21c.

[0077] Specifically, main light sensors 21a and 21c may be disposed on the position shifted from the optical axis of top surface LEDs 20a and 20b which are light sources. That is, since LEDs have high directivity, it is preferable to dispose main light sensors 21a and 21c on the position where the light from top surface LEDs 20a and 20b is not directly incident on, or to dispose so as not to be incident on.

[0078] One example of storage state detection characteristics detected by main light sensor 21a at this time is illustrated in Fig. 9. As illustrated in Fig. 9, it can be

seen that the illuminance decreases when the storage amount increases. However, in a case where only top surface LEDs 20a and 20b are turned on (lower side surface LED 20g is not turn on), even when the storage amount is same, error CEA occurs between maximum value (when the storage items are biased downward) MACA and minimum value (when the storage items are biased upward) MICA. As a result, it is needed to correct this error CEA. A method for the correction will be described below. Calculation control unit 1 stores the measured illuminance information in memory 2 as detection data A (S104).

[0079] In Fig. 9, the vertical axis of the graph represents "illuminance". However, a relative value such as a "relative illuminance" or an "illuminance attenuation rate" with respect to the reference storage room illuminance when the storage items are not stored in the storage room, can also be used. That is, attenuation rate calculation unit 81 in the calculation control unit 1 calculates the attenuation rate from the reference storage room illuminance in a state where the storage items are stored, based on the reference storage room illuminance in a state where the storage items are not stored in the storage room and the detected illuminance at light sensor 21. In this case, it is easy to correspond to the luminosity variations or the like that is initial characteristics of LEDs'. In addition, the vertical axis can also represent an "illuminance attenuation amount" with respect to the reference storage room illuminance when the storage items are not stored in the storage room. Hereinafter, a same concept will be used regarding the illuminance.

[0080] Top surface LEDs 20a and 20b can be controlled by calculation control unit 1 such that the detected illuminance at light sensor 21 in a state where the storage items are not stored in the storage room becomes a predetermined value. The controlling of the illuminance of top surface LEDs 20a and 20b is performed before the user uses refrigerator 100. In this way, it is possible to absorb the illuminance variations of each individual top surface LEDs 20a and 20b.

[0081] In addition, the output value based on the detected illuminance at light sensor 21 is a current value or a voltage value, thus, the attenuation rate (%) is calculated by comparing the output values.

[0082] In addition, the relative data between the illuminance attenuation rate and the storage amount is experimentally acquired in advance for each different types in a capacity, the width, the height of refrigerator 100 to be stored in calculation control unit 1.

[0083] Then, as the relative data between the illuminance attenuation rate of detected illuminance at light sensor 21 in a state where the storage items are not stored in the storage room and the storage amount, a plurality of relative data respectively corresponding to a plurality of light sources are stored.

[0084] In addition, the detected illuminance of light sensor 21 is a read out value after a predetermined time (for example, two seconds) from the time when top surface

LEDs 20a and 20b is turned on. An average time during top surface LEDs 20a and 20b is turned on may be the detected illuminance.

[0085] Next, calculation control unit 1, after top surface LEDs 20a and 20b are turned off, turns on lower side surface LED 20g disposed on the wall surface in the lower side that is a lower section of refrigerator 100 (S105). For example, a case where storage items 23c and 23d (for example, foods) are stored on internal storage shelf 18 as illustrated in Fig. 10, is assumed. At this time, light 24f output from LED 20g (component of light is illustrated in Fig. 10 as arrows. A dotted line indicates that the luminosity is attenuated) is reflected at storage items 23c and attenuated, and diffuses to another direction as light 24g. Light 24g further repeats the reflection at the wall surface of refrigerating room 12 and other storage items. In addition, light 24h reflected at storage items 23d is also attenuated and diffuses to other direction as light 24i and 24j, and further repeats the reflection at the wall surface of refrigerating room 12 and other storage items. After the repeated reflection like this, the brightness distribution in refrigerating room 12 is saturated to be stabilized.

[0086] In accordance with the desired detection accuracy, at least any one of lower side surface LEDs 20g and 20h may be turned on.

[0087] When lower side surface LEDs 20g is turned on, the detection is performed by main light sensor 21a. Since lower side surface LED 20g and main light sensor 21a are mounted on the same wall surface (Fig. 3A and Fig. 3B), both are not facing each other. Since the detection is performed with this combination, most of the components of light from lower side surface LED 20g are not directly incident on main light sensor 21a but are incident on via the reflection at the wall surface and the storage items. As a result, it is possible to detect the indirect illumination light that includes the light reflected at the storage items in the storage room.

[0088] An example of storage state detection characteristics by main light sensor 21a at this time is illustrated in Fig. 11. As illustrated in Fig. 11, it can be understood that the illuminance decreases with the increase of the storage amount. However, in a case where only lower side surface LED 20g is turned on (a case where top surface LEDs 20a and 20b are not turned on), even when the storage amount is same, there is an error CEB between maximum value (when the storage items are biased upward) MACB and minimum value (when the storage items are biased downward) MICB. As a result, it is needed to correct this error CEB. A method for the correction will be described below. Accordingly, it is possible to decrease the reason of variations caused by the bias of the storage items in the storage room, and possible to improve the estimation accuracy of the storage amount caused by the storage state of the storage items.

[0089] Calculation control unit 1 stores the measured illuminance information in memory 2 as detection data B (S106).

[0090] As described above, in a case where the stor-

age items are biased in upper section, when top surface LEDs 20a and 20b are turned on, the illuminance attenuation due to the increase of the storage amount increases (Fig. 9), and when the lower side surface LED 20g is turned on, the illuminance attenuation due to the increase of the storage amount decreases (Fig. 11). On the other hand, in a case where the storage items are biased in lower section, when top surface LEDs 20a and 20b are turned on, the illuminance attenuation due to the increase of the storage amount decreases (Fig. 9), and when the lower side surface LED 20g is turned on, the illuminance attenuation due to the increase of the storage amount increases (Fig. 11).

[0091] That is, it can be said that, when top surface LEDs 20a and 20b that are in the upper section are turned on, the sensitivity with respect to the storage items in the upper section is high, and when the lower side surface LED 20g that is on lower section is turned on, the sensitivity with respect to the storage items in the lower section is high.

[0092] In the present embodiment, the detection of the storage state of the storage items is performed by combining the detection result detected by sequentially turning on top surface LEDs 20a and 20b in the upper section and lower side surface LED 20g in the lower section. Specifically, calculation control unit 1, for example, calculates an average value of the detection data A (characteristics in Fig. 9) and the detection data B (characteristics in Fig. 11) as detection data C (S107). The storage state detection characteristics of the detection data C, that is, maximum value after averaging MACC and the minimum value after averaging MICC are illustrated in Fig. 12. When comparing Fig. 12, Fig. 9 and Fig. 11, by using the average value, error is almost eliminated, it is understood that the value is corrected such that the storage state can be detected with high accuracy regardless of the bias in placement of the storage items in the upper and lower section. At this time, calculation control unit 1 functions as an attenuation rate calculation correction unit that corrects the reference data of attenuation rate

[0093] In the example described above, the correction of the bias in placement of the storage items in a vertical direction is described. Additionally, regarding the bias in placement of the storage items in a horizontal direction or back-front direction, by a same concept as described above, refrigerating room 12 may be divided into two sections and LEDs or light sensor 21 may be provided respectively. The number of LEDs and light sensor 21 may be increased, but it is possible to detect the storage state with higher accuracy.

[0094] Next, calculation control unit 1 performs a process of correcting the errors generated when there is an obstacle in the path of light incident on main light sen-

sor 21a (obstacle correction process). Calculation control unit 1 includes attenuation rate calculation unit 81 that calculates the attenuation rate of the detected illuminance based on the detected illuminance at light sensor 21 and the reference data. Calculation control unit 1 functions as an attenuation rate calculation correction unit in the obstacle correction process and below-described reflection object correction process. In this case, storage state estimation unit 82 estimates the storage amount of the storage items based on the calculation result of attenuation rate calculation unit 81 and the calculation result of attenuation rate calculation correction unit.

[0095] Fig. 13 is a diagram for explaining an example of storage in the vicinity of main light sensor 21a in refrigerator 100 in the first embodiment of the present invention. Fig. 14 is a diagram for explaining an example of error occurrence due to the storage items in the vicinity of main light sensor 21a in same refrigerator 100. Fig. 15 is a diagram illustrating storage state detection characteristics in the vicinity of main light sensor 21a in same refrigerator 100.

[0096] As illustrated in Fig. 13, a case where storage item 23e (hereinafter, also referred to as obstacle) is placed on door storage shelf 19 in the lower part is assumed. In this case, since storage item 23e exists in the vicinity of main light sensor 21a, there is possibility that storage item 23e may be an obstacle that narrows the path of light incident on main light sensor 21a.

[0097] An example of storage state detection characteristics by main light sensor 21a when the obstacle exists like this is illustrated in Fig. 14 (detection data C). As illustrated in Fig. 14, a maximum value (a) of determination characteristics F when the obstacle does not exist (solid line) attenuates to a maximum value (b) of determination characteristics G when the obstacle exists (dotted line). That is, an error DE is generated according to the existence of obstacles. As similar to this, a minimum value (c) of determination characteristics F when the obstacle does not exist attenuates to a minimum value (d) of determination characteristics F when the obstacle exists, and the error DE is generated.

[0098] In the present embodiment, in order to correct these errors, the storage state of storage item 23e is detected using lower side surface LED 20h that is provided on the wall surface in the opposite side where lower side surface LED 20g is provided, and sub-light sensor 21b disposed in the shifted position on the door side of the same wall surface as where main light sensor 21a is disposed.

[0099] As illustrated in Fig. 7B, calculation control unit 1 turns off lower side surface LED 20g and turns on lower side surface LED 20h (S108), and acquires detection data D of sub-light sensor 21b (S109). The characteristics of detection data D is illustrated in Fig. 15. If the size of storage items 23e is large enough to a level of narrowing the path of light incident on the main light sensor 21a, the path of light linking lower side surface LED 20h and sub-light sensor 21b is shielded. For this reason, detec-

tion data D of sub-light sensor 21b rapidly decreases (refer to Fig. 15).

[0100] Using this phenomenon, calculation control unit 1 determines the existence of the obstacle by comparing detection data D and predetermined threshold value E (S110). When detection data D is larger than threshold value E, it is determined that the obstacle does not exist (region (a) in Fig. 15), when detection data D is smaller than threshold value E, it is determined that the obstacle exists (region (b) in Fig. 15). When it is determined that the obstacle exists, calculation control unit 1 determines the storage state using determination characteristics F at the time when the obstacle does not exist illustrated in Fig. 14 (S111). When it is determined that the obstacle does not exist, calculation control unit 1 determines the storage state using determination characteristics G at the time when the obstacle exists illustrated in Fig. 14 (S112).

[0101] That is, calculation control unit 1 has two kinds of reference data (determination characteristics F and G) of both the cases where the obstacle exists and does not exist in advance, and determines the storage state by selecting any one thereof in the obstacle correction process.

[0102] In this way, in the present embodiment, it is possible to correct the error generated in the case where there is an obstacle on the path of light incident on main light sensor 21a.

[0103] In the above, the correction process of error generated due to the storage items in the vicinity of main light sensor 21a is described. However, the process can be also used as the process of detecting the storage state of storage items 23e in the heat insulation door. At this time, main light sensor 21a may be disposed on the position to be in shadow when storage items 23e are disposed on door storage shelf 19. At this time, calculation control unit 1 functions as the attenuation rate calculation correction unit that corrects the reference data of attenuation rate calculation unit 81 based on the storage state of the storage items in the heat insulation door in the storage room. Calculation control unit 1 functions as the attenuation rate calculation correction unit that corrects the reference data of attenuation rate calculation unit 81 based on the storage state of the storage items in the vicinity of light sensor 21. In this way, it is possible to reliably improve the estimation accuracy of the storage amount caused by the bias in placement of the storage items in the heat insulation door.

[0104] Furthermore, refrigerator 100 in the present embodiment can perform the correction of the error generated in a case where storage item 23f having a high reflection rate (hereinafter, referred to as a reflection object) exists in the vicinity of main light sensor 21a. This method of correction (process of correcting the reflection object) will be described.

[0105] Fig. 16 is a diagram for explaining a storing example of a reflection object in the vicinity of main light sensor 21a in refrigerator 100 in the first embodiment of

the present invention. Fig. 17 is a diagram for explaining an example of error occurrence due to the reflection object in the vicinity of main light sensor 21a in refrigerator 100. Fig. 18A to Fig. 18C are diagrams illustrating relationship between wavelength and reflection rate of the light in same refrigerator 100. Fig. 19 is a diagram illustrating reflection object detection characteristics in the vicinity of main light sensor 21a in same refrigerator 100.

[0106] Generally, the storage items having a high reflection rate (reflection object) are the objects having a white color or a color close to white. In addition, an object that has a low diffusion of light on the surface and a light-condensing property such as a metal container, is also defined as a reflection object.

[0107] In Fig. 16, it is assumed that storage item 23f disposed in the vicinity of main light sensor 21a is a reflection object. When the reflection rate of storage item 23f is high, the light attenuation due to the reflection is small, or in some case, the light is condensed without being diffused. For this reason, there is a tendency that the illuminance in the vicinity of storage item 23f increases. Accordingly, the illuminance in the vicinity of main light sensor 21a also increases.

[0108] As illustrated in an example of storage state detection characteristics detected by main light sensor 21a (detection data C) in Fig. 17, errors are generated due to the difference in reflection rate of storage item 23f. For example, error J is generated in characteristics (b) at the time when the storage item having a slightly high reflection rate exists indicated by a dotted line, with respect to characteristics (a) at the time when the reflection object does not exist indicated by a solid line, and error H is generated in characteristics (c) at the time when the storage item having a high reflection rate exists indicated by a dashed line.

[0109] In order to correct this error, in the present embodiment, a reflection influence caused by storage item 23f is detected using blue LED 22a and main light sensor 21a. Generally, a white object has a high reflection rate, therefore, an example of identifying a white object will be described here.

[0110] First, the reason for using blue LED 22a will be described. For example, as illustrated in Fig. 18A (reflection rate characteristics at a red object), light of blue wavelength band BW having a peak wave length of 400 to 500 nm (light of blue LED 22a having peak wave length band) has a low reflection rate at the red object. In addition, as illustrated in Fig. 18B (reflection rate characteristics at a blue object), light of blue LED 22a having peak wave length band BW also has a low reflection rate of equal to or lower than 50% at the blue object. On the other hand, as illustrated in Fig. 18C (reflection rate characteristics at a white object), since the white object has characteristics of strongly reflecting the light of the entire wavelength band, the reflection rate thereof is also high with respect to the light of blue LED 22a having peak wave length band BW. That is, since the wavelength of blue light has difficulty in reflecting at the object other

than white object, it is suitable for distinguish a white object. Therefore, in the present embodiment, the white object is identified using blue LED 22a.

[0111] For example, it is assumed that light having a wavelength of red color instead of blue is used. In this case, as illustrated in Fig. 18A, light of red wavelength band RW having a peak wave length of approximately 650 nm has a high reflection rate at the red object. It is a similar reflection rate to the reflection rate at the white object as illustrated in Fig. 18C. That is, since the red light reflects in a certain level even at the red object which has low reflection rate, it is difficult to distinguish the white and red objects. Therefore, in order to perform the identification reflection object, it is preferable to use blue LED 22a.

[0112] Since the reflection rate is affected by the color of the object, for example, if a chromaticity sensor using wavelength of RGB is used for detecting the reflection object, it is possible to identify with higher accuracy.

[0113] In addition, an object that has a low diffusion of light such as a metal container condenses the light regardless of the wavelength of the light. Thus, it is possible to detect utilizing such characteristics.

[0114] For example, as illustrated in Fig. 19, since there is a relationship between the error due to the reflection object and the output of main light sensor 21a when blue LED 22a is turned on, the error component is corrected utilizing such relationship.

[0115] Specifically, first, calculation control unit 1 turns off internal lighting 20 and turns on blue LED 22a (S113), and stores detection data K detected by main light sensor 21a in memory 2 (S114).

[0116] Next, calculation control unit 1 compares threshold value L determined as illustrated in Fig. 19 and detection data K (S115). Fig. 19 is a diagram illustrating a relationship between the influence of error due to the reflection object when the blue LED is turned on and the illuminance (detection data K). As a result of comparison in STEP S115, if detection data K is smaller, the error is determined to be ES which means the influence of error due to the reflection object is small, and the correction is not performed (S116). On the other hand, if detection data K is larger, the error is determined to be EL which means the influence of the error exists, the value of the error J or the error H is estimated based on error determination characteristics M of error due to the reflection object, and the correction of detection data C illustrated in Fig. 17 is performed (S117).

[0117] In detail, correction of detection data C is performed by subtracting the value of the error J or the error H.

[0118] By performing each STEP (process of acquiring basic data, process of obstacle correction and process of reflection object correction) described above, calculation control unit 1 calculates storage amount detection characteristics after the correction. At this time, calculation control unit 1 functions as an attenuation rate calculation correction unit that corrects the reference data of

attenuation rate calculation unit 81 based on the reflection rate of the storage items in the storage room. As a result, it is possible to reliably improve the estimation accuracy of storage amount caused by the reflection rate of the storage items.

[0119] Fig. 20 is a storage state detection characteristics diagram after the correction calculation in the first embodiment of the present invention.

[0120] Fig. 20 illustrates the detection characteristics (after the correction) of the storage amount after performing the acquiring of basic data, obstacle correction and reflection object correction by calculation control unit 1 through each STEP illustrated in Fig. 7A and Fig. 7B. The error between the maximum value after the correction (a) and minimum value after the correction (b) is extremely small, it is understood that the storage state can be accurately estimated in an analog manner. Calculation control unit 1 performs the detection of the storage amount using the characteristics after the correction. Specifically, storage state estimation unit 82 estimates the storage amount of the storage items based on the calculation result by attenuation rate calculation unit 81 (STEP 118). Storage state estimation unit 82 estimates the storage state of the storage items by the output value based on the illumination light from light sensor 21.

[0121] In the present embodiment, in the estimation of the storage state, as illustrated in Fig. 20, the specification is made to determine the storage amount in five steps of level one to five by providing a plurality of threshold values P, Q, R, and S. In detail, storage state estimation unit 82 of calculation control unit 1 determines the storage amount as; a storage amount of level one when the threshold value is equal to or larger than P, a storage amount of level two when the threshold value is in P to Q, a storage amount of level three when the threshold value is in Q to R, a storage amount of level four when the threshold value is in R to S, and a storage amount of level five when the threshold value is equal to or less than S. That is, in a case where the attenuation rate calculated by attenuation rate calculation unit 81 is large, storage state estimation unit 82 estimates that the storage amount is large.

[0122] In the example described above, storage state estimation unit 82 estimates the storage amount of the storage items based on the value of attenuation rate calculated by attenuation rate calculation unit 81. That is, the description is regarding the estimation of storage amount by the absolute value of illuminance.

[0123] However, the present invention is not limited to this example. For example, it may be configured to have a configuration in which storage state estimation unit 82 estimates storage amount based on the calculation result of attenuation rate calculation unit 81, specifically, a configuration in which the attenuation rate calculation unit calculates the attenuation rate from a reference storage room illuminance, by setting the calculation result up to the previous calculation (both of the previous calculation results or earlier calculation results may be good) as a

reference storage room illuminance.

[0124] In this way, only the data up to previous calculation may be stored in memory 2, and the control in calculation control unit 1 becomes easy.

[0125] For example, in the relationship in Fig. 20, when determining the increase of the storage amount, if the storage amount before being changed is in level three, the storage amount is determined so as to move to level four only when the change of illuminance is larger than difference of "threshold value Q - threshold value R", and is held in level 3 in the other cases. As a result, even a detection error may be generated in several percent due to the external noise or the like, it is possible to prevent the change of the storage state being erroneously detected. When determining the decrease of the storage amount, the detection can be performed in the same concept. In this way, it is possible to estimate the relative change of the storage amount based on the relative value of the change of illuminance.

[0126] Furthermore, calculation control unit 1 may be configured to normally estimate the relative changes of the storage amount based on the relative value of the change of illuminance, and periodically estimate the absolute value of the storage amount based on the absolute value of illuminance. By such a configuration, even in a case where the change of storage amount with the passage of time is very small and where the determined level of storage amount is not changed, it is possible to determine the correct storage amount by estimating the absolute value periodically.

[0127] In addition, it is also possible that storage state estimation unit 82 of calculation control unit 1, using the detection result of door opening and closing detection sensor 3, estimates the storage state (increase or decrease) of the storage items in the storage room based on the output value of light sensor 21 before opening the door and the output value of light sensor 21 after closing the door.

[0128] For example, it is also possible that storage state estimation unit 82, in a case where the change amount of the output value from light sensor 21 before opening the door and the output value from light sensor 21 after closing the door is small, estimates that the storage amount of the storage items in the storage room are not changed.

[0129] In this way, in a case where refrigerator 100 is in an energy-saving operation, the change of storage amount before and after the door opening and closing is small, it is determined that there is no need to cancel the energy-saving operation, thus, refrigerator 100 continues the energy-saving operation, eventually it is possible to save power.

[0130] The output value based on the detected illuminance at light sensor 21 is a current value or a voltage value, and the attenuation rate (%) is calculated by comparing the output value. The attenuation rate (%) may be stored in memory 2, and the control in calculation control unit 1 becomes easy.

[0131] Even in a case of the configuration where the attenuation rate from the reference storage room illuminance is calculated by setting the calculation result up to the previous calculation as the reference storage room illuminance, that is, in a case of estimating the relative change of the storage amount (estimating the increase or decrease of the storage amount) based on the relative value of the change of illuminance, the basic flow in Fig. 7A and Fig. 7B is similar. However, in the process of obstacle correction, by preparing two kinds of threshold values in which the change amount is different according to the existence of obstacles, the obstacle correction may be performed by selecting any one of those threshold values.

[0132] In the process of reflection object correction, when the reflection object exists, the reflection object correction may be performed by subtracting a certain value such that the storage amount is determined to be large.

[0133] As illustrated in Fig. 20, intervals between threshold values P to S are set to be wide when the storage amount is small, and to be narrow when the storage amount is large. This setting is set under the consideration that, as the storage amount decreases, the slope of the storage amount detection characteristics (after correction) increases, and as the storage amount increases, the slope decreases. Each of intervals P to S is set such that the intervals between the storage levels one to five be equal.

[0134] In the estimation of the storage amount, the determination may be performed in a complete analog manner (that is, based on the characteristics diagram in Fig. 20, calculating the absolute value of the storage amount corresponding to the absolute value of illuminance), without performing the step dividing using the plurality of threshold values as described above.

[0135] After the estimation of the storage state, calculation control unit 1 controls cooling system 35 such as compressor 30, cooling fan 31, and air amount control damper 32, according to the storage amount, the change of the storage amount or the position of the storage or the like, and changes the conditions in order for performing the optimal cooling operation.

[0136] Even when the positional relationship of LEDs and light sensor 21 described above is reversed, the method of detecting the storage state described above may be applied.

[0137] During sequentially turning on the LEDs and detecting the storage state of the storage items, calculation control unit 1 can also notify the user by causing the lamp of display unit 17 to flicker. Furthermore, calculation control unit 1, after the detection of the storage state, can also notify the user by displaying the detection result on display unit 17.

[0138] A case is assumed that the heat insulation door is detected to be in an opened state by door opening and closing detection sensor 3, from the time when the heat insulation door is detected to be in a closed state by door opening and closing detection sensor 3 to the time when

the series of control operation is ended by calculation control unit 1. In this case, after ending the series of control operations in force, and starts again the series of control operations by calculation control unit 1 after the heat insulation door is detected to be in a closed state by calculation control unit 1. In this way, even in a case where the heat insulation door is opened during the control operation, by performing the series of control operation again, it is possible to detect the storage state with higher accuracy.

[0139] In the present embodiment, as illustrated in Fig. 7A and Fig. 7B, an example of performing all of the process such as the process of acquiring the basic data, the obstacle correction process, and the reflection object correction process, is described. However, the present invention is not limited to the example. For example, any of the obstacle correction processes and the reflection object correction processes may be skipped.

[0140] As a simple way, by performing the process of acquiring the basic data (S103 to S107), and based on the result thereof, performing the determination of the storage amount (S118), it is possible to estimate the storage amount of the storage items.

[0141] In the process of acquiring the basic data (S103 to S107), regarding the order of turning on top surface LEDs 20a and 20b, and lower side surface LED 20g, any of them may be turned on first.

[0142] In this case, refrigerator 100 in the present embodiment may have a configuration to include; top surface LEDs 20a and 20b and lower side surface LEDs 20g and 20h disposed in refrigerating room 12, and main light sensor 21a and 21c that are light sensor 21 which detects the illumination light. Refrigerator 100 can estimate the storage state of the storage items based on the illuminance attenuation amount at main light sensors 21a and 21c. In this way, it is possible to cope with the variations of the initial characteristics of LEDs which are light sources, and possible to estimate the entire storage state in refrigerating room 12 with high accuracy.

[0143] In the process of acquiring the basic data (S103 to S107), STEPS S105 to S107 (process of setting average value of data A and B to as C) are not essential, but acquiring data A may be regarded as a process of acquiring the basic data.

[0144] The obstacle correction process and the reflection object correction process are not essential, the storage state of the storage items may be estimated only by the process of acquiring the basic data.

[0145] It is also possible to estimate the storage state of the storage items by combining the process of acquiring the basic data and the obstacle correction process.

[0146] It is also possible to estimate the storage state of the storage items by combining the process of acquiring the basic data and the reflection object correction process.

[0147] In the present embodiment, in Fig. 7A, a case of starting the detection of the storage state (operation of acquiring the basic data) after a predetermined time

is counted by timer 4 (S102) from the time when refrigerating room door 12a is closed, is described. However, after the detection of the door being opened or closed in STEP S101, the process can be moved to the process of acquiring the basic data after the confirmation that output value at light sensor 21 is equal to or less than the predetermined value (the state of no illumination light) by calculation control unit 1. In this way, the influence by the external light can reliably be eliminated. It is also possible to detect the abnormality such as a failure of light sensor 21, and possible to improve the reliability of refrigerator 100.

[0148] In the present embodiment, the illumination light from the light source repeats the reflections in the storage room to go around the entire positions in the refrigerator, and is incident on light sensor 21 in the storage room. In this way, it is possible to detect the storage state with a simple configuration in which the number of parts is small. Only any one of main light sensors 21a and 21c may be disposed. In this way, it is possible to further reduce the cost. At this time, calculation control unit 1 is to estimate the storage state of the storage items from the storage situations with respect to each light source, based on the result of the light receiving from the plurality of light sources and single light sensor 21 in the storage room. In a case where the storage room is divided into a plurality of sections (divided into two sections in a height direction, depth direction and horizontal width direction), at least one of the light sources among the plurality of light sources is provided in the section where light sensor 21 is disposed, and estimates the storage state of the storage items based on the detection result at light sensor 21, of the illumination light from the light sources of each section.

[0149] The attenuation amount of illuminance detected by main light sensors 21a and 21c can be used as the attenuation amount of illuminance in an actual storage state with respect to the standard illuminance in the storage room in a state where there is no storage item in the storage room, it is possible to estimate the storage state of the storage items using this. In this way, it is possible to cope with not only the variations of the LEDs which are light sources but also the individual variation in the storage room in refrigerator 100, and possible to further improve the estimation accuracy of the storage state of the storage items.

[0150] The attenuation amount of illumination detected by main light sensors 21a and 21c is the amount in which the indirect illumination light that includes the reflection light at the storage items in the storage room is detected and calculated. In this way, it is possible to easily estimate the storage state of the storage items with high accuracy.

[0151] Main light sensors 21a and 21c are disposed so as to be shifted from the optical axis of the light sources. In this way, since main light sensors 21a and 21c do not receive the direct light from the light sources, it is possible to easily estimate the storage state of the storage items entirely in the refrigerator with high accuracy.

[0152] Main light sensors 21a and 21c and the light sources have a configuration to be disposed either on the surface not facing each other or so as not to face each other, in the storage room. In this way, main light sensors 21a and 21c can reliably be prevented from receiving the direct light from the light sources, and it is possible to easily estimate the storage state of the storage items in the entire refrigerator with high accuracy.

[0153] By providing the attenuation rate calculation correction unit that corrects the attenuation amount of illuminance at main light sensors 21a and 21c according to the storage state, the variation factors due to the bias in placement of the storage items in the storage room can be absorbed, and it is possible to improve the estimation accuracy of the storage amount caused by the storage state of the storage items.

[0154] As an attenuation rate calculation correction unit that corrects the attenuation amount of illuminance at main light sensors 21a and 21c by the storage state, by providing means for correcting the vertical storage state of the storage items in the storage room, it is possible to reliably improve the estimation accuracy of the storage amount caused by the vertical bias in placement of the storage items.

[0155] As an attenuation rate calculation correction unit that corrects the attenuation amount of illuminance at main light sensors 21a and 21c by storage state, by providing means for correcting the storage state of the storage items at the heat insulation door in the storage room, it is possible to reliably improve the estimation accuracy of the storage amount caused by the bias in placement of the storage items in the heat insulation door.

[0156] As an attenuation rate calculation correction unit that corrects the attenuation amount of illuminance at main light sensors 21a and 21c by storage state, by providing means for correcting the storage state of the storage items in the vicinity of light sensor 21 in the storage room, it is possible to reliably improve the estimation accuracy of the storage amount caused by the generation of the shadow by the storage items with respect to light sensor 21.

[0157] As an attenuation rate calculation correction unit that corrects the attenuation amount of illuminance at main light sensors 21a and 21c by the storage state, by providing means for correcting the reflection rate of the storage items in the storage room, it is possible to reliably improve the estimation accuracy of the storage amount caused by the reflection of the storage items.

[0158] By disposing light sensor 21 at the lower position than the light source, the influence of dew condensation due to the flow-in of outside air in the opening and closing of the door can be decreased by light sensor 21, it is possible to estimate the storage state of the storage items with a high accuracy based on the attenuation amount of illuminance at light sensor 21.

[0159] Internal lighting 20 and light sensor 21 are provided at refrigerating room door 12a side than the center position in the depth direction of refrigerating room 12.

In this way, it is possible to reliably detect the storage state of the storage items near the entrance where the flowed-in outside air by the opening and closing of the door, easily influences.

[0160] Internal lighting 20 and light sensor 21 are provided between the front end portion of internal storage shelf 18 included in refrigerating room 12 and refrigerating room door 12a. The vertical space between refrigerating room door 12a and the front end portion of internal storage shelf 18 has a low possibility of being blocked by the storage items. In this way, a stable light path from the light source can be secured, and it is possible to estimate the storage state of the storage items with high accuracy based on the attenuation amount of illuminance at light sensor 21 by the existence of the storage items at the heat insulation door or internal storage shelf 18.

[0161] Since refrigerating room 12 is divided into a plurality of sections, it is possible to perform the detection of the storage state with high accuracy regardless of the bias in placement of the storage items.

[0162] Since at least a part of light source used for the detection of the storage state is in a combined use as internal lighting 20, it is possible to detect the storage state with a simple configuration without providing new light sources. In a case where internal lighting 20 and at least a part of light source used for the detection of the storage state are in a combined use, it is possible to further improve the detection accuracy of the storage state by changing the brightness for lighting when the door is opened and the brightness for lighting needed for detection of the storage state.

[0163] Since the detection is performed with the combination in which the LED and light sensor 21 are disposed so as not to face each other, the light component directly incident on light sensor 21 from the LED can be suppressed, it is possible to increase the attenuation rate of the light by the storage items, and to improve the detection accuracy.

[0164] With a configuration for identifying and correcting the storage state in the vicinity of LED or light sensor 21, for example, it is possible to suppress the errors due to the obstacles with respect to the incidence path of the light in the vicinity of light sensor 21, and the errors due to the reflection object stored in the vicinity of light sensor 21.

(Second Embodiment)

[0165] Hereinafter, the configuration of refrigerators 200 to 205 in the second embodiment of the present invention will be described based on Fig. 21 to Fig. 25.

[0166] The configuration the same as or similar to the configuration described in the first embodiment will be referenced by the same numerals and the description will not be repeated.

[0167] Fig. 21 is a cross-sectional view seen from the side of refrigerator 200 in the second embodiment of the present invention. Fig. 22 is a diagram for explaining the

state in which storage item 23h is stored in the back of the refrigerating room in refrigerator 200. Fig. 23A is a cross-sectional view seen from the top illustrating an example of arranging light sensor 21 in refrigerator 201 in the second embodiment of the present invention. Fig. 23B is a cross-sectional view seen from the top illustrating an example of arranging light sensor 21 in refrigerator 202 in the second embodiment of the present invention. Fig. 24A is a cross-sectional view seen from the side illustrating an example of arranging light sensor 21 in refrigerator 203 in the second embodiment of the present invention. Fig. 24B is a cross-sectional view seen from the side illustrating an example of arranging light sensor 21 in refrigerator 204 in the second embodiment of the present invention. Fig. 25 is a cross-sectional view seen from the top illustrating an example of arranging light sensor 21 to the air path in refrigerator 205 in the second embodiment of the present invention.

[0168] In the present embodiment, examples of various methods of disposing light sensor 21 in a case where the detection is performed using internal lighting 20 mainly provided on the side surface, will be described.

[0169] The positional relationship between the LEDs and light sensor 21 will be described.

[0170] In the example illustrated in Fig. 21 and Fig. 22, main light sensors 21d and 21e are disposed on the top surface. Lights from lighting LEDs 20c to 20f illuminated from refrigerating room door 12a side to the depth direction and light from lower side surface LED 20g are reflected at the inner wall in the refrigerator and the foods, cross the inside of the whole refrigerator, and are incident on main light sensors 21d and 21e. For this reason, main light sensor 21d is disposed at the outer side with an illumination angle β where the emission luminosity of lighting LEDs 20c to 20f and lower side surface LED 20g is equal to or higher than 50%, such that lights from lighting LEDs 20c to 20f and light from lower side surface LED 20g are not directly incident on main light sensor 21d.

[0171] In order to cause the light to cross the inside of the whole refrigerator, it is preferable to detect the internal door side where the light is reflected at the back in the refrigerator and returned. Therefore, top surface light sensor 21d is provided on the position of refrigerating room door 12a side than 1/2 (center) position in depth direction in the refrigerator. However, in order to detect the storage state in the back side in the refrigerator more accurately, main light sensor 21e is installed in a supplement to main light sensor 21d. Therefore, main light sensor 21e is disposed on the back side in the refrigerator and within the incident angle β of lighting LED 20c.

[0172] When refrigerating room door 12a is opening and closing, outside air flows into the refrigerator and the internal temperature is slightly increased. At this time, the storage items near the door are more easily influenced by such a temperature change than the storage items of back side in the refrigerator. Accordingly, it is needed to detect storage state of the storage items near

the door side more accurately, the effect of providing main light sensor 21a on the refrigerating room door 12a side is higher.

[0173] On account of the structural design, there is a case that this condition cannot be met. Those are cases in which it is difficult to provide main light sensor 21a on the refrigerating room door 12a side, or main light sensor 21a comes within the illumination angle of LED. In such cases, it is necessary that main light sensor 21a is not installed so as to face LED light source as possible, such that the illumination light of LED is not directly incident on main light sensor 21a.

[0174] In the present embodiment, as illustrated in Fig. 22, among main light sensors 21d and 21e, even in a case where any one of the sensors (in this case, main light sensor 21e) is blocked by storage items 23h, it is possible to detect the storage state by another main light sensor 21d.

[0175] In the description above, main light sensor 21d is disposed on the top surface of refrigerating room door 12a side than 1/2 (center) position in the depth direction in the refrigerating room. In addition, main light sensor 21e is provided on the top surface in the back side than 1/2 (center) position in the depth direction. However, the present invention is not limited to this example.

[0176] For example, as illustrated in refrigerator 201 in Fig. 23A, main light sensor 21f may be disposed on the door side in the left than 1/2 (center) position in the storage room in the horizontal direction, main light sensor 21g may be disposed on the door side in the right than 1/2 (center) position in the horizontal width in the refrigerator.

[0177] As illustrated in refrigerator 202 in Fig. 23B, main light sensor 21h may be disposed on refrigerating room door 12a, and main light sensor 21i may be disposed on the back side in the right than 1/2 (center) position in the horizontal width in the refrigerator. With this configuration, it is possible to detect the storage state of not only the foods on the left and right side but also the foods on the front and back side in detail. By providing main light sensor 21h on refrigerating room door 12a, main light sensor 21h becomes to be disposed so as to look over the inside of the whole refrigerator toward the depth direction, the storage amount in the refrigerator can easily be detected. In order to acquire the similar effects, by providing the main light sensor toward the depth direction, it is also possible to provide the main light sensor on the wall surface in the refrigerator.

[0178] As illustrated in refrigerator 203 in Fig. 24A, main light sensor 21j may be disposed on the top portion in the storage room and refrigerating room door 12a side, and main light sensor 21k may be disposed on the lower portion of the storage room and refrigerating room door 12a side. As a result, it is possible to detect the light amount in the upper storage space than 1/2 (center) position of the height in the refrigerator by main light sensor 21j, and to detect the light amount in the lower storage space than 1/2 (center) position of the height in the re-

frigerator by main light sensor 21k.

[0179] Generally, since main light sensors 21j and 21k are provided on the upper and lower portion in refrigerating room 12 where the height is highest compared to other storage room, it is possible to detect the food storage state in detail.

[0180] As illustrated in refrigerator 204 in Fig. 24B, main light sensor 21m may be disposed on the top portion in the storage room and refrigerating room door 12a side and main light sensor 21n may be disposed on the lower portion of the storage room and on the back side. By this configuration, it is possible to detect the front and upper side of the storage space by main light sensor 21m and to detect the back and lower side of the storage space by main light sensor 21n. As a result, it is possible to detect in detail the storage state of the storage items in the vertical direction as well as the storage state of the storage items in the back and front direction.

[0181] As illustrated in refrigerator 205 in Fig. 25, in addition to light sensor 21(not illustrated) provided on the door side in the refrigerator, main light sensors 21p and 21q may be provided in cooling air path 25 provided for blowing the cooling air into refrigerating room 12. At this time, the light is incident on sub-light sensor 21b via discharge port 26, but since discharge port 26 for cooling air path 25 to the storage room is surely opened, main light sensors 21p and 21q can secure the light incident path without being blocked by the storage items. In a case where discharge port 26 is blocked by the storage items such as foods, since the luminosity deteriorates, it is possible to detect the decrease of cooling air blowing efficiency into refrigerating room 12.

[0182] Light sensor 21 as well as discharge port 26 of the air path may be provided near the suction port.

[0183] In the description up to this point, a case of using two light sensors among light sensors 21a to 21q is described. However, the number of light sensors 21 used is not limited thereto, one light sensor may be used for reducing the amount of materials used, or a plurality of light sensors may be provided for improving the detection accuracy easily. In addition, the placement of the plurality of light sensor 21 is not limited to the above-described pattern either, when refrigerator 200 is divided into two sections, the light source or light sensor 21 may be disposed in both sections.

[0184] In order to perform the detection in further detail, the angle may be freely changed by driving light sensor 21 or the LEDs by a motor-actuator.

[0185] Even the positional relationship of LEDs and light sensor 21 described above may be in reverse, the method of detecting the storage state is still applicable.

[0186] As described above, in the present embodiment, in refrigerating room 12 divided into sections by the heat insulation wall and heat insulation door, lighting LEDs 20c to 20f, lower side surface LEDs 20g and 20h and main light sensor 21a to 21q are provided as the storage state detection unit that detects the storage state. In addition, at least one of light sensors 21 is provided

on the door side than the center position in the depth direction in refrigerating room 12. In this way, the temperature of the food affected by the storage state can be controlled in cooling so as to be in proper temperature, and it is possible to improve the retaining of freshness and to control the power consumption by suppressing the "excessive cooling".

[0187] By providing light sensor 21 that configures the storage state detection unit on the refrigerating room door 12a side than the center position in the depth direction of storage room, it is possible to accurately detect the storage state of the food near the entrance where the food is easily affected by the outside air flowed-in due to the opening and closing of the door, and is possible to maintain an appropriate temperature. Since, in case of refrigerating room 12, for example, there is a space between internal storage shelf 18 and door storage shelf 19, by disposing light sensor 21 here, it is possible to prevent the storage state detection unit from being blocked by the stored foods.

[0188] When light sensor 21 is provided on refrigerating room door 12a, it is possible to provide light sensors 21 so as to look over the inside of the whole refrigerator toward the depth direction from the door side in the refrigerator.

[0189] When refrigerating room 12 is divided into two sections of front and back at the center position in the depth direction, by providing light sensors 21 in each section, it is possible to accurately detect the storage state of the storage items on the back side in the refrigerator.

[0190] When refrigerating room 12 is divided into two sections of right and left at the center position in the horizontal width, if light sensors 21 are provided in each of the sections, the bias in placement of the stored foods in right and left can be identified.

[0191] When refrigerating room 12 is divided into two sections of upper and lower at the center position in the height, light sensors 21 can be provided in each section. In this way, generally, in refrigerating room 12 where the height is highest, by disposing light sensors 21 on the upper and lower side, it is possible to accurately detect the storage state in the whole refrigerator.

[0192] By providing light sensors 21 on the outside of the illumination range where the luminosity of LEDs is equal to or higher than 50%, since the illumination light of LEDs is incident on light sensors 21 after the reflection or blocking at the storage items without being directly incident on light sensor 21, detection of the storage state can be facilitated.

[0193] It is also possible to provide light sensors 21 in cooling air path 25 for blowing the cooling air into the storage room. In this way, since discharge port 26 of cooling air path 25 to the storage room is surely opened, incident path of light to light sensors 21 can be secured without being blocked by the foods. In a case where the discharge port is blocked by the storage items such as foods, since the luminosity of the light decreases, it is possible to detect the decrease of efficiency in blowing

of cooling air into refrigerating room 12.

[0194] When means for changing angle by which the forwarding direction of LEDs and light sensors 21 is provided, even in wide storage room, it is possible to detect the storage state of every corner in the refrigerator.

[0195] Using the configurations of refrigerators 100 and 200 to 205 described above, it is possible to apply such configurations to the refrigerators for home use or industrial use. In this way, using the functions of detecting the storage amount in refrigerators 100 and 200 to 205, it is possible to implement and apply to the control for switching the operation mode to power saving operation and the like.

[0196] As described above, since refrigerators 100 and 200 to 205 in each embodiment can estimate the whole storage amount as well as detecting the position of the storage items in the storage room, by performing the control of the temperature according to the storage state. Therefore, it is possible to exert a beneficial effect of improving the freshness retaining and suppressing the excessive cooling, and then controlling the power consumption.

[0197] In each embodiment described above, the description is made using an example of detecting the storage state of the storage items in refrigerating room 12 as the storage room. However, the present invention is not limited to this example. It may be also applicable to other storage rooms, for example, such as ice making room 13, temperature switching room 14, freezing room 15, and vegetable room 16.

INDUSTRIAL APPLICABILITY

[0198] As described above, according to the present invention, it is possible to obtain an exceptional effect in which the cooling according to the storage state of the storage items in the refrigerator is possible. Accordingly, the refrigerator that is provided with means for detecting the storage state of the storage items in the refrigerator, is useful.

REFERENCE MARKS IN THE DRAWINGS

[0199]

1	calculation control unit	
2	memory	
3	door opening and closing detection sensor	
4	timer	50
11	refrigerator body	
12	refrigerating room	
12a	refrigerating room door	
13	ice making room	
14	temperature switching room	55
15	freezing room	
16	vegetable room	
17	display unit	

18	internal storage shelf	
19	door storage shelf	
20	internal lighting	
20a, 20b	top surface LED	
5 20c to 20f	lighting LED	
20g, 20h	lower side surface LED	
21	light sensor	
21a, 21c to 21q	main light sensor	
21b	sub-light sensor	
10 22a, 22b	blue LED	
23a to 23h	storage items	
24a to 24j	light	
25	cooling air path	
26	discharge port	
15 30	compressor	
31	cooling fan	
32	air amount control damper	
35	cooling system	
81	attenuation rate calculation unit	
20 82	storage state estimation unit	
100, 200 to 205	refrigerator	

Claims

1. A refrigerator comprising:

a storage room that is divided into sections by a heat insulation wall and a heat insulation door, and stores storage items;
a light source that is disposed inside the storage room;
a light sensor that detects illumination light illuminated from the light source; and
a calculation control unit that performs a calculation process based on a detection result of the light sensor,
wherein the calculation control unit includes an attenuation rate calculation unit that calculates an attenuation rate from a reference storage room illuminance in a state that the storage items are stored, based on the reference storage room illuminance in a state that the storage items are not stored in the storage room and a detected illuminance by the light sensor, and a storage state estimation unit that estimates a storage amount of the storage items, based on a calculation result of the attenuation rate calculation unit.

2. The refrigerator of Claim 1, wherein, in a case where the attenuation rate calculated by the attenuation rate calculation unit is large, the storage state estimation unit estimates that the storage amount is large.

3. The refrigerator of Claim 1 or 2, further comprising:

a door opening and closing detection unit that detects opening and closing of the heat insulation door,

wherein, in a case where the door opening and closing detection unit detects a closed state, the calculation control unit starts the calculation process. 5

4. The refrigerator of Claim 1, wherein the light sensor is disposed on a heat insulation door side than a center position in a depth direction in the storage room, and detects reflection light which is the illumination light reflected by a wall surface in the storage room or by the storage items. 10 15

5. The refrigerator of Claim 4, wherein the light sensor is provided between a vertical surface that includes an end portion of a front side of an internal storage shelf provided in the storage room and a vertical surface that includes an end portion of a back side of the heat insulation door. 20

6. The refrigerator of Claim 4 or 5, wherein the light source is disposed on an upper position than the light sensor, inside the storage room. 25

7. The refrigerator of Claim 4 or 5, wherein the light sensor is disposed at a position shifted from an optical axis of the light source, inside the storage room. 30

35

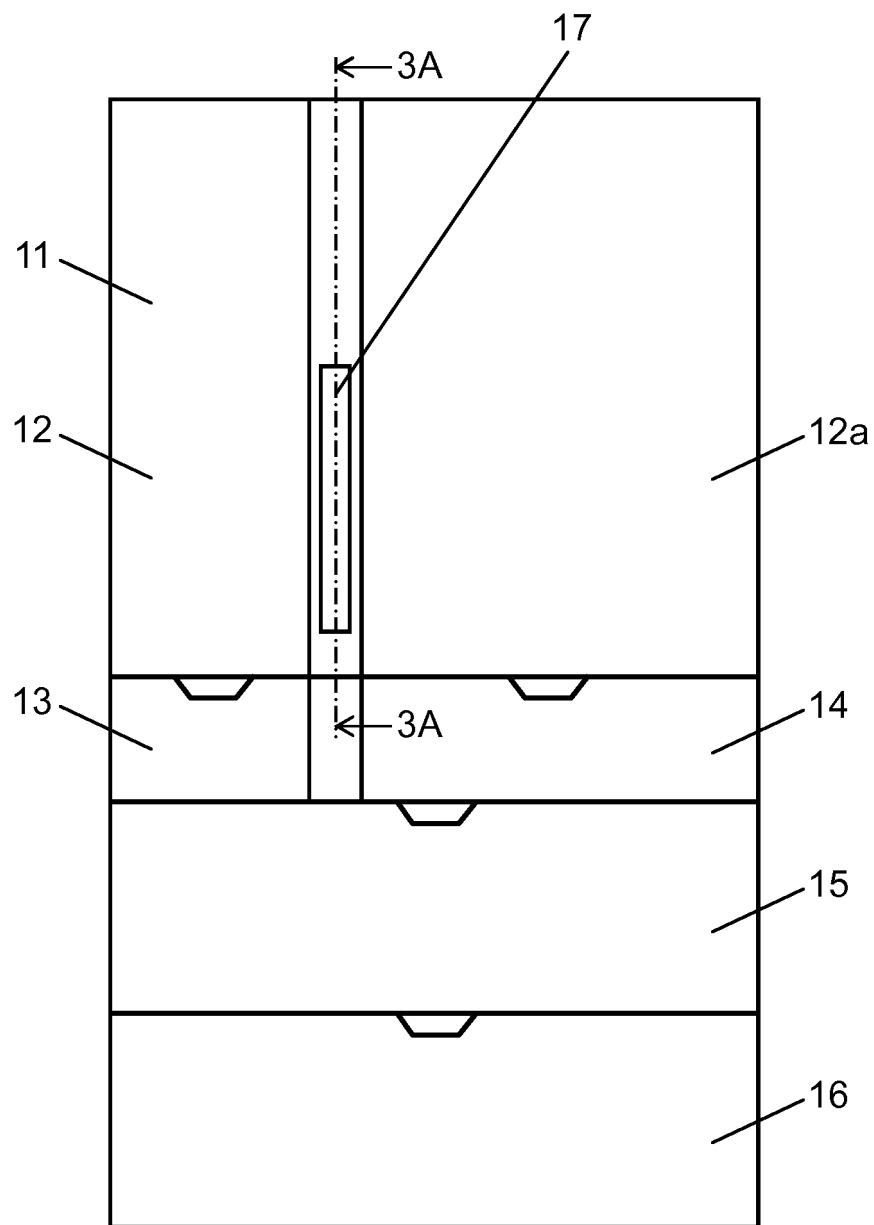
40

45

50

55

FIG. 1



100

FIG. 2

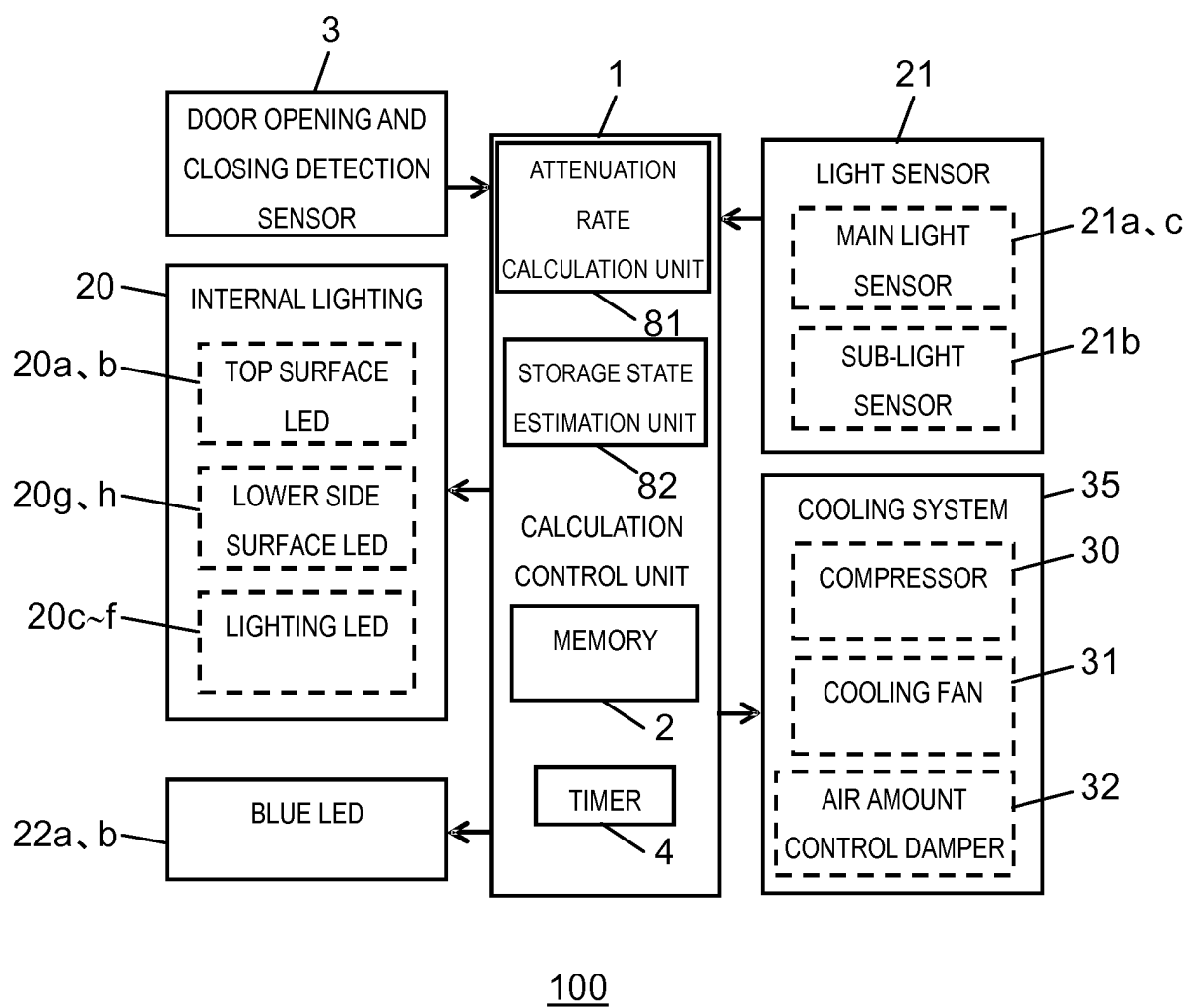


FIG. 3A

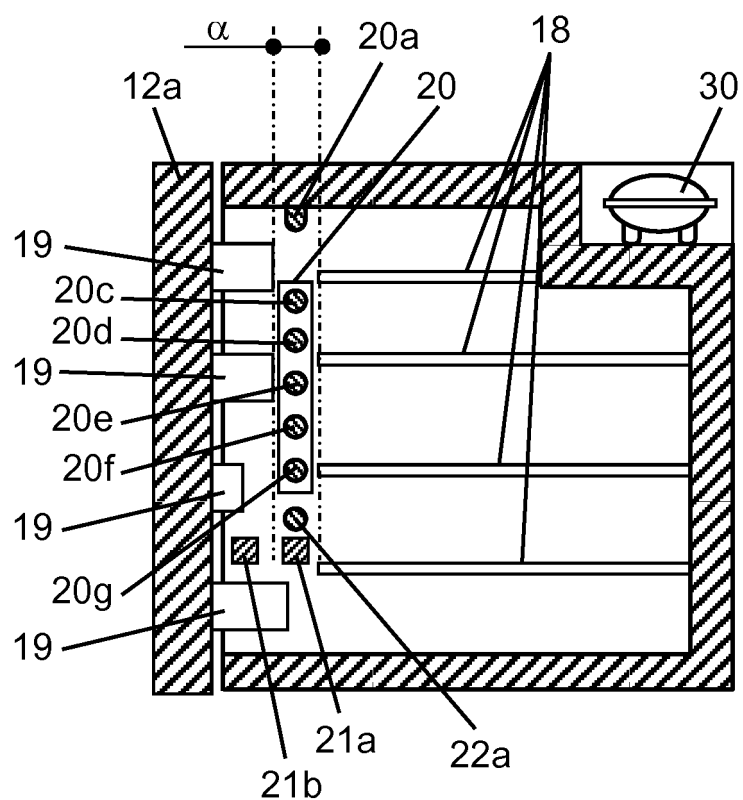


FIG. 3B

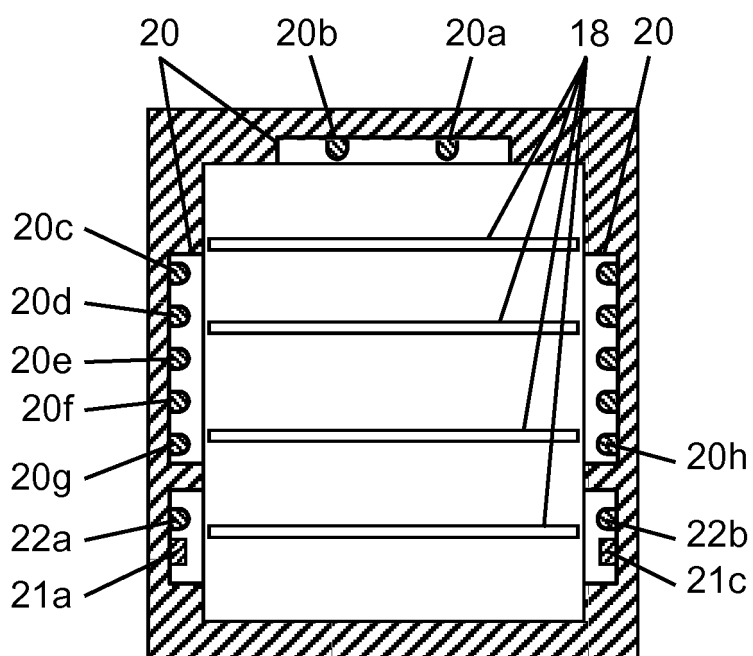


FIG. 4

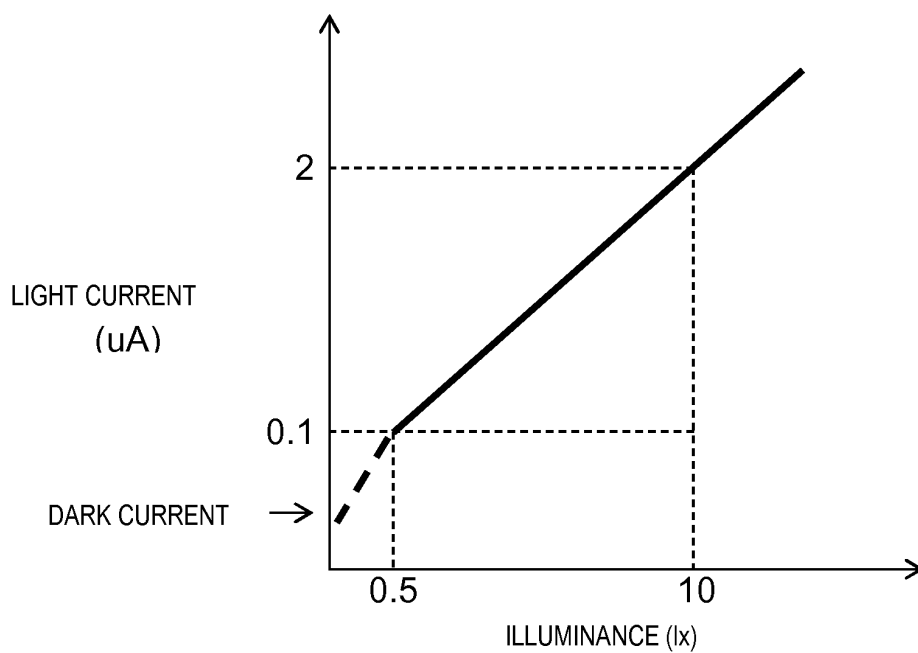


FIG. 5

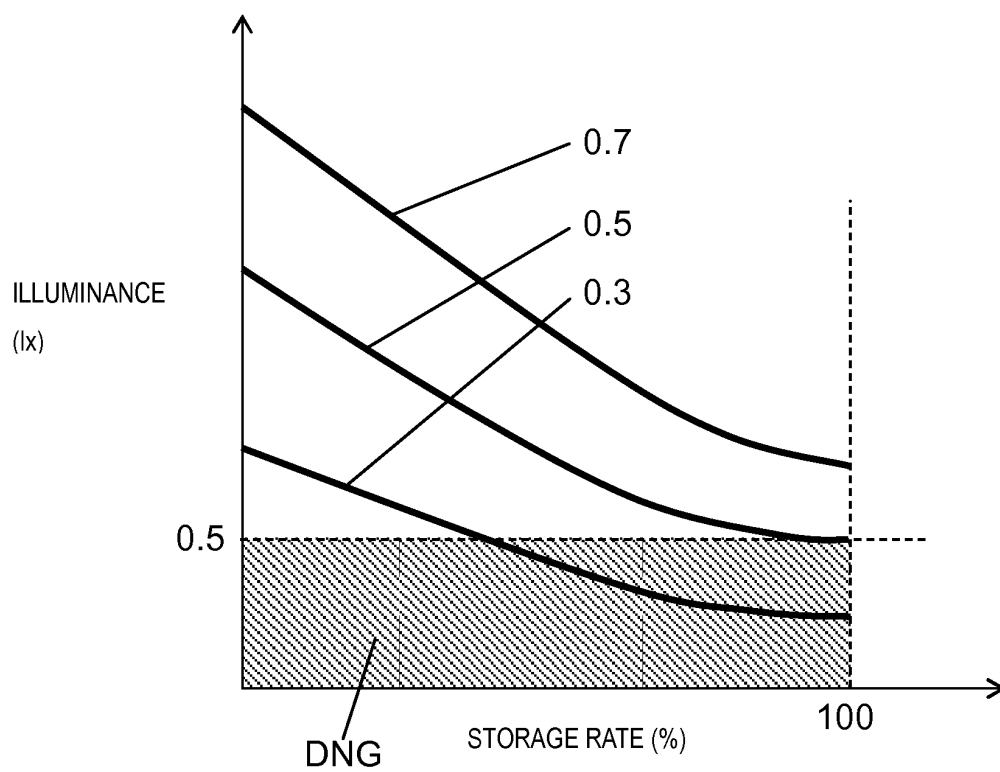


FIG. 6

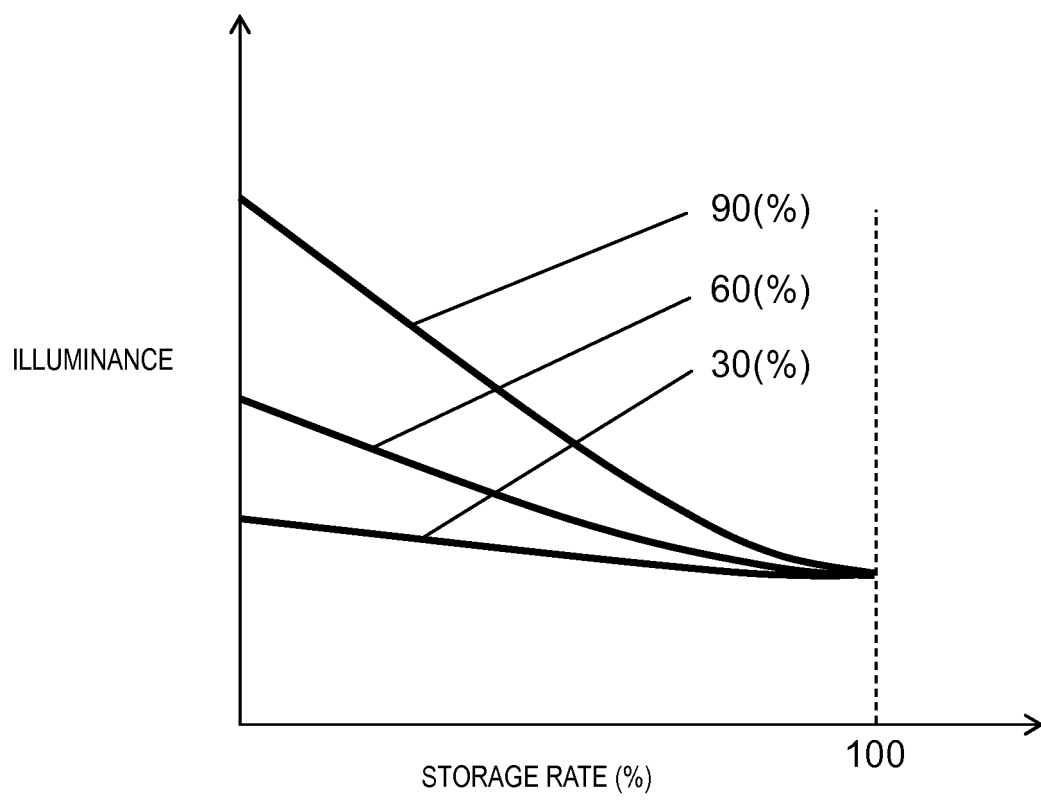


FIG. 7A

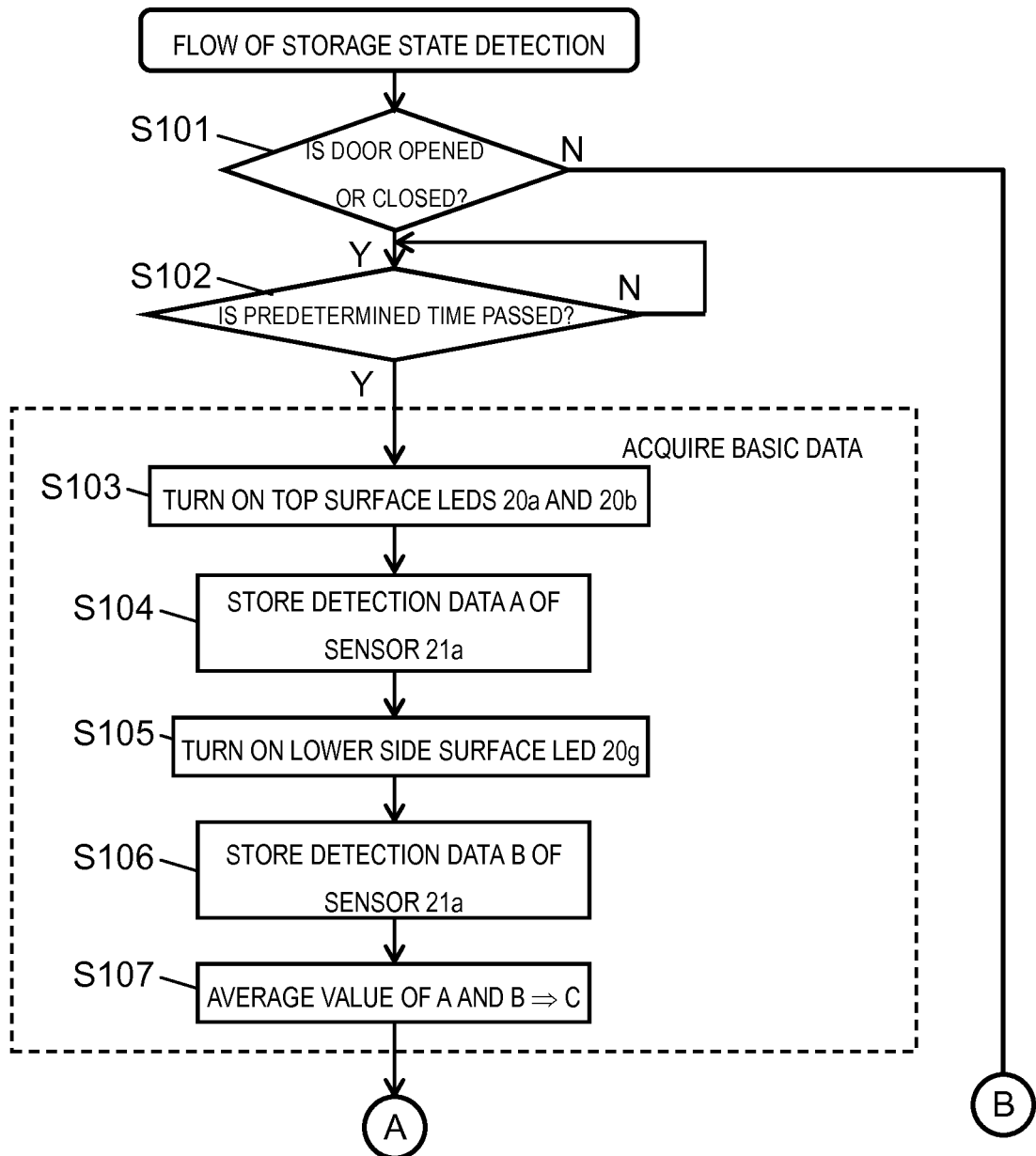


FIG. 7B

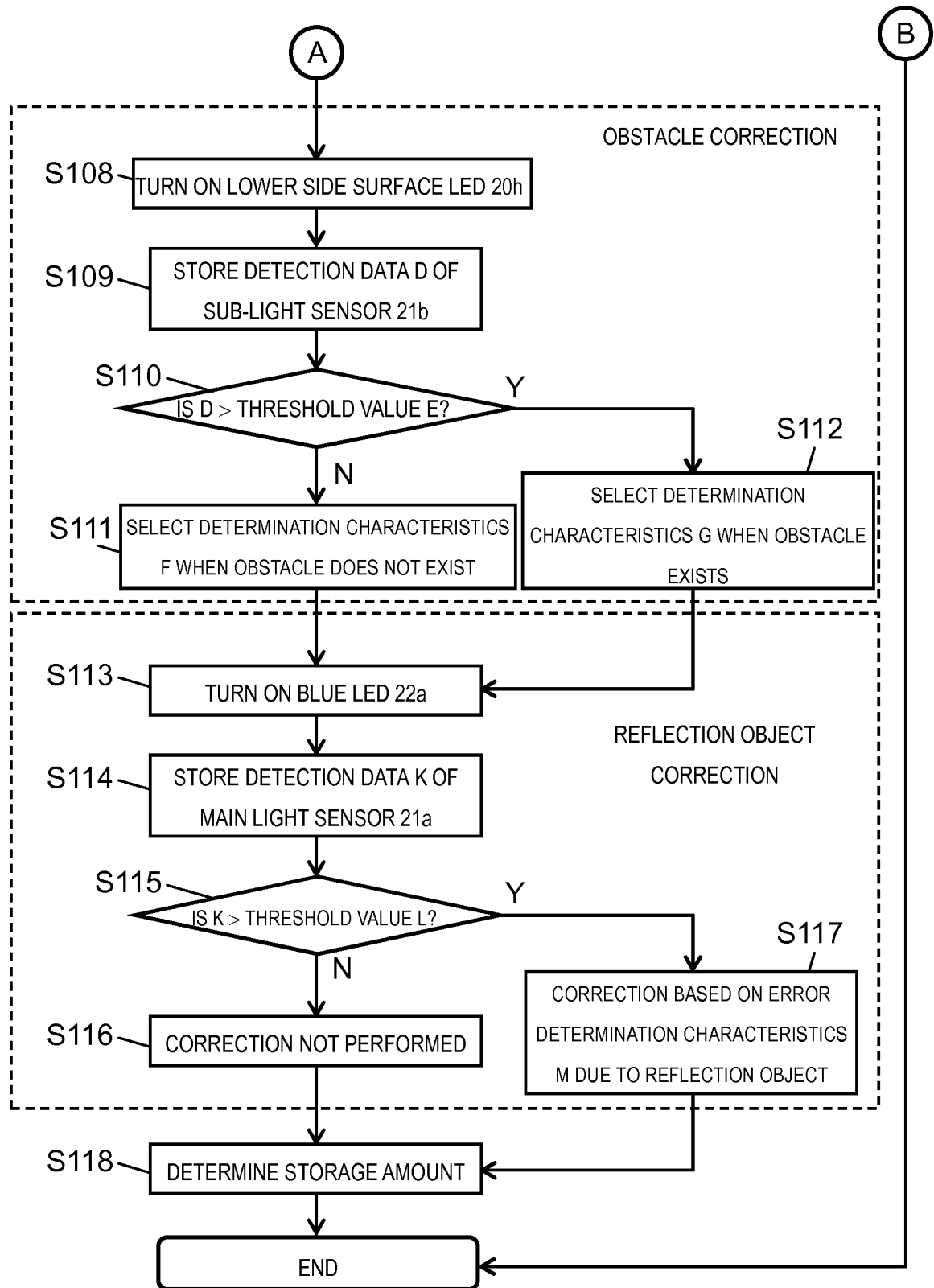


FIG. 8

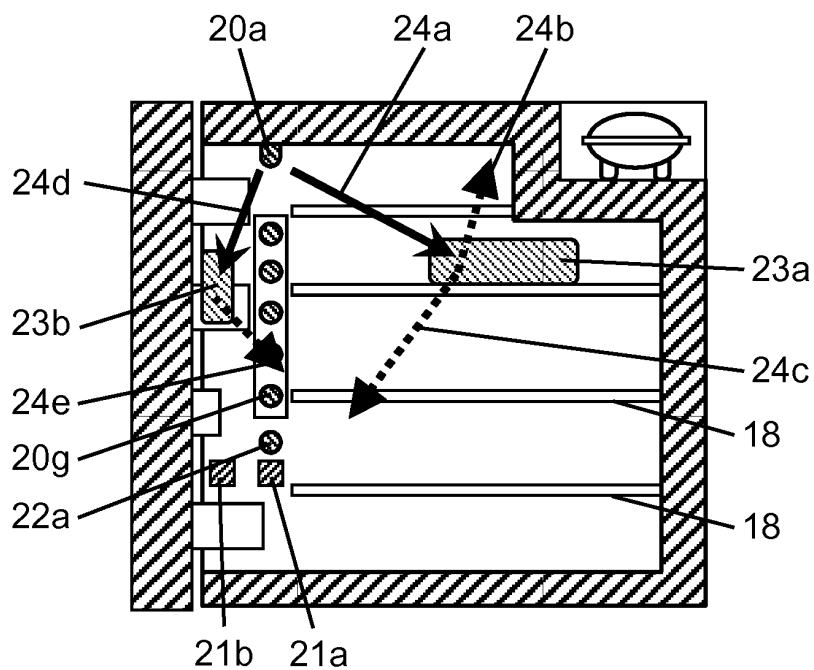


FIG. 9

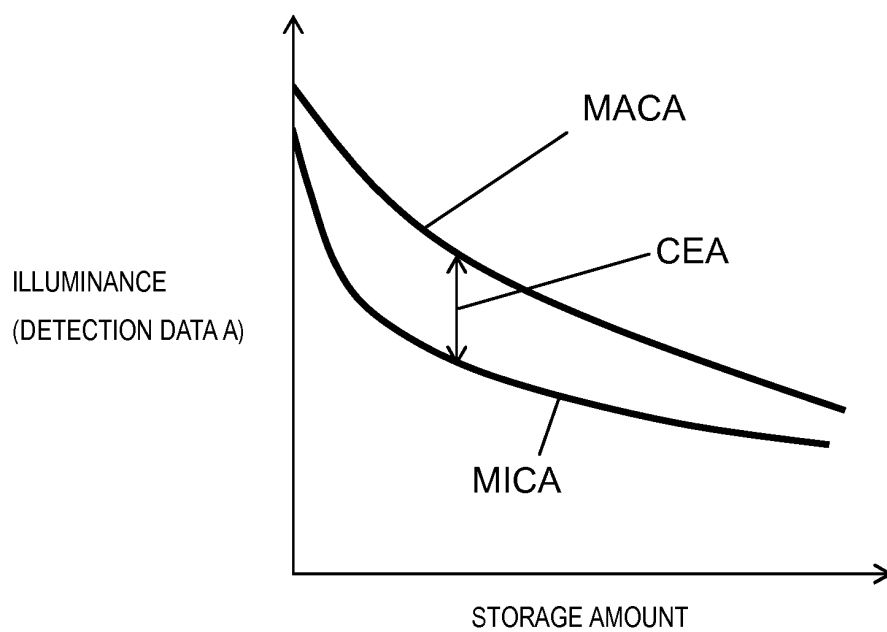


FIG. 10

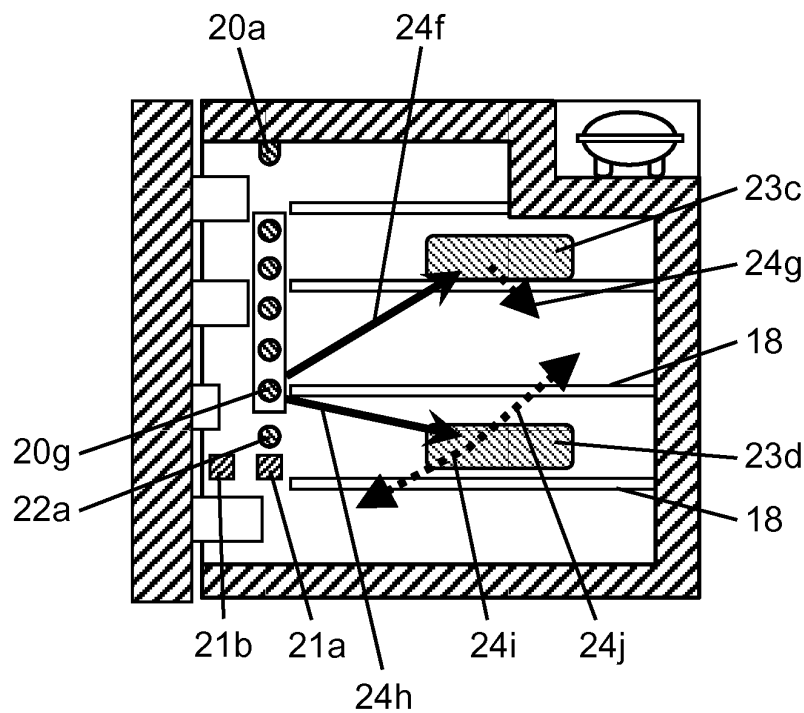


FIG. 11

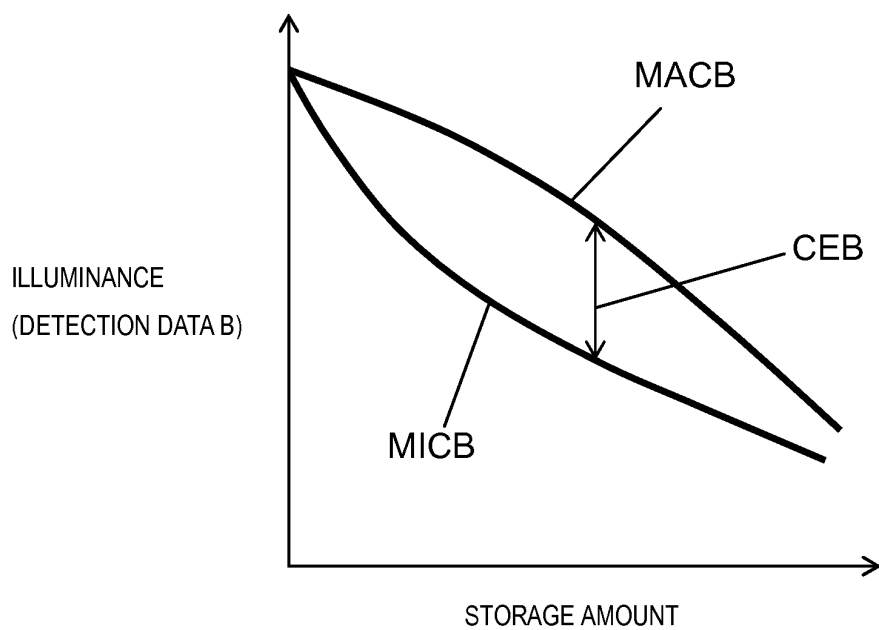


FIG. 12

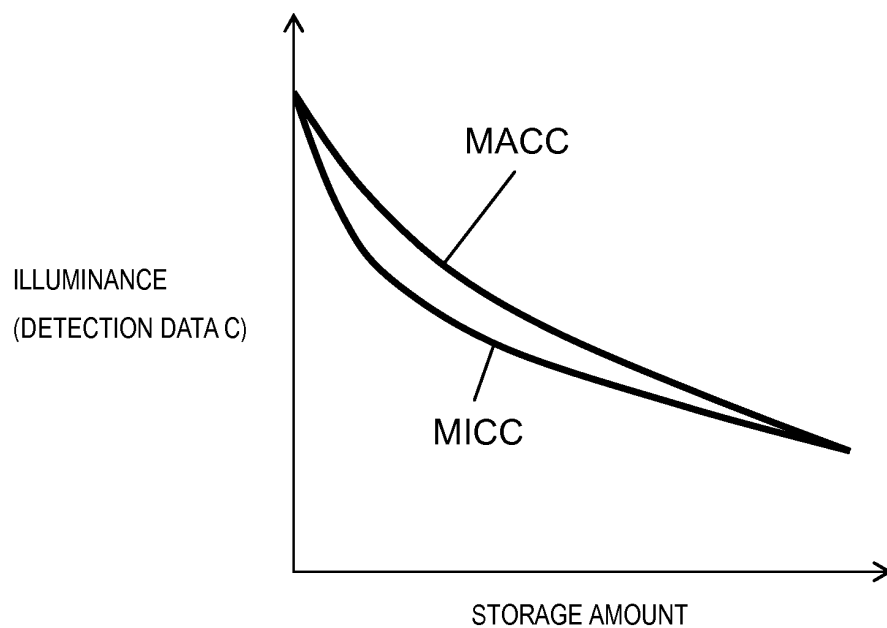


FIG. 13

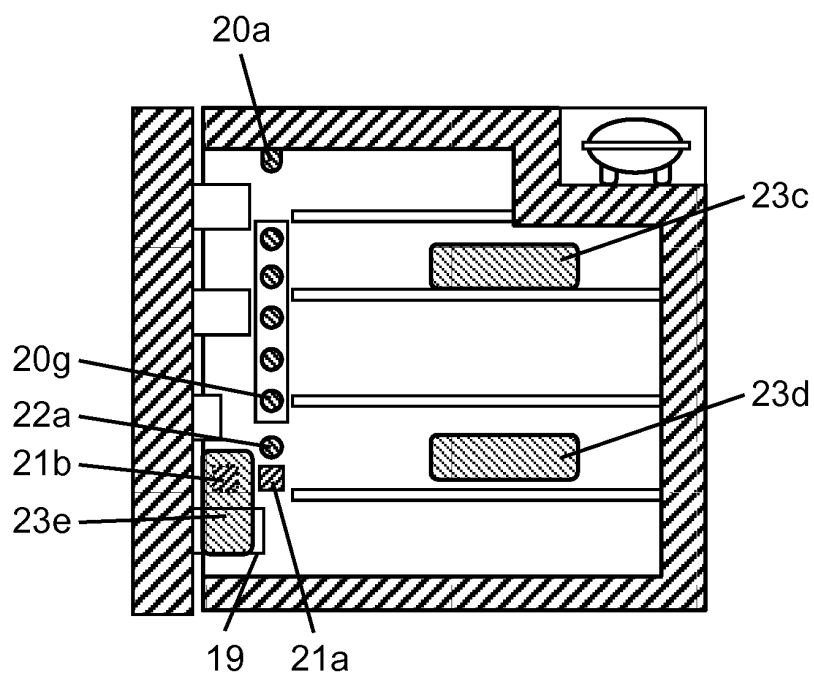


FIG. 14

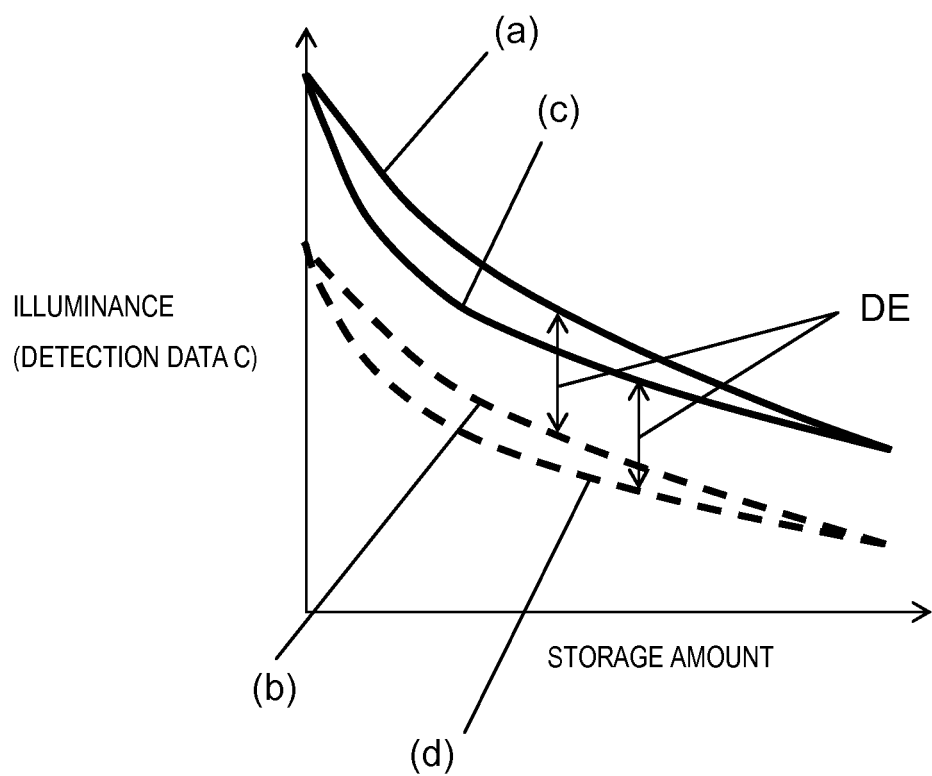


FIG. 15

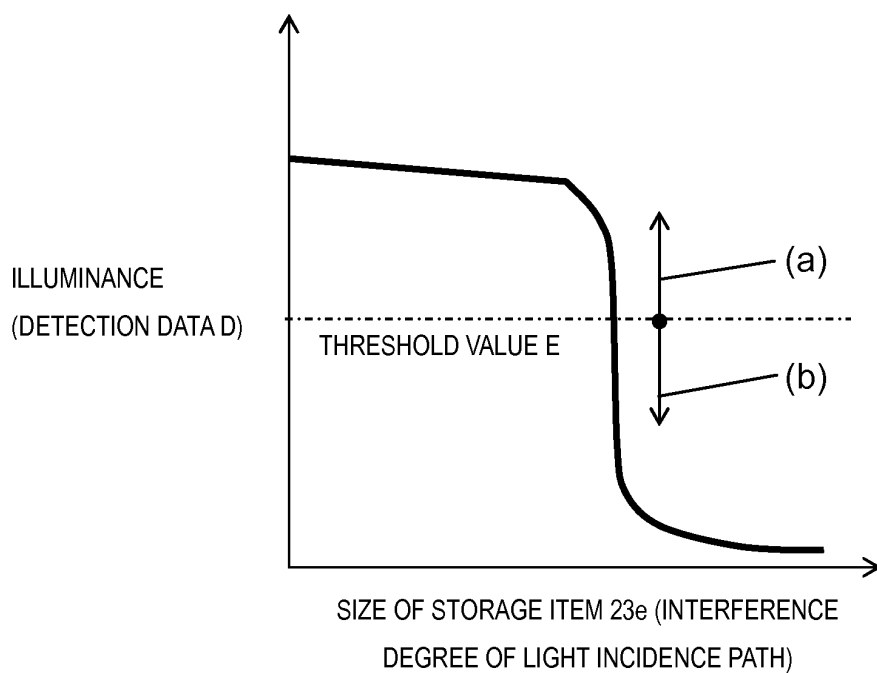


FIG. 16

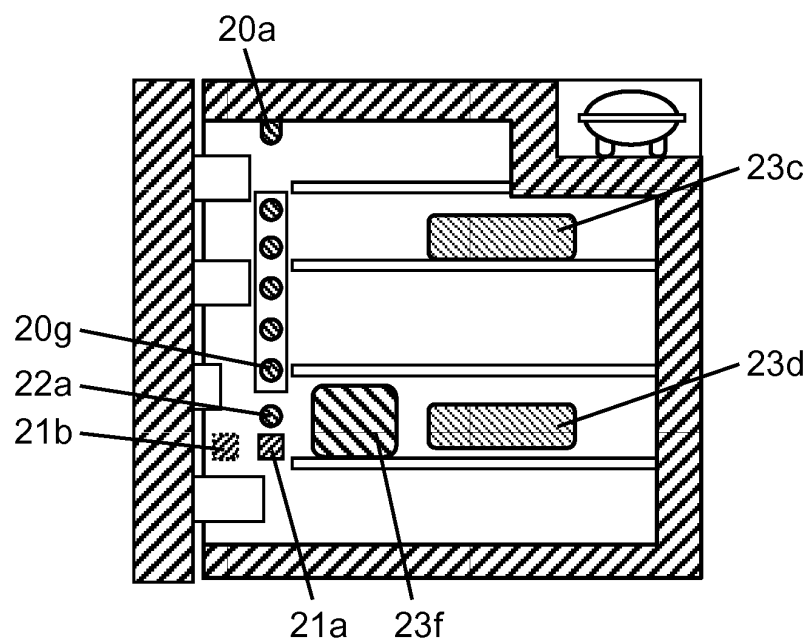


FIG. 17

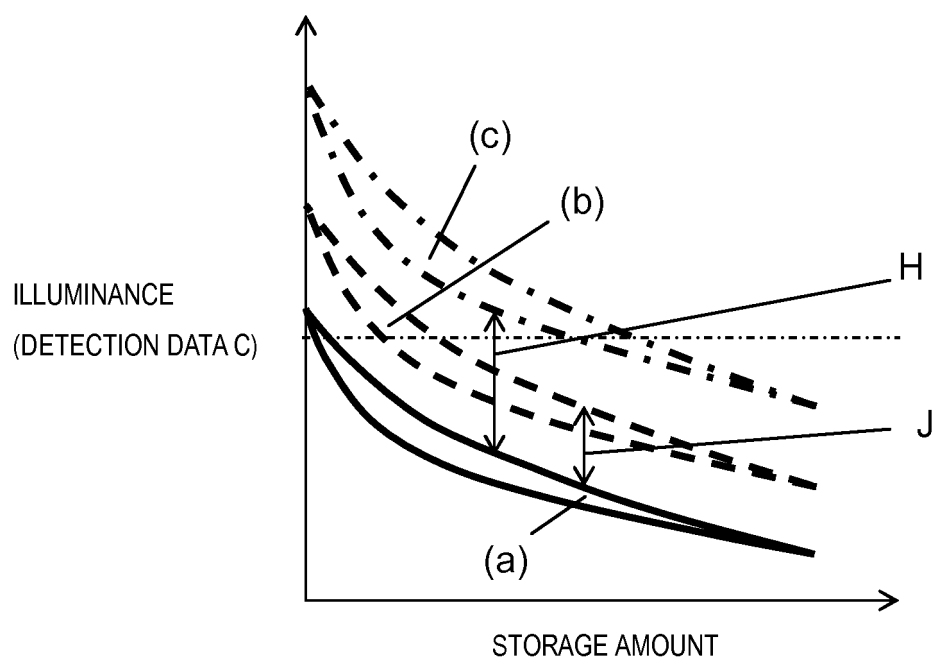


FIG. 18A

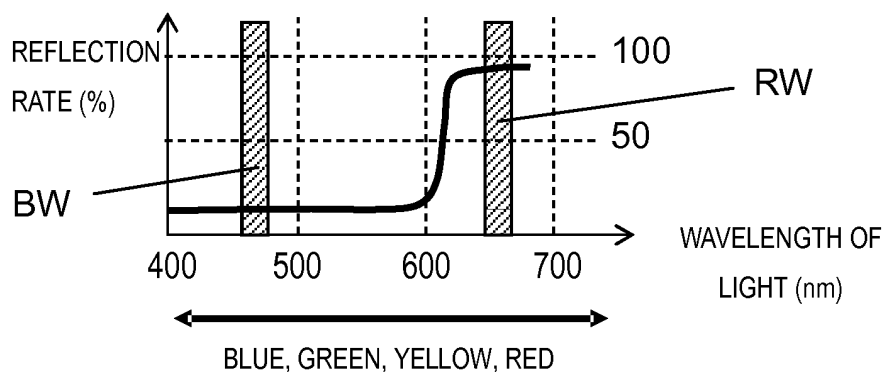


FIG. 18B

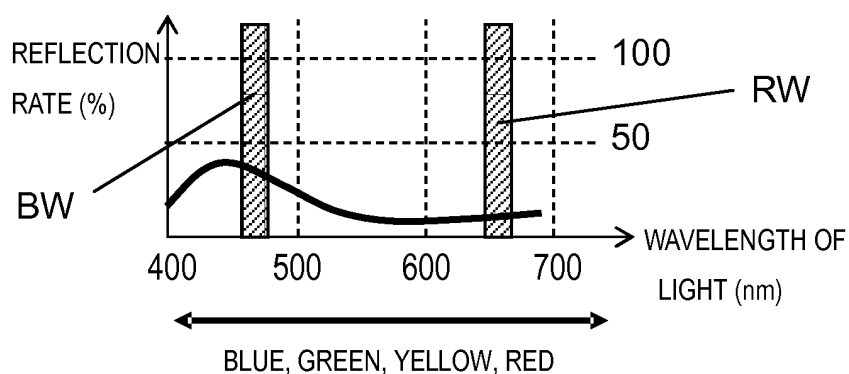


FIG. 18C

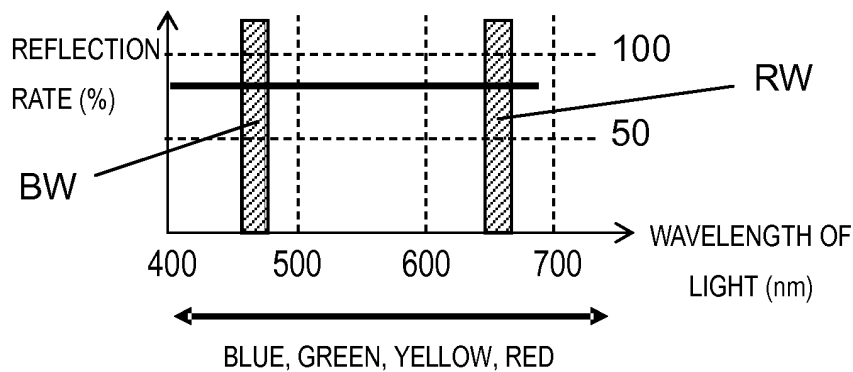


FIG. 19

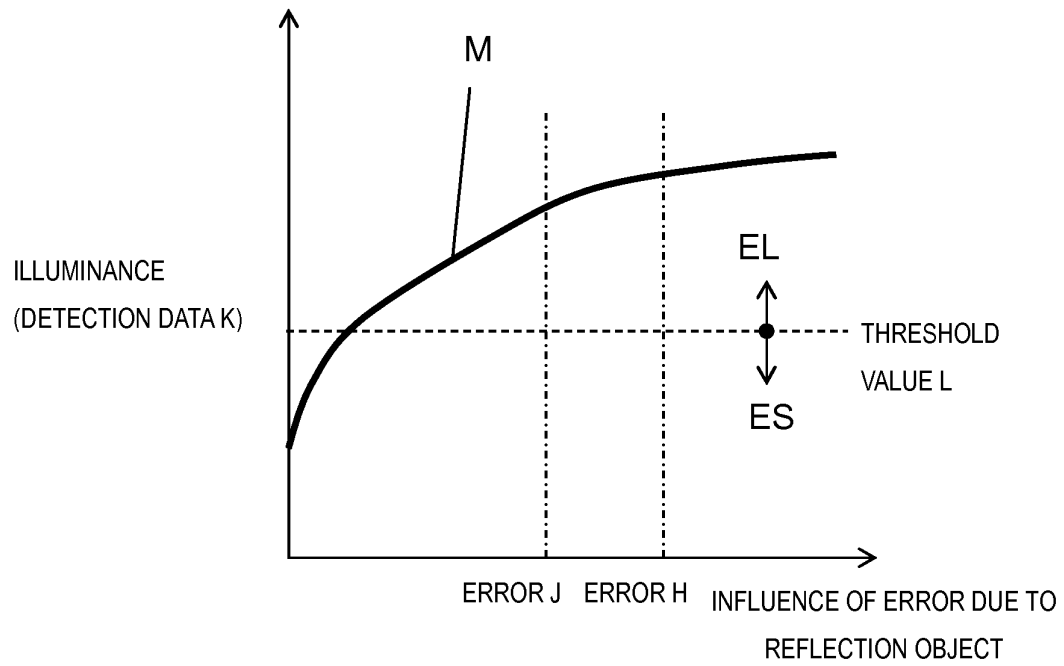


FIG. 20

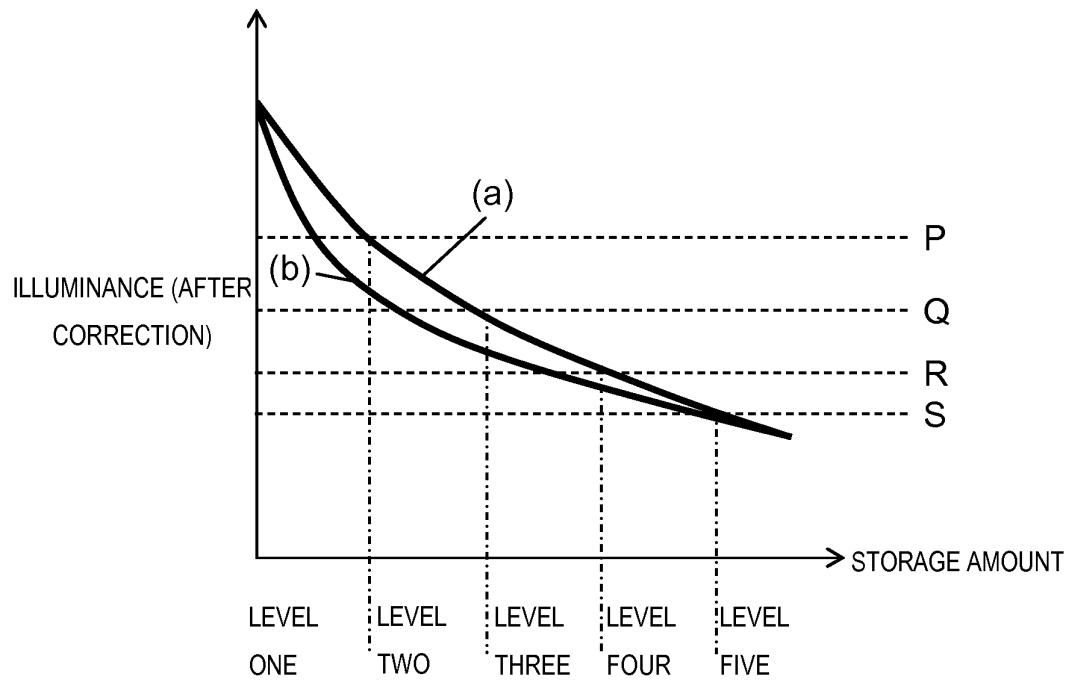


FIG. 21

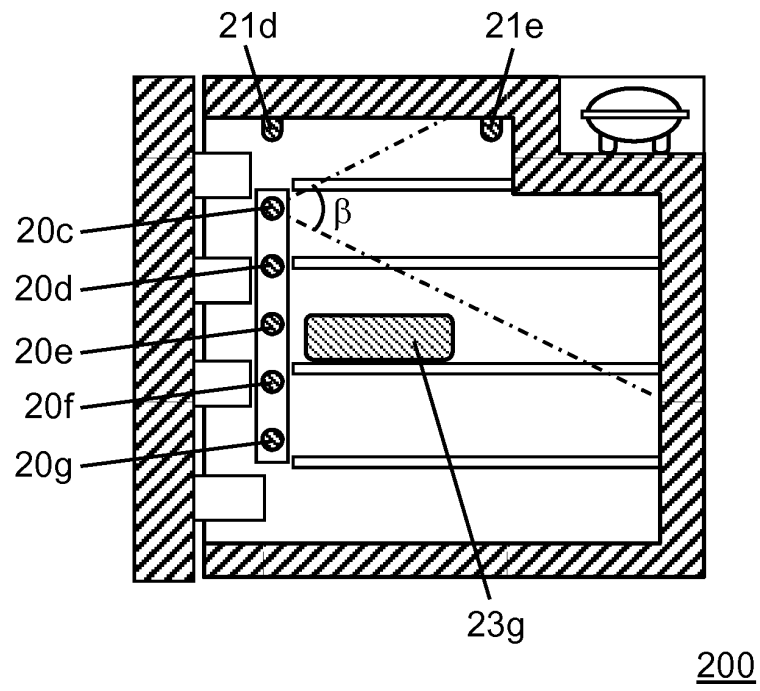


FIG. 22

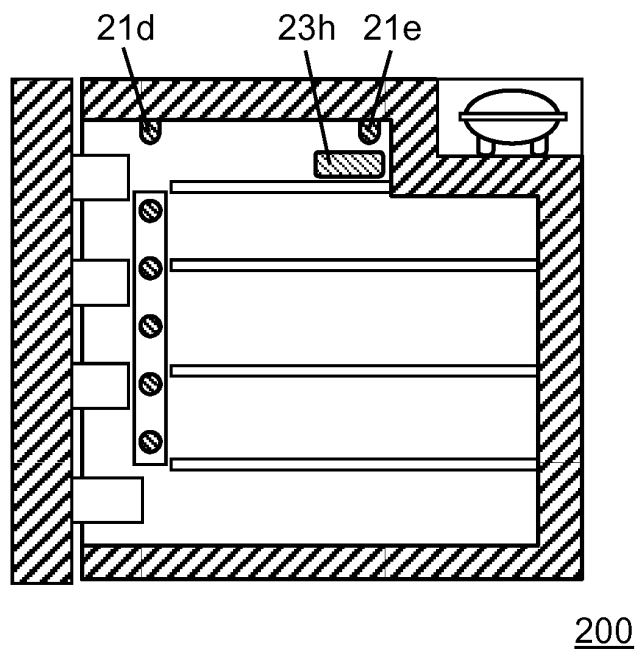


FIG. 23A

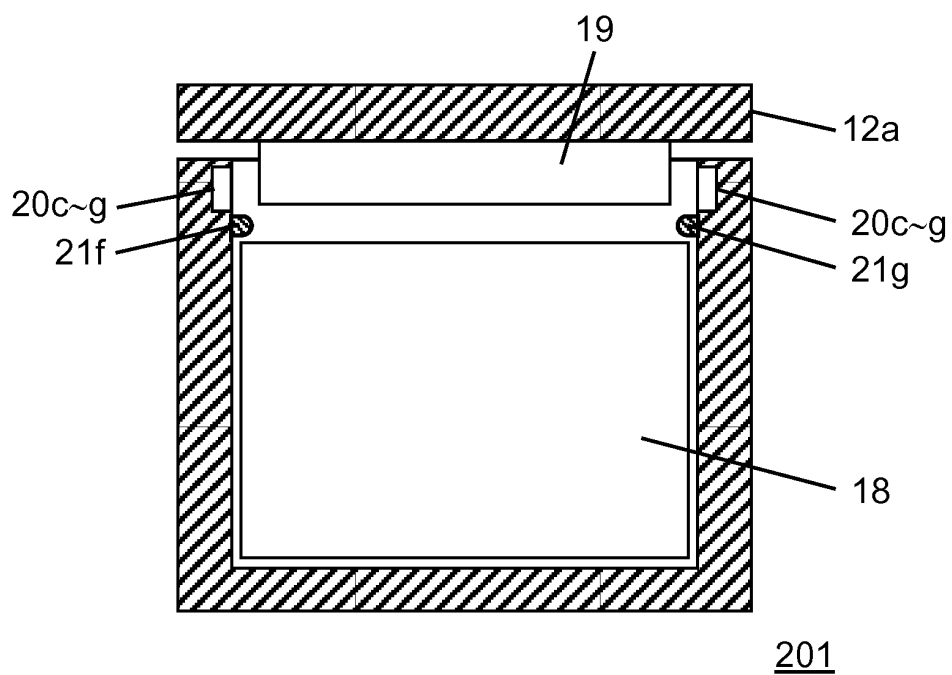


FIG. 23B

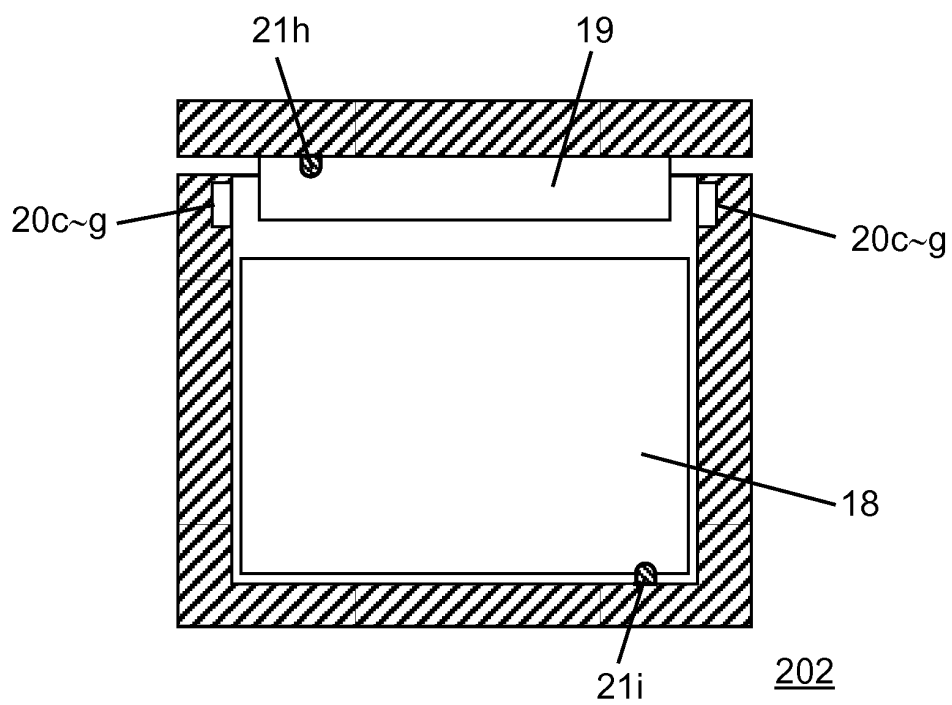


FIG. 24A

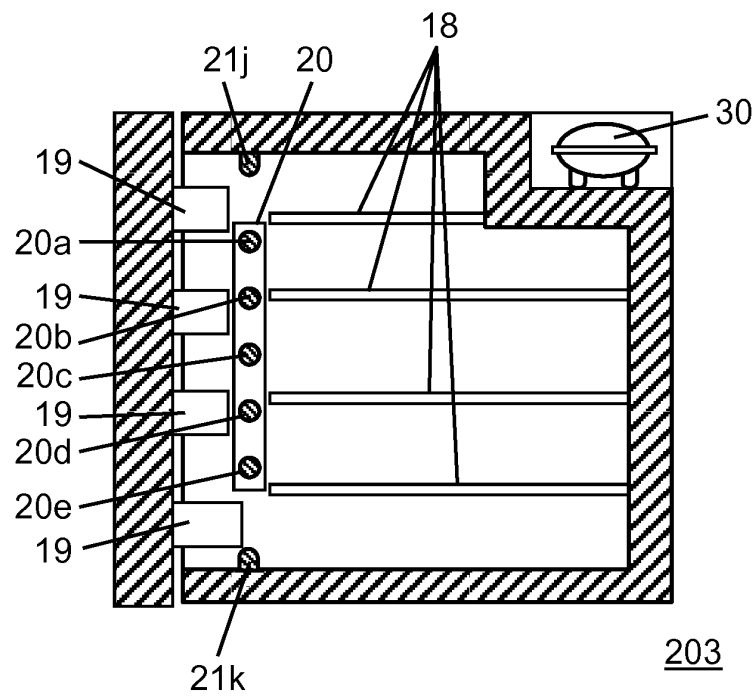


FIG. 24B

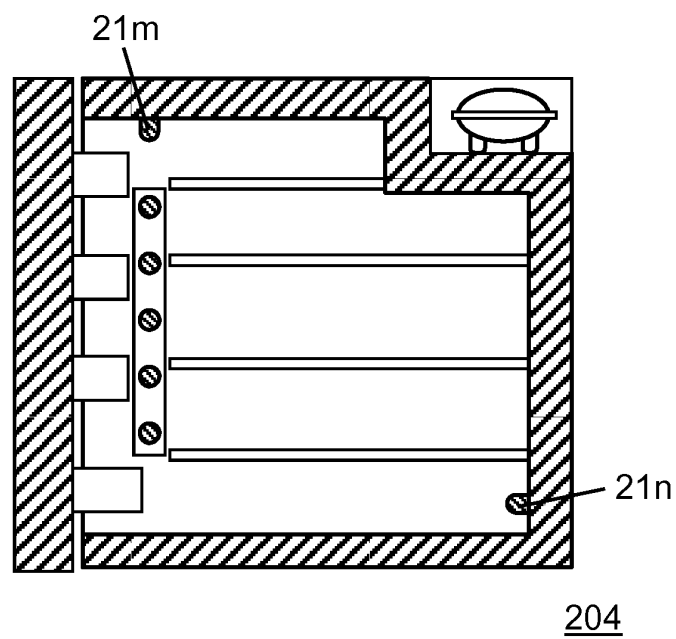


FIG. 25

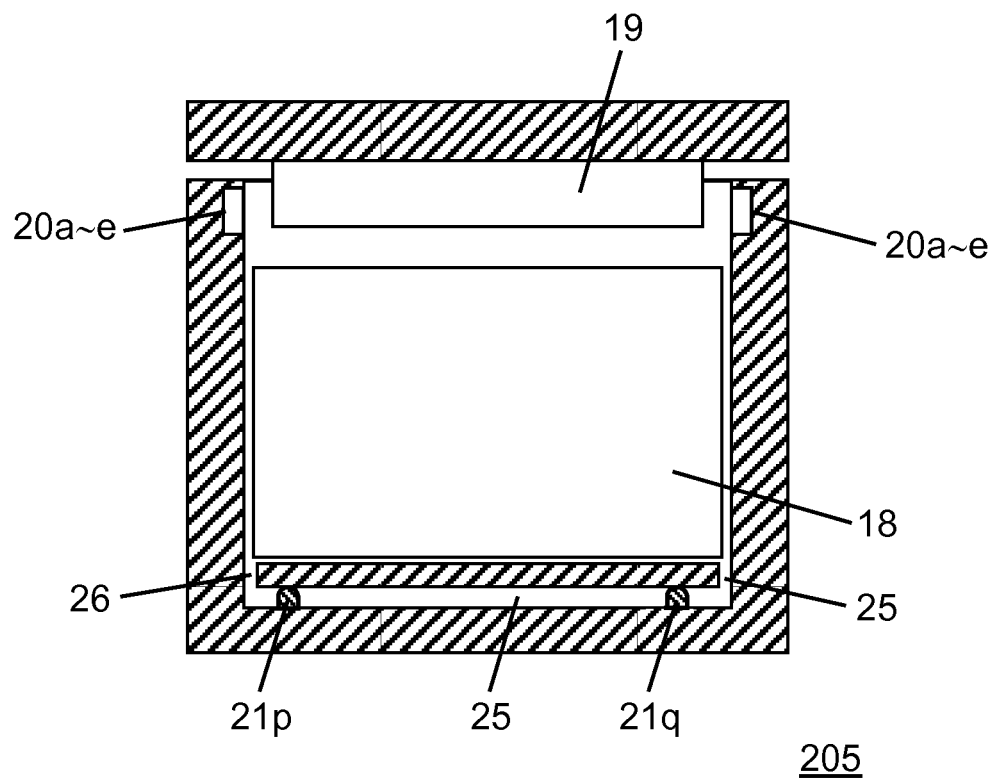
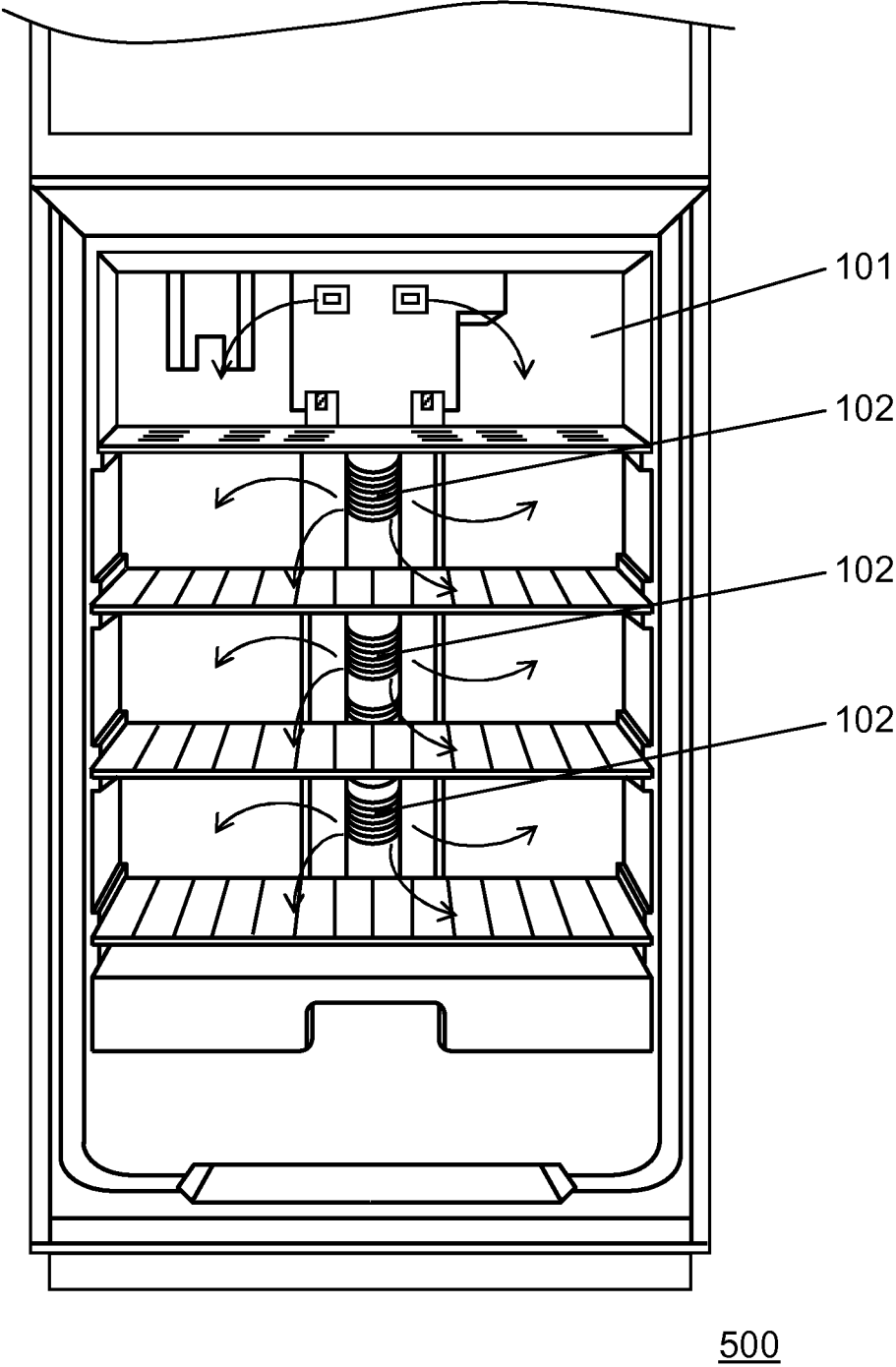


FIG. 26



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2012/001375

A. CLASSIFICATION OF SUBJECT MATTER

F25D11/00(2006.01)i, F25D23/00(2006.01)i, F25D27/00(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, F25D27/00, 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	1996-2012
Kokai Jitsuyo Shinan Koho	1971-2012	Toroku Jitsuyo Shinan Koho	1994-2012

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 8-303922 A (Matsushita Refrigeration Co.), 22 November 1996 (22.11.1996), entire text; all drawings (particularly, paragraphs [0013], [0015] to [0024]; fig. 1) (Family: none)	1, 2 1-3
X Y	JP 2010-151367 A (Panasonic Corp.), 08 July 2010 (08.07.2010), entire text; all drawings (particularly, paragraphs [0037], [0040] to [0042]; fig. 1) (Family: none)	1, 2 1-3

☒ 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
23 March, 2012 (23.03.12)Date of mailing of the international search report
03 April, 2012 (03.04.12)Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2012/001375

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2006-336963 A (Matsushita Electric Industrial Co., Ltd.), 14 December 2006 (14.12.2006), entire text; all drawings (particularly, paragraphs [0024], [0026], [0035] to [0037]; fig. 2, 4, 6) (Family: none)	1-3
Y	JP 2010-196697 A (Panasonic Corp.), 09 September 2010 (09.09.2010), entire text; all drawings (particularly, paragraphs [0008], [0009]; fig. 29) & JP 2010-197037 A & JP 2010-197038 A & JP 2010-197036 A & EP 2251623 A1 & WO 2010/073652 A1	1-3
Y	JP 2010-255877 A (Panasonic Corp.), 11 November 2010 (11.11.2010), entire text; all drawings (particularly, paragraphs [0021], [0024], [0030], [0036]; fig. 2 to 8) (Family: none)	1-3
P,X	JP 2011-43263 A (Mitsubishi Electric Corp.), 03 March 2011 (03.03.2011), entire text; all drawings (particularly, paragraphs [0013], [0014] to [0017], [0021], [0031] to [0036], [0052] to [0056]; all drawings) (Family: none)	1-7
A	JP 2008-70000 A (Matsushita Electric Industrial Co., Ltd.), 27 March 2008 (27.03.2008), entire text; all drawings (particularly, paragraphs [0055], [0056]; fig. 5, 6) (Family: none)	4-7

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 8247608 A [0007]