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(71) Applicant (*for all designated States except US*): **LG ELECTRONICS, INC.** [KR/KR]; 20, Yoido-dong, Yongdungpo-ku, Seoul 150-010 (KR).

(72) Inventors; and
(75) Inventors/Applicants (*for US only*): **KIM, Su-Cheong** [KR/KR]; 906, Educational-Industrial Complex, Busan National University, Jangjun 2-dong, Gumjung-gu, Busan 609-735 (KR). **SHIN, Jong-Min** [KR/KR]; 110-1003 Samsung Apt., Munhyun-dong, Nam-gu, Busan 608-040 (KR). **LEE, Su-Won** [KR/KR]; 108-1801 Daedonghwangtobang 1-cha Apt., Daebang-dong, Changwon-city, Gyeongsangnam-do 641-100 (KR). **KIM, Cheol-Hwan** [KR/KR]; 1205-703 Buyoung Apt., Buguk-ri, Jangyu-myun, Gimhae-city, Gyeongsangnam-do 621-833 (KR). **KWON, Yong-Chol** [KR/KR]; 101-1104 Hanrim Elysion Apt., Namyang-dong, Changwon-city, Gyeongsangnam-do 641-091 (KR). **SON, Ku-Young** [KR/KR]; 101-1402 Greencore Apt., Manduk 3-dong, Buk-gu, Busan 616-782 (KR).

(74) Agent: **LEE, Kwang-Yeon**; Lee & Kim, 5th Floor, New-Seoul Bldg., 828-8 Yoksam 1-dong, Kangnam-ku, Seoul 135-935 (KR).

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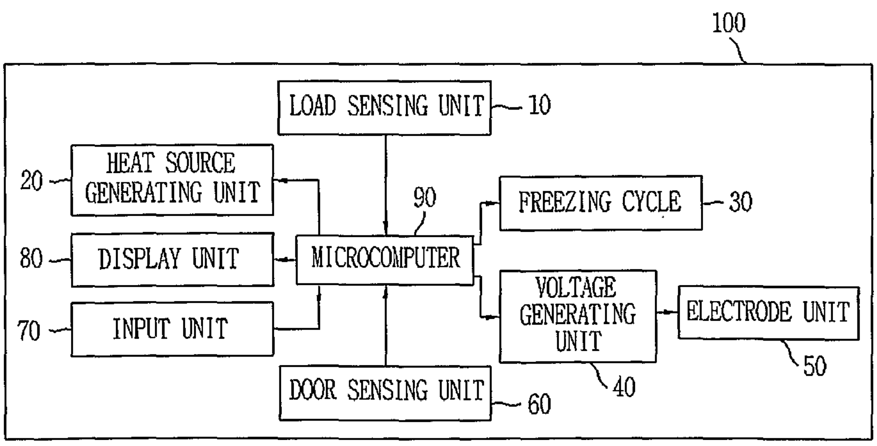

(57) Abstract: The present invention discloses a refrigerator which can keep the contents in a non-frozen state by an electric field generated by a radio frequency voltage. The refrigerator includes a setting unit for setting a amplitude and frequency cf a voltage, a generating unit for generating an electric field according to the voltage having the set amplitude and frequency, and applying the electric field to a storing space for storing the contents, and a freezing cycle for cooling the storing space. The contents are kept in a non-frozen state below a phase transition temperature.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Description

REFRIGERATOR

Technical Field

[1] The present invention relates to a refrigerator, and more particularly, to a refrigerator which can keep the contents in a non-frozen state by an electric field generated by a radio frequency voltage.

Background Art

[2] In general, an electrostatic atmosphere is made in a refrigerator, and meats and fishes are thawed in the refrigerator at a minus temperature. In addition, fruits are kept fresh in the refrigerator.

[3] This technology uses supercooling. Supercooling means that a molten object or a solid cooled below a phase transition temperature in a balanced state is not changed.

[4] This technology is mentioned in Korea Laid-Open Patent Official Gazette 2000-0011081 disclosing an electrostatic field processing method, an electrostatic field processing apparatus, and electrodes therefor.

[5] Fig. 1 is a structure view illustrating a conventional apparatus for thawing and freshness keeping. A cooling box 1 includes an insulation 2 and an outer wall 5. A temperature control device (not shown) is installed in the cooling box 1. A metal shelf 7 installed in the cooling box 1 has a two layer structure. Vegetables, meats or marine products are mounted on each layer for thawing, freshness keeping or ripening. The metal shelf 7 is isolated from the bottom of the cooling box 1 by insulators 9. A high voltage generating device 3 can generate 0 to 5000V of DC and AC voltages. The inner surface of the insulation 2 is covered with an insulating plate 2a such as vinyl chloride. A high voltage cable 4 for outputting the voltage of the high voltage generating device 3 accesses the metal shelf 7 through the outer wall 5 and the insulation 2.

[6] When the user opens a door installed on the front surface of the cooling box 1, a safety switch 13 (refer to Fig. 2) is turned off to block the output of the high voltage generating device 3.

[7] Fig. 2 is a circuit view illustrating the high voltage generating device 3. 100V of AC is supplied to a primary side of a voltage adjusting transformer 15. Reference numeral 11 denotes a power lamp and 19 denotes an operating state lamp. When the door 6 is closed and the safety switch 13 is on, a relay 14 is operated. The operation of the relay 14 is displayed by a relay operation lamp 12. Relay contact points 14a, 14b

and 14c are closed by the operation of the relay 14, and 100V of AC is applied to the primary side of the voltage adjusting transformer 15.

[8] The applied voltage is adjusted by an adjusting knob 15a at a secondary side of the voltage adjusting transformer 15. The adjusted voltage is displayed on a voltmeter. The adjusting knob 15a is connected to a primary side of a boosting transformer 17 at the secondary side of the voltage adjusting transformer 15. The boosting transformer 17 boosts a voltage at a rate of 1:50. For example, when 60V of voltage is applied, it is boosted to 3000V.

[9] One end O_1 of the secondary side output of the boosting transformer 17 is connected to the metal shelf 7 isolated from the cooling box 1 through the high voltage cable 4, and the other end O_2 of the output is grounded. Since the outer wall 5 is grounded, if the user contacts the outer wall 5 of the cooling box 1, he/she does not receive an electric shock. In Fig. 1, the metal shelf 7 exposed in the cooling box 1 must be maintained in an insulated state. It is thus necessary to separate the metal shelf 7 from the walls of the cooling box 1 (the air performs insulation). If the contents 8 mounted on the metal shelf 7 contact the walls of the cooling box 1, the current flows to the ground through the walls of the cooling box 1. Drop of the applied voltage is prevented by adhering the insulating plate 2a to the inner walls. When the metal shelf 7 is not exposed but covered with vinyl chloride, an electric field atmosphere is made in the whole cooling box 1.

[10] The conventional cooling box 1 controls only the amplitude of the voltage applied to the metal shelf 7 to supercool the foods. Accordingly, supercooling occurs at -5°C, to prevent freezing of the foods. In the case that the amplitude of the voltage is varied, a minimum temperature for generating supercooling is -5°C. The foods cannot be supercooled below -5°C. In addition, the conventional art does not suggest a control apparatus and method based on a state of foods.

Disclosure of Invention

Technical Problem

[11] An object of the present invention is to provide a refrigerator which can lower a minimum temperature for generating supercooling.

[12] Another object of the present invention is to provide a refrigerator which uses an appropriate region of energy keeping the contents in a non-frozen state, when the user intends to keep the contents in the non-frozen state.

[13] Yet another object of the present invention is to provide a refrigerator which can ef-

ficiently perform non-freezing control according to a degree of load in a storing space.

[14] Yet another object of the present invention is to provide a refrigerator which can control a temperature of the contents kept in a non-frozen state by adjusting energy supplied to the contents.

[15] Yet another object of the present invention is to provide a refrigerator which can efficiently execute a non-freezing mode by checking a state of the contents in a storing space.

[16] Yet another object of the present invention is to provide a refrigerator which can notify a state of the contents to the user.

[17] Yet another object of the present invention is to provide a refrigerator which can minimize damages of the contents by executing a freezing release mode according to a state of the contents.

Technical Solution

[18] In order to achieve the above-described objects of the invention, there is provided a refrigerator, including: a setting unit for setting a amplitude and frequency of a voltage; a generating unit for generating an electric field according to the voltage having the set amplitude and frequency, and applying the electric field to a storing space for storing the contents; and a freezing cycle for cooling the storing space, whereby the contents are kept in a non-frozen state below a phase transition temperature.

[19] Preferably, the setting unit sets the amplitude and frequency of the voltage according to a degree of load in the storing space.

[20] Preferably, the refrigerator further includes a load sensing unit for sensing the degree of load in the storing space.

[21] Preferably, the degree of load includes at least one of a capacity of the storing space, a kind and state of the contents, and a temperature of the storing space.

[22] Preferably, the refrigerator further includes a current sensing unit for sensing a current flowing through the generating unit.

[23] Preferably, the refrigerator further includes a heat source generating unit for forcibly raising a temperature of the storing space or the contents.

[24] Preferably, the refrigerator further includes a display unit for notifying the state of the contents to the user.

[25] According to another aspect of the present invention, there is provided a refrigerator, including: an energy setting unit for setting a quantity of energy according to a degree of load in a storing space for storing the contents; an energy generating unit

for generating the set quantity of energy and applying the energy to the storing space; and a freezing cycle for cooling the storing space, whereby the contents are kept in a non-frozen state below a phase transition temperature.

[26] According to yet another aspect of the present invention, there is provided a refrigerator, including: a setting unit for setting a amplitude of a voltage having a high frequency characteristic; a generating unit for generating an electric field according to the set voltage, and applying the electric field to a storing space for storing the contents; and a freezing cycle for cooling the storing space, whereby the contents are kept in a non-frozen state below a phase transition temperature.

[27] According to yet another aspect of the present invention, there is provided a control method of a refrigerator, including the steps of: checking a state of the contents stored in a storing space; and executing a non-freezing mode or a freezing release mode according to the checking result.

Brief Description of the Drawings

[28] The present invention will become better understood with reference to the accompanying drawings which are given only by way of illustration and thus are not limitative of the present invention, wherein:

[29] Fig. 1 is a structure view illustrating a conventional apparatus for thawing and freshness keeping;

[30] Fig. 2 is a circuit view illustrating a high voltage generating device of Fig. 1;

[31] Fig. 3 is a block diagram illustrating a refrigerator in accordance with the present invention;

[32] Figs. 4 and 5 are structure views illustrating examples of the refrigerator in accordance with the present invention;

[33] Figs. 6 and 7 are graphs showing supercooling in the refrigerator in accordance with the present invention;

[34] Figs. 8 and 9 are graphs showing correlation between power and a non-freezing temperature in the simplified refrigerator in accordance with the present invention;

[35] Figs. 10 to 12 are graphs showing relation curves between a voltage and a frequency for maintaining a non-frozen state according to a degree of load;

[36] Figs. 13 and 14 are a structure view illustrating current sensing by a current sensor, and a graph showing relation between a current and a quantity of the contents;

[37] Figs. 15 to 17 are graphs showing data sensed by a current or voltage sensor; and

[38] Fig. 18 is a graph showing a temperature of the contents sensed by a temperature sensor.

Mode for the Invention

[39] A refrigerator in accordance with the present invention will now be described in detail with reference to the accompanying drawings.

[40] Fig. 3 is a block diagram illustrating the refrigerator in accordance with the present invention, and Figs. 4 and 5 are structure views illustrating examples of the refrigerator in accordance with the present invention.

[41] The refrigerator 100 includes a load sensing unit 10 for checking a state of a storing space A or B and the contents (not shown) stored in the storing space A or B, a heat source generating unit 20 for generating heat in the storing space A or B or the contents, a freezing cycle 30 for cooling the storing space A or B, a voltage generating unit 40 for generating a voltage to apply an electric field to the storing space A or B, an electrode unit 50 for receiving the voltage and generating the electric field, a door sensing unit 60 for sensing opening and closing of a door 120, an input unit 70 for enabling the user to input a degree of cooling, or selection of a non-freezing mode or a freezing release mode, a display unit 80 for displaying an operating state of the refrigerator 100, and a microcomputer 90 for controlling freezing or refrigerating of the refrigerator 100, and executing the non-freezing mode and the freezing release mode using supercooling. A power supply unit (not shown) is essentially installed to supply power to the aforementioned elements. However, power supply is easily recognized by those skilled in the art, and thus explanations thereof are omitted.

[42] In detail, the load sensing unit 10 senses or stores the state of the storing space A or B and the state of the contents stored in the storing space A or B, and transmits the sensing result to the microcomputer 90. For example, the load sensing unit 10 can be a thermometer for storing information on a capacity of the storing space A or B which is the state of the storing space A or B, or sensing a temperature of the storing space A or B or the contents, or a hardness meter, an ammeter, a voltmeter, a scale, an optical sensor (or laser sensor) or a pressure sensor for deciding whether the contents have been stored in the storing space A or B. Especially, the load sensing unit 10 can be the ammeter or the voltmeter. When the storing space A or B is empty and when the contents are stored in the storing space A and B, an electric field applied resistor has different resistance values. Therefore, whether the contents have been stored can be checked by the different resistance values and resulting current values. The microcomputer 90 confirms a quantity and a moisture content of the contents according to the current value, the voltage value and the resistance value from the load sensing unit 20, and identifies a kind of the contents having the moisture content.

[43] In addition, the load sensing unit 10 can sense a frozen state of the contents cooled in a keeping mode or a non-freezing mode. For example, if the contents having a liquid phase are kept below a phase transition temperature, the load sensing unit 10 senses phase transition of the contents. The load sensing unit 10 can be a temperature sensor for sensing a temperature of the contents, a voltage sensor or a current sensor for sensing a voltage or a current by an electric field flowing thorough the contents in the non-freezing mode, or a hardness sensor for deciding freezing by phase transition by sensing hardness of the contents. The process of checking the state of the contents by the load sensing unit 10 will later be explained in detail.

[44] The heat source generating unit 20 forcibly raises the temperature of the storing space A or B or the contents as in a ripening mode of the refrigerator 100. For example, a heater for raising the temperature of the contents by externally generating and transmitting heat to the contents, or a means for generating heat in the contents by applying electric waves such as microwaves to the contents can be used as the heat source generating unit 20.

[45] The freezing cycle 30 is classified into indirect cooling and direct cooling according to a method of cooling the contents. Fig. 4 shows an indirect cooling type refrigerator and Fig. 5 shows a direct cooling type refrigerator, which will later be explained in detail.

[46] The voltage generating unit 40 generates an AC voltage according to a predetermined amplitude and frequency. The voltage generating unit 40 generates the AC voltage by varying at least one of the amplitude of the voltage and the frequency of the voltage. Especially, the voltage generating unit 40 applies the AC voltage generated according to the set values (amplitude of voltage, frequency of voltage, etc.) of the microcomputer 90 to the electrode unit 50, so that the resulting electric field can be applied to the storing space A or B. In accordance with the present invention, the voltage generating unit 40 variably sets the frequency of the voltage.

[47] The electrode unit 50 converts the AC voltage from the voltage generating unit 40 into the electric field, and applies the electric field to the storing space A or B. Generally, the electrode unit 50 is a plate or conductive wire made of Cu or Pt.

[48] Since the electric field applied to the storing space A or B or the contents by the electrode unit 50 originates from the radio frequency AC voltage, polarity of the electric field is varied according to the frequency. The water molecules containing O having polarity and H having + polarity are continuously vibrated, rotated and translated by the electric field, and thus maintained in the liquid phase below the phase

transition temperature without crystallization.

[49] If the voltage has a frequency below 1kHz, the electrode unit 50 cannot pass through an insulating material in a casing 110. Even if rotation of water molecules of the contents is induced according to the frequency, the speed and vibration are weak, so that phase transition to a solid occurs at a phase transition temperature. Therefore, the voltage generating unit 40 uses the AC voltage having a frequency of a radio frequency band. The voltage and frequency regions will be discussed later.

[50] The door sensing unit 60 stops the operation of the voltage generating unit 40 by opening of the door 120 for opening and closing the storing space A or B. The door sensing unit 60 can notify opening to the microcomputer 90 to perform the stop operation, or stop the voltage generating unit 40 by shorting out power applied to the voltage generating unit 40.

[51] The input unit 70 enables the user to input execution of the non-freezing mode for the storing space A or B or the contents as well as temperature setting for freezing and refrigerating control, and selection of a service type (flake ice, water, etc.) of a dispenser. In addition, the user can input information on the contents such as the kind of the contents through the input unit 70. The input unit 70 can be a barcode reader or an RFD reader for providing the information on the contents to the microcomputer 90.

[52] The display unit 80 basically displays a freezing temperature, a refrigerating temperature and the service type of the dispenser, and additionally displays the keeping mode, the ripening mode, the frozen state, the non-freezing mode, the freezing release mode, and the state of the storing space A or B or the contents (for example, quantity of contents, storage or non-storage, freezing or non-freezing, etc.)

[53] The microcomputer 90 basically controls freezing and refrigerating, and further executes the non-freezing mode according to the present invention.

[54] The microcomputer 90 enables the voltage generating unit 40 to generate the AC voltage having the set frequency and amplitude and apply the AC voltage to the electrode unit 50. In this case, the microcomputer 90 fixes the degree of load (for example, a resistance value, a current value, etc.) from the load sensing unit 10 to specific values, and makes the voltage generating unit 40 generate the AC voltage having the frequency and amplitude corresponding to the degree of load. In addition, it can be applied when the kind of the contents stored in the storing space A or B is preset (for example, a meat storing space, a vegetable storing space, a fruit storing space, a wine storing space, etc.).

[55] When the microcomputer 90 executes the non-freezing mode, the microcomputer

90 decides the operation or intensity of the non-freezing mode according to the sensing result of the load sensing unit 10.

[56] In regard to the operation of the non-freezing mode, when the microcomputer 90 decides that nothing is stored in the storing space A or B according to the sensing result of the load sensing unit 10, the microcomputer 90 needs not to operate the non-freezing mode. Accordingly, the microcomputer 90 displays the non-stored state on the display unit 80 and does not operate the non-freezing mode, thereby reducing power consumption and rapidly notifying the current state to the user.

[57] In regard to the intensity of the non-freezing mode, when the microcomputer 90 executes the non-freezing mode, the microcomputer 90 can set or vary a non-freezing temperature for executing the non-freezing mode. Here, the microcomputer 90 can set or vary the non-freezing temperature according to relation between energy in cooling (energy taken from the contents) and energy applied by the electric field (energy supplied to the contents) discussed later. In addition, the microcomputer 90 checks a quantity of the contents stored in the storing space A or B according to the sensing result of the load sensing unit 10, and adjusts a amplitude and frequency of a voltage to apply an electric field according to the quantity of the contents, thereby controlling the intensity of the non-freezing mode. As a result, the microcomputer 90 generates the electric field having appropriate intensity according to the quantity of the contents, which results in low power consumption.

[58] The microcomputer 90 notifies information on the quantity of the contents based on the sensing result to the user through the display unit 80. Therefore, the user can acquire information on a free space without checking the storing space A or B.

[59] The microcomputer 90 recognizes the frozen state of the contents according to the sensed or measured value of the load sensing unit 10, and executes the freezing release mode. If the freezing mode is being executed by the freezing cycle 30, the microcomputer 90 releases freezing of the contents by executing the refrigerating mode, or by forcibly raising the temperature of the storing space A or B or the contents by operating the heat source generating unit 20 in addition to the refrigerating mode. When freezing is released by the heat source generating unit 20, all the contents in the storing space A or B are affected. Accordingly, the microcomputer 90 must precisely decide the frozen state of the contents according to the sensing result of the load sensing unit 10.

[60] The deciding method of the microcomputer 90 will later be explained.

[61] Figs. 4 and 5 are structure views illustrating examples of the refrigerator in

accordance with the present invention. Fig. 4 is a cross-sectional view illustrating an indirect cooling type refrigerator, and Fig. 5 is a cross-sectional view illustrating a direct cooling type refrigerator.

[62] The indirect cooling type refrigerator includes a casing 110 having one surface opened, and including a storing space A inside and a shelf 130 for partially partitioning the storing space A, and a door 120 for opening and closing the opened surface of the casing 110.

[63] A heat source generating unit 20 is formed in a hot wire type inserted into an inner surface 112b of the casing 110, like a heater.

[64] A freezing cycle 30 of the indirect cooling type refrigerator includes a compressor 32 for compressing refrigerants, an evaporator 33 for generating cool air (indicated by arrows) for cooling the storing space A or the contents, a fan 34 for forcibly flowing the cool air, a suction duct 36 for supplying the cool air to the storing space A, and a discharge duct 38 for inducing the cool air passing through the storing space A to the evaporator 33. Although not illustrated, the freezing cycle 30 further includes a condenser, a drier and an expanding unit.

[65] Electrode units 50a and 50b are formed between the inner surfaces 112a and 112c facing the storing space A and the outer surface of the casing 110. The electrode units 50a and 50b are installed to face the storing space A, for applying an electric field to the whole storing space A. The storing space A is separated from the ends of the electrode units 50a and 50b at predetermined intervals in the inner or center directions of the electrode units 50a and 50b, for applying the uniform electric field to the storing space A or the contents.

[66] The suction duct 36 and the discharge duct 38 are formed on the inner surface 112b of the casing 110 to be isolated from the heat source generating unit 20 at a predetermined interval. The inner surfaces 112a, 112b and 112c of the casing 110 are made of a hydrophobic material, and thus not frozen during the non-freezing mode due to reduction of surface tension of water. The outer surface and the inner surfaces 112a, 112b and 112c of the casing 110 are made of an insulating material, thereby preventing the user from receiving an electric shock from the electrode units 50a and 50b, and preventing the contents from electrically contacting the electrode units 50a and 50b through the inner surfaces 112a, 112b and 112c.

[67] A casing 110, a door 120, a shelf 130 and a heat source generating unit 20 of the direct cooling type refrigerator of Fig. 5 are identical to those of the indirect cooling type refrigerator of Fig. 4. Inner surfaces 114a, 114b and 114c of the casing 110 are

identical to the inner surfaces 112a, 112b and 112c of the casing 110 except for the suction duct 36 and the discharge duct 38.

[68] A freezing cycle 30 of the direct cooling type refrigerator of Fig. 5 includes a compressor 32 for compressing refrigerants, and an evaporator 39 installed in the casing 110 adjacently to the inner surfaces 114a, 114b and 114c of the casing 110 around the storing space B, for evaporating the refrigerants. The direct cooling type freezing cycle 30 includes a condenser (not shown) and an expansion valve (not shown).

[69] Especially, electrode units 50a and 50d are inserted between the evaporator 39 and the casing 110, for preventing cool air from being intercepted by the evaporator 39.

[70] Figs. 6 and 7 are graphs showing supercooling in the refrigerator in accordance with the present invention.

[71] Fig. 6 shows an experiment structure and condition of Fig. 7. Referring to Fig. 7, a storing space S1 is formed in a casing 111, 0.1ℓof distilled water is contained in the storing space S1, and electrodes 50e and 50f are inserted into the sidewalls of the casing 111 to be symmetrically disposed to the storing space S1. The electrode surfaces of the electrodes 50e and 50f facing the storing surface S1 are wider than the surface of the storing space S1. An interval between the electrodes 50e and 50f is 2 0mm. The casing 111 is made of an acrylic material. The casing 111 is kept and cooled in a storing space uniformly supplying cool air (refrigerating apparatus which does not have an additional electric field generator except the electrodes 50e and 50f).

[72] Here, the microcomputer 90 makes the voltage generating unit 40 apply 0.91kV(6.76mA) and 20kHz of Ac voltage to the electrode unit 50, and the temperature of the storing space is about -7°C. As shown in the supercooling graph of Fig. 7, since the refrigerator 100 has supercooling at -6.5°C below the phase transition temperature, it maintains the non-frozen state of water.

[73] The present inventors investigated the survival rate of Giardias, flagellates causing diarrhea to a human body before and after electric field processing. 408 Giardias were used in a non-nutrient state. The present inventors investigated the survival rate of Giardias with the existence and absence of the electric field. When the electric field was not used, 396 Giardias were left, namely, the survival rate was 96.6%. It means that Giardias were not naturally removed. Conversely, when the electric field was used, no Giardia was left. The above experiment result was obtained in the non-nutrient state. However, it was expected that the similar result would be obtained in the nutrient state, namely, the food keeping state of the refrigerator. As described above,

the electric field serves to efficiently remove microorganisms causing decay such as Giardia.

[74] Figs. 8 and 9 are graphs showing correlation between power and the non-freezing temperature in the simplified refrigerator in accordance with the present invention. Figs. 8 and 9 are applied to the experiment structure of Fig. 6. The keeping temperature (control temperature) in the storing space in which the casing 111 is kept, namely, the inside temperature is fixed to -6°C. Here, the microcomputer 90 sets and applies a plurality of quantities of power energy to the voltage generating unit 40, and measures resulting variations of the non-freezing temperature.

[75] Fig. 8 is a graph showing the non-freezing temperature of water supplied with different quantities of power energy. As depicted in Fig. 8, in a reference line 0 which is not supplied with power energy, water is maintained in the non-frozen state to -5°C by cooling, and phase-transited to the frozen state 3 hours from cooling.

[76] In a first energy line I (1.38W), since a quantity of energy applied to water is quite large, even if water is cooled at the phase transition temperature (0°C in 1 air pressure), it is maintained at almost 0°C and not supercooled.

[77] In a second energy line II (0.98W), water is maintained in the supercooled state, and the supercooling temperature ranges from -3 to -3.5°C.

[78] In a third energy line III (0.91W), water is maintained in the supercooled state, and the supercooling temperature ranges from -4 to -5°C.

[79] In a fourth energy line IV (0.62W), water is maintained in the supercooled state, and the supercooling temperature ranges from -5.5 to -5.8°C.

[80] In a fifth energy line V (0.36W), water is frozen (phase transition) without reaching the supercooled state.

[81] Fig. 9 is a graph showing correlation between the first to fifth energy lines I to V of Fig. 8. As shown in Fig. 9, in the cool air supply state, the quantity of the energy applied to the contents, namely, water and the non-freezing temperature of water have proportional relation. That is, when the quantity of the energy applied to the contents is large, the non-freezing temperature rises, and when the quantity of the energy applied to the contents is small, the non-freezing temperature falls. However, if the quantity of energy is too small, it does not cause the motion of the water molecules and adjust the supercooled state, thereby reaching the result of the fifth energy line V.

[82]

[83] In this experiment, the non-freezing temperature is determined according to the quantity of energy applied when the keeping temperature (indoor temperature, inside

temperature) is -6°C. If the keeping temperature is changed, the quantity of the applied energy must be changed. When the keeping temperature is constant, the microcomputer 90 stores the simple correlation information between the quantity of energy and the non-freezing temperature. In the case that the keeping temperature is adjusted or varied, the microcomputer 90 must store the correlation information between the quantity of energy and the non-freezing temperature in consideration of the variations of the keeping temperature.

[84] Figs. 10 to 12 are graphs showing relation curves between the voltage and the frequency for maintaining the non-frozen state according to the degree of load. In the case that the contents are contained in a plastic container and stored in the refrigerator of Fig. 4 or 5, or contained in the casing 111 of Fig. 6 and non-freezing treated, each curve shows the voltage and frequency regions keeping the non-frozen state by supercooling.

[85] Fig. 10 exemplifies water. As a quantity of water increases to 0.1ℓ, 2ℓ, 5ℓ and 10ℓ, when a voltage and a frequency are set in each region to maintain motion of water molecules, the non-frozen state is maintained.

[86] Fig. 11 exemplifies vegetables and shows a voltage and frequency region maintaining the non-frozen state in the same condition as Fig. 10. When a quantity of vegetables is 100g, the non-frozen state is maintained in the voltage and frequency region of Fig. 11.

[87] Fig. 12 exemplifies meat and shows a voltage and frequency region maintaining the non-frozen state in the same condition as Fig. 10. As a quantity of meat increases to 50g, 200g and 3kg, when a voltage and a frequency are set in each region, the non-frozen state is maintained.

[88] The load is varied according to the quantity and kind of the contents. When the voltage and frequency region for maintaining the non-frozen state of the contents is set, even if the kind or quantity of the contents is varied as shown in Figs. 10 to 12, the contents can be kept in the non-frozen state by applying a voltage having at least 1kHz of frequency.

[89] Figs. 13 and 14 are a structure view illustrating current sensing by the current sensor, and a graph showing relation between the current and the quantity of the contents.

[90] Fig. 13 shows a method of forming the load sensing unit 10 which is the current sensor. The load sensing unit 10 must be connected in series to the power source and the electrode units 50a and 50b. That is, the load sensing unit 10 senses the current

applied to the electrode units 50a and 50b and the current flowing through the storing space A and the contents. Fig. 13 exemplifies the indirect cooling type non-freezing refrigerator of Fig. 4. However, the connecting method can be applied to the direct cooling type non-freezing refrigerator of Fig. 5.

[91] Fig. 14 is a graph showing relation between the sensed current value and the quantity of the contents. Referring to Fig. 14, when the current value is approximate to 0, it is decided that nothing is stored in the storing space A or B. As the current value increases, the quantity of the contents increases. The microcomputer 90 can decide storage or non-storage of the contents which is the state of the contents, and the quantity of the contents from the relation graph of Fig. 14. The microcomputer 90 adjusts the operation and intensity of the non-freezing mode according to the decision result, thereby efficiently controlling the non-freezing mode.

[92] Figs. 15 to 17 are graphs showing data sensed by the current or voltage sensor. Here, the data are acquired when the contents are water. When water existing in the supercooled state which is the non-frozen state is instantaneously frozen, the current and power sharply increase. The current sensor and the voltage sensor sense such variations and decide the frozen state.

[93] Fig. 15 is a graph showing variations of a power factor, Fig. 16 is a graph showing variations of power, and Fig. 17 is a graph showing variations of a current. Here, 20kHz of AC voltage is applied. When the power factor, the power and the current sharply increase in each graph, freezing starts. When the microcomputer 90 confirms the sharp increase by the measured values of the load sensing unit 10, the microcomputer 90 decides that the contents have been frozen.

[94] In addition, when the contents start to be frozen, hardness of the contents sharply increases. If the load sensing unit 10 is a hardness sensor which is a contact type sensor, the frozen state is verified by the sharp increase of hardness.

[95] Fig. 18 is a graph showing the temperature of the contents sensed by the temperature sensor. Here, the contents are water. The temperature sensor can be a contact type or a non-contact type.

[96] As illustrated in Fig. 18, when a temperature inside the refrigerator, namely, a control temperature is maintained at about -7°C, the temperature of water is gradually lowered and sharply increased to the phase transition temperature before about -6°C. The sharp temperature rise to the phase transition temperature means phase transition of water. That is, water has been converted into ice. Therefore, the microcomputer 90 confirms the sharp temperature rise and the temperature rise to the phase transition

temperature by the temperature sensed by the temperature sensor which is the load sensing unit 10, and decides that water has been frozen.

[97] In accordance with the present invention, the refrigerator can control and maintain various non-frozen states by lowering the minimum temperature for causing supercooling.

[98] When the user intends to keep the contents in the non-frozen state, the refrigerator uses the appropriate region of energy keeping the contents in the non-frozen state. As a result, the present invention can be easily applied to individual electric apparatuses.

[99] The refrigerator can stably maintain the non-frozen state and reduce power consumption by executing the non-freezing mode according to the degree of load in the storing space.

[100] The refrigerator can control the temperature of the contents kept in the non-frozen state by controlling energy supplied to the contents.

[101] The refrigerator can check the state of the contents in the storing space, notify the state to the user, and efficiently execute the non-freezing mode.

[102] The refrigerator can minimize damages of the contents by executing the freezing release mode according to the state of the contents.

[103] Although the preferred embodiments of the present invention have been described, it is understood that the present invention should not be limited to these preferred embodiments but various changes and modifications can be made by one skilled in the art within the spirit and scope of the present invention as hereinafter claimed.

Claims

[1] A refrigerator, comprising:
a setting unit for setting a amplitude and frequency of a voltage;
a generating unit for generating an electric field according to the voltage having the set amplitude and frequency, and applying the electric field to a storing space for storing the contents; and
a freezing cycle for cooling the storing space,
whereby the contents are kept in a non-frozen state below a phase transition temperature.

[2] The refrigerator of claim 1, wherein the setting unit sets the amplitude and frequency of the voltage according to a degree of load in the storing space.

[3] The refrigerator of claim 1, further comprising a load sensing unit for sensing the degree of load in the storing space.

[4] The refrigerator of either claim 2 or 3, wherein the degree of load comprises at least one of a capacity of the storing space, a kind and state of the contents, and a temperature of the storing space.

[5] The refrigerator of claim 1, further comprising a current sensing unit for sensing a current flowing through the generating unit.

[6] The refrigerator of claim 1, further comprising a heat source generating unit for forcibly raising a temperature of the storing space or the contents.

[7] The refrigerator of claim 1, further comprising a display unit for notifying the state of the contents to the user.

[8] A refrigerator, comprising:
an energy setting unit for setting a quantity of energy according to a degree of load in a storing space for storing the contents;
an energy generating unit for generating the set quantity of energy and applying the energy to the storing space; and
a freezing cycle for cooling the storing space,
whereby the contents are kept in a non-frozen state below a phase transition temperature.

[9] The refrigerator of claim 8, wherein the energy generating unit generates and applies an electric field.

[10] The refrigerator of claim 8, wherein the degree of load comprises at least one of a capacity of the storing space, a kind and state of the contents, and a

temperature of the storing space.

[11] The refrigerator of claim 8, wherein the energy setting unit sets the quantity of energy according to a amplitude and frequency of a voltage.

[12] The refrigerator of claim 8, further comprising a state checking unit for checking a state of the contents.

[13] The refrigerator of claim 12, wherein the state checking unit comprises at least one of a hardness meter, a thermometer, a voltmeter and an ammeter.

[14] The refrigerator of claim 8, further comprising a freezing release unit for releasing freezing according to the state of the contents.

[15] A refrigerator, comprising:
a setting unit for setting a amplitude of a voltage having a high frequency characteristic;
a generating unit for generating an electric field according to the set voltage, and applying the electric field to a storing space for storing the contents; and
a freezing cycle for cooling the storing space,
whereby the contents are kept in a non-frozen state below a phase transition temperature.

[16] The refrigerator of claim 15, wherein the setting unit sets the amplitude of the voltage according to a degree of load in the storing space.

[17] The refrigerator of claim 15, further comprising a state checking unit for checking a non-frozen state of the contents.

[18] The refrigerator of claim 15, further comprising a heat source generating unit for forcibly raising a temperature of the storing space or the contents.

[19] A control method of a refrigerator, comprising the steps of:
checking a state of the contents stored in a storing space; and
executing a non-freezing mode or a freezing release mode according to the checking result.

[20] The control method of claim 19, wherein the state checking step comprises the steps of:
measuring at least one of a temperature, hardness, voltage and current of the contents; and
deciding the state of the contents according to the measured value.

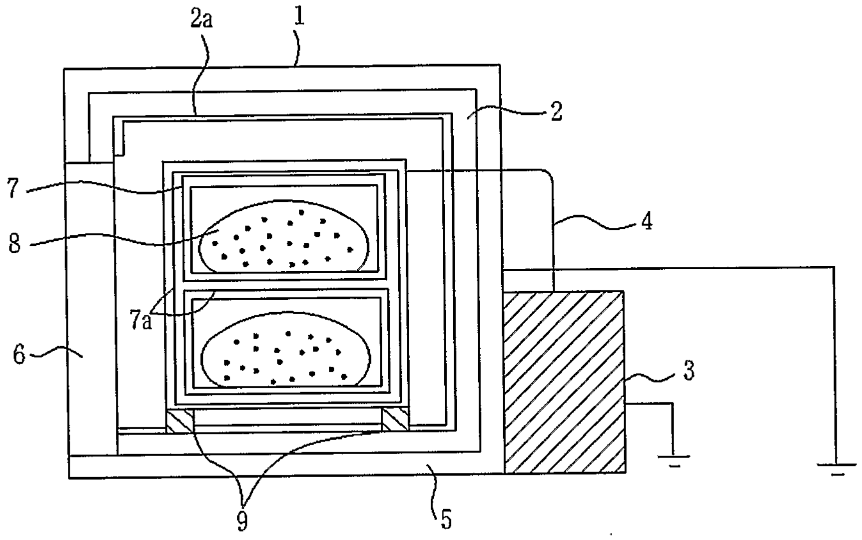
[21] The control method of claim 19, wherein the freezing release mode comprises at least a refrigerating mode.

[22] The control method of claim 19, wherein the freezing release mode comprises a

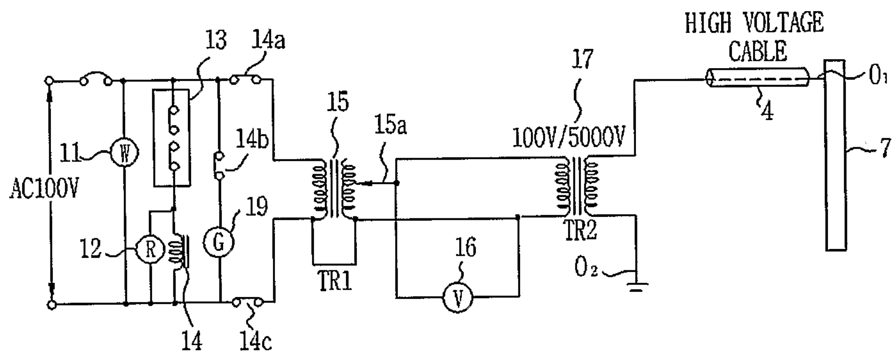
heat generating mode for generating heat in the storing space or the contents.

[23] The control method of claim 19, wherein the step for executing the non-freezing mode comprises a step for controlling an operation or intensity of the non-freezing mode according to the checked result.

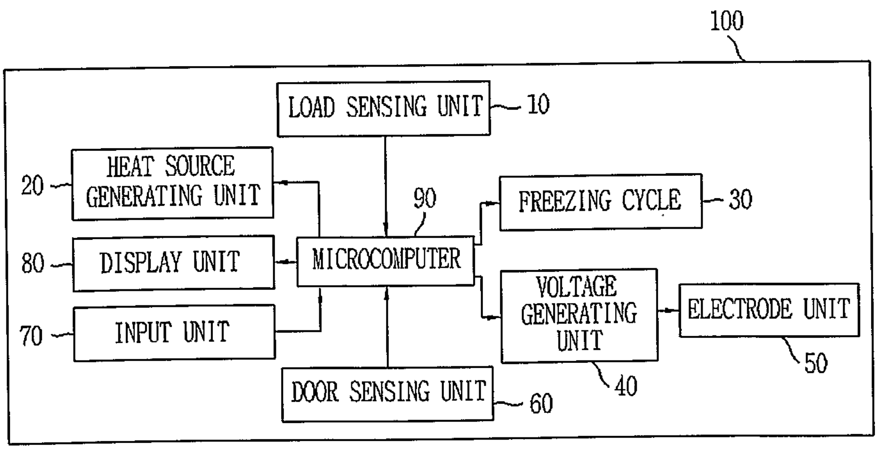
[Fig. 1]



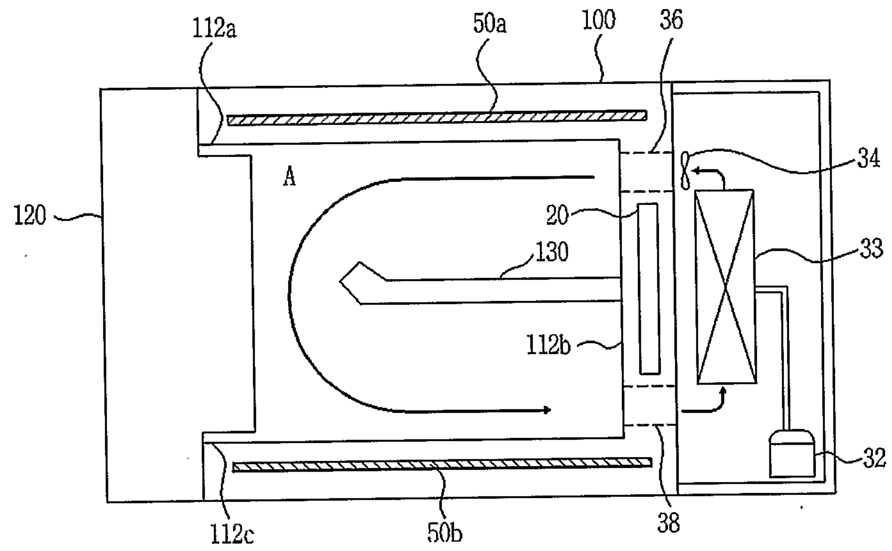
[Fig. 2]



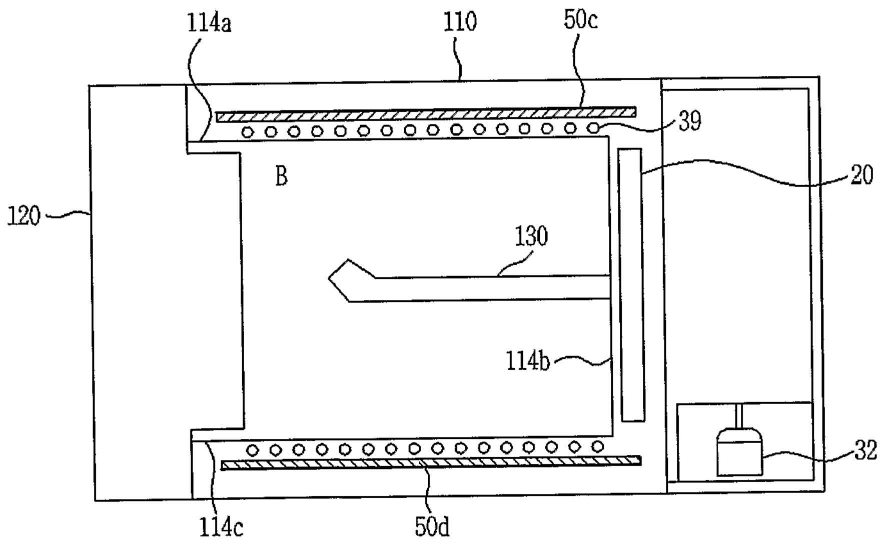
[Fig. 3]



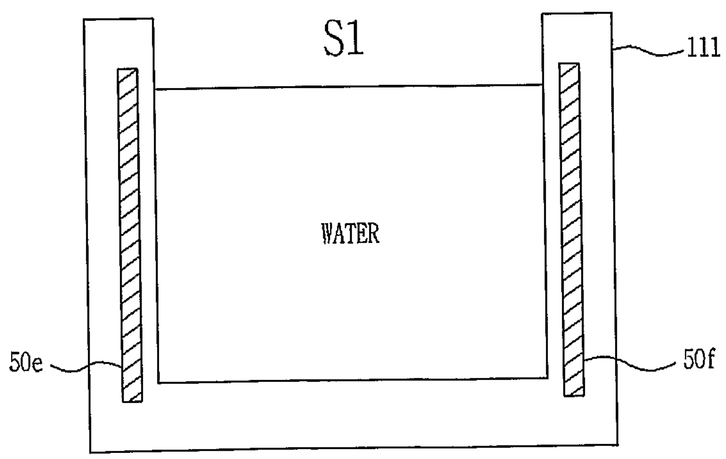
[Fig. 4]



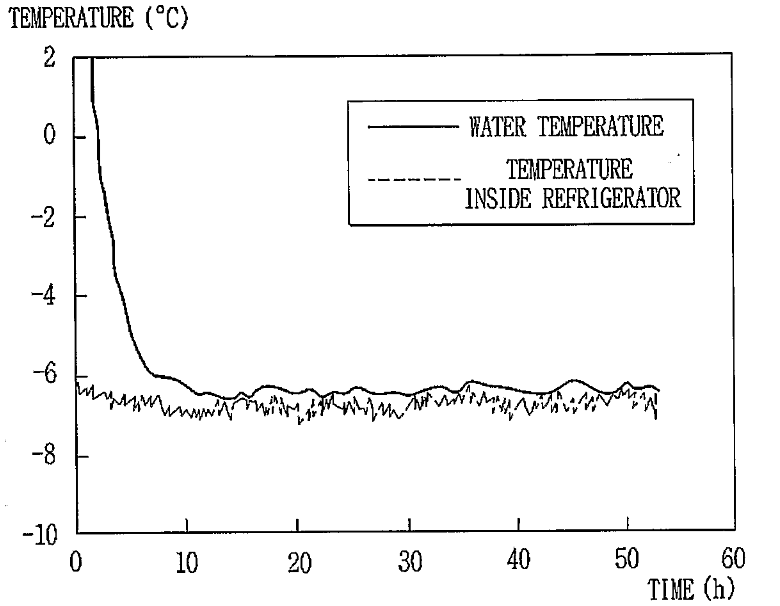
[Fig. 5]



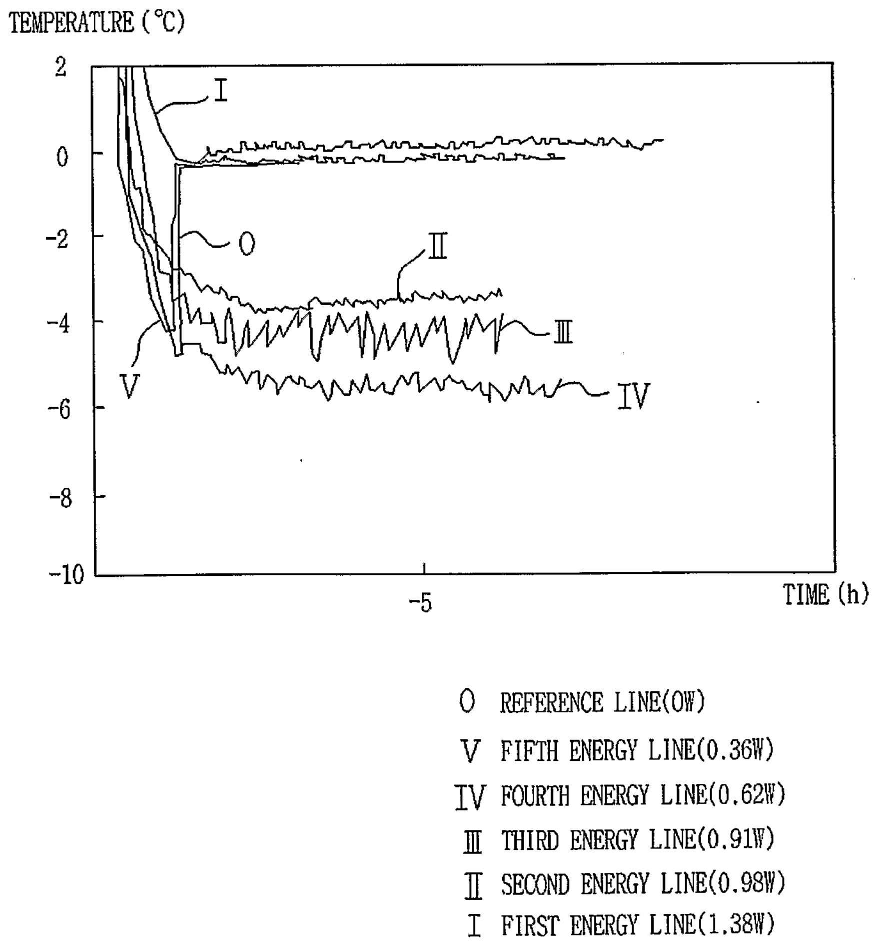
[Fig. 6]



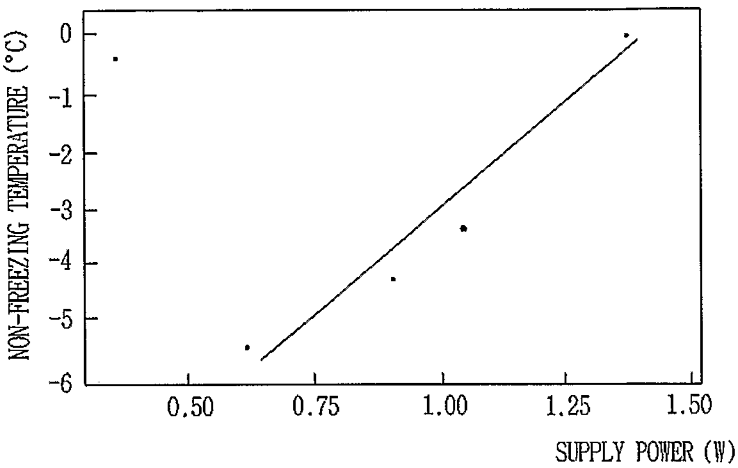
[Fig. 7]


TEMPERATURE (°C)
2
0
-2
-4
-6
-8
-10
WATER TEMPERATURE
TEMPERATURE INSIDE REFRIGERATOR
0
10
20
30
40
50
60
TIME (h)

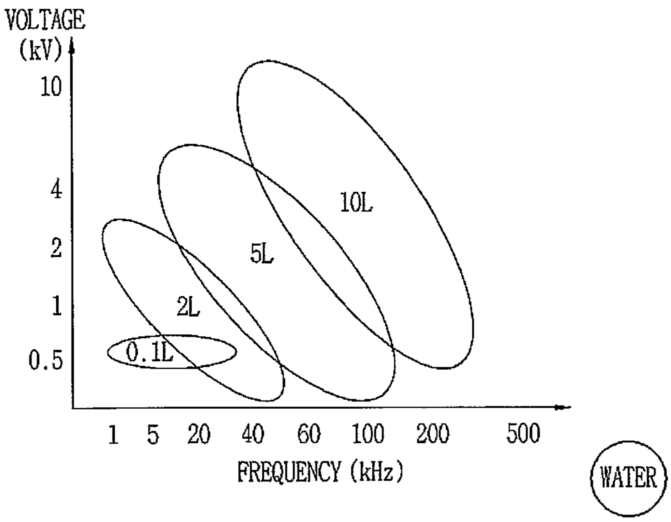
[Fig. 8]


TEMPERATURE (°C)
2
0
-2
-4
-6
-8
-10
I
0
II
III
V
IV
-5
TIME (h)
0 REFERENCE LINE(0W)
V FIFTH ENERGY LINE(0.36W)
IV FOURTH ENERGY LINE(0.62W)
III THIRD ENERGY LINE(0.91W)
II SECOND ENERGY LINE(0.98W)
I FIRST ENERGY LINE(1.38W)

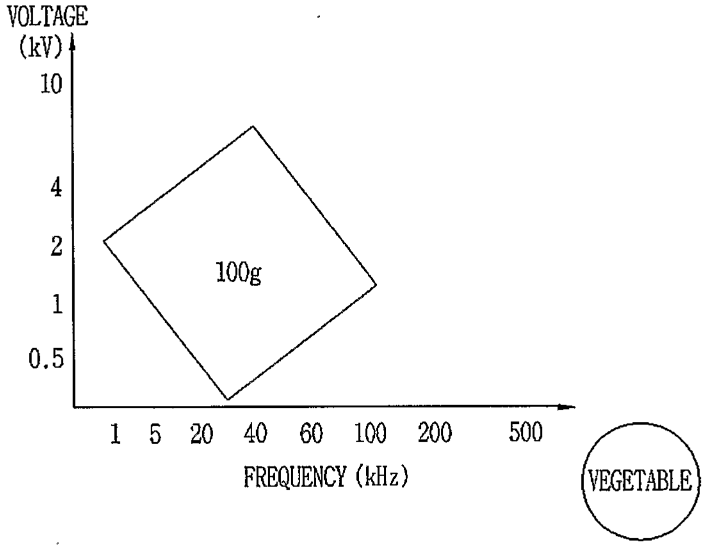
[Fig. 9]


NON-FREEZING TEMPERATURE (°C)
0
-1
-2
-3
-4
-5
-6
0.50
0.75
1.00
1.25
1.50
SUPPLY POWER (W)

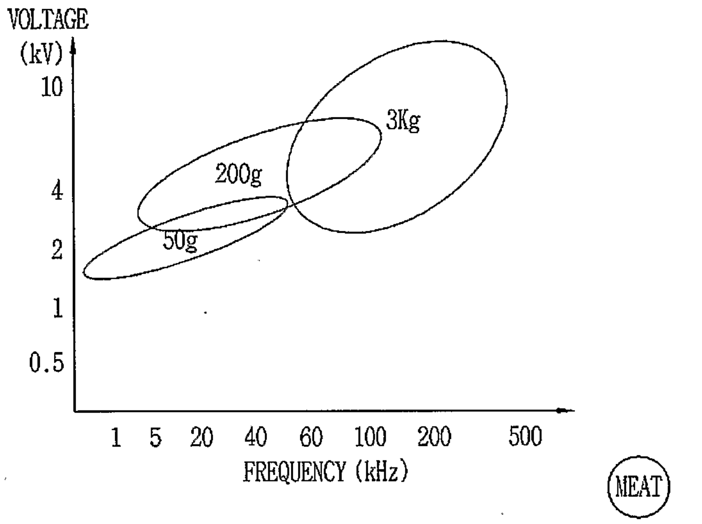
[Fig. 10]


VOLTAGE (kV)
10
4
2
1
0.5
10L
5L
2L
0.1L
1 5 20 40 60 100 200 500
FREQUENCY (kHz)
WATER

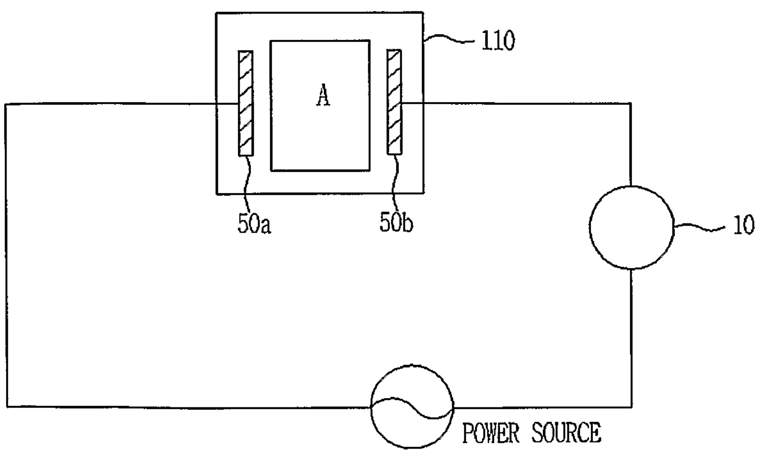
[Fig. 11]



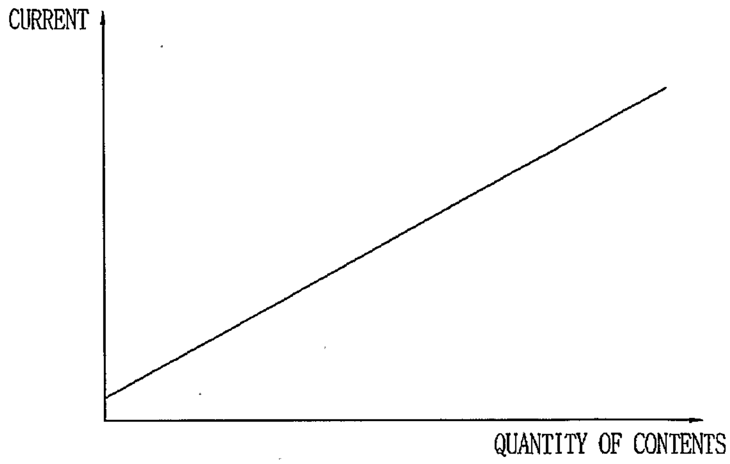
[Fig. 12]



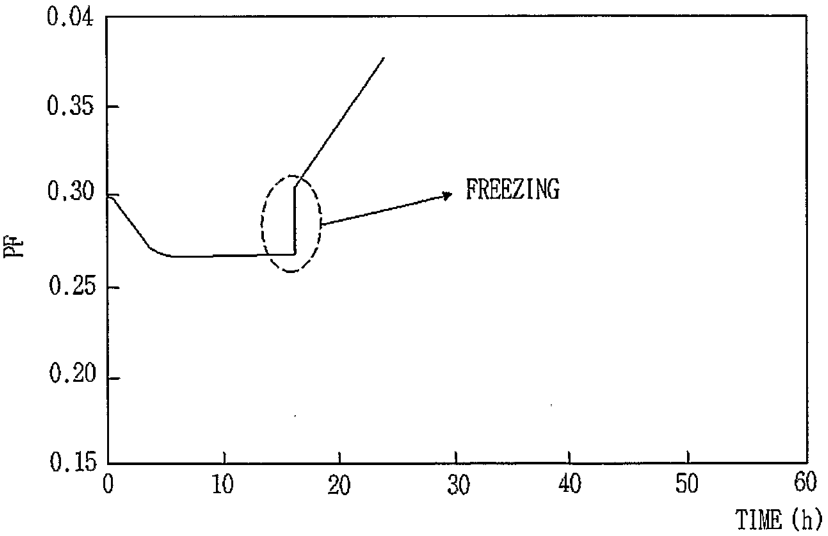
[Fig. 13]



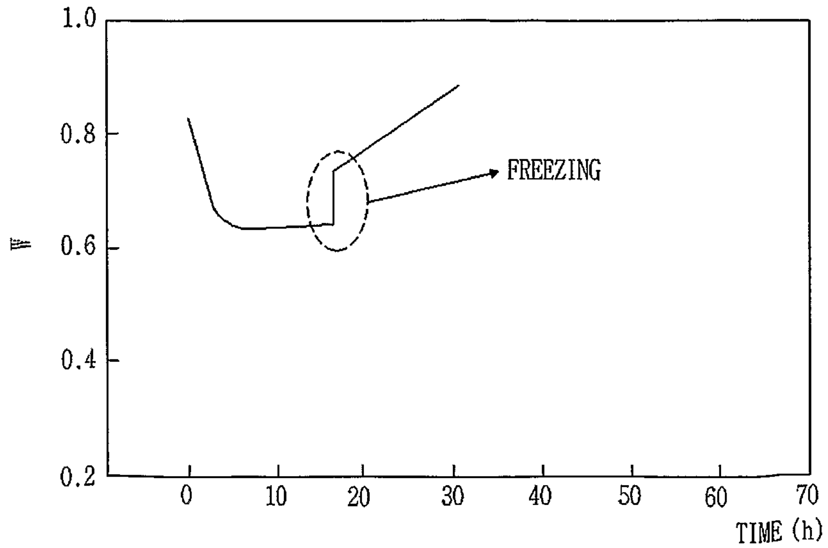
[Fig. 14]



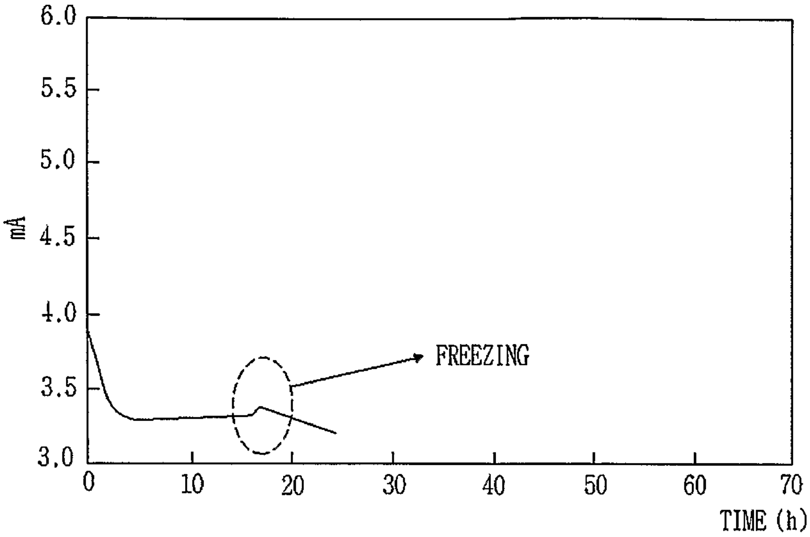
[Fig. 15]



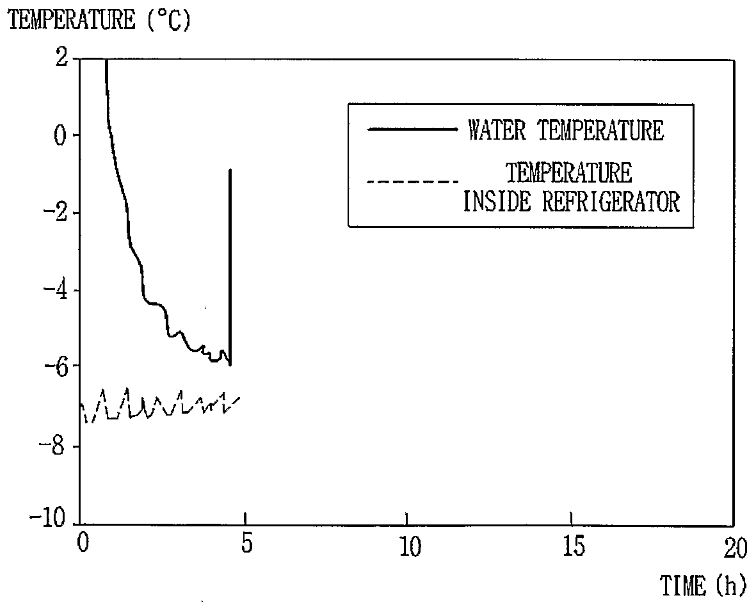
[Fig. 16]



[Fig. 17]


6.0
5.5
5.0
mA 4.5
4.0
3.5
3.0
0
10
20
30
40
50
60
70
TIME (h)
FREEZING

[Fig. 18]


TEMPERATURE (°C)
2
0
-2
-4
-6
-8
-10
0
5
10
15
20
TIME (h)
WATER TEMPERATURE
TEMPERATURE INSIDE REFRIGERATOR