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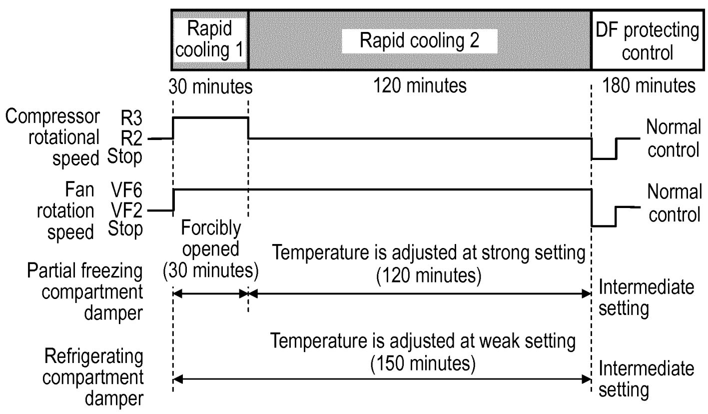
(54) REFRIGERATOR

(57) A refrigerator includes storage compartment (107), air blower (116) that blows cool air from cooler (115) to storage compartment (107), and a controller that controls air blower (116). The controller controls blow of the cool air so that cool air of a relatively low temperature equal to or lower than a freezing point of a food item is introduced into storage compartment (107), and then cool air of a higher temperature is introduced, and thereby moisture on a surface of the food item stored in storage compartment (107) is frozen, and finally the whole food item is stored at a slight freezing temperature.

FIG. 7



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Description

TECHNICAL FIELD

[0001] The present invention relates to a refrigerator that slightly freezes a food item in a short time.

BACKGROUND ART

[0002] In general, partially-frozen storage refers to slight freezing of a food item such as meat or fish at -3°C and can prolong a storage period of a food item as compared with cold storage (approximately 4°C) and chilled storage (approximately 1°C). Furthermore, partially-frozen storage does not harden the whole food item unlike frozen storage and therefore has an advantage of being capable of cutting a partially-frozen food item with small force without thawing the hardened food item.

[0003] Furthermore, in a case where a food item is slightly frozen in a partial freezing compartment of a household refrigerator, oxidative and enzymatic decomposition of the food item can be suppressed by slightly freezing the food item in a short time. This makes it possible to store the food item while preserving freshness more.

[0004] One example of an operation method for rapidly cooling a food item is a method for performing a rapid cooling operation of large cooling power and then switching to a normal operation for keeping a storage temperature (PTL 1). Power of the operation is typically changed by changing a flow rate at which cool air cooled by an evaporator is introduced into an accommodating compartment or by changing frequency of introduction of the cool air. Therefore, in the case of rapid cooling, cool air cooler than a final target temperature of a food item is introduced into an accommodating compartment at a relatively large flow rate.

[0005] However, in a case where such a rapid cooling method is applied to a partial freezing compartment, there is a possibility that a temperature of a food item becomes lower than a target storage temperature after switching from the "rapid cooling operation" to the "normal operation". That is, there is a possibility of deep freezing. Furthermore, in order to keep the advantage of being capable of cutting a stored food item with small force, it is important not to increase cooling performance during the rapid cooling operation too much. It is very difficult to achieve a delicate balance between rapid cooling and deep freezing in a case where food items of various sizes, various initial temperatures, and various packaging states are put into a household refrigerator.

Citation List

Patent Literature

[0006] PTL 1: Japanese Patent No. 4121197

SUMMARY OF THE INVENTION

[0007] The present invention has been made in view of the above conventional problems, and an object of the present invention is to provide a refrigerator that can store a food item in a partially-frozen state while shortening a time to slight freezing of the food item without deep-freezing the food item.

[0008] More specifically, a refrigerator according to one example of an exemplary embodiment of the present invention includes: a storage compartment; an air blower that blows cool air from a cooler to the storage compartment; and a controller that controls the air blower. The controller controls the air blower so that a first rapid cooling operation for introducing cool air equal to or lower than a freezing point of a food item into the storage compartment, a second rapid cooling operation for introducing cool air having a temperature higher than the cool air in the first rapid cooling operation after the first rapid cooling operation, and a normal cooling operation for introducing cool air having a temperature higher than the cool air in the second rapid cooling operation after the second rapid cooling operation are performed, and the controller controls the air blower so that the food item is stored at a temperature of 0°C or lower.

[0009] According to such a configuration, in the first rapid cooling operation, cool air of a relatively low temperature is introduced, so that a temperature difference between the food item and the cool air is increased, and thus increasing a cooling speed. In the second rapid cooling operation, cool air of a higher temperature is introduced. By thus giving temperature change stimulation to moisture of the food item in a super cooled state, it is possible to accelerate freezing while promoting canceling of the super cooled state. Furthermore, the normal cooling operation for partial freezing storage can make a temperature and hardness of the food item after completion of slight freezing equivalent to a normal slightly-frozen food item.

[0010] According to such a configuration, it is possible to shorten a time to slight freezing without hardening a food item more than a normal slightly-frozen food item. Furthermore, according to such a configuration, it is possible to prevent deep freezing with certainty irrespective of a volume and a condition of food since a temperature close to a final target temperature can be attained in multiple stages. This makes it possible to slightly freeze a food item in a short time without deep-freezing the food item.

[0011] A refrigerator according to an example of an exemplary embodiment of the present invention may be configured such that a time of the second rapid cooling operation is set longer than a time of the first rapid cooling operation. According to such a configuration, a temperature of a food item after canceling of super cooling can be made close to a final target temperature in a relatively short time. It is therefore possible to complete slight freezing in a short time with certainty.

[0012] A refrigerator according to an example of an exemplary embodiment of the present invention may be configured such that a volume of cool air in at least one of the first rapid cooling operation and the second rapid cooling operation is set larger than a volume of cool air in the normal cooling operation. According to such a configuration, it is possible to accelerate cooling of a food item and progress of slight freezing. Furthermore, it is possible to further increase temperature change stimulation for a food item. As a result, it is possible to achieve slight freezing in a shorter time.

[0013] A refrigerator according to an example of an exemplary embodiment of the present invention may be configured such that the air blower includes an air blowing machine that blows cool air from the cooler to the storage compartment, a duct, and a damper provided in the duct. The controller may be configured to control operation of the air blowing machine and the damper. According to such a configuration, it is possible to promptly change cooling performance. This makes it possible to give rapid temperature change stimulation to a food item, thereby canceling a super cooled state with more certainty. As a result, it is possible to achieve slight freezing in a short time with more certainty.

[0014] A refrigerator according to an example of an exemplary embodiment of the present invention may be configured such that a forced non-cooling time is set between the first rapid cooling operation and the second rapid cooling operation. According to such a configuration, it is possible to give large temperature change stimulation to a food item, thereby canceling a super cooled state with more certainty. As a result, it is possible to achieve slight freezing in a short time with more certainty.

[0015] A refrigerator according to an example of an exemplary embodiment of the present invention may be configured such that a highly heat-conductive member is provided on a bottom surface of the storage compartment. According to such a configuration, the food item can be cooled not only from a surface exposed to cool air, but also from a bottom surface through thermal conduction from the highly heat-conductive member. It is therefore possible to cool the food item more rapidly. Furthermore, since temperature change stimulation from the bottom surface is added, larger temperature stimulation can be given to the food item. This makes it possible to cancel a super cooled state with more certainty, thereby achieving slight freezing in a shorter time with more certainty.

BRIEF DESCRIPTION OF DRAWINGS

[0016]

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

FIG.2 is a cross-sectional view taken along line 2-2 in FIG. 1.

FIG. 3 is an enlarged view of a main part of a refrigerating compartment according to the first exemplary embodiment of the present invention.

FIG. 4 is a block diagram for control of the refrigerator according to the first exemplary embodiment of the present invention.

FIG. 5 is a flowchart for control of the refrigerator according to the first exemplary embodiment of the present invention from detection of an input load to a rapid cooling operation.

FIG. 6 is a sequence chart for detection of an input load of the refrigerator according to the first exemplary embodiment of the present invention.

FIG. 7 is a sequence chart for a rapid cooling operation of the refrigerator according to the first exemplary embodiment of the present invention.

FIG. 8 is a view showing the relationship between a slightly freezing start time and a POV value after a lapse of three days of the refrigerator according to the first exemplary embodiment of the present invention.

FIG. 9A is a view showing a change of a temperature in a storage compartment of a refrigerator and a surface temperature of a food item according to the first exemplary embodiment of the present invention.

FIG. 9B is a view showing a cooling state of the storage compartment of the refrigerator according to the first exemplary embodiment of the present invention.

FIG. 10A is a view showing the relationship between a temperature gradient ΔT and a rotational speed of a compressor at the time of performing rapid cooling 1 in the refrigerator according to a second exemplary embodiment of the present invention.

FIG. 10B is a view showing the relationship between a temperature gradient ΔT and an operation time at the time of performing rapid cooling 2 in the refrigerator according to the second exemplary embodiment of the present invention.

FIG. 11A is a view showing a change of a temperature in a storage compartment of a refrigerator and a surface temperature of a food item according to a third exemplary embodiment of the present invention.

FIG. 11B is a view showing a cooling state of the storage compartment of the refrigerator according to the third exemplary embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS

[0017] Exemplary embodiments according to the present invention are hereinafter described with reference to the drawings. The present invention is not limited by the exemplary embodiments.

(First exemplary embodiment)

[0018] FIG. 1 is a front view of a refrigerator according to a first exemplary embodiment of the present invention,

FIG. 2 is a cross-sectional view taken along line 2-2 in FIG. 1, and FIG. 3 is an enlarged view of a main part of a refrigerating compartment according to the first exemplary embodiment of the present invention. FIG. 4 is a block diagram for control of the refrigerator according to the exemplary embodiment of the present invention, and FIG. 5 is a flowchart for control of the refrigerator according to the first exemplary embodiment of the present invention from a detection of an input load to a rapid cooling operation.

[0019] In FIG. 1 and FIG. 2, the inside of refrigerator 101 is divided into an upper stage, an intermediate stage, and a lower stage, and includes a plurality of storage compartments. More specifically, refrigerator 101 includes, on the upper stage, refrigerating compartment 102 having a double-hinged-type door (refrigerating compartment door 102a) on a front side of refrigerating compartment 102. Refrigerator 101 also includes, below refrigerating compartment 102, first freezing compartment 103 having a drawer door (first freezing compartment door) and ice-making compartment 105 disposed in parallel with first freezing compartment 103 laterally and having a drawer door (ice-making compartment door 105a). On the intermediate stage, refrigerator 101 includes, below freezing compartment 103 and ice-making compartment 105, a second freezing compartment 104 having a drawer door (second freezing compartment door 104a). On the lower stage, refrigerator 101 includes vegetable compartment 106 having a drawer door (vegetable compartment door 106a). Vegetable compartment 106 is a lowermost compartment.

[0020] Refrigerating compartment 102, and ice-making compartment 105 and first freezing compartment 103 which are disposed in parallel with each other laterally are horizontally separated from each other by heat insulating partition wall 111. Similarly, ice-making compartment 105 and first freezing compartment 103 which are disposed in parallel with each other laterally and second freezing compartment 104 are horizontally separated from each other by heat insulating partition wall 111. Similarly, second freezing compartment 104 and vegetable compartment 106 are also horizontally separated from each other by heat insulating partition wall 111.

[0021] Refrigerator 101 is configured such that heat insulating wall 110 is filled between outer box 108 and inner box 109. In refrigerator 101, temperature changeable compartment 107 is defined as a storage compartment independent from refrigerating compartment 102 in a lower portion of the inside of refrigerating compartment 102 disposed on the upper part of refrigerator 101. Temperature changeable compartment 107 is configured as a switching compartment. In this exemplary embodiment, temperature changeable compartment 107 is configured such that a first temperature zone (chilled) which is a refrigerating temperature zone near 0°C, and a second temperature zone (slight freezing) of an approximately -3°C which is a temperature zone between the first temperature zone and a freezing temperature zone of approximately -6°C or below can be set selectively.

[0022] Next, a configuration of a cooling system is described. Cooling compartment 114 is provided behind a back surface of second freezing compartment 104, and cooler 115 is disposed inside cooling compartment 114. Cooler 115 constitutes a refrigeration cycle for cooling refrigerator 101 in cooperation with compressor 112 provided in machine compartment 113 disposed on an upper portion of refrigerator 101. Air blowing fan 116 for forcibly circulating cool air produced by heat exchange in cooler 115 is disposed in cooling compartment 114. Damper device 117a which distributes cool air flowing into refrigerating compartment 102 and damper device 117b which distributes cool air flowing into temperature changeable compartment 107 are disposed above air blowing fan 116. Different temperature zones can be used in the storage compartments. Specifically, for example, a temperature zone of approximately 2°C to 3°C can be set in refrigerating compartment 102, and a temperature zone of approximately 2°C to 5°C can be set in vegetable compartment 106. Furthermore, a temperature zone of approximately -18°C to -20°C can be set in first freezing compartment 103 and second freezing compartment 104. With such a configuration, a temperature zone suitable for the preservation of food can be selected in each storage compartment, and the food can be stored at a temperature suitable for the preservation of the food. Accordingly, it is possible to realize higher freshness keeping performance and long period preservation.

[0023] Next, a configuration of temperature changeable compartment 107 and a configuration of illumination device 121 which is mounted on a ceiling surface of temperature changeable compartment 107 are described with reference to FIG. 3 and FIG. 4.

[0024] As illustrated in FIG. 3, temperature changeable compartment 107 is configured as follows. An upper portion of temperature changeable compartment 107 is constituted of synthetic-resin upper surface cover 122 which is utilized also as shelf plate 118 positioned at the lowermost stage of refrigerating compartment 102. A lower side of upper surface cover 122 is constituted of synthetic-resin accommodating case 123 which is accommodated in temperature changeable compartment 107 in a state where accommodating case 123 can be pulled out in a longitudinal direction; and opening/closing door 124 which is provided on an opening on a front surface of upper surface cover 122 of temperature changeable compartment 107 in an openable manner. Opening/closing door 124 is configured such that, when the door is closed, opening/closing door 124 is brought into close contact with front surface wall 123b of accommodating case 123 so that an inside of temperature changeable compartment 107 is brought into a substantially hermetically sealed space. Opening/closing door 124 is made of a synthetic resin having high transparency such that a user can visually recognize foods accommodated in the inside of temperature changeable compartment 107.

[0025] Further, door opening/closing detection part 127 is mounted on a depth-side wall surface of temperature changeable compartment 107 such that door opening/closing detection part 127 is engaged with rear surface wall 123a of accommodating case 123 when opening/closing door 124 is closed. In this exemplary embodiment, aluminum bottom plate 128 is fitted in a bottom surface of accommodating case 123 thus realizing the enhancement of cooling performance and the enhancement of visibility due to diffusion of illumination light from illumination device 121. Note, however, that door opening/closing detection part 127 and aluminum bottom plate 128 is not essential.

[0026] Further, behind the depth-side wall surface of temperature changeable compartment 107, temperature changeable compartment back surface duct 125 which guides cool air distributed by damper device 117 to temperature changeable compartment 107 is formed. On the ceiling surface of temperature changeable compartment 107, temperature changeable compartment ceiling surface duct 126 is disposed on a downstream side of temperature changeable compartment back surface duct 125. Temperature changeable compartment ceiling surface duct 126 is constituted of heat insulating duct member 126a which is formed of a foamed heat insulating member having heat insulation property, and synthetic-resin-made duct cover 126b which covers an outer periphery of heat insulating duct member 126a and forms an ornamental plate. Temperature changeable compartment ceiling surface duct 126 constitutes a duct with upper surface cover 122, and has cool air blow-off port 129 which blows off cool air into the inside of temperature changeable compartment 107 on an upper surface portion of accommodating case 123.

[0027] Inside temperature changeable compartment 107, illumination device 121 which illuminates the inside of temperature changeable compartment 107 is disposed. The illumination device 121 is disposed on an opening/closing door side in front of a depth-side center position of temperature changeable compartment ceiling surface duct 126 in a state where illumination device 121 is embedded in duct cover 126a.

[0028] Refrigerating compartment 102 is provided with refrigerating compartment door switch 130 that detects an opened/closed state of refrigerating compartment door 102a, and at an arbitrary place outside or inside refrigerator 101, setting part 131 which switches a temperature zone and an operation mode of temperature changeable compartment 107 is disposed. Signal S1 is input to control microcomputer 132 from refrigerating compartment door switch 130, signal S2 is input to control microcomputer 132 from setting part 131, and signal S3 is input to control microcomputer 132 from door opening/closing detection part 127. Further, from control microcomputer 132, signal S4 is input to compressor 112, signal S5 is input to air blowing fan 116, signal S6 is input to damper device 117a, and signal S7 is input to damper device 117b respectively so that a predetermined cooling operation is performed.

[0029] Hereinafter, the manner of operation and effects of the refrigerator having the above-mentioned configuration are described with reference to FIG. 5 to FIG. 7.

[0030] First, in a state where a temperature zone of temperature changeable compartment 107 is set to the second temperature zone (partial freezing) by setting part 131, when opening/closing door 124 is closed, refrigerating compartment door switch 130 detects closing of refrigerating compartment door 102a (STEP 1). In response to the detection of closing of refrigerating compartment door 102a by refrigerating compartment door switch 130 (STEP 1), the presence or absence of an input load is determined by input food presence/absence determination part 134. More specifically, in a case where five minutes or more have passed after start of compressor 112 and compressor 112 is operated at a predetermined rotational speed which is set corresponding to an outside air temperature (STEP 2), the rapid cooling starting determination as to whether or not the inside of temperature changeable compartment 107 is rapidly cooled is started (STEP 3). In STEP 2, when five minutes have not passed after start of compressor 112, at a point of time that five minutes have passed, processing shifts to STEP 3.

[0031] In STEP 3, when it is determined that there is no load, a normal slight freezing control is performed (STEP 4). On the other hand, when it is determined that an input load is present in STEP 3, a predetermined rapid cooling operation is started. Details of the rapid cooling operation will be described later. In short, rapid cooling 1 (a first rapid cooling operation) in STEP 5 is performed, and then rapid cooling 2 (a second rapid cooling operation) in STEP 6 is performed. After the predetermined rapid cooling operation is finished, a deep freeze protecting operation in STEP 7 is performed.

[0032] Preferably, the rapid cooling canceling determination (STEP 8) in which the presence or absence of an input load is determined again is performed between rapid cooling 1 in STEP 5 and rapid cooling 2 in STEP 6. The rapid cooling canceling determination (STEP 8) is substantially equal to the rapid cooling starting determination performed for advancing STEP 2 to STEP 3 described later.

[0033] The rapid cooling canceling determination may be performed based on a gradient of a temperature (a degree of a temperature change) detected by temperature changeable compartment temperature sensor 133 when damper device 117b for temperature changeable compartment (partial freezing compartment) 107 is forcibly closed for a predetermined time.

[0034] The detection sequence of input food presence/absence determination part 134 relating to the rapid cooling starting determination for advancing STEP 2 to STEP 3 is described with reference to FIG. 6.

[0035] After start of the rapid cooling starting determination, damper device 117a for the refrigerating compartment is forcibly opened, and damper device 117b for temperature changeable compartment (partial freezing compartment) 107 is forcibly closed. Furthermore, compressor 112 is operated for three minutes while keeping the predetermined rotational speed and discharging cool air at a predetermined flow rate. After a lapse of three minutes, damper device 117a for the refrigerating compartment is forcibly closed, and damper device 117b for temperature changeable compartment (partial freezing compartment) 107 is forcibly opened. A temperature in temperature changeable compartment 107 after a lapse of four minutes from the start of input load detection sequence and a temperature in temperature changeable compartment 107 after a lapse of five minutes from the start of input load detection sequence are detected by temperature changeable compartment temperature sensor 133, and a temperature gradient ΔT is calculated. When a value of temperature gradient ΔT is larger than a predetermined threshold value which is set based on a partial freezing compartment temperature after a lapse of four minutes, it is determined that an input load is present, and the rapid cooling operation is started.

[0036] In the above-mentioned detection sequence, by stopping cooling of temperature changeable compartment 107 for three minutes from the start of the detection, a temperature changing state of temperature changeable compartment 107 can be made stable and thus stabilizing a temperature gradient AT. Usually, during a partial freezing operation, a rotational speed of compressor 112, a flow rate of discharged cool air, and an amount of load already accommodated in temperature changeable compartment 107 are not fixed, and a temperature inside the compartment is always increasing or decreasing. Even in a case where these conditions vary immediately before detection, the determination needs to be made by using a certain threshold value. By continuing an operation under the above-mentioned predetermined conditions for three minutes prior to the start of cooling of temperature changeable compartment 107, a value of temperature gradient ΔT can mainly reflect an input thermal load. As a result, regardless of an operation state immediately before the detection, accurate determination can be made in a stable manner.

[0037] In addition, by starting cooling after raising a temperature in temperature changeable compartment 107 in a first-half three minutes, an absolute value of a temperature gradient ΔT can be increased compared to a case where the cooling is started immediately. This increases the value of temperature gradient ΔT and an S/N ratio of a measurement variation of temperature changeable compartment temperature sensor 133. As a result, it is possible to increase accuracy of determination based on the value of temperature gradient ΔT.

[0038] Further, by forcibly cooling refrigerating compartment 102 in a concentrated manner in first-half three minutes, a temperature of refrigerating compartment 102 is lowered compared to a normal operation time. Accordingly, when a temperature of refrigerating compartment 102 is adjusted again, damper device 117a is closed for a longer time compared to a normal case. As described later, to increase a speed of slight freezing of a surface layer of a food item, it is important that a state where damper device 117a is closed and only damper device 117b is opened is continued after start of rapid cooling. The above-mentioned preliminary cooling of refrigerating compartment 102 has an effect of extending a continuous opening time of damper device 117b, and thus accelerating slight freezing of a surface layer of a food item.

[0039] After a lapse of three minutes, damper device 117a is closed and damper device 117b is opened. Accordingly, temperature changeable compartment 107 is cooled at a maximum cooling speed. A temperature gradient may be influenced depending on an opening/closing timing immediately after the damper devices are opened or closed. Accordingly, the determination is performed using, as an index, a value of temperature gradient ΔT obtained after four to five minutes in which the temperature in temperature changeable compartment 107 becomes stable.

[0040] Compared to a case where there is no input thermal load in temperature changeable compartment 107 (indicated by symbol b in FIG. 6), in a case where a certain large amount of thermal load is put in the temperature changeable compartment 107 (indicated by symbol a in FIG. 6), the decrease of an indoor temperature detected by temperature changeable compartment temperature sensor 133 becomes slow, and a value of temperature gradient ΔT becomes small.

[0041] A threshold value of temperature gradient ΔT is set in a variable manner in accordance with the following various conditions. In a case where the temperature inside the compartment after three minutes is relatively high, an absolute value of the threshold value of temperature gradient ΔT is set relatively large because the temperature tends to decrease during cooling in second-half two minutes. Meanwhile, in a case where the temperature inside the compartment after three minutes is relatively low, the absolute value of the threshold value of temperature gradient ΔT is set relatively small. When an outside air temperature is relatively high, cooling performance during second-half two minutes is likely to become relatively low. Accordingly, an absolute value of a threshold value of temperature gradient ΔT is set to a relatively small value. When a rotational speed of compressor 112 is relatively high, cooling performance becomes relatively high. Accordingly, an absolute value of a threshold value of temperature gradient ΔT is set to a relatively large value.

[0042] In determining the presence or the absence of an input thermal load in accordance with the detection sequence, particularly when a value of a temperature gradient ΔT is close to a threshold value, whether or not the determination can be accurately made is decided probabilistically in accordance with a normal distribution. The erroneous determination includes a first erroneous determination of determining that there is no input thermal load even though an input thermal load is present (it is not necessary to perform rapid cooling) and a second erroneous determination of determining that an input thermal load is present even though there is no input thermal load (it is necessary to perform rapid cooling). A threshold value of temperature gradient ΔT may be set such that a probability of the first erroneous determination is equal to a probability of the second erroneous determination. When it makes sense to rapidly and reliably cool an input thermal load in use, to minimize a probability of the first erroneous determination, a threshold value of a temperature gradient ΔT is set to a large value compared to the above-mentioned case where probabilities of the first and second erroneous determinations are equal. On the other hand, in a case where it is disadvantageous to excessively cool an object to be cooled which is already cooled inside temperature changeable compartment 107, a threshold value of temperature gradient ΔT may be set small as compared to the above-mentioned case, to minimize a probability of the second erroneous determination.

[0043] To increase a probability of accurate determination, it is effective to set an amount of intrusion of heat into temperature changeable compartment 107 from the wall surface to a fixed value. When temperature changeable compartment 107 is disposed in refrigerating compartment 102, regardless of a change in outside air temperature, a change in temperature of refrigerating compartment 102 falls within a predetermined range. Accordingly, an amount of intrusion of heat can be easily set to a fixed value, and it is effective for enhancing determination accuracy.

[0044] In the case where a temperature in temperature changeable compartment 107 becomes a predetermined temperature or more and opening/closing door 124 is opened for a predetermined time or more, rapid cooling described later or cooling by a normal partial freezing operation may be started without using the detection sequence shown in FIG. 6. As a result, a temperature in the partial freezing compartment (temperature changeable compartment 107) can be quickly lowered without taking time for a detection operation. Accordingly, it is possible to prevent the deterioration of freshness due to a rise of a food temperature.

[0045] Next, a rapid cooling operation sequence shown in FIG. 7 is described. In this exemplary embodiment, the rapid cooling operation includes rapid cooling 1 (first rapid cooling operation) of relatively high cooling performance and rapid cooling 2 (second rapid cooling operation) of cooling performance higher than a normal partial freezing operation and lower than rapid cooling 1. During rapid cooling 1 operation, a rotational speed of compressor 112 is set higher as compared to a rotational speed of compressor 112 in the normal operation time, and a flow rate (volume) of cool air introduced to temperature changeable compartment 107 is set large. Damper device 117b for temperature changeable compartment 107 is forcibly set to an opened state, and damper device 117a for refrigerating compartment 102 is set harder to open. Furthermore, compressor 112 is set so as not to stop.

[0046] During rapid cooling 2 operation, by adjusting a temperature in temperature changeable compartment 107, it is possible to prevent a food from being cooled to a predetermined temperature or below. Rapid cooling 2 is operated under any one of the above-mentioned operation conditions at the time of performing rapid cooling 1 operation. Alternatively, rapid cooling 2 may be operated under a condition between an operation condition at the time of performing rapid cooling 1 operation and an operation condition at the time of performing a normal operation.

[0047] In this exemplary embodiment, rapid cooling 1 of high cooling performance accelerates slight freezing of a food item. Meanwhile, if rapid cooling 1 is continued, temperature changeable compartment 107 having a limited capacity is mainly cooled, and therefore cold of cooler 115 is not fully discharged into the compartment, and the temperature of cooler 115 tends to continue to decrease. As a result, an operation of compressor 112 must be stopped for protecting compressor 112 from low pressure. As described later, to accelerate slight freezing, it is necessary to continue the cooling in a sequential manner. Accordingly, it is necessary to prevent a temperature of cooler 115 from becoming lower than a predetermined temperature. For this reason, in this exemplary embodiment, rapid cooling 1 is finished in thirty minutes, and rapid cooling 2 of a lower rotational speed is started. In rapid cooling 2, a rotational speed of compressor 112 is set such that the decrease of a temperature of cooler 115 below a predetermined temperature is prevented even when compressor 112 is continuously operated. In the case where a temperature of cooler 115 decreases even when such an operation is performed, damper device 117a may be forcibly opened.

[0048] By providing rapid cooling 2 which exhibits the lower cooling performance than rapid cooling 1, it is possible to acquire an effect of avoiding the occurrence of a phenomenon that a food item which is already slightly frozen in temperature changeable compartment 107 is made hard by deep freezing, a phenomenon that frost is formed in temperature changeable compartment 107, and a phenomenon that a food item placed adjacently to temperature changeable compartment 107 is unexpectedly slightly frozen and the like.

[0049] To rapidly realizing slight freezing of a food item, it is necessary to continuously cool the food item for a predetermined time due to the following reason. In a case where a food item is slightly frozen, when a surface layer of the food item is slightly frozen, a specific heat on the surface layer of the food item becomes approximately a half of a specific heat of a unfrozen portion in the inside of the food item, and a thermal conductivity on the surface layer of the food item becomes approximately four times as large as a thermal conductivity in the unfrozen portion. When the cooling is temporarily stopped in such a situation, heat of the unfrozen portion is easily transferred to the slightly frozen portion by heat conduction and hence, a temperature of the slightly frozen portion is easily increased again. As a result, a temperature of a portion which is temporarily slightly frozen is easily increased to 0°C, and melting is started. The repetition of slight freezing and melting physically deteriorates a food item and lowers a quality of the food item and hence, the repetition of slight freezing and melting is not preferable.

[0050] To realize slight freezing of a surface layer rapidly, it is necessary to grow a slightly frozen layer to a degree such that the slightly frozen layer exhibits a heat insulating effect so that the slightly frozen layer itself exhibits a latent heat accumulating effect thus preventing heat inside the food item from being transferred to an outermost layer. For example, in this exemplary embodiment, the slightly frozen layer is grown to a thickness of approximately 1 mm. In this way, a slightly frozen layer can be formed in a surface layer of a food item with certainty. In such a case where a slightly frozen layer is formed, a time required for generating a slightly frozen layer is hardly influenced by a super cooling phenomenon and is therefore relatively stable.

[0051] Food items such as meat and fish contain phospholipid in cell membranes, and contain neutral lipid in subcutaneous tissues. However, an unsaturated fatty acid which is a constitutional element of the phospholipid and the neutral lipid is automatically oxidized by being brought into contact with oxygen thus generating hydroxyperoxide. When a human eats hydroxyperoxide, hydroxyperoxide works as a harmful substance because DNA is damaged due to a radical reaction in a human body and a physiologically active substance is oxidized.

[0052] When a slightly frozen layer is uniformly formed on a surface layer of a food item by the above-mentioned rapid cooling operation, an ice in an extracellular fluid exhibits a diffusion coefficient of oxygen smaller than that of water by two or more digits. Accordingly, it is possible to substantially block cells and the inside of a food from oxygen. Since oxygen is essential for the aforementioned autoxidation, it is possible to prevent generation of hydroxyperoxide by blocking cells and the inside of a food item from oxygen. In this manner, by accelerating slight freezing of the surface layer, oxidation of a food item containing fat can be suppressed, and the increase of values such as AV (Acid Value), POV (Peroxide Value), and TBA (Thiobarbituric Acid) which are oxidation indexes is suppressed.

[0053] FIG. 8 is a view showing the relationship between a surface layer freezing time at the time of freezing a food item and a POV value after a lapse of three days. In FIG. 8, a POV value taken on a vertical axis is indicated in a relativized manner by setting a POV value in a 0th day as 1.0. From FIG. 8, it is found that, with respect to two kinds of fish food items, when a surface layer slight freezing time exceeds a predetermined time, an oxidation index value is increased during three preservation days. It is also found that, to suppress the increase of a POV value during three storage days thus substantially preventing oxidation, it is effective to slightly freeze a surface of a food item within eight hours so as to block contact between oxygen and fat. In the same manner, it is also found that when the surface layer of a food item is slightly frozen within eight hours, a K value is not increased during three days.

[0054] In a case of beef, pork, and the like, it is found that when a surface layer slight freezing is performed within eight hours, an oxidation index value after a lapse of seven days is not increased.

[0055] In view of these, in this exemplary embodiment, cooling performance during rapid cooling operation is set such that a surface of a food item is slightly frozen within eight hours.

[0056] In the midst of rapid cooling 1, a rapid cooling canceling determination may be performed in which a continuation of the rapid cooling operation is determined again. The canceling determination is basically equal to the detection sequence shown in FIG. 6. However, a threshold value of temperature gradient ΔT is decided separately. The rapid cooling canceling determination may be performed a plurality of times. Even when the second erroneous determination is performed in accordance with the detection sequence, by performing the rapid cooling canceling determination, the rapid cooling operation can be stopped in the midst of operation. Accordingly, unnecessary rapid cooling can be stopped thus preventing the energy consumption from being excessively increased.

[0057] When rapid cooling 2 is finished, the normal partial freezing operation is performed. When a temperature of cooler 115 is lower than a predetermined temperature at the time of shifting the operation mode, there may be a case where it is determined that cooling is unnecessary so that compressor 112 is stopped. Usually, while compressor 112 is stopped, air blowing fan 116 for blowing cool air of cooler 115 into refrigerator 101 is stopped. However, during shifting of an operation mode, air blowing fan 116 may be operated. With such an operation, the increase of a temperature of cooler 115 can be accelerated thus shortening a stop time of compressor 112 compared to a normal time. As a stop time of compressor 112 is shorter, a time until the slight freezing can be achieved becomes shorter due to the above-mentioned reasons. Accordingly, it is possible to acquire a desirable result in terms of keeping freshness.

[0058] After an operation mode returns to a normal partial freezing operation, as shown in FIG. 7, a protection time is provided for a predetermined time in which the rapid cooling is not started and the normal partial freezing operation is continued. When a food item which is slightly frozen exists in temperature changeable compartment 107 before a thermal load is put in temperature changeable compartment 107, a temperature of the food item may be temporarily lowered due to rapid cooling operation, and the food item may be further hardened from a slightly frozen state. By providing the protection time, a temperature of the food item approaches a temperature substantially the same as a temperature at the time of performing the normal partial freezing operation during the protection time so that a hardness of the food item is also returned to a desired hardness. When the projection time is not provided and a thermal load is continuously put into temperature changeable compartment 107, a state of an existing slightly frozen food item approaches a frozen state from a slightly frozen state thus giving rise to a drawback such as the decrease of advantageous effects of slight freezing or the like. However, the present invention can prevent the occurrence of such a drawback.

[0059] As the above-mentioned protection time becomes longer, a temperature of an existing slightly frozen food item is reliably and easily returned to a slightly freezing temperature. A length of the protection time is set such that a temperature of a food item falls within a range of slightly freezing temperature zone during a standard preservation period of a food item by taking into account the increase of a temperature during protection time and the increase of a temperature during a defrost operation which is periodically performed. Alternatively, the length of the protection time may be set such that a force for cutting a food item is not increased to a predetermined value or more during a standard preservation period of the food item.

[0060] As one example, FIG. 7 shows an example where a rapid cooling operation (rapid cooling 1 and rapid cooling 2) time is set to 2.5 hours, and a protection time is set to 3 hours. In this case, one rapid cooling cycle is 5.5 hours, and this cycle is substantially equal to a time cycle for preparing breakfast, lunch, or dinner in general. Accordingly, even when a rapid cooling operation is started with the increase of a partial freezing compartment temperature at a certain meal preparation time, rapid cooling can be performed at a next meal preparation time in the same manner. Accordingly, freshness of an existing slightly frozen food can be reliably kept.

[0061] In a case where a thermal load is introduced during the protection time, only the detection sequence is operated, and the rapid cooling starting determination is made. In a case where it is determined that rapid cooling is needed, rapid cooling starts immediately after the end of the protection time.

[0062] As described above, refrigerator 101 according to this exemplary embodiment includes: storage compartment (temperature changeable compartment 107); the air blower (air blowing fan 116) for blowing cool air from cooler 115 to the storage compartment; and the controller (control microcomputer 132) for controlling the air blower. The controller controls a blow amount (flow amount) of cool air, and thereby a surface of a food item stored in the storage compartment is slightly frozen, and the food item is stored at a slight freezing temperature. With such a configuration, oxidation of foods can be prevented by blocking contact between food items and oxygen due to formation of slightly frozen layer and, at the same time, dividing and cutting of food items can be easily performed, and flavor of food is not deteriorated, and therefore food items to be preserved can be preserved while keeping freshness.

[0063] In refrigerator 101 of this exemplary embodiment, the air blower includes a duct (refrigerating compartment duct 120) for blowing cool air from cooler 115 to the storage compartment, a damper (damper device 117a) disposed in the duct, and a temperature sensor (temperature changeable temperature sensor 133) which detects a temperature in the storage compartment. Further, the controller is configured to control blowing of cooling air or the like such that the damper device is forcibly opened for a predetermined time so that surfaces of food items preserved in the storage compartment are rapidly slightly frozen and, thereafter, opening and closing of the damper device is controlled based on a temperature detected by the temperature sensor such that the food items are preserved at a slightly freezing temperature. With such a configuration, by starting the rapid cooling immediately after a food item is put into the temperature changeable compartment, contact between the food item and oxygen can be blocked in a shorter time thus preventing oxidation of the food item. Accordingly, the food item can be preserved while further keeping freshness of the food item.

[0064] Refrigerator 101 according to this exemplary embodiment is configured such that the damper device is forcibly opened for a predetermined time and, at the same time, the compressor is continuously operated. With such a configuration, the contact between the food item and oxygen can be blocked in a shorter time thus preventing oxidation of the food item. Accordingly, the food item can be preserved while further keeping freshness of the food item.

[0065] Refrigerator 101 of this exemplary embodiment includes: the storage compartment; air blower 116 for blowing cool air from cooler 115 to the storage compartment; temperature sensor 133 which detects a temperature in the storage compartment; and input food presence/absence determination part 134 which determines the presence or absence of an input food item in the storage compartment. Input food presence/absence determination part 134 is configured to forcibly stop the blowing of air by air blower 116 for a predetermined time and to determine the presence or absence of an input food item in the storage compartment based on a temperature gradient (a degree of a temperature change) detected by temperature sensor 133. With such a configuration, the determination of the presence or absence of the input food item in the storage compartment can be performed with a simple configuration.

[0066] Input food presence/absence determination part 134 is configured such that after air blower 116 is forcibly stopped for a predetermined time, air blower 116 is forcibly operated for a predetermined time, and input food presence/absence determination part 134 determines the presence or absence of an input food item in the storage compartment based on a gradient of a temperature detected by temperature sensor 133 during the period that air blower 116 is forcibly operated. With such a configuration, the determination of the presence or absence of the input food item in the storage compartment can be performed with certainty with a simple configuration.

[0067] Input food presence/absence determination part 134 may be configured such that the determination of the presence or absence of an input food item in the storage compartment is performed a plurality of times. With such a configuration, the determination of the presence or absence of the input food item in the storage compartment can be performed with more certainty with a simple configuration.

[0068] Refrigerator 101 of this exemplary embodiment may include storage compartment opening/closing detection part 127 which detects opening/closing of the storage compartment (temperature changeable compartment 107). With such a configuration, since controller 132 is operated in response to the detection of an open/close state of the storage compartment by storage compartment opening/closing detection part 127, oxidation of a food item can be prevented more reliably so that a preserved food item can be preserved while keeping freshness of the food item.

[0069] The storage compartment (temperature changeable compartment 107) is incorporated in a corner of another storage compartment (refrigerating compartment 102), and a temperature in the storage compartment is controlled independently from a temperature in the other storage compartment. With such a configuration, a slightly frozen layer which is once formed on a food item is maintained in a stable manner thus maintaining an antioxidation effect.

[0070] In order to accelerate slight freezing of a food item while preventing deep freezing, the controller controls the temperature in the storage compartment while utilizing both of an optimum cooling speed and stimulation for canceling super cooling.

[0071] FIG. 9A illustrates a change of a temperature in a storage compartment of a refrigerator and a surface temperature of a food item according to the first exemplary embodiment of the present invention, and Fig. 9B illustrates a cooling state of the storage compartment of the refrigerator according to the first exemplary embodiment of the present invention.

[0072] In FIGS. 9A and 9B, a purpose of rapid cooling 1 is to rapidly cool a food item so that a surface temperature of the food item becomes close to a freezing point or becomes equal to or lower than the freezing point. In rapid cooling 1, various conditions are set so that the rotational speed of compressor 112 is increased, for example, from R2 to R3 in order to increase a temperature difference between a food item and cool air and the rotational speed of air blowing fan 116 is increased, for example, from VF2 to VF6 and thereby a blow amount is increased in order to increase heat transfer, as illustrated in FIG. 7. Note that R2, R3, VF2, and VF6 each represent an arbitrary rotational speed. In this exemplary embodiment, a relationship R2 < R3 and a relationship VF2 < VF 6 are established as illustrated in FIGS. 7 and 10A.

[0073] In a case where the surface temperature of the food item becomes lower than a freezing temperature, rapid cooling itself is more likely to cancel super cooling than slow cooling.

[0074] Meanwhile, a purpose of rapid cooling 2 and thereafter is to cancel super cooling as compared with rapid cooling 1. In rapid cooling 2 and thereafter, a set temperature is gradually increased so that a final target temperature of the whole food item falls in a range from the freezing temperature to a standard slight freezing temperature, as compared with rapid cooling 1. In rapid cooling 2 and thereafter, the inside temperature fluctuates up down across the set temperature due to opening/closing of damper device 117a. In a case where the food item has not been frozen yet at this point in time, this fluctuation in temperature acts as stimulation for accelerating canceling of super cooling. Continued normal control operation makes the temperature of the food item close to the standard slight freezing temperature. As described above, according to the configuration of this exemplary embodiment, a food item stored in a slightly frozen state in refrigerator 101 is not deep-frozen at any moment. It is therefore possible to keep good handling such as being capable of easily cutting a stored food item for cooking.

(Second exemplary embodiment)

[0075] FIG. 10A is a view showing the relationship between temperature gradient ΔT and a rotational speed of a compressor at the time of performing rapid cooling 1 in a refrigerator according to a second exemplary embodiment of the present invention, and FIG. 10B is a view showing the relationship between temperature gradient ΔT and an operation time of the compressor at the time of performing rapid cooling 2 in the refrigerator according to the second exemplary embodiment of the present invention. The description with respect to parts identical with the corresponding parts in the first exemplary embodiment is omitted, and only parts which make the second exemplary embodiment different from the first exemplary embodiment are described.

[0076] In the rapid cooling determination sequence shown in FIG. 6, a magnitude of a value of a temperature gradient ΔT is substantially proportional to an input thermal load under a fixed condition. In refrigerator 101 of this exemplary embodiment, an operation control is performed in which a cooling amount is increased in proportion to an amount of input thermal load. As shown in FIG. 10A, rapid cooling is performed when an absolute value of temperature gradient ΔT is larger than $\Delta T0$, and a rotational speed is increased from R2 to R3. When an absolute value is larger than a temperature gradient $\Delta T1$, the rotational speed is further increased to R4. Note that

R2, R3, and R4 each represent an arbitrary rotational speed. In this exemplary embodiment, a relationship R2 < R3 < R4 is established as illustrated in FIG. 10A. In this manner, when an input thermal load is large, cooling performance is increased by lowering a temperature of cooler 115 so that a time until a surface layer is slightly frozen can be reliably shortened. In such an operation, when a time for rapid cooling 1 is extended, there arises an adverse effect such as frosting of the inside of temperature changeable compartment 107 or freezing of a food item in a storage compartment disposed adjacently to temperature changeable compartment 107. Accordingly, it is desirable that rapid cooling 1 time is not extended.

[0077] As shown in FIG. 10B, when an absolute value of a temperature gradient ΔT falls within a range of from $\Delta T0$ to $\Delta T1$ inclusive, although a time for rapid cooling 2 is t1, when an absolute value of a temperature gradient ΔT is equal to or more than $\Delta T1$, a time for rapid cooling 2 is extended in proportion to a value of a temperature gradient ΔT. However, even in a case where a thermal load of the temperature gradient $\Delta T2$ or more is input, the time of rapid cooling 2 is not extended to t2 or longer. An upper limit line t2 of rapid cooling 2 is set as appropriate such that an adverse effect such as frosting or freezing of a food item does not occur. As described above, refrigerator 101 according to this exemplary embodiment is configured such that a rapid cooling operation condition is adjusted in accordance with an amount of input thermal load. It is therefore possible to shorten a time to surface layer slight freezing with certainty. Meanwhile, it is possible to prevent adverse effect caused by super cooling and an unnecessary increase of operation cost.

(Third exemplary embodiment)

[0078] FIG. 11A illustrates a change of a temperature in a storage compartment of a refrigerator and a surface temperature of a food item according to the third exemplary embodiment of the present invention, and Fig. 11B illustrates a cooling state of the storage compartment of the refrigerator according to the third exemplary embodiment of the present invention. The description with respect to parts identical with the corresponding parts in the first exemplary embodiment is omitted, and only parts which make the second exemplary embodiment different from the first exemplary embodiment are described.

[0079] In this exemplary embodiment, a forced non-cooling time is provided between rapid cooling 1 and rapid cooling 2 unlike the first exemplary embodiment, and thereby a temperature of a surface of a food item is fluctuated up down so that canceling of super cooling of water is accelerated. Specifically, cooling of the storage compartment (temperature changeable compartment 107) is stopped by stopping operation of compressor 112 for approximately ten minutes or forcibly closing damper device 117a. In a case where the temperature of the surface layer of the food item is equal to or lower than a freezing point at the end of rapid cooling 1, it is intended that rise in temperature during stoppage acts as stimulation for slight freezing of the surface layer. According to such a configuration, it is possible to accelerate slight freezing of a food item and prevent oxidation degradation while preventing temperature drop leading to deep freezing.

INDUSTRIAL APPLICABILITY

[0080] As described above, the present invention provides a refrigerator that can slightly freeze a food item in a short time without deep-freezing the food item. Therefore, the present invention is applicable to not only a household refrigerator, but also an industrial refrigerator and can be widely used, for example, for a showcase and a prefabricated refrigerator.

REFERENCE MARKS IN THE DRAWINGS

[0081]

101: refrigerator
102: refrigerating compartment (storage compartment)
107: temperature changeable compartment (storage compartment, partial freezing compartment)
112: compressor
115: cooler
116: air blowing fan (air blower)
117, 117a, 117b: damper device (damper)
120: refrigerating compartment duct (duct)
121: illumination device
122: upper surface cover
123: accommodating case
123a: rear surface wall
123b: front surface wall
124: opening/closing door
125: temperature changeable compartment back surface duct
126: temperature changeable compartment ceiling surface duct
126a: heat insulating duct member
126b: duct cover
127: door opening/closing detection part (storage compartment opening/closing detection part)
128: bottom plate
129: cool air blow-off port
130: refrigerating compartment door switch
131: setting part
132: control microcomputer (controller)
133: temperature changeable compartment temperature sensor (temperature sensor)
134: input food presence/absence determination part

Claims

1. A refrigerator comprising:

   a storage compartment;
   an air blower that blows cool air from a cooler to the storage compartment; and
   a controller that controls the air blower,
   wherein the controller controls the air blower so that a first rapid cooling operation for introducing cool air equal to or lower than a freezing point of a food item into the storage compartment, a second rapid cooling operation for introducing cool air having a temperature higher than the cool air in the first rapid cooling operation after the first rapid cooling operation, and a normal cooling operation for introducing cool air having a temperature higher than the cool air in the second rapid cooling operation after the second rapid cooling operation are performed, and
   the controller controls the air blower so that the food item is stored at a temperature of 0°C or lower.

2. The refrigerator according to claim 1, wherein a time of the second rapid cooling operation is set longer than a time of the first rapid cooling operation.

3. The refrigerator according to claim 1 or 2, wherein a volume of cool air in at least one of the first rapid cooling operation and the second rapid cooling operation is set larger than a volume of cool air in the normal cooling operation.

4. The refrigerator according to any one of claims 1 to 3, wherein
   the air blower includes an air blowing machine that blows the cool air from the cooler to the storage compartment, a duct, and a damper provided in the duct, and
   the controller controls operation of the air blowing machine and the damper.

5. The refrigerator according to any one of claims 1 to 4, wherein a forced non-cooling time is set between the first rapid cooling operation and the second rapid cooling operation.

6. The refrigerator according to any one of claims 1 to 5, wherein a highly heat-conductive member is provided on a bottom surface of the storage compartment.

FIG. 1

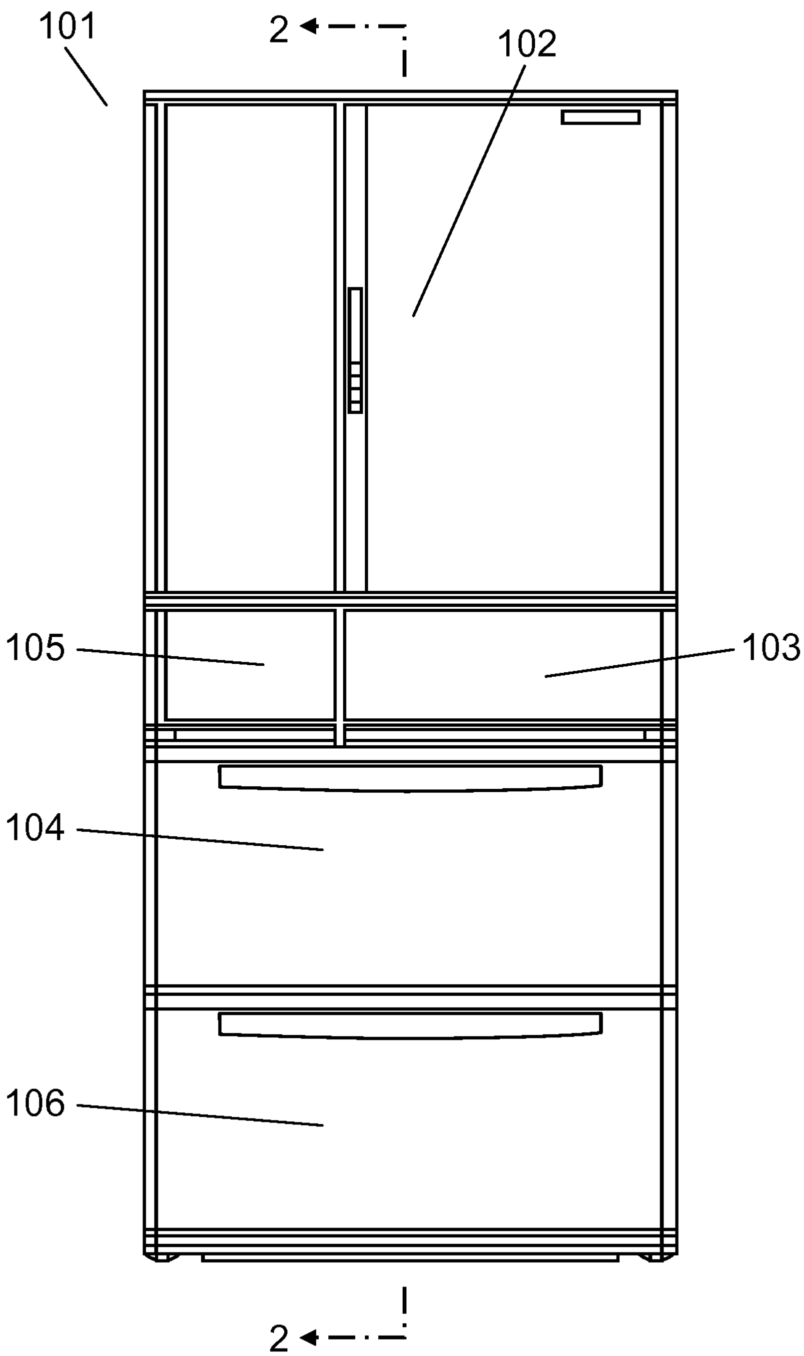

FIG. 2

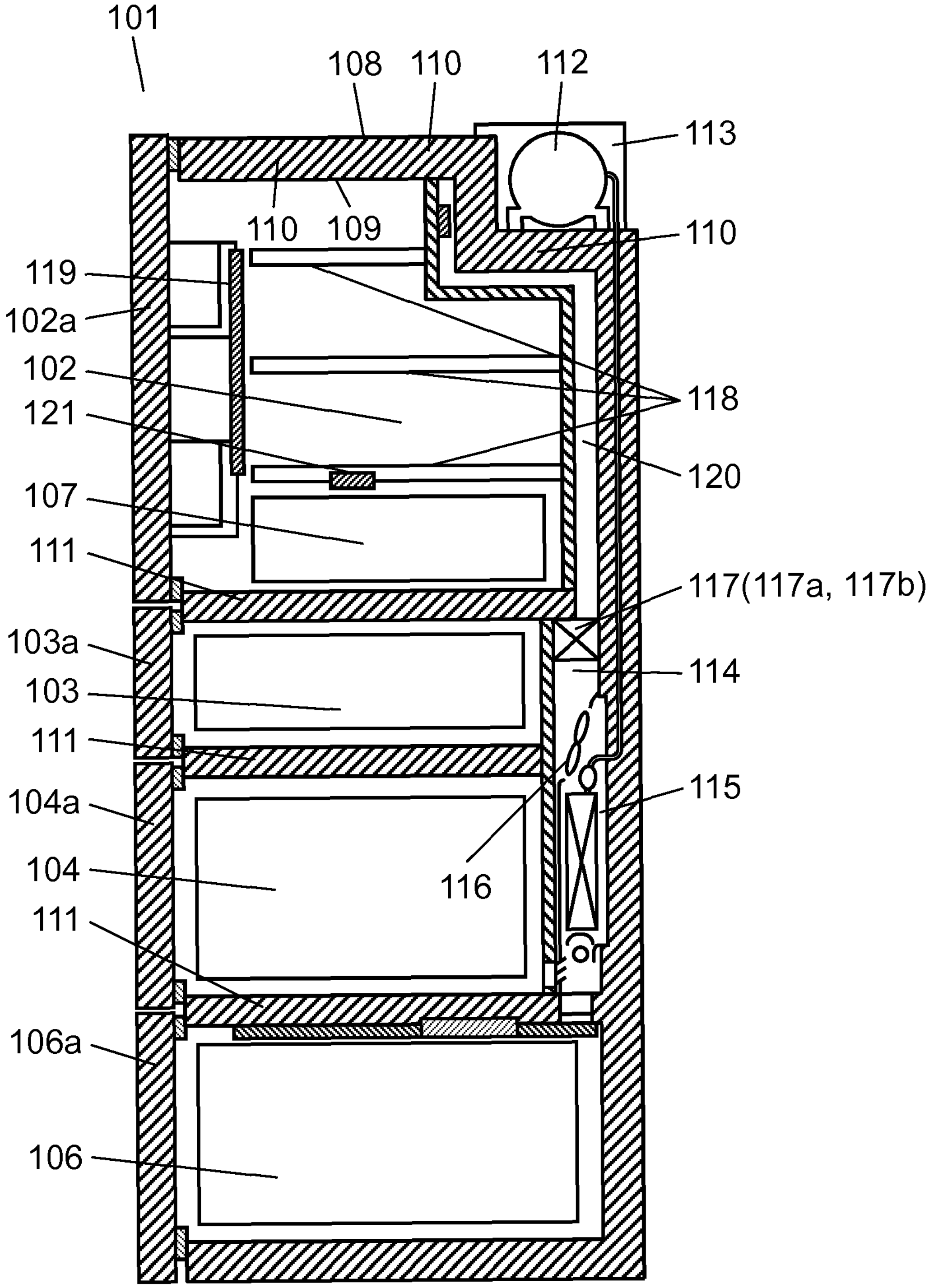
101
108
110
112
113
110
109
110
119
102a
102
118
121
120
107
111
117(117a, 117b)
103a
114
103
111
115
104a
116
104
111
106a
106

FIG. 3

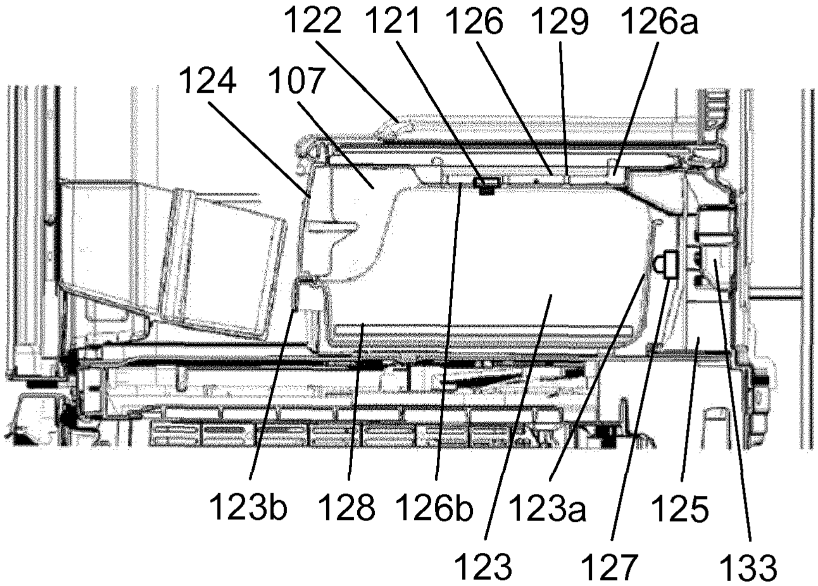
122
121
126
129
126a
124
107
123b
128
126b
123a
125
123
127
133

FIG. 4

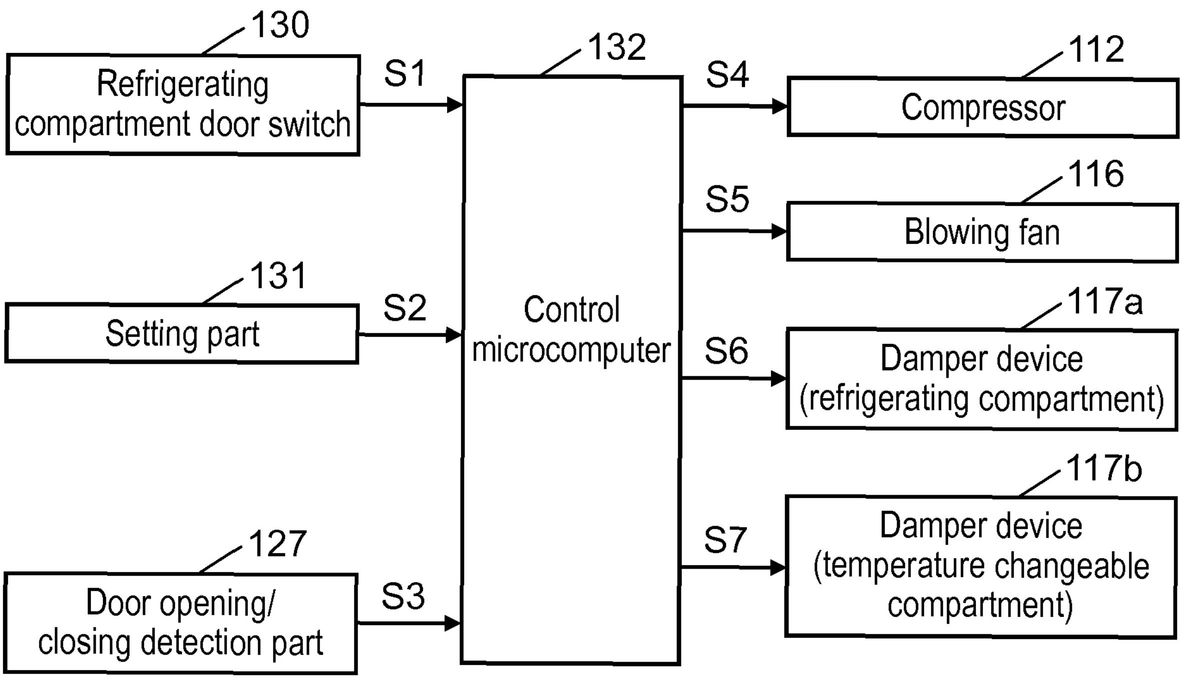
130
Refrigerating compartment door switch
S1
131
Setting part
S2
127
Door opening/ closing detection part
S3
132
Control microcomputer
S4
112
Compressor
S5
116
Blowing fan
S6
117a
Damper device (refrigerating compartment)
S7
117b
Damper device (temperature changeable compartment)

FIG. 5

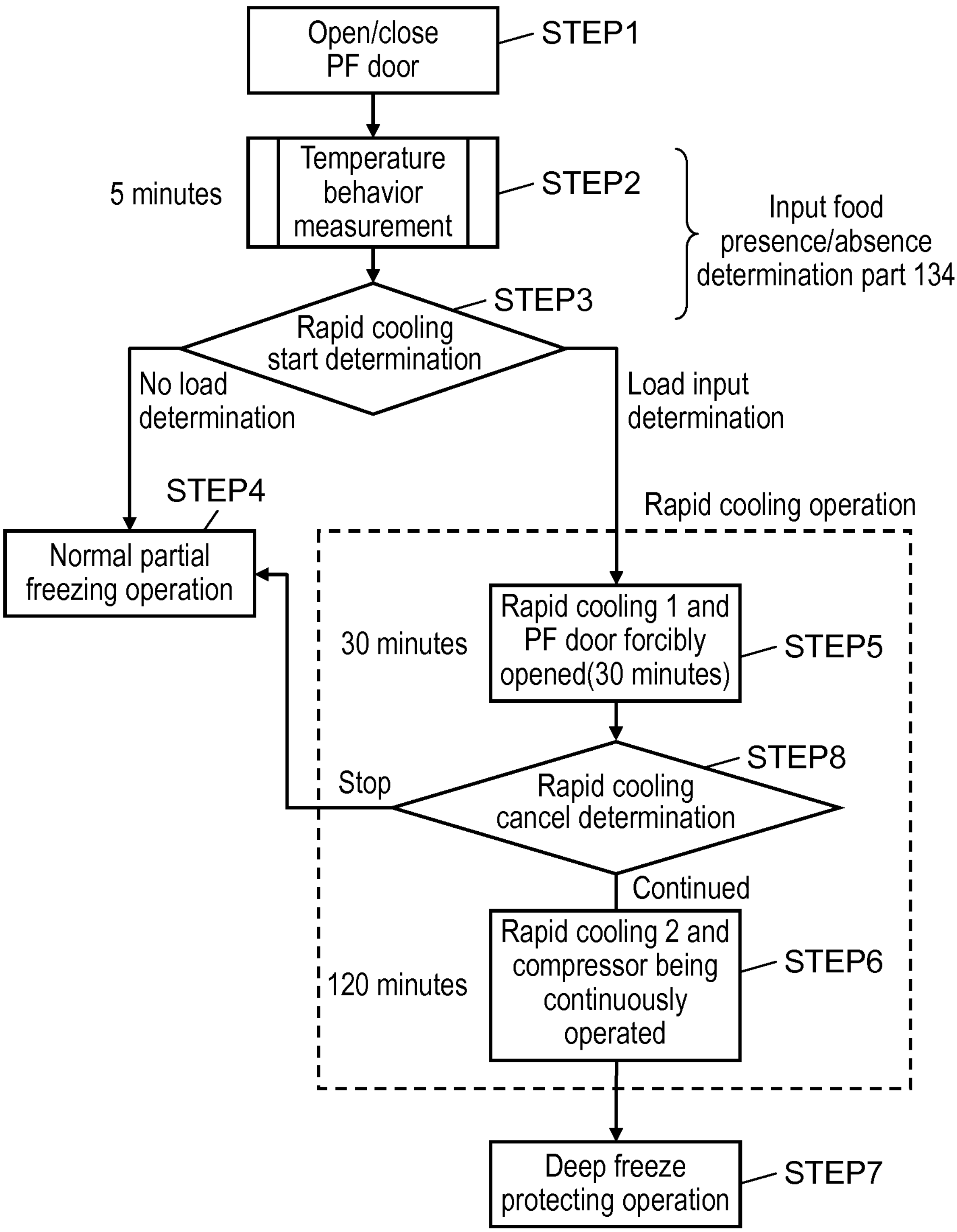
Open/close
PF door
STEP1
5 minutes
Temperature
behavior
measurement
STEP2
Input food
presence/absence
determination part 134
Rapid cooling
start determination
STEP3
No load
determination
Load input
determination
STEP4
Rapid cooling operation
Normal partial
freezing operation
30 minutes
Rapid cooling 1 and
PF door forcibly
opened(30 minutes)
STEP5
STEP8
Stop
Rapid cooling
cancel determination
Continued
120 minutes
Rapid cooling 2 and
compressor being
continuously
operated
STEP6
Deep freeze
protecting operation
STEP7

FIG. 6

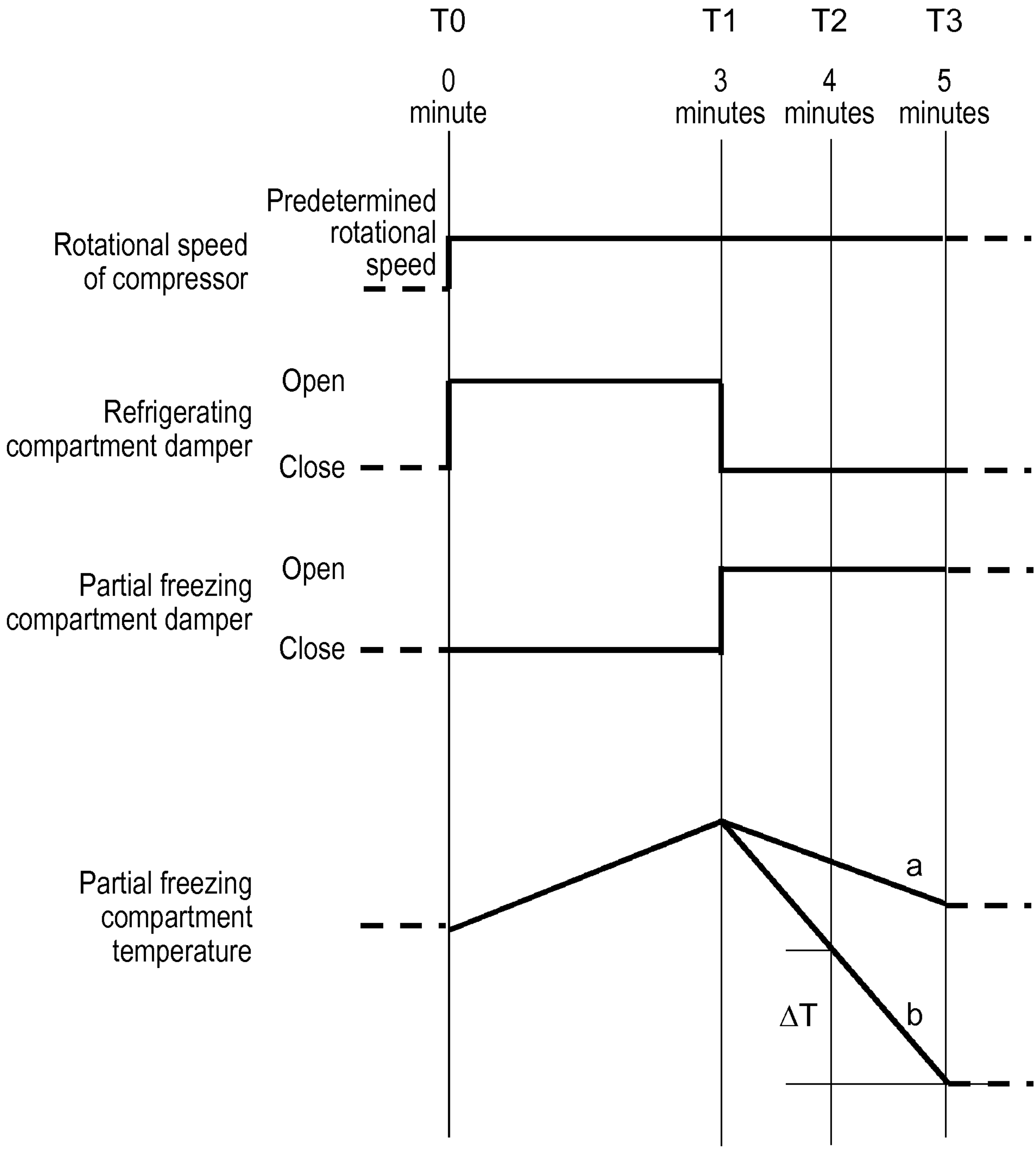
T0
T1
T2
T3
0 minute
3 minutes
4 minutes
5 minutes
Rotational speed of compressor
Predetermined rotational speed
Refrigerating compartment damper
Open
Close
Partial freezing compartment damper
Open
Close
Partial freezing compartment temperature
a
b
ΔT

FIG. 7

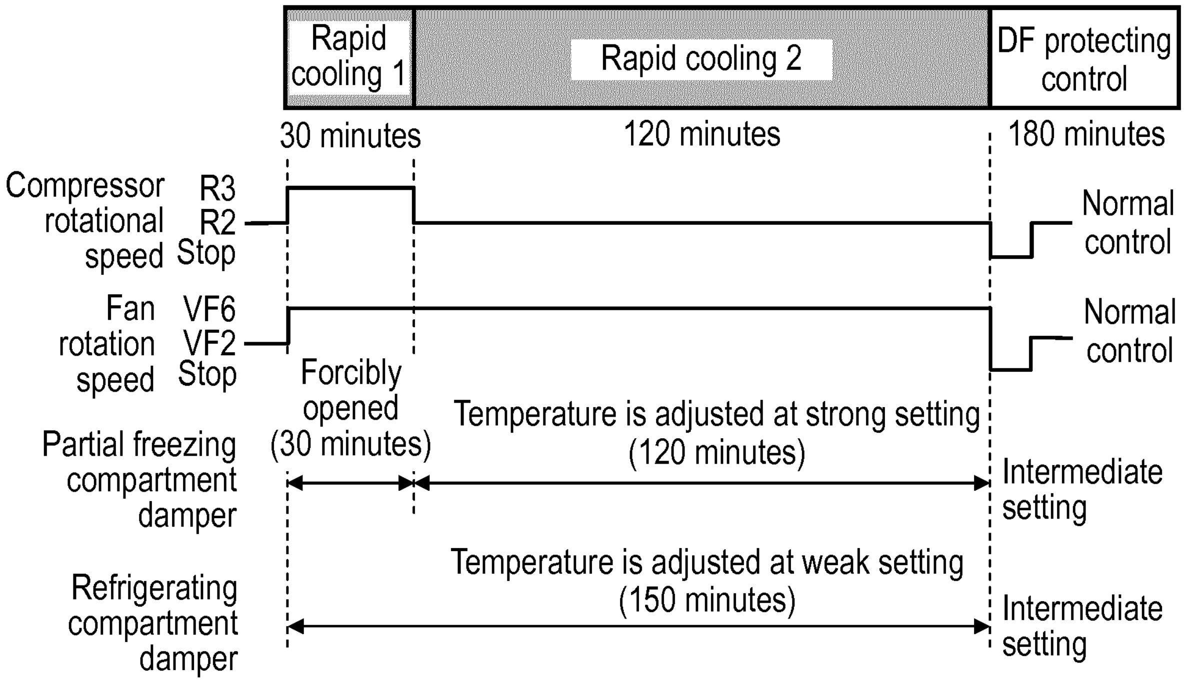
Rapid cooling 1
Rapid cooling 2
DF protecting control
30 minutes
120 minutes
180 minutes
Compressor rotational speed
R3
R2
Stop
Normal control
Fan rotation speed
VF6
VF2
Stop
Normal control
Forcibly opened (30 minutes)
Temperature is adjusted at strong setting (120 minutes)
Partial freezing compartment damper
Intermediate setting
Temperature is adjusted at weak setting (150 minutes)
Refrigerating compartment damper
Intermediate setting

FIG. 8

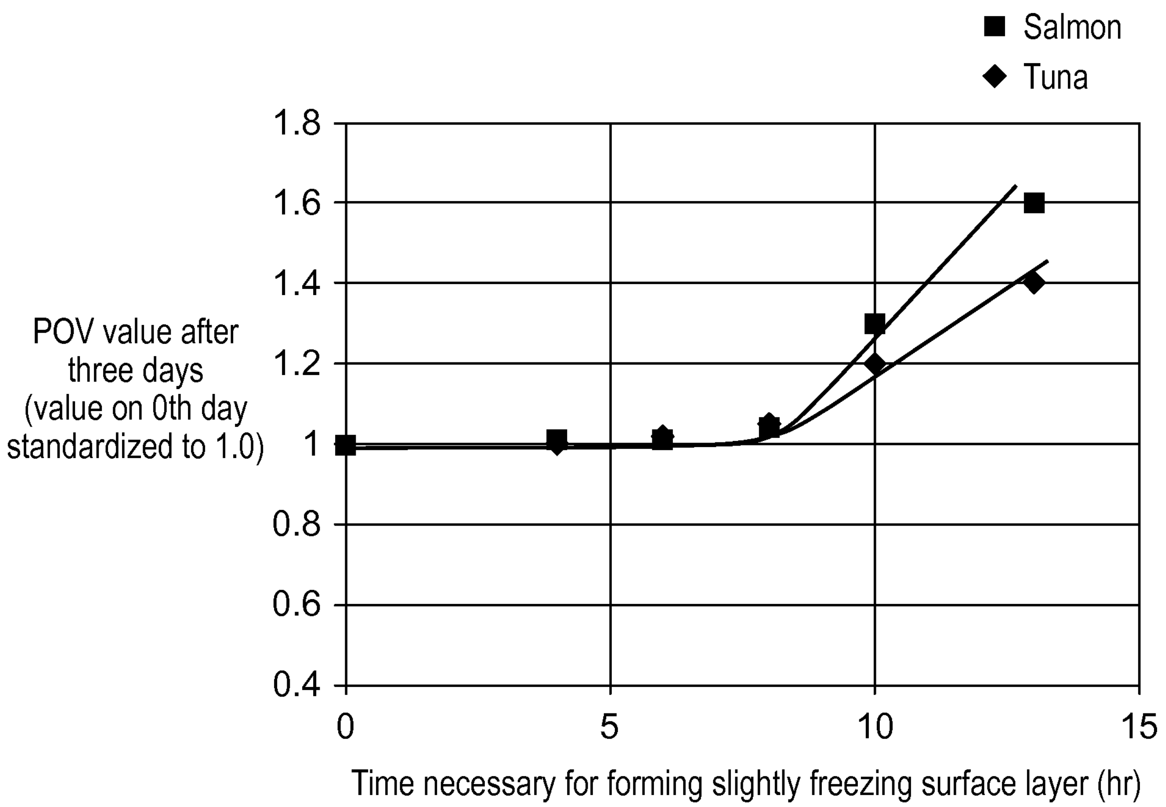
Salmon
Tuna
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
POV value after three days (value on 0th day standardized to 1.0)
0
5
10
15
Time necessary for forming slightly freezing surface layer (hr)

FIG. 9A

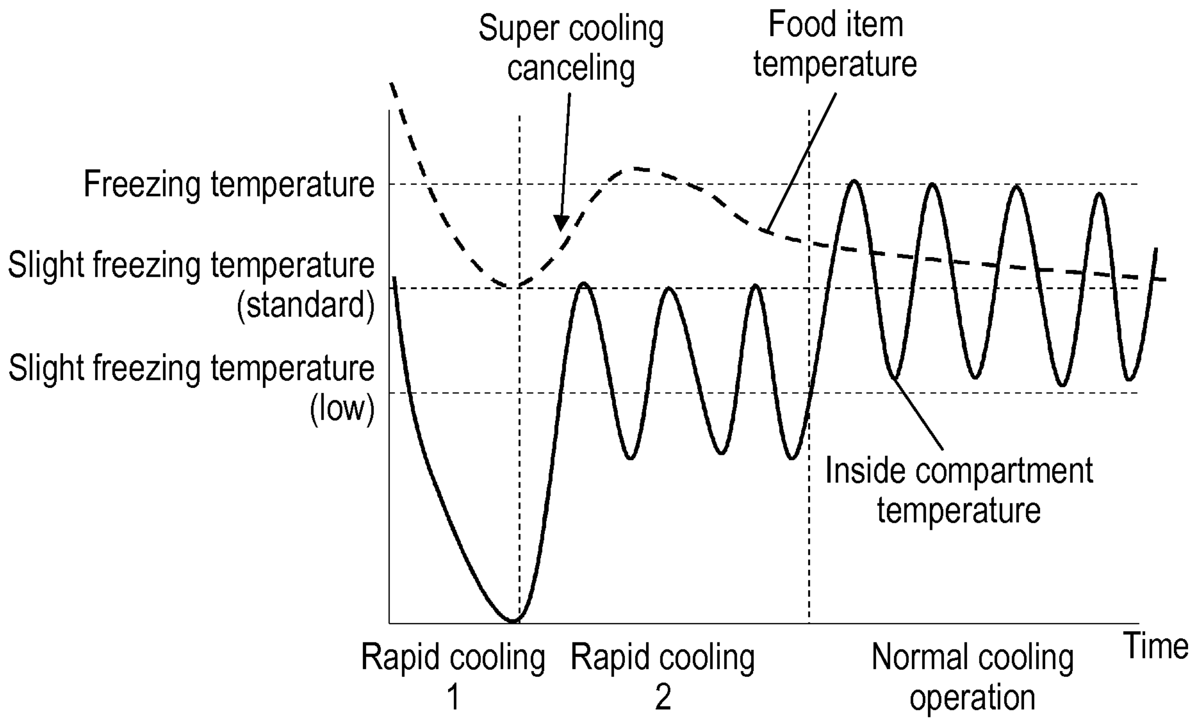

FIG. 9B

	Rapid cooling 1	Rapid cooling 2	Normal operation
Purpose	Rapid cooling	Super cooling canceling	Slight freezing completion
Temperature difference	Large	Medium	Small
Volume	Large	Large	Small

FIG. 10A

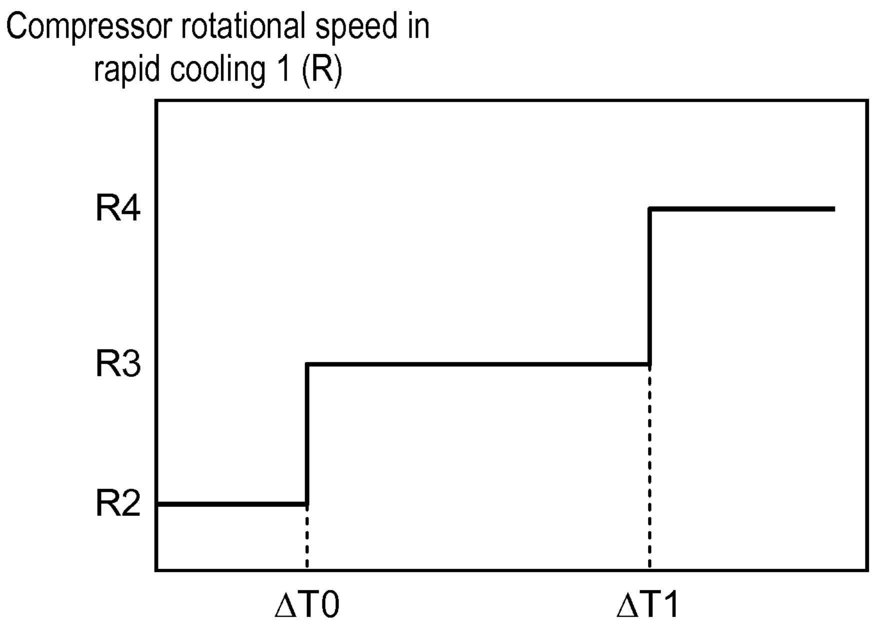

FIG. 10B

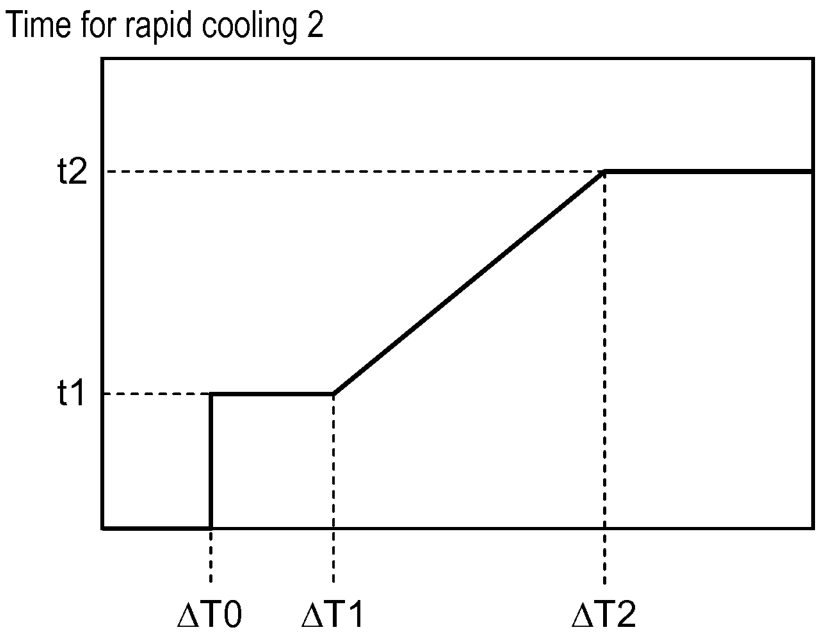

FIG. 11A

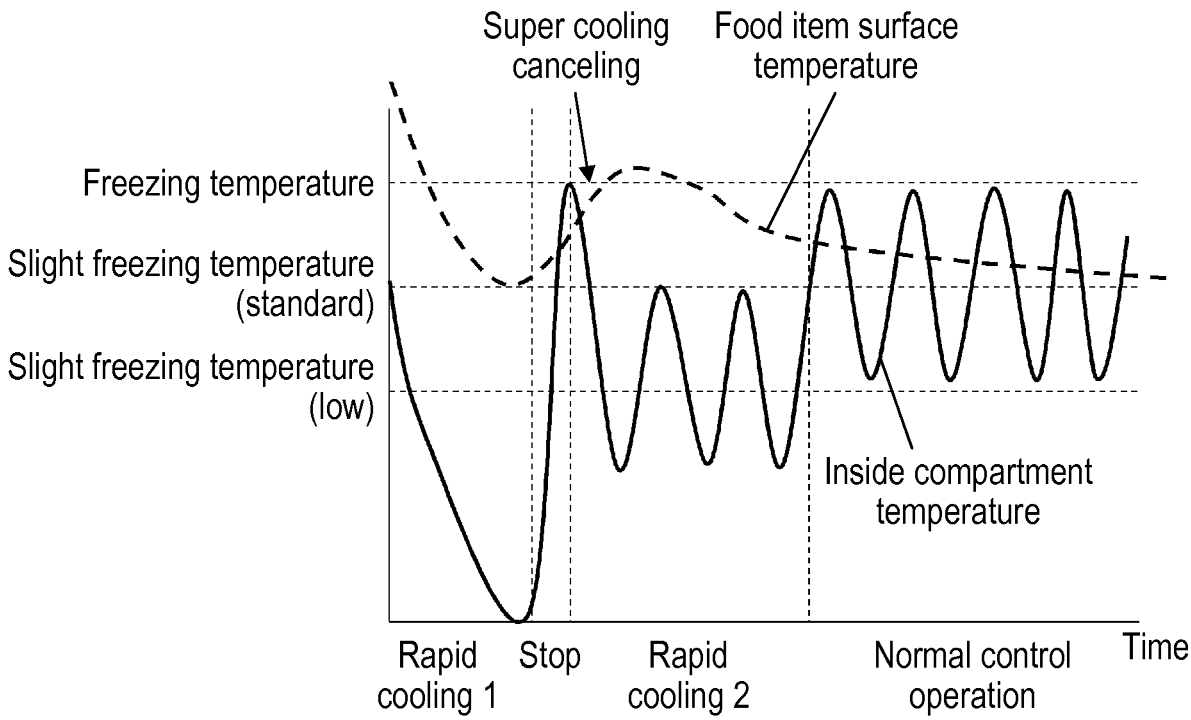

FIG. 11B

	Rapid cooling 1	Stop	Rapid cooling 2	Normal operation
Purpose	Rapid cooling	Super cooling canceling	Slight freezing progress	Slight freezing completion
Temperature difference	Large	Small	Medium	Small
Volume	Large	Zero	Large	Small

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/004067

A. CLASSIFICATION OF SUBJECT MATTER
F25D11/00(2006.01)i, *F25D17/08*(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, F25D17/08

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	1996-2016
Kokai Jitsuyo Shinan Koho	1971-2016	Toroku Jitsuyo Shinan Koho	1994-2016

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 2002-022335 A (Toshiba Corp.), 23 January 2002 (23.01.2002), paragraphs [0018] to [0061]; fig. 1 to 10 & TW 548392 B	1-4 5-6
Y	JP 2010-035484 A (Mitsubishi Electric Corp.), 18 February 2010 (18.02.2010), paragraphs [0040] to [0046]; fig. 11 & CN 101642268 A & TW 201010627 A	5-6

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 November 2016 (21.11.16)	29 November 2016 (29.11.16)

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

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

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 4121197 B **[0006]**