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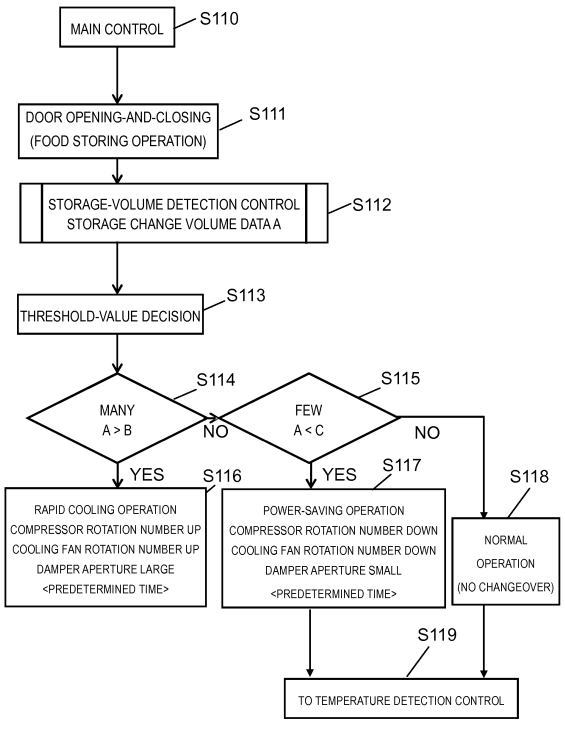
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(54) REFRIGERATOR

(57) Refrigerator (50) includes a storage chamber partitioned by a heat insulation wall and a heat insulation door, for storing a storage object, storage-volume estimating unit (23) for estimating a storage volume in the storage chamber, and memory unit (64) for memorizing a result of estimation by storage-volume estimating unit (23). Further, refrigerator (50) includes arithmetic control unit (22) for calculating a storage change volume based on a result of estimation of the storage volume up to a last time memorized in memory unit (64) and a result of estimation by the storage-volume estimating unit, and for controlling an output operation of an electrofunctional part. The arithmetic control unit compares a predetermined threshold value with the storage change volume, and decides that a storage volume changed when the storage change volume exceeds the threshold value, and controls an output operation of the electrofunctional part.

FIG. 7



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Description

TECHNICAL FIELD

[0001] The present invention relates to a refrigerator including means for detecting a storage volume in a storage chamber.

BACKGROUND ART

[0002] As a method of cooling a household refrigerator in recent years, an indirect cooling system for circulating cold air in the refrigerator with a fan is general. Such a conventional refrigerator has a cold-compartment temperature sensor that detects a temperature in a cold compartment, and a freezing-compartment temperature sensor that detects a temperature in a freezing compartment, in a refrigerator. Further, the conventional refrigerator holds a temperature in the refrigerator at a proper temperature, by performing temperature control according to detection results which are output from these sensors.

[0003] For example, as a refrigerator that uniformly holds an in-refrigerator temperature, there is a refrigerator provided with a movable cold-air blowing apparatus (see Patent Literature 1, for example).

[0004] FIG. 34 is a main-part front view of conventional refrigerator 100, and FIG. 35 is a view for schematically showing behaviors of configuration parts such as temperature sensors of conventional refrigerator 100.

[0005] As shown in FIG. 34, in conventional refrigerator 100, movable cold-air blowing apparatus 102 provided in cold compartment 101 makes the in-refrigerator temperature uniform by laterally supplying cold air.

[0006] As shown in FIG. 35, in conventional refrigerator 100, when a temperature detected by the freezing-compartment temperature sensor increases to a predetermined temperature (ON temperature), the refrigerator drives a compressor, and also when a temperature detected by the cold-compartment temperature sensor is equal to or higher than a temperature of a predetermined value (open temperature), the refrigerator operates to set "close→open" to a cold-compartment damper. In this way, the refrigerator drives a cooling fan (hereinafter, this operation is called "cold-compartment and freezing-compartment simultaneous cooling a").

[0007] Thereafter, when the detected temperature by the cold-compartment temperature sensor reaches a predetermined temperature (close temperature), the refrigerator operates to set "open→close" to the cold-compartment damper, and performs a cooling operation at only a freezing compartment side (hereinafter, this operation is called "freezing-compartment independent cooling b").

[0008] Thereafter, when the detected temperature by the freezing-compartment temperature sensor reaches a predetermined temperature (OFF temperature), the refrigerator stops the compressor (hereinafter, this operation is called "cooling-stop c").

[0009] Then, conventional refrigerator 100 sequentially repeats a series of operation including the cold-compartment and freezing-compartment simultaneous cooling a, freezing-compartment independent cooling b, and cooling-stop c, during a normal operation of the refrigerator.

[0010] In the case of refrigerator 100 having a freezing-compartment damper, an operation of driving the compressor and the cooling fan is added to the above series of operation, by setting the cold-compartment damper to "open" and setting the freezing compartment to "close" (hereinafter, this operation is called "cold-compartment independent cooling d".

[0011] However, in conventional refrigerator 100, even when an in-refrigerator temperature is set uniform, a storage object is not necessarily preserved at an optimum temperature. This is because refrigerator 100 detects an atmospheric temperature in the refrigerator or a return-air temperature with the temperature sensors as temperature detecting means, and because refrigerator 100 does not include means for directly detecting a temperature of the storage object.

[0012] That is, there is a difference between an atmospheric temperature and an actual temperature of the storage object in refrigerator 100. For example, a transition period is assumed during which a temperature in refrigerator 100 reaches a set temperature after the inside of the refrigerator is cooled from a state that the temperature in the refrigerator rises immediately after a storage object is input, after the door is opened for a long time, or immediately after a defrosting operation. During this period, there arises a temperature difference dependent on a volume of a storage object, a specific heat of a storage object or a heat capacity, between a detected temperature by temperature detecting means arranged in the refrigerator and a temperature of the storage object. Therefore, time taken until reaching an optimum preservation temperature changes depending on a storage volume. Specifically, it is general that a cooling time until reaching an optimum preservation temperature is long when a storage volume is large. Therefore, an excessive cooling operation sometimes occurs.

[0013] Further, when a temperature of the storage object is stabilized at a low temperature by cooling after passing a sufficient time, the storage object keeps the temperature with a self heat capacity. However, when a storage volume is large, there is a high possibility that a storage object is placed near a discharge opening, and cold air directly touches the storage object. Therefore, the storage object tends to be cooled excessively. Further, because the heat capacity becomes larger when the storage volume is larger, a temperature difference between the air and the food becomes smaller than that when the storage volume is a normal storage volume. Therefore, there is a tendency of excessive cooling. Consequently, according to a conventional cooling control, the storage object tends to become in a "too cold" state, and it is difficult to cool the storage object at an optimum

temperature. Further, during this period, refrigerator 100 performs a cooling operation while consuming excessive energy, resulting in the occurrence of wasteful energy.

[0014] In recent years, a working form changes, and households in which both husband and wife work are increasing. Further, opportunities of buying in a large supermarket and the like are increasing. Accordingly, persons performing a bulk buying of foods at one time for one week are increasing in holidays. Therefore, the storage volume in refrigerator 100 tends to increase more than that of a conventional practice. On the other hand, on weekdays, a storage object such as foods is not added in many cases, and a life pattern of a general house is changing.

[0015] Further, when a storage volume increases large, because conventional refrigerator 100 performs a temperature control according to results of detection by temperature sensors arranged in the refrigerator, a time difference occurs from when a storage object is input until the temperature sensors detect an increase in the temperature. This is attributable to a fact that the temperature sensors are normally molded with a resin so that the temperature sensors cannot easily follow a rapid temperature change. Accordingly, it takes time from when the storage object is input until a rapid cooling operation is started by increasing rotation numbers of a compressor and a cooling fan. That is, there is also a problem in that because it takes a long time until the temperature reaches an optimum preservation temperature for the storage object, a food freshness preservation characteristic becomes lower.

Citation List

Patent Literature

[0016] PTL1: Unexamined Japanese Patent Publication No. H08-247608

SUMMARY OF THE INVENTION

[0017] The present invention has been made in view of the above problems, and provides a refrigerator capable of starting a rapid cooling operation by increasing rotation numbers of a compressor and a cooling fan without generating a time difference from input of a storage object.

[0018] The refrigerator according to the present invention includes a storage chamber partitioned by a heat insulation wall and a heat insulation door, for storing a storage object, a storage-volume estimating unit for estimating a storage volume in the storage chamber, and a memory unit for memorizing a result of estimation by the storage-volume estimating unit. Further, the refrigerator includes an arithmetic control unit for controlling an output operation of an electrofunctional part by calculating a storage change volume based on a result of estimation of a storage volume up to the last time memorized in the memory unit, and a result of estimation by the storage-volume estimating unit. The arithmetic control unit controls the output operation of the electrofunctional part, by comparing a predetermined threshold value with a storage change volume, and by deciding that the storage volume changed when the storage change volume exceeded the threshold value.

BRIEF DESCRIPTION OF DRAWINGS

[0019]

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

FIG. 2 is a cross-sectional view along a 2-2 line in FIG. 1 of the refrigerator according to the first embodiment of the present invention.

FIG. 3 is a control block diagram of the refrigerator according to the first embodiment of the present invention.

FIG. 4 is an explanatory view of a storage-state detecting operation of the refrigerator according to the first embodiment of the present invention.

FIG. 5A is a diagram showing an operation of the refrigerator, and showing a temperature change relative to time, according to the first embodiment of the present invention.

FIG. 5B is a diagram showing an operation of the refrigerator, and showing a temperature change relative to time, according to the first embodiment of the present invention.

FIG. 6 is a flowchart showing a storage-volume detection control of the refrigerator according to the first embodiment of the present invention.

FIG. 7 is a flowchart showing a cooling-operation decision control using a storage-volume detection control of the refrigerator according to the first embodiment of the present invention.

FIG. 8 is a flowchart showing another example of a cooling-operation decision control using a storage-volume detection control of the refrigerator according to the first embodiment of the present invention.

FIG. 9 is a flowchart showing still other example of a cooling-operation decision control using a storage-volume detection control of the refrigerator according to the first embodiment of the present invention.

FIG. 10 is a flowchart showing a control of performing a cooling operation decision after a temperature detection control by the refrigerator according to the first embodiment of the present invention.

FIG. 11A is a view showing a relationship between a storage volume change and a temperature change of the refrigerator and a cooling operation decision according to the first embodiment of the present invention.

FIG. 11B is a view showing a relationship between a storage volume change and a temperature change of the refrigerator and a cooling operation decision

according to the first embodiment of the present invention.

FIG. 12 is a diagram schematically showing a temperature behavior of a temperature sensor when a storage object is input at a cold-compartment and freezing-compartment simultaneous cooling time of the refrigerator according to the first embodiment of the present invention.

FIG. 13 is a diagram schematically showing a temperature behavior of a temperature sensor when a storage object is input at a freezing-compartment independent cooling time of the refrigerator according to the first embodiment of the present invention.

FIG. 14 is a diagram schematically showing a temperature behavior of a temperature sensor when a storage object is input at a cooling-stop time of the refrigerator according to the first embodiment of the present invention.

FIG. 15 is an explanatory diagram of forecast of a life pattern using a learning function of the refrigerator and a start-and-end timing of a power-saving operation according to the first embodiment of the present invention.

FIG. 16 is a flowchart showing a learning operation control of the refrigerator according to the first embodiment of the present invention.

FIG. 17 is a diagram for explaining a "bulk-buying day" decision by the learning function of the refrigerator according to the first embodiment of the present invention.

FIG. 18 is an explanatory diagram of forecast of a life pattern using a separate learning function and a start-and-end timing of a power-saving operation according to the first embodiment of the present invention.

FIG. 19 is a flowchart showing a learning operation control in a separate mode according to the first embodiment of the present invention.

FIG. 20 is an explanatory diagram of a storage-volume detecting operation according to a third embodiment of the present invention.

FIG. 21 is an explanatory diagram of a storage-volume detecting operation according to the third embodiment of the present invention.

FIG. 22 is an explanatory diagram of a storage-volume detecting operation according to a fourth embodiment of the present invention.

FIG. 23 is a front view of a refrigerator according to a fifth embodiment of the present invention.

FIG. 24 is a front view of a refrigerator according to a sixth embodiment of the present invention.

FIG. 25 is a cross-sectional view along a 25-25 line in FIG. 24 of the refrigerator according to the sixth embodiment of the present invention.

FIG. 26 is an explanatory diagram of a light-volume detecting operation according to the sixth embodiment of the present invention.

FIG. 27 is a control block diagram of the refrigerator according to the sixth embodiment of the present invention.

FIG. 28A is a control flowchart at a power source input time of the refrigerator according to the sixth embodiment of the present invention.

FIG. 28B is a control flowchart of absence detection A of the refrigerator according to the sixth embodiment of the present invention.

FIG. 28C is a control flowchart of a using-state decision A of the refrigerator according to the sixth embodiment of the present invention.

FIG. 28D is a control flowchart of absence detection B of the refrigerator according to the sixth embodiment of the present invention.

FIG. 28E is a control flowchart of a using-state decision B of the refrigerator according to the sixth embodiment of the present invention.

FIG. 28F is a control flowchart of a using-state decision C of the refrigerator according to the sixth embodiment of the present invention.

FIG. 28G is a control flowchart of another example of absence detection B of the refrigerator according to the sixth embodiment of the present invention.

FIG. 28H is a control flowchart of a using-state decision D of the refrigerator according to the sixth embodiment of the present invention.

FIG. 29A is an operation image diagram of a basic defrost timing of the refrigerator according to the sixth embodiment of the present invention.

FIG. 29B is an operation image diagram of a defrost timing of the refrigerator when the user returns home according to the sixth embodiment of the present invention.

FIG. 29C is an operation image diagram when there is a time safe in a defrost time of the refrigerator according to the sixth embodiment of the present invention.

FIG. 29D is an operation image diagram when the user is absent during defrosting in the refrigerator according to the sixth embodiment of the present invention.

FIG. 30 is an operation image diagram of a defrost timing according to the seventh embodiment of the present invention.

FIG. 31A is a control flowchart according to a seventh embodiment of the present invention.

FIG. 31B is a control flowchart according to the seventh embodiment of the present invention.

FIG. 32A is a control flowchart according to an eighth embodiment of the present invention.

FIG. 32B is a control flowchart according to the eighth embodiment of the present invention.

FIG. 33A is a control flowchart according to a ninth embodiment of the present invention.

FIG. 33B is a control flowchart according to the ninth embodiment of the present invention.

FIG. 34 is a main-part front view of the conventional refrigerator.

FIG. 35 is a view schematically showing behaviors of configuration parts such as temperature sensors of the conventional refrigerator.

DESCRIPTION OF EMBODIMENTS

[0020] Embodiments of the present invention are described below with reference to the drawings. The present invention is not limited by these embodiments.

FIRST EXEMPLARY EMBODIMENT

[0021] Hereinafter, a first embodiment of the present invention is described.

[0022] FIG. 1 is a front view of refrigerator 50 according to the first embodiment of the present invention.

[0023] As shown in FIG. 1, refrigerator 50 includes refrigerator main body 11. Refrigerator main body 11 is a heat-insulation box body, and is insulated from the surrounding, in a structure having an outer box mainly made of steel plate, an inner box formed with a resin such as ABS, and a heat insulation material such as urethane in a space between the outer box and the inner box.

[0024] Refrigerator main body 11 is partitioned into a plurality of store rooms (storage chambers) by heat insulation. At a top part, cold compartment 12 is provided. At a lower part of cold compartment 12, ice compartment 13 and change compartment 14 are laterally provided. Freezing compartment 15 is arranged at a lower part of ice compartment 13 and change compartment 14, and vegetable compartment 16 is arranged at a lowest part.

[0025] In front of each storage chamber, a door for separating from outside air is configured at a front opening part of refrigerator main body 11. Near a center part of cold compartment door 12a of cold compartment 12, there are arranged operating unit 17 for performing an in-refrigerator temperature setting of each compartment and setting of ice making and a rapid cooling, and display unit 91 as an example of informing means for providing various information to the user.

[0026] FIG. 2 is a cross-sectional view along a 2-2 line in FIG. 1 of refrigerator 50 according to the first embodiment of the present invention.

[0027] As shown in FIG. 2, a plurality of storage shelves 18 are provided in cold compartment 12, and a part of storage shelves 18 is configured to be vertically movable.

[0028] In cold compartment 12, there is provided a storage-state detecting unit configured by illuminating unit 19 configured by a lamp and a plurality of LEDs, light emitting unit 20 such as LEDs, and light-volume detecting unit 21 such as an illuminance (light) sensor.

[0029] Illuminating unit 19 is arranged in a longitudinal direction on each of a left-side wall surface and a right-side wall surface positioned in front of a front end (this side) of storage shelf 18, nearer than a half of a depth dimension in the refrigerator, viewed from door-open-side front surface in refrigerator 50. Further, light emitting unit 20 is arranged adjacent to a position close to illuminating unit 19, and light-volume detecting unit 21 is arranged at a rear position in cold compartment 12.

[0030] Further, the arrangement of light-volume detecting unit 21 is not limited to the above example, and light-volume detecting unit 21 may be arranged at any position in the refrigerator so far as light-volume detecting unit 21 is arranged at a position where the light irradiated by light emitting unit 20 can be received via storage object 33 (see FIG. 4) and an in-refrigerator structure.

[0031] In a machine room formed in a top rear area in cold compartment 12, high-voltage side configuration parts of a freezing cycle such as compressor 30 and a drier that removes moisture are stored.

[0032] On a rear surface of freezing compartment 15, a cooling chamber for generating cold air is provided. In the cooling chamber, there are provided a cooler, and cooling fan 31 (see FIG. 3) for sending the cold air as cooling means cooled by the cooler to cold compartment 12, change compartment 14, ice compartment 13, vegetable compartment 16, and freezing compartment 15. Further, to remove frost and ice adhered to the cooler and a periphery of the cooler, a radiant heater (defrosting unit 68 (see FIG. 3)), a drain pan, a drain tube evaporation tray, and the like are configured.

[0033] Cold compartment 12 is temperature-controlled normally at 1°C to 5°C as a lower limit at which the storage object is not frozen, to perform refrigerated preservation. Vegetable compartment 16 at a lowest part is temperature-controlled at 2°C to 7°C which is equal to or slightly higher than the temperature in cold compartment 12.

[0034] Freezing compartment 15 is set in a freezing temperature range, and is temperature-controlled normally at -22°C to -15°C for freezed preservation. However, to improve a freezed preservation state, freezing compartment 15 is sometimes set to be temperature-controlled at a low temperature of -30°C or -25°C, for example.

[0035] Ice compartment 13 makes ice with an automatic ice machine (not shown) set at an upper part in the compartment using water sent from a water storage tank (not shown), and stores the ice in an ice storage container (not shown) arranged at a lower part in the compartment.

[0036] Change compartment 14 can be changed over to a temperature range set in advance between a cold preservation temperature range and a freezing temperature range, in addition to a cold preservation temperature range set at 1°C to 5°C, a vegetable temperature range set at 2°C to 7°C, and a freezing temperature range normally set at -22°C to -15°C. Change compartment 14 is a storage chamber including an independent door provided in parallel with ice compartment 13, and includes a drawer-type door in many cases.

[0037] In the present embodiment, change compartment 14 is a storage chamber capable of adjusting a temperature at temperatures including temperature ranges of cold storage and freezing. However, change compartment 14 may be configured as a storage chamber specializing in a changeover in an intermediate tem-

perature range between cold storage and freezing, by assigning a cold storage function to storage chamber 12 and vegetable compartment 16 and assigning a freezing function to freezing compartment 15. The specialized temperature range may be set in a storage chamber fixed to freezing, to follow an increased demand for frozen foods in recent years, for example.

[0038] An operation and work of refrigerator 50 configured as described above are described.

[0039] FIG. 3 is a control block diagram of refrigerator 50 according to the first embodiment of the present invention.

[0040] As shown in FIG. 3, refrigerator 50 includes light-volume detecting unit 21, temperature sensor 61, door-open-close detecting unit 62, arithmetic control unit 22, light emitting unit 20, compressor 30, cooling fan 31, temperature compensation heater 32, damper 67, defrosting unit 68, and display unit 91.

[0041] To measure an external environment, refrigerator 50 may further include outer-air temperature sensor 63 and out-refrigerator illuminance sensor 72.

[0042] Arithmetic control unit 22 has storage-volume estimating unit 23, temperature-information deciding unit 70, door-open-close information deciding unit 71, comparison-information deciding unit 24, change-information deciding unit 25, memory unit 64, operation-start deciding unit 65, and operation-end deciding unit 66.

[0043] In refrigerator 50 according to the present embodiment, when a door open-and-close operation is performed, door-open-close detecting unit 62 detects an open operation or a close operation, and inputs this signal to arithmetic control unit 22 configured by a microcomputer or the like, and door-open-close information deciding unit 71 decides a door open-and-close operation. When it is decided that a door is closed, arithmetic control unit 22 sequentially operates light emitting unit 20 by a program determined in advance.

[0044] Light-volume detecting unit 21 detects a light volume of the vicinity, and inputs this information to arithmetic control unit 22. Storage-volume estimating unit 23 obtains storage information of a storage volume and a position of the storage object.

[0045] Upon obtaining the storage information, comparison-information deciding unit 24 compares storage information before the opening of the door with storage information after the closing of the door, for example, and obtains comparison information as a result.

[0046] Next, change-information deciding unit 25 compares the comparison information with a predetermined threshold value, and obtains storage information of a storage volume and a position of the storage object.

[0047] Operation-start deciding unit 65 of arithmetic control unit 22 performs a start decision of a power-saving operation and a rapid cooling operation based on the obtained change information, determines operations of compressor 30, cooling fan 31, temperature compensation heater 32, damper 67, defrosting unit 68, and display unit 91 concerning the cooling operation, and starts operation. Operation-end deciding unit 66 of arithmetic control unit 22 performs an end decision of a power-saving operation and the rapid cooling operation, and ends the operations of the above-described configuration elements.

[0048] Operations of light emitting unit 20 and light-volume detecting unit 21 that constitute the storage-state detecting means are described in detail.

[0049] FIG. 4 is an explanatory view of a storage-state detecting operation of refrigerator 50 according to the first embodiment of the present invention.

[0050] Irradiation lights 34a output from light emitting units 20 arranged on left-and-right both sidewalls of refrigerator 50 irradiate inside cold compartment 12 and storage object 33 stored inside cold compartment 12. Further, a part of irradiation lights 34a is incident to light-volume detecting unit 21 arranged in cold compartment 12. FIG. 4 shows a state that when storage object 33 is stored in cold compartment 12, depending on presence of storage object 33, there occur an area A where irradiation lights 34a from both the left-and-right sidewalls are shielded, an area B where any one of irradiation lights 34a is shielded, and an area C where none of left and right irradiation lights 34a is shielded.

[0051] In this case, light-volume detecting unit 21 is in the area B where any one of irradiation lights 34a is shielded, and detects and outputs a corresponding light volume. When a volume of storage object 33 is large, a detected light volume by light-volume detecting unit 21 decreases because the area A where both lights are shielded increases.

[0052] When a storage volume is small, a detected light volume by light-volume detecting unit 21 increases because the area C where none of irradiation lights 34a is shielded increases.

[0053] In this way, by detecting by light-volume detecting unit 21 a light volume change attributable to presence of storage object 33 and a difference in a volume of storage object 33, volumes (example: large or small) of storage object 33 in the refrigerator can be classified by deciding a detection result by using a predetermined threshold value set in advance.

[0054] Further, by using light emitting unit 20 also as illuminating unit 19 provided in refrigerator 50 or by using a substrate of light emitting unit 20 also as a substrate of illuminating unit 19, a storage state can be detected in a simpler configuration without additionally providing a light source and a material.

[0055] Next, an operation of a temperature control of a storage chamber of refrigerator 50 is described.

[0056] FIGS. 5A and 5B are diagrams showing an operation of refrigerator 50, and showing a temperature change relative to time, according to the first embodiment of the present invention.

[0057] FIG. 5A shows a temperature change in refrigerator 50 when an increase volume of a storage volume is larger than a standard, and FIG. 5B shows a temperature change of refrigerator 50 when an increase volume

of a storage volume is smaller than a standard. Solid lines indicate a temperature of storage object 33 in the refrigerator and a representative temperature in the storage chamber according to the present embodiment. Broken lines indicate a temperature of storage object 33 and time dependence of a representative temperature of a storage chamber when a control of a conventional refrigerator is performed.

[0058] A set temperature Ko is a preset preservation temperature of storage object 33. When an increase volume of a storage volume is larger and smaller than a standard, arithmetic control unit 22 changes over an operation state of refrigerator 50 based on a decision result of a storage volume by storage-volume estimating unit 23. To simplify the description, it is assumed that a kind of each storage object 33 is the same. A decision standard of "large, standard, small" of an increase volume of a storage volume is different depending on a size, a configuration, and a control system of a refrigerator. Therefore, the decision standard is not limited to the example described in the present specification.

[0059] In FIG. 5A, it is assumed that the door of refrigerator 50 is opened to preserve storage object 33 in the storage chamber, and the door is closed after inputting storage object 33 such as a food. Accordingly, when more storage object 33 of the same kind than a standard is stored, a detected light volume by light-volume detecting unit 21 becomes smaller than that when a volume of storage object 33 is the standard. Based on a decrease level of this detected light volume, change-information deciding unit 25 decides that an increase volume of a storage volume in the refrigerator is large. In this case, as shown in FIG. 5A, according to a conventional cooling operation (broken lines), a heat capacity held by the storage object is large. Further, according to conventional temperature detecting means, a time delay and the like occur. Accordingly, a cooling volume cannot be rapidly increased. Therefore, a temperature increases to some extent, and thereafter, a cooling volume increases, and cooling occurs, and the temperature approaches the set temperature Ko. However, because the cooling volume is increasing, a certain level of an excessive cooling state occurs, and is stabilized thereafter at Ko.

[0060] On the other hand, refrigerator 50 according to the present embodiment can rapidly detect an input volume of food at a door closing time. Therefore, when an increase of a certain constant storage volume or more is detected, for example, a cooling volume can be rapidly increased to suppress the increase in the in-refrigerator temperature and input storage object 33 can be quickly cooled. Further, to prevent excessive cooling, a cooling volume can be decreased when a temperature reaches a vicinity of the set temperature. Accordingly, power saving can be achieved by preventing an excessive cooling state.

[0061] When an increase volume of a storage volume is smaller than a standard, a detected light volume by light-volume detecting unit 21 becomes larger than that when the increase volume of a storage volume is the standard. Based on an increase level of the detected light volume, change-information deciding unit 25 decides that the increase volume of a storage volume in the refrigerator is small.

[0062] In this case, as shown in FIG. 5B, according to the conventional cooling operation (broken lines), time taken by storage object 33 to reach a set temperature is fast, and power is sometimes consumed more than is necessary, resulting in a cooling operation. Further, an excessive cooling state sometime occurs due to an increase of a cooling volume by a door opening-and-closing signal and the like.

[0063] Accordingly, arithmetic control unit 22 suppresses a rotation number of compressor 30 or decreases a circulation volume of cold air, and automatically changes over to a power-saving operation so that a temperature reaches a set temperature within a prescribed time. By this operation, an energy-saving effect can be obtained by mitigating a temperature behavior in the refrigerator, and noise reduction can be also performed by suppressing a rotation speed of cooling fan 31.

[0064] Next, a storage-volume detection control using light emitting unit 20 and light-volume detecting unit 21 is described.

[0065] FIG. 6 is a flowchart showing a storage-volume detection control of refrigerator 50 according to the first embodiment of the present invention.

[0066] In FIG. 6, when arithmetic control unit 22 detects a door open-and-close operation (S101) from the normal main control (S100), arithmetic control unit 22 confirms that the door is in a closed state (S102), and starts the storage-volume detection control (S103) when the door is in the closed state.

[0067] In the storage-volume detection control (S103), a plurality of light emitting units 20 are sequentially lit (S104). Each time, light-volume detecting unit 21 detects and outputs a light volume and illuminance to arithmetic control unit 22 (S105).

[0068] Then, storage-volume estimating unit 23 obtains storage information about a storage chamber (S106). Then, comparison-information deciding unit 24 compares storage information before the opening of the door with storage information after the closing of the door, storage information between before and after the opening and closing of the door at a past plurality of times, or storage information between before and after a constant time, and obtains comparison information (S107).

[0069] Then, change-information deciding unit 25 obtains change information about a storage state based on the storage information obtained in step S106 and the comparison information obtained in step S107 (S108). The obtained change information about the storage state is memorized in memory unit 64 (S109), and a database of a certain period is built up.

[0070] Arithmetic control unit 22 performs a decision control of the cooling operation, based on this database (S110).

[0071] A detailed example of performing the cooling-operation control based on the above-described storage-volume detection control is described with reference to FIG. 7 to FIG. 9.

[0072] FIG. 7 is a flowchart showing a cooling-operation decision control using the storage-volume detection control of refrigerator 50 according to the first embodiment of the present invention. In the example in FIG. 7, a relative evaluation of a storage volume of storage object 33 is performed.

[0073] In FIG. 7, during the main control (S110), when a door open-and-close operation is detected (S111), the storage detection control (S112) is started.

[0074] Specifically, as shown in steps S104 to S109 in FIG. 6, change information about a storage state is obtained based on storage information and comparison information.

[0075] Arithmetic control unit 22 performs a threshold-value decision to storage-change volume data A obtained from the change information (S113). When it is decided that the storage-change volume data A exceeds a standard storage-change volume B set in advance (S114, YES), operation-start deciding unit 65 performs a rapid cooling operation (S116). In a rapid cooling operation, various operations are performed; a cooling-medium circulation volume is increased by increasing a rotation number of compressor 30 so that a cooling volume is increased, an air volume is increased by increasing a rotation number of cooling fan 31, and an aperture of cold-compartment damper 67a is increased.

[0076] On the other hand, when it is decided that the storage-change volume data A is equal to or smaller than the standard storage-change volume B set in advance (S114, NO), arithmetic control unit 22 decides whether the storage-change volume data A is smaller than a standard storage-change volume C set in advance ($C < B$). When the storage-change volume data A is smaller than the standard storage-change volume C set in advance (S115, YES), operation-start deciding unit 65 performs a power-saving operation (S117). In the power-saving operation, various operations are performed; a cooling-medium circulation volume is decreased by decreasing a rotation number of compressor 30 so that a cooling volume is decreased, an air volume is decreased by decreasing a rotation number of cooling fan 31, and an aperture of cold-compartment damper 67a is decreased. In other cases (S115, NO), the normal operation is continued (S118).

[0077] When the process proceeds to step S117 or step S118, the process next proceeds to a temperature detection control (S119). The standard storage-change volume B and the standard storage-change volume C satisfy a relationship of ($C < B$).

[0078] Further, for the storage-change volume data A obtained from the change information of the storage volume, there can be used an absolute change volume, a relative change volume, a change rate, or a change pattern, relevant to attenuation of illuminance by light-volume detecting unit 21 from before the opening of the door to after the closing of the door. In the case of performing a decision based on the change pattern, by classifying a storage volume into a plurality of levels such as "large, medium, and small", for example, and by deciding that a storage volume change from before the door opening to after the door closing is "small→large" or "small→medium", arithmetic control unit 22 can adjust a cooling volume by matching this storage change pattern.

[0079] In the above-described example, refrigerator 50 includes cold compartment 12 as a storage chamber for storing storage object 33, partitioned by a heat insulation wall and a heat insulation door. Further, refrigerator 50 includes storage-volume estimating unit 23 for estimating a storage volume in the storage chamber, and memory unit 64 for memorizing a result of estimation by storage-volume estimating unit 23. Refrigerator 50 further includes arithmetic control unit 22 for calculating a storage change volume based on a result of estimation of a storage volume up to the last time memorized in memory unit 64 and a result of estimation by storage-volume estimating unit 23, and for controlling an output operation of the electrofunctional part. Arithmetic control unit 22 compares a predetermined threshold value with a storage change volume, decides that the storage volume changed when the storage change volume exceeds the threshold value, and controls the output operation of the electrofunctional part.

[0080] In this example, when a storage change volume (relative value) exceeds a threshold value, an output control is performed by deciding that the storage volume changed. Accordingly, an energy-saving characteristic at an actual using time can be enhanced by increasing an energy-saving-conscious operation rate. By using the threshold value, chattering in the output operation of the electrofunctional part and a trip phenomenon of compressor 30 can be prevented. Further, by comparing the predetermined threshold value with a storage change volume, it is determined that the storage volume changed when the storage change volume exceeds the threshold value. With this operation, a particular variation that storage-volume estimating unit 23 potentially has can be absorbed, and an output side can be properly controlled.

[0081] When the storage change volume does not exceed the threshold value, arithmetic control unit 22 may be configured not to change the output operation of the electrofunctional part. According to this configuration, when a storage change volume does not exceed the threshold value, it is determined that there is no change in the storage volume. By maintaining a storage volume memorized in memory unit 64 which is before storage-volume estimating unit 23 obtains an estimation result, a small change (small-lot storage) can be properly managed.

[0082] Further, the electrofunctional part can include at least one of cooling fan 31, damper 67, and compressor 30 for changing a cooling volume in the storage chamber. With this configuration, an energy-saving character-

istic at an actual using time can be improved by improving an energy-saving-conscious operation rate.

[0083] FIG. 8 is a flowchart showing another example of the cooling-operation decision control using the storage-volume detection control of refrigerator 50 according to the first embodiment of the present invention.

[0084] In the example of FIG. 8, an absolute evaluation of a storage volume of storage object 33 is performed.

[0085] In FIG. 8, in performing the main control (S120), when a door open-and-close operation is detected (S121), a storage-volume detection control (S122) starts. In the storage-volume detection control, storage-volume estimating unit 23 obtains storage information. In this example, comparison information and change information are not calculated. Therefore, in this example, comparison-information deciding unit 24 and change-information deciding unit 25 are not necessarily required.

[0086] Next, arithmetic control unit 22 performs a threshold-value decision to storage volume data G obtained from the storage information (S123). When it is decided that the storage volume data G is larger than a standard storage volume H set in advance (S124, YES), operation-start deciding unit 65 performs a rapid cooling operation (S126).

[0087] On the other hand, when the storage volume data G is equal to or smaller than the standard storage volume H set in advance (S124, NO), and also when the storage volume data G is smaller than a standard storage volume I set in advance (S125, YES), operation-start deciding unit 65 performs a power-saving operation (S127). In other cases (S125, NO), the normal operation is continued (S128). When the process proceeds to step S127 or step S128, the process proceeds to a temperature detection control

[0088] (S129). The standard storage volume H and the standard storage volume I satisfy a relationship of $I < H$.

[0089] FIG. 9 is a flowchart showing still other example of a cooling-operation decision control using a storage-volume detection control of refrigerator 50 according to the first embodiment of the present invention.

[0090] FIG. 9 also shows an example of performing an absolute evaluation of a storage volume of storage object 33.

[0091] In FIG. 9, during the main control (S130), when a door open-and-close operation is detected (S131), standard-storage volume data J is read from memory unit 64 (S132).

[0092] At this time, it is assumed that data of a storage volume of a certain constant period (for example, three weeks) is being memorized in memory unit 64. This data of the storage volume is calculated, and the standard-storage volume data J is calculated.

[0093] Next, a storage-volume detection control is started (S133) and storage information is decided. Then, a threshold-value decision is performed to storage-volume data K obtained from the storage information (S134). When the storage-volume data K is larger than a value obtained by multiplying a determined coefficient α (1.15, for example) to the standard-storage volume data J (S135, YES), operation-start deciding unit 65 performs a rapid cooling operation (S137). On the other hand, when the storage-volume data K is equal to or smaller than a value obtained by multiplying the determined coefficient α (1.15, for example) to the standard-storage volume data J (S135, NO), and also when storage-change volume data K is smaller than a value obtained by multiplying a determined coefficient β (1.05, for example) to the standard-storage volume data J (S136, YES), operation-start deciding unit 65 performs a power-saving operation (S138). In other cases (S136, NO), the normal operation is continued (S139). When the process proceeds to step S138 or step S139, the process proceeds to a temperature detection control (S140).

[0094] The coefficient α and the coefficient β satisfy a relationship of $\beta < \alpha$.

[0095] In the above example, refrigerator 50 includes a storage chamber for storing a storage object, partitioned by a heat insulation wall and a heat insulation door, and storage-volume estimating unit 23 for estimating a storage volume in the storage chamber based on a standard value held in advance. Further, refrigerator 50 includes arithmetic control unit 22 for calculating a storage volume in the storage chamber, and controlling an output operation of the electrofunctional part, based on a result of estimation by storage-volume estimating unit 23. Further, arithmetic control unit 22 controls an output operation of the electrofunctional part based on a predetermined threshold value and a storage volume.

[0096] With this configuration, it is possible to use only a portion suitable for estimating a storage volume for calculation, and an output operation can be optimized. Further, because an absolute volume can be output, it is not necessary to consider a variation in time series, or a variation generated by relative comparison.

[0097] It is also possible to configure such that an output operation of the electrofunctional part is controlled, by holding a plurality of threshold values, and by deciding a storage volume in the storage chamber in a plurality of groups based on the threshold values.

[0098] With this configuration, based on a plurality of threshold values, a storage volume in the storage chamber can be output by deciding the storage volume in a plurality of groups, control can be simplified, and easiness of handling the display function and the like can be improved.

[0099] Next, the temperature detection control in steps S119, S129, S140 described with reference to FIG. 7 to FIG. 9 are described.

[0100] FIG. 10 is a flowchart showing a control of performing a cooling operation decision after a temperature detection control by refrigerator 50 according to the first embodiment of the present invention.

[0101] In FIG. 10, after the temperature detection control is started, it is confirmed whether predetermined time has passed (S141). When a predetermined time has not passed, the passing of the time is awaited (S141, NO).

[0102] When the predetermined time has passed (S141, YES), a temperature in the refrigerator is detected with temperature sensor 61 (see FIG. 3). Temperature-information deciding unit 70 decides temperature information (S143). The decided information is memorized in memory unit 64, and a database of a certain constant period is built up (S144).

[0103] Next, a threshold-value decision is performed to the temperature information data D obtained from the temperature information (S145). When the temperature information data D is higher than a standard temperature E set in advance (S146, YES), operation-start deciding unit 65 performs a rapid cooling operation (S148). On the other hand, when the temperature information data D is equal to or lower than the standard temperature E set in advance (S146, NO), and also when the temperature information data D is lower than a standard temperature F set in advance (S147, YES), operation-start deciding unit 65 performs a power-saving operation (S149). In other cases (S147, NO), the normal operation is continued (S150). The standard temperature E and the standard temperature F satisfy a relationship of E > F.

[0104] By the above operation, it is possible to realize the automatic rapid cooling and the cooling operation of automatic power saving corresponding to a food storage volume change at a buying time and a using state of the refrigerator.

[0105] Next, a cooling operation decision based on a decision result of a storage volume change and a temperature change is described.

[0106] FIGS. 11A and 11B are views showing relationships between a storage volume change and a temperature change of refrigerator 50 according to the first embodiment of the present invention.

[0107] In FIGS. 11A and 11B, the normal operation is performed between the standard storage-change volume B and the standard storage-change volume C, and between the standard temperature E and the standard temperature F, and therefore, these sections are not shown.

[0108] As shown in FIG. 11A, a storage volume change from before the door opening to after the door closing is detected and decided. When the obtained storage-change volume data A is larger than the standard storage-change volume B set in advance, for example, a rapid cooling operation is performed.

[0109] On the other hand, when the obtained storage-change volume data A is smaller than the standard storage-change volume B set in advance and the standard storage-change volume C set in advance, basically a power-saving operation is performed.

[0110] As shown in FIG. 11A, by detecting and deciding the temperature information obtained by temperature sensor 61, when the obtained temperature information data D is larger than the standard temperature E set in advance, for example a rapid cooling operation is performed. On the other hand, when the obtained temperature information data D is smaller than the standard temperature E set in advance and the standard temperature F set in advance, a power-saving operation is performed.

[0111] The standard storage-change volume B, the standard storage-change volume C, the standard temperature E, and the standard temperature F may be set by outside-air temperature or by storage volume. For example, when an outside-air temperature is low, the in-refrigerator temperature does not easily increase even when there is door opening-and-closing or when a food is input. Therefore, energy saving can be realized by facilitating a power-saving operation, by setting the standard temperature E or the standard temperature F high and by setting the standard storage-change volume B or the standard storage-change volume C large. On the other hand, when an outside-air temperature is high, the in-refrigerator temperature becomes high when there is door opening-and-closing or when a food is input. Therefore, a high freshness preservation characteristic of storage object can be realized by facilitating a rapid cooling operation, by setting the standard temperature E or the standard temperature F low and by setting the standard storage-change volume B or the standard storage-change volume C small.

[0112] Further, when a storage volume in refrigerator 50 is large, the in-refrigerator temperature does not easily increase because of a cold-storage effect of food even when there is door opening-and-closing or when a food is input. Therefore, energy saving can be realized by facilitating a power-saving operation, by setting the standard temperature E or the standard temperature F high and by setting the standard storage-change volume B or the standard storage-change volume C large. On the other hand, when a storage volume in refrigerator 50 is small, the in-refrigerator temperature becomes high when there is door opening-and-closing or when a food is input. Therefore, a high freshness preservation characteristic of storage object can be realized by facilitating a rapid cooling operation, by setting the standard temperature E or the standard temperature F low and by setting the standard storage-change volume B or the standard storage-change volume C small.

[0113] Further, as shown in FIG. 11B, the setting of the standard temperatures E, F or the standard storage-change volumes B, C may be changed by matching a storage change volume or a temperature increase in the refrigerator.

[0114] For example, a rapid cooling operation is performed when a storage volume is greatly increased due to a bulk buying, or when a heated cooked food is stored in the refrigerator which affects the temperature in refrigerator 50 although the increase in the storage volume is small. Further, a rapid cooling operation is also performed when a temperature in refrigerator 50 gradually changes although the increase in the storage volume from before the door opening to after the door closing is small such as when food is stored in refrigerator 50 in a divided small lot, or when the temperature in refrigerator 50 greatly changes because the door of refrigerator 50

is kept opened for a long time in a half-opened state, for example. With this operation, because storage object 33 is cooled to an optimum preservation temperature in a short time, a high freshness preservation characteristic of storage object 33 can be realized.

[0115] On the other hand, when only confirming a storage object in refrigerator 50 or when a change in a storage volume is small when taking out beverage and returning it to the refrigerator and also when a temperature change in the refrigerator is small, "too cold" can be prevented by performing a power-saving operation, and an optimum cooling operation can be realized by matching a life pattern of each house.

[0116] In the above example, refrigerator 50 includes a storage chamber for storing a storage object, partitioned by a heat insulation wall and a heat insulation door, temperature sensor 61 as temperature detecting means for detecting a temperature in the storage chamber, and storage-volume estimating unit 23 for estimating a storage volume in the storage chamber. Further, refrigerator 50 includes memory unit 64 for memorizing a result of estimation by storage-volume estimating unit 23, a cooling unit for cooling inside the storage chamber, and arithmetic control unit 22 for controlling the cooling unit by performing a calculation based on input data of temperature sensor 61, storage-volume estimating unit 23, and memory unit 64. At the time of normal operation, arithmetic control unit 22 controls the output operation of the cooling unit based on a temperature of temperature sensor 61, and also controls the cooling unit by prioritizing over a temperature change when it is decided that the storage volume in the storage chamber changed.

[0117] Accordingly, as compared with a case of detecting a storage volume change by using only a thermistor, the storage volume change can be quickly detected in real time, and a temperature increase of food can be suppressed by a quick cooling-capacity control. Further, overshoot (excessive cooling) at a time of load reduction can be suppressed, and an energy-saving characteristic can be improved.

[0118] A rapid cooling operation and a power-saving operation are described in detail with reference to FIG. 12 to FIG. 14.

[0119] FIG. 12 is a diagram schematically showing a temperature behavior of temperature sensor 61 when a storage object is input at a time of simultaneous cooling of cold-compartment and freezing-compartment of refrigerator 50 according to the first embodiment of the present invention. FIG. 13 is a diagram schematically showing a temperature behavior of temperature sensor 61 when a storage object is input at a freezing-compartment independent cooling time of refrigerator 50 according to the embodiment. FIG. 14 is a diagram schematically showing a temperature behavior of temperature sensor 61 when a storage object is input at a cooling-stop time of refrigerator 50 according to the embodiment.

[0120] There are two methods for the rapid cooling operation. One method is for increasing an air volume of the cold compartment, and the other method is for lowering a discharged-air temperature from the cold compartment. As concrete means for the former, a rotation number of cooling fan 32 is increased, or an aperture of damper 67 of cold compartment 12 is increased. With this operation, the air volume of cold compartment 12 is increased, and a rapid cooling operation is performed. Accordingly, because a rotation number and the like of cooling fan 31 can be optimized by matching a storage state in each house, a power consumption volume can be suppressed. On the other hand, as concrete means for the latter, by increasing a rotation number of compressor 30, a cooling-medium circulation volume is increased to decrease a discharged-air temperature from the cold compartment and a rapid cooling operation is performed.

[0121] In the power-saving operation, a rotation number of compressor 30 is lowered to decrease a cooling-medium circulation volume and increase a discharged-air temperature into the refrigerator. Accordingly, because a rotation number and the like of compressor 30 can be optimized by matching a storage state in each house, a power consumption can be suppressed.

[0122] As shown in FIG. 12, when a storage object is input at the time of cold-compartment and freezing-compartment simultaneous cooling a, the conventional refrigerator (broken lines) generates a time difference from when the storage object is input until temperature sensor 61 detects a temperature increase. After detecting the temperature increase, a rotation number of compressor 30 is gradually increased. Therefore, it takes time to cool the input storage object to a target temperature.

[0123] Further, there is also a problem of reduction in freshness preservation characteristic of storage object, because of an increase in the temperature of a cooler due to return of a return air (warm air) from cold compartment 12 to the cooler, and because of an increase in freezing compartment 15 due to an increase in a discharged-air temperature that is heat-exchanged by the cooler.

[0124] Refrigerator 50 according to the present embodiment calculates a storage-volume change volume from before the door opening to after the door closing. When a storage-volume increase volume is larger than a predetermined threshold value, first, cooling-pattern identification means of arithmetic control unit 22 identifies that a cooling pattern at this time is the cold-compartment and freezing-compartment simultaneous cooling a, and immediately thereafter, refrigerator 50 increases the rotation number of compressor 30. With this operation, a cooling-medium circulation volume increases, a cooling capacity increases, and a discharged-air temperature from cold compartment 12 decreases immediately after storage object 33 is input. Therefore, input storage object 33 can be cooled to an optimum preservation temperature in a shorter time than that in the conventional refrigerator.

[0125] Further, in refrigerator 50 having damper 67 of

the freezing compartment, by calculating a storage-volume change volume from before the door opening to after the door closing, when a storage-volume increase volume is larger than a predetermined threshold value, refrigerator 50 performs an operation of setting "open→close" to damper 67 of the freezing compartment. With this operation, flow of warm air from the cold compartment to freezing compartment 15 due to the input of a storage object can be prevented. Then, after a constant time, refrigerator 50 performs an operation of setting "close→open" to damper 67 of freezing compartment 15, at the time point when a temperature detected by temperature sensor 61 of cold compartment 12 becomes equal to or lower than a certain predetermined temperature or when a temperature detected by temperature sensor 61 of freezing compartment 15 becomes equal to or higher than a certain predetermined temperature.

[0126] As shown in FIG. 13, when storage object 33 is input during freezing-compartment independent cooling b, the conventional refrigerator generates a time difference from when the storage object is input until temperature sensor 61 detects a temperature increase. Therefore, there is a case that a temperature detected by temperature sensor 61 of freezing compartment 15 reaches an OFF temperature of a predetermined value and compressor 30 stops, until temperature sensor 61 of cold compartment 12 detects a temperature increase. Thereafter, at the time point when a temperature detected by temperature sensor 61 of cold compartment 12 reaches an open temperature, refrigerator 50 controls to set "close→open" to damper 67 of cold compartment 12. With this operation, because compressor 30 or cooling fan 31 is driven and cools input storage object 33, it takes time to cool input storage object 33 to a target temperature.

[0127] On the other hand, refrigerator 50 according to the present embodiment calculates a storage-volume change volume from before the door opening to after the door closing. When a storage-volume increase volume is larger than a predetermined threshold value, first, cooling-pattern identification means of arithmetic control unit 22 identifies that a cooling pattern at this time is the freezing-compartment independent cooling b, and immediately thereafter, refrigerator 50 controls to operate "close→open" to damper 67 of cold compartment 12 and increases the rotation number of compressor 30. With this operation, because discharged air flows to cold compartment 12, input storage object 33 can be cooled to an optimum preservation temperature in a shorter time than that achieved by conventional refrigerator 50.

[0128] Further, in refrigerator 50 having damper 67 of freezing compartment 15, a storage-volume change volume from before the door opening to after the door closing is calculated. When a storage-volume change volume is larger than a predetermined threshold value, refrigerator 50 immediately operates to set "open→close" to damper 67 of freezing compartment 15. With this operation, flow of warm air from cold compartment 12 into freezing compartment 15 due to the input of storage object 33 can be prevented. Then, after a constant time, or at the time point when a temperature detected by temperature sensor 61 of cold compartment 12 becomes equal to or lower than a certain predetermined temperature or when a temperature detected by temperature sensor 61 of freezing compartment 15 becomes equal to or higher than a certain predetermined temperature, refrigerator 50 operates to set "close→open" to damper 67 of freezing compartment 15.

[0129] As shown in FIG. 14, when storage object 33 is input at a cooling-stop c time, in the conventional refrigerator, compressor 30 is not driven until a temperature detected by temperature sensor 61 of freezing compartment 15 reaches the ON temperature. Thereafter, at the time point when a temperature detected by temperature sensor 61 of cold compartment 12 reaches an open temperature, refrigerator 50 controls to set "close→open" to damper 67 of cold compartment 12, drives compressor 30 and cooling fan 31, and cools the input storage object. Therefore, it takes time to cool storage object 33 to a target temperature.

[0130] On the other hand, refrigerator 50 according to the present embodiment calculates a storage-volume change volume from before the door opening to after the door closing. When a storage-volume increase volume is larger than a predetermined threshold value, first, cooling-pattern identification means of arithmetic control unit 22 identifies that a cooling pattern at this time is the cooling-stop c. Thereafter, when compressor 30 is after having stopped a constant time (ten minutes, for example), refrigerator 50 drives compressor 30 in high rotation regardless of a temperature detected by temperature sensor 61, and operates to set "close→open" to damper 67 of cold compartment 12. With this operation, because cold compartment 12 can be quickly cooled while securing starting of compressor 30, input storage object 33 can be cooled to an optimum preservation temperature in a shorter time than that achieved by the conventional refrigerator.

[0131] Further, in refrigerator 50 having damper 67 of freezing compartment 15, there is a case that during a stop of compressor 30, cooling is performed by using frost adhered to the cooler, by setting "open" to damper 67 of cold compartment 12 and setting "close" to damper 67 of freezing compartment 15. In this case, at the time point of detecting a storage volume increase, only cold compartment 12 is operated by starting while securing starting of compressor 30, with damper 67 of freezing compartment kept in a "close" state. With this operation, input storage object 33 can be cooled to an optimum preservation temperature in a shorter time than that of the conventional refrigerator. However, at the time point when a temperature detected by temperature sensor 61 of freezing compartment 15 becomes equal to or higher than a certain predetermined temperature, refrigerator 50 operates to set "close→open" to damper 67 of freezing compartment 15.

[0132] Further, in refrigerator 50 having damper 67 of freezing compartment 15, when a storage object is input at a cold-compartment independent cooling d time, refrigerator 50 calculates a storage-volume change volume from before the door opening to after the door closing. When a storage-volume increase volume is larger than a predetermined threshold value, first, cooling-pattern identification means of arithmetic control unit 22 identifies that a cooling pattern at this time is the cold-compartment independent cooling d. Thereafter, a rotation number of compressor 30 is immediately increased in a similar manner to that of the cold-compartment and freezing-compartment simultaneous cooling a time. With this operation, because a discharged-air temperature from cold compartment 12 decreases, input storage object 33 can be cooled to an optimum preservation temperature in a shorter time than that of the conventional refrigerator. Then, after a constant time, or at the time point when a temperature detected by temperature sensor 61 of cold compartment 12 becomes equal to or lower than a certain predetermined temperature or when a temperature detected by temperature sensor 61 of freezing compartment 15 becomes equal to or higher than a certain predetermined temperature, refrigerator 50 controls to set "close→open" to damper 67 of freezing compartment 15.

[0133] The above-described rapid cooling operation is canceled by operation-end deciding unit 66, and the normal operation or the cooling operation of automatic power saving is started, after compressor 30 stops after a lapse of a constant time or at the time point when a temperature detected by temperature sensor 61 of cold compartment 12 becomes equal to or lower than a certain predetermined temperature.

[0134] By the above operation, optimum automatic rapid cooling and a cooling operation of automatic power saving can be realized by matching the cooling pattern of refrigerator 50.

[0135] Regarding the automatic rapid cooling and the cooling operation of automatic power saving in refrigerator 50 according to the present embodiment, a function by the intention of the user such as a change of the in-refrigerator temperature setting and a rapid freeze function, for example, can be also prioritized.

[0136] Forecast of a life pattern by the learning function and a start-and-end timing of a power-saving operation according to the present embodiment are described.

[0137] FIG. 15 is an explanatory diagram of forecast of a life pattern using a learning function of refrigerator 50 and a start-and-end timing of a power-saving operation according to the first embodiment of the present invention.

[0138] The learning function according to the present embodiment is that arithmetic control unit 22 decides presence of a life style of a constant pattern, based on obtained temperature information, door opening-and-closing information, storage information, or change information of a storage state that are accumulated by memory unit 64 during a constant period (three weeks, for example). By the forecast based on a learning result, start and end timings of a power-saving operation are determined, and a power-saving operation for automatically controlling the operations of compressor 30, cooling fan 31, temperature compensation heater 32, damper 67, defrosting unit 68, and display unit 91 as electronic load parts are performed.

[0139] In general, on holidays, the door is opened and closed frequently, and a heat load in refrigerator 50 is large. On weekdays, during a working time, particularly in a household in which both husband and wife work, there is no door opening-and-closing in the daytime, and a heat load in refrigerator 50 is small.

[0140] In the example shown in FIG. 15, one hour is considered as one section, 24 sections correspond to one day, and 168 sections correspond to one week (seven days).

[0141] During one section, time during which an in-refrigerator temperature that is equal to or higher than the standard temperature E continued for a constant time, and time during which a storage-volume increase is equal to or larger than the standard storage-change volume B are memorized. Then, a learning result one week before, two weeks before, and three weeks before a measuring day is extracted. When two thirds or more of three weeks is a time zone in which the in-refrigerator temperature that is equal to or higher than the standard temperature E continues for a constant time, or when two thirds or more of three weeks is a time zone in which a storage-volume increase that is equal to or larger than the standard storage-change volume B is detected, this time zone is decided as "heat-load large time" and is learned as such. Further, in addition to the in-refrigerator temperature and the storage-volume increase, a number of door open-close times may be learned. In this case, from the learning result, when two thirds or more of three weeks is time when a total number of times of opening-and-closing the doors of cold compartment 12 and freezing compartment 15 is equal to or larger than a constant number of times (five or more times, for example) during one section, this time zone can be decided as "heat-load large time" and can be learned as such.

[0142] Further, a temperature difference between freezing compartment 15 and an outside of the refrigerator is larger than a temperature difference between cold compartment 12 and the outside of the refrigerator, and the in-refrigerator temperature easily increases by door opening-and-closing. Therefore, when two thirds or more of three weeks is time when a total number of times of opening-and-closing the door of freezing compartment 15 is equal to or larger than a constant number of times (two or more times, for example) during one section, this time zone may be decided as "heat-load large time".

[0143] In a general house, in many cases, the user has life of a certain constant pattern in a day. Further, life of a certain constant life pattern is held in many cases in the same day of the week, with one week as a unit. It is very effective to perform a cooling operation of refriger-

ator 50 by considering these factors, and this leads to power saving. It is desirable to update data rewriting in a unit of one section (unit time: 60 minutes, for example). However, the updating may be in a day unit or a week unit.

[0144] Then, from a forecast result of a user's life pattern, a start-and-end timing of a power-saving operation is determined. A power-saving operation is performed in time other than a time zone that is decided as "heat-load large time" by a learning result, and the power-saving operation is shifted to the normal operation at the time point when the "heat-load large time" has come.

[0145] However, as a shift time from the power-saving operation to the normal operation, actually, the power-saving operation ends and is changed over to the normal operation predetermined time (one hour, for example) before start of the "heat-load large time". This is because, in the "heat-load large time", a temperature in refrigerator 50 is assumed to become high due to frequent door opening-and-closing and for preservation of a warm cooked product in a time zone of cooking, for example. Thereafter, at the time point of the end of the "heat-load large time", the power-saving operation is started again when the in-refrigerator temperature is equal to or lower than the standard temperature E.

[0146] Next, a control flow diagram of a learning operation control is described.

[0147] FIG. 16 is a flowchart showing a learning operation control of refrigerator 50 according to the first embodiment of the present invention.

[0148] In FIG. 16, after the learning operation control has started, it is confirmed that the operation is the normal operation (S151). Next, it is decided whether it is an end time of the "heat-load large time" decided by the learning result (S152).

[0149] When it is decided that it is the end time of "heat-load large time" (S152, YES), it is decided whether a current temperature in refrigerator 50 is equal to or lower than the standard temperature E (S153).

[0150] When it is decided in step S153 that the in-refrigerator temperature is equal to or lower than the standard temperature E, the normal operation is changed over to a power-saving operation (S154). On the other hand when it is decided in step S152 that it is not the end time of "heat-load large time" (S152, NO), or when it is decided in step S153 that the in-refrigerator temperature exceeds the standard temperature E (S153, NO), the normal operation is continued (S151).

[0151] Then, it is confirmed that the operation is the power-saving operation (S154), and it is decided whether it is predetermined time before start of the "heat-load large time" (S155). When it is decided that it is predetermined time before start of the "heat-load large time" (S155, YES), the power-saving operation is changed over to the normal operation (S151). On the other hand, when it is decided in step S155 that it is not predetermined time before start of the "heat-load large time" (S155, NO), the power-saving operation is continued (S154).

[0152] By the above operation, it is possible to virtually detect a day of the week, by patterning and learning a food storage volume change at a buying time, and a storage state and a using environment in each house, and by separating the data for every seven days, for example. With the above operation, by performing the normal operation in only a day of the week and time in which a heat load of refrigerator 50 is assumed to be large, "too cold" can be prevented by suppressing a rotation number of compressor 30 and cooling fan 31 in a day of the week and time in which a heat load of refrigerator 50 is assumed to be small. In this way, energy saving can be automatically realized by matching a life pattern of each house.

[0153] Next, another example of forecast of a life pattern by the learning function and a start-and-end timing of the power-saving operation is described.

[0154] FIG. 17 is a diagram for explaining a "bulk-buying day" decision by the learning function of refrigerator 50 according to the first embodiment of the present invention. FIG. 18 is an explanatory diagram of forecast of a life pattern using a separate learning function and a start-and-end timing of the power-saving operation according to the first embodiment of the present invention.

[0155] In the example shown in FIG. 17, a day when there is a storage-volume increase equal to or larger than the standard storage change volume B is decided for each day.

[0156] Based on bulk-buying tendency that increases in recent years, a number of times of buying is assumed as twice a week, for example. In this case, as an example, a storage volume increases once on a weekday and once on a holiday. On other days, a storage volume in cold compartment 12 shifts in a reduction direction to some extent, because a storage object is used for cooking and the like.

[0157] On a bulk-buying day, the in-refrigerator temperature is estimated to increase due to a storage-volume increase in cold compartment 12. Therefore, by forecasting and learning a "bulk-buying day", input storage object 33 can be cooled to an optimum preservation temperature in a short time by increasing a cooling volume on the day that is forecasted as the "bulk-buying day". Consequently, a high freshness preservation characteristic of storage object 33 can be realized.

[0158] On a day that is forecasted as other than the "bulk-buying day", the power-saving operation is performed by decreasing the cooling volume. With this operation, a cooling volume can be adjusted by matching a storage state and a using state. Therefore, by preventing "too cold", energy saving can be realized by performing an optimum cooling operation by matching a life pattern of each house.

[0159] A decision method of a "bulk-buying day" is described. When one day is considered as one section, seven sections correspond to one week (seven days). Days when there are storage-volume increases equal to or more than the standard storage-change volume B during this period is memorized. Then, a learning result one week before, two weeks before, and three weeks before

this day is extracted. When two thirds or more of past three weeks are days in which there is a storage-volume increase equal to or more than the standard storage change volume B, the corresponding day of the week is decided and learned as a "bulk-buying day". In the example shown in FIG. 17, Wednesday and Saturday are decided as "bulk-buying days".

[0160] A "bulk-buying day" may be decided and learned from a decrease volume from the average storage volume. In this case, a storage volume at every constant time is memorized, and an average storage volume in each house is learned from data of past three weeks. When a storage volume during this time becomes smaller by a constant volume or more (10% or more, for example) than the learned average storage volume, a day next to this day is memorized. When two thirds or more of past three weeks is a corresponding day, the corresponding day of the week is decided and learned as a "bulk-buying day".

[0161] In learning the "bulk-buying day", it is necessary to divide a period from morning to the morning of the next day, or a period from night to the night of the next day as one day. It is easy to divide one day by adding a clock function to refrigerator 50. However, this has a disadvantage of increasing cost.

[0162] It is possible to divide one day, by arranging out-refrigerator illuminance sensor 72 (see FIG. 3) outside refrigerator 50 and by deciding night time from a result of detection by out-refrigerator illuminance sensor 72. For example, a time when average illuminance during one hour becomes equal to or lower than a prescribed value (5 Lx or lower, for example) is a time when sleeping starts. Time from this hour to hour when the average illuminance returns to equal to or higher than the prescribed value and when the average illuminance become equal to or lower than the prescribed value again is decided as one day.

[0163] By deciding in this way, one day can be divided at low cost and accurately. Further, during a night time, refrigerator 50 is little used, and time during which a number of door open-close times is small is assumed to continue. Therefore, by deciding and learning from a combination of a result of detection by door-open-close detecting unit 62 and a result of detection by out-refrigerator illuminance sensor 72, one day can be divided in higher precision. It is also possible to calculate one day by detecting a temperature change during daytime and nighttime with outer-air temperature sensor 63. Also in this case, one day can be divided in high precision in a similar manner to that when out-refrigerator illuminance sensor 72 is used.

[0164] When a "bulk-buying day" is assumed, it is considered that, in returning home after the buying, the user immediately stores the bought food into refrigerator 50 in many cases. Therefore, from the number of times of opening and closing the door of refrigerator 50, it is possible to decide and learn "unused time" during which refrigerator 50 is not used. Accordingly, by increasing a cooling volume predetermined time before the "unused time", input storage object 33 can be cooled to an optimum preservation temperature in a short time. Accordingly, a high freshness preservation characteristic of storage object 33 can be realized.

[0165] A decision method of an "unused time" is described with reference to FIG. 18.

[0166] As shown in FIG. 18, from a number of door open-close times in one section, time when there is door opening-and-closing at or smaller than a constant number of times during one hour (once or less, for example), for example, is memorized. From a learning result one week before, two weeks before, and three weeks before a corresponding day, when there is a time zone in which there are door openings and closings at only a constant number of times or less during one hour in two thirds or more of three weeks, the corresponding time zone is decided and learned as an "unused time".

[0167] By arranging out-refrigerator illuminance sensor 72 outside refrigerator 50, and by memorizing a result of detection by out-refrigerator illuminance sensor 72, decision accuracy of the "unused time" can be further enhanced. Whether a periphery of a set position of refrigerator 50 is bright or dark can be detected from an output of out-refrigerator illuminance sensor 72. Therefore, it is possible to discriminate between a daytime when there is a possibility of mainly the user becoming active and a night time when there is a low possibility of the user becoming active.

[0168] By detecting a periphery of refrigerator 50 with out-refrigerator illuminance sensor 72, detected information is output to arithmetic control unit 22. Time during which average illuminance in one section is equal to or lower than a prescribed value (5 Lx or lower, for example) is memorized. When two thirds or more of three weeks is a time zone during which average illuminance in one section is equal to or lower than a prescribed value (5 Lx or lower, for example) from a learning result one week before, two weeks before, and three weeks before a corresponding day, the corresponding time zone may be decided and learned as an "unused time".

[0169] In this way, start and end timings of the power-saving operation are determined from a forecast result of a life pattern of the user. On a day that is decided as a day other than a "bulk-buying day" from a learning result, the power-saving operation is performed in a time zone other than a learned "heat-load large time", and the power-saving operation is shifted to the normal operation at the time point of becoming the "heat-load large time". This is because, in the "heat-load large time", a temperature in refrigerator 50 is assumed to be high due to frequent door opening-and-closing and for preservation of a warm cooked product during a time zone of cooking, for example.

[0170] However, as a shift time from the power-saving operation to the normal operation, actually, the power-saving operation ends and is changed over to the normal operation predetermined time (one hour, for example)

before start of the "heat-load large time". Accordingly, on a day which is decided as other than a "bulk-buying day", the normal operation is performed in only a time zone in which a heat load of refrigerator 50 is assumed to be large. In a time zone in which a heat load to refrigerator 50 is assumed to be small, "too cold" can be prevented by suppressing a rotation number of compressor 30 or the cooling fan. In this way, energy saving can be automatically realized by matching a life pattern of each house.

[0171] When it is decided that a day is a "bulk-buying day" from a forecast result of a life pattern of the user, the power-saving operation is performed in a learned "unused time" zone, and the power-saving operation is shifted to the normal operation at the time point of becoming an end of the "unused time". This is because there is a high possibility that immediately after the user returns home from shopping, the user inputs the bought product into refrigerator 50, and at this time, a temperature in refrigerator 50 becomes high. However, as a shift time from the power-saving operation to the normal operation, actually, the power-saving operation ends and is changed over to the normal operation predetermined time (one hour, for example) before end of the "unused time". Accordingly, on a day which is decided as a "bulk-buying day", it is assumed that an in-refrigerator temperature becomes high based on a storage-volume increase due to a bulk buying in addition to a temperature increase in the refrigerator due to frequent door opening-and-closing in a time zone of cooking and preservation of a warm cooked product. Therefore, as compared with a day which is decided as other than a "bulk-buying day", a high freshness preservation characteristic of storage object can be realized by decreasing the power-saving operation and by securing a sufficient cooling volume on the day which is decided as a "bulk-buying day".

[0172] Next, a control flow diagram of a learning operation control when learning a "bulk-buying day" is described with reference to FIG. 19.

[0173] FIG. 19 is a flowchart showing a learning operation control in a separate mode according to the first embodiment of the present invention.

[0174] In FIG. 19, upon starting a learning operation control, it is decided from a learning result whether this day is the "bulk-buying day" (S160).

[0175] When it is decided that this day is the "bulk-buying day" (S160, YES), it is confirmed that the operation is the normal operation (S162).

[0176] Then, it is decided whether it is a start time of the "unused time" decided by the learning result (S163). When it is decided that it is a start time of the "unused time" (S163, YES), it is decided whether a current temperature in refrigerator 50 is equal to or lower than the standard temperature E (S164).

[0177] When it is decided that the in-refrigerator temperature is equal to or lower than the standard temperature E (S164, YES), the normal operation is changed over to a power-saving operation (S165). On the other hand, when it is decided in step S163 that it is not the start time of the "unused time", or when it is decided in step S164 that the in-refrigerator temperature exceeds the standard temperature E, the normal operation is continued (S162).

[0178] When it is confirmed that an operation is the power-saving operation (S165), next, it is determined whether predetermined time before end of the "unused time" has passed (S166). When it is decided that it is predetermined time before end of the "unused time" (S166, YES), the power-saving operation is changed over to the normal operation (S162). On the other hand, when it is decided in step S166 that it is not predetermined time before end of the "unused time", the power-saving operation is continued (S165).

[0179] On the other hand when it is decided in step S160 that this is not the "bulk-buying day" (S160, NO), it is confirmed that the operation is the normal operation (S172), and it is decided whether it is the end time of the "heat-load large time" decided by the learning result (S173). When it is decided that it is the end time of the "heat-load large time" (S173, YES), it is decided whether a current temperature in refrigerator 50 is equal to or lower than the standard temperature E (S174).

[0180] When it is decided that the in-refrigerator temperature is equal to or lower than the standard temperature E (S174, YES), the normal operation is changed over to a power-saving operation (S175). On the other hand, when it is decided in step S173 that it is not the end time of the "heat-load large time", or when it is decided in step S174 that the temperature exceeds the standard temperature E, the normal operation is continued (S172).

[0181] When it is confirmed that the operation is the power-saving operation (S175), next it is decided whether it is predetermined time before start of the "heat-load large time" (S176). When it is decided that it is predetermined time before start of the "heat-load large time" (S176, YES), the power-saving operation is changed over to the normal operation (S172). On the other hand, when it is decided in step S176 that it is not predetermined time before start of the "heat-load large time", the power-saving operation is continued (S176, NO).

[0182] As described above in refrigerator 50 according to the present embodiment, in a time zone in which a storage state and a temperature in refrigerator 50 are estimated to greatly change due to a bulk buying and the like, input storage object 33 can be cooled to an optimum preservation temperature in a short time by increasing a cooling volume. Accordingly, a high freshness preservation characteristic of storage object 33 can be realized, and a cooling volume can be adjusted by matching a storage state and a using state. Therefore, energy saving can be realized by preventing "too cold" and by performing an optimum cooling operation by matching a life pattern in each house.

[0183] Further, a life pattern is forecasted from information accumulated in memory unit 64. A time zone of

a life pattern in which a storage volume change is forecasted to be small and also a temperature increase in refrigerator 50 is forecasted to be small is decided as a time zone in which refrigerator 50 is little used and also a heat load is small. Then, when in this time zone, the power-saving operation is automatically started. Accordingly, "too cold" is prevented by suppressing rotation numbers of compressor 30 and cooling fan 31. Therefore, energy saving can be automatically realized by matching a life pattern of each house.

[0184] Further, a life pattern is forecasted from information accumulated in memory unit 64. A time zone of a life pattern in which an increase in a storage volume in refrigerator 50 is forecasted is decided as a time zone in which a heat load is large, and the power-saving operation automatically ends predetermined time before this time zone. Accordingly, because input storage object 33 can be cooled to an optimum preservation temperature in a short time, a high freshness preservation characteristic of storage object 33 can be realized. Further, the cooling operation is performed by matching a life pattern of each house, by increasing a cooling volume based on the learning and forecasting of time zones in which a warm cooked product and the like are cold-preserved in refrigerator 50 and cooking is performed by frequently opening and closing the door of refrigerator 50. Therefore, a high freshness preservation characteristic of storage object 33 can be realized.

[0185] As described above, refrigerator 50 includes a storage chamber for storing a storage object, partitioned by a heat insulation wall and a heat insulation door, storage-volume estimating unit 23 for estimating a storage volume in the storage chamber, and memory unit 64 for memorizing a result of estimation by storage-volume estimating unit 23. Further, arithmetic control unit 22 functions as a storage-volume-change forecast unit that forecasts a future storage volume change in the storage chamber from the data of memory unit 64, and also controls an output operation of the electrofunctional part based on the future storage volume change-forecast data of the storage-volume-change forecast unit. Further, arithmetic control unit 22 controls the output operation of the electrofunctional part based on the future storage volume change-forecast data of the storage-volume-change forecast unit. Accordingly, improvement of a food-freshness preservation characteristic that matches a buying-scheduled date and time and an energy-saving characteristic can be enhanced.

[0186] Further, arithmetic control unit 22 estimates a storage-volume-increase forecast date and time of the user based on storage volume data of a constant period memorized in memory unit 64 and the future storage volume change-forecast data of the storage-volume-change forecast unit. Then, a control of increasing a cooling volume in the storage chamber is performed predetermined time before the storage-volume-increase forecast date and time. Accordingly, by increasing the cooling volume in the storage chamber predetermined time (scheduled buying date and time) before a storage-volume-increase forecast date and time, a food-freshness preservation characteristic can be securely improved.

[0187] When storage-volume estimating unit 23 decides that there is no change in the storage volume in the storage chamber, arithmetic control unit 22 lowers the cooling volume in the storage chamber, predetermined time after a storage-volume-increase forecast date and time. Accordingly, both an energy-saving characteristic and a food-freshness-preservation characteristic can be materialized.

[0188] In the present embodiment, an example of the storage-state detecting unit provided in cold compartment 12 is shown. However, the present invention is not limited to this example, and the storage-state detecting unit may be provided in at least one of cold compartment 12, ice compartment 13, change compartment 14, freezing compartment 15, and vegetable compartment 16.

[0189] The present embodiment is not necessarily limited to the configuration of refrigerator 50 shown in FIG. 2, and can be also applied to a conventionally-general type of a refrigerator in which compressor 30 is arranged by providing a machine room in a rear area of a storage chamber at a lowest part of a heat-insulation box body.

[0190] Further, refrigerator 50 may include a storage chamber for storing a storage object, partitioned by a heat insulation wall and a heat insulation door, a deodorizing and sterilizing unit for deodorizing or sterilizing inside the storage chamber, and storage-volume estimating unit 23 for estimating a storage volume in the storage chamber. Further, refrigerator 50 may include memory unit 64 for memorizing a result of estimation by storage-volume estimating unit 23, and arithmetic control unit 22 for calculating a storage change volume based on a result of estimation by storage-volume estimating unit 23 and memory unit 64, and for controlling an output operation of the deodorizing and sterilizing unit. Arithmetic control unit 22 changes a deodorizing and sterilizing capacity of the deodorizing and sterilizing unit when it is decided that a storage volume in the storage chamber changed.

[0191] Further, for the deodorizing and sterilizing unit, an electrostatic spray apparatus for spraying a mist in the storage chamber can be also used.

[0192] Accordingly, by performing the deodorization and sterilization control by quickly catching a storage volume change, a sterilization and deodorization function can be improved and a humidity control can be adequately performed according to the storage volume change.

[0193] Further, refrigerator 50 includes door-open-close detecting unit 62 for detecting opening and closing of a heat insulation door. Arithmetic control unit 22 controls an output operation of the electrofunctional part when a storage change volume from before the door opening to the door closing exceeds a predetermined threshold value, based on a result of detection by door-open-close detecting unit 62.

[0194] Accordingly, by comparing a storage volume before the door opening with a storage volume after the

door closing, a storage volume change can be more securely understood.

[0195] It may be configured such that a storage volume in memory unit 64 is maintained and an output operation of the electrofunctional part is not changed, when a storage change volume does not exceed a threshold value.

[0196] In this case, when the threshold value is not exceeded, it is decided that there is no change in the storage volume, and a storage volume of memory unit 64 before the result of estimation by storage-volume estimating unit 23 is maintained. Accordingly, the present embodiment can be also properly applied to a small change of a storage volume (small-lot storage).

[0197] As the electrofunctional part that is output controlled, a cooling fan or a compressor for changing a cooling volume in the storage chamber may be used.

[0198] Accordingly, an energy-saving characteristic at an actual using time can be enhanced by increasing an energy-saving-conscious operation rate.

[0199] In the above description, it is described that light emitting unit 20 and light-volume detecting unit 21 are configured to be included as storage-state detecting means. However, the storage-state detecting means according to the present invention is not limited to this configuration. For example, it is also possible to use means for detecting an inclination of an in-refrigerator temperature and for detecting a storage state by using a current change at an operation time of the cooling function part.

SECOND EXEMPLARY EMBODIMENT

[0200] Next, a second embodiment of the present invention is described.

[0201] In the present embodiment, only portions different from those in the configuration and the technical idea described in detail in the first embodiment are described in detail. Portions of which configurations are the same as those described in detail in the first embodiment, and portions in which no inconvenience occurs when the same technical idea is applied can be applied in combination with the present embodiment, and their detailed descriptions are omitted.

[0202] Refrigerator 50 according to the second embodiment includes door-open-close detecting unit 62 for detecting a door opened-and-closed state of refrigerator 50. During a period when detecting a door-closed state, a series of operation of light emitting unit 20, light-volume detecting unit 21, arithmetic control unit 22, and storage-volume estimating unit 23 described in the first embodiment are started.

[0203] Based on this operation, by detecting a door opened-and-closed state of refrigerator 50, and by operating light emitting unit 20 and light-volume detecting unit 21 after a lapse of a certain constant time since the door is in the closed state, an influence of background light and an influence of afterglow can be easily avoided.

[0204] A change in a storage volume follows a series of operation. First, the user opens the door, inputs or takes out a food, and closes the door last. Therefore, it is sufficient to detect a storage volume only after the door is opened and closed. That is, based on the inclusion of door-open-close detecting unit 62, a minimum detecting operation is sufficient, and power consumption by light emitting unit 20 and the like can be deleted.

[0205] In a household refrigerator, by relating door-open-and-close detection and in-refrigerator illumination, a light-on/light-off control of illuminating unit 19 in the refrigerator is performed according to door opening-and-closing. By sharing the door opened-and-closed state detecting function in this control, a simple configuration can be realized without adding a part.

[0206] In the present embodiment, arithmetic control unit 22 calculates when predetermined time elapsed after door-open-close detecting unit 62 detects a close operation of a heat insulation door, and controls an output operation of the electrofunctional part.

[0207] Accordingly, by comparing stabilized states after the door is closed, a storage volume change can be more securely understood.

THIRD EXEMPLARY EMBODIMENT

[0208] A third embodiment of the present invention is described.

[0209] FIGS. 20 and 21 are explanatory diagrams (cross-sectional view corresponding to FIG. 2) of a storage-volume detecting operation according to the third embodiment of the present invention.

[0210] Also in the present embodiment, detailed descriptions are omitted for portions of which configurations and technical ideas are the same as those in refrigerators 50 of the first embodiment and the second embodiment. The configurations described in the first embodiment and the second embodiment can be applied in combination with the present embodiment.

[0211] In FIG. 20, illuminating unit 19 is arranged in a longitudinal direction on each of a left-side wall surface and a right-side wall surface positioned in front of a front end of storage shelf 18, nearer than a half of a depth dimension in the refrigerator, viewed from door-open-side front surface in the refrigerator.

[0212] In illuminating units 19, light emitting units 20a to 20d are arranged at equal intervals in a longitudinal direction, and can irradiate whole parts from an upper part to a lower part in cold compartment 12. Further, light-volume detecting units 21a to 21d are arranged at rear positions in cold compartment 12, and are configured to detect light volume attenuation due to shielding of light mainly by storage object 33. Light-volume detecting unit 21e is arranged on a ceiling surface of cold compartment 12, and detects light volume attenuation due to light reflection by mainly storage object 33. For light-volume detecting units 21a to 21e, illuminance sensors, and chrominance sensors and the like capable of identifying chrominance (RGB) in addition to illuminance are used.

[0213] As shown in FIG. 21, a storage volume can be

also detected in high precision by providing light emitting unit 20e on a ceiling surface in the refrigerator and light-volume detecting unit 21f at a lower side. Light emitting unit 20e on the ceiling surface is arranged at a nearer side than a half of an in-refrigerator depth dimension viewed from a door-open side in refrigerator 50. Further, in the present embodiment, light emitting unit 20e on the ceiling surface is arranged at a door side far from a front end of storage shelf 18, and at a rear side of door shelves 27a to 27c fitted to the door. By arranging in this way, a front surface (light axis direction) of light emitting unit 20e of the ceiling surface is not shielded by storage objects 33 on storage shelf 18 and door shelves 27a to 27c.

[0214] Further, for the same reason, light-volume detecting unit 21f at a lower side is also arranged at a door side far from the front end of storage shelf 18, and also at a rear side of door shelves 27a to 27c fitted to the door, and further at a height equal to or lower than lowest storage shelf 18. A set surface of lower light-volume detecting unit 21f may be one of a side surface and a lower surface in the refrigerator. A positional relationship between light emitting unit 20e on the ceiling surface and lower light-volume detecting unit 21f may set opposite.

[0215] In this way, by configuring such that the inside of the refrigerator is irradiated from the ceiling surface and a light volume is detected at a lower part, light is transmitted to storage shelf 18 and door shelves 27a to 27c. Therefore, detection of a storage volume can be accurately performed.

[0216] In the storage chamber that is long in a height direction like cold compartment 12, light from light emitting unit 20e on the ceiling surface does not easily reach a lower storage object. Therefore, it is preferable to sufficiently irradiate inside the refrigerator by also using a lower light emitting unit such as light emitting unit 20d.

[0217] So far as light-volume detecting units 21a to 21f are arranged at positions irradiated by light emitting units 20a to 20d via storage object 33 and an in-refrigerator structure, light-volume detecting units 21a to 21f may be arranged at any positions in the refrigerator. When high precision is not required for estimating a storage volume, it is not necessary to set a plurality of light-volume detecting units 21, and only one light-volume detecting unit 21 is sufficient.

FOURTH EXEMPLARY EMBODIMENT

[0218] Next, a fourth embodiment of the present invention is described.

[0219] FIG. 22 is an explanatory diagram of a storage-volume detecting operation according to the fourth embodiment of the present invention.

[0220] Also in the present embodiment, detailed descriptions are omitted for portions of which configurations and technical ideas are the same as those in refrigerators 50 of the first embodiment to the third embodiment. The configurations described in the first embodiment to the third embodiment can be applied in combination with the present embodiment.

[0221] As shown in FIG. 22, in the present embodiment, air-volume adjusting units 28a to 28d are arranged at rear positions in cold compartment 12. Irradiation lights 34a output from light emitting units 20a to 20d irradiate inside cold compartment 12 and storage object 33 stored inside cold compartment 12.

[0222] Irradiation light 34b as a part of the output light is incident to light-volume detecting units 21a to 21e arranged in cold compartment 12. A volume of storage object 33 in the refrigerator can be classified by deciding a light volume detection result from a predetermined threshold value set in advance.

[0223] At this time, a difference occurs in light volumes detected by storage-state detecting units 21a to 21e respectively, depending on a storage state. For example, as shown in FIG. 22, when storage object 33 is input to storage shelf 18b, a light volume change from before to after the input of storage object 33 detected by light-volume detecting unit 21a becomes smaller than a light volume change detected by other storage-state detecting units 21b to 21e. Accordingly, input of storage object 33 to storage shelf 18b is detected, and a volume of storage object 33 is classified. Thereafter, air-volume adjusting unit 28a adjusts an air volume according to a detected storage-increase volume, and a rapid cooling operation is performed.

[0224] This rapid cooling operation is canceled after the compressor stops after a lapse of a constant time or at the time point when a temperature detected by a cold compartment sensor becomes equal to lower than a certain predetermined temperature. Then, the normal operation or the cooling operation of automatic power saving is started.

[0225] As described above, in the present embodiment, by providing air-volume adjusting units 28a to 28d, a periphery of the input storage object can be efficiently cooled. Therefore, an optimum cooling operation of automatic rapid cooling can be realized.

[0226] Positions of air-volume adjusting units 28a to 28d are not limited to the example of the present embodiment, and air-volume adjusting units 28a to 28d may be arranged at any positions in the refrigerator.

FIFTH EXEMPLARY EMBODIMENT

[0227] Next, a fifth embodiment is described in detail with reference to a drawing.

[0228] FIG. 23 is a front view of refrigerator 50 according to the fifth embodiment of the present invention. Refrigerator 50 according to the present embodiment has functions described in the first embodiment to the fourth embodiment.

[0229] In FIG. 23, in refrigerator main body 11 consisting of inner box 11a and outer box 11b, cold compartment 12, ice compartment 13, freezing compartment 15, and vegetable compartment 16 are arranged from above in inner box 11a provided via a heat insulation wall. At the

side of ice compartment 13, change compartment 14 capable of changing over between many temperatures in the compartment is also provided.

[0230] Cold compartment 12 of which using frequency of inputting and outputting a storage object is highest and a storage capacity is also largest has a front opening of the compartment blocked with cold compartment doors 12a as double rotation doors of which both sides are supported with hinges. A drawer-type door is provided in each of ice compartment 13, change compartment 14, vegetable compartment 16, and freezing compartment 15.

[0231] Cold compartment 12 is vertically partitioned with a plurality of storage shelves 18 at suitable intervals in the compartment held at a cold preservation temperature. At a bottom part of cold compartment 12, there are provided a water supply tank for supplying ice-making water to cold compartment 12 and low-temperature compartment 12b for holding a chilled temperature.

[0232] Specifically, an upper space of storage shelf 18 is a storage space for preserving food. In the present embodiment, storage shelf 18a for mounting food for storing in a storage space formed at a top, storage shelf 18b for mounting food for storing food in a second top storage space, and storage shelf 18c for mounting food for storing in a lowest storage space are provided as storage shelf 18. In a lowest storage area, a water supply tank and low-temperature compartment 12b for holding at a chilled temperature are arranged.

[0233] In cold compartment 12, there is set illuminating unit 19 in which a plurality of LEDs are stored at equal intervals in a longitudinal direction at a front side of a side surface in the storage chamber. At a rear-surface side in the storage chamber, light-volume detecting unit 21 made of an illuminance sensor is set. On a rear surface wall above storage shelf 18a for mounting food for storing in a storage space formed at a top and also below inner box 11a at a ceiling-surface side, light-volume detecting unit 21a is provided. Light-volume detecting unit 21b is provided on a rear surface wall above storage shelf 18b for mounting food for storing in a second top storage space and also below storage shelf 18a.

[0234] In the present embodiment, a state that storage objects 33 as food are placed on storage shelf 18b is shown.

[0235] Above light-volume detecting unit 21, cold-air blowing opening 4 is provided. Near storage-state detecting unit 21a at an upper side, cold-air blowing opening 4a is provided. Near storage-state detecting unit 21b at a lower side, cold-air blowing opening 4b is provided.

[0236] An operation of refrigerator 50 configured as described above is described below.

[0237] Illuminating unit 19 is lit in a state that cold compartment door 12a is closed. In the refrigerator, light from illuminating unit 19 reaches light-volume detecting unit 21a for detecting illuminance of a top storage space via air. In middle storage shelf 18b, a part of light from illuminating unit 19 passes through between storage objects 33 and reaches storage-state detecting unit 21b that detects illuminance of a second storage space. A part of other light beams is incident to storage objects 33 and is absorbed, and a part of light beams is reflected and scattered. Therefore, sides of storage objects 33 opposite to illuminating unit 19, that is, rear surface sides of storage objects 33 that become in shade, become dark with a small light volume.

[0238] When a height of storage object 33 is larger and also when a storage volume of storage object 33 is larger, light of illuminating unit 19 is shielded. Therefore, a volume of light reaching light-volume detecting unit 21 at a rear side becomes smaller.

[0239] Therefore, light-volume detecting unit 21 made of this illuminance sensor functions as a detecting unit for detecting an empty space of a storage space in the storage chamber in non-contact manner.

[0240] In this way, light-volume detecting unit 21 detects a light volume, and displays that a space capable of storing food is present at an upper part of storage shelf 18 relative to a middle part, in display unit 91 (see FIG. 1) on the outer surface of cold compartment door 12a as a door.

[0241] That is, a state of a storage object in cold compartment 12 can be informed to the user, by display unit 91 as recognizing means for displaying the presence of a space on the outer surface of cold compartment door 12a provided at a front surface side of cold compartment 12 as a storage chamber provided with light-volume detecting unit 21.

[0242] By confirming the display shown in display unit 91 as the recognizing means, the user can mount, without hesitation, food on storage shelf 18a as a top storage space that is displayed as a space having a small volume of storage object 33, by opening cold compartment door 12a, and can quickly close old compartment door 12a.

[0243] Further, there is assumed a case that storage objects 33 as food are stored at a front side of cold-air blow opening 4b and that too many storage objects 33 are stored. In such a case, when a light volume detected by light-volume detecting unit 21 near cold-air blowing opening 4 is smaller than a predetermined value, display unit 91 on the outer surface of cold compartment door 12a displays that there are too many storage objects in the storage space detected by the illuminance sensor and that the operation becomes a power increase operation.

[0244] When there are too many storage objects 33 or when storage object 33 is stored near cold-air blowing opening 4, storage object 33 becomes a cold-air ventilation resistance. Consequently, a cold air circulation volume per unit time decreases, and cooling time becomes long. When a cold air circulation volume decreases, an air volume of an evaporator becomes lower, and a heat exchange volume decreases. Therefore, an evaporation temperature decreases, and a compressor input also increases due to an increase of a high-and-low pressure difference of a freezing cycle.

[0245] An attempt to maintain a cooling time requires increasing a rotation number of a fan for circulating a cold air and increasing rotation of compressor 30. Therefore, this also becomes a factor of a power increase.

[0246] Accordingly, by informing the user of a power-increase tendency of increasing a power consumption volume due to these increases, and by urging optimum arrangement of storage object 33, refrigerator 50 that can achieve energy saving and realizes more energy saving can be provided to the user. This can contribute to reduction of CO_2.

[0247] From the above, an open time of cold compartment door 12a can be shortened, high-temperature outside air entering from cold compartment door 12a can be suppressed, and energy saving becomes possible. Further, because a temporary temperature increase in cold compartment 12 can be also suppressed, a temperature increase of food as storage object 33 can be also suppressed, and quality degradation can be decreased.

[0248] Further, because a power increase operation can be informed by display unit 91 as recognizing means, the user can be warned to perform the energy-saving operation. The recognizing means is not limited to display unit 91, and a configuration to give warning in voice, for example is also possible.

[0249] Particularly, the configuration according to the present embodiment has higher effect than the conventional configuration when there is a possibility of storing various kinds of food as stored in a household refrigerator.

[0250] Refrigerator 50 according to the present embodiment includes a storage chamber for storing a storage object, partitioned by a heat insulation wall and a heat insulation door, storage-volume estimating unit 23 for estimating a storage volume in the storage chamber, and memory unit 64 for memorizing a result of estimation by storage-volume estimating unit 23. Further, refrigerator 50 includes arithmetic control unit 22 for calculating a storage change volume based on a result of estimation up to a last time of memory unit 64 and a result of estimation by storage-volume estimating unit 23, and for controlling an output operation of the electrofunctional part. Further, arithmetic control unit 22 informs by informing means the user of an operation state of refrigerator 50 when it is decided that a storage volume in the storage chamber has changed.

[0251] Accordingly, based on estimation of a storage volume, storage volume information can be informed to the user. Consequently, easiness of handling can be improved.

SIXTH EXEMPLARY EMBODIMENT

[0252] Next, a sixth embodiment according to the present invention is described with reference to a drawing.

[0253] FIG. 24 is a front view of refrigerator 150 according to a sixth embodiment of the present invention.

[0254] As shown in FIG. 24, refrigerator 150 has refrigerator main body 151.

[0255] Refrigerator main body 151 is a heat-insulation box body, and is insulated from the surrounding, in a structure having an outer box mainly made of steel plate, an inner box formed with a resin such as ABS, and a heat insulation material such as urethane in a space between the outer box and the inner box.

[0256] Refrigerator main body 151 is partitioned into a plurality of store rooms by heat insulation, and cold compartment 152 is provided at a top part. At a lower part of cold compartment 152, ice compartment 153 and change compartment 154 are laterally provided. Freezing compartment 155 is arranged at a lower part of ice compartment 153 and change compartment 154, and vegetable compartment 156 is arranged at a lowest part.

[0257] In front of each storage chamber, a door for separating from outside air is configured at a front opening part of refrigerator main body 151. Near a center part of cold compartment door 152a of cold compartment 152, there is arranged operating unit 157 for performing an in-refrigerator temperature setting of each compartment and setting of ice making and a rapid cooling.

[0258] FIG. 25 is a cross-sectional view along a 25-25 line in FIG. 24 of refrigerator 150 according to the sixth embodiment of the present invention.

[0259] As shown in FIG. 25, a plurality of storage shelves 158 are provided in cold compartment 152, and a part of storage shelves 158 is configured to be vertically movable.

[0260] In cold compartment 152, there are provided illuminating unit 159 configured by a lamp and a plurality of LEDs, light emitting unit 160 such as LEDs as means capable of detecting a storage state, and light-volume detecting unit 161 such as an illuminance (light) sensor.

[0261] Illuminating unit 159 is arranged in a longitudinal direction on each of a left-side wall surface and a right-side wall surface positioned in front of a front end of storage shelf 158, nearer than a half of a depth dimension in the refrigerator, viewed from a door-open-side front surface in the refrigerator 150.

[0262] Further, light emitting unit 160 is arranged adjacent to a position close to illuminating unit 159, and light-volume detecting unit 161 is arranged at a rear position in cold compartment 152.

[0263] So far as light-volume detecting unit 161 is arranged at a position irradiated by light emitting unit 160 via storage object 173 (see FIG. 26) and an in-refrigerator structure, light-volume detecting unit 161 may be arranged at any position in the refrigerator.

[0264] Matters relating to essential parts of the invention according to the present embodiment may be applied to a type of refrigerator main body 151 in which compressor 170 is arranged by providing a machine room in a lowest-part storage chamber rear area of a heat-insulation box body that has been conventionally general.

[0265] In a machine room formed in a top rear area in cold compartment 152, high-voltage side configuration

parts of a freezing cycle such as compressor 170 and a drier that removes moisture are stored.

[0266] On a rear surface of freezing compartment 155, a cooling chamber for generating cold air is provided. In the cooling chamber, there are provided a cooler, and cooling fan 171 (see FIG. 27) for sending the cold air as cooling means cooled by the cooler to cold compartment 152, change compartment 154, ice compartment 153, vegetable compartment 156, and freezing compartment 155. Further, to remove frost and ice adhered to the cooler and a periphery of the cooler, a radiant heater, a drain pan, a drain tube evaporation tray, and the like are configured as defrosting unit 195 (see FIG. 27).

[0267] Cold compartment 152 is normally set at 1°C to 5°C as a lower limit at which the storage object is not frozen, and vegetable compartment 156 at a lowest part is set at 2°C to 7°C which is equal to or slightly higher than the temperature in cold compartment 152 for cold preservation. Freezing compartment 155 is set in a freezing temperature range, and is normally set at -22°C to -15°C for freezed preservation. However, to improve a freezed preservation state, freezing compartment 15 is sometimes set at a low temperature of -30°C or -25°C, for example.

[0268] Ice compartment 153 makes ice with an automatic ice machine (not shown) set at an upper part in the compartment using water sent from a water storage tank (not shown) in cold compartment 152, and stores the ice in an ice storage container (not shown) arranged at a lower part in the compartment.

[0269] Change compartment 14 can be changed over to a temperature range set in advance between a cold preservation temperature range and a freezing temperature range, in addition to a cold preservation temperature range set at 1°C to 5°C, a vegetable temperature range set at 2°C to 7°C, and a freezing temperature range normally set at -22°C to -15°C. Change compartment 154 is a storage chamber including an independent door provided in parallel with ice compartment 153, and includes a drawer-type door in many cases.

[0270] In the present embodiment, change compartment 154 is a storage chamber including temperature ranges of cold storage and freezing. However, change compartment 154 may be configured as a storage chamber specializing in a changeover in an intermediate temperature range between cold storage and freezing, by assigning cold storage to cold compartment 152 and vegetable compartment 156 and assigning freezing to freezing compartment 155. The specialized temperature range may be set in a storage chamber fixed to freezing, to follow an increased demand for frozen foods in recent years, for example.

[0271] An operation and work of refrigerator 150 configured as described above are described below.

[0272] FIG. 26 is an explanatory diagram of a light-volume detecting operation according to the sixth embodiment of the present invention.

[0273] Operations of light emitting unit 160 and light-volume detecting unit 161 that constitute means capable of detecting a storage state are described in detail with reference to FIG. 26.

[0274] Irradiation lights 174a output from light emitting units 160 arranged on left-and-right both sidewalls of refrigerator 150 irradiate inside cold compartment 152 and storage object 173 stored inside cold compartment 152. Further, a part of irradiation lights 174a is incident to light-volume detecting unit 161 arranged in cold compartment 152.

[0275] FIG. 26 shows a state that when storage object 173 is stored in cold compartment 152, depending on presence of storage object 173, there occur an area A where irradiation lights 174a from both the left-and-right sidewalls are shielded, an area B where any one of irradiation lights 174a is shielded, and an area C where none of left and right irradiation lights 174a is shielded.

[0276] In this case, light-volume detecting unit 161 is in the area B where any one of irradiation lights 174a is shielded, and detects and outputs a corresponding light volume. When a volume of storage object 173 is large, a detected light volume by light-volume detecting unit 161 decreases because the area A where both lights are shielded increases. When a storage volume is small, a detected light volume by light-volume detecting unit 161 increases because the area C where none of irradiation lights 174a is shielded increases.

[0277] In this way, by detecting by light-volume detecting unit 161 a light volume change attributable to presence of storage object 173 and a difference in a volume of storage object 173, volumes (example: large or small) of storage object 173 in the refrigerator can be classified by deciding a light volume detection result by using a predetermined threshold value set in advance.

[0278] Further, by using light emitting unit 160 also as illuminating unit 159 normally provided in refrigerator 150 or by using a substrate of light emitting unit 159 also as a substrate of light emitting unit 160, a storage state can be detected in a simpler configuration without additionally providing a light source and a material.

[0279] Next, a control operation of refrigerator 150 is described.

[0280] FIG. 27 is a control block diagram of refrigerator 150 according to the sixth embodiment of the present invention.

[0281] As shown in FIG. 27, refrigerator 150 includes light-volume detecting unit 161, temperature sensor 191, door-open-close detecting unit 192, arithmetic control unit 163, light emitting unit 160, compressor 170, cooling fan 171, temperature compensation heater 172, damper 193, and defrosting unit 195.

[0282] Arithmetic control unit 163 has storage-volume estimating unit 162, memory unit 194, and timer 196.

[0283] After the door is closed, refrigerator 150 operates light emitting unit 160 accordingly by a program determined in advance, and each time, light-volume detecting unit 161 detects a light volume in the vicinity. Then, refrigerator 150 has this light volume information input to

arithmetic control unit 163, calculates the information, estimates an output value of the calculation as a storage volume in the storage chamber, and occasionally memorizes the storage volume in memory unit 194.

[0284] Arithmetic control unit 163 appropriately performs an arithmetic processing based on data memorized in memory unit 194, and determines an operation timing of defrosting unit 195.

[0285] For example, when a detection output by light-volume detecting unit 161 does not change during a constant period or when a change width is smaller than a determined threshold value, arithmetic control unit 163 decides that refrigerator 150 is not being used, and controls to perform a defrosting operation in a cycle that is extended to more than a normal defrosting cycle. Further, by using output data of other temperature sensor 191 and door-open-close detecting unit 192, arithmetic control unit 163 further understands a person's life state, appropriately operates compressor 170, cooling fan 171, temperature compensation heater 172 and damper 193, and also controls the defrosting operation.

[0286] The operations are described in detail below.

[0287] FIG. 28A is a control flowchart at a power source input time of refrigerator 150 according to the sixth embodiment of the present invention, FIG. 28B is a control flowchart of absence detection A of refrigerator 150 according to the same embodiment, FIG. 28C is a control flowchart of the using-state decision A of refrigerator 150 according to the same embodiment, and FIG. 28D is a control flowchart of absence detection B of refrigerator 150 according to the same embodiment.

[0288] FIG. 28E is a control flowchart of the using-state decision B of refrigerator 150 according to the sixth embodiment of the present invention, FIG. 28F is a control flowchart of the using-state decision C of refrigerator 150 according to the same embodiment, FIG. 28G is a control flowchart of another example of absence detection B of refrigerator 150 according to the same embodiment, and FIG. 28H is a control flowchart of the using-state decision D of refrigerator 150 according to the same embodiment.

[0289] In FIG. 28A, when a power source of refrigerator 150 is turned on (S201), as an initial preparation, initial values (A = 0, B = 0, for example) are set to Flag A and Flag B for deciding a defrosting cycle based on a storage change, timer tc is set to 0, and defrosting cycle t_{d0} is set to a predetermined value (S202).

[0290] Next, the process proceeds to step S203, and a cooling operation is started. The storage chamber of refrigerator 150 is cooled to a temperature range set in advance.

[0291] Next in step S204, it is decided whether defrosting operation time (defrosting cycle t_{d0}) reached. That is, when cooling operation $time_{tc}$ after the power source is turned on has not passed t_{d0} time (S204, NO), the normal cooling is continued. On the other hand, when cooling operation time tc has passed t_{d0} time (S204, YES), the defrosting operation is started (S205). However, at this time, to suppress a storage-chamber temperature increase due to entering of warm air into the storage chamber that is assumed after defrosting, an in-refrigerator temperature lower than a normal in-refrigerator temperature may be secured by continuing cooling for a constant time before starting the defrosting.

[0292] In step S205, after the defrosting is started, compressor 170 stops, and defrosting unit 195 melts and liquefies by heating the frost adhered around the cooler. Liquefied defrosted water flows on a lower surface of the cooling chamber, and is discharged to an outside of the refrigerator. Further, when a temperature of the cooler itself increases and when it is detected that a temperature detected by temperature sensor fitted to the cooler or a periphery of the cooler has become a determined temperature or higher, the defrosting ends (S206), and the process proceeds to step S207 to proceed to "absence detection A" as the normal control.

[0293] The "absence detection A" is described next with reference to FIGS. 28B and 28C.

[0294] In the normal cooling mode and in an "absence detection A" mode, as a preparation, "1" is set to Flag A for deciding a defrosting cycle according to a storage volume change and "0" is set to the timer tc, for example, and defrosting cycle t_{d1} is set to a predetermined value. Next, in step S213, the cooling operation is started, counting of timer tc is started, and the process proceeds to a "using-state decision A" process in step S214.

[0295] A control flowchart of the "using-state decision A" is described with reference to FIG. 28C.

[0296] When the using-state decision A is started, it is decided in step S232 whether "1" is being set to Flag A. When "1" is being set to flag A (S232, YES), it is decided that there is no storage volume change in the corresponding period and the process proceeds to step S233. When other than "1" is being set to Flag A (S232, NO), it is decided that there was a storage volume change in the corresponding period. The using-state decision A ends without performing a storage-volume change decision.

[0297] When the process proceeds to step S233, it is decided whether a storage change volume ΔM as a difference between the standard storage volume memorized in memory unit 194 and a latest storage volume is equal to or smaller than a predetermined threshold value Mc.

[0298] When it is decided that the storage change volume ΔM is equal to or smaller than the predetermined threshold value Mc (S233, YES), the process proceeds to step S234. In step S234, because a storage change volume is equal to or smaller than the threshold value, it is decided that there is not change in the storage volume because a person is not present (absent), Flag A is maintained at "1", and the using-state decision A ends. On the other hand, when the storage change volume ΔM is larger than the predetermined threshold value Mc (S233, NO), the process proceeds to step S235. Then, it is decided that there was a storage volume change, that is, the user is at home, "0" is set to Flag A, and the using-state decision A ends.

[0299] By discriminating a storage volume change in this way, user presence or absence is decided. By making a database of this decision, absence for a long period can be decided.

[0300] Referring back to FIG. 28B, when the process proceeds from the "using-state decision A" in step S214 to step S215, it is decided whether a defrost timing is reached (S215). When it is decided that time of the timer tc exceeds the defrosting cycle t_{d1} (S215, YES), the process proceeds to step S216, and the defrosting operation is started. Specifically, arithmetic control unit 163 stops compressor 170, and starts current conduction to defrosting unit 195. After the defrosting is started, defrosting unit 195 melts and liquefies by heating the frost adhered around the cooler. Then, the frost adhered to the cooler is melted and liquefied. Defrosted water flows on the lower surface of the cooling chamber. Further, when a temperature of the cooler itself increases and when the temperature sensor fitted to the cooler or a periphery of the cooler detects a determined or higher temperature, the defrosting ends (S218).

[0301] Also during the defrosting operation, the above-described "using-state decision A" process is operated, and a storage volume change is decided (S217).

[0302] After ending the defrosting, the process proceeds to step S219. When it is continuously decided that the storage change volume ΔM is smaller than the threshold value and when "1" is being set to Flag A (S219, YES), it is decided that the absent state is continued, and the process proceeds to the "absence detection B" process in step S220. On the other hand, when it is decided that the storage change volume ΔM is larger than the threshold value Mc and when "0" is being set to Flag A (S219, NO), the process proceeds to the "absence detection A" process in step S221. In this case, the above-described "absence detection A" process is performed again.

[0303] Next, the "absence detection B" process for deciding extension of a defrosting cycle is described with reference to FIGS. 28D to 28F.

[0304] As a condition for proceeding to the "absence detection B" process, as described in the above control flowchart, it is a premise that it is forecast that the storage change volume ΔM from the end of a second last defrosting is smaller than the threshold value Mc, a person is not present, and a storage change is small.

[0305] After the process proceeds to the "absence detection B" process, in step S252, as a preparation, an initial value "1" is set to Flag B for deciding a defrosting cycle determined by a storage change, "0" is set to the timer tc, and the next defrosting cycle t_{d1} is set. In step S253, the cooling operation is started. Next, in step S254, the "using-state decision B" process is controlled.

[0306] The "using-state decision B" process is described with reference to FIG. 28E. After the process proceeds to the "using-state decision B" process, the process proceeds to step S272, and it is decided whether "1" is being set to Flag B. When "1" is being set to Flag B (S272, YES), it is decided that there was not storage volume change in the past, and the process proceeds to step S273. On the other hand, when other than "1" is being set to Flag B (S272, NO), it is decided that there was a storage volume change in the past, and the using-state decision B ends without performing the storage-volume change decision.

[0307] After the process proceeds to step S273, it is decided whether the storage change volume ΔM as a difference between the standard storage volume memorized in memory unit 194 and a latest storage volume is equal to or smaller than the predetermined threshold value Mc. When the storage change volume ΔM is equal to or smaller than the predetermined threshold value Mc (S273, YES), the process proceeds to step S274, Flag B is maintained at "1" (Flag A is also kept at "1"), and the "using-state decision B" process ends.

[0308] On the other hand, when the storage change volume ΔM is larger than the predetermined threshold value Mc (S273, NO), the process proceeds to step S275. Then, it is decided that there was a storage volume change, that is, the user is at home (by returning home) and uses refrigerator 150, "0" is set to Flag A and Flag B, and the using-state decision B ends.

[0309] In this way, a storage state in the storage chamber is detected. When a change in the storage state is not continuous (small), it can be decided that there is no storage change because the refrigerator is not being used due to absence. By accumulating this information, long-term absence can be decided.

[0310] Referring back to FIG. 28D, after the "using-state decision B" process in step S254 ends, it is decided whether a defrost timing is reached, in step S255. When time of the timer tc exceeds the defrosting cycle t_{d1} (S255, YES), the process proceeds to step S256. On the other hand, when time of the timer tc is equal to or smaller than the defrosting cycle t_{d1} (S255, NO), the using-state decision B (S254) is repeatedly performed.

[0311] In step S255, when time of the timer tc exceeds t_{d1}, the process proceeds to step S256, and it is decided whether "1" is being set to Flag B. When "1" is being set to Flag B, it is decided that there is no storage volume change and that the absent state is continued, and the process proceeds to step S257. In step S257, the defrosting cycle t_{d1} is extended to t_{d2} (for example, a cycle that is normally 14 hours is extended to 26 hours).

[0312] On the other hand, in step S256, when other than "1" is being set to Flag B, after starting the "absence detection B" control, it is decided that there was a storage change, that is, a state changed to the presence state. Then, the process immediately proceeds to step S265, and defrosting is started. After normally performing the defrosting, the defrosting ends in step S266, and the process proceeds to the "absence detection A" process in step S267.

[0313] When the defrosting cycle is extended in step S257, the process proceeds to the "using-state decision C" process in step S258.

[0314] The "using-state decision C" process is described with reference to the control flowchart in FIG. 28F. After the process proceeds to the "using-state decision C" process, in step S282, it is decided whether the storage change volume ΔM between the standard storage volume memorized in memory unit 194 and a latest storage volume is equal to or smaller than the predetermined threshold value Mc. When it is decided that the storage change volume ΔM is equal to or smaller than the predetermined threshold value Mc (S282, YES), the using-state decision C ends.

[0315] On the other hand, when the storage change volume ΔM is larger than the predetermined threshold value Mc (S282, NO), the process immediately proceeds to step S284, and the defrosting operation is performed. After ending the defrosting operation (S285), the process proceeds to the "absence detection A" process (S286).

[0316] In the above description, the control of immediately performing the defrosting operation is described. However, by estimating the cooling capacity of the cooler, when there is some room even when the defrosting is not immediately performed, start of the defrosting may be extended to the timing of the defrosting cycle t_{d2}.

[0317] Referring back to FIG. 28D, after the "using-state decision C" process in step S258 ends, arithmetic control unit 163 decides whether time of the timer tc exceeds the defrosting cycle t_{d2}. When the time of the timer tc does not exceed the defrosting cycle t_{d2}, (S259, NO) the "using-state decision C" process is repeated.

[0318] On the other hand, when time of the timer tc exceeds a defrosting cycle t_{d2}, the process proceeds to step S260, and the defrosting operation is started. During the defrosting, the process proceeds to step S261 in FIG. 28D, and the "using-state decision B" process is performed. After ending the defrosting in step S262, the process proceeds to step S263. In step S263, it is decided whether "1" is being set to Flag B.

[0319] When "1" is being set to Flag B for deciding a defrosting cycle to be determined based on a storage volume change (S263, YES), it is decided that absence continues, and the process proceeds to the "absence detection B" process. On the other hand, when other than "1" is being set to Flag B (S263, NO), it is decided that the absent state was canceled, and the process proceeds to the "absence detection A" process (S267).

[0320] Concerning the "absence detection B" process, although Flag B is set, it is also possible to perform program designing by using only Flag A. Next, this control is described with reference to the control flowchart in FIG. 28G.

[0321] When it is decided that the user is absent from decision in step S219 in FIG. 28B and when the process proceeds to the "absence detection B" process, the process proceeds to the control flow in FIG. 28G.

[0322] After the process proceeds to the "absence detection B" process, in step S302, "0" is set to the timer tc, and the defrosting cycle t_{d2} (defrosting cycle when the user is absent) is set to a predetermined value ("1" is being set to Flag A from the preceding routine).

[0323] Next, after the cooling operation is started in step S303, the "using-state decision A" process described with reference to FIG. 28C is performed (S304).

[0324] Next, in step S305, the time of the timer tc is compared with the normal defrosting cycle t_{d1}. When the time of the timer tc does not exceed the defrosting cycle t_{d1} (S305, NO), the "using-state decision A" process is continuously performed (S304). When the time of the timer tc exceeds the defrosting cycle t_{d1} (S305, YES), the process proceeds to the "using-state decision D" process in step S306.

[0325] The "using-state decision D" process in step S306 is described with reference to FIG. 28H.

[0326] After the process proceeds to the "using-state decision D", in step S322, it is decided whether "1" is being set to Flag A for deciding a defrosting cycle to be determined based on a storage change.

[0327] When "1" is being set to Flag A (S322, YES), the process proceeds to step S323. In step S323, it is decided whether the storage change volume ΔM between the storage volume memorized in memory unit 194 and a latest storage volume is equal to or smaller than the predetermined threshold value Mc.

[0328] When the storage change volume ΔM is equal to or smaller than the predetermined threshold value Mc (S323, YES), the "using-state decision D" process ends. When the storage change volume ΔM is larger than the predetermined threshold value Mc, the process proceeds to step S325, and the defrosting operation is performed. After ending the defrosting operation (S326), the process proceeds to the "absence detection A" process (S327).

[0329] In step S322, when other than "1" is being set to Flag A (S322, NO), it is decided that there was a storage volume change, and the process proceeds to step S325, and the defrosting operation is performed. After ending the defrosting operation (S326), the process proceeds to the "absence detection A" process.

[0330] Referring back to FIG. 28G, after the "using-state decision D" process ends, the process proceeds to step S307, and it is decided whether the time of the timer tc exceeds the defrosting cycle t_{d2}.

[0331] When the time of the timer tc does not exceed the defrosting cycle t_{d2} (S307, NO), the "using-state decision D" process is continuously repeated. On the other hand, when the time of the timer tc exceeds the defrosting cycle t_{d2} (S307, YES), the process proceeds to step S308, and the defrosting is started.

[0332] In step S308, defrosting is started. The "using-state decision A" process is performed in step S309 until the defrosting ends in step S310.

[0333] After ending the defrosting in step S310, the process proceeds to step S311, and it is decided whether "1" is being set to Flag A for deciding a defrosting cycle to be determined based on a storage change. When "1" is being set to Flag A (S311, YES), it is decided that the absent state is continued, and the process proceeds to the "absence detection B" process (S312). On the other

hand, when "1" is not being set to Flag A (S311, NO), it is decided that the user is at home by canceling the absent state. The process proceeds to step S313, and proceeds to the "absence detection A" process.

[0334] As described above, according to refrigerator 150 of the present embodiment, it decided that when there is no storage change, a person is not present, that is, the user is in the absent state, or, it is decided that using frequency of refrigerator 150 is low even when the user is at home, and this state continues for predetermined time. When a volume of frost adhered to the cooler is small and when it is decided that there is sufficient cooling capacity, power used for the heater can be decreased and in-refrigerator temperature increase can be prevented, by automatically cutting off (decreasing) the defrosting operation. Accordingly, a high freshness preservation characteristic can be improved by achieving energy saving and by further suppressing a temperature variation.

[0335] Next, an operation image of a defrost timing is described with reference to FIGS. 29A to 29D. FIG. 29A is an operation image diagram of a basic defrost timing of refrigerator 150 according to the sixth embodiment of the present invention. FIG. 29B is an operation image diagram of a defrost timing of refrigerator 150 when the user returns home. FIG. 29C is an operation image diagram when there is a time safe in a defrost time of refrigerator 150. FIG. 29D is an operation image diagram when the user is absent during defrosting in refrigerator 150.

[0336] When the user leaves for a travel or for homecoming, it can be assumed that the user opens and closes the door of the refrigerator and takes in and out food until before leaving. Therefore, there is a case that a certain level of frost is adhered to the cooler. Depending on the case, a large volume of frost that hinders the cooling is adhered to the cooler.

[0337] Assuming that the user left for a travel at the A point in FIG. 29A, a subsequent storage volume change is basically extremely small, and the door is not basically opened or closed until the user returns home. After a lapse of a certain time, defrosting is started at the B point, and frost is melted and discharged. Therefore, current is conducted to a defrosting heater as defrosting unit 195. After ending the defrosting at the B point, the cooler returns to a state having no frost.

[0338] Next, the cooling operation is performed between the B and C points. However, during this period, because the user is absent, there is no door opening-and-closing, and a volume of frost adhered to the cooler is extremely small. However, when an interval between the A and B points is extremely small and also when there was input of a large volume of food or door opening-and-closing before defrosting, an in-storage-chamber temperature after ending the defrosting at the B point is relatively high, and a volume of water vapor contained in the storage chamber is also large. Therefore, although the inside of the storage chamber is sufficiently cooled to a set temperature by the cooling operation after the B point, there is a possibility that much of the water vapor after dehumidification and cooling inside the storage chamber is adhered to the cooler as frost.

[0339] Therefore, after the cooling operation between the B and C points, when the normal defrosting cycle is reached, the normal defrosting operation is performed and the remaining frost is removed. When the absent state is also continued at the C point, the in-refrigerator temperature is a sufficient cooling temperature, and the cooling operation can be continued to a D point while keeping sufficient cooling performance by the cooling operation between C and D points.

[0340] When the absent state is also continued between the C and D points, upon reaching the defrost timing D point, refrigerator 150 according to the present embodiment detects that there is no storage change. When it is decided that the absent state is continued accordingly, the defrosting operation at the D point is cut off because there is also sufficient cooling capacity. By continuing the cooling operation, heater input can be decreased and in-refrigerator temperature increase due to defrosting can be suppressed. Accordingly, energy saving can be achieved. Further, by securely performing the defrosting operation at the extended E point, cooling performance can be accurately secured.

[0341] As shown in FIG. 29B, when the user returns home at any time between D and E points and thereafter when it is detected that there was a change in a storage volume in refrigerator 150, the defrosting operation is immediately performed at an X point. A cooling volume is secured, and the defrosting operation is performed after the cycle is returned to the normal defrosting cycle t_{d1} and after the time reaches a Y point.

[0342] However, when there is still sufficient cooling capacity at the X point and also when a possibility of occurrence of cooling shortage is small, the defrosting operation may be continuously extended.

[0343] On the other hand, as shown in FIG. 29C, there is a case that a certain extremely high load enters the storage chamber or a large volume of frost is adhered to the cooler before the user leaves for a travel. At this time, there is a case that although there is no door opening-and-closing after an A' point when the user leaves for a travel, there is already a large volume of frosting, and by the defrosting at a B' point, a temperature does not reach a predetermined temperature even when the time is at an upper limit value (60 minutes, for example) in a predetermined defrosting time and the defrosting ends. In this case, by setting a next defrosting cycle to t_{ds} shorter than t_{d1}, the cooling operation can be performed to a C' point, for example.

[0344] Next, by performing the defrosting operation at the C' point, when the defrosting time ends within a predetermined time, the cooling operation is performed again in the normal cycle t_{d1}. Then, the defrosting operation is performed again at the D' point continuously at two times, and the defrosting operation ends. When a storage volume change is small, the defrosting cycle is

changed to t_{d2}, and the cooling operation is performed continuously.

[0345] When the door is opened and closed before an E' point, the defrosting cycle is returned to t_{d1}, and the defrosting operation is performed when the E' point is reached. When there was a storage change between E' and F' points, the defrosting operation is immediately performed at the time point of detecting the storage change. When there is no storage change up to the F' point, the defrosting operation is performed at a timing of the F' point. That is, by cutting off the defrosting operation that is normally performed at the E' point, energy saving is achieved.

[0346] Further, as shown in FIG. 29D, when the user left for a travel during the defrosting, there is a possibility that the door was opened and closed and food was input during the defrosting. In such a case, the defrosting operation is performed at two times at a B" point and a C" point as is normally performed. When it is decided that absence continues, the defrosting operation at a next D" point is cut off, and the cooling operation is continued.

[0347] As described above, in the present embodiment, energy saving can be achieved by suppressing a defrosting operation which is performed with a high heater input regardless of sufficient cooling capacity with a small volume of frost adhered to the cooler. Further, because a temperature increase can be prevented, a freshness preservation characteristic can be improved.

[0348] Further, in the present embodiment, by extending the defrosting cycle, a number of times of defrosting can be decreased and a temperature variation can be also suppressed. Accordingly, because a freshness preservation characteristic is improved and a number of times of operation decreases, a temperature increase in defrosting unit 195 and the peripheral member can be decreased, and reliability improves.

[0349] In the present embodiment, the defrosting operation is controlled by detecting a storage change, and energy saving is achieved. However, gradual cooling can be performed by lowering a rotation number of compressor 170 and a rotation number of cooling fan 171, or further energy saving can be achieved by lowering a number of ON/OFF times of compressor 170, for example.

[0350] When the user is absent, it is considered that there is no temperature increase in food due to door opening-and-closing. Therefore, a set temperature in the storage chamber can be set higher than a normal temperature (higher by about 1 K). Accordingly, energy saving can be achieved.

[0351] In the present embodiment, detection of absence of the user is performed by using a storage volume change. However, the present invention is not limited to this example. For example, an absent state may be detected based on a rapid change in an output value of an illuminance sensor set on an outside surface of the refrigerator such as a door surface and capable of detecting a door open-and-close operation and an illuminance change in the chamber, or based on a detection of an operation of a person such as when an illumination is turned on or when a curtain is opened, or based on a change in a temperature sensor of a set environment due to turning on of an air conditioning apparatus. In this case, a person's lifestyle habit can be accurately detected.

[0352] In the present embodiment, although a value of Flag is "0" or "1", the present invention is not limited to this example. For example no change may be set as "1", increase may be set as "2", and decrease may be set as "0". In this case, the cooling operation can be performed further in detail.

[0353] In the present embodiment, although a value of Flag is "0" or "1", the present invention is not limited to this example. For example, an analog detection output value (value obtained by converting a voltage volume of 0 to 5V, for example) may be used. In this case, because a storage level can be detected further in detail, a detailed control matching a food volume and a change volume becomes possible.

[0354] In the present embodiment, a person's behavior pattern is forecasted and a using state of the refrigerator is estimated, and a defrosting cycle and an application voltage are changed by matching the forecast and the estimation. Accordingly, a freshness preservation characteristic of storage object 173 can be improved, by achieving energy saving by decreasing unnecessary heating by setting an optimum defrosting cycle and an application voltage of defrosting unit 195 and by suppressing a temperature variation.

[0355] When a change in a storage volume is smaller than a predetermined threshold value, an interval for operating defrosting unit 195 is extended. In this case, when there is little operation by a person, that is, when absence is decided and when this absent state continues for a constant period or more, a defrosting cycle is extended. Accordingly, a freshness preservation characteristic can be maintained by decreasing unnecessary heating of defrosting unit 195, and by suppressing a temperature variation while achieving energy saving.

[0356] With a time point after operation of defrosting unit 195 as a base point, when there is a constant number or more of a period during which there is no door opening-and-closing, and also when a change in a storage volume during this period is smaller than a predetermined threshold value, an interval for operating defrosting unit 195 is extended. Accordingly, a person's behavior pattern can be understood and forecasted in high precision, and absence can be decided in high precision. Therefore, further energy saving can be achieved.

[0357] With a time point after a lapse of a certain constant time after operation of defrosting unit 195 as a base point, when a temperature variation in the storage chamber is equal to or smaller than a certain threshold value, or when a change in a storage volume during this period is smaller than a predetermined threshold value, an interval for operating defrosting unit 195 is extended. Accordingly, by understanding a heat load which is basically important for refrigerator 150, a more accurate using

state can be understood. Consequently, at the absent time, further energy saving can be achieved by extending the defrosting cycle.

[0358] Further, the storage-state detecting means is configured by a light source and an optical sensor set in the storage chamber. Accordingly, because the irradiation light of the light source is spread in a whole inside of the refrigerator by repeating reflection in the storage chamber, and is incident to the optical sensor. Therefore, a storage state can be detected with a small number of parts and also in a simple configuration.

[0359] In the case of using a light source of the storage-state detecting means also for in-refrigerator illumination, a storage state can be detected in a simple configuration without additionally providing a light source.

[0360] Further, when the light source of the storage-state detecting means is configured by a plurality of LEDs, light of high light intensity is incident to the optical sensor. Therefore, detection sensitivity of the optical sensor based on a storage state can be enhanced. Further, by lighting a plurality of LEDs respectively at different positions, because a detection value of the optical sensor changes depending on a storage state and the LED to be lit, the storage state can be estimated further in detail.

[0361] Refrigerator 150 according to the present embodiment includes a storage chamber for storing a storage object, partitioned by a heat insulation wall and a heat insulation door, a cooler for cooling the storage chamber, and defrosting unit 195 for defrosting the cooler. Further, refrigerator 150 includes storage-volume estimating unit 162 for estimating a storage volume in the storage chamber, and memory unit 194 for memorizing a result of estimation by storage-volume estimating unit 162. Further, refrigerator 150 includes arithmetic control unit 163 that calculates a storage change volume based on a result of estimation up to a last time in memory unit 194 and a result of estimation by storage-volume estimating unit 162, and that controls an output operation of defrosting unit 195. Arithmetic control unit 163 controls an interval for operating defrosting unit 195 at a next time from a calculation result of a storage change volume in the storage chamber.

[0362] Further, arithmetic control unit 163 decides that there is no change in a storage volume when a storage change volume in the storage chamber does not exceed a predetermined threshold value within predetermined time, and extends an interval for operating defrosting unit 195 at a next time.

[0363] Accordingly, when a storage volume change is small, a defrosting cycle can be extended and an energy-saving characteristic can be improved.

[0364] Further, refrigerator 150 includes door-open-close detecting unit 192 for detecting opening and closing of a heat insulation door. With a time point after operation of defrosting unit 195 as a base point, when a period during which a heat insulation door is not opened or closed is equal to or larger than a constant time, arithmetic control unit 163 extends an interval for operating defrosting unit 195.

[0365] Accordingly, triggered by the door opening-and-closing, detection precision can be improved.

[0366] Refrigerator 150 includes temperature sensor 191 as temperature detecting means for detecting a temperature in the storage chamber. With a time point after a lapse of a certain constant time after operation of defrosting unit 195 as a base point, when a temperature variation in the storage chamber is equal to or smaller than a certain predetermined value, arithmetic control unit 163 extends the interval for operating defrosting unit 195.

[0367] Accordingly, by considering a temperature detected by the temperature detecting means, further detection precision can be improved.

[0368] When a calculation result of a storage change volume in the storage chamber is in a decrease direction, arithmetic control unit 163 can also extend an interval for operating at a next time defrosting unit 195.

[0369] Accordingly, when a calculation result of a storage change volume in the storage chamber is in a decrease direction, it is decided that a load decreases. Therefore, by controlling the defrosting cycle to be extended, an energy-saving characteristic can be further improved.

[0370] In the present embodiment, operations are described by assuming user absence due to a travel and the like. However, when using frequency of the refrigerator is low during temporary presence of the user (when a change in the storage volume is small although there is door opening-and-closing to some extent), a similar arithmetic control can be performed. Accordingly, even when the door-open-close detecting unit assumes absence in a state of no opening-and-closing of the door, it is also possible to manage when a change in the storage volume is small although there is door opening-and-closing to some extent. Consequently, an energy-saving characteristic can be further improved.

SEVENTH EXEMPLARY EMBODIMENT

[0371] Next, a seventh embodiment according to the present invention is described.

[0372] FIG. 30 is an operation image diagram of a defrost timing according to the seventh embodiment of the present invention, and FIGS. 31A and 31B are control flowcharts according to the same embodiment.

[0373] In the present embodiment, portions different from those in the configuration described in the sixth embodiment are mainly described in detail. A detailed description is omitted for portions of which configurations are the same as those in the sixth embodiment and portions to which the same technical idea can be applied. The configurations described in the sixth embodiment can be applied in combination with the present embodiment.

[0374] In general, when a user leaves a house for a travel or for homecoming, a food volume in refrigerator

150 tends to decrease during a process up to a departure day. This is because food has a freshness expiration date, and when the user is absent for a long period, a possibility that food of which a freshness expiration date expires is stored becomes high. Therefore, the food must be disposed of. To prevent this situation, a tendency of efficiently using all food before a departure is prominent. For this reason, a volume of food stored in the storage chamber tends to become small.

[0375] Then, during a period of a normal use of the refrigerator, the storage volume is occasionally detected and calculated. A result of the calculation is stored in memory unit 194 and is set in a database, and a standard storage volume Ms is calculated.

[0376] When the user becomes absent for a long period due to an overseas traveling, homecoming, or a long-term business trip, for example, it is detected beforehand that a storage volume in the storage chamber is a storage volume Mb that is smaller than that when the refrigerator is normally used.

[0377] A difference ΔMd between the storage volume Mb and a standard storage volume Ms is compared with a difference ΔMe between a predetermined absence-decision storage volume Mo (a fixed value, or a value obtained by multiplying α (0.8, for example) to the standard storage volume Ms) and the standard storage volume Ms. At this time, when ΔMd is larger than ΔMe, it is decided that there is a possibility of absence of the user, and the process proceeds to the "absence detection" process. In other cases, the cooling operation is performed as normally performed. When the "absence detection" process is performed, the above-described defrost control is performed, and the defrosting operation is cut off. Consequently, energy saving can be achieved.

[0378] Operations are described with reference to the control flowchart in FIGS. 31A and 31B. Because an outline is described with reference to FIGS. 28B and 28C, only detailed portions are described by omitting duplicated portions.

[0379] In the "absence detection A" process in FIG 31A, various parameters are set in step S212. Next, in step S213, the timer tc is started, and the process proceeds to step S222.

[0380] In step S222, a difference ΔMd between a current calculated storage volume Mb and the standard storage volume Ms is compared with a difference ΔMe between the current calculated storage volume Mb and the absence decision storage volume Mo. When ΔMd is larger than ΔMe (S222, YES), it is decided that the refrigerator is used in a method different from the normal method. "1" is kept set in Flag A by assuming that a possibility of user absence is high (S223).

[0381] On the other hand, when ΔMe is equal to or larger than ΔMd (S222, NO), it is decided that the refrigerator is used in the normal method and the user is at home, and "0" is set to Flag A (S224). Then, in step S214 afterward, the operations are the same as those described with reference to FIG. 28B in the sixth embodiment.

[0382] Further, as a separate processing flow, operations are described with reference to FIG. 31B.

[0383] In FIG. 31B, after the using-state decision A is started, in step S232, it is decided whether "1" is being set to Flag A.

[0384] When "1" is being set to Flag A (S232, YES), the process proceeds to step S239. In step S239, a difference ΔMd between a current calculated storage volume Mb and the standard storage volume Ms is compared with a difference ΔMe between the current calculated storage volume Mb and the absence decision storage volume Mo. When ΔMd is larger than ΔMe (S239, YES), it is decided that the refrigerator is used in a method different from the normal method, assuming that the use is absent, and the process proceeds to step S233. When the change volume ΔM of the storage volume is equal to or smaller than the predetermined threshold value Mc, in step S234, "1" is kept set in Flag A. When ΔMe is equal to or larger than ΔMd (S239, NO), and also when the change volume ΔM of the storage volume is equal to or larger than the predetermined threshold value Mc (S233, NO), it is decided that the refrigerator is used in the normal method and the user is at home, and the process proceeds to step S235 and "0" is set to Flag A. The "using-state decision A" process is ended, and the process proceeds to a main routine.

[0385] As described above, in the present embodiment, by calculating and standardizing the normal storage state, when the storage is in a state decreased from the assumed storage state, it is decided that the user is in the absent state. By controlling the defrosting operation and the like, energy saving can be achieved.

EIGHTH EXEMPLARY EMBODIMENT

[0386] Next, an eighth embodiment according to the present invention is described.

[0387] FIGS. 32A and 32B are control flowcharts according to the eighth embodiment of the present invention.

[0388] The configurations described in the sixth embodiment and the seventh embodiment can be applied in combination with the present embodiment.

[0389] After the process proceeds to the "absence detection A" process in FIG. 32A, various parameters are set in step S332. Specifically, "0" is set to the number of door opening-and-closing times Dn, "1" is set to Flag A, "0" is set to the timer tc, and the defrosting cycle t_{d1} is set to a predetermined value. Next, the process proceeds to step S213, the timer tc is started, and the process proceeds to the "using-state decision A" process in step S214.

[0390] The "using-state decision A" process according to the present embodiment is described with reference to FIG. 32B.

[0391] After starting the "using-state decision A" process, in step S232, it is decided whether "1" is being set

to Flag A. When "1" is being set to Flag A (S232, YES), the process proceeds to step S333.

[0392] In step S333, it is decided whether the storage change volume ΔM is equal to or smaller than the predetermined threshold value Mc or whether the number of door opening-and-closing times is "0". When the storage change volume ΔM is equal to or smaller than the predetermined threshold value Mc or when the number of door opening-and-closing times is "0" (S333, YES), it is decided that the user is in the absent state, and "1" is kept set in Flag A (S234).

[0393] On the other hand, when the storage change volume ΔM is larger than Mc or when the number of door opening-and-closing times is not "0", it is decided that there is a possibility that the user is at home. In step S235, "0" is set to Flag A, the "using-state decision A" process ends, and the process proceeds to the main routine.

[0394] By these controls, in addition to the storage change, the number of door opening-and-closing times can be also used as decision indexes of "presence" and "absence" of the user. Accordingly, the absence detection can be performed in higher precision, and energy saving can be achieved.

[0395] As described above, according to the present embodiment, with a time point after operation of the defrosting unit as a base point, when a period during which there is no door opening-and-closing is equal to or larger than a constant time, and also when a change in a storage volume during this period is smaller than a predetermined threshold value, the defrosting unit is not operated. Accordingly, when a storage volume decreases from the assumed storage state, it is decided that the user is in the absent state, and energy saving can be achieved by controlling the proper defrosting operation and the like.

NINTH EXEMPLARY EMBODIMENT

[0396] Next, a ninth embodiment according to the present invention is described.

[0397] FIGS. 33A and 33B are control flowcharts according to the ninth embodiment of the present invention. The configurations described in the sixth embodiment to the eighth embodiment can be applied in combination with the present embodiment.

[0398] After the process proceeds to the "absence detection A" process in FIG. 33A, various parameters are set in step S342. Specifically, "1" is set to Flag A, "0" is set to the timer tc, and the defrosting cycle t_{d1}, a cold compartment temperature variation T_{PC}, and the freezing compartment temperature variation T_{FC} are set, respectively.

[0399] Next, the process proceeds to step S213, the timer tc is started, and the process proceeds to the "using-state decision A" process in step S214.

[0400] The "using-state decision A" process according to the present embodiment is described with reference to FIG. 33B.

[0401] After starting the "using-state decision A", in step S232, it is decided whether "1" is being set to Flag A. When "1" is being set to Flag A (S232, YES), the process proceeds to step S343.

[0402] In step S343, it is decided whether the storage change volume ΔM is equal to or smaller than the predetermined threshold value Mc, whether the cold compartment temperature variation T_{PC} is smaller than the predetermined variation width T_{PCS}, or whether the freezing compartment temperature variation T_{FC} is smaller than the predetermined variation width T_{FCS}. When any one of the relationships is satisfied (S343, YES), it is decided that there is no input of food or there is no door opening-and-closing or heat load, and it is decided that the user is absent. "1" is kept set in Flag A (S234), and the "using-state decision A" process ends.

[0403] On the other hand, when the storage change volume ΔM is larger than the threshold value Mc, and also when the cold compartment temperature variation T_{PC} and the freezing compartment temperature variation T_{FC} are equal to or larger than the predetermined variation widths T_{PCS} and T_{FCS}, respectively, it is decided that there is a possibility that the user is at home. In this case, in step S235, "0" is set to Flag A, the "using-state decision A" process is ended, and the process proceeds to the main routine.

[0404] By the above-described process, in addition to the storage change, the temperature variation can be also used as decision indexes of "presence" and "absence" of the user. Accordingly, the absence detection can be performed in higher precision, and energy saving can be achieved.

[0405] As described above, according to the present embodiment, with a time point after a lapse of a certain constant time after operation of the defrosting unit as a base point, when a temperature variation in the storage chamber is equal to or smaller than a certain threshold value, or when a change in a storage volume during this period is smaller than a predetermined threshold value, an interval for operating the defrosting unit is extended. Accordingly, further energy saving can be achieved.

INDUSTRIAL APPLICABILITY

[0406] As described above, the refrigerator according to the present invention can start a rapid cooling operation by increasing rotation numbers of a compressor and a cooling fan without generating a time difference from input of a storage object. Therefore, the refrigerator is useful as a household refrigerator or a business refrigerator that has a storage volume detecting function and changes over the operation mode to the power-saving operation and the like by using a detection result.

REFERENCE MARKS IN THE DRAWINGS

[0407]

4, 4a, 4b cold-air blowing opening
11, 151 refrigerator main body
11a inner box
11b outer box
12, 152 cold compartment
12a, 152a cold compartment door
12b low-temperature compartment
13, 153 ice compartment
14, 154 change compartment
15, 155 freezing compartment
16, 156 vegetable compartment
17, 157 operating unit
18a to 18d, 158 storage shelf
19, 159 illuminating unit
20, 20a to 20e, 160 light emitting unit
21, 21a to 21f, 161 light-volume detecting unit
22, 163 arithmetic control unit
23, 162 storage-volume estimating unit
24 comparison-information deciding unit
25 change-information deciding unit
27a to 27c door shelf
28a to 28d air-volume adjusting unit
30, 170 compressor
31, 171 cooling fan
32, 172 temperature compensation heater
33, 173 stored object
34a, 34b, 174a irradiation light
50, 150 refrigerator
61, 191 temperature sensor
62, 192 door-open-close detecting unit
63 outer-air temperature sensor
64, 194 memory unit
65 operation-start deciding unit
66 operation-end deciding unit
67, 193 damper
68, 195 defrosting unit
70 temperature-information deciding unit
71 door-open-close information deciding unit
72 out-refrigerator illuminance sensor
91 display unit
196 timer

Claims

1. A refrigerator comprising:

a storage chamber partitioned by a heat insulation wall and a heat insulation door, for storing a storage object;
a storage-volume estimating unit for estimating a storage volume in the storage chamber;
a memory unit for memorizing a result of estimation by the storage-volume estimating unit; and
an arithmetic control unit for calculating a storage change volume based on a result of estimation of the storage volume up to a last time memorized in the memory unit and a result of estimation by the storage-volume estimating unit, and for controlling an output operation of an electrofunctional part,
wherein the arithmetic control unit compares a predetermined threshold value with the storage change volume, and decides that the storage volume has changed when the storage change volume exceeds the threshold value, and controls the output operation of the electrofunctional part.

2. The refrigerator according to claim 1, further comprising a door-open-close detecting unit for detecting opening and closing of the heat insulation door,
wherein the arithmetic control unit controls the output operation of the electrofunctional part when the storage change volume between the storage volume before an open operation of the heat insulation door and the storage volume after a close operation of the heat insulation door exceeds the predetermined threshold value, based on a result of detection by the door-open-close detecting unit.

3. The refrigerator according to claim 2,
wherein the arithmetic control unit calculates when predetermined time elapsed after the door-open-close detecting unit detects the close operation of the heat insulation door, and controls the output operation of the electrofunctional part.

4. The refrigerator according to claim 1,
wherein when the storage change volume does not exceed the threshold value, the arithmetic control unit does not change the output operation of the electrofunctional part.

5. The refrigerator according to any one of claims 1 to 4,
wherein the electrofunctional part includes at least one of a cooling fan, a damper, and a compressor for changing a cooling volume in the storage chamber.

FIG. 1

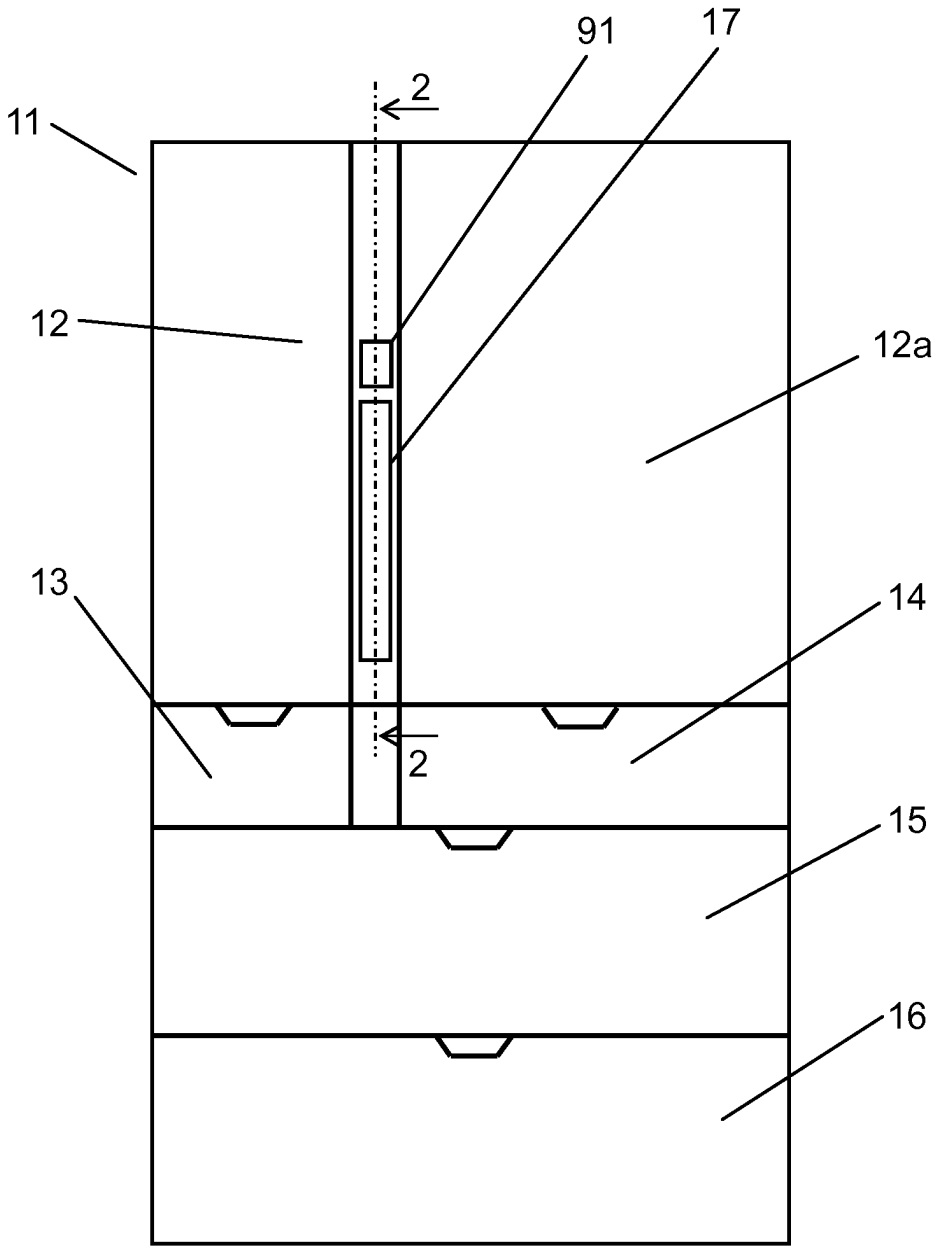


FIG. 2

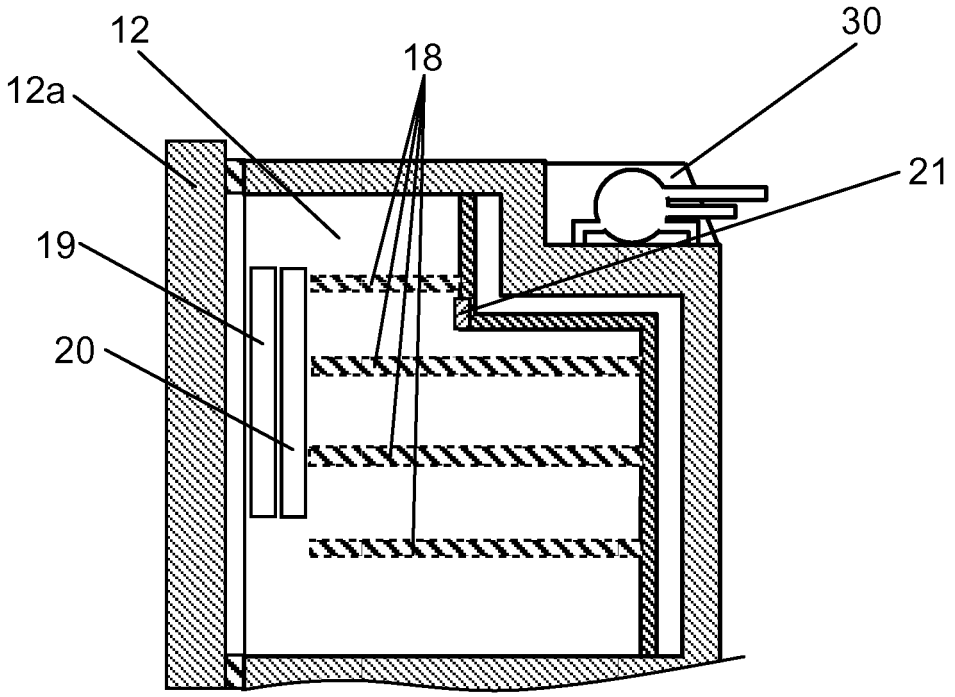


FIG. 3

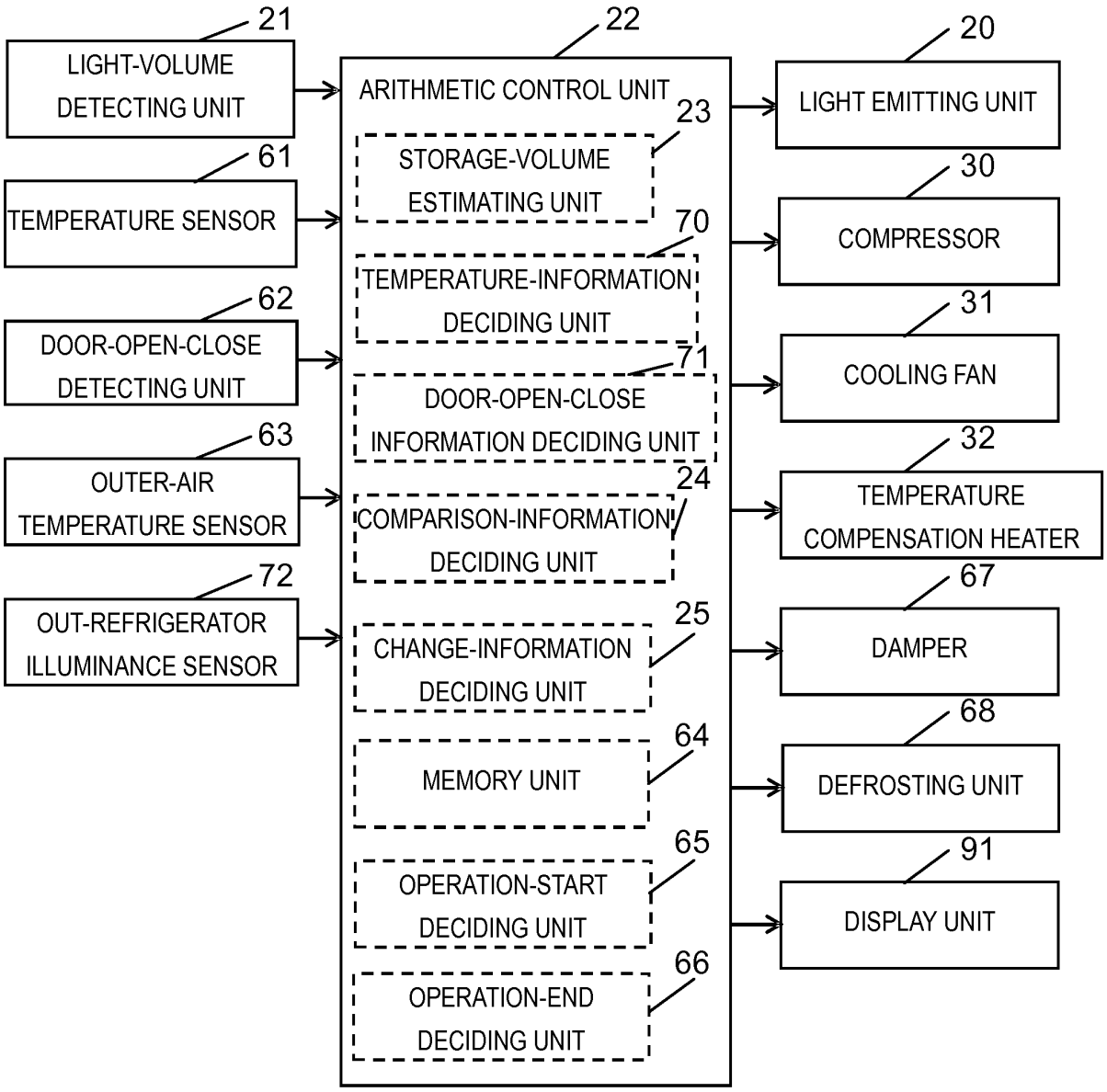

21
LIGHT-VOLUME DETECTING UNIT
61
TEMPERATURE SENSOR
62
DOOR-OPEN-CLOSE DETECTING UNIT
63
OUTER-AIR TEMPERATURE SENSOR
72
OUT-REFRIGERATOR ILLUMINANCE SENSOR
22
ARITHMETIC CONTROL UNIT
23
STORAGE-VOLUME ESTIMATING UNIT
70
TEMPERATURE-INFORMATION DECIDING UNIT
71
DOOR-OPEN-CLOSE INFORMATION DECIDING UNIT
24
COMPARISON-INFORMATION DECIDING UNIT
25
CHANGE-INFORMATION DECIDING UNIT
64
MEMORY UNIT
65
OPERATION-START DECIDING UNIT
66
OPERATION-END DECIDING UNIT
20
LIGHT EMITTING UNIT
30
COMPRESSOR
31
COOLING FAN
32
TEMPERATURE COMPENSATION HEATER
67
DAMPER
68
DEFROSTING UNIT
91
DISPLAY UNIT
50

FIG. 4

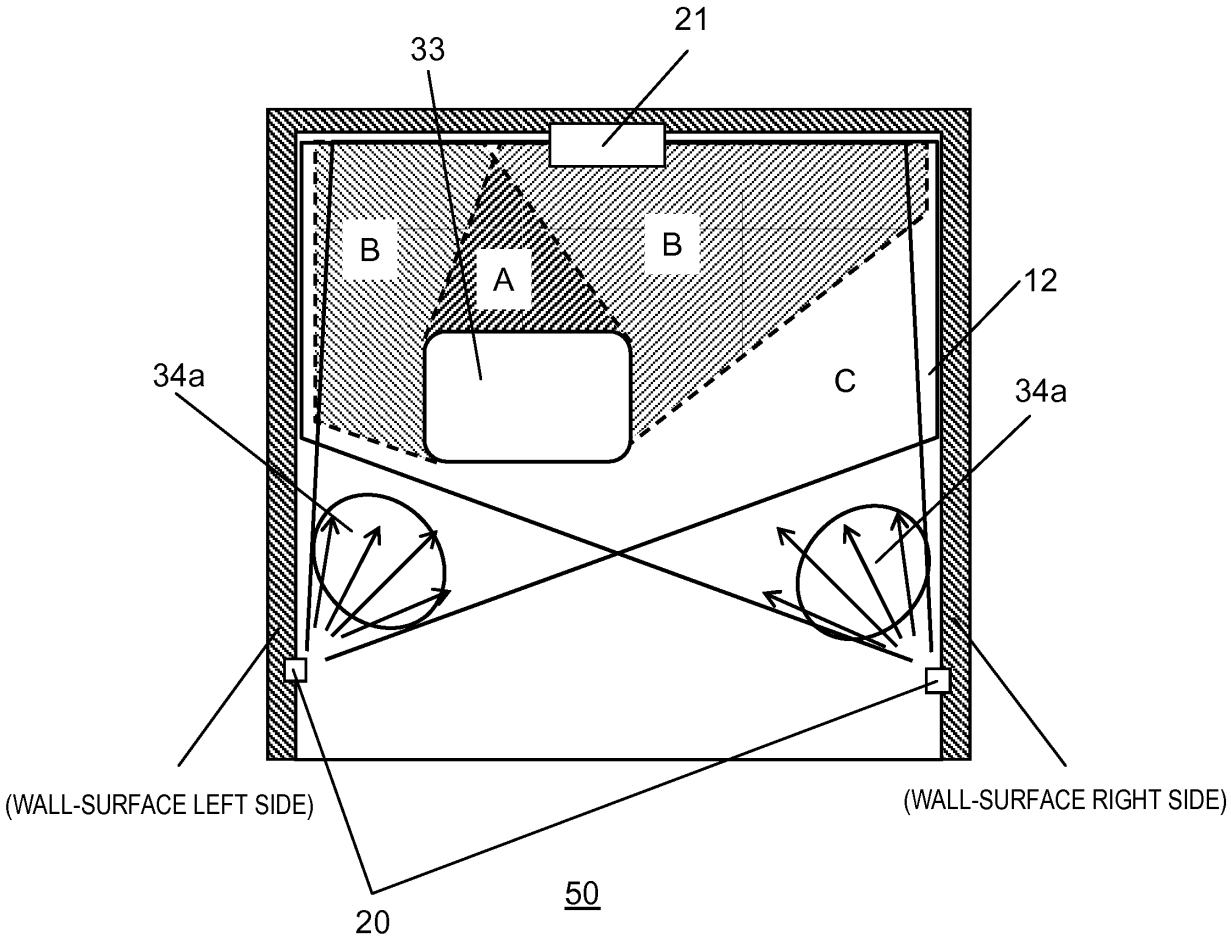

21
33
B
A
B
12
34a
C
34a
(WALL-SURFACE LEFT SIDE)
(WALL-SURFACE RIGHT SIDE)
50
20

FIG. 5A

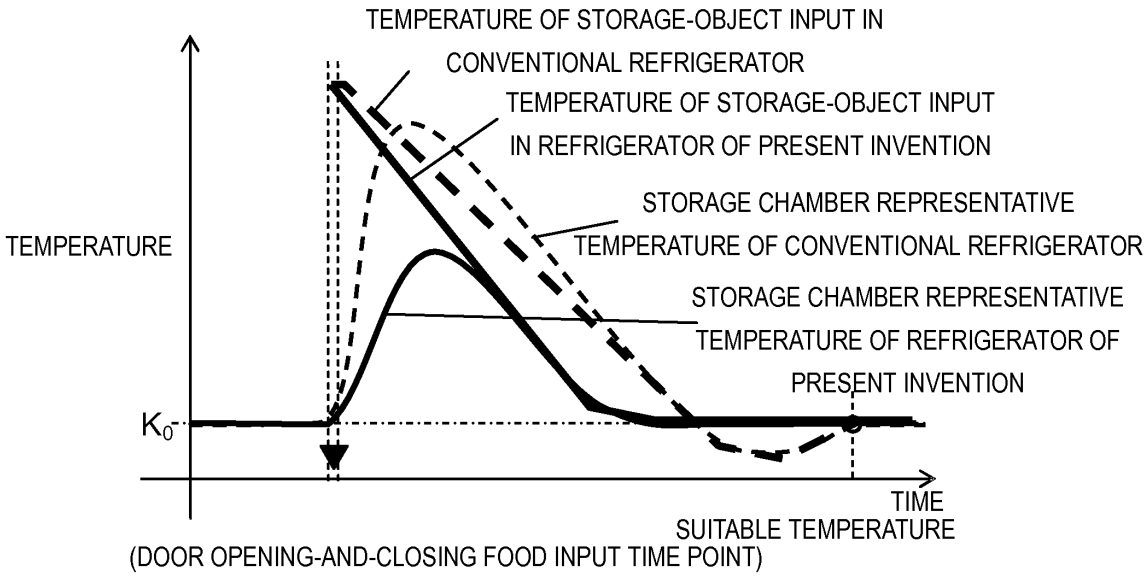

TEMPERATURE OF STORAGE-OBJECT INPUT IN
CONVENTIONAL REFRIGERATOR
TEMPERATURE OF STORAGE-OBJECT INPUT
IN REFRIGERATOR OF PRESENT INVENTION
STORAGE CHAMBER REPRESENTATIVE
TEMPERATURE OF CONVENTIONAL REFRIGERATOR
STORAGE CHAMBER REPRESENTATIVE
TEMPERATURE OF REFRIGERATOR OF
PRESENT INVENTION
TEMPERATURE
K0
TIME
SUITABLE TEMPERATURE
(DOOR OPENING-AND-CLOSING FOOD INPUT TIME POINT)

FIG. 5B

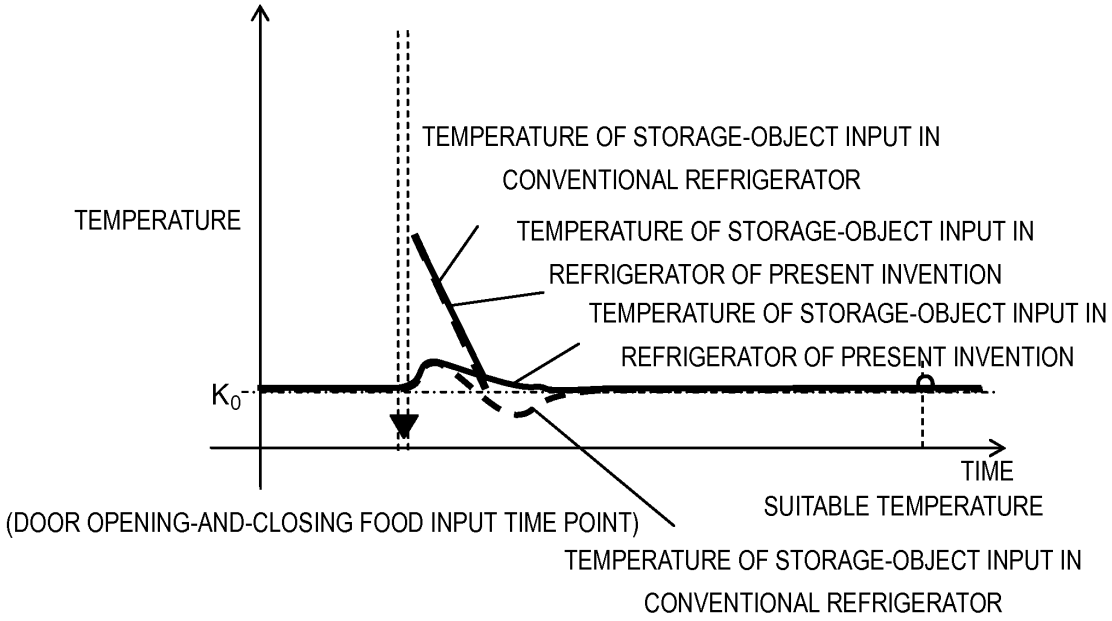

TEMPERATURE OF STORAGE-OBJECT INPUT IN
CONVENTIONAL REFRIGERATOR
TEMPERATURE
TEMPERATURE OF STORAGE-OBJECT INPUT IN
REFRIGERATOR OF PRESENT INVENTION
TEMPERATURE OF STORAGE-OBJECT INPUT IN
REFRIGERATOR OF PRESENT INVENTION
K0
TIME
SUITABLE TEMPERATURE
(DOOR OPENING-AND-CLOSING FOOD INPUT TIME POINT)
TEMPERATURE OF STORAGE-OBJECT INPUT IN
CONVENTIONAL REFRIGERATOR

FIG. 6

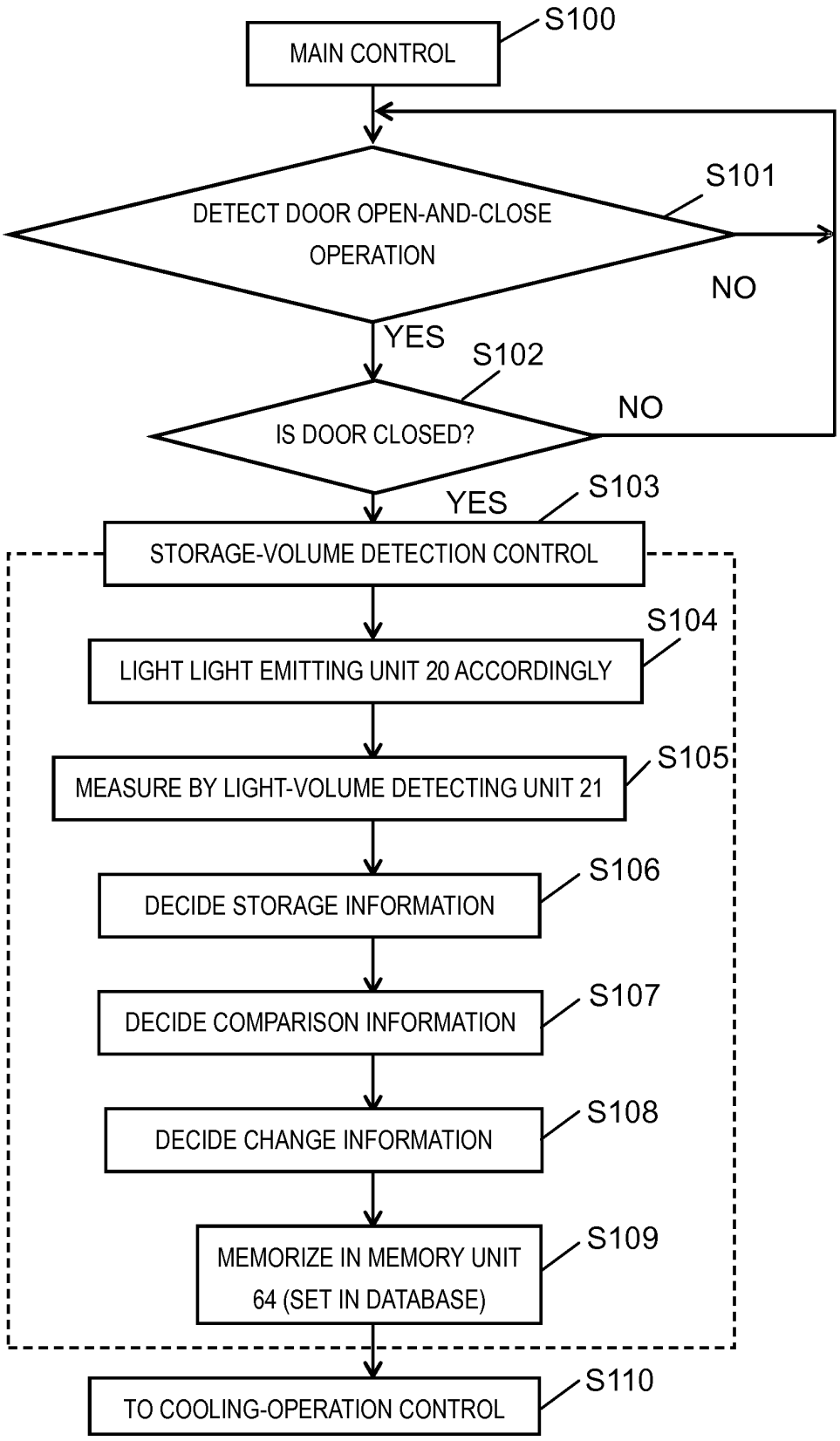

S100
MAIN CONTROL
S101
DETECT DOOR OPEN-AND-CLOSE OPERATION
NO
YES
S102
IS DOOR CLOSED?
NO
YES
S103
STORAGE-VOLUME DETECTION CONTROL
S104
LIGHT LIGHT EMITTING UNIT 20 ACCORDINGLY
S105
MEASURE BY LIGHT-VOLUME DETECTING UNIT 21
S106
DECIDE STORAGE INFORMATION
S107
DECIDE COMPARISON INFORMATION
S108
DECIDE CHANGE INFORMATION
S109
MEMORIZE IN MEMORY UNIT 64 (SET IN DATABASE)
S110
TO COOLING-OPERATION CONTROL

FIG. 7

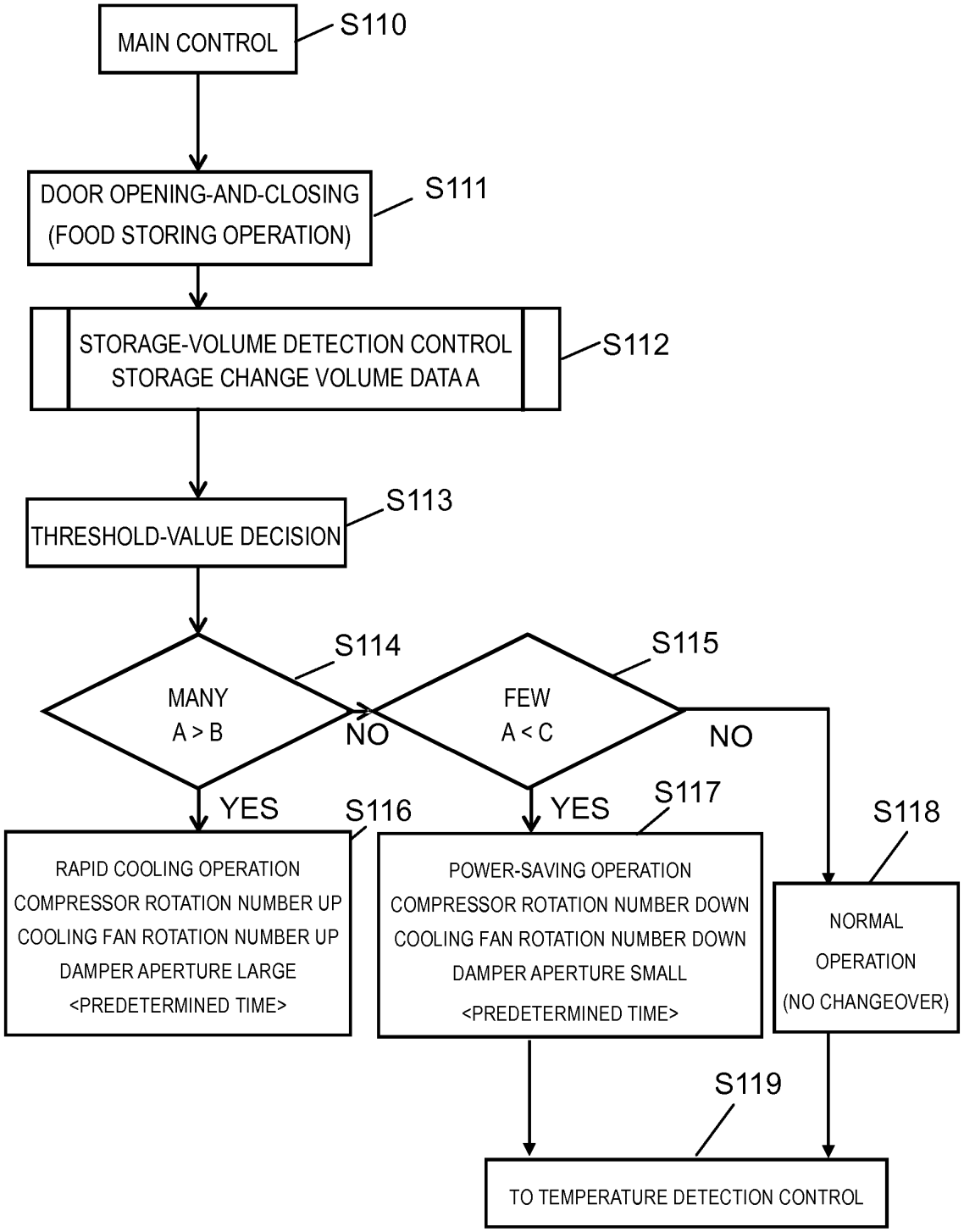

MAIN CONTROL
S110
DOOR OPENING-AND-CLOSING
(FOOD STORING OPERATION)
S111
STORAGE-VOLUME DETECTION CONTROL
STORAGE CHANGE VOLUME DATA A
S112
THRESHOLD-VALUE DECISION
S113
MANY
A > B
S114
NO
FEW
A < C
S115
NO
YES
S116
YES
S117
S118
RAPID COOLING OPERATION
COMPRESSOR ROTATION NUMBER UP
COOLING FAN ROTATION NUMBER UP
DAMPER APERTURE LARGE
<PREDETERMINED TIME>
POWER-SAVING OPERATION
COMPRESSOR ROTATION NUMBER DOWN
COOLING FAN ROTATION NUMBER DOWN
DAMPER APERTURE SMALL
<PREDETERMINED TIME>
NORMAL
OPERATION
(NO CHANGEOVER)
S119
TO TEMPERATURE DETECTION CONTROL

FIG. 8

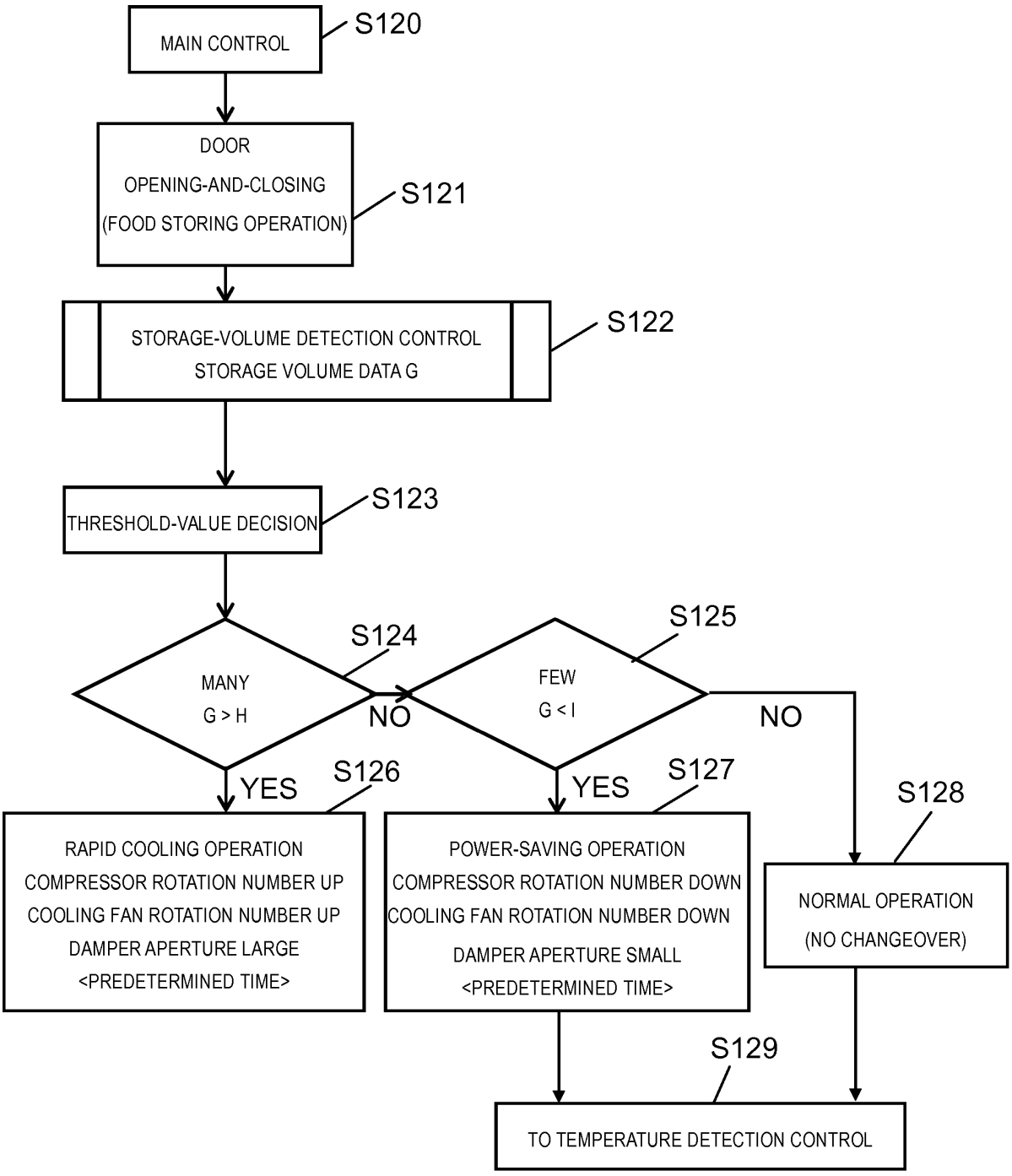

MAIN CONTROL
S120
DOOR
OPENING-AND-CLOSING
(FOOD STORING OPERATION)
S121
STORAGE-VOLUME DETECTION CONTROL
STORAGE VOLUME DATA G
S122
THRESHOLD-VALUE DECISION
S123
MANY
G > H
S124
NO
FEW
G < I
S125
NO
YES
S126
YES
S127
S128
RAPID COOLING OPERATION
COMPRESSOR ROTATION NUMBER UP
COOLING FAN ROTATION NUMBER UP
DAMPER APERTURE LARGE
<PREDETERMINED TIME>
POWER-SAVING OPERATION
COMPRESSOR ROTATION NUMBER DOWN
COOLING FAN ROTATION NUMBER DOWN
DAMPER APERTURE SMALL
<PREDETERMINED TIME>
NORMAL OPERATION
(NO CHANGEOVER)
S129
TO TEMPERATURE DETECTION CONTROL

FIG. 9

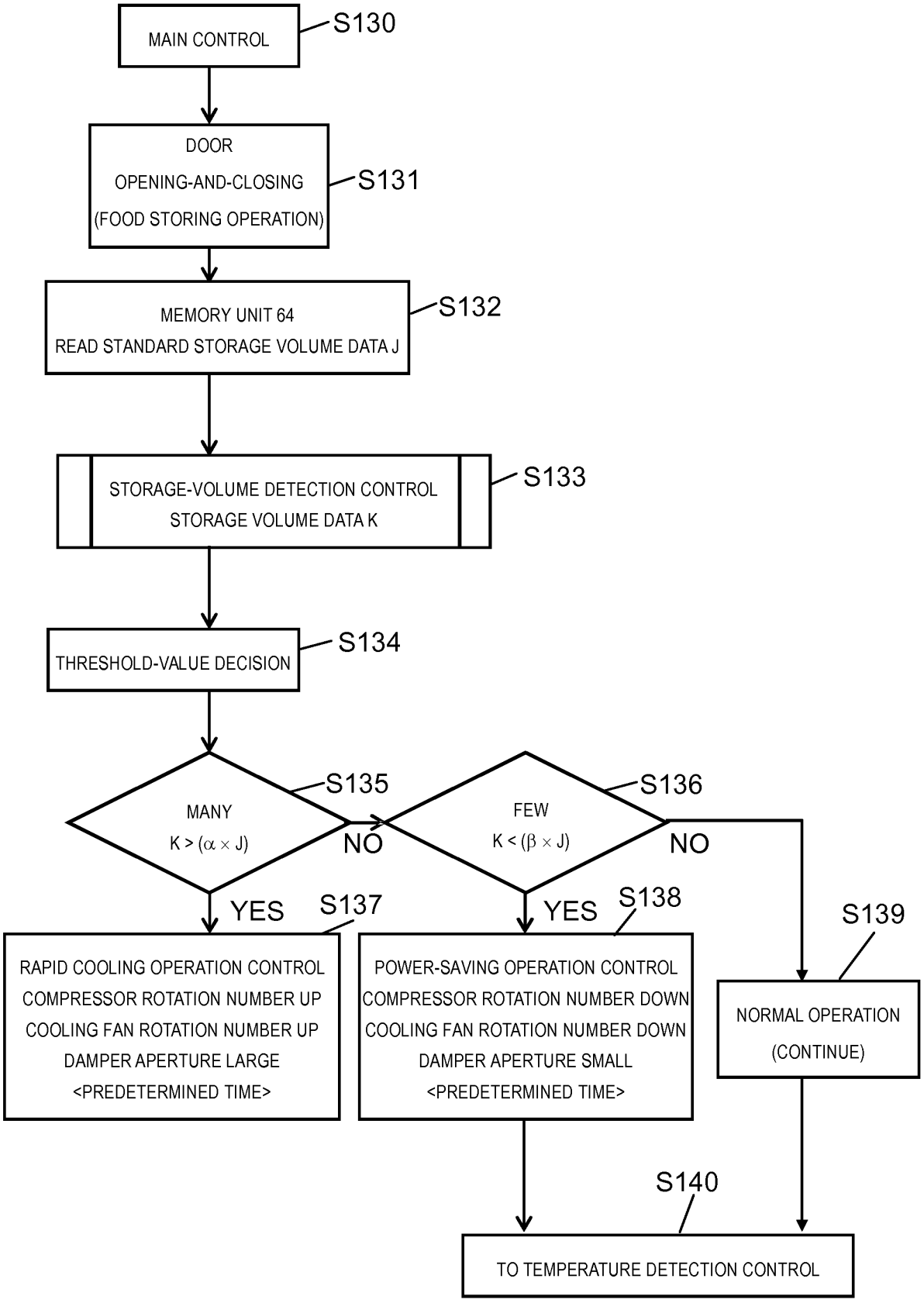

MAIN CONTROL
S130
DOOR
OPENING-AND-CLOSING
(FOOD STORING OPERATION)
S131
MEMORY UNIT 64
READ STANDARD STORAGE VOLUME DATA J
S132
STORAGE-VOLUME DETECTION CONTROL
STORAGE VOLUME DATA K
S133
THRESHOLD-VALUE DECISION
S134
MANY
K > (α × J)
S135
NO
FEW
K < (β × J)
S136
NO
YES
S137
YES
S138
S139
RAPID COOLING OPERATION CONTROL
COMPRESSOR ROTATION NUMBER UP
COOLING FAN ROTATION NUMBER UP
DAMPER APERTURE LARGE
<PREDETERMINED TIME>
POWER-SAVING OPERATION CONTROL
COMPRESSOR ROTATION NUMBER DOWN
COOLING FAN ROTATION NUMBER DOWN
DAMPER APERTURE SMALL
<PREDETERMINED TIME>
NORMAL OPERATION
(CONTINUE)
S140
TO TEMPERATURE DETECTION CONTROL

FIG. 10

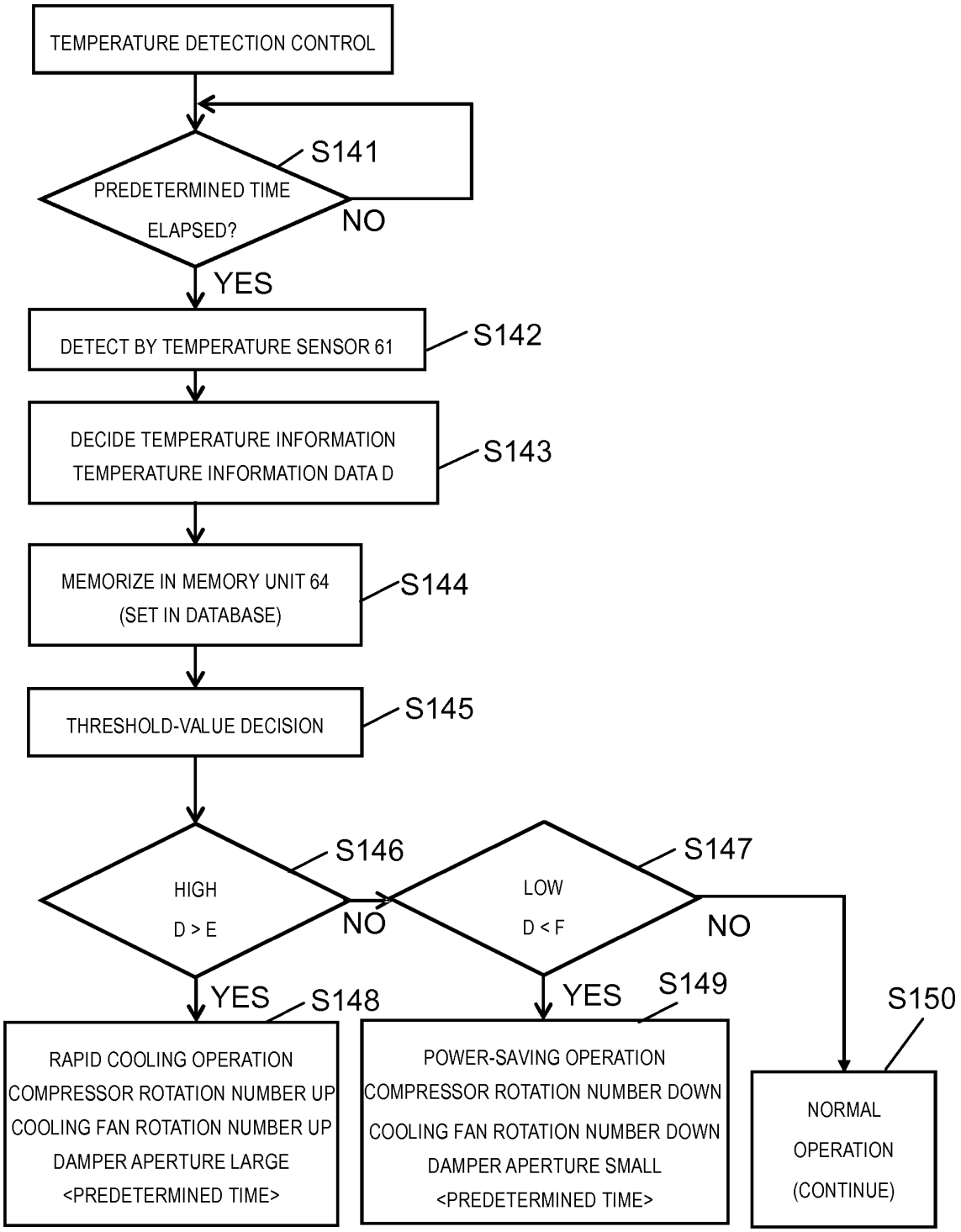

TEMPERATURE DETECTION CONTROL
S141
PREDETERMINED TIME ELAPSED?
NO
YES
DETECT BY TEMPERATURE SENSOR 61
S142
DECIDE TEMPERATURE INFORMATION TEMPERATURE INFORMATION DATA D
S143
MEMORIZE IN MEMORY UNIT 64 (SET IN DATABASE)
S144
THRESHOLD-VALUE DECISION
S145
HIGH D > E
S146
NO
LOW D < F
S147
NO
YES
S148
YES
S149
S150
RAPID COOLING OPERATION COMPRESSOR ROTATION NUMBER UP COOLING FAN ROTATION NUMBER UP DAMPER APERTURE LARGE <PREDETERMINED TIME>
POWER-SAVING OPERATION COMPRESSOR ROTATION NUMBER DOWN COOLING FAN ROTATION NUMBER DOWN DAMPER APERTURE SMALL <PREDETERMINED TIME>
NORMAL OPERATION (CONTINUE)

FIG. 11A

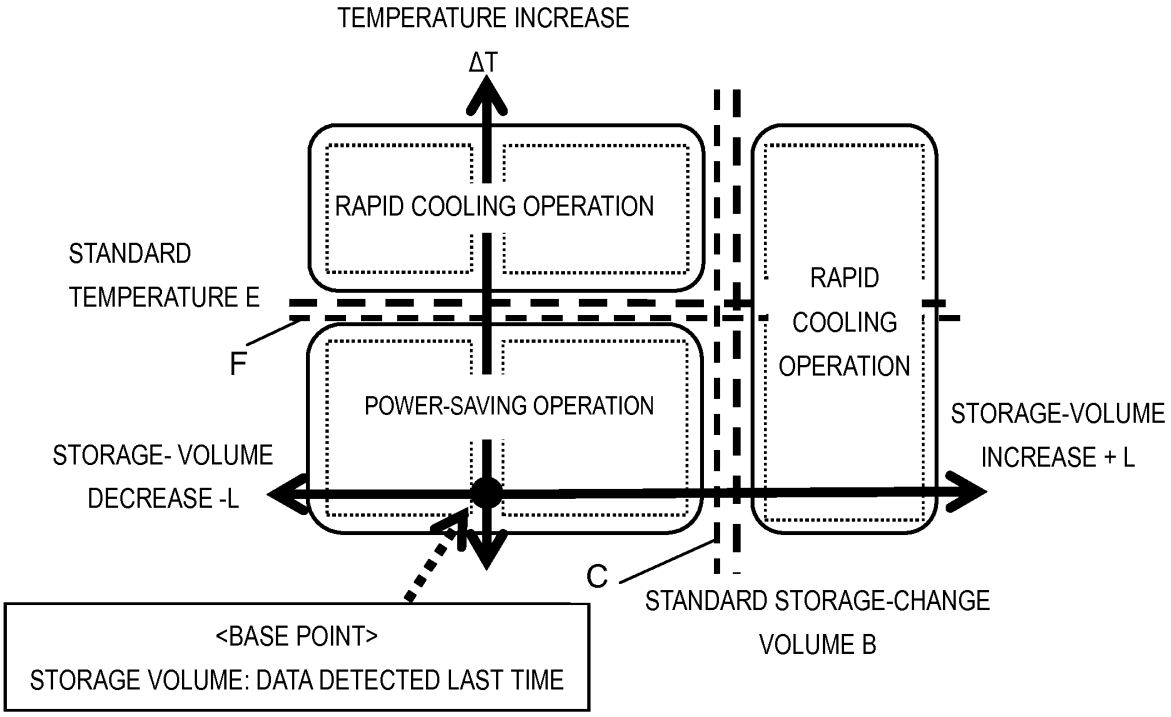


FIG. 11B

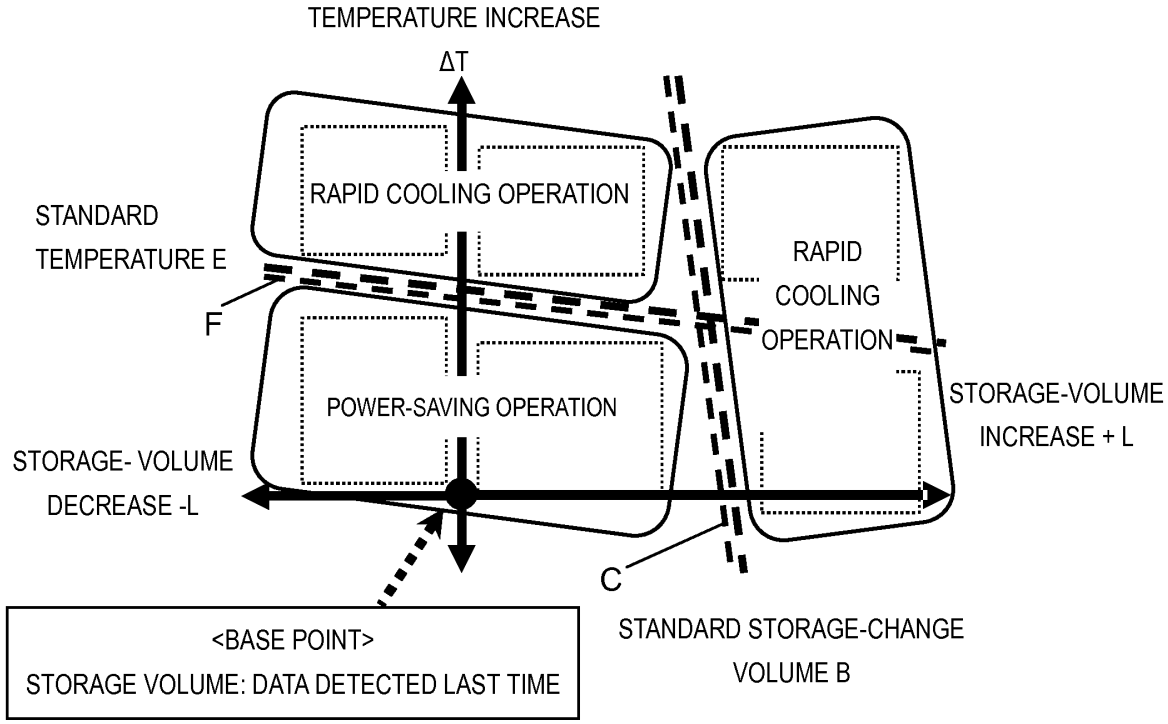


FIG. 12

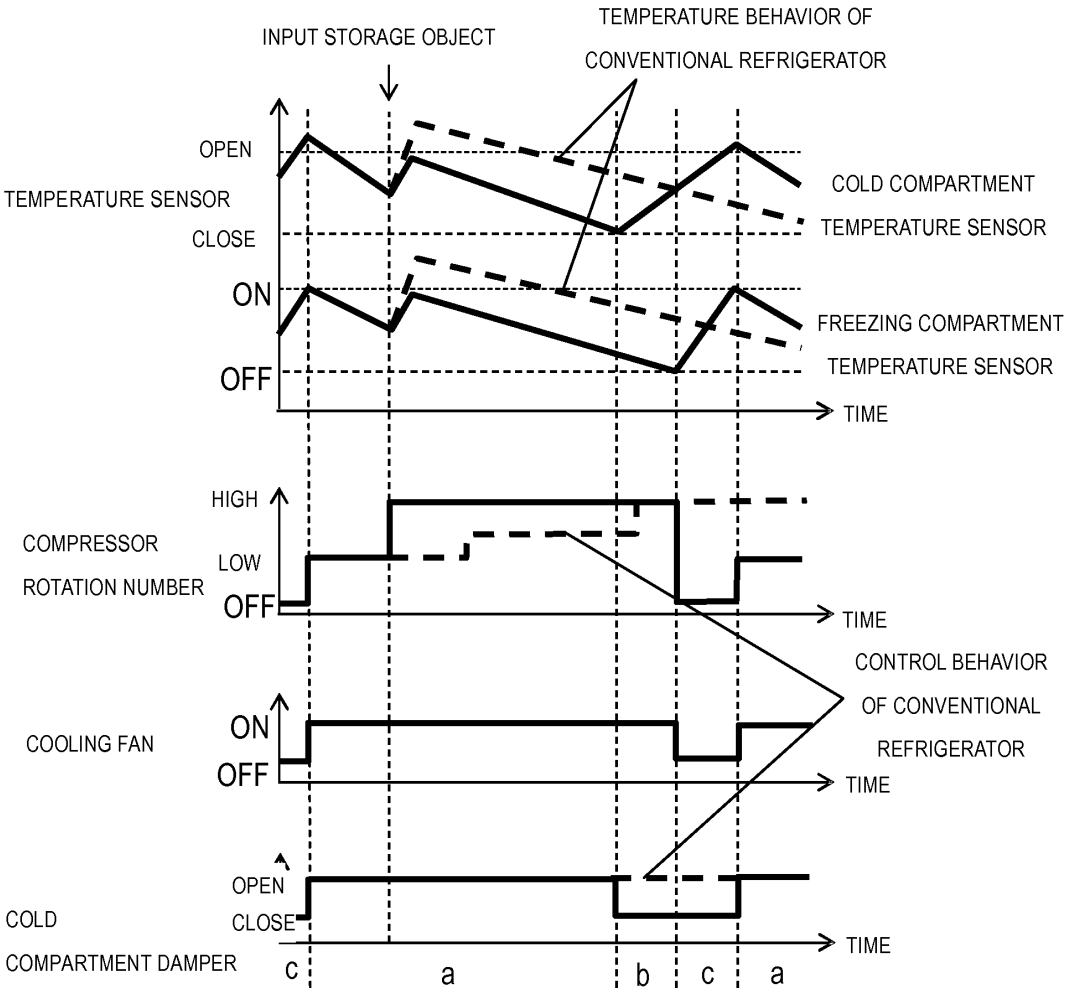

INPUT STORAGE OBJECT
TEMPERATURE BEHAVIOR OF
CONVENTIONAL REFRIGERATOR
OPEN
TEMPERATURE SENSOR
CLOSE
COLD COMPARTMENT
TEMPERATURE SENSOR
ON
OFF
FREEZING COMPARTMENT
TEMPERATURE SENSOR
TIME
HIGH
COMPRESSOR
ROTATION NUMBER
LOW
OFF
TIME
CONTROL BEHAVIOR
OF CONVENTIONAL
REFRIGERATOR
COOLING FAN
ON
OFF
TIME
OPEN
COLD
COMPARTMENT DAMPER
CLOSE
TIME
c
a
b
c
a

FIG. 13

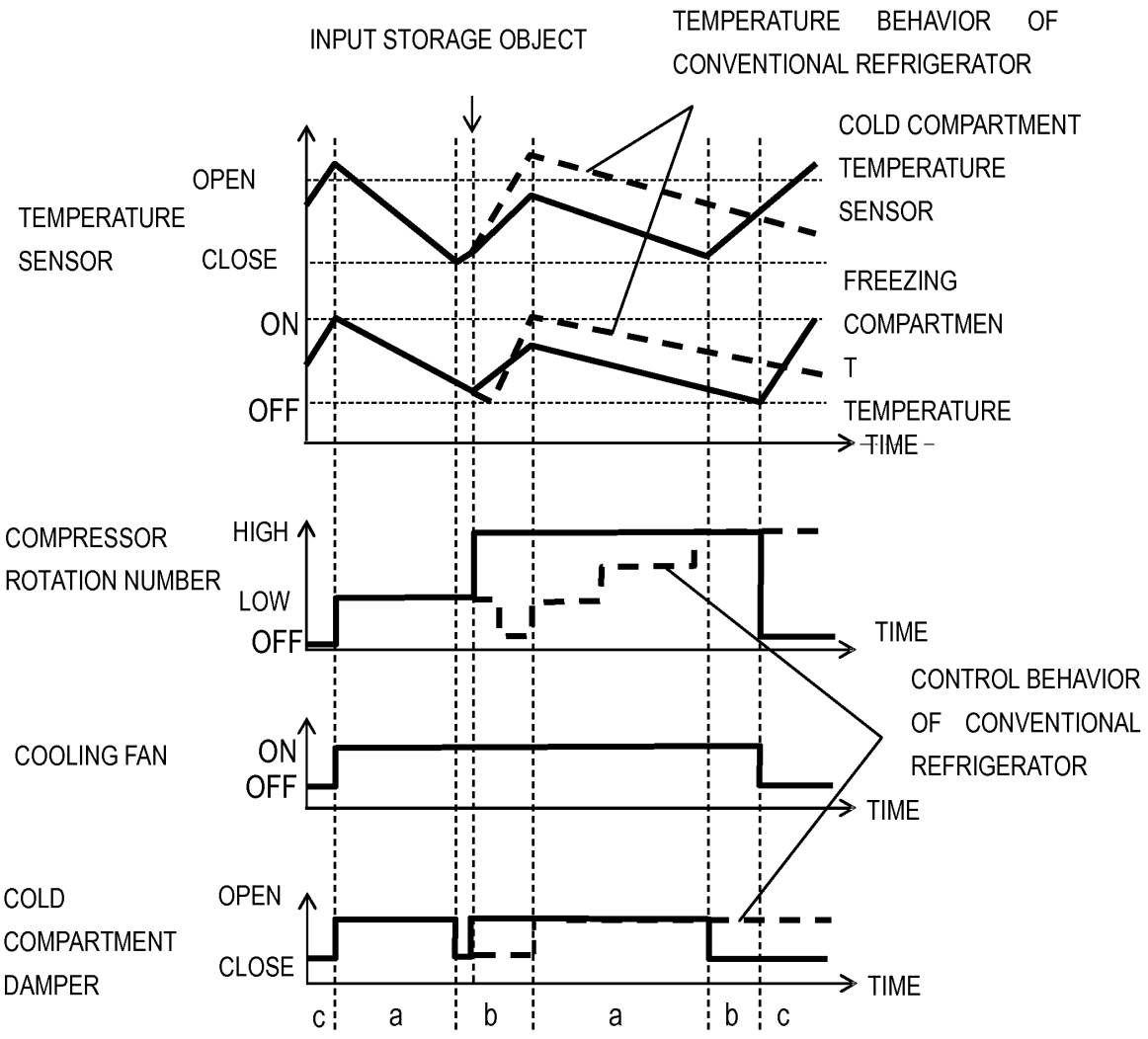

INPUT STORAGE OBJECT
TEMPERATURE BEHAVIOR OF CONVENTIONAL REFRIGERATOR
COLD COMPARTMENT TEMPERATURE SENSOR
FREEZING COMPARTMENT TEMPERATURE
TEMPERATURE SENSOR
OPEN
CLOSE
ON
OFF
TIME
COMPRESSOR ROTATION NUMBER
HIGH
LOW
OFF
TIME
CONTROL BEHAVIOR OF CONVENTIONAL REFRIGERATOR
COOLING FAN
ON
OFF
TIME
COLD COMPARTMENT DAMPER
OPEN
CLOSE
TIME
c
a
b
a
b
c

FIG. 14

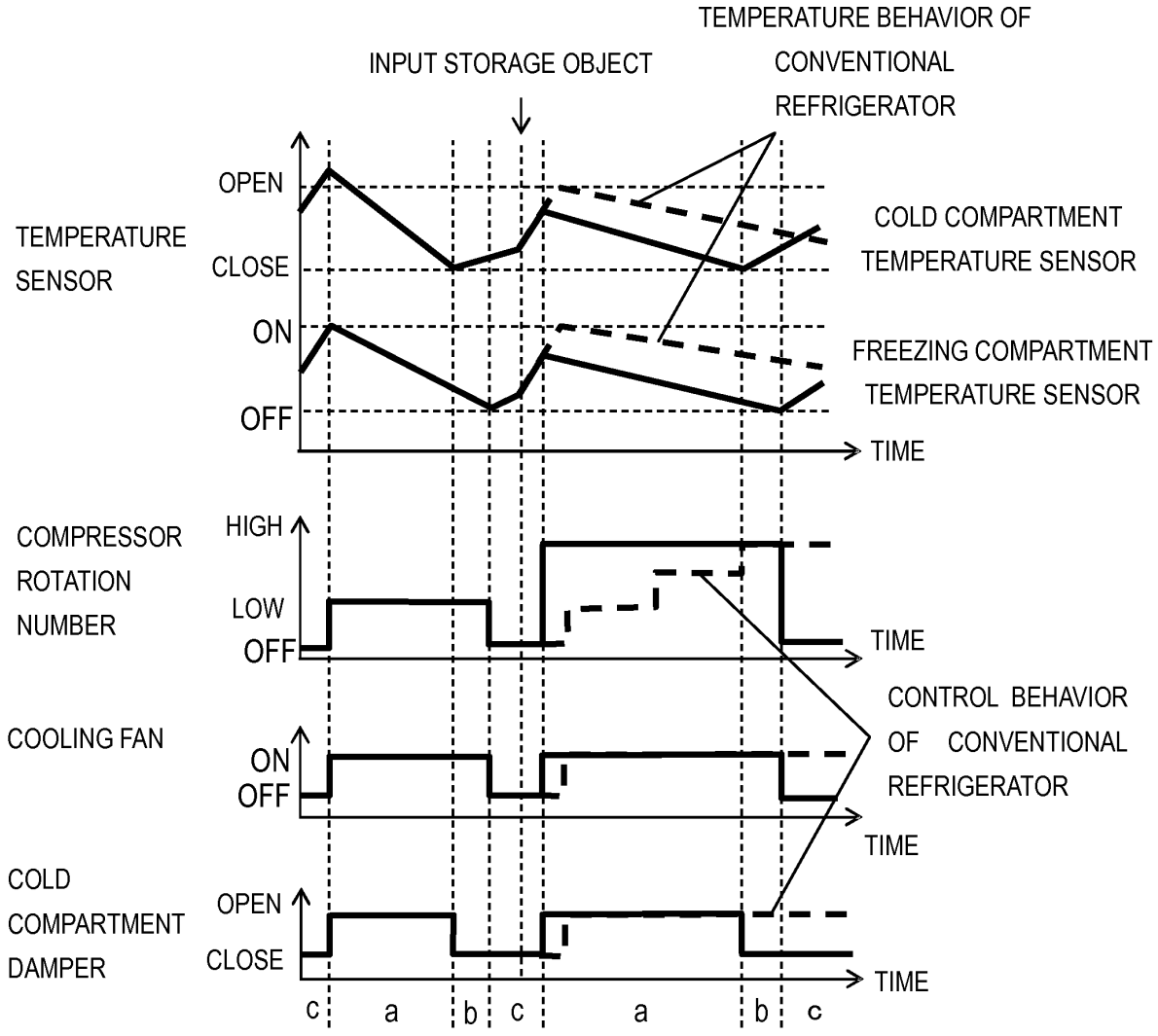

TEMPERATURE BEHAVIOR OF CONVENTIONAL REFRIGERATOR
INPUT STORAGE OBJECT
TEMPERATURE SENSOR
OPEN
CLOSE
ON
OFF
COLD COMPARTMENT TEMPERATURE SENSOR
FREEZING COMPARTMENT TEMPERATURE SENSOR
TIME
COMPRESSOR ROTATION NUMBER
HIGH
LOW
OFF
TIME
CONTROL BEHAVIOR OF CONVENTIONAL REFRIGERATOR
COOLING FAN
ON
OFF
TIME
COLD COMPARTMENT DAMPER
OPEN
CLOSE
TIME
c
a
b
c
a
b
c

FIG. 15

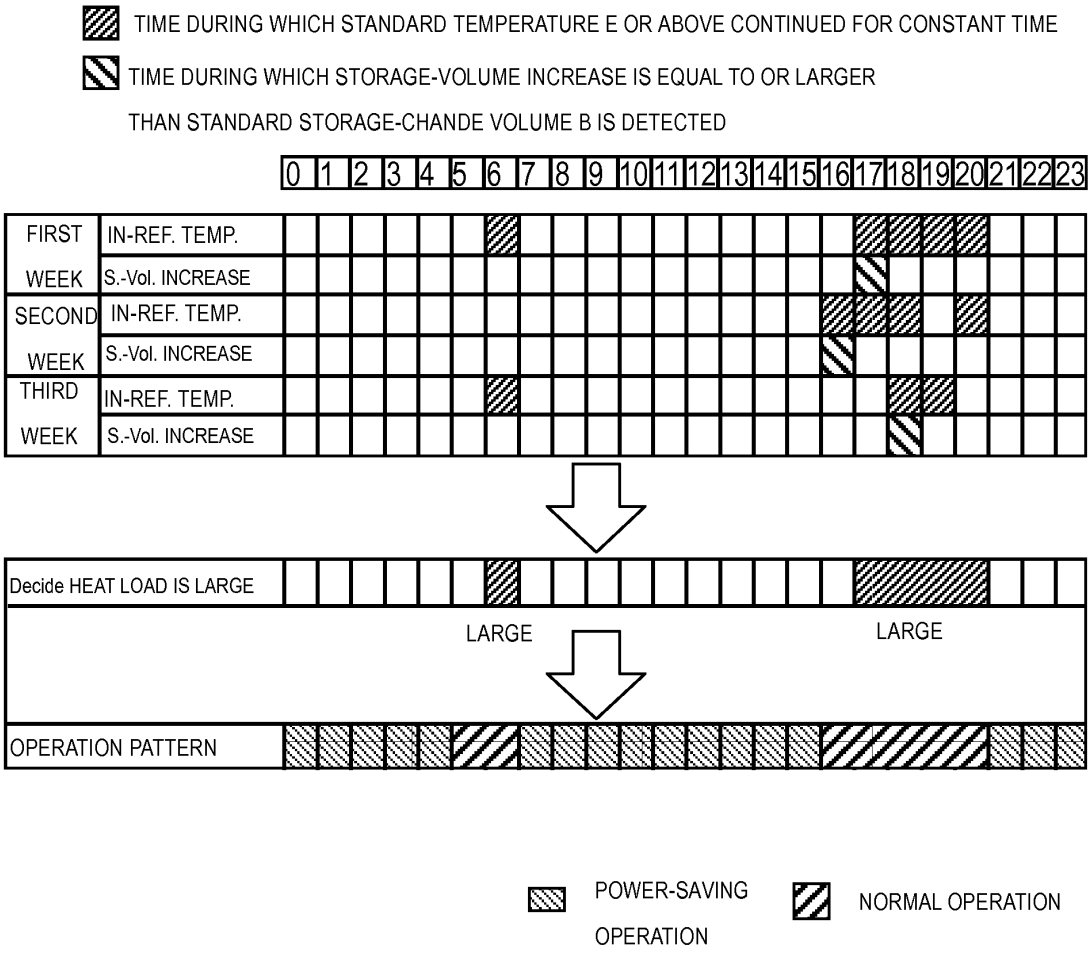

TIME DURING WHICH STANDARD TEMPERATURE E OR ABOVE CONTINUED FOR CONSTANT TIME
TIME DURING WHICH STORAGE-VOLUME INCREASE IS EQUAL TO OR LARGER THAN STANDARD STORAGE-CHANDE VOLUME B IS DETECTED
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
FIRST WEEK
IN-REF. TEMP.
S.-Vol. INCREASE
SECOND WEEK
IN-REF. TEMP.
S.-Vol. INCREASE
THIRD WEEK
IN-REF. TEMP.
S.-Vol. INCREASE
Decide HEAT LOAD IS LARGE
LARGE
LARGE
OPERATION PATTERN
POWER-SAVING OPERATION
NORMAL OPERATION

FIG. 16

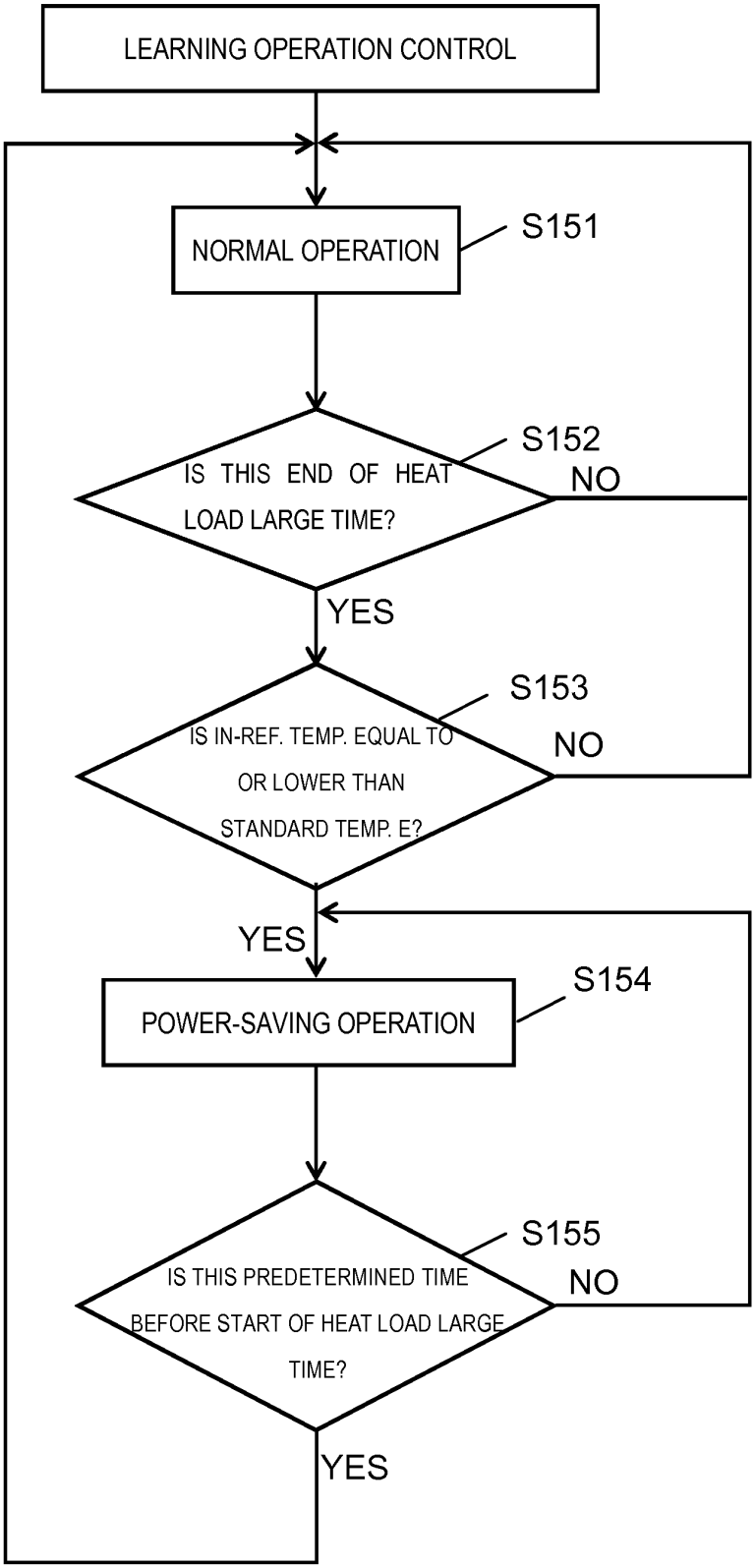

LEARNING OPERATION CONTROL
NORMAL OPERATION
S151
IS THIS END OF HEAT LOAD LARGE TIME?
S152
NO
YES
IS IN-REF. TEMP. EQUAL TO OR LOWER THAN STANDARD TEMP. E?
S153
NO
YES
POWER-SAVING OPERATION
S154
IS THIS PREDETERMINED TIME BEFORE START OF HEAT LOAD LARGE TIME?
S155
NO
YES

FIG. 17

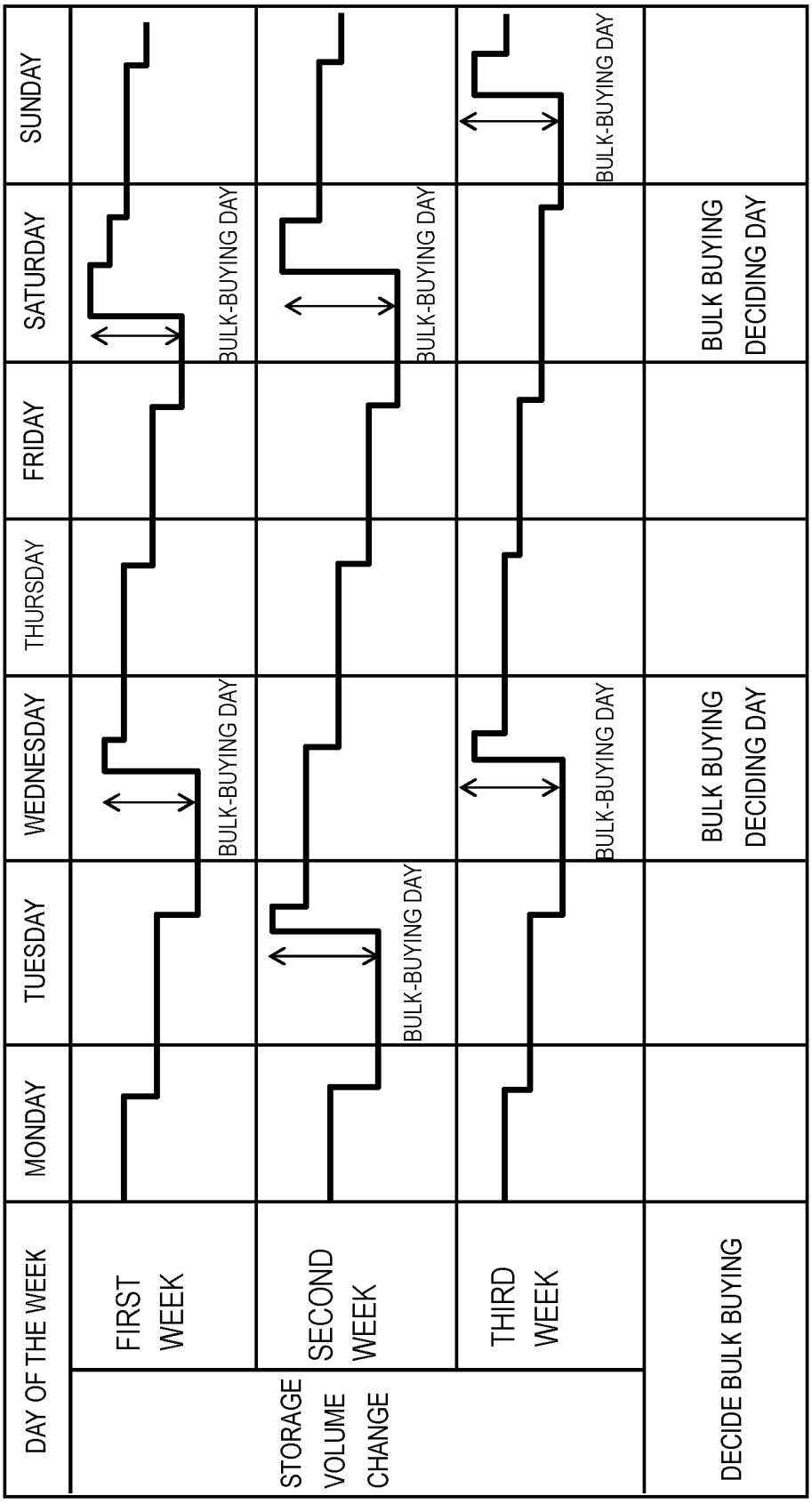

DAY OF THE WEEK
MONDAY
TUESDAY
WEDNESDAY
THURSDAY
FRIDAY
SATURDAY
SUNDAY
FIRST WEEK
SECOND WEEK
THIRD WEEK
STORAGE VOLUME CHANGE
BULK-BUYING DAY
BULK-BUYING DAY
BULK-BUYING DAY
BULK-BUYING DAY
BULK-BUYING DAY
BULK BUYING DECIDING DAY
BULK BUYING DECIDING DAY
DECIDE BULK BUYING

FIG. 18

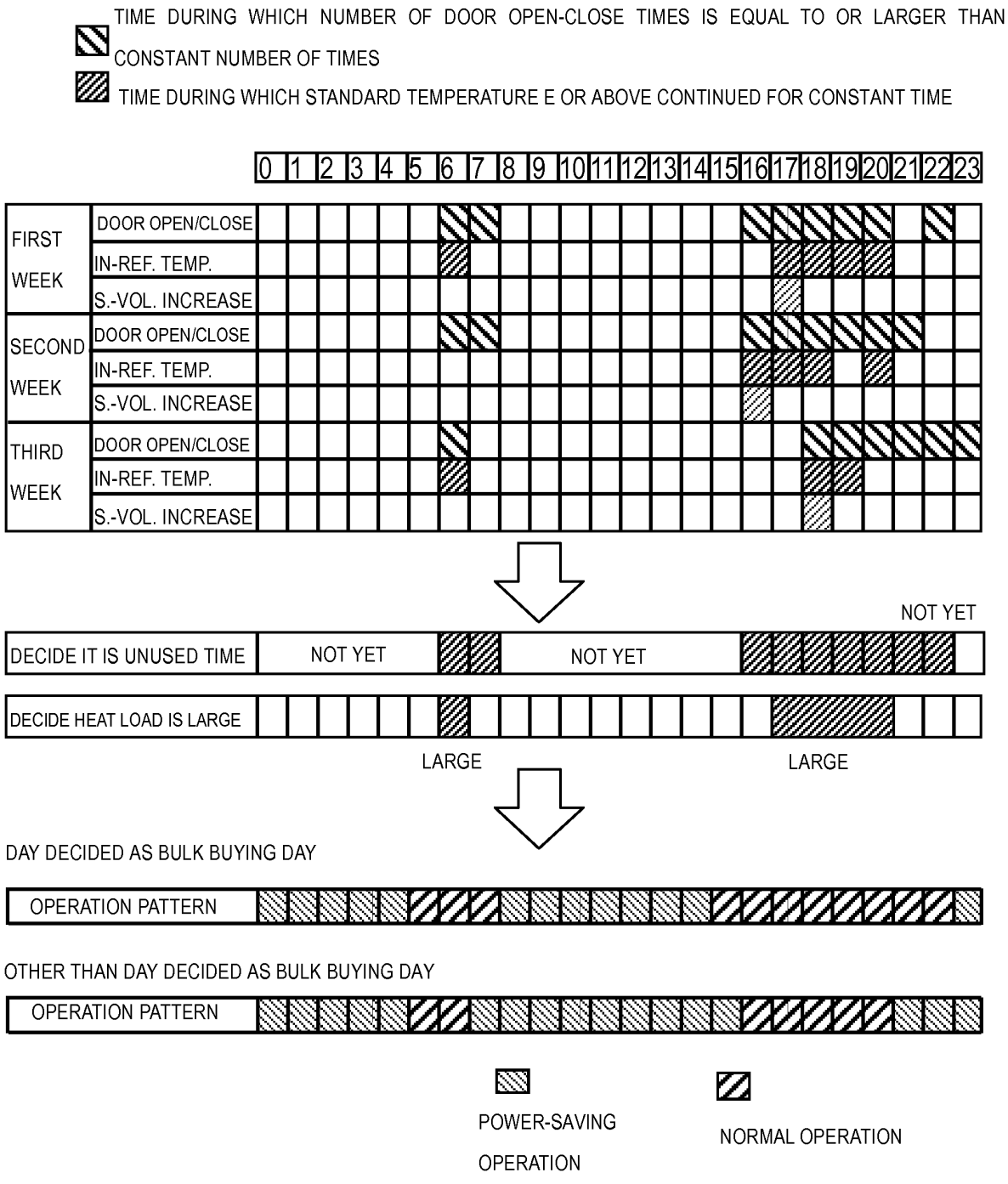

TIME DURING WHICH NUMBER OF DOOR OPEN-CLOSE TIMES IS EQUAL TO OR LARGER THAN CONSTANT NUMBER OF TIMES
TIME DURING WHICH STANDARD TEMPERATURE E OR ABOVE CONTINUED FOR CONSTANT TIME
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
FIRST WEEK
SECOND WEEK
THIRD WEEK
DOOR OPEN/CLOSE
IN-REF. TEMP.
S.-VOL. INCREASE
NOT YET
DECIDE IT IS UNUSED TIME
NOT YET
NOT YET
DECIDE HEAT LOAD IS LARGE
LARGE
LARGE
DAY DECIDED AS BULK BUYING DAY
OPERATION PATTERN
OTHER THAN DAY DECIDED AS BULK BUYING DAY
OPERATION PATTERN
POWER-SAVING OPERATION
NORMAL OPERATION

FIG. 19

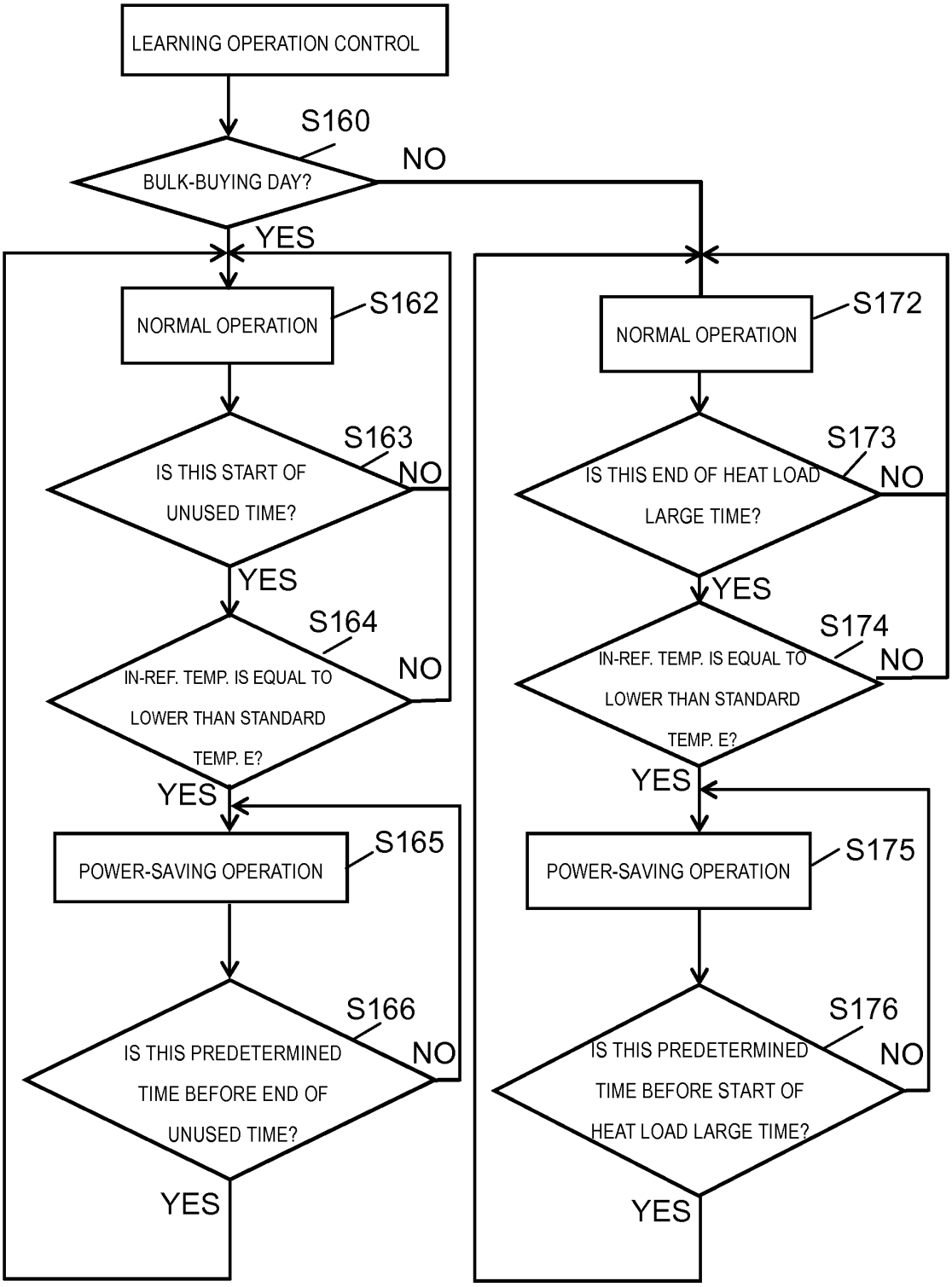

LEARNING OPERATION CONTROL
S160
BULK-BUYING DAY?
NO
YES
NORMAL OPERATION
S162
S163
IS THIS START OF UNUSED TIME?
NO
YES
S164
IN-REF. TEMP. IS EQUAL TO LOWER THAN STANDARD TEMP. E?
NO
YES
POWER-SAVING OPERATION
S165
S166
IS THIS PREDETERMINED TIME BEFORE END OF UNUSED TIME?
NO
YES
NORMAL OPERATION
S172
S173
IS THIS END OF HEAT LOAD LARGE TIME?
NO
YES
S174
IN-REF. TEMP. IS EQUAL TO LOWER THAN STANDARD TEMP. E?
NO
YES
POWER-SAVING OPERATION
S175
S176
IS THIS PREDETERMINED TIME BEFORE START OF HEAT LOAD LARGE TIME?
NO
YES

FIG. 20

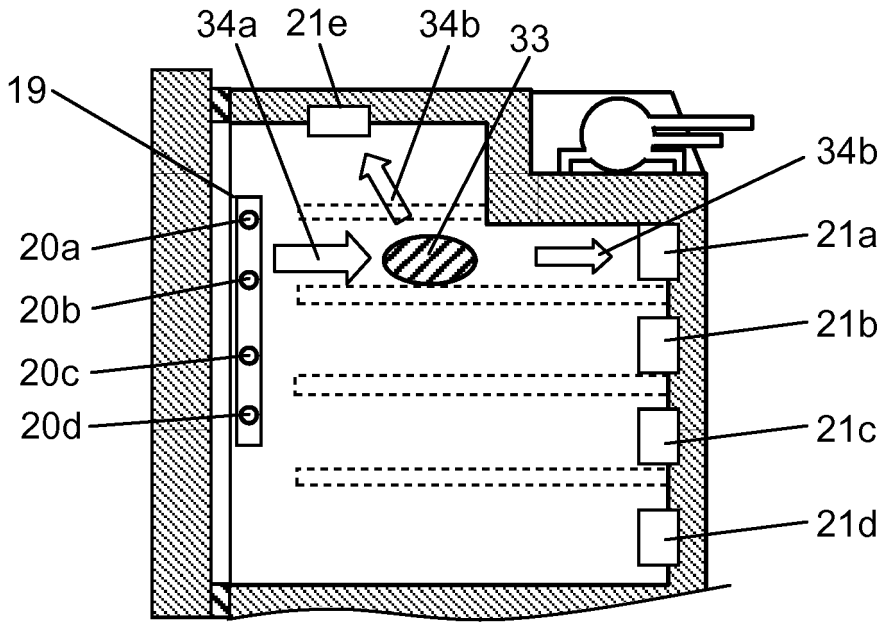


FIG. 21

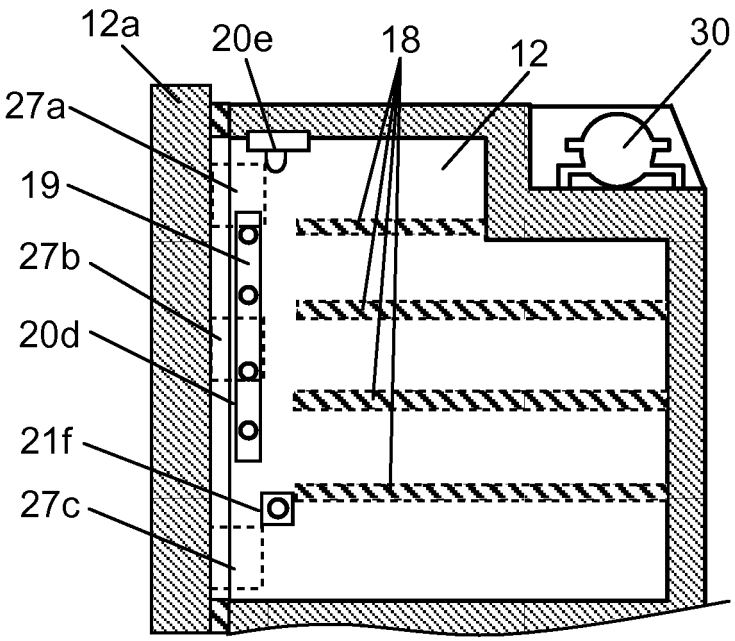


FIG. 22

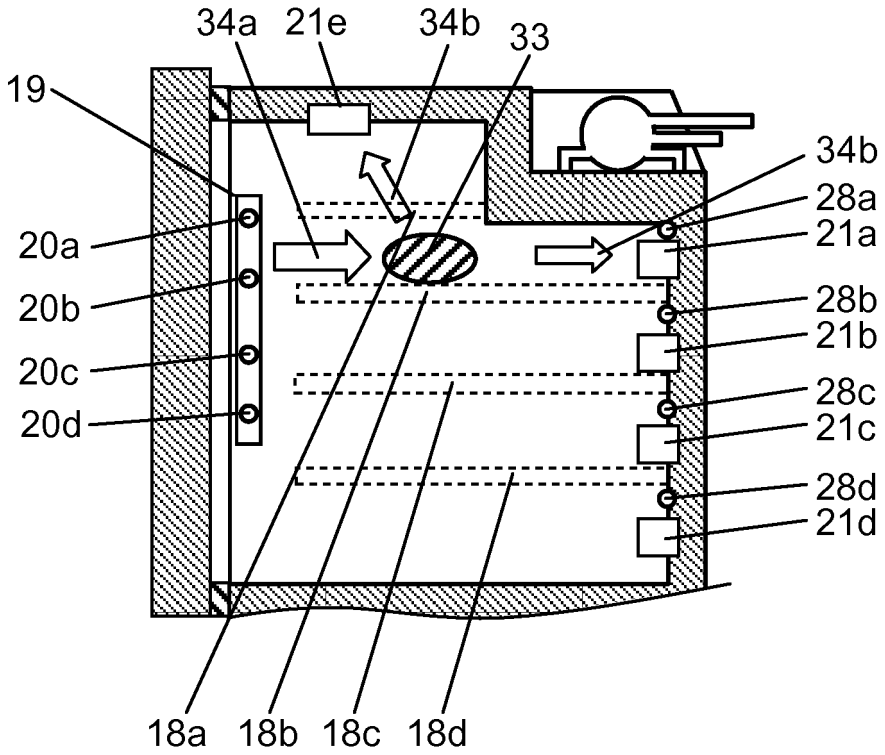

34a
21e
34b
33
19
34b
28a
21a
20a
20b
28b
21b
20c
28c
21c
20d
28d
21d
18a
18b
18c
18d

FIG. 23

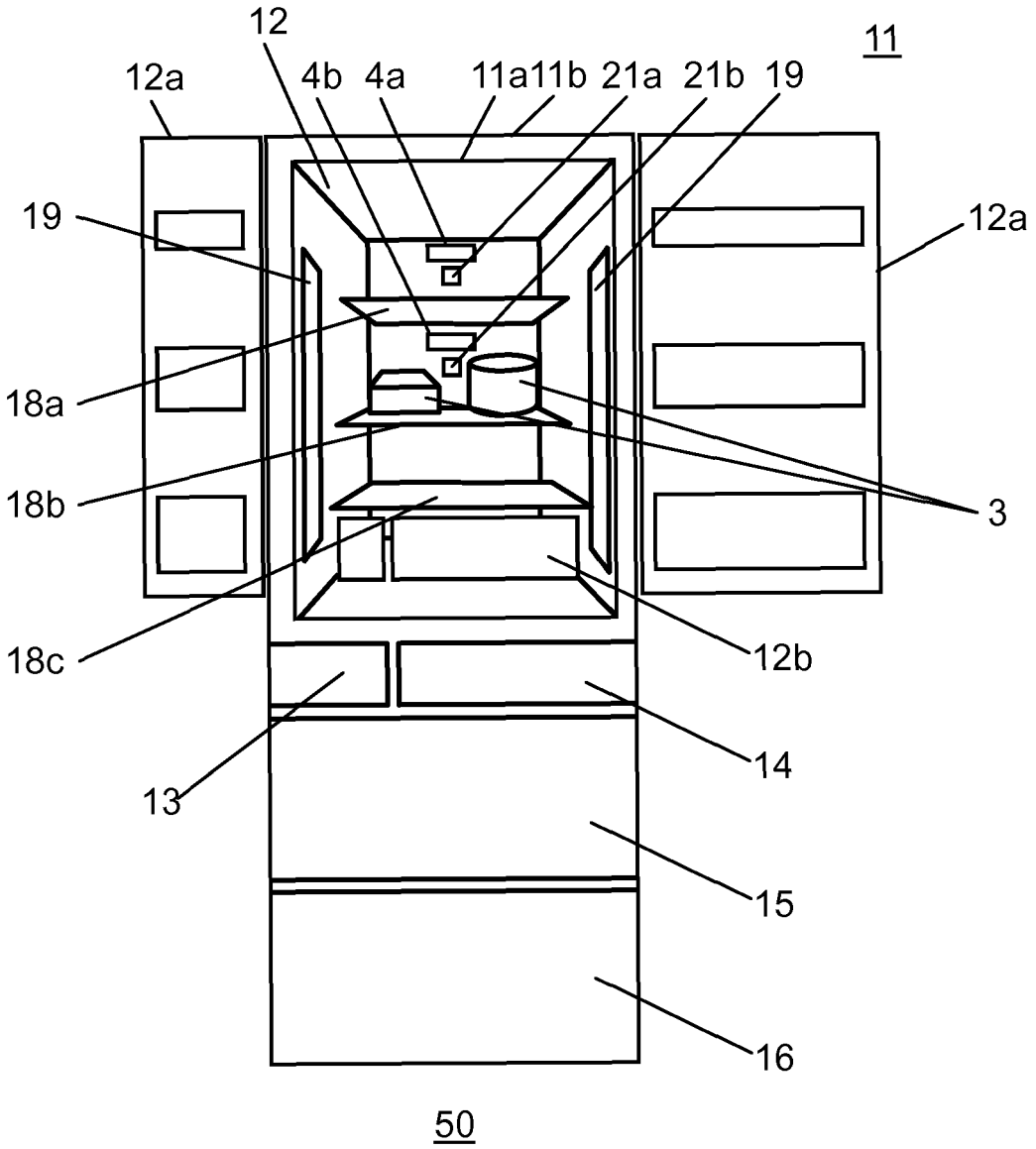

12
11
12a
4b
4a
11a
11b
21a
21b
19
19
12a
18a
18b
3
18c
12b
14
13
15
16
50

FIG. 24

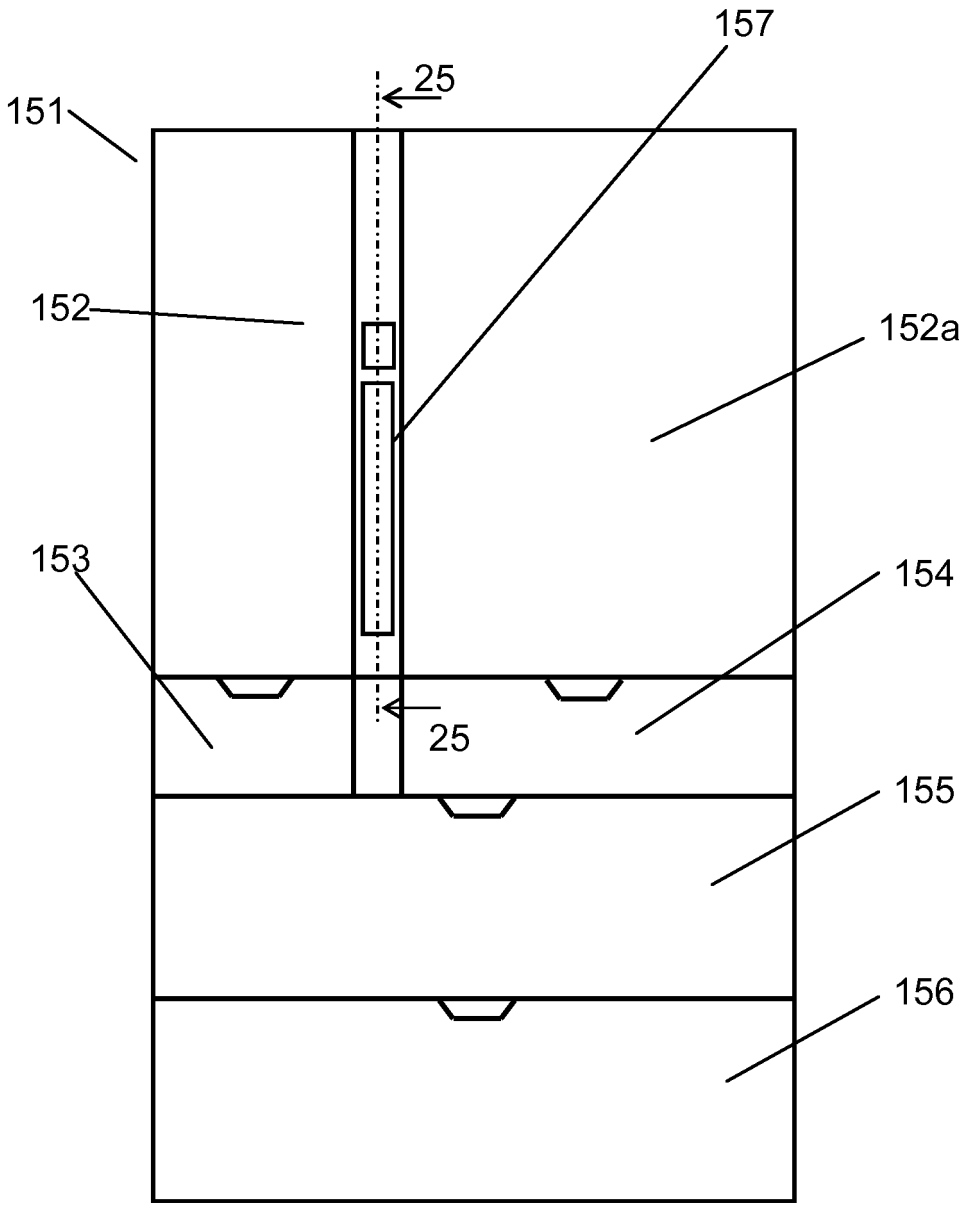


FIG. 25

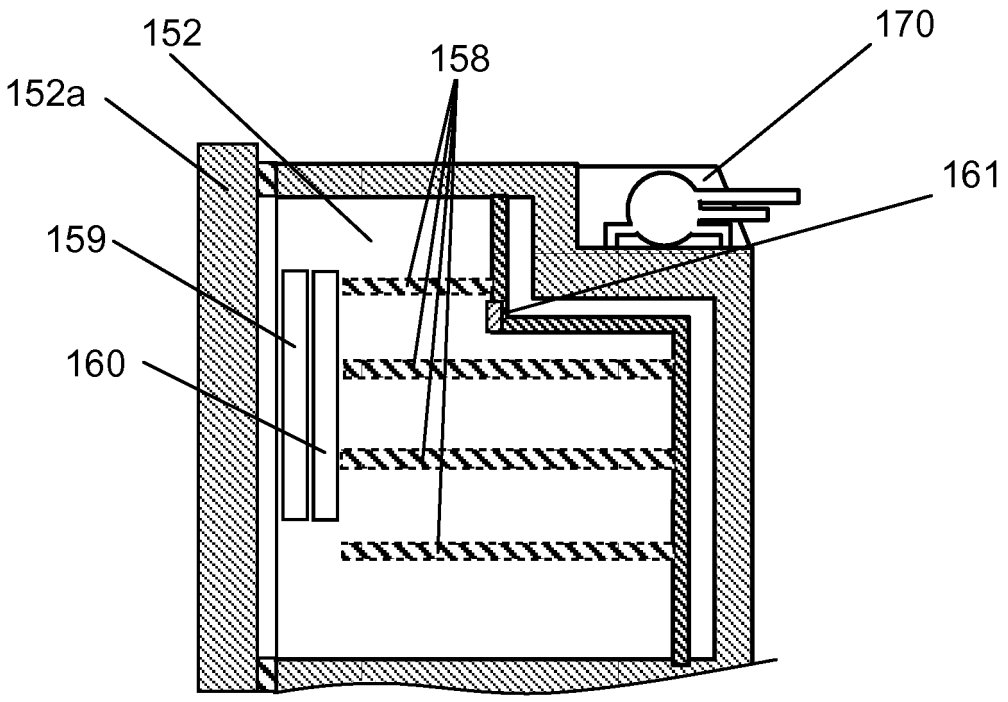


FIG. 26

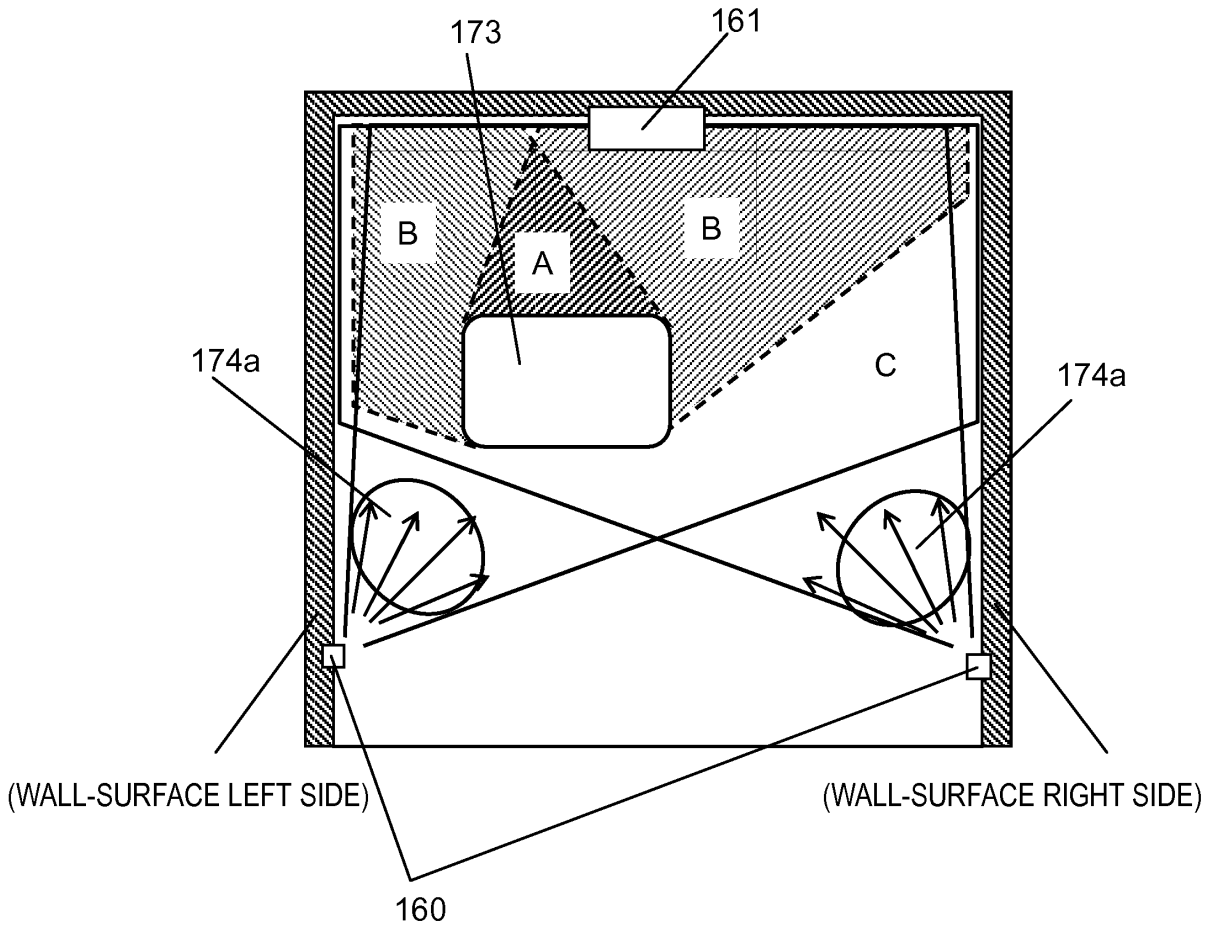

173
161
B
A
B
C
174a
174a
(WALL-SURFACE LEFT SIDE)
(WALL-SURFACE RIGHT SIDE)
160

FIG. 27

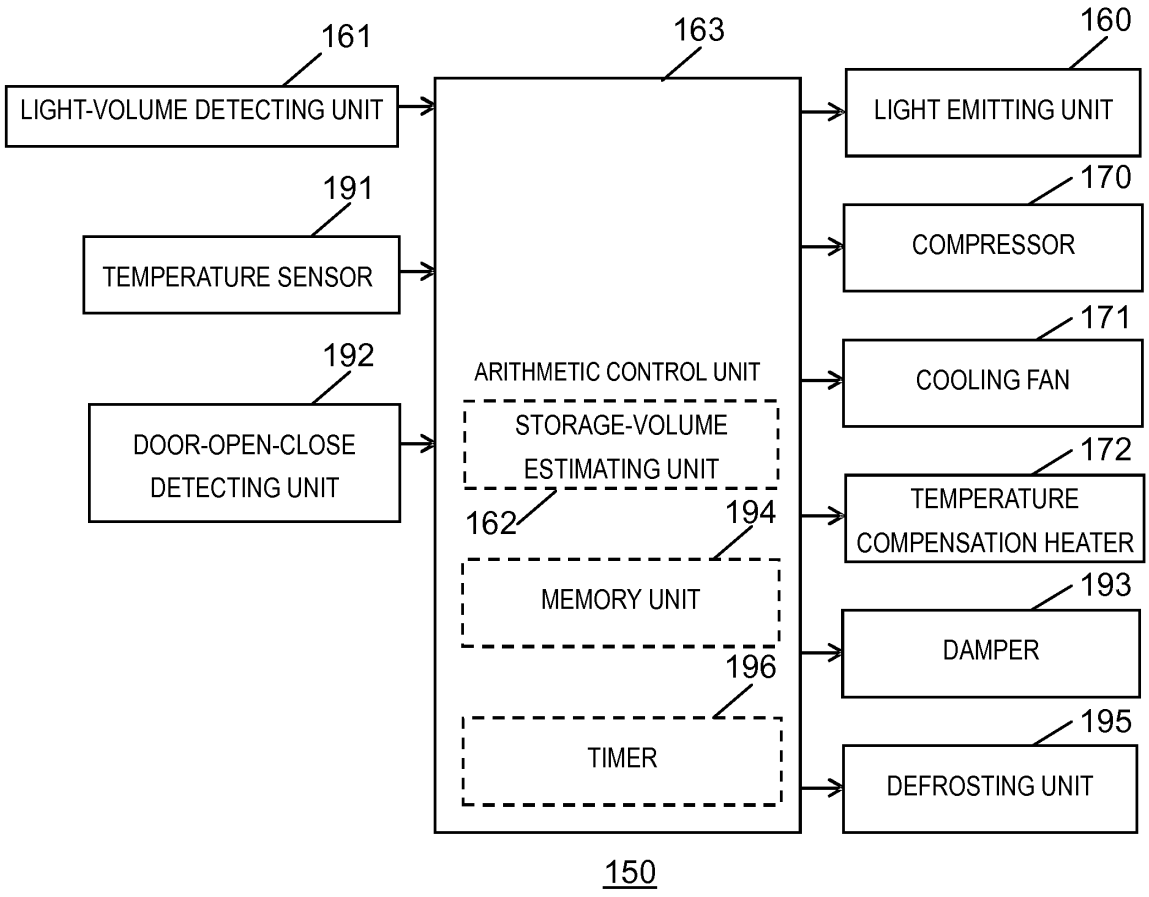

161
LIGHT-VOLUME DETECTING UNIT
191
TEMPERATURE SENSOR
192
DOOR-OPEN-CLOSE DETECTING UNIT
163
ARITHMETIC CONTROL UNIT
STORAGE-VOLUME ESTIMATING UNIT
162
194
MEMORY UNIT
196
TIMER
150
160
LIGHT EMITTING UNIT
170
COMPRESSOR
171
COOLING FAN
172
TEMPERATURE COMPENSATION HEATER
193
DAMPER
195
DEFROSTING UNIT

FIG. 28A

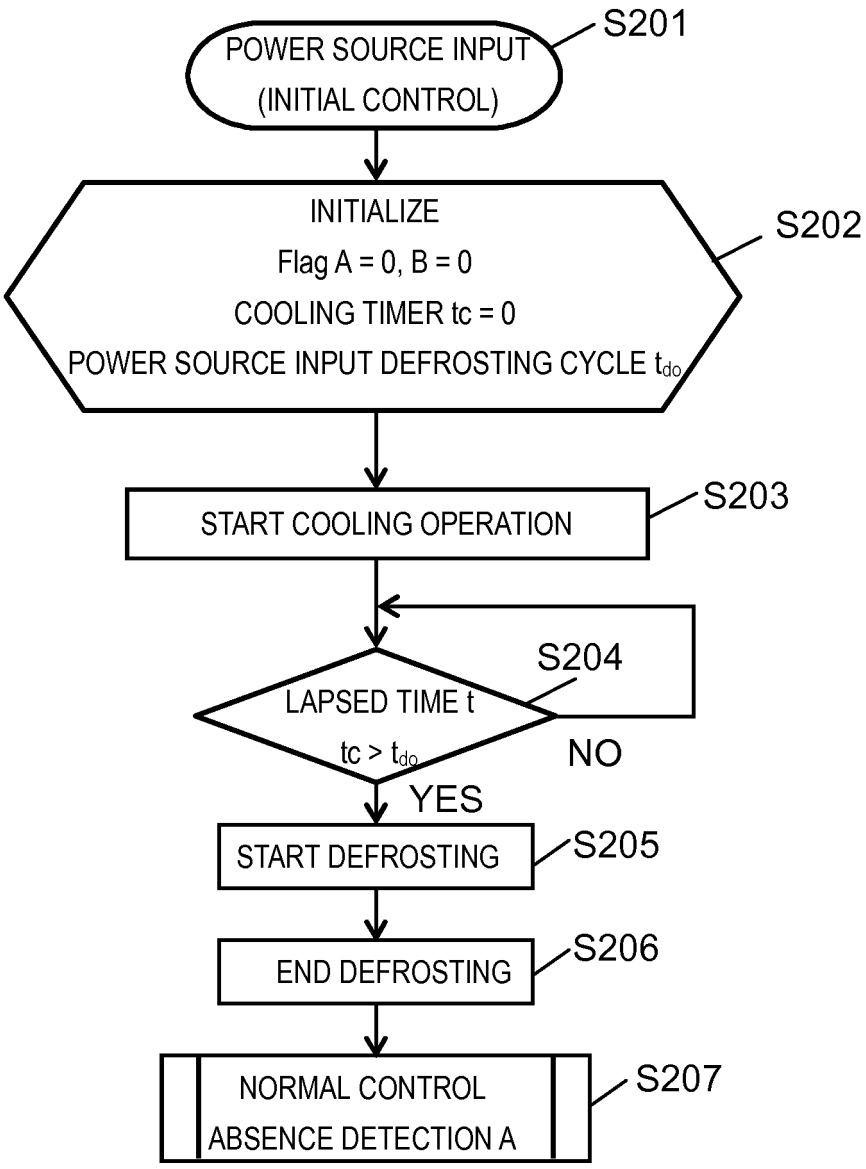

S201
POWER SOURCE INPUT
(INITIAL CONTROL)
S202
INITIALIZE
Flag A = 0, B = 0
COOLING TIMER tc = 0
POWER SOURCE INPUT DEFROSTING CYCLE t_{do}
S203
START COOLING OPERATION
S204
LAPSED TIME t
$tc > t_{do}$
NO
YES
S205
START DEFROSTING
S206
END DEFROSTING
S207
NORMAL CONTROL
ABSENCE DETECTION A

FIG. 28B

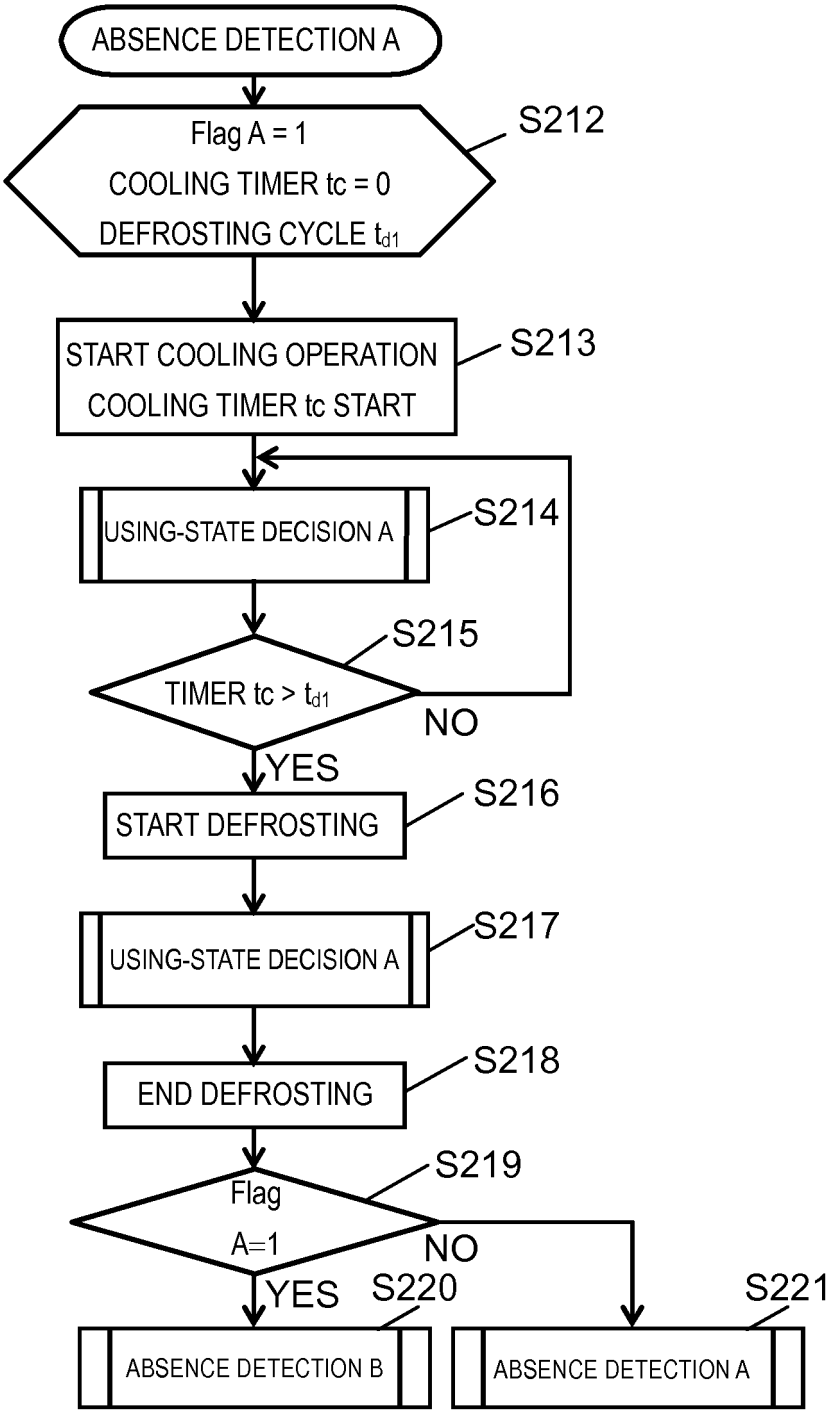

ABSENCE DETECTION A
Flag A = 1
COOLING TIMER tc = 0
DEFROSTING CYCLE t_{d1}
S212
START COOLING OPERATION
COOLING TIMER tc START
S213
USING-STATE DECISION A
S214
TIMER tc > t_{d1}
S215
NO
YES
START DEFROSTING
S216
USING-STATE DECISION A
S217
END DEFROSTING
S218
Flag
A=1
S219
NO
YES
S220
S221
ABSENCE DETECTION B
ABSENCE DETECTION A

FIG. 28C

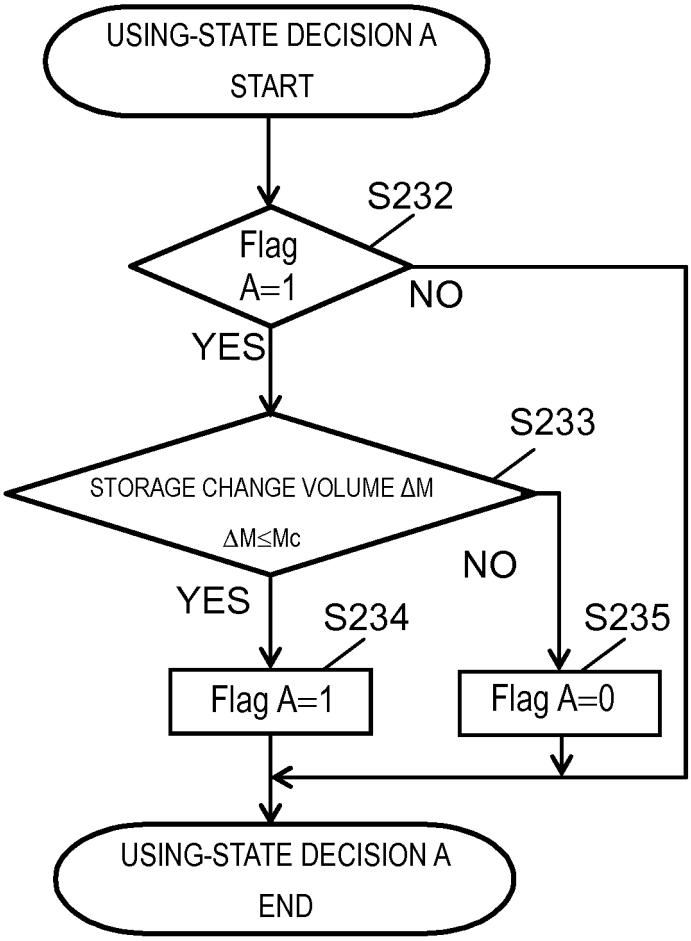

USING-STATE DECISION A START
S232
Flag A=1
NO
YES
S233
STORAGE CHANGE VOLUME ΔM
ΔM≤Mc
NO
YES
S234
S235
Flag A=1
Flag A=0
USING-STATE DECISION A END

FIG. 28D

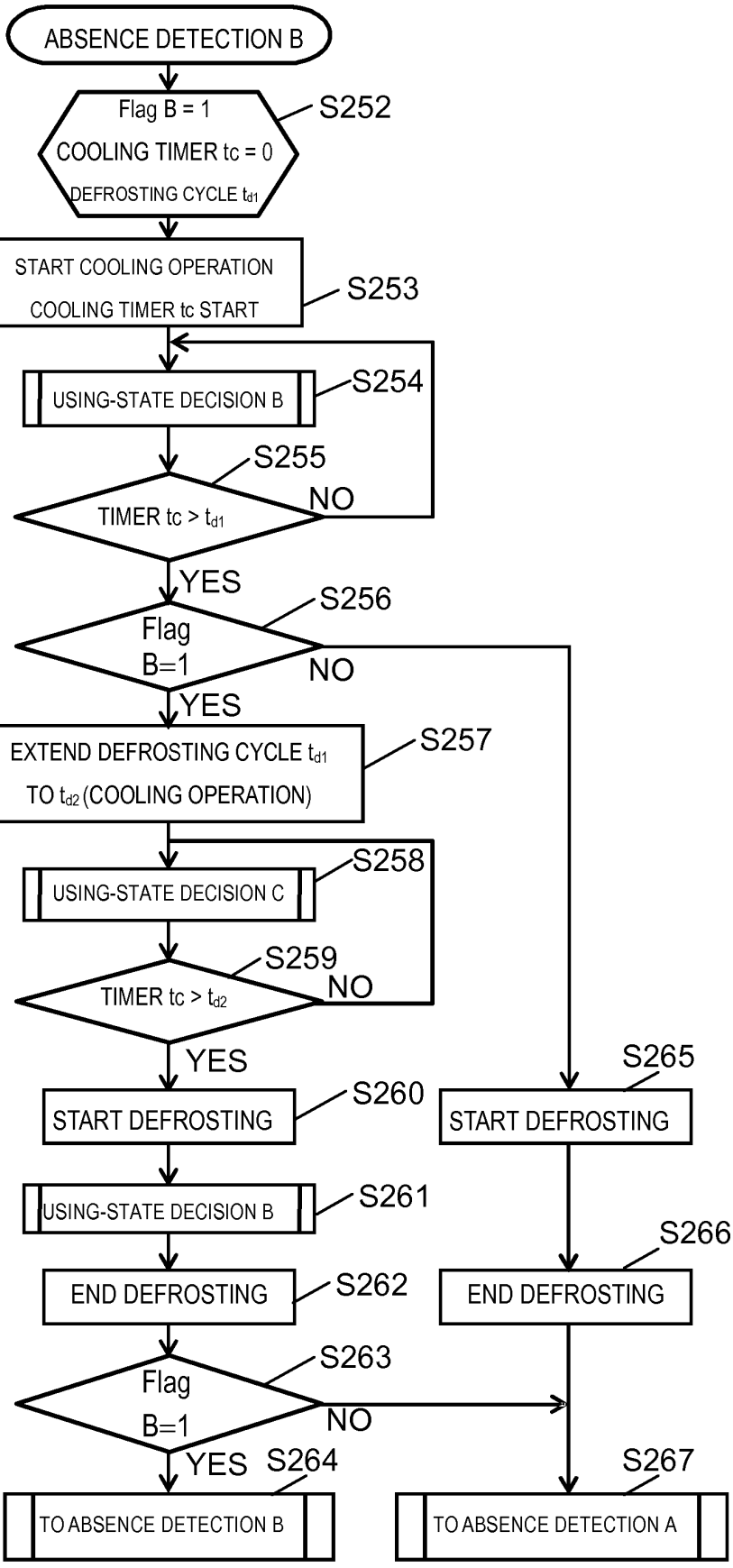

ABSENCE DETECTION B
Flag B = 1
COOLING TIMER tc = 0
DEFROSTING CYCLE t_{d1}
S252
START COOLING OPERATION
COOLING TIMER tc START
S253
USING-STATE DECISION B
S254
S255
TIMER tc > t_{d1}
NO
YES
S256
Flag B=1
NO
YES
EXTEND DEFROSTING CYCLE t_{d1} TO t_{d2} (COOLING OPERATION)
S257
USING-STATE DECISION C
S258
S259
TIMER tc > t_{d2}
NO
YES
START DEFROSTING
S260
S265
START DEFROSTING
USING-STATE DECISION B
S261
S266
END DEFROSTING
S262
END DEFROSTING
S263
Flag B=1
NO
YES
S264
S267
TO ABSENCE DETECTION B
TO ABSENCE DETECTION A

FIG. 28E

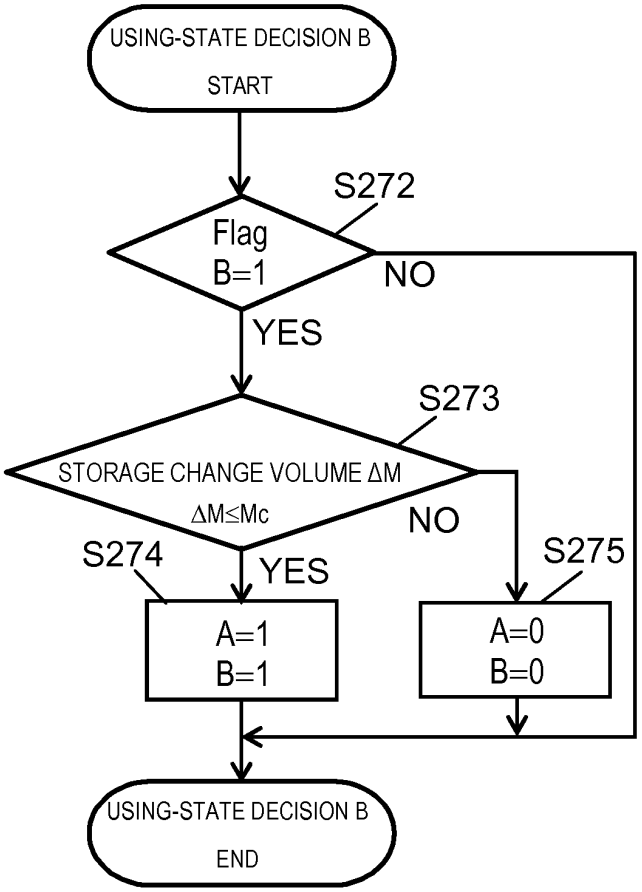


FIG. 28F

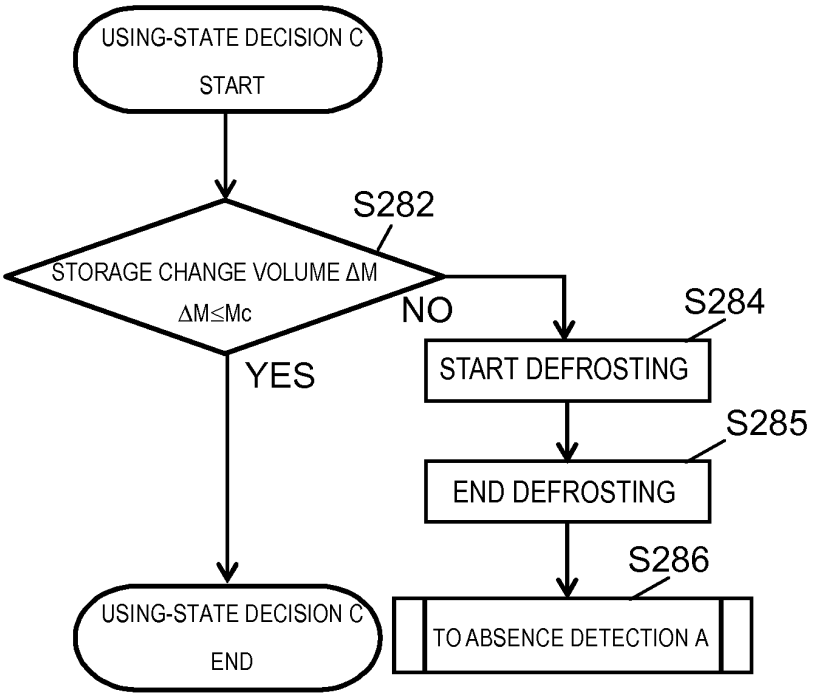


FIG. 28G

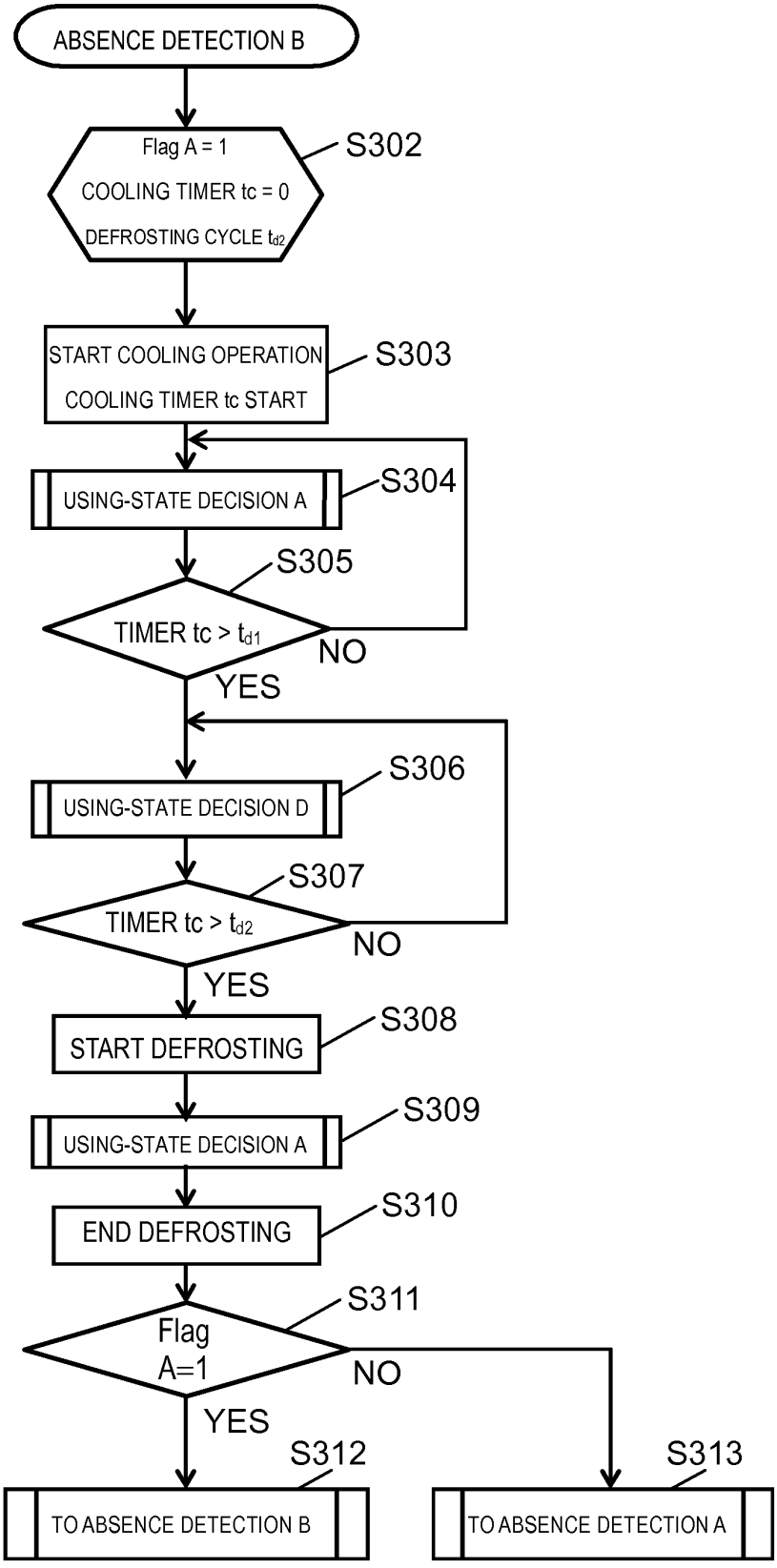

ABSENCE DETECTION B
Flag A = 1
COOLING TIMER tc = 0
DEFROSTING CYCLE t_{d2}
S302
START COOLING OPERATION
COOLING TIMER tc START
S303
USING-STATE DECISION A
S304
S305
TIMER tc > t_{d1}
NO
YES
USING-STATE DECISION D
S306
S307
TIMER tc > t_{d2}
NO
YES
START DEFROSTING
S308
USING-STATE DECISION A
S309
END DEFROSTING
S310
S311
Flag A=1
NO
YES
S312
S313
TO ABSENCE DETECTION B
TO ABSENCE DETECTION A

FIG. 28H

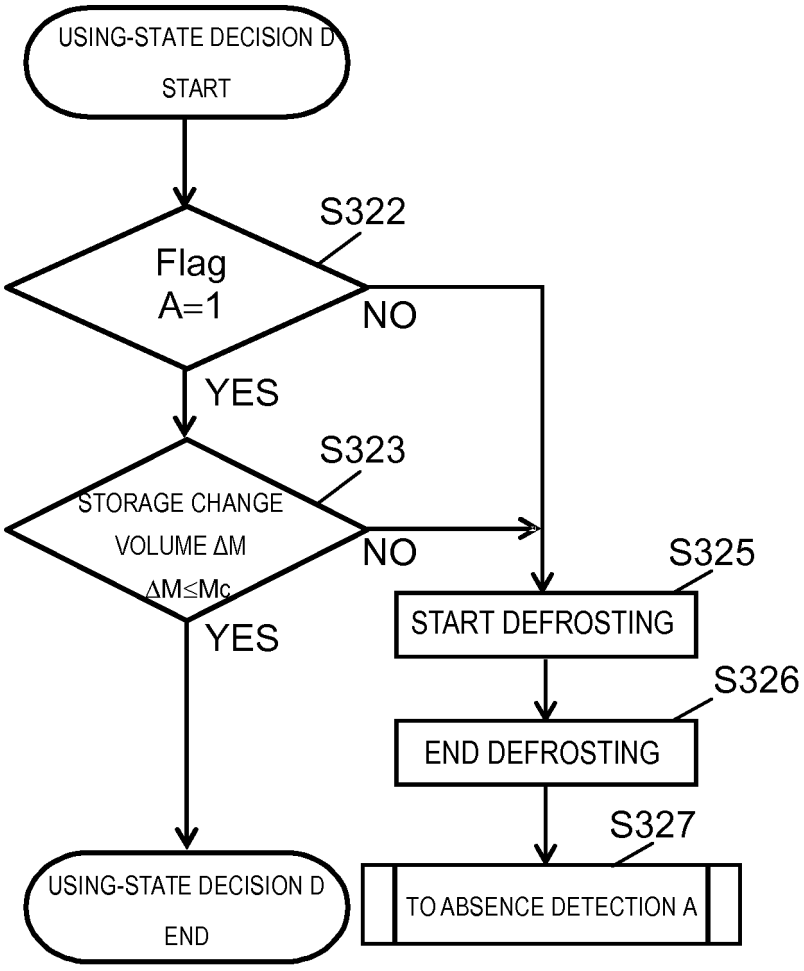

USING-STATE DECISION D START
S322
Flag A=1
NO
YES
S323
STORAGE CHANGE VOLUME ΔM
ΔM≤Mc
NO
YES
S325
START DEFROSTING
S326
END DEFROSTING
S327
TO ABSENCE DETECTION A
USING-STATE DECISION D END

FIG. 29A

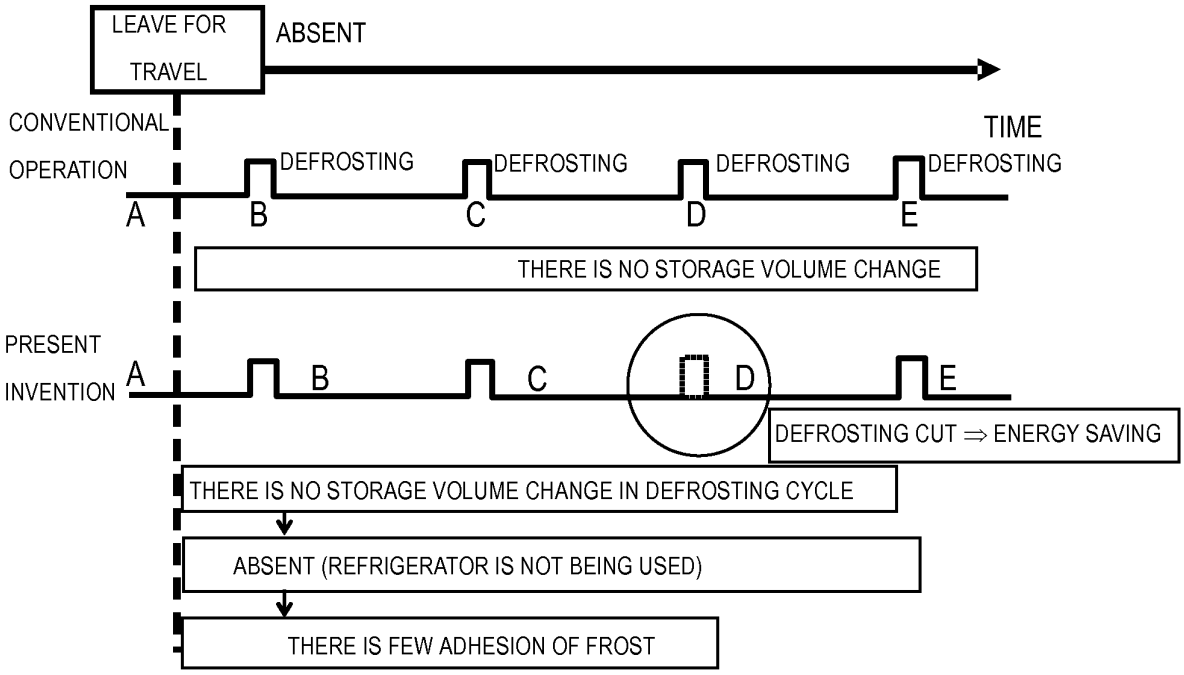


FIG. 29B

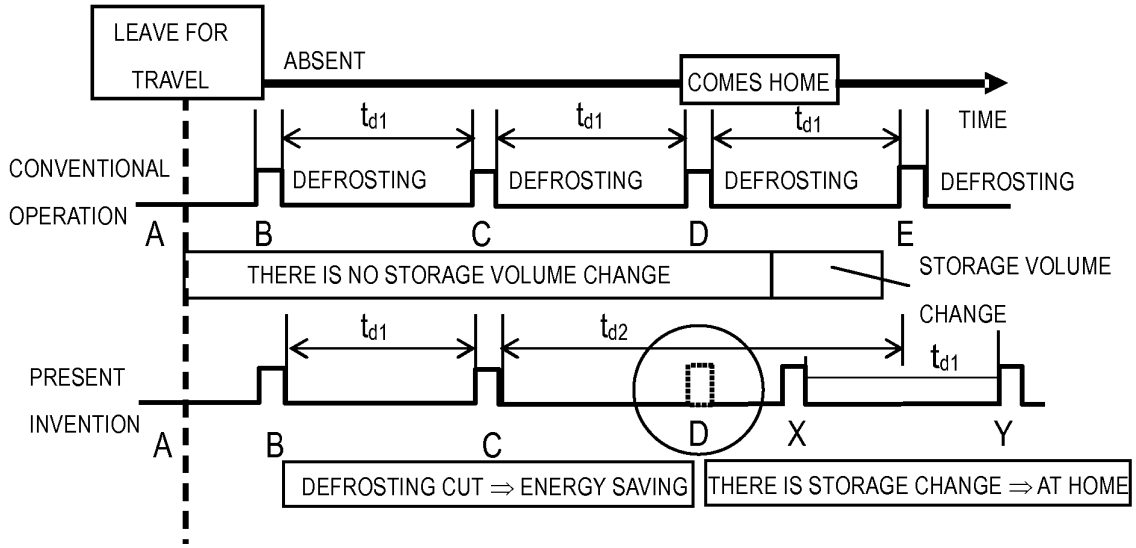


FIG. 29C

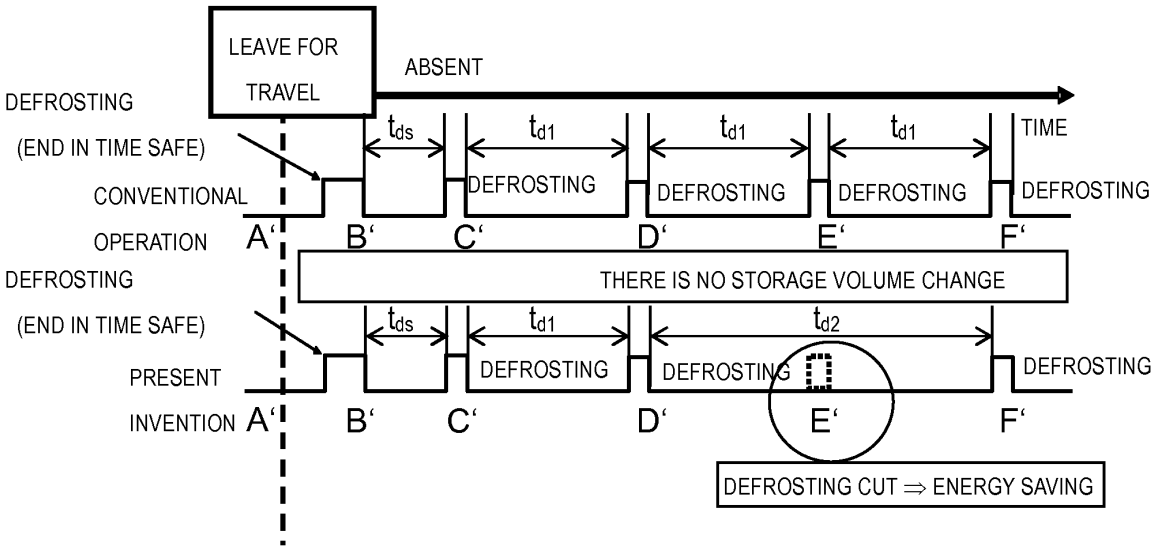


FIG. 29D

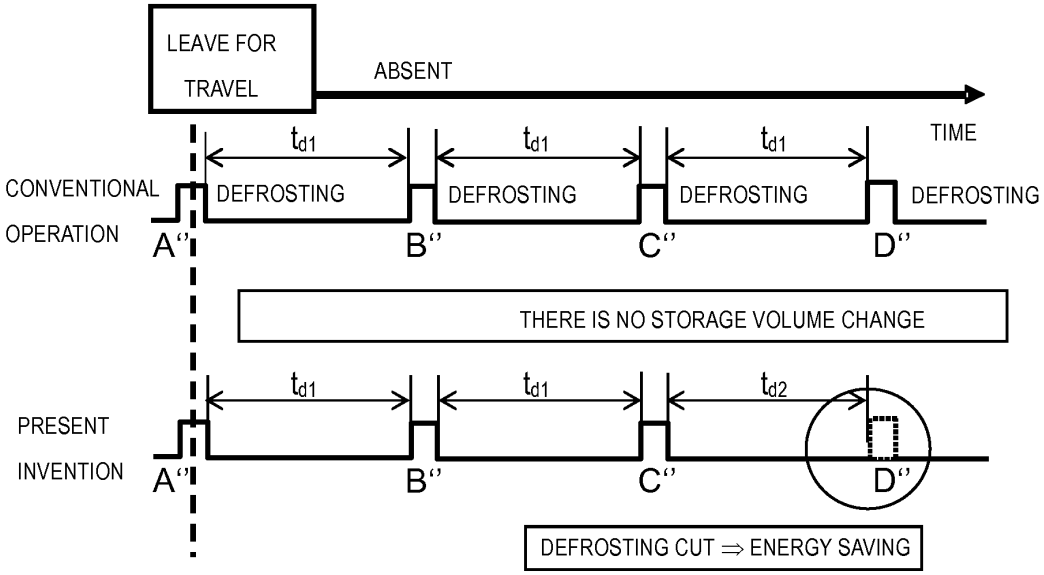


FIG. 30

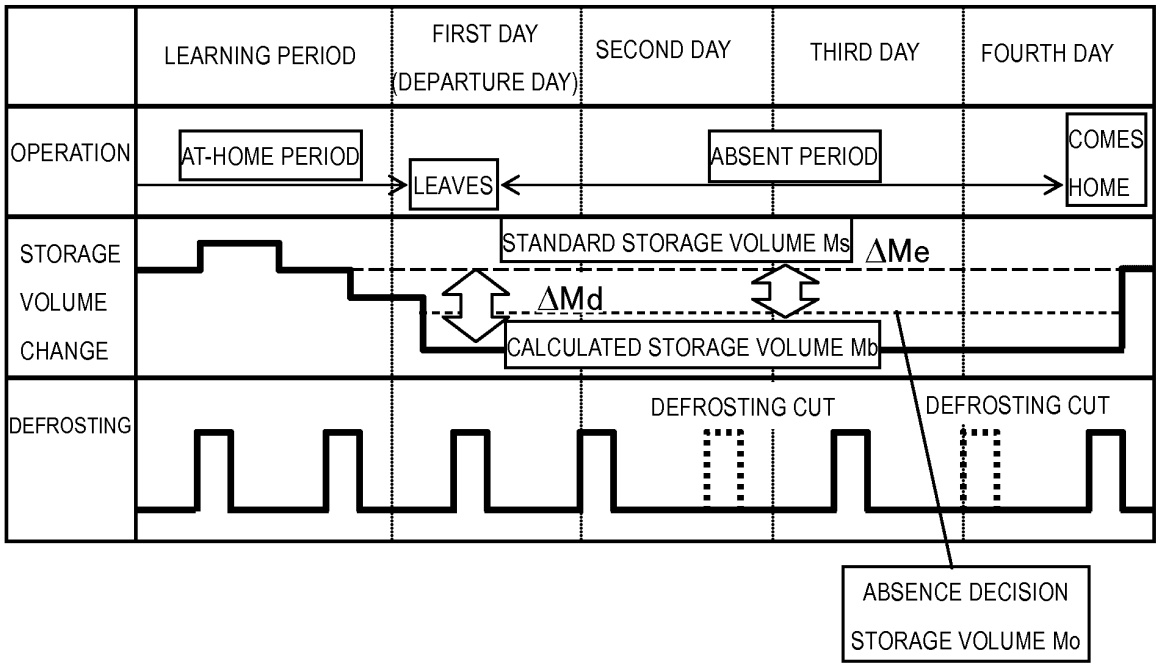

LEARNING PERIOD
FIRST DAY
(DEPARTURE DAY)
SECOND DAY
THIRD DAY
FOURTH DAY
OPERATION
AT-HOME PERIOD
LEAVES
ABSENT PERIOD
COMES HOME
STORAGE VOLUME CHANGE
STANDARD STORAGE VOLUME Ms
ΔMe
ΔMd
CALCULATED STORAGE VOLUME Mb
DEFROSTING
DEFROSTING CUT
DEFROSTING CUT
ABSENCE DECISION STORAGE VOLUME Mo

FIG. 31A

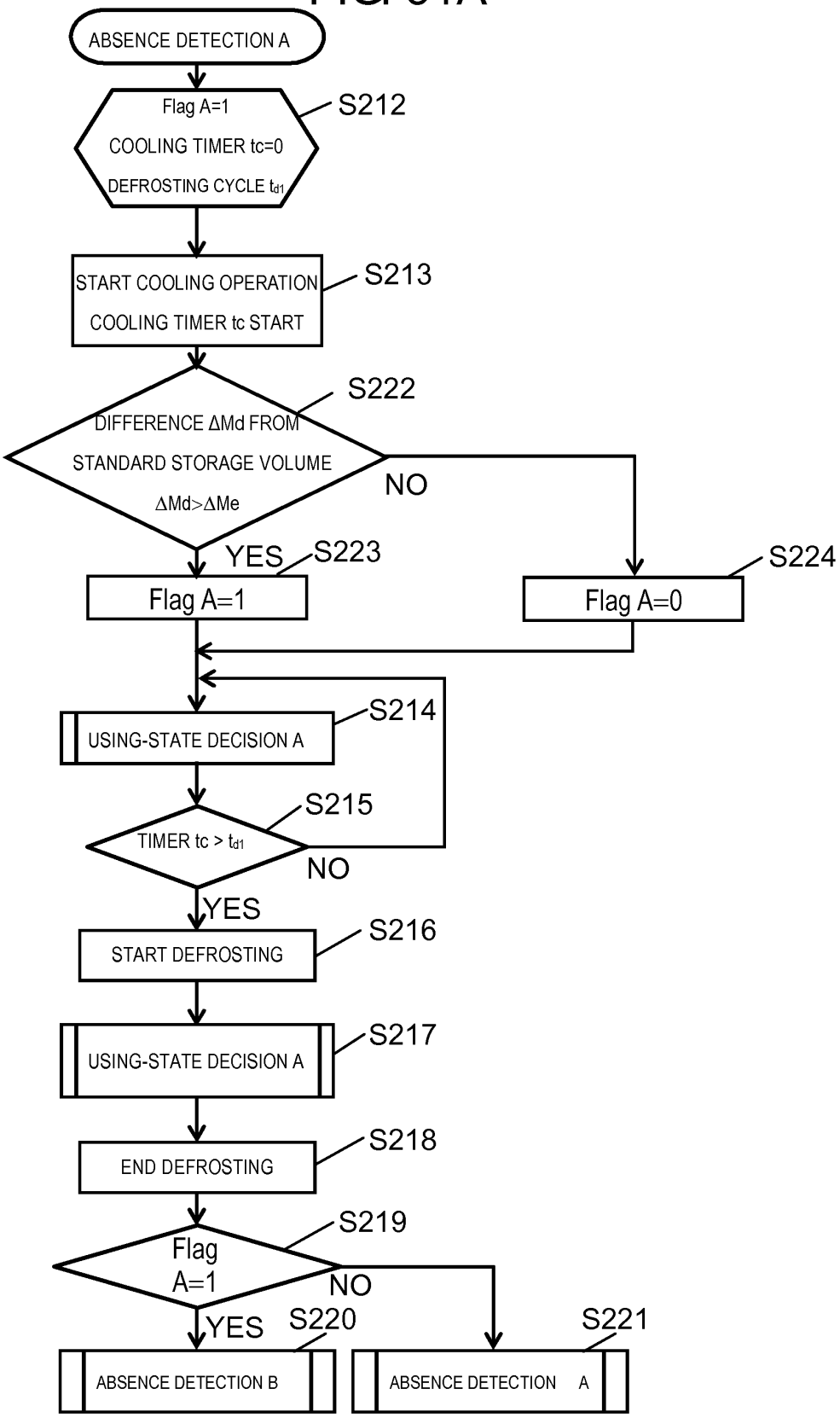

ABSENCE DETECTION A
Flag A=1
COOLING TIMER tc=0
DEFROSTING CYCLE t_{d1}
S212
START COOLING OPERATION
COOLING TIMER tc START
S213
DIFFERENCE ΔMd FROM
STANDARD STORAGE VOLUME
ΔMd>ΔMe
S222
NO
YES
S223
Flag A=1
Flag A=0
S224
USING-STATE DECISION A
S214
TIMER tc > t_{d1}
S215
NO
YES
START DEFROSTING
S216
USING-STATE DECISION A
S217
END DEFROSTING
S218
Flag
A=1
S219
NO
YES
S220
S221
ABSENCE DETECTION B
ABSENCE DETECTION A

FIG. 31B

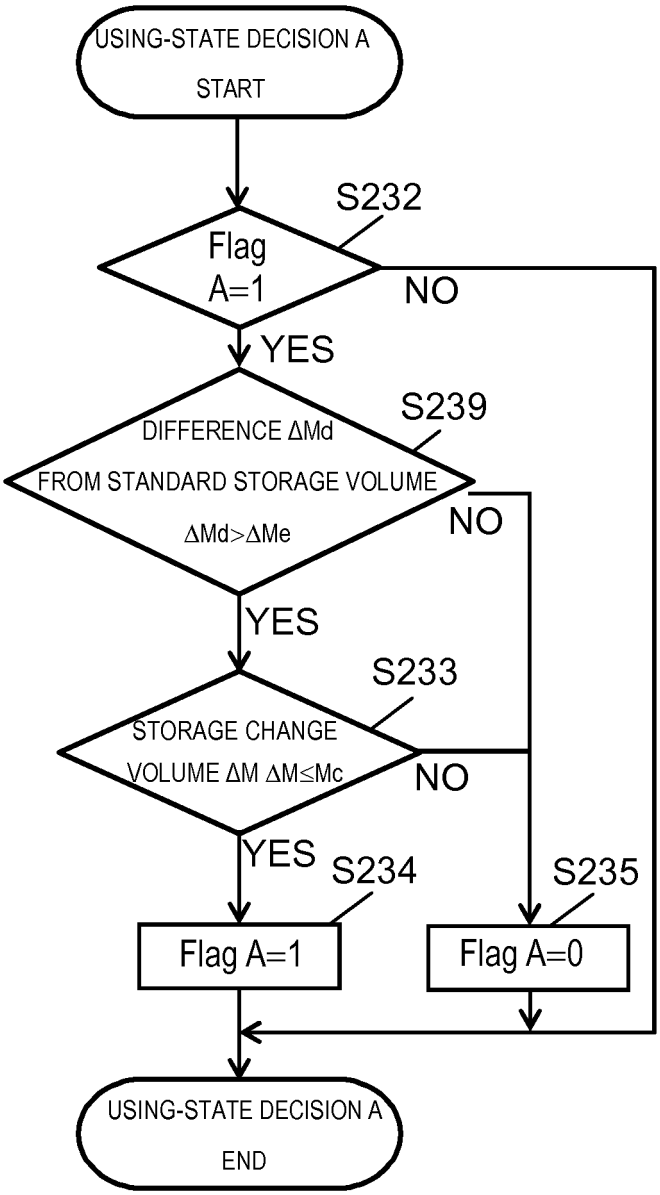

USING-STATE DECISION A START
S232
Flag A=1
NO
YES
S239
DIFFERENCE ΔMd FROM STANDARD STORAGE VOLUME
ΔMd>ΔMe
NO
YES
S233
STORAGE CHANGE VOLUME ΔM ΔM≤Mc
NO
YES
S234
S235
Flag A=1
Flag A=0
USING-STATE DECISION A END

FIG. 32A

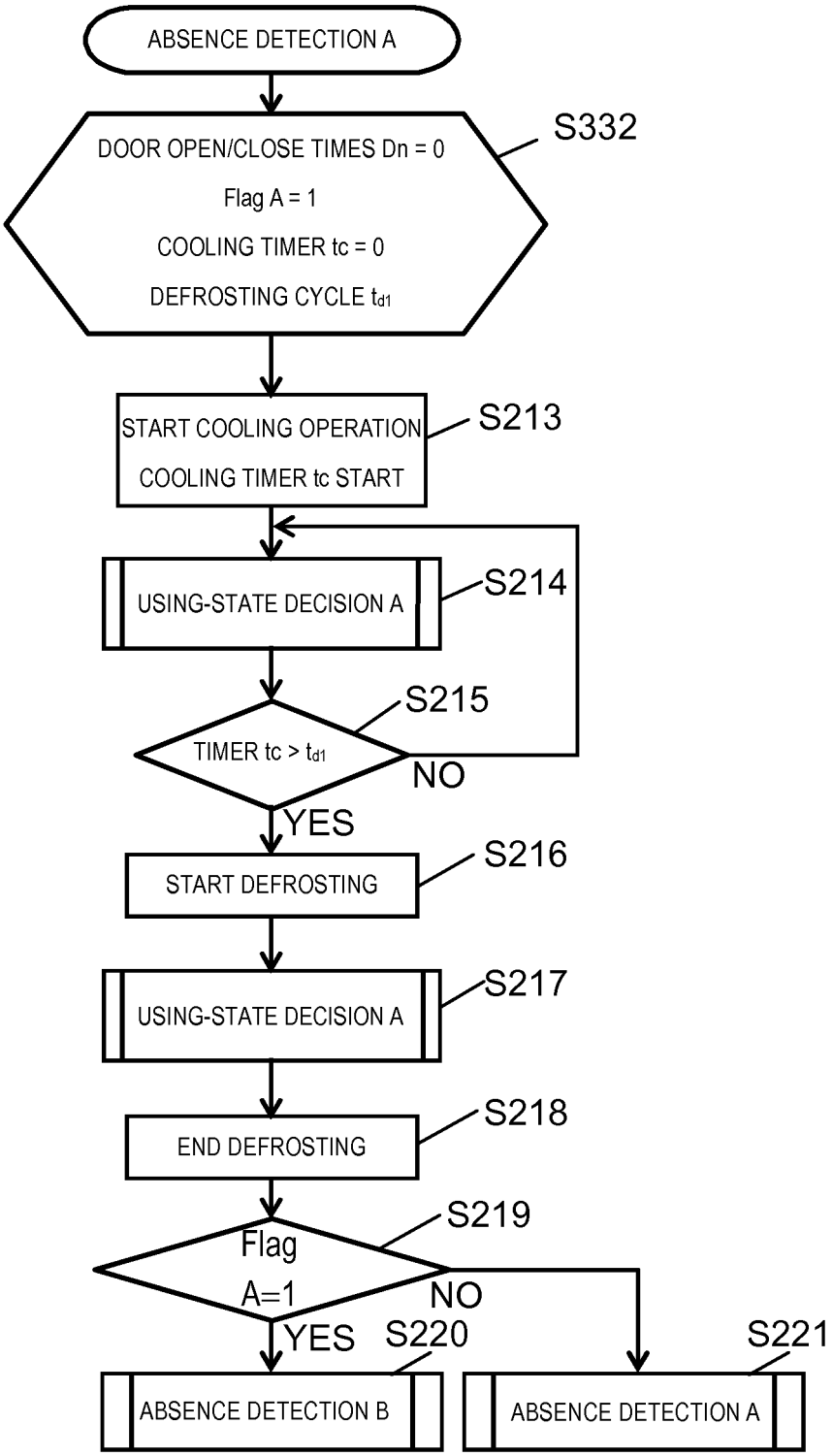

ABSENCE DETECTION A
S332
DOOR OPEN/CLOSE TIMES Dn = 0
Flag A = 1
COOLING TIMER tc = 0
DEFROSTING CYCLE t_{d1}
START COOLING OPERATION
COOLING TIMER tc START
S213
USING-STATE DECISION A
S214
S215
TIMER tc > t_{d1}
NO
YES
START DEFROSTING
S216
USING-STATE DECISION A
S217
END DEFROSTING
S218
S219
Flag
A=1
NO
YES
S220
S221
ABSENCE DETECTION B
ABSENCE DETECTION A

FIG. 32B

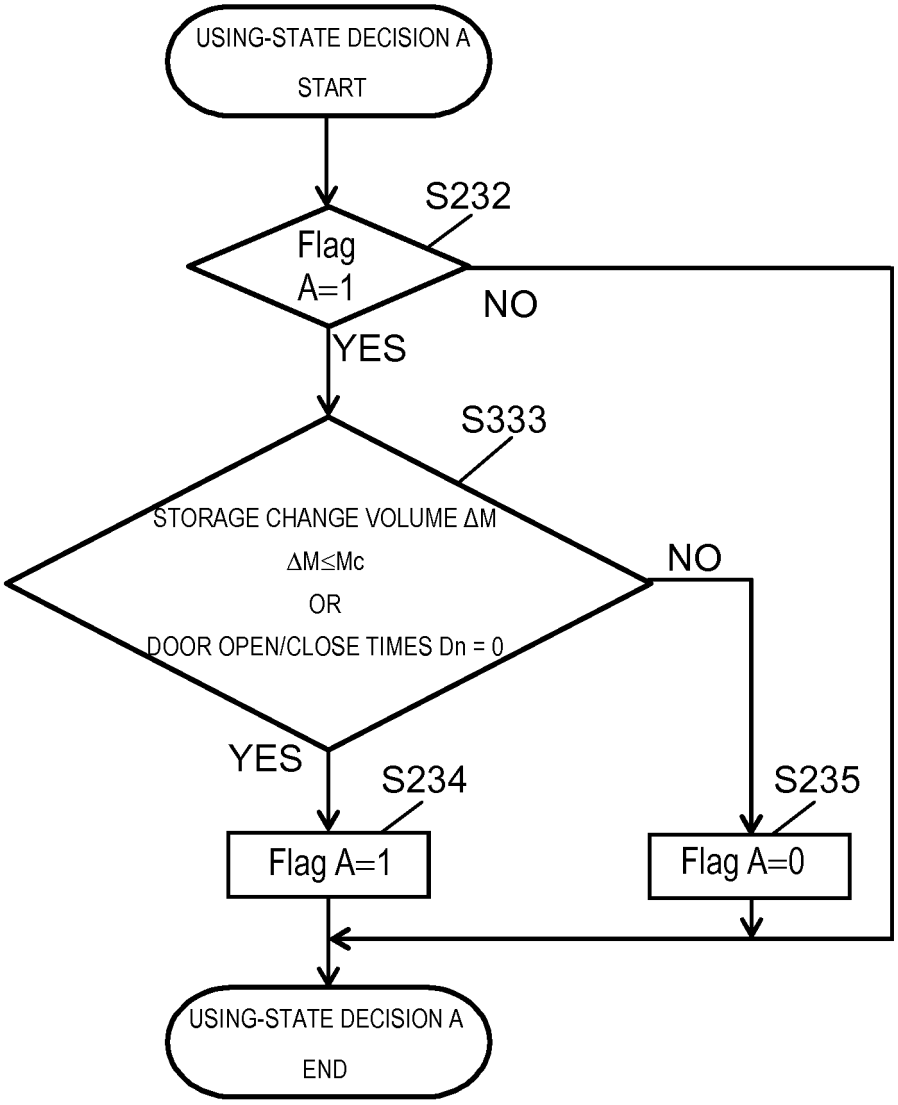

USING-STATE DECISION A
START
S232
Flag
A=1
NO
YES
S333
STORAGE CHANGE VOLUME ΔM
ΔM≤Mc
OR
DOOR OPEN/CLOSE TIMES Dn = 0
NO
YES
S234
S235
Flag A=1
Flag A=0
USING-STATE DECISION A
END

FIG. 33A

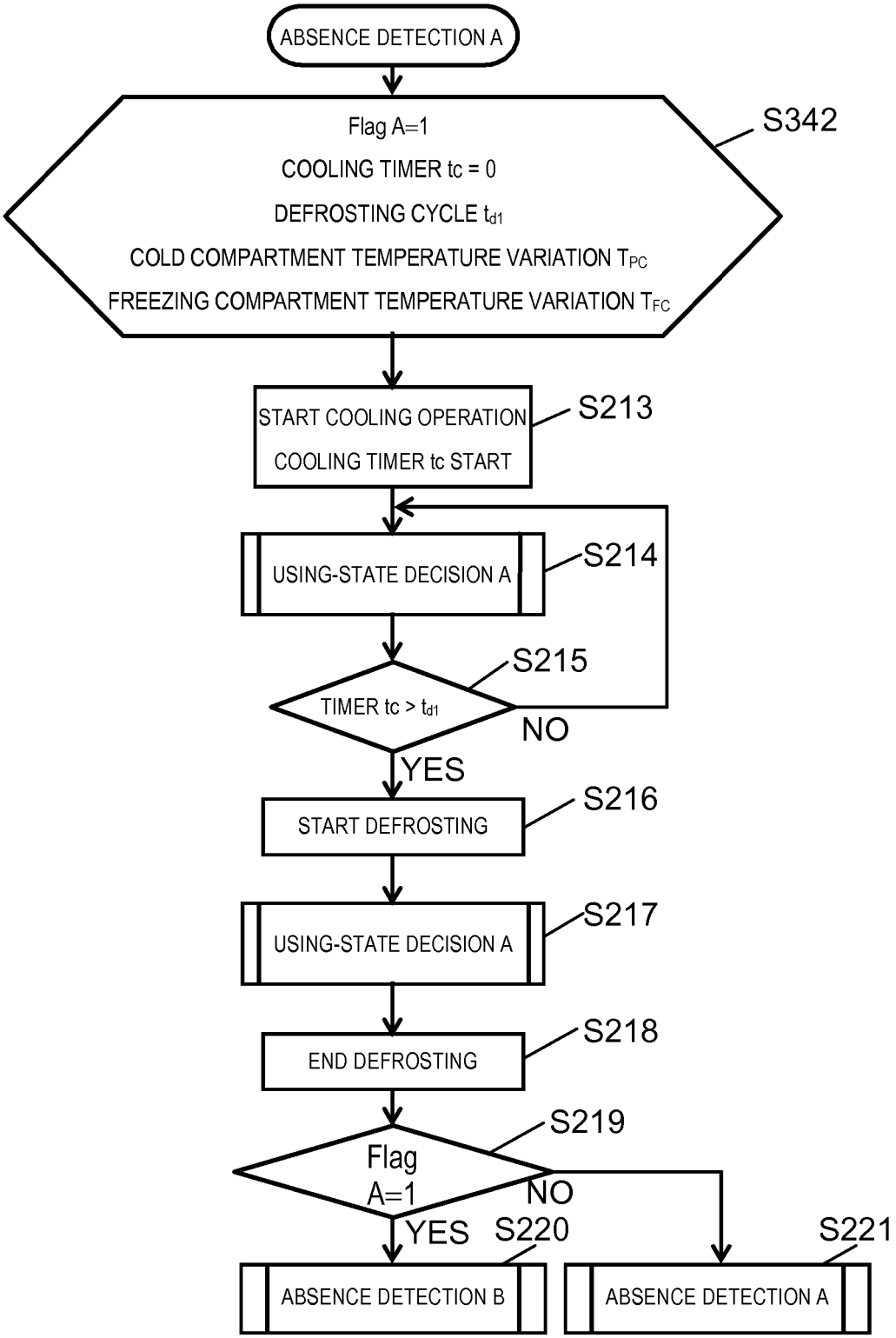

ABSENCE DETECTION A
Flag A=1
COOLING TIMER tc = 0
DEFROSTING CYCLE t_{d1}
COLD COMPARTMENT TEMPERATURE VARIATION T_{PC}
FREEZING COMPARTMENT TEMPERATURE VARIATION T_{FC}
S342
START COOLING OPERATION
COOLING TIMER tc START
S213
USING-STATE DECISION A
S214
TIMER tc > t_{d1}
S215
NO
YES
START DEFROSTING
S216
USING-STATE DECISION A
S217
END DEFROSTING
S218
Flag A=1
S219
NO
YES
S220
S221
ABSENCE DETECTION B
ABSENCE DETECTION A

FIG. 33B

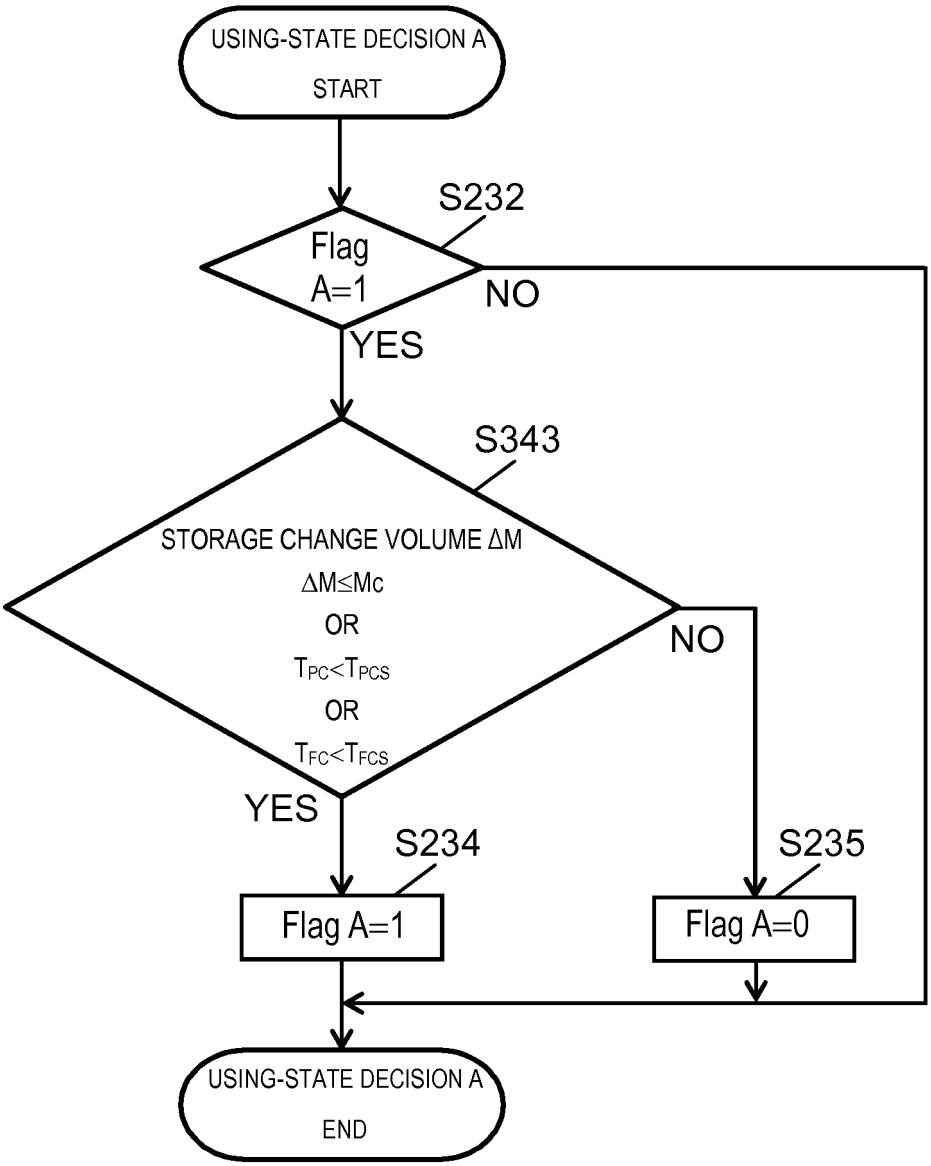

USING-STATE DECISION A START
S232
Flag A=1
NO
YES
S343
STORAGE CHANGE VOLUME ΔM
ΔM≤Mc
OR
TPC<TPCS
OR
TFC<TFCS
NO
YES
S234
S235
Flag A=1
Flag A=0
USING-STATE DECISION A END

FIG. 34

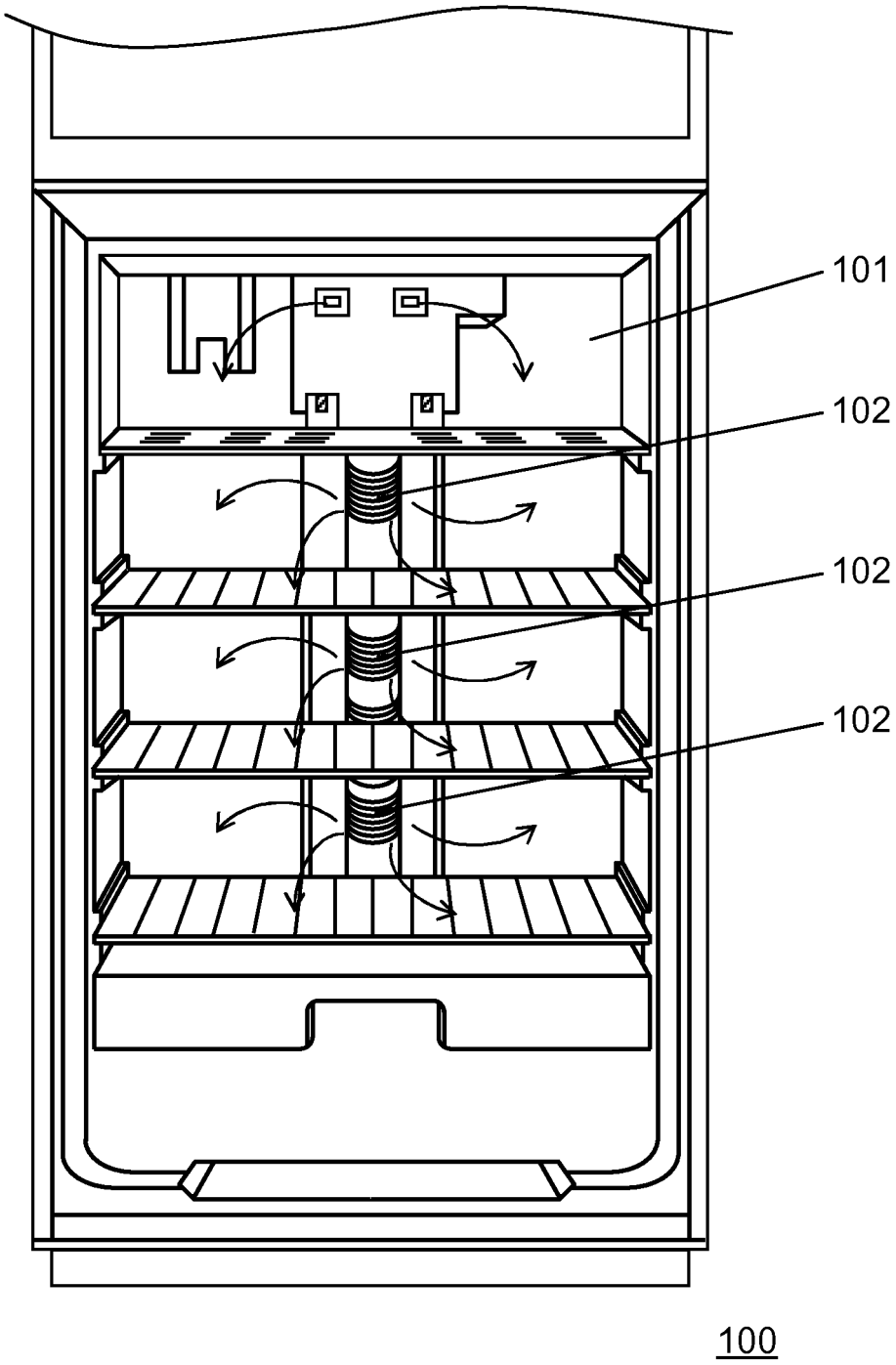
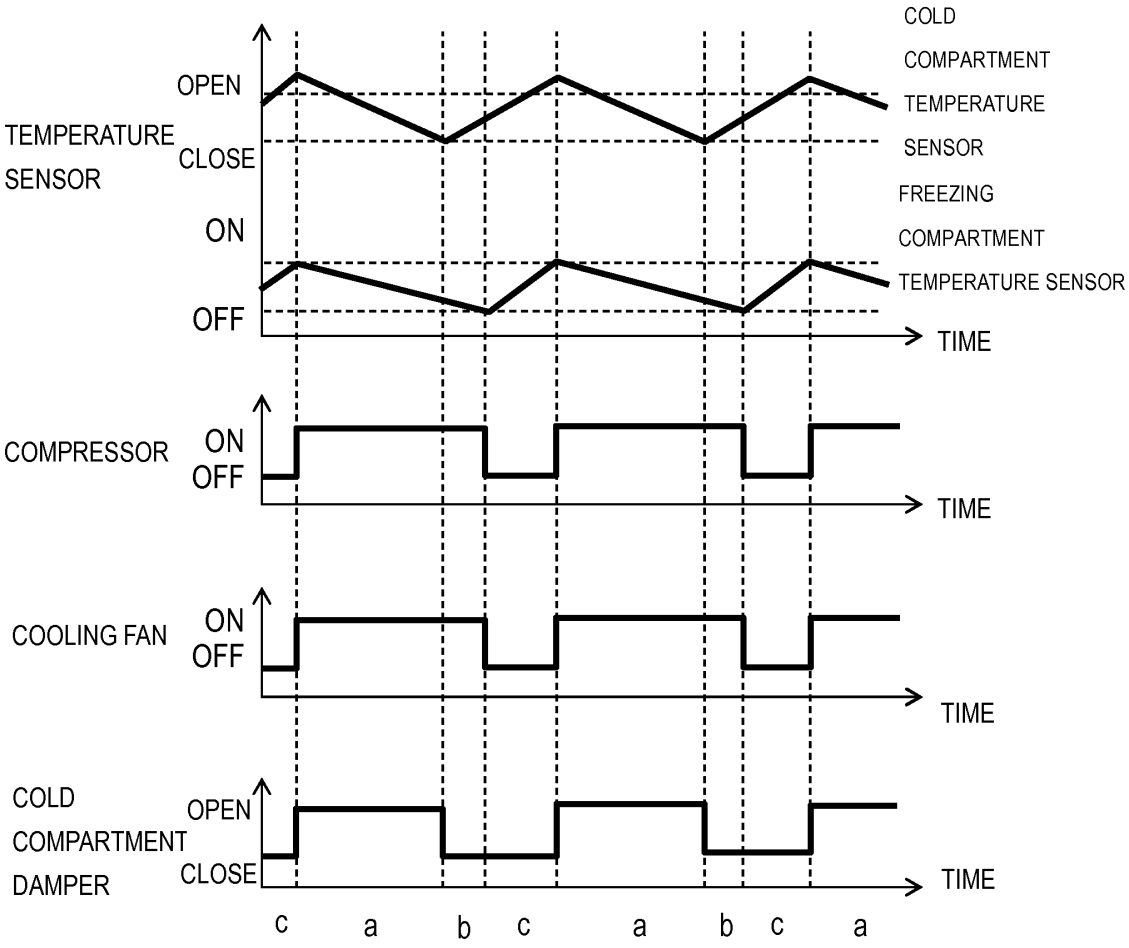


FIG. 35


COLD
COMPARTMENT
TEMPERATURE
SENSOR
FREEZING
COMPARTMENT
TEMPERATURE SENSOR
TEMPERATURE
SENSOR
OPEN
CLOSE
ON
OFF
TIME
COMPRESSOR
ON
OFF
TIME
COOLING FAN
ON
OFF
TIME
COLD
COMPARTMENT
DAMPER
OPEN
CLOSE
TIME
c a b c a b c a

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/002997

A. CLASSIFICATION OF SUBJECT MATTER
F25D11/00(2006.01)i, *F25D23/00*(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

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.
Y	JP 2011-43263 A (Mitsubishi Electric Corp.), 03 March 2011 (03.03.2011), paragraphs [0012] to [0020]; fig. 1 to 7 (Family: none)	1-5
Y	JP 2007-46833 A (Funai Electric Co., Ltd.), 22 February 2007 (22.02.2007), paragraphs [0026], [0037], [0052] to [0053] (Family: none)	1-5
A	JP 8-303922 A (Matsushita Refrigeration Co.), 22 November 1996 (22.11.1996), paragraphs [0022] to [0025]; fig. 1 to 4 (Family: none)	1-5

☐ 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	Date of mailing of the international search report
18 July, 2012 (18.07.12)	31 July, 2012 (31.07.12)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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Patent documents cited in the description

- JP H08247608 B **[0016]**