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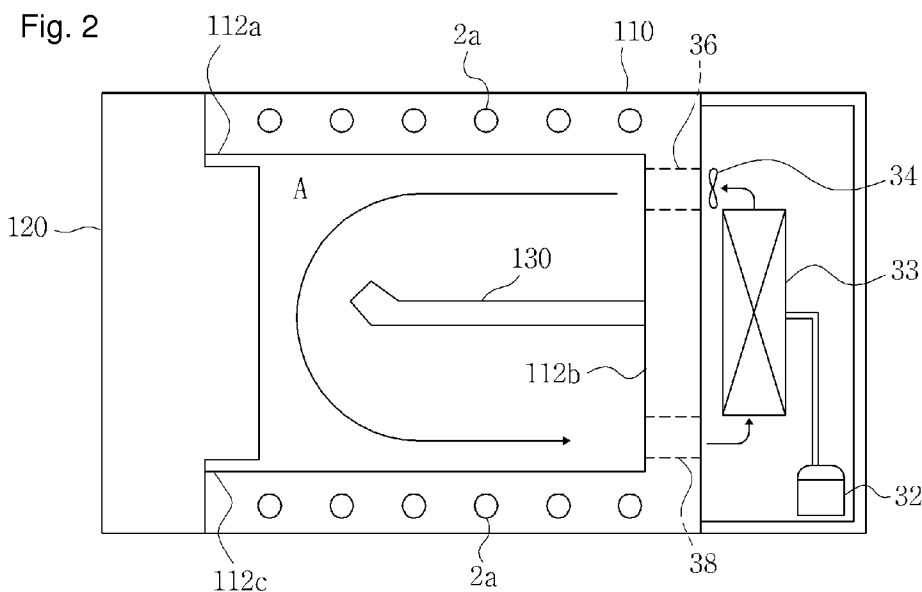
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(54) Title: SUPERCOOLING APPARATUS



(57) Abstract: The present invention is directed to a supercooling apparatus capable of maintaining a supercooled state of a stored item stably for an extended period of time by supplying energy through a magnetic field being generated. The supercooling apparatus comprises: a container having a defined storage space to store an item; a refrigeration cycle for cooling the storage space; and a power supply path consisting of wires wound around the storage space and a power source for supplying power to the wires, so as to maintain the stored item in a non-frozen state at a phase transition temperature or below.

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# Description

## SUPERCOOLING APPARATUS

### Technical Field

- [1] The present invention relates to a supercooling apparatus, and more particularly, to a supercooling apparatus capable of maintaining a supercooled state of a stored item stably for an extended period of time by supplying energy through a magnetic field being generated.

### Background Art

- [2] A term "supercooling" describes a phenomenon that melt or solid does not change even after it is cooled down to a temperature lower than the phase transition temperature at equilibrium state. In general, every material has its own stable state at a given temperature, so if temperature changes gradually, atoms of the substance keep abreast with the changes of temperature while maintaining its stable state at each temperature. However, if temperature changes abruptly, there is not enough time for the atoms to get into a stable state corresponding to each temperature. What happens then is the atoms either keep the stable state at a start temperature, or partially change to a state at a predetermined end temperature then stop.
- [3] For example, when water is cooled slowly, it does not freeze for some time even though the temperature is below 0°C. However, when an object becomes a supercooled state, it is a sort of metastable state where the unstable equilibrium state breaks easily even by a very small stimulus or minor external disturbance, so the object easily transits to a more stable state. That is to say, if a small piece of the material is put into a supercooled liquid, or if the liquid is subject to impact on a sudden, it starts being solidified immediately and temperature of the liquid is raised to a freezing point, maintaining a stable equilibrium state at the temperature.
- [4] Normally, foods like vegetables, fruits, meats, or beverages are kept either refrigerated or frozen to retain freshness. Those foods contain liquid such as water. When the liquid is cooled below the phase transition temperature, it transits to a solid phase at one point.
- [5] Although a certain stored item like water can be kept in a supercooled state for a short period of time, there are increasing demands nowadays for keeping foods in a supercooled state for an extended period of time.

### Disclosure of Invention

#### Technical Problem

- [6] The present invention is directed to provide a supercooling apparatus that is capable of maintaining the supercooled state of a stored item stably for a long period of time,

by supplying energy to the stored item.

[7] Another object of the present invention is to provide a supercooling apparatus that is capable of preventing water from freezing, by lowering the phase transition temperature of water.

[8] A further object of the present invention is to provide a supercooling apparatus that is capable of maintaining the supercooled state of a stored item stably for a long period of time, by supplying energy through a magnetic field to the stored item.

[9] A still further object of the present invention is to provide a supercooling apparatus that is capable of maintaining the liquid state of a stored item stably for a long period of time at the stored item's phase transition temperature or below, by generating a magnetic field to cause the moving polar molecules (e.g., water) to do at least one of rotation, vibration, and translation movements continuously, the magnetic field being generated by winding a wire around a storage space for example.

### **Technical Solution**

[10] In order to achieve the above-described objects of the invention, there is provided a supercooling apparatus, including: a container having a defined storage space to store an item; a refrigeration cycle for cooling the storage space; and a power supply path consisting of wires wound around the storage space and a power source for supplying power to the wires, so as to maintain the stored item in a non-frozen state at a phase transition temperature or below.

[11] In an exemplary embodiment, the power source applies an AC power through the wires.

[12] In an exemplary embodiment, the power supply path includes a capacitor.

[13] Another aspect of the present invention provides a supercooling apparatus, including: a container having a defined storage space to store an item; a refrigeration cycle for cooling the storage space; and an energy supply unit for applying a magnetic field to the storage space, so as to maintain the stored item in a non-frozen state at a phase transition temperature or below.

[14] Preferably, the energy supply unit changes direction of the magnetic field at regular time intervals.

[15] Moreover, the energy supply unit consists of wires wound around the storage space at a predetermined turns or excess, and a power source for supplying a high-voltage AC power to the wires.

### **Advantageous Effects**

[16] In conclusion, the supercooling apparatus of the present invention can be advantageously used to keep a stored item in a supercooled state stably for an extended period of time, by taking energy out of an object through the refrigeration cycle yet

supplying energy in another form to allow molecules to continuously do at least one of rotation, vibration, and translation movements for the prevention of phase transition.

[17] Moreover, the supercooling apparatus of the present invention controls quantities of energy to be supplied and to be taken away, so that it can keep a stored item stably in a supercooled state at a lower temperature.

[18] Further, the supercooling apparatus of the present invention generates a magnetic field in a storage space, supplying energy to a stored item therein. In result, the stored item is maintained in a supercooled state stably for a long period of time.

### **Brief Description of the Drawings**

[19] FIG. 1 is a conceptual view of a supercooling apparatus for maintaining a supercooled state through a magnetic field;

[20] FIG. 2 and FIG. 3 are exemplary embodiments of the supercooling apparatus of FIG. 1;

[21] FIG. 4 is a drawing for explaining an overall operation of a supercooling apparatus to maintain a supercooled state through a magnetic field; and

[22] FIG. 5 and FIG. 6 respectively show one embodiment of the supercooling apparatus of FIG. 1, and a graph reflecting a supercooling phenomenon.

[23]

### **Mode for the Invention**

[24] When liquid such as water is cooled slowly, it does not freeze for some time even though the temperature is below 0°C. However, when an object becomes a supercooled state, it is a sort of metastable state where the unstable equilibrium state breaks easily even by a very small stimulus or minor external disturbance, so the object easily transits to a more stable state. That is to say, if a small piece of the material is put into a supercooled liquid, or if the liquid is subject to impact on a sudden, it starts being solidified immediately and temperature of the liquid is raised to a freezing point, maintaining a stable equilibrium state at the temperature.

[25] Even if the temperature is lower than the phase transition temperature at this time, the supercooled state can be maintained continuously as long as molecules are allowed to do at least one of the following: rotation, vibration, and translation constantly. In other words, if energy is supplied at the same time with the liquid cooling process (i.e. offsetting the energy absorbed during the cooling process) and to inhibit phase transition from liquid to solid, the liquid phase can be maintained stably for an extended period of time even at temperature lower than the phase transition temperature.

[26] Therefore, a supercooling apparatus of the present invention supplies energy of a magnetic field to molecules of a target item to let the molecules continuously do at

least one of rotation, vibration, and translation movements even below the phase transition temperature.

[27]

[28] It is a well-known fact to a person skilled in the art that molecules of liquid, especially polar molecules of liquid, are oriented in a specific direction when an electric field is applied. Similarly, it is another fact to a person skilled in the art can easily predict that molecules of liquid, especially polar molecules of liquid, move in a different direction at the application of a magnetic force exerted from a magnetic field being generated when the molecules move. Taking advantage of such facts, the present invention apparatus is invented to have a means for taking energy out of the stored item, and a means for supplying less energy through a magnetic field than the lost energy so as to cause water molecules in the stored item to do at least one of rotation, vibration, and translation movements. As such, the stored item may be kept in a liquid state at the phase transition temperature or below for an extended period of time.

[29] FIG. 1 is a conceptual view of a supercooling apparatus for maintaining a supercooled state through a magnetic field. To this end, there is provided a container 1 to store liquid, and a wire 2 winds around the container 1. The wire is connected to a power supply 3 via a capacitor 4 to receive power (preferably, high-voltage AC), and generates a magnetic field inside the container 1.

[30] Though not shown, a cooling cycle makes it possible to deprive heat energy and supply another kind of energy. When an item is placed in the container 1, a cooling cycle (not shown) takes heat from the item and lowers its temperature, and at the same time applies power (preferably, high-voltage AC) to the wire 2 to create a magnetic field in the storage space, supplying energy to the item.

[31] The capacitor 4 is connected between the wire 1 and the power supply 3 to enhance stability for circuits when high-voltage AC is applied to the wire 1.

[32] Through this configuration a magnetic field is created even below the phase transition temperature of polar molecules, such as water or moisture, contained in foods, and those molecules having received energy through the magnetic field makes at least one of rotation, vibration, and translation movements. In result, the foods are not solidified or frozen, but kept in a cooled state stably for a long period of time. Here, if AC to change the direction of a magnetic field at regular intervals is applied to the wire 1, the direction of the magnetic field is changed at every fixed time interval. Needless to say, water molecules contained in foods or stored items will do at least one of rotation, vibration, and translation movements. A cylindrical container and a wire wound around the cylinder in a helical shape are shown only as illustrative of a means for supplying a magnetic field to the container.

[33]

- [34] Hereinafter, preferred embodiments of a supercooling apparatus according to the present invention will be described in detail with reference to the accompanying drawings.
- [35] FIG. 2 and FIG. 3 respectively show an exemplary embodiment of the supercooling apparatus of FIG. 1. FIG. 2 is an example of an indirect cooling type supercooling apparatus. An indirect cooling type refrigerator is constituted of a casing 110 which has one open side and a storage space A being partially divided by a shelf 130, and a door 120 for opening or closing the open side of the casing 110. A refrigeration cycle 30 of the indirect cooling type refrigerator includes a compressor 32 for compressing a refrigerant, an evaporator 33 for producing chilled air (indicated by arrows) to cool the storage space A or a stored item, a fan 34 for forcibly circulating the produced chilled air, an inlet(or suction) duct 36 for introducing the chilled air into the storage space A, and an outlet(or discharge) duct 38 for leading the chilled air having passed through the storage space A to the evaporator 33. Although not shown, the refrigeration cycle 30 can further include a condenser, a drier, an expansion unit, etc.
- [36] Wires 2a are provided between inner faces 112a and 112c facing the storage space A and the outer faces of the casing 110. Preferably, the wires are spirally coiled to be able to apply a magnetic field to the entire storage space.
- [37] The inlet duct 36 and the outlet duct 38 are formed in the inner face 112b of the casing 110. In addition, surfaces of the inner faces 112a, 112b, and 112c of the casing 110 are made of a hydrophobic material such that the surface tension of water or moisture is reduced and do not freeze during the supercooling mode. Needless to say, the outer faces and the inner faces 112a, 112b, and 112c of the casing 110 are made of an insulating material to protect a user from the exposure to a magnetic field.
- [38] FIG. 3 is an example of a direct cooling type supercooling apparatus. The direct cooling type refrigerator of FIG. 3 has the same door 120 and shelf 130 as the indirect cooling type refrigerator of FIG. 2, but, unlike in the inner faces 112a, 112b, and 112c of the casing 110 in FIG. 2, there are not the inlet duct 36 and the outlet duct 38 in the inner faces 114a, 114b, and 114c of the casing 110 in FIG. 3. A refrigeration cycle 30 of the direct cooling type refrigerator includes a compressor 32 for compressing a refrigerant, and an evaporator 39 installed inside the casing 110 near the inner surfaces 114a, 114b, and 114c of the casing adjacent to the storage space to evaporate the refrigerant. Although not shown, the direct cooling type refrigeration cycle 30 further includes a condenser, an expansion valve, etc.
- [39] Similarly, wires 2b are provided between inner faces 114a and 114b facing the storage space A and the outer faces of the casing 110. Preferably, the wires are spirally coiled to be able to apply a magnetic field to the entire storage space.
- [40] FIG. 4 is shown to explain the overall operation method of a supercooling apparatus

using a magnetic field to maintain a supercooled state. As illustrated, a supercooling apparatus 100 includes a load detector 20 to detect state of the storage space, state of a stored item (not shown) put in the storage space, etc.; a refrigeration cycle 30 to cool the storage space; a power generator 40 for generating voltage so that a magnetic field may be applied to the storage space; wires 50 for generating a magnetic field at the application of the generated voltage; a door sensor 60 for sensing an open/closed state of a door 120; an input unit 70 through which a user inputs a desired refrigeration degree, whether to execute a supercooling mode, etc.; a display unit 80 for displaying an operation state of the supercooling apparatus 100; and a Micom 90 for executing the supercooling mode.

- [41] In detail, the load detector 20 detects or stores the state of the storage space or the state of a stored item in the storage space, and provides it to the Micom 90. For example, the load detector 20 can store information on volume of the storage space as the state of the storage space, or it can be used in the form of a thermometer to detect temperature of a stored item or in the form of one of a durometer, an amperemeter, a voltmeter, a weight scale, an optical sensor (or laser sensor) or a pressure sensor to check the presence of an item in the storage space. Particularly, an amperemeter or a voltmeter is useful as the load detector 20 because both show a change in the total resistance value of a magnetic field-dependent resistor when the storage space is empty and when there is any stored item in the storage space. To be short, the changed resistance value tells whether there is an item kept in the storage space. Based on the resistance value provided from the load detector 20, the Micom 90 finds out the amount and moisture content of the stored item(s) and identifies a kind of the stored item having the moisture content accordingly.
- [42] The refrigeration cycle 30 is classified by a cooling method of stored items: indirect cooling type and direct cooling type.
- [43] The power generator 40 generates an AC voltage according to a predetermined magnitude and frequency. The power generator 40 can produce an AC voltage by varying the magnitude and/or the frequency of a given voltage. Particularly, the power generator 40 applies to the wires 50 an AC voltage based on a preset value (the magnitude of a voltage, the frequency of a voltage, etc.) from the Micom 90, so that a magnetic field may be applied to the storage space.
- [44] The wires 50 are means for converting the AC voltage from the power generator 40 into a magnetic field and applying the magnetic field to the storage space. Since a high-frequency AC voltage in the wires 50 induced a magnetic field in the storage space or the stored item(s), the direction of the magnetic field changes at regular time intervals by a given frequency. In the presence of a magnetic field having such characteristics, polar water molecules continuously vibrate, rotate, or translate. This is how

the water molecules are not crystallized, but maintain a liquid phase even at the phase transition temperature or below.

- [45] The door sensor 60 stops the operation of the power generator 40 as the door 120 opening/closing the storage space is opened. To this end, it may inform the Micom 90 that the door 120 is opened to let the Micom 90 stop the operation of the power generator 40, or it may cut the power being supplied to the power generator 40, or it may use a switch controlling power supply depending on an opened/closed state of the door to intercept the power being supplied to the power generator 40.
- [46] The input unit 70 is used by a user not only to set temperature for freezing and refrigeration control in general and selecting an ice or water dispenser, but also to give a control command to perform a supercooling mode on a storage space or stored item(s). Moreover, the user can input information about a stored item, e.g., kind or amount of a stored item, through the input unit 70. The input unit 70 may be a barcode scanner or an RFID reader, and provide the information on a stored item from reading to the Micom 90. Further, the input unit 70 allows the user to input or select a desired supercooling temperature (temperature to maintain a supercooled state) for a storage space or a stored item.
- [47] The display unit 80 basically shows freezing and refrigeration temperatures, and which dispenser (water or ice dispenser) is being served. Also, it can also show estimated time to reach the onset of a supercooled state, or whether a supercooling operation is ON or cancelled.
- [48] The Micom 90 is involved in the refrigeration and freeze control in general, and controls a supercooling mode according to the present invention to be executed.
- [49] When a storage space or a stored item is maintained in a supercooled state, the Micom 90 stores information on relations between an amount of energy to be supplied to the storage space or to a stored item/an amount of energy to be taken away and cooling temperatures. As such, the Micom 90 can control over the setup and application of a proper amount of energy based on a target supercooling temperature, the calculation of an amount of energy, the calculation of a supercooling temperature according to a given energy, and so forth. Energy in a variety of forms can be used here. In this invention, a magnetic field energy is used. Since stored items are most likely to contain moisture to a great content, the Micom 90 calculates energy to take by using specific heat of water, obtaining mass from the load detector 20, and operating temperature information with the load detector 20. In case of applying a magnetic field energy for example, the Micom 90 calculates the energy to be supplied based on a function of voltage, current and frequency. These calculation processes are well known to those skilled in the art which the present invention pertains.
- [50] The Micom 90 acquires information on the situation of a storage space of a stored

item from the input unit 70 or the load detector 20, and generates an AC voltage having the magnitude and frequency corresponding to the acquired information or the degree of load, thereby being in charge of carrying out the artificial intelligence-based non-freezing mode.

- [51] To carry out a supercooling mode, the Micom 90 can set or vary a temperature for the supercooling mode to be operated. The temperature setup or variation is done by the Micom 90 in use of a relation between energy quantities Q1 and Q2 and a supercooling temperature (to be described). To this end, the Micom 90 controls the power generator 40 to adjust an energy quantity Q2 corresponding to a magnetic field induced around the wires 50. In detail, the energy quantity adjustment is accomplished by controlling the magnitude and frequency of a given voltage (or current), and the correlation among voltage, current and frequency yields an amount of energy. Since these energy calculation processes are obvious to those skilled in the art which the present invention pertains, they will not be explained.
- [52] The Micom 90 also controls the operation of a non-freezing actuator consisting of the power generator 40 and the wires 50. In so doing, it performs an efficient control like a sleep mode to maintain a non-freezing mode while reducing power consumption of the supercooling apparatus 100.
- [53] FIG. 5 shows one embodiment of the supercooling apparatus of FIG. 1, and FIG. 6 is a graph reflecting a supercooling phenomenon. FIG. 5 depicts a structure and conditions for an experiment of FIG. 6. As shown, 0.1ℓ(liter)of distilled water was put into a storage space S1 of a casing 111, and similar to the wires 1 in FIG. 1, wires 2c wound around the storage space S1. The casing 111 is made out of an acrylic material, and slid into and cooled down in a refrigerating space (i.e. space having no supplementary magnetic field generator besides the wires 2c) to which chilled air is uniformly supplied. An inside temperature of the refrigerating space is about -7°C.
- [54] FIG. 6 diagrammatically shows a supercooling phenomenon occurring in a supercooling apparatus when power is supplied to the wires 2c. Normally, when water is cooled down below its phase transition temperature in a common refrigeration device, the water is subject to phase transition. Even if the phase transition does not occur for some time by gradually cooling the water, the water can easily be coagulated even by a very small stimulus, such as throwing a small piece therein or creating a minor external disturbance. However, since a magnetic field induced around the wires 2c is formed in a storage space and energy is supplied to the storage space, water molecules that are most likely present in a stored item in the storage space continuously do at least one of rotation, vibration, and translation movements. Consequently, the stored item is maintained in a liquid phase below the phase transition temperature. As is shown in the graph, the liquid state is maintained for a long period of time even at the phase

transition temperature or below.

[55]

[56] The present invention has been described in detail with reference to the embodiments and the attached drawings. However, the scope of the present invention is not limited to the embodiments and the drawings, but defined by the appended claims.

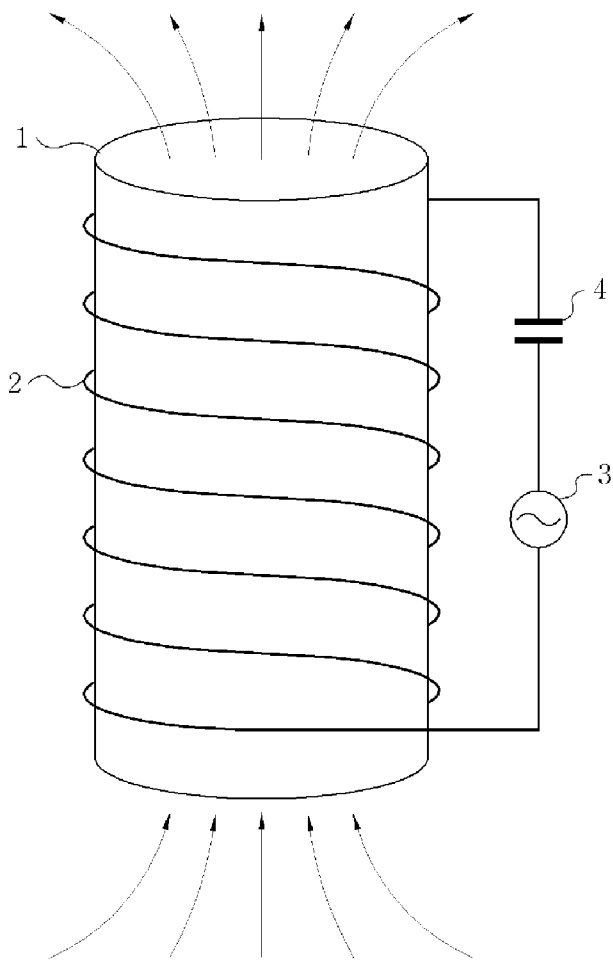
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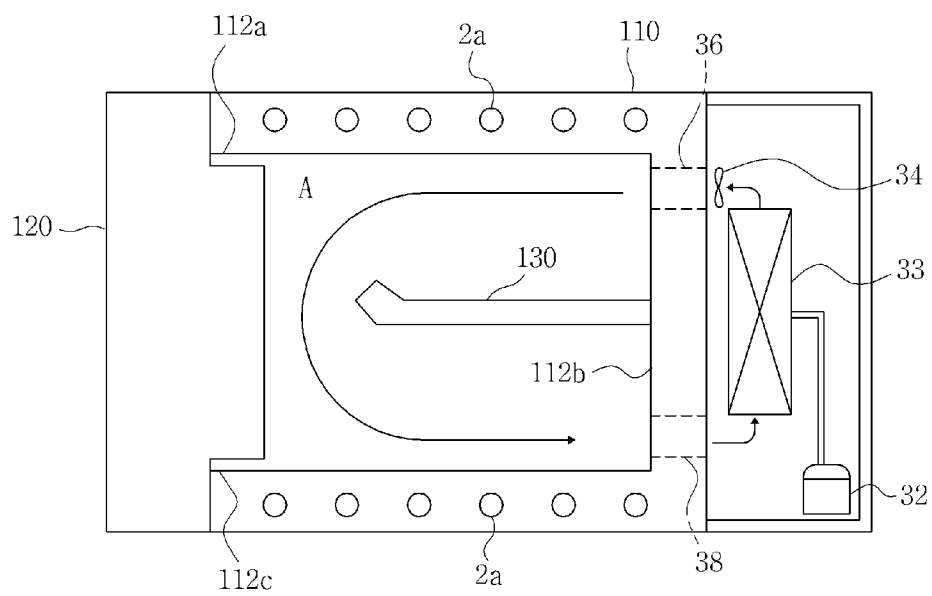
## Claims

- [1] A supercooling apparatus, comprising:  
a container having a defined storage space to store an item;  
a refrigeration cycle for cooling the storage space; and  
a power supply path consisting of wires wound around the storage space and a power source for supplying power to the wires, so as to maintain the stored item in a non-frozen state at a phase transition temperature or below.
- [2] The supercooling apparatus of claim 1, wherein the power source applies an AC power through the wires.
- [3] The supercooling apparatus of claim 1, wherein the power supply path includes a capacitor.
- [4] A supercooling apparatus, comprising:  
a container having a defined storage space to store an item;  
a refrigeration cycle for cooling the storage space; and  
an energy supply unit for applying a magnetic field to the storage space, so as to maintain the stored item in a non-frozen state at a phase transition temperature or below.
- [5] The supercooling apparatus of claim 4, wherein the energy supply unit changes direction of the magnetic field at regular time intervals.
- [6] The supercooling apparatus of claim 4 or claim 5, wherein the energy supply unit consists of wires wound around the storage space at a predetermined turns or excess, and a power source for supplying a high-voltage AC power to the wires.
- [7] The supercooling apparatus of claim 6, wherein the energy supply unit includes a capacitor connected serially to the wires and the power source, respectively.

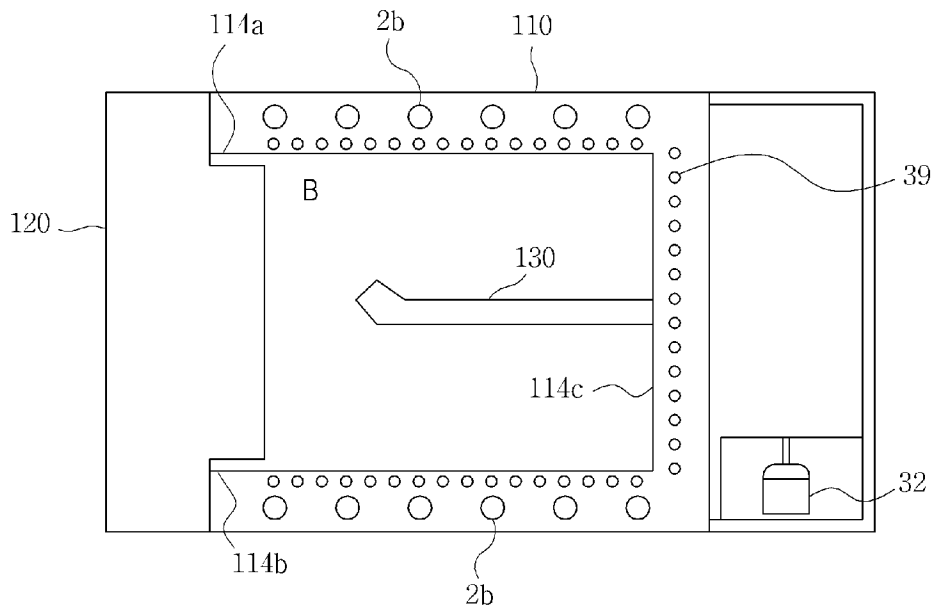
[Fig. 1]



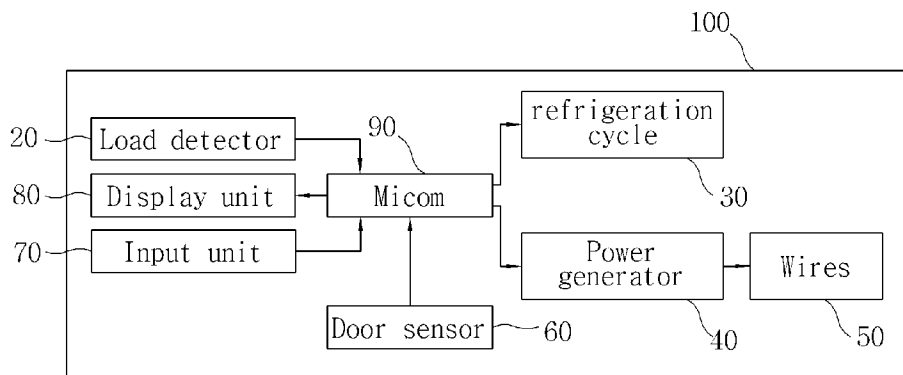
[Fig. 2]



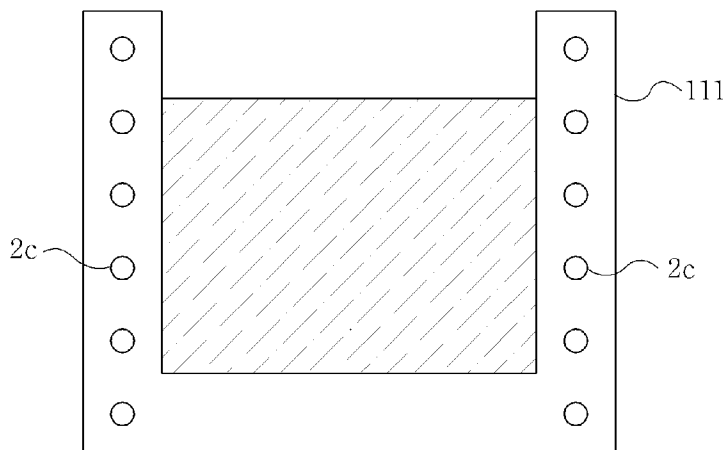
[Fig. 3]



[Fig. 4]



[Fig. 5]



[Fig. 6]

