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(54) **METHOD OF CONTROLLING ATOMIZING DEVICE, METHOD OF CONTROLLING DISCHARGE
DEVICE, AND REFRIGERATOR**

VERFAHREN ZUR STEUERUNG EINER ATOMISIERUNGSVORRICHTUNG, VERFAHREN ZUR
STEUERUNG EINER ENTLADEVORRICHTUNG UND KÜHLVORRICHTUNG

PROCÉDÉ DE COMMANDE D'UN DISPOSITIF D'ATOMISATION, PROCÉDÉ DE COMMANDE D'UN
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Description

Technical Field

[0001] The present invention relates to a method of controlling an atomizing device or a discharge device which are installed in a storage space for vegetables or the like, and to a refrigerator equipped with at least one of the devices.

Background Art

[0002] Influential factors for deterioration of freshness of vegetables include temperature, humidity, ambient gas, microorganisms, and light. Vegetables are living things and respiration and transpiration occur on the surfaces of vegetables. In order to maintain the freshness of vegetables, it is necessary to reduce respiration of the vegetables and transpiration of water from the vegetables. Except for some vegetables susceptible chilling damage, respiration of most vegetables is reduced at a low temperature, and transpiration can be reduced in high humidity.

[0003] In this connection, prior art document EP 2 208 950 A1 discloses a refrigerator, wherein an atomization apparatus is provided for spraying mist in a storage compartment to increase humidity therein. The atomization apparatus comprises an atomization state determination unit which determines an atomization state and outputs the predetermined signal indicative of the atomization state. A control means is provided for controlling an operation of the atomization unit according to this signal. When the detected signal is in a specified range it is assumed that the atomization unit performs proper spray. Further parameters such as inside temperature detected by an inside temperature detection unit, as well detection of the voltage applied by the voltage application unit are considered. Prior art document EP 2 199 714 A1 discloses a refrigerator which comprises a heat-insulated storage compartment as well as an atomization unit for increasing humidity in the storage compartment. The atomization unit is included in a mist spray apparatus for spraying mist into the compartment. The atomization unit comprises an atomization tip, and the mist being sprayed into the storage compartment is sprayed from the atomization tip by application of a corresponding high voltage. The refrigerator further comprises a temperature adjustment unit which is configured to adjust a temperature of the atomization tip, and specifically the temperature of the atomization tip is adjusted to a dew point or below to cause water inside the storage compartment to form dew condensation on the cooled atomization tip. The atomization tip is configured to generate the mist containing radicals, the generating mist adhering to vegetables and fruit stored in the storage compartment to suppress low temperature damages and to support an appropriate humidity level.

[0004] Finally, prior art document EP 2 025 411 A1

discloses an electrostatic atomization apparatus wherein the apparatus comprises an emitter electrode as well as an opposed electrode disposed in an opposed relation to the emitter electrode so that upon application of a high voltage an electrical field can be applied. The emitter electrode is coupled to a liquid supply means for supplying a liquid to the emitter electrode, and the liquid can be sprayed from the emitter electrode depending on the voltage applied to the emitter electrode. Specifically, the liquid supplied to the emitter electrode is electrostatically charged because of the application of the high voltage, and small liquid particles are discharged at the end of the emitter electrode. When discharging is performed, the discharge conditions are detected and evaluated, and a controller is provided for controlling high voltage applied to the emitter electrode and opposed electrode so as to maintain predetermined discharge conditions based on corresponding detection results. The discharge voltage (high voltage) is adjusted to continuously generate small liquid particles to be emitted by the emitter electrode. The control is performed in view of a target value by determining whether detected values lie within a predetermined range of target values. This allows for adjusting the size of the charged small particles.

[0005] Moreover, in recent years, household refrigerators are provided with a sealed dedicated vegetable container for the purpose of preserving vegetables. Vegetables are cooled to an appropriate temperature in the vegetable container, and the humidity in the refrigerator is increased so as to reduce respiration of and transpiration from the vegetables. Here, there is known a device for spraying mist as a unit to increase the humidity in the refrigerator.

[0006] As a refrigerator provided with spraying capability of this type, there is a refrigerator, in which a spray device humidifies the space in a vegetable container so as to keep transpiration from vegetables under control by spraying mist with an ultrasonic atomizing device when the vegetable container is at a low temperature (for example, see Patent Literature (PTL) 1).

[0007] FIG. 15 is a partial vertical cross-sectional view of the vegetable container of the conventional refrigerator described in PTL 1. FIG. 16 is a schematic enlarged perspective view of an ultrasonic atomizing device mounted in the vegetable container of the conventional refrigerator.

[0008] As shown in FIG. 15, a vegetable compartment 21 is provided in the lower portion of a body case 26 of a refrigerator main body 20, and the front opening of the vegetable compartment 21 is designed to be closed by a drawer door 22, which may be drawn in a freely openable and closable manner. The vegetable compartment 21 is partitioned from the upper refrigerator compartment (not shown) by a partition plate 2.

[0009] A fixing hanger 23 is fixed to the inner surface of the drawer door 22, and a vegetable container 1 which stores food such as vegetables is mounted on the fixing hanger 23. The top opening of the vegetable container

1 is sealed by a lid 3. The inside of the vegetable container 1 is provided with a thaw compartment 4 which is equipped with an ultrasonic atomizing device 5.

[0010] As shown in FIG. 16, the ultrasonic atomizing device 5 includes a mist diffuser 6, a water storage container 7, a humidity sensor 8, and a hose receiver 9. The water storage container 7 is connected to a defrost water hose 10 via the hose receiver 9. A portion of the defrost water hose 10 is provided with a cleaning filter 11 for cleaning defrost water.

[0011] Hereinafter, the operation of the refrigerator as configured in this manner will be described.

[0012] Cooling air cooled by a heat exchange cooler (not shown) circulates along the outer surface of the vegetable container 1 and a lid 3 so that the vegetable container 1 is cooled, and thus the food stored therein is cooled. The defrost water generated from the cooler when the refrigerator is in operation is cleaned by the cleaning filter 11 as passing through the defrost water hose 10, and is supplied to the water storage container 7 of the ultrasonic atomizing device 5.

[0013] Next, when the humidity in the vegetable container is detected to be 90% or less by the humidity sensor 8, the ultrasonic atomizing device 5 starts to humidify the inside of the refrigerator and can control the humidity to an appropriate level in order to keep the vegetables in the vegetable container 1 fresh.

[0014] On the other hand, when the humidity in the refrigerator is detected to be 90% or more by the humidity sensor 8, the ultrasonic atomizing device 5 stops excessive humidification. Consequently, the inside of the vegetable container 1 can be quickly humidified by the ultrasonic atomizing device 5 so as to always keep the inside of the vegetable container 1 in high humidity, and thus transpiration of the vegetables is reduced and the vegetables can be kept fresh.

[0015] Patent Literature (PTL) 2 discloses a refrigerator which is provided with an ozone water spray device.

[0016] The refrigerator disclosed in PTL 2 includes an ozone generator, an exhaust outlet, a water supply conduit directly connected to the city water system, and an ozone water supply conduit near the vegetable compartment. The ozone water supply conduit is led to the vegetable compartment. The ozone generator is connected to the water supply conduit directly connected to the city water system. The exhaust outlet is connected to the ozone water supply conduit. The vegetable compartment is provided with an ultrasonic element therein.

[0017] In the above-described configuration, ozone generated by the ozone generator comes into contact with water to produce ozone water. The generated ozone water is led to the vegetable compartment of the refrigerator, is atomized by an ultrasonic transducer, and is sprayed into the vegetable compartment.

[Citation List]

[Patent Literature]

5 **[0018]**

[PTL 1] Japanese Unexamined Patent Application Publication No. 6-257933

10 [PTL 2] Japanese Unexamined Patent Application Publication No. 2000-220949

[Summary of Invention]

[Technical Problem]

15 **[0019]** However, in the above-described conventional configuration, start and stop of the atomizing device is generally controlled according to the humidity in the refrigerator, detected by the humidity sensor. An atomized state achieved by the atomizing device cannot be practically determined by the above control, and thus precision and responsiveness of the control is somewhat insufficient. Particularly, in a storage compartment of the refrigerator, i.e., substantially sealed, low temperature space, an excessive amount of atomization causes water rot of vegetables and the like, and condensation forms in the refrigerator. On the other hand, a smaller amount of atomization causes an insufficient humidification of the storage compartment, and thus vegetables and the like cannot be kept fresh.

20 **[0020]** From the viewpoint of safety security of food, it is demanded that smelly component occurs from food be properly deodorized, and an increase in the microorganisms adhering to food be reduced.

25 **[0021]** It is an object of the present invention to provide a refrigerator which can efficiently perform atomization with a more appropriate spray volume, the refrigerator being equipped with an atomizing unit to increase freshness keeping ability by spraying mist. It is another object of the present invention to provide a refrigerator which is equipped with a discharge device for efficiently generating more appropriate amount of ozone, the refrigerator being equipped with a sterilization, deodorizing function using ozone.

30 **Solution to Problem**

35 **[0022]** In order to solve the above-described existing problem, the present invention provides a method of controlling an atomization device of a refrigerator, the atomization device including: an atomization electrode; a voltage application unit configured to apply a voltage to the atomization electrode; a control unit configured to control the voltage application unit; and an atomization state detection unit configured to detect an atomization state of the atomization electrode, the method comprising calculating an atomization rate and controlling atomization according to the atomization rate on the atomization elec-

trode in a subsequent predetermined cycle by the control unit according to the atomization state detected by the atomization state detection unit in a predetermined cycle.

[0023] Thus, appropriate atomization can be achieved by controlling the operation of the atomizing unit based on appropriate recognition of an atomized state of the atomizing unit.

[0024] In addition, the present invention provides a method of controlling a discharge device of a refrigerator, the discharge device including: a discharge electrode; a voltage application unit configured to apply a voltage to the discharge electrode; a control unit configured to control the voltage application unit; and a discharge state detection unit configured to detect a discharge state of the discharge electrode, the method comprising calculating an atomization rate and controlling discharge according to the atomization rate, on the discharge electrode in a subsequent predetermined cycle by the control unit according to the discharge state detected by the discharge state detection unit in a predetermined cycle.

[0025] Thus, appropriate discharge can be achieved by controlling the operation of a discharge unit based on precise recognition of discharged state of ozone.

Advantageous Effects of Invention

[0026] The atomizing device or the discharge device of the present invention can improve the quality of a refrigerator provided with the atomizing device or the discharge device by achieving appropriate atomization or discharge.

Brief Description of Drawings

[0027]

[FIG. 1] FIG. 1 is a vertical cross-sectional view of a refrigerator in Embodiment 1 of the present invention.

[FIG. 2] FIG. 2 is a principal cross-sectional view of an electrostatic atomizing device in the refrigerator in Embodiment 1 of the present invention.

[FIG. 3] FIG. 3 is a graph showing the relationship of dew point-atomization electrode temperature in the electrostatic atomizing device in the refrigerator in Embodiment 1 of the present invention.

[FIG. 4] FIG. 4 schematically shows a method of controlling an electrostatic atomizing device in the refrigerator in Embodiment 1 of the present invention.

[FIG. 5] FIG. 5 is a control flowchart for the electrostatic atomizing device in the refrigerator in Embodiment 1 of the present invention.

[FIG. 6] FIG. 6 is a control time chart for the electrostatic atomizing device in the refrigerator in Embodiment 1 of the present invention.

[FIG. 7] FIG. 7 is a vertical cross-sectional view of a refrigerator in Embodiment 2 of the present invention.

[FIG. 8] FIG. 8 is a cross-sectional perspective view of the main portion of the refrigerator in Embodiment 2 of the present invention.

[FIG. 9] FIG. 9 is a configuration diagram of a discharge device of the refrigerator in Embodiment 2 of the present invention.

[FIG. 10] FIG. 10 is a graph showing a temperature dependence of a discharge current of the discharge device of the refrigerator in Embodiment 2 of the present invention.

[FIG. 11] FIG. 11 is a graph showing a humidity dependence of the discharge current of the discharge device of the refrigerator in Embodiment 2 of the present invention.

[FIG. 12] FIG. 12 is a graph showing the relationship between an ozone concentration and the discharge current of the discharge device of the refrigerator in Embodiment 2 of the present invention.

[FIG. 13] FIG. 13 is a control flowchart for the discharge device of the refrigerator in Embodiment 2 of the present invention.

[FIG. 14] FIG. 14 is a control time chart for the discharge device of the refrigerator in Embodiment 2 of the present invention.

[FIG. 15] FIG. 15 is a principal cross-sectional view of an atomizing device in a conventional refrigerator.

[FIG. 16] FIG. 16 is an enlarged perspective view showing the main portion of an ultrasonic atomizing device provided in a vegetable compartment of the conventional refrigerator.

Description of Embodiments

[0028] A first aspect of the invention provides a method of controlling an atomization device of a refrigerator, the atomization device including: an atomization electrode; a voltage application unit configured to apply a voltage to the atomization electrode; a control unit configured to control the voltage application unit; and an atomization state detection unit configured to detect an atomization state of the atomization electrode, the method comprising calculating an atomization rate and controlling atomization according to the atomization rate on the atomization electrode in a subsequent predetermined cycle by the control unit according to the atomization state detected by the atomization state detection unit in a predetermined cycle.

[0029] Accordingly, an atomized state can be appropriately fed back, and appropriate amount of dew condensation on the atomization electrode efficiently proceeds, and thus fine mist can be stably supplied to each storage compartment.

[0030] By the feedback control, wasted energy can be reduced, and energy saving effect can also be achieved.

[0031] In addition, excess water vapor in the storage compartment can be caused to form dew condensation on the atomization tip easily and reliably. The supplied mist is at nano level, and is uniformly attached to the

surface of produce such as vegetables by spraying the fine mist, and thus the freshness of the food can be improved.

[0032] Furthermore, the generated fine mist contains ozone and OH radical, and the inside of a vegetable compartment can be deodorized, and the surfaces of the vegetables can be made antimicrobial, or sterilized by the oxidizing power of the ozone and OH radical, and in addition, harmful matter adhering to the vegetable surface, such as an agricultural chemicals or wax can be oxidized, decomposed and removed.

[0033] A second aspect of the invention provides the method of controlling an atomizing device in the first aspect of the invention, in which the atomization state detection unit detects a value of a current in the voltage application unit. Accordingly, the atomized state of the atomization electrode can be properly detected by a simple unit.

[0034] A third aspect of the invention provides the method of controlling an atomizing device in the first or second aspect of the invention, in which the atomization device further includes: a cooling unit configured to cool the atomization electrode; and a heating unit configured to heat the atomization electrode, and the method comprises calculating an atomization rate and controlling by the control unit an amount of heating by the heating unit according to the atomization rate in the subsequent predetermined cycle, and controlling atomization on the atomization electrode in the subsequent predetermined cycle according to the atomization state detected by the atomization state detection unit in the predetermined cycle. Accordingly, atomization on the atomization electrode can be efficiently achieved by using the water content in the air effectively.

[0035] A fourth aspect of the invention provides the method of controlling an atomizing device in the third aspect of the invention, in which when the controlling unit determines that an atomization rate calculated according to the atomization state detection unit decreases and substantially no atomization occurs, the control unit determines that water adhering to the atomization electrode has frozen, and increases the amount of heating by the heating unit in the subsequent predetermined cycle. Accordingly, accuracy in determination of a frozen state is reduced, and even when a frozen state occurs, a normal atomization state can be recovered in a short time.

[0036] A fifth aspect of the invention provides the method of controlling an atomizing device in the fourth aspect of the invention, in which the amount of heating by the heating unit in the subsequent predetermined cycle is set to a predetermined specific amount of heating. Accordingly, the atomization electrode has a high temperature after the freezing is resolved, and atomization may be difficult to be achieved. However, even in such a case, reduction in temperature of the atomization electrode is accelerated by setting a heater output to a low level after resolving the freezing irrespective of atomization state determination, and thus reatomization is achieved early.

In addition, energy saving effect is also be achieved by reducing wasted heating by a heater.

[0037] A sixth aspect of the invention provides the method of controlling an atomizing device in the fourth aspect of the invention, in which the amount of heating by the heating unit in the subsequent predetermined cycle after resolving the freezing is set to be substantially equivalent to an amount of heating before the freezing. Accordingly, even when the heater output after resolving the freezing is much different from the heater output in the final stable atomization, stable atomization state can be recovered early by setting the heater output as of stable atomization before the freezing when the temperature of the atomization electrode is reduced somewhat after resolving the freezing, and thus wasteful heating by a heater can be avoided.

[0038] A seventh aspect of the invention provides a method of controlling a discharge device of a refrigerator, the discharge device including: a discharge electrode; a voltage application unit configured to apply a voltage to the discharge electrode; a control unit configured to control the voltage application unit; and a discharge state detection unit configured to detect a discharge state of the discharge electrode, the method comprising calculating an atomization rate and controlling discharge according to the atomization rate on the discharge electrode in a subsequent predetermined cycle by the control unit according to the discharge state detected by the discharge state detection unit in a predetermined cycle. Accordingly, a discharged state can be appropriately fed back, and a predetermined amount of ozone is generated efficiently and stably on the discharge electrode and can be supplied to the storage compartment.

[0039] An eighth aspect of the invention provides the method of controlling a discharge device in the seventh aspect of the invention, in which the discharge state detection unit detects a discharge current which flows from the discharge electrode to a counter electrode. Accordingly, the discharged state of the discharge electrode can be properly detected by a simple unit.

[0040] A ninth aspect of the invention provides the method of controlling a discharge device in the seventh or eighth aspect of the invention, in which the controlling of discharge on the discharge electrode is achieved by controlling a time in which the voltage application unit applies the voltage. Accordingly, a discharge amount (generated amount of ozone) can be properly controlled by a simple unit.

[0041] A tenth aspect of the invention provides a refrigerator including a control unit configured to execute the method of controlling an atomization device or the method of controlling a discharge device according to any one of the first to ninth aspects. Accordingly, the freshness in the storage compartment can be improved. In addition, sterilizing, deodorizing capability of the storage compartment can be improved.

[0042] Hereinafter, the embodiments of the present invention will be described with reference to the drawings.

The same components as those of a conventional embodiment and the previously described embodiment are labeled with the same reference symbols, and detailed description is omitted. The present invention is not limited by the embodiments.

[Embodiment 1]

[0043] FIG. 1 is a vertical cross-sectional view of a refrigerator in Embodiment 1 of the present invention. FIG. 2 is a principal cross-sectional view of an electrostatic atomizing device in the refrigerator in Embodiment 1 of the present invention.

[0044] In FIG. 1, a heat insulating body 101 which is the main body of a refrigerator 100 includes an outer casing 102 mainly composed of a steel plate, an inner casing 103 molded with a resin such as ABS, and foam heat insulation material such as rigid urethane foam, which is filled in the space between the outer casing 102 and the inner casing 103. The heat insulating body 101 is insulated from the surroundings, and is partitioned with heat insulation into a plurality of storage compartments by partition walls. In the heat insulating body 101, a refrigerator compartment 104 as a first storage compartment is disposed at the top portion of the heat insulating body 101; a switchable compartment 105 as a fourth storage compartment, and an icemaker compartment 106 as a fifth storage compartment are disposed side-by-side below the refrigerator compartment 104; a freezer compartment 107 as a second storage compartment is disposed below the switchable compartment 105 and the icemaker compartment 106; and a vegetable compartment 108 as a third storage compartment is disposed at the lowest portion.

[0045] The refrigerator compartment 104 is set in a refrigeration temperature range which is for refrigeration preservation causing no freezing, and is specifically set in a range of 1 to 5°C normally. The vegetable compartment 108 is set in a temperature range which is the same or slightly higher than the temperature range of the refrigerator compartment 104, and is specifically set in a normal vegetable range which is 2 to 7°C. The freezer compartment 107 is set in a freezer temperature range, and is specifically set in a range of -22 to -15°C for frozen storage. In order to improve frozen storage state, the freezer compartment 107 may be set at a low temperature of -30°C or -25°C, for example.

[0046] The switchable compartment 105 can switch the temperature range to a predetermined temperature range between the refrigeration temperature range and the freezer temperature range, in addition to the refrigeration temperature range, the vegetables temperature range, and the freezer temperature range. The switchable compartment 105 is a storage compartment having an independent door and installed by the side of the icemaker compartment 106, and the independent door is often a drawer-type door.

[0047] In the present embodiment, the switchable

compartment 105 covers switchable temperature ranges including the refrigeration temperature range and the freezer temperature range. However, the switchable compartment 105 may be a storage compartment for specific use of switching to the above-mentioned temperature range between the refrigeration temperature range and the freezer temperature range, and the refrigerator compartment 104 and the vegetable compartment 108 are for only refrigeration, and the freezer compartment 108 is for only freezing. Alternatively, the switchable compartment 105 may be a storage compartment having a specific temperature range which is fixed.

[0048] The icemaker compartment 106 makes ice by an automatic ice machine (not shown) provided at the upper portion of the icemaker compartment 106, using the water sent from the water storage tank

[0049] (not shown) in the refrigerator compartment 104, and stores the ice in an ice storage container (not shown) disposed at the lower portion of the icemaker compartment 106.

[0050] The top surface of the heat insulating body 101 has a step-like recess in the direction to the back of the refrigerator 100, and a machine chamber 101a is formed in the step-like recess. The machine chamber 101a stores a compressor 109, and the components in the high voltage side of refrigeration cycle, such as a dryer (not shown) for removing water content. That is to say, the machine chamber 101a which stores the compressor 109 is formed by embedding in the rear area of the uppermost portion of the refrigerator compartment 104.

[0051] In this manner, the rear area of the storage compartment at the uppermost portion of the heat insulating body 101 is provided with the machine chamber 101a, and the compressor 109 is installed therein, the rear area being a dead space which is hard to reach, and thus the space of the machine chamber in the conventional refrigerator, which is located at the lowermost portion of the heat insulating body 101 and is easily accessible by a user, can be effectively used as the space for a storage compartment, and therefore, storability and user-friendliness are much improved.

[0052] The refrigeration cycle is formed by a series of refrigerant passages which includes the compressor 109, a condenser, a capillary which is a pressure reducer, and a cooler 112, and, for example, isobutane, which is a hydrocarbon-based coolant, is sealed as a coolant in the refrigeration cycle.

[0053] The compressor 109 is a reciprocating type compressor which compresses a coolant by a piston reciprocally moving inside a cylinder. In a refrigeration cycle in which a three-way valve or a switching valve is used in the heat insulating body 101, the functional parts are disposed in the machine chamber 101a in some cases.

[0054] In the present embodiment, the pressure reducer included in the refrigeration cycle is a capillary, however, a pulse motor-driven electronic expansion valve which can freely control the flow rate of a coolant may be used.

[0055] It is to be noted that the below-described essential features of the invention in the present embodiment may be applied to a typically conventional refrigerator in which the rear area of the storage compartment at the lowermost portion of the heat insulating body 101 is provided with the machine chamber, and the compressor 109 is disposed therein. Furthermore, in the below-described essential features of the invention in the present embodiment, the fourth storage compartment is not limited to the freezer compartment, and may be used as a switchable compartment.

[0056] A cooling compartment 110 for generating cold air is provided behind the freezer compartment 107. The back side partition wall 111 having heat insulation properties which is formed to partition between a carrier air passage (not shown) for flowing cold air to each compartment and each storage compartment is disposed therebetween. In addition, a partition plate (not shown) for separating a freezer compartment discharge air passage (not shown) from the cooling compartment 110 is provided. The cooler 112 is disposed in the cooling compartment 110. In the upper space of the cooler 112, a cooling fan 113 is disposed which sends cold air to the refrigerator compartment 104, the switchable compartment 105, the icemaker compartment 106, the vegetable compartment 108, and the freezer compartment 107 by forced convection system, the cold air being cooled by the cooler 112.

[0057] In the space below the cooler 130, a radiant heater 114 made up of a glass tube is provided for removing frost and ice which adhere to the cooler 112 and the surroundings during cooling. The lower portion of the radiant heater 114 is provided with a drain pan 115 for receiving defrosted water generated during defrosting. The deepest portion of the drain pan 115 is connected to a drain tube 116 which penetrates to the outside of the refrigerator. An evaporation pan 117 is disposed downstream of the drain tube 116. Evaporation pan 117 is disposed outside the warehouse.

[0058] A second partition wall 125 is a member which separates the freezer compartment 107 from the vegetable compartment 108, and is composed of a heat insulation material such as styrene foam in order to ensure the insulation properties of each storage compartment.

[0059] Next, an electrostatic atomizing device will be described with reference to FIG. 2. An electrostatic atomizing device 131 is installed in a recess 125a which is an installation portion provided in part of the inner wall surface of the storage compartment of the second partition wall 125. The recess 125a is a portion which is provided as a hollow or a through hole in part of the wall surface so as to have a temperature lower than the temperature of other parts.

[0060] The electrostatic atomizing device 131 mainly includes an atomization unit 139, a voltage application unit 133, and an outer case 137. Part of the outer case 137 is provided with an atomizing port 132 and a humidity supply port 138. The atomization unit 139 is provided

with an atomization electrode 135 which is an atomization tip. The atomization electrode 135 is disposed adjacent to a cooling pin 134 which is a heat transfer cooling unit, and the below-described condensation prevention member 140, the cooling pin 134 being composed of highly thermally conductive member such as aluminum or stainless steel.

[0061] The atomization unit 139 is provided with an atomization electrode 135. The atomization electrode 135 is an electrode connection member composed of highly thermally conductive member such as aluminum, stainless steel, or brass. The atomization electrode 135 is fixed to the substantially central position of one end of the cooling pin 134.

[0062] The cooling pin 134 is preferably composed of a highly thermally conductive member such as aluminum or copper. In order to thermally conduct cold heat from one end of the cooling pin 134 to the other end thereof efficiently, the circumference of the cooling pin 134 is covered with heat insulation material 152. The condensation prevention member 140 is disposed on the surface of the cooling pin 134 that is exposed toward the atomization electrode 135.

[0063] The above-mentioned condensation prevention member 140 is composed of a material, for example, a resin or ceramic which has lower thermal conductivity than the cooling pin 134 composed of a metal. Among all, a resin having a low thermal conductivity, more preferably, heat insulation material including porous medium such as foamed resin are suitably used in a range of allowable intensity. In addition, a composite material obtained by attaching a resin sheet or plate which is not foamed to the surface of heat insulation material including porous medium is also suitably used.

[0064] Because the cooling pin 134 is in the heat insulation material 152, dissipation of the cold heat from the cooling pin 134 to the periphery is avoided, and thus the atomization electrode 135 can be efficiently cooled. In addition, the surface of the cooling pin 134 that is exposed toward the atomization electrode 135 is covered by the condensation prevention member 140 having a lower thermal conductivity, and thus decrease in temperature of the corresponding surface is reduced, and dew condensation on the surface is avoided. Therefore, decrease in dew point of the periphery of the atomization electrode 135 is avoided, dew condensation on the cooled atomization electrode 135 efficiently proceeds, and fine mist can be stably supplied to each storage compartment even in a low humidity atmosphere of 50% at 0°C.

[0065] As seen from FIG. 2, the condensation prevention member 140 has the area of exposed surface larger than the area which is in contact with the cooling pin (heat transfer cooling unit) 134.

[0066] The cold heat from the cooling pin 134 is diffused to a large area of the condensation prevention member 140, and decrease in local temperature of the surface immediately on the condensation prevention member 140 is reduced. Consequently, the correspond-

ing surface can be reliably prevented from being reduced below a dew point in temperature. In this manner, undesired dew condensation is avoided, reduction in the dew point in the vicinity of the atomization electrode is also avoided, and thus dew condensation on the cooled atomization electrode 135 efficiently proceeds. Consequently, fine mist can be stably supplied to each storage compartment even in a low humidity atmosphere.

[0067] In addition, with the condensation prevention member 140 having a large area, the condensation prevention member 140 can serve as a flange. That is to say, because of the surface contact between the outer case 137 and the condensation prevention member 140, cold air leakage from the freezer compartment 107 can be efficiently sealed. Accordingly, undesired dew condensation is prevented more reliably.

[0068] Specifically, an adhesive, a screw, or the like may be used as a method for making surface contact between the condensation prevention member 140 and the outer case 137, and fixing the former to the latter.

[0069] A counter electrode 136 is fixed to the condensation prevention member 140, and the cooling pin 134 and the atomization electrode 135 are also fixed to the condensation prevention member 140. Thus, these electrodes and the member may be integrated together and are preferably fixed to the outer case with a screw or the like. In this case, replacement of a member at the time of maintenance can be made easily. In addition, because the counter electrode is fixed to the condensation prevention member, the distance between the tip of the atomization electrode 135 and the counter electrode 136 is not likely to be changed by the influence of thermal expansion of the refrigerator case and the outer case 137, and thus atomization can be controlled with high accuracy. Consequently, the effect is obtained that ozone and OH radical in addition to the amount of fine mist can be more stably supplied. Furthermore, because the electrostatic atomization device is formed in a compact manner, the effect is obtained that the space of each storage compartment can be used more effectively.

[0070] The cooling pin 134, which is the heat transfer cooling unit, is formed in a cylindrical shape having a diameter of approximately 10 mm and a length of approximately 20 mm, for example. The cooling pin 134 has a thermal capacity which is 50 times or more and 1000 times or less, preferably 100 times or more and 500 times or less than the thermal capacity of the atomization electrode 135 having a diameter of approximately 1 mm and a length of approximately 5 mm. In this manner, the thermal capacity of the cooling pin 134 is made 50 times or more and 1000 times or less than the thermal capacity of the atomization electrode 135, and thus a significant direct affect on the atomization electrode due to a temperature change in a cooling unit is further prevented, and consequently stable mist atomization with a low fluctuating load can be achieved.

[0071] Regarding the upper limit of the thermal capacity, the thermal capacity of the cooling pin 134 is 500

times or less, preferably 1000 times or less than the thermal capacity of the atomization electrode 135. When the thermal capacity is too high, a large amount of energy is required to cool the cooling pin 134, and thus it is difficult to cool the cooling pin with saved energy. However, by keeping the thermal capacity in the aforementioned range and satisfying the above saved energy condition, a significant influence on the atomization electrode when the thermal fluctuating load from the cooling unit changes is reduced, and thus the atomization electrode can be stably cooled with saved energy. Furthermore, by keeping the thermal capacity in the aforementioned range, a time lag required to cool the atomization electrode via the cooling pin 134 can be set in an appropriate range. Therefore, a delay in the start-up of cooling of the atomization electrode, that is to say, water content supply to the atomization device can be prevented, and thus the atomization electrode can be stably and properly cooled.

[0072] Because the cooling pin 134 which is the heat transfer cooling unit has a cylindrical shape in the present embodiment, even with a little tight fitting tolerance for inserting the cooling pin 134 into the recess 125a of the heat insulation material 152, the cooling pin 134 can be press-fitted and secured to the recess 125a while rotating the electrostatic atomization device 131, and thus the cooling pin 134 can be mounted with no clearance. The cooling pin 134 may have a rectangular prism or regular polygon shape, and when the cooling pin 134 has such a polygonal shape, positioning thereof is much easier than with a cylindrical shape, and thus the electrostatic atomization device 131 can be disposed in an accurate position.

[0073] The cooling pin 134 which is the heat transfer cooling unit is fixed to the outer case 137, and has a projection portion 134a which projects from the outer. The cooling pin 134 has the projection portion 134a on the other side of the atomization electrode 135, and the projection portion 134a is fitted into a deepest recess 125b which is further deeper than the recess 125a of the second partition wall 125.

[0074] Thus, the back of the cooling pin 134, which is the heat transfer cooling unit, is provided with the deepest recess 125b which is further deeper than the recess 125a. The heat insulation material 152 near the freezer compartment 107 is thinner than other portion in the second partition wall 125 near the top surface of the vegetable compartment 108. By using the thin portion of the heat insulation material 152 as a thermal relaxation member, the cold air of the freezer compartment 107 from the back surface cools the cooling pin 134 via the thin portion of the heat insulation material 152 which is a thermal relaxation member.

[0075] The cooling pin 134 which is the heat transfer cooling unit in the present embodiment has the projection portion 134a on the opposite side from the atomization electrode 135 which is an atomization tip. A cooling pin (heat transfer cooling unit) end 134b near the projection portion 134a is located closest to the cooling unit in the

atomization unit 139, the cooling pin 134 is cooled by the cold air which is a cooling medium starting from the cooling pin end 134b which is the most distant part in the cooling pin 134 from the atomization electrode 135.

[0076] A cooling pin heat insulation area 153 is provided between the cooling pin 134 and the outer case 137. The cooling pin heat insulation area 153 has a function of thermally insulating between the below-described heating unit 154 and the cooling pin 134, and is a hollow or composed of heat insulation materials. Furthermore, the heating unit 154 is disposed in the vicinity of the aforementioned condensation prevention member 140. Specifically, the heating unit 154 is disposed to be in contact with the condensation prevention member 140, or with the adjacent outer case.

[0077] With the above configuration, the condensation prevention member 140 is heated by heat conduction from the heating unit 154, and the temperature of the surface of the condensation prevention member 140 can be easily maintained above the dew point. In addition, the temperature of the atomization electrode 135 can be efficiently increased by heat conduction from the condensation prevention member 140.

[0078] On the other hand, the heat conduction from the heating unit 154 to the cooling pin 134 via the outer case 137 is reduced by the effect of the cooling pin heat insulation area 153. In this manner, undesired heat conduction is prevented, indirect heating of the atomization electrode 135 by heating unit 154 through the condensation prevention member 140 efficiently proceeds. Consequently, the temperature control of the atomization electrode 135 can be made easily.

[0079] In this manner, unnecessary dew condensation on the surface of the condensation prevention member 140 is prevented, reduction in dew point in the vicinity of atomization electrode 135 is avoided, and the temperature of the atomization electrode 135 can be efficiently adjusted. Consequently, the effect is obtained that dew condensation on the atomization electrode 135 efficiently proceeds, and fine mist is supplied to the storage compartment (vegetable compartment 108).

[0080] The counter electrode 136 in a doughnut/disc shape is mounted at a position opposed to the atomization electrode 135 near the storage compartment (vegetable compartment 108) with a constant distance from the tip of the atomization electrode 135, and the atomizing port 132 is disposed on the extension.

[0081] The voltage application unit 133 is disposed in the vicinity of the atomization unit 139, and the negative and positive potential sides of the voltage application unit 133 for generating a high voltage are electrically connected to the atomization electrode 135 and the counter electrode 136, respectively.

[0082] In the vicinity of the atomization electrode 135, discharge always occurs for atomizing mist. The tip of the atomization electrode 135 may be worn due to the discharge. In general, the refrigerator 100 keeps running for a long period of 10 years or more, and thus the surface

of the atomization electrode 135 needs to have a highly reliable surface treatment. As the surface treatment of the atomization electrode 135, for example, nickel plating, gold plating, or platinum plating are preferable.

[0083] The counter electrode 136 is composed of stainless steel, for example. In order to ensure the long term reliability of the counter electrode 136, particularly to prevent adhesion of foreign matter and contamination, it is desirable to perform surface treatment such as platinum plating, for example.

[0084] The voltage application unit 133 communicates with the control unit 146 of the refrigerator main body, and sets application of a high voltage ON/OFF according to an input signal from the refrigerator 100 or the electrostatic atomization device 131 under the control of the control unit 146.

[0085] In the present embodiment, the voltage application unit 133 is installed in the electrostatic atomization device 131. Because the inside of the storage compartment (vegetable compartment 108) is in a low temperature high humidity atmosphere, board material or coating material is coated on the substrate surface of the voltage application unit 133 for prevention of moisture.

[0086] However, when the voltage application unit 133 is installed in a hot section outside the storage compartment, coating may not be performed.

[0087] Hereinafter, the operation of the thus configured refrigerator 100 and electrostatic atomization device 131 in the present embodiment will be described.

[0088] First, the operation of a refrigeration cycle will be described. The refrigeration cycle operates to perform cooling operation upon receiving a signal from a control substrate (not shown) according to a preset temperature in the refrigeration. A high temperature, high pressure cooling medium discharged by the operation of the compressor 109 is compressed and liquefied somewhat by a condenser (not shown), and is sent through the lateral and the back surfaces of the heat insulating body 101 which is the refrigerator main body, and refrigerant piping disposed at the frontage of the heat insulating body 101 (not shown), and is compressed and liquefied to reach a capillary tube (not shown) while preventing dew condensation of the heat insulating body 101. Subsequently, the cooling medium is decompressed and reduced in pressure at the capillary tube while heat is exchanged with a suction pipe (not shown) to the compressor 109, and is sent to the cooler 112 as a low temperature, low pressure cooling medium.

[0089] Here, the low temperature, low pressure cooling medium exchanges heat with the air in each storage compartment such as the freezer compartment discharge air passage (not shown), the air being conveyed by the operation of the cooling fan 113, and the cooling medium in the cooler 112 is vaporized. In the above step, the cold air for cooling each storage compartment is generated in the cooling compartment 110. Low temperature cold air is sent from the cooling fan 113 to the refrigerator compartment 104, the switchable compartment 105, the

icemaker compartment 106, the vegetable compartment 108, and the freezer compartment 107. The cold air is shunted using an air passage or a damper, and thus each storage compartment is cooled to a temperature in a target temperature range. Particularly, the temperature of the vegetable compartment 108 is adjusted in a range of 2 to 7°C by cold air distribution which is made by opening or closing of a damper (not shown) in the air passage, and by ON/OFF operation of a heater (not shown). It is to be noted that the vegetable compartment 108 generally has no temperature detection unit.

[0090] In part of a portion of the second partition wall 125, the portion being in relatively high humidity environment, the heat insulation material 152 has a wall thickness thinner than the other portions, and particularly, a deepest recess is present behind the cooling pin 134. The thickness of the heat insulation material in the aforementioned thin portion is approximately 0 to 10 mm, for example. In the refrigerator 100 in the present embodiment, the thickness of this level is suitable for the thermal relaxation member positioned between the cooling pin 134 and the cooling unit. Thus, the recess 125a formed in the second partition wall 125, and the electrostatic atomization device 131 having the projection portion 134a of cooling pin 134 is inserted into the deepest recess 125b at the rearmost of the recess 125a.

[0091] When the second partition wall 125 is thick or the cooling pin 134 is thin, sufficient cooling of the cooling pin 134 may not be achieved. In this case, in order to cool the cooling pin 134 more efficiently by the cold air of the freezer compartment 107, the deepest recess 125b preferably has a shape projecting toward the freezer compartment 107 having a lower temperature. Specifically, the thickness of the heat insulation material 152 is zero at the thinnest portion of the heat insulation material 152, and the cooling pin (heat transfer cooling unit) end 134b is in direct contact with a back side partition wall surface 151 which is a second partition wall surface, and the back side partition wall surface 151 which is the second partition wall surface has a shape projecting toward the freezer compartment. The length of the projection toward the freezer compartment is preferable 20% of the entire length of the cooling pin 134 or longer. For example, when the entire length of the cooling pin 134 is 20 mm, the length of the projection is approximately 4 mm or longer.

[0092] For example, in the case where the cooling pin 134 is inserted with a slight inclination or the surface flatness of the cooling pin 134 end is not sufficient when the cooling pin 134 is directly made contact with the back side partition wall surface 151 which is the second partition wall surface as described above, the contact area therebetween is decreased, and conduction of cold heat is reduced, and thus the cooling pin 134 may not be sufficiently cooled.

[0093] In such a case, it is preferable to install good conductor having flexibility between the cooling pin 134 and the back side partition wall surface 151. With this

arrangement, the contact area is increased, and conduction of cold heat is improved, and thus the cooling pin 134 is sufficiently cooled. Specifically, the good conductor to be installed is preferably rubber in which conductor such as carbon is distributed, a sheet including an elastomeric material, or the like. It is also effective to coat grease or grease in which good conductor is distributed between the cooling pin 134 and the back side partition wall surface 151. In addition, rubber, elastomer, and grease cause the contact area to be increased to promote heat conduction, and indirectly help to improve heat conduction, and thus a sudden temperature change is prevented, and therefore are effective for stable atomization.

[0094] The cold air of the freezer compartment, which is a cooling medium in the back of the cooling pin 134, is at -17 to -20°C, for example, and the cooling pin 134 which is the heat transfer cooling unit is cooled to -5 to -10°C, for example, via the heat insulation material 152.

[0095] Because the cooling pin 134 is a good heat conduction member and conducts cold heat well, the atomization electrode 135 which is the atomization tip is also cooled to approximately -3 to -8°C via the cooling pin 134.

[0096] The side of the cooling pin 134 that is exposed to the space near the atomization electrode 135 is covered by the condensation prevention member 140. Because the thermal conductivity of the condensation prevention member 140 is lower than the thermal conductivity of the cooling pin, conduction of cold heat from the cooling pin 134 to the condensation prevention member 140 is reduced, and the temperature of the condensation prevention member 140 becomes higher than the temperature of the cooling pin 134. For example, the temperature of the condensation prevention member 140 becomes approximately 3 to -2°C.

[0097] The condensation prevention member 140 extends over an area larger than the contact area with the cooling pin 134, and thus cold heat also conducts the condensation prevention member 140 and is diffused to the surroundings. For this reason, the minimum temperature of the surface of the condensation prevention member 140 increases by 1 to 2°C, for example. The condensation prevention member 140 extends over an area larger than the contact area with the cooling pin 134, and is in surface contact with the outer case in the extended area. In addition, the condensation prevention member 140 completely blocks the cold air from the freezer compartment 107 by the surface contact with the outer case 137.

[0098] Here, the vegetable compartment 108 has a temperature of 2 to 7°C, and is in a relatively high humidity state due to the transpiration from vegetables, and thus when the atomization electrode 135 which is the atomization tip has a temperature at the dew point or below, water is generated on the atomization electrode 135 including the tip, and drops of water adhere thereto.

[0099] A high voltage (for example, 4 to 10 kV) is applied to the atomization electrode 135 which is the atomization tip and to which drops of water adhere, by the

voltage application unit 133. Then, corona discharge occurs, and the drops of water at the tip end of the atomization electrode 135 which is the atomization tip are made finer by electrostatic energy. Because the droplets are charged, nano-level fine mist having invisible charged droplets in the order of several nm is generated by Rayleigh fission. Ozone and OH radicals are generated associated with the generation of fine mist. The voltage applied across the electrodes is an extremely high voltage of 4 to 10 kV, however, the discharge current value is in the order of several pA, and is an extremely low input of 0.5 to 1.5 W.

[0100] Specifically, assume that the atomization electrode 135 is a reference potential side (0 V), and the counter electrode 136 is a high voltage side (+7kV), then air insulation layer between the atomization electrode 135 and the counter electrode 136 is broken down, and because of static electricity force, discharge occurs in dew condensation water adhering to the tip of the atomization electrode 135. The dew condensation water is then charged, and is made finer particles. Because the counter electrode 136 is the positive side, the charged fine mist is attracted thereto, and the droplets are further micro-atomized, and nano-level fine mist having invisible charged droplets in the order of several nm and including radicals is attracted to the counter electrode 136. Thus fine mist is sprayed toward the storage compartment (vegetable compartment 108) by the inertial force of the fine mist.

[0101] When water is not present on the atomization electrode 135, the discharge distance is increased, and thus the air insulation layer cannot be broken down and discharge phenomenon does not occur. Consequently, no current flows between the atomization electrode 135 and the counter electrode 136.

[0102] In the above, the operation and effect of the electrostatic atomization device have been roughly described, and hereinafter, the configuration, operation, and effect of the control method of the present invention using the aforementioned electrostatic atomization device will be described in detail.

[0103] First, the fact that atomization proceeds only in a certain specific temperature range and the necessity of a method of controlling in the temperature range will be described with reference to FIG. 3.

[0104] The vertical axis of FIG. 3 is the temperature difference which is obtained by subtracting the atomization electrode temperature from the dew point in the vicinity of the atomization electrode. Higher the value of the temperature difference is (the dew point is high and the atomization electrode temperature is low), more likely to proceed dew condensation on the atomization electrode is, and an atomization state changes according to the amount of dew condensation. The above phenomenon will be described stepwise in the ascending order of the difference of temperature.

[0105] In the area where the temperature difference is low (lower part of FIG. 3), the amount of dew condensa-

tion water is small and even when a high voltage is applied to the atomization electrode, atomization does not proceed. Because the amount of dew condensation water is small and atomization does not proceed, the value of corresponding discharge current is substantially zero.

[0106] When the temperature difference increases (middle part of FIG. 3), the amount of dew condensation water increases, and atomization of dew condensation water starts to occur. At this time, the amount of dew condensation water is moderate, and the value of corresponding discharge current is also moderate.

[0107] However, when the temperature difference increases further increases (upper part of FIG. 3), the amount of dew condensation water increases too much, and even when a high voltage is applied to the atomization electrode, atomization due to division of the dew condensation water does not proceed by a force of the surface charge induced by the voltage. The state is called excessive dew condensation state. In this case, the amount of dew condensation is large, and the value of corresponding discharge current also large. The reason why discharge current is large even though atomization does not proceed is that a leak current other than the discharge current for atomization increases.

[0108] In the above, the fact that the discharge current varies with a state of atomization has been described, a corresponding change also occurs in the voltage at the time of discharge (discharge voltage). As described below, dew point - atomization electrode temperature can be controlled according to the value of discharge current or a corresponding voltage.

[0109] In this manner, atomization does not proceed when "dew point - atomization electrode temperature" is large or small, but proceeds only in a certain temperature range. Practically, the temperature difference ΔT is approximately 2 to 3°C, and is a quite narrow temperature range.

[0110] The above fact means that particularly, when the dew point in the vicinity of the atomization electrode varies, favorable atomization in process may substantially stop even with a dew point variation of 2 to 3°C. The dew point variation of 2 to 3°C corresponds to approximately 10% in relative humidity, and for example, when a refrigerator door is opened or closed, or the electrostatic atomization device is disposed in the vegetable compartment, the variation can be easily caused by a change in the amount of the vegetables. Particularly when the electrostatic atomization device is disposed in the vegetable compartment, an approximately 10% increase in humidity may occur due to an increase of the amount of vegetables, and a control method for maintaining an atomization state even with such a humidity change is necessary.

[0111] Next, the configuration of the control of the present invention for ensuring stable atomization against the aforementioned humidity change (dew point change) will be described in detail with reference to FIGS. 4, 5, and 6.

[0112] In the present invention, as shown in FIG. 4, the

control unit determines an atomization state according to a state of the atomization electrode, and controls the voltage application unit and the heating unit according to the determination, and thus controls "dew point - atomization electrode temperature" at an appropriate value for atomization.

[0113] FIG. 5 is a flowchart of the above-described operation, and the step will be described with reference to FIG. 5.

[0114] The terms which are used in FIG. 6 will be described before FIG. 5 is described.

[0115] First, an atomization state control cycle is a cycle corresponding to a time interval for determining an atomization state. For example, the atomization state control cycle is defined as the interval from opening of a damper to the subsequent closing of the damper in synchronization with opening and closing of the damper for introducing cold air into a storage compartment such as the vegetable compartment. The length of cycle may be changed for each cycle in such a manner that "first cycle: the interval from the first opening of the damper to the first opening of the damper", and "second cycle: the interval from the first opening of the damper to the third opening of the damper."

[0116] The atomization rate stated below is defined as a value proportional to an atomization time, for example, $\text{atomization rate} = (\text{atomization time}) / (\text{interval of atomization state control cycle})$, or $\text{atomization rate} = (\text{atomization time}) / (\text{time in which a high voltage is applied to the atomization electrode out of the atomization state control cycle})$, however, a parameter which has a strong correlation with the above parameters may replace the parameters. The latter of the above two definitions is more preferable than the former because the time in which a high voltage is not applied to the atomization electrode is already subtracted from the denominator of the expression of the latter, and thus the sensitivity of the atomization rate with respect to a change in atomization time is improved.

[0117] The above-mentioned atomization time indicates a time interval in which a constant discharge current or voltage flowing or being applied between the atomization electrode and the counter electrode is observed. Generally, atomization time is defined in terms of observation time in which a discharge current or a discharge voltage which exceeds a predetermined threshold value.

[0118] Here, it should be noted that even though no atomization practically occurs, observed discharge current at the time of excessive dew condensation in FIG. 3 is higher than the discharge current at the time of atomization. This is because a leak current increases.

[0119] Referring back to FIG. 5, the step of the control method will be described. First, a control unit determines an atomization state in Nth atomization state control cycle N (STEP 1). When the result of the determination shows "atomization rate > atomization target", the amount of heating by the heating unit is increased (STEP 2) in the subsequent atomization state control cycle (atomization

state control cycle N+1) (STEP 2). Accordingly, the temperature of the atomization electrode is increased. Consequently, the atomization rate decreases and approaches the target value.

[0120] On the other hand, when the result of the determination shows "atomization rate = atomization target" (STEP 1), the amount of heating by the heating unit is maintained in the subsequent atomization state control cycle (STEP 2). Accordingly, the temperature of the atomization electrode does not change, and the atomization rate is also maintained.

[0121] Furthermore, when the result of the determination shows "atomization rate < atomization target" (STEP 1), the amount of heating by the heating unit is decreased in the subsequent atomization state control cycle (STEP 3). Thus, the temperature of the atomization electrode decreases. Consequently, the atomization rate increases and approaches the target value.

[0122] The above atomization target may be a value having no range. For example, the atomization target may be a value having a range such as 40% or higher and 70% or lower. Specifically, the atomization target is set as the above-mentioned specific atomization rate or specific atomization rate range. Optionally, it is also possible to set an atomization target related to a representative value of an appropriate discharge current or voltage in an atomization state control cycle. For example, an atomization target may be set to an average discharge current value of 2 to 3 pA, or an average discharge voltage of 1.5 to 2.8 kV. The above atomization target is set in terms of a lower limit concentration determined by performance of freshness maintenance, disinfection, deodorization, and the like, and an upper limit concentration determined by ozone smell and the like.

[0123] By repeating the above-described "atomization state determination (STEP 1)" and "change (increase, maintenance, decrease) of the amount of heating by the heating unit (STEP 2 to 4)," the atomization rate can be made close to the target value.

[0124] Next, the operation in time series and a temperature change achieved as a result of the operation will be described with reference to FIGS. 2, 4, and 5 using the time chart in FIG. 6

[0125] FIG. 6 shows change in time of variables on the vertical axis, where the horizontal axis indicates time, and the variables are the dew point (dew point in the vicinity of the electrode), the temperature of the atomization electrode, the dew point - temperature of the atomization electrode, the temperature of the cooling unit (freezer compartment), open and close of the damper disposed in the air passage for supplying cold air to the vegetable compartment (not shown), and an input by the heating unit from the top to the bottom.

[0126] As shown in the upper part of FIG. 6, the time axis is divided into two major atomization state control cycles, which are atomization state control cycle N and atomization state control cycle N+1 in sequence of time. Each atomization state control cycle is divided into two

intervals, for example, the atomization state control cycle N is divided into two intervals of from tN, close to tN, open, and from tN, open to tN+1, close. In the interval of from tN, close to tN, open, the damper is closed, and air with a low dew point and a low temperature does not flow in, and thus the dew point increases, whereas in the interval of from tN, open to tN+1, close, the damper is opened, and air with a low dew point and a low temperature flows in, and thus the dew point decreases.

[0127] On the other hand, when the damper is closed, the temperature of the cooling unit (freezer compartment) decreases because cold air is not supplied to other storage compartments, whereas when the damper is opened, the temperature of the cooling unit increases because cold air is supplied to the vegetable compartment and cold air in the freezer compartment becomes insufficient. Accordingly, the atomization electrode 135 which is indirectly cooled by the cooling pin 134 in addition to the cooling pin 134 cooled by the cooling unit have a temperature change similar to the temperature change of the cooling unit.

[0128] Next, "dew point - atomization electrode temperature" will be described.

[0129] In the atomization state control cycle N, "dew point - atomization electrode temperature" is higher (area of a high temperature) than the atomization temperature range in which atomization can occur.

[0130] Here, although not shown in the FIG. 6, the atomization rate defined by (atomization time / interval of atomization state control cycle) x 100 is calculated by the control unit 146, and the calculated value was 100%. Assume that the atomization target is set to the atomization rate of 20%, then based on this, the control unit determines the atomization state of atomization rate > atomization target in STEP 1 of FIG. 5.

[0131] In response to the determination, the amount of heating by the heating unit 154 is increased in the atomization state control cycle N+1. Accordingly, the input of the heating unit in FIG. 6 is increased to a constant value after the tN+1, close. Because of the input to the heating unit 154, the temperature of the condensation prevention member 140 adjacent to the heating unit 154 increases, and the temperature of the atomization electrode 135 adjacent to the condensation prevention member 140 is also increased. Because of the presence of the cooling pin heat insulation area 153, transfer of heat from the heating unit 154 to the cooling pin 134 is reduced, and an increase in the temperature of the condensation prevention member 140 and the atomization electrode 135 is efficiently achieved.

[0132] The above-described temperature change can be verified by an increase in the temperature of the atomization electrode after tN+1, close in FIG. 6. As a result of the increase in the atomization electrode temperature, "dew point - atomization electrode temperature" decreases to an atomization temperature range. Although not shown here, the atomization rate of the atomization state control cycle N+1 became 15%, which was closer to the

atomization target of 20% than the atomization rate in the preceding cycle.

[0133] Hereinafter, by repeating the above step, an atomization state close to the atomization target can be maintained in a short time by efficiently using the heating of the heating unit.

[0134] Here, the case has been described in which the atomization target is achieved by increasing the temperature of the atomization electrode from an excessive dew condensation state in which "dew point - atomization electrode temperature" is high. On the other hand, in the case in which "dew point - atomization electrode temperature" is low, the atomization rate can be made closer to the atomization target by reducing the input to the heating unit input.

[0135] When the magnitude of a change in input to the heating unit is large, an atomization target can be achieved in a short time, but the atomization rate may exceed the atomization target, on the other hand, when the magnitude is small, the atomization rate can be precisely adjusted to the atomization target, but it takes time for the adjustment. Practically, the magnitude of a change of the heating unit is determined in consideration of adjustment precision and time, however, in view of adjustment precision and time necessary for the adjustment, it is preferable to set the aforementioned change to be increased when the difference between the atomization rate and the atomization target is large, and to set the aforementioned change to be decreased when the difference between the atomization rate and the atomization target is small.

[0136] Next, a method of recovering atomization stop due to freeze of the present invention will be described.

[0137] Because dew condensation on the atomization electrode in a refrigerator proceeds in a super cooling state in many cases, freezing can be avoided with the passage of time.

[0138] In order to solve this problem, when the atomization rate in an atomization state control cycle suddenly decreases in the subsequent atomization state control cycle and is reduced to substantially zero, it is determined that the atomization electrode is frozen. Based on the determination, the temperature of the atomization electrode 135 is then raised by increasing the amount heating of the heating unit in the subsequent atomization state control cycle.

[0139] Because freezing suddenly occur and the atomization rate suddenly decreases, occurrence of freezing can be determined with a high probability by the above-described determination. In addition, as described above, the atomization electrode 135 can be efficiently heated by the effect of the cooling pin 134 and the cooling pin heat insulation area 153. In this manner, freezing can be resolved in a short time without using wasteful energy.

[0140] Because the temperature of the atomization electrode has been increased after resolving the freezing, in some case, atomization may be difficult to be achieved even when the dew point is high. Even in such

a case, it is preferable to quickly reduce the temperature of the atomization electrode by setting an input to the heating unit after resolving the freezing to be low irrespective of determination of an atomization state. In this manner, reatomization can be achieved early. In addition, energy saving effect is also be achieved by reducing wasted heating by a heater.

[0141] It is also effective to set the amount of heating by the heating unit to be substantially equal to the amount of heating before freezing in a constant atomization state control cycle after resolving the freezing.

[0142] Thus even when the amount of heating by the heating unit after resolving the freezing is significantly different from the amount of heating due to finally stable atomization, it is possible to return to a stable atomization state early by setting the amount of heating by the heating unit to the heating amount at the time of stable atomization before the freezing when the temperature of the atomization electrode is reduced to some extent after resolving the freezing, for example, in 1 to 2 atomization state control cycles after resolving the freezing, and thus wasteful heating by a heater can be avoided.

[0143] It is preferable to set the timing of heating of the heating unit to be substantially matched to the time when the temperature of the atomization electrode and the heat transfer cooling unit decreases. As described in FIG. 6, the temperature of the heat transfer cooling unit is cooled by the cooling unit (freezer compartment), and thus the temperature changes similarly to the cooling unit (freezer compartment). Therefore, the atomization electrode temperature has a minimum value at t_N , open in atomization state control period N. However, the difference between the dew point and the atomization electrode temperature as described above increases, and thus dew point - atomization electrode temperature has a large value, and an excessive dew condensation state is assumed.

[0144] However, when the input of the heating unit is increased in the interval of from t_N , close to t_N , open in which the temperatures of the atomization electrode and the heat transfer cooling unit decrease, and the amount heating of the heating unit is reduced during the interval of from t_N , open to t_{N+1} , close, the temperature of the atomization electrode increases in the interval of from t_N , close to t_N , open, and decreases in the interval of from t_N , open to t_{N+1} , close, and thus a temperature change similar to that of the dew point is observed. In this case, the difference between the dew point and the atomization electrode temperature reduces, and dew point - atomization electrode temperature also reduces, and falls in the atomization temperature range. In this manner, an excessive dew condensation state is avoided.

[0145] In addition, the minimum temperature of the atomization electrode is raised by increasing the amount of heating by the heating unit when the temperatures of the atomization electrode and the heat transfer cooling unit decrease, and thus the effect is obtained that freezing is avoided.

[0146] When frost forms in the cooler 112 in the refrigerator, the temperature is raised temporarily to remove the frost, and in this case, the temperature of the freezer compartment which is the cooling unit is raised, and thus the temperatures of the cooling pin 134 and the atomization electrode 135 rise. Thus it is effective to reduce the amount of heating by the heating unit to a low level like after resolving the freezing, in certain atomization state control cycles after resolving the freezing (specifically after 1 or 2 cycles) irrespective of the result of determination of an atomization state. Similarly, it is possible to return to a stable atomization state early by setting the amount of heating by the heating unit to the heating amount at the time of stable atomization before the freezing in 1 to 2 atomization state control cycles after resolving the freezing, and thus wasteful heating by a heater can be avoided.

[0147] By adopting the configuration in which the deepest recess 125b of the cooling pin 134 has a shape projecting toward the freezer compartment 107 having a lower temperature, the cooling pin 134 can be easily cooled to a low temperature which is necessary for dew condensation in a low humidity atmosphere, and thus stable supply of fine mist can be achieved. Then, the contact area between the surface of the back side partition wall surface 151 and the cooling pin (heat transfer cooling unit) end 134b is ensured by inserting grease, rubber, or elastomer therebetween, and thus the effect is obtained that cooling of the cooling pin 134 efficiently proceeds. In addition, the effect can be further improved by combining grease, rubber, or elastomer with a conductive material.

[0148] The electrostatic atomization device 131 in the present embodiment applies a high voltage between the atomization electrode 135 which is the atomization tip and the counter electrode 136, and thus ozone is also generated when fine mist is generated, however, the ozone concentration in the storage compartment (vegetable compartment 108) can be adjusted by ON/OFF operation of the electrostatic atomization device 131. By appropriately adjusting the ozone concentration, degradation such as etiolation of vegetables due to excessive ozone can be prevented, and antimicrobial, bactericidal effect on the surfaces of vegetables can be increased.

[0149] In the present embodiment, the atomization electrode 135 is set as a reference potential side (0 V), and a positive potential (+7 kV) is applied to the counter electrode 136 so as to generate a high voltage potential difference between the electrodes, however, the counter electrode 136 may be set as a reference potential side (0 V), and a negative potential (-7 kV) may be applied to the atomization electrode 135 so as to generate a high voltage potential difference between the electrodes. In this case, the counter electrode 136 near the storage compartment (vegetable compartment 108) serves as the reference potential side, and thus an electric shock does not occur even if a hand of a user of the refrigerator comes close to the counter electrode 136. When the atomization electrode 135 is set to a negative potential of

-7 kV, the counter electrode 136 may not be particularly provided because the storage compartment (vegetable compartment 108) side can serve as a reference potential side.

[0150] In this case, for example, the insulated storage compartment (vegetable compartment 108) is provided with a conductive storage container which is electrically connected and detachably attached to a (conductive) retaining member of the storage container, and the retaining member is connected to a reference potential unit to be grounded (0 V).

[0151] Accordingly, the atomization unit 139, and the storage container, the retaining member always maintain a potential difference therebetween, and a stable electric field is generated, and thus stable spray is achieved by the atomization unit 139. In addition, the entire storage container is at a reference potential, thus sprayed mist can be diffused to the entire storage container. Furthermore, electrification of the surrounding objects can also be prevented.

[0152] In this manner, without particularly arranging the counter electrode 136, mist atomization is achieved by generating a potential difference between the atomization electrode 135 and a grounded retaining member which is provided in part of the storage compartment (vegetable compartment 108) side, and thus a stable electric field is generated in a simpler configuration. Consequently, stable atomization is achieved by the atomization unit.

[0153] In the present embodiment, the cooling medium for cooling the cooling pin 134 which is the heat transfer cooling unit is cold air of the freezer compartment 107, however, cold air which is cooled by using a cooling source which is generated by the refrigeration cycle of the refrigerator 100, or heat transfer from a cooling tube using cold air or cold temperature from the cooling source of the refrigerator 100 may be used. Thus, by adjusting the temperature of the cooling tube, the cooling pin 134 which is the heat transfer cooling unit can be cooled to any temperature, and temperature control for cooling the atomization electrode 135 can be easily performed. Cold air of the discharge air passage of the icemaker compartment 106 or cold air of a low temperature air passage such as a freezer compartment return air passage may be used as a cooling medium. In this manner, the electrostatic atomization device 131 can be installed at many locations.

[0154] In the present embodiment, the vegetable compartment 108 is a storage compartment into which mist is sprayed by the electrostatic atomization device 131 (atomization unit 139), however, a storage compartment in other temperature range, such as the refrigerator compartment 104 and the switchable compartment 105 may be a storage compartment into which mist is sprayed. In this case, various applications may be made.

[Embodiment 2]

[0155] FIG. 7 is a vertical cross-sectional view of a refrigerator in Embodiment 2 of the present invention; FIG. 8 is a cross-sectional perspective view of the main portion of the refrigerator in Embodiment 2 of the present invention; FIG. 9 is a configuration diagram of a discharge device of the refrigerator in Embodiment 2 of the present invention; FIG. 10 is a graph showing a temperature dependence of a discharge current of the discharge device of the refrigerator in Embodiment 2 of the present invention; FIG. 11 is a graph showing a humidity dependence of the discharge current of the discharge device of the refrigerator in Embodiment 2 of the present invention; FIG. 12 is a graph showing the relationship between an ozone concentration and the discharge current of the discharge device of the refrigerator in Embodiment 2 of the present invention; FIG. 13 is a control flowchart for the discharge device of the refrigerator in Embodiment 2 of the present invention; and FIG. 14 is a control time chart for the discharge device of the refrigerator in Embodiment 2 of the present invention.

[0156] Description of the same configuration as in Embodiment 1 and part of Embodiment 2 to which the same technical idea as in Embodiment 1 can be applied will not be given, however, the present embodiment may be combined with the configuration of Embodiment 1 for application as long as the combination does not cause a failure.

[0157] A refrigerator in the present Embodiment 2 will be described with reference to FIGS. 7, 8, and 9.

[0158] The cooling compartment 110 for generating cold air is provided behind the freezer compartment 107 and the vegetable compartment 108. In addition, the cooling compartment 110 and each storage compartment are provided with a discharge air passage 141 for transporting cold air, and a suction air passage 142 for returning cold air from each storage compartment to the cooling compartment. A vegetable compartment discharge air passage 141a allows cold air to be discharged to the vegetable compartment, and the vegetable compartment 108 is provided with the vegetable compartment suction air passage 142.

[0159] The cooler 112 is disposed in the cooling compartment 110, and in the upper space of the cooler 112, a cooling fan 113 is disposed which sends cold air to the refrigerator compartment 104, the switchable compartment 105, the icemaker compartment 106, the vegetable compartment 108, and the freezer compartment 107 by forced convection system, the cold air being cooled by the cooler 112.

[0160] The cooling fan 113 sends cold air, which is cooled by the cooler 112 in the cooling compartment 110, to the vegetable compartment 108 through the vegetable compartment discharge air passage 141a, and a damper 130 is disposed in the middle of the vegetable compartment discharge air passage 141a.

[0161] In vegetable compartment 108, there are dis-

posed a lower storage container 119 which placed on a frame attached to a drawer door 118 of the vegetable compartment 108, and an upper storage container 120 which is placed on the lower storage container 119.

[0162] There are provided a vegetable compartment discharge port 143 for discharging cold air through the vegetable compartment discharge air passage 141a, the cold air being cooled by the cooler 112 in the lower portion behind the vegetable compartment 108, a vegetable compartment suction air passage 142a for returning cold air to the cooling compartment 110, and a vegetable compartment suction port 144 as a suction port.

[0163] It is to be noted that the below-described essential features of the invention in the present embodiment may be applied to a typically conventional refrigerator in which the door is opened/closed with a frame attached to the door and a rail provided in the inner casing.

[0164] The top surface of the vegetable compartment 108 is provided with a discharge device 200. The vegetable compartment 108 has a structure which allows ozone to be discharged directly from the discharge device 200.

[0165] The discharge device 200 includes a discharge unit 201, a voltage application unit 202, a discharge state detection unit 203, and an outer case 204. Part of the outer cases 204 is provided with an ozone injection port 205. The discharge unit 201 is formed by a needle-shaped discharge electrode 206 to which a high negative voltage is applied, a doughnut/disc shaped counter electrode 207 opposed to the discharge electrode 206, and a resin fixing member 208 which is disposed so as to maintain a constant distance between the counter electrode 207 and the discharge electrode 206. The discharge unit 201 is disposed in the outer case 204.

[0166] In addition, the voltage application unit 202 is disposed in the vicinity of the discharge unit 201. For example, a high voltage of approximately -5kV is applied to the discharge electrode 206, and the ground which is a reference potential (0 V) is applied to the counter electrode 207 by the voltage application unit 202.

[0167] The voltage application unit 202 communicates with a control unit 210, and sets application of a high voltage ON/OFF according to a voltage application time (application rate) of a high voltage under the control of the control unit 210.

[0168] The discharge state detection unit 203 is connected to the voltage application unit 202 to detect a current which flows between the discharge electrode 206 and the counter electrode 207 (discharge current), and outputs an analog signal or a digital signal as a monitor voltage to the control unit 210.

[0169] In order to indirectly supply ozone, which is supplied from the discharge device 200, to the refrigerator compartment 104, the switchable compartment 105, the icemaker compartment 106, and the freezer compartment 107, the vegetable compartment 108 is provided with the discharge air passage 141 for transporting cold air, which has been cooled in the cooling compartment,

to each storage compartment.

[0170] Strong oxidation power of ozone generated by the discharge device 200 has a function of suppressing an increase of microorganisms such as mold, yeast, and virus which adhere to the structural material of the refrigerator 100 or the surfaces of food and food containers stored in each storage compartment when the ozone comes into contact with the structural material and the surfaces.

[0171] In addition, contact of ozone with air with the smell which is generated from the food and the like stored in the refrigerator 100 causes smell components to be oxidized and decomposed, and thus deodorizing effect is obtained by the decomposition of smell.

[0172] Hereinafter, the operation and effect of the refrigerator 100 of the present embodiment configured in this manner will be described.

[0173] The vegetable compartment 108 is cooled by cold air which has been cooled by the cooler 112, and the cold air for cooling the vegetable compartment 108 is sent from the cooling fan 113 and passes through the discharge air passage 141, the vegetable compartment discharge air passage 141a which is shunted from the middle of the discharge air passage 141, and the vegetable compartment damper 130a, and then flows into the vegetable compartment 108 through the vegetable compartment discharge port 143. The cold air which has flowed into the vegetable compartment 108 circulates through the outer periphery of the lower storage container 119 to cool the lower storage container 119, and is sucked in through the vegetable compartment suction port 144, passes through the vegetable compartment suction air passage 142a, and returns to the cooling compartment 110. The vegetable compartment 108 is cooled by the circulation of cold air, and when a temperature sensor (not shown), which is installed in the vegetable compartment 108, detects a temperature lower than or equal to a target temperature range, the vegetable compartment damper 130a is closed, and thus flow of cold air into the vegetable compartment 108 is controlled so as to be stopped.

[0174] In the above step, the discharge device 200 is controlled so as to spray ozone directly to the vegetable compartment 108. Further, the ozone generated from the discharge device 200 is sucked in the vegetable compartment suction air passage 142a, and is indirectly sprayed from mist discharge ports of the refrigerator compartment 104, the switchable compartment 105, the icemaker compartment 106, and the freezer compartment 107 to the respective storage compartments. Thus, the ozone is supplied to the refrigerator compartment 104, the switchable compartment 105, the icemaker compartment 106, the vegetable compartment 108, and freezer compartment 107 which are storage compartments of the refrigerator 100. In this manner, ozone is supplied to the all storage compartments of the refrigerator.

[0175] Because ozone has strong oxidation power, higher the ozone concentration is, greater the advanta-

geous effects of antimicrobial effect against microorganisms such as mold, bacteria, and virus, and thus decomposition of smell components further proceeds and provides advantageous effect in deodorization. On the other hand, peculiar smell of ozone is hated by many users of refrigerator, and also harmful to human body, and thus the concentration of ozone should be low as much as possible from the viewpoint of the users of refrigerator.

[0176] By studying the relationship between antimicrobial effect of ozone and ozone smell, it has been verified that ozone with an ozone concentration of 5 ppb or higher has bacterial eradication rate of 99%, while an ozone concentration of 30 ppb is a tolerance limit value in terms of bad smell for users of refrigerator. Furthermore, it has been verified by previous BOX experiments that ozone with an ozone concentration of 80 ppb or higher causes damage to the external appearance of vegetables. Based on the above-described verified result, the control unit 210 controls the discharge device to supply ozone to each storage compartment so that the concentration of ozone in each partition of storage compartment of the refrigerator is 5 ppb or higher and 30 ppb or lower. Consequently, the ozone supplied to each storage compartment exhibits a disinfecting effect, and ozone smell does not bother users of the refrigerator.

[0177] In the above, the operation and effect of the discharge device have been roughly described, and hereinafter, the configuration, operation, and effect of the control method of the present invention using the aforementioned discharge device will be described in detail.

[0178] First, the characteristics of discharged current of the discharge device will be described with reference to FIG. 10.

[0179] FIGS. 10 and 11 show discharge current which is measured in a 100 liter box, where the discharge current is a current which flows through the discharge electrode and the counter electrode when a constant voltage is applied to the discharge electrode and the counter electrode. FIG. 10 shows a graph with the temperature varied at a humidity of constant 99%Rh, and FIG. 11 shows a graph with the humidity varied at a temperature of 5°C. As seen from these graphs, the discharge current increases as the temperature and humidity decrease.

[0180] On the other hand, FIG. 12 is a graph showing discharge current and measured concentration of ozone generated by discharge which is caused by applying a voltage to the discharge electrode and the counter electrode after a discharge device is installed in a 100 liter box similarly. As seen from the graph, the amount of generated ozone per unit of time increases as the discharge current increases, and thus the ozone concentration increases.

[0181] Based on the above result, it is found that the discharge current of the discharge device increases, i.e., the amount of generated ozone increases as the temperature and humidity decrease.

[0182] The above result indicates that the amount of generated ozone varies particularly according to the state

of the temperature and humidity in the vicinity of the discharge device installed in the refrigerator. As shown in FIGS. 10 and 11, a change in the discharge current is large even in a temperature range of 1 to 5°C and in a humidity range of 40 to 99%Rh, and a change in the temperature and humidity in the above range often occurs, for example, by opening or closing the door, or a change in the amount of vegetables stored in the vegetable compartment in practical use of a refrigerator.

[0183] Thus, even when the above temperature or humidity change occurs, the refrigerator needs to be controlled so that the ozone therein is maintained at a target ozone concentration (5 ppb or higher and 30 ppb or lower).

[0184] On the other hand, in order to diffuse the ozone generated from the discharge device to each storage compartment of the refrigerator, it is effective to install a discharge device near the vegetable compartment suction port and diffuse the ozone by utilizing the discharge air passage of the refrigerator as described above, and thus the discharge device is installed near the vegetable compartment suction port.

[0185] However, on the other hand, a change in the temperature and humidity in the vicinity of the discharge device becomes larger than the change in the temperature and humidity near the center of the storage compartment. Therefore, as described in FIGS. 10 to 12, the discharge current of the discharge device is not stable, and accordingly, the generated amount of ozone is not stable.

[0186] In addition, it has been found by the past study that in addition to ozone, a very small amount of negative ions is also discharged from the discharge device, and thus the vicinity of the discharge device is charged with negative ions, thereby causing a problem in that the discharge current is reduced.

[0187] Thus, the control for solving the aforementioned problem and maintaining the inside of the refrigerator at a target ozone concentration irrespective of the aforementioned change in the temperature and humidity will be described in detail with reference to FIGS. 9, 13, and 14.

[0188] The control unit in FIG. 9 recognizes a discharge current and a voltage application time by the discharge state detection unit, determines the amount of ozone which is generated from the discharge device, controls the voltage application unit based on the determination, and controls the amount of ozone at an ozone target concentration (5 ppb or higher and 30 ppb or lower), the ozone being generated from the discharge device.

[0189] FIG. 13 is a flowchart of the above-described operation, and FIG. 14 is a control time chart of the above-described operation. The terms used in FIGS. 13 and 14 are as follows.

[0190] First, a discharge state control cycle is a cycle corresponding to the time interval in which a discharge state is determined. For example, in synchronization with opening and closing of the damper 130a which introduc-

es cold air into a storage compartments such as the vegetable compartment, discharge state control cycle can be defined as the time interval from opening of the damper 130a to the subsequent opening of the damper 130a. The length of cycle may be changed for each cycle in such a manner that "first cycle: the interval up to the first opening of the damper", and "second cycle: the interval from the first opening of the damper to the third opening of the damper."

[0191] The voltage application rate is defined as voltage application = (time interval in which a voltage is applied) / (time interval of discharge state control cycle). The discharged electric charge is defined as discharged electric charge = (discharge current) x (time interval in which a voltage is applied).

[0192] As seen from the relationship in the discharged electric charge, the discharged electric charge is an integral value of discharge current (the amount of ozone generated per unit of time) and a time interval in which a voltage is applied (time interval in which ozone is generated), and thus indicates the amount of ozone generated from the discharge device during the time interval in which a voltage is applied. On the other hand, per-cycle discharged electric charge indicates the total amount of discharged electric charge which is generated by actually applying a voltage to the discharge device during one cycle of discharge current state control cycle. The per-cycle discharged electric charge can be converted to the total amount of ozone which is generated during one discharge state control cycle, and thus can also be converted to an ozone concentration in a storage compartment. Thus, per-cycle discharged electric charge is made associated with an ozone target concentration (5 ppb or higher and 30 ppb or lower) in the refrigerator, and the minimum ozone target concentration is denoted as the minimum discharged electric charge (Qmin), and the maximum ozone target concentration is denoted as the maximum discharge electric charge (Qmax).

[0193] Here, referring back to FIG. 13, the step of the control method will be described. First, a discharge state is determined by a control unit in the Nth discharge state control cycle N (STEP 1). When the determination indicates "discharge amount (discharged electric charge) < discharge target", an application time of voltage (voltage application rate) is increased by the control unit in the subsequent discharge state control cycle (discharge state control cycle N+1) (STEP 2). Consequently, the discharge amount (discharged electric charge) is increased in the discharge state control cycle N+1, and the discharge amount (discharged electric charge) approaches the discharge target.

[0194] When discharge state determination indicates "discharge amount = discharge target" (STEP 1), the application time of voltage (voltage application rate) is maintained by the control unit in the subsequent discharge control cycle (STEP 3).

[0195] When the discharge state determination indicates "discharge amount (discharged electric charge) >

discharge target" (STEP 1), the application time of voltage (voltage application rate) is decreased by the control unit in the subsequent discharge control cycle (discharge state control cycle N+1) (STEP 2). Consequently, the discharge amount (discharged electric charge) is decreased in the discharge state control cycle N+1, and the discharge amount (discharged electric charge) approaches the discharge target.

[0196] By repeating "discharge state determination (STEP 1)" and "change of the application time of voltage (from STEP 2 to STEP 4)" by the above control, voltage application time (application rate) is appropriately adjusted, and the discharge amount approaches the discharge target.

[0197] Next, the operation in time series and per-cycle discharged electric charge achieved as a result of the operation will be described with reference to the time chart of FIG. 14.

[0198] In FIG. 14, the horizontal axis is the time axis. Starting from the top, the vertical axis has the discharge target (discharged electric charge target value: Qmin, Qmax), per-cycle discharged electric charge, discharge current, temperature and humidity in the vicinity of the discharge device, and state of open or close of a damper which is provided to maintain the vegetable compartment at a constant temperature.

[0199] As shown in the upper part of FIG. 14, the time axis is divided into two major discharge state control cycles, which are discharge state control cycle N and discharge state control cycle N+1 in sequence of time. Each discharge state control cycle is divided into two intervals, for example, the discharge state control cycle N is divided into two intervals of tN, close to tN, open, and tN, open to tN+1, close.

[0200] In the interval of from tN, close to tN, open, the damper is closed, and thus inflow of cold air through the air passage is stopped, and the temperature increases with the passage of time. Because the damper is in a state of close, the humidity also increases with the passage of time due to transpiration of water content from the vegetables and the like which are stored in the vegetable compartment. On the other hand, in the interval of from tN, open to tN+1, close, the damper is in a state of open, and thus cold air with a low temperature and humidity which has been cooled by the cooler flows in, and the temperature and humidity in the vicinity of the discharge device decrease with the passage of time.

[0201] Therefore, in the interval of from tN, close to tN, open, as described in FIGS. 10 to 12, the discharge current on the vertical axis gradually decreases as the temperature and humidity increase. On the other hand, in the interval of from tN, open to tN+1, close, the discharge current gradually increases as the temperature and humidity decrease.

[0202] After the above operation in time series, in the interval of the discharge current control cycle N, the discharge current varies with the passage of time, while the discharged electric charge (discharge current x voltage

application time (application rate)) gradually increases, and the value of per-cycle discharged electric charge can be recognized at $tN+1$, close by the control unit.

[0203] Here, a discharge state in the discharge state control cycle N is determined by the control unit in STEP 1, and the process proceeds to the subsequent STEP 2 and STEP 3.

[0204] In the example of FIG. 14, discharge amount (discharged electric charge) $<$ discharge target is determined in STEP 1, and in response to this, the process proceeds to STEP 2, and the voltage application time (voltage application rate) is increased, and thus the voltage application time for the discharge device (application rate) is increased in the discharge state control cycle $N+1$.

[0205] By repeating the above operation hereinafter, the discharge target can be effectively maintained.

[0206] Alternatively, as a method for stably discharging ozone from the discharge device, a method may be used in which a discharge current is read by a discharge state detection unit, and a constant discharge current (for example, 10 pA) is achieved. However, with the above method, the same amount of ozone is generated irrespective of the state of open or close of the damper. Therefore, although it is desirable to increase the amount of generated ozone in a state of closed damper in consideration of the case where ozone is diffused to all compartments, there is a problem in that a technique of maintaining a constant discharge current cannot be used in that case. Thus, control in terms of the time interval of a discharge state control cycle is more effective because an increase in the discharge current can be utilized in a state of opened damper.

[0207] In the present embodiment, the counter electrode 207 is set as a reference potential side (0 V), and a negative potential (-7 kV) is applied to the discharge electrode 206 so as to generate a high voltage potential difference between the electrodes, however, the discharge electrode 206 may be set as a reference potential side (0 V), and a negative potential (-7 kV) may be applied to the counter electrode 207 so as to generate a high voltage potential difference between the electrodes. When the discharge electrode 206 is set to a negative potential of -7 kV, the counter electrode 207 may not be particularly provided because the storage compartment (vegetable compartment 108) side can serve as a reference potential side.

[0208] In this case, for example, the insulated storage compartment (vegetable compartment 108) is provided with a conductive storage container which is electrically connected and detachably attached to a (conductive) retaining member of the storage container, and the retaining member is connected to a reference potential unit to be grounded (0 V).

[0209] Accordingly, the discharge unit 201, and the storage container, the retaining member always maintain a potential difference therebetween, and a stable electric field is generated, and thus ozone can be stably dis-

charged from the discharge unit 201. In addition, the entire storage container is at a reference potential, thus the discharged ozone can be diffused to the entire storage container. Furthermore, electrification of the surrounding objects can also be prevented.

[0210] In this manner, without particularly arranging the counter electrode 207, ozone diffusion is achieved by generating a potential difference between the discharge electrode 206 and a grounded retaining member which is provided in part of the storage compartment (vegetable compartment 108) side, and thus a stable electric field is generated in a simpler configuration. Consequently, stable atomization is achieved by the atomization unit. [Industrial Applicability]

[0211] As described above, the refrigerator according to the present invention can achieve appropriate atomization in each storage compartment by applying the control method using the electrostatic atomization device of the invention, and thus can be applied to not only a household or industrial refrigerator, or a refrigerator exclusively for vegetables, but also low-temperature distribution of food such as vegetables, or warehouse.

[Reference Signs List]

[0212]

100	Refrigerator
101	Heat insulating body
102	Outer casing
103	Inner casing
104	Refrigerator compartment
105	Switchable compartment
106	Icemaker compartment
107	Freezer compartment
108	Vegetable compartment
109	Compressor
110	Cooling compartment
111	Back side partition wall
112	Cooler
113	Cooling fan
114	Radiant heater
115	Drain pan
116	Drain tube
117	Evaporation pan
125	Second partition wall
125a	Recess
125b	Deepest recess
131	Electrostatic atomization device
132	Atomizing port
133	Voltage application unit
134	Cooling pin (heat transfer cooling unit)
134a	Projection portion
134b	Cooling pin (heat transfer cooling unit) end
135	Atomization electrode
136	Counter electrode
137	Outer case
138	Humidity supply port

139 Atomization unit
 140 Condensation prevention member
 146 Control unit
 151 Back side partition wall surface
 152 Heat insulation material
 153 Cooling pin heat insulation area
 154 Heating unit
 200 Discharge device
 201 Discharge unit
 202 Voltage application unit
 203 Discharge state detection unit
 204 Outer case
 205 Ozone injection port
 206 Discharge electrode
 207 Counter electrode
 208 Fixing member
 210 Control unit

Claims

1. A method of controlling an atomization device (131) of a refrigerator, (100) the atomization device (131) including:

an atomization electrode (135);
 a voltage application unit (133) configured to apply a voltage to the atomization electrode (135);
 a control unit (146) configured to control the voltage application unit (133); and
 an atomization state detection unit (203) configured to detect an atomization state of the atomization electrode (135); a cooling pin (134) which is connected to the atomization electrode (135) for cooling the atomization electrode (135) and whose circumference is covered by a heat insulation material (152);
 a condensation prevention member (140) which covers a part of the cooling pin (134), which part is exposed to a side of the atomization electrode; (135) and a heating unit (154) configured to heat the atomization electrode (135) and the condensation prevention member, (140)
 the method comprising

controlling to increase an amount of heating by the heating unit (154) in a subsequent predetermined cycle, when the control unit (146) calculates an atomization rate according to the atomization state detected by the atomization state detection unit (203) in a predetermined cycle and determines that the calculated atomization rate decreases and substantially no atomization occurs.

2. The method of controlling an atomization device (131) according to claim 1, wherein the atomization state detection unit (203)

detects a value of a current in the voltage application unit (133).

3. The method of controlling an atomization device (131) according to claim 1, wherein the amount of heating by the heating unit (154) in the subsequent predetermined cycle is set to a predetermined specific amount of heating.
4. The method of controlling an atomization device (131) according to claim 1, wherein the control unit (146) determines that water adhering to the atomization electrode (135) has frozen, and wherein the amount of heating by the heating unit (154) in the subsequent predetermined cycle after resolving the freezing is set to be substantially equivalent to an amount of heating before the freezing.
5. A refrigerator (100) comprising a control unit (146) configured to execute the method of controlling an atomization device (131) according to any one of claims 1 to 4.

Patentansprüche

1. Verfahren zum Regeln einer Zerstäubungseinrichtung (131) eines Kühlschranks (100), wobei die Zerstäubungseinrichtung (131) enthält:

eine Zerstäubungselektrode (135);
 eine Einheit (133) zum Anlegen einer Spannung, welche eingerichtet ist, eine Spannung an die Zerstäubungselektrode (135) anzulegen;
 eine Regelungseinheit (146), welche eingerichtet ist, die Einheit (133) zum Anlegen einer Spannung zu regeln; und
 eine Einheit (203) zum Erfassen des Zerstäubungszustandes, welche eingerichtet ist, einen Zerstäubungszustand der Zerstäubungselektrode (135) zu erfassen;
 einen Kühlbolzen (134), welcher zur Kühlung der Zerstäubungselektrode (135) mit der Zerstäubungselektrode (135) verbunden ist und dessen Umfang von einem Wärmeisolationmaterial (152) bedeckt ist;
 ein Bauteil (140) zum Vermeiden von Kondensation, welches einen Teil des Kühlbolzens (134) bedeckt, welcher der Zerstäubungselektrode (135) zugewandt ist; und
 eine Heizeinheit (154), welche eingerichtet ist, die Zerstäubungselektrode (135) und das Bauteil (140) zum Vermeiden von Kondensation zu erwärmen;
 wobei das Verfahren enthält:

Regeln, um eine Wärmemenge durch die

- Heizeinheit (154) in einem nachfolgenden vorgegebenen Zyklus zu erhöhen, wenn die Regelungseinheit (146) eine Zerstäubungsrate gemäß des Zerstäubungszustandes berechnet, welcher von der Einheit (203) zum Erfassen des Zerstäubungszustandes in einem vorgegebenen Zyklus erfasst wird, und ermittelt, dass sich die berechnete Zerstäubungsrate verringert und im Wesentlichen keine Zerstäubung auftritt. 5 10
2. Verfahren zum Regeln einer Zerstäubungseinrichtung (131) nach Anspruch 1, wobei die Einheit (203) zum Erfassen des Zerstäubungszustandes einen Wert eines Stromes in der Einheit (133) zum Anlegen einer Spannung erfasst. 15
3. Verfahren zum Regeln einer Zerstäubungseinrichtung (131) nach Anspruch 1, wobei die Wärmemenge durch die Heizeinheit (154) in dem nachfolgenden vorgegebenen Zyklus auf eine bestimmte vorgegebene Wärmemenge eingestellt wird. 20
4. Verfahren zum Regeln einer Zerstäubungseinrichtung (131) nach Anspruch 1, wobei die Regelungseinheit (146) ermittelt, dass an der Zerstäubungselektrode (135) haftendes Wasser gefroren ist; und wobei die Wärmemenge durch die Heizeinheit (154) in dem nachfolgenden vorgegebenen Zyklus nach Auflösen des Vereisens eingestellt wird, um im Wesentlichen gleichwertig zu einer Wärmemenge vor dem Vereisen zu sein. 25 30
5. Kühlschrank (100) enthaltend eine Regelungseinheit (146), welche eingerichtet ist, das Verfahren zum Regeln einer Zerstäubungseinrichtung (131) nach einem der Ansprüche 1 bis 4 durchzuführen. 35

Revendications

1. Procédé de réglage d'un dispositif de pulvérisation (131) d'un réfrigérateur (100), ledit dispositif de pulvérisation (131) comprenant: 45
- une électrode de pulvérisation (135);
 - une unité (133) d'application de tension qui est configurée pour appliquer une tension à ladite électrode de pulvérisation (135); 50
 - une unité de réglage (146) qui est configurée pour régler ladite unité (133) d'application de tension; et
 - une unité (203) de détection de l'état de pulvérisation qui est configurée pour détecter un état de pulvérisation de ladite électrode de pulvérisation (135); 55
 - une broche de refroidissement (134) qui, pour

refroidir ladite électrode de pulvérisation (135), est reliée à l'électrode de pulvérisation (135) et dont la circonférence est recouverte d'une matière d'isolation thermique (152);
un élément (140) de prévention de la condensation qui couvre une partie de ladite broche de refroidissement (134), laquelle est tournée vers ladite électrode de pulvérisation (135); et
une unité de chauffage (154) qui est configurée pour chauffer ladite électrode de pulvérisation (135) et ledit élément (140) de prévention de la condensation;
le procédé comprenant:

régler pour augmenter une quantité de chaleur par ladite unité de chauffage (154) dans un cycle subséquent prédéterminé, lorsque ladite unité de réglage (146) calcule un taux de pulvérisation selon l'état de pulvérisation détecté par ladite unité (203) de détection de l'état de pulvérisation dans un cycle prédéterminé et détermine que le taux de pulvérisation calculé diminue et que, pour l'essentiel, aucune pulvérisation n'a lieu.

2. Procédé de réglage d'un dispositif de pulvérisation (131) selon la revendication 1, dans lequel ladite unité (203) de détection de l'état de pulvérisation détecte une valeur d'un courant dans ladite unité (133) d'application de tension.
3. Procédé de réglage d'un dispositif de pulvérisation (131) selon la revendication 1, dans lequel la quantité de chaleur par ladite unité de chauffage (154) dans le cycle subséquent prédéterminé est réglée à une quantité de chaleur spécifique prédéterminée.
4. Procédé de réglage d'un dispositif de pulvérisation (131) selon la revendication 1, dans lequel ladite unité de réglage (146) détermine que de l'eau adhérent sur l'électrode de pulvérisation (135) a gelé, et dans lequel la quantité de chaleur par ladite unité de chauffage (154) dans le cycle subséquent prédéterminé, après avoir supprimé le gel, est réglée de manière à être pour l'essentiel équivalente à une quantité de chaleur avant le gel. 40
5. Réfrigérateur (100) comprenant une unité de réglage (146) configurée pour mettre en oeuvre le procédé de réglage d'un dispositif de pulvérisation (131) selon l'une quelconque des revendications 1 à 4. 45

FIG. 1

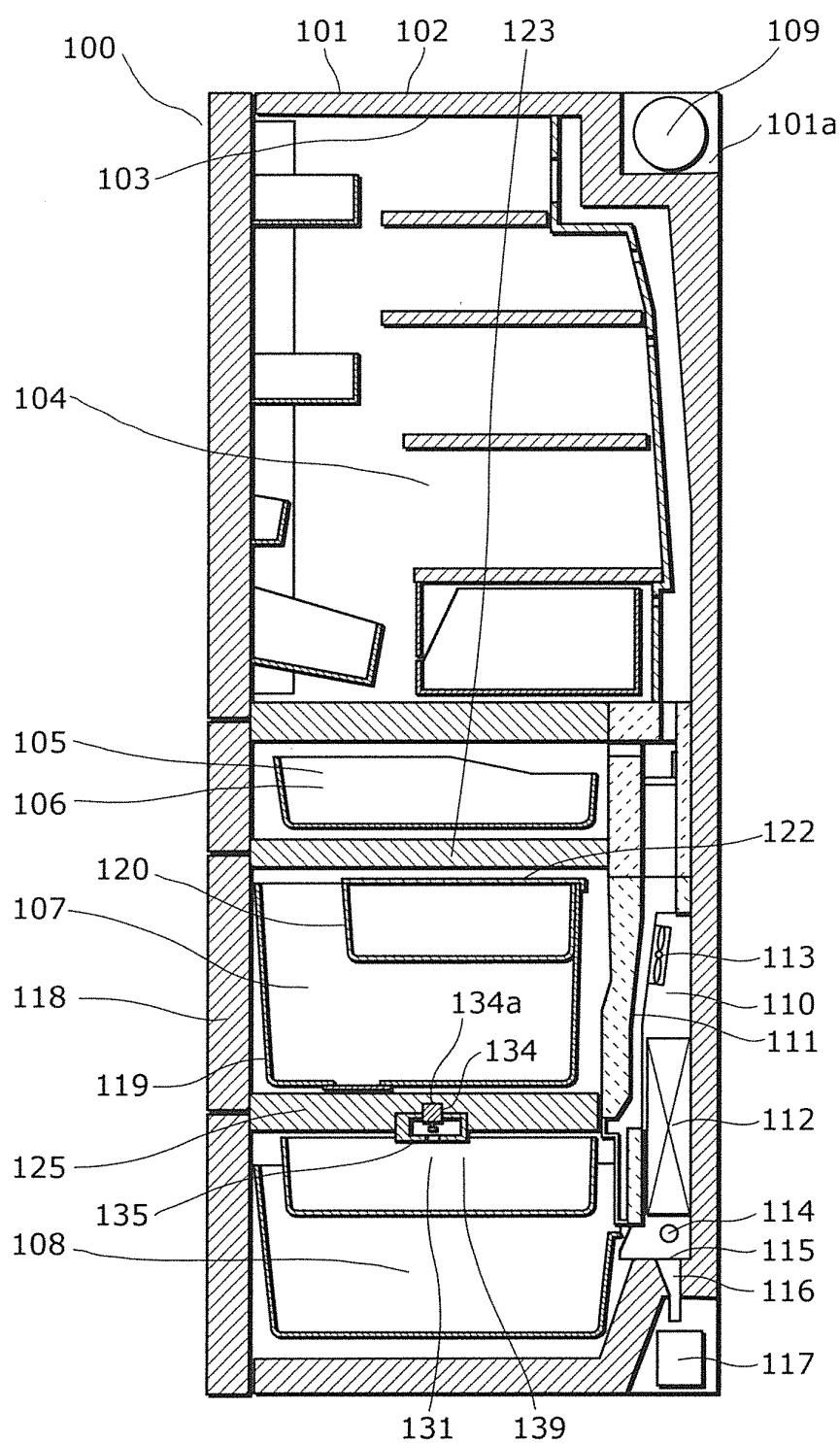


FIG. 2

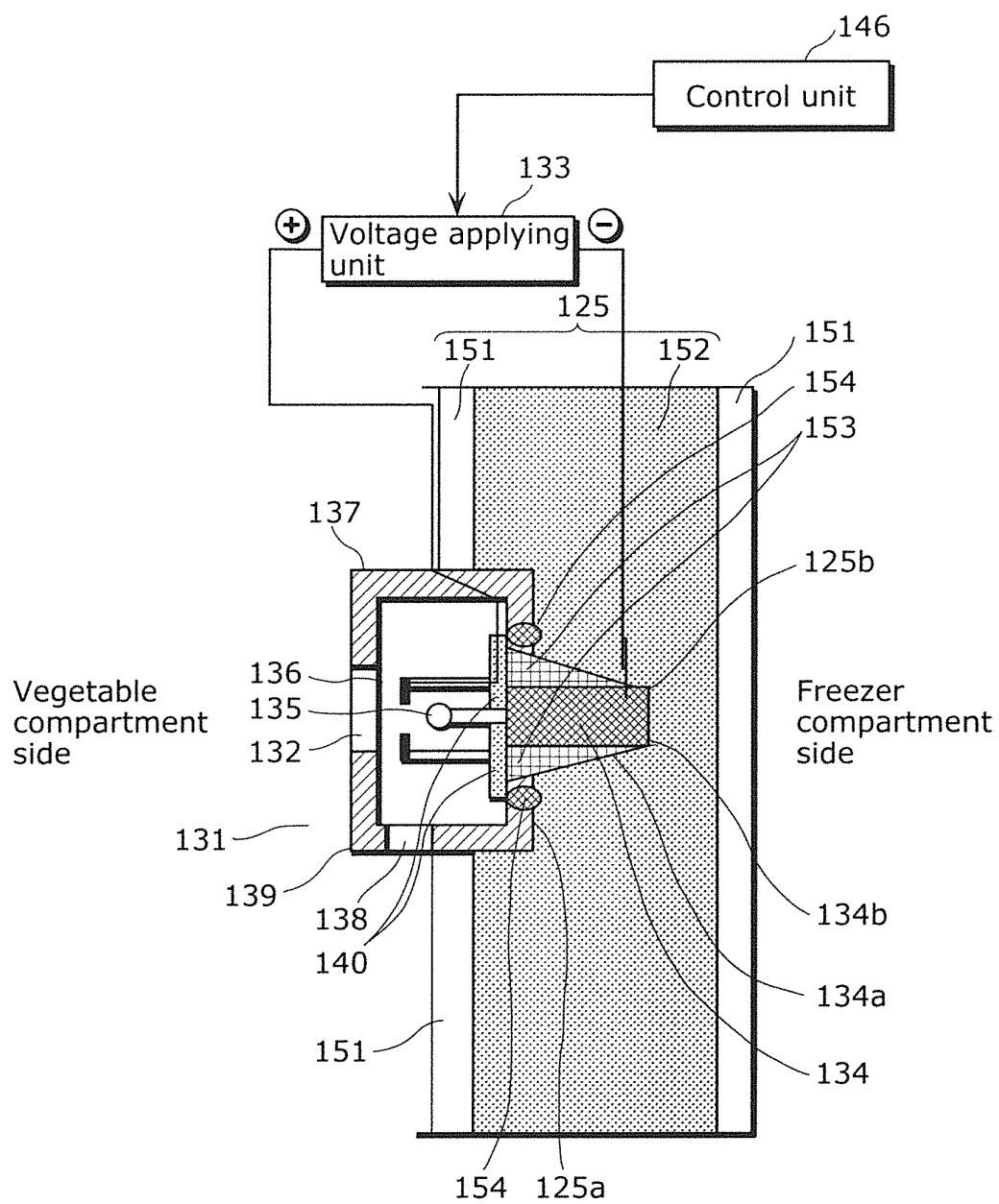


FIG. 3

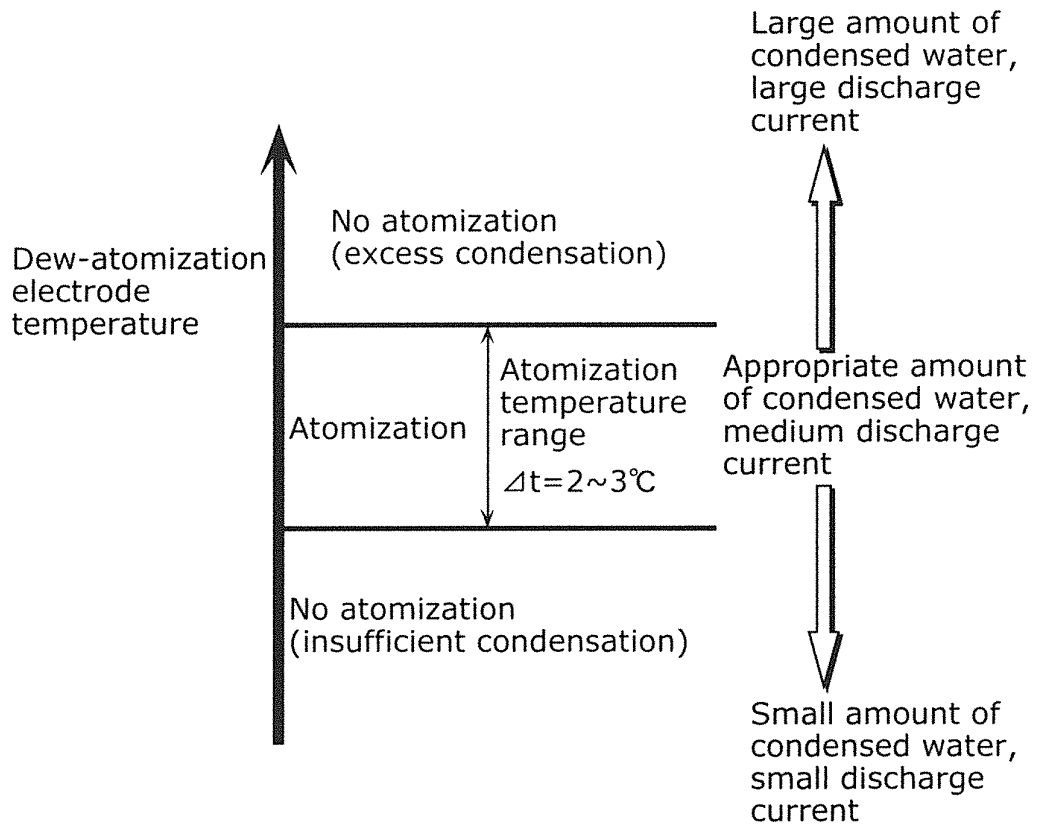


FIG. 4

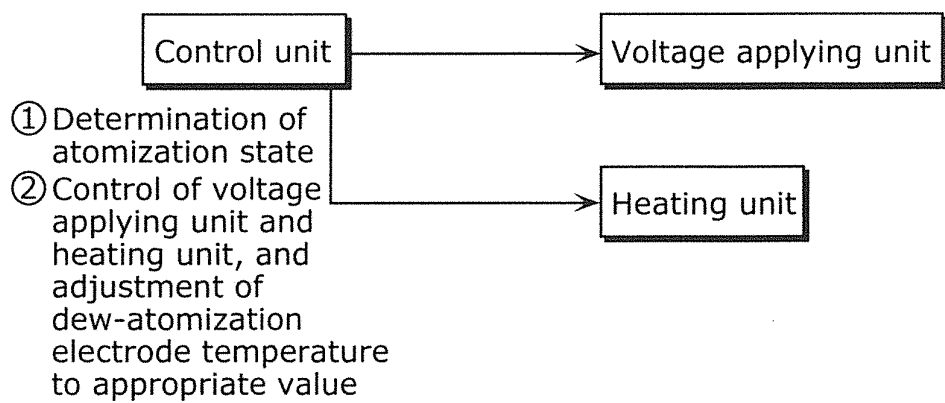


FIG. 5

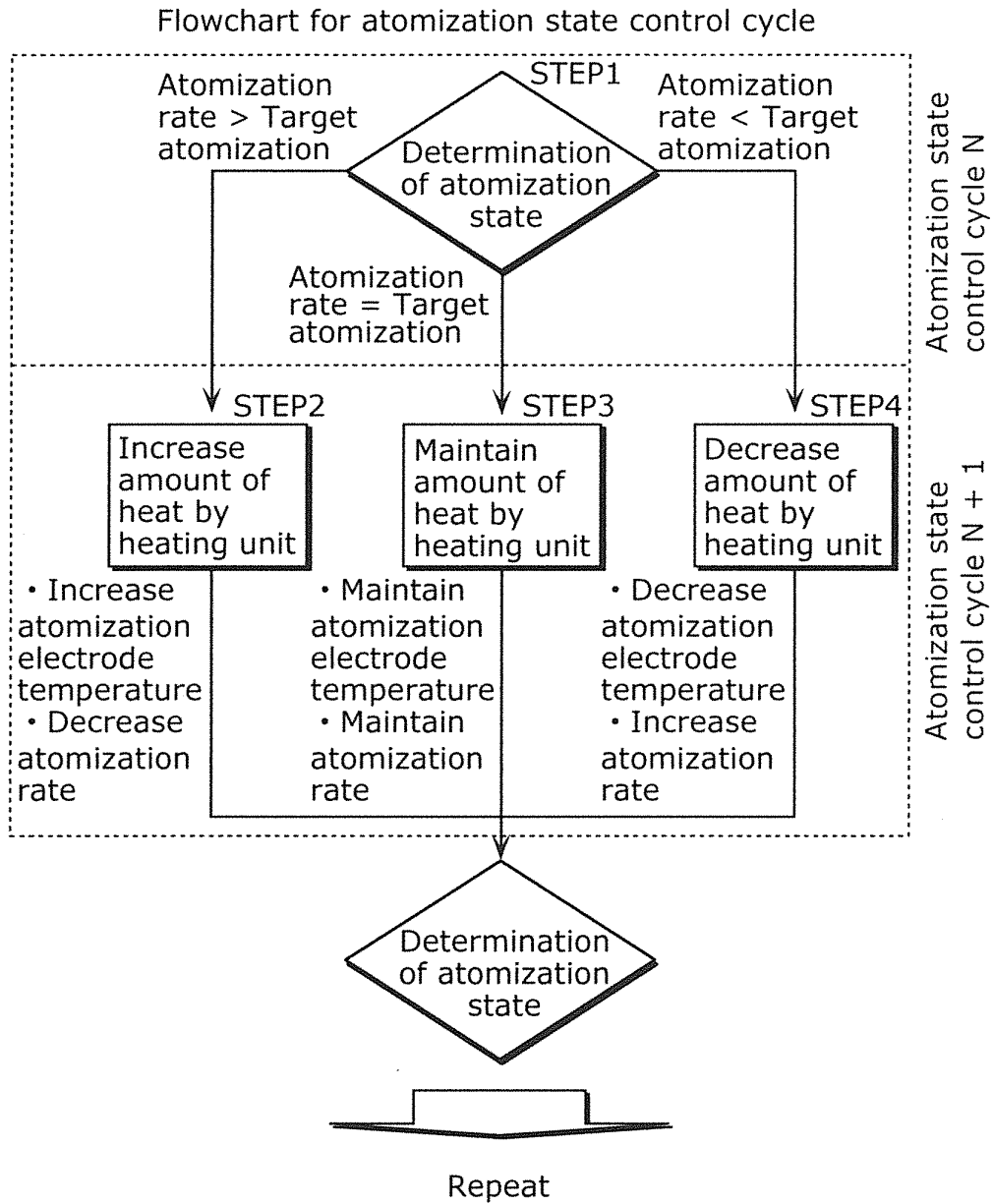


FIG. 6

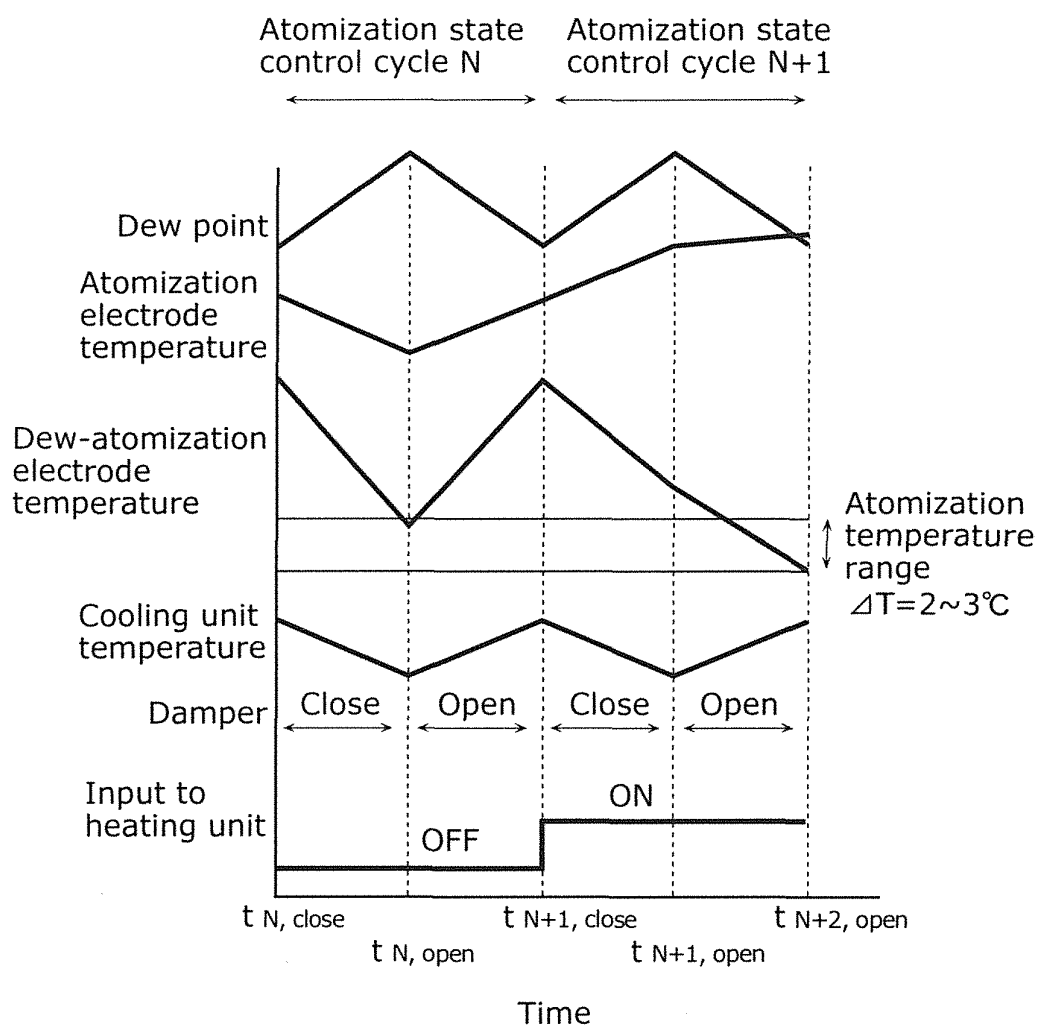


FIG. 7

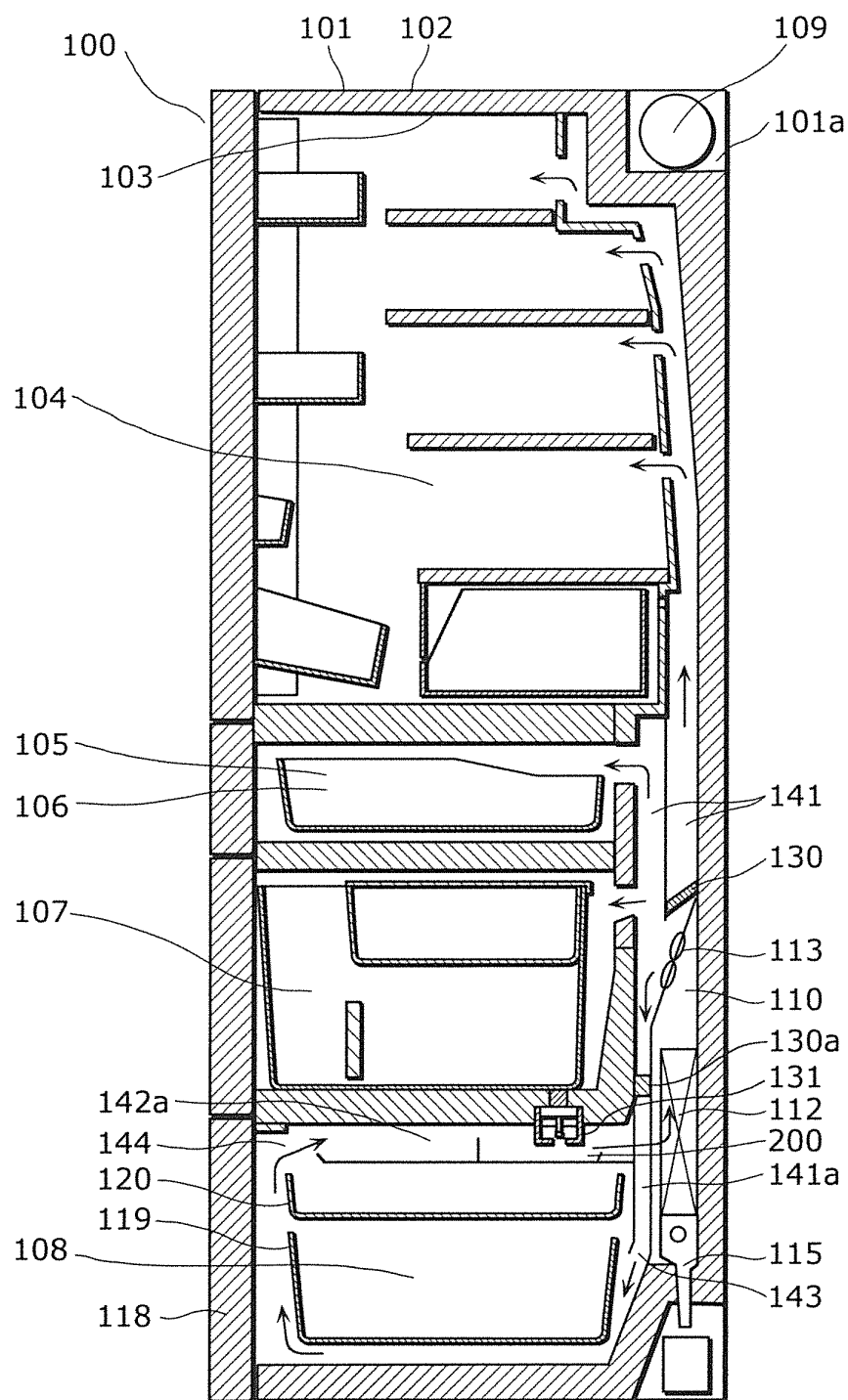


FIG. 8

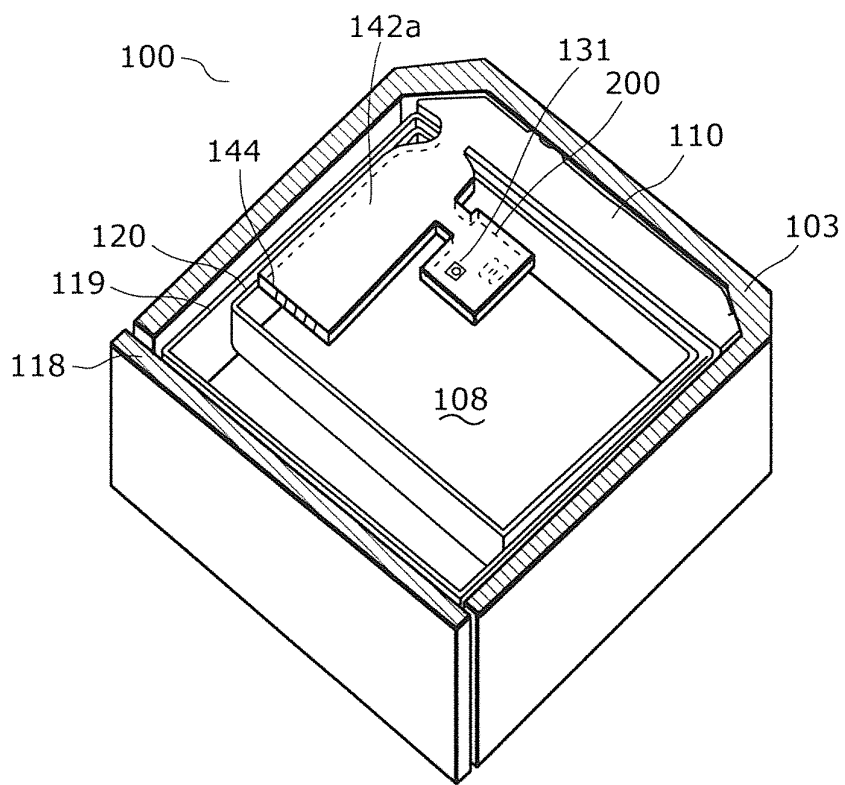


FIG. 9

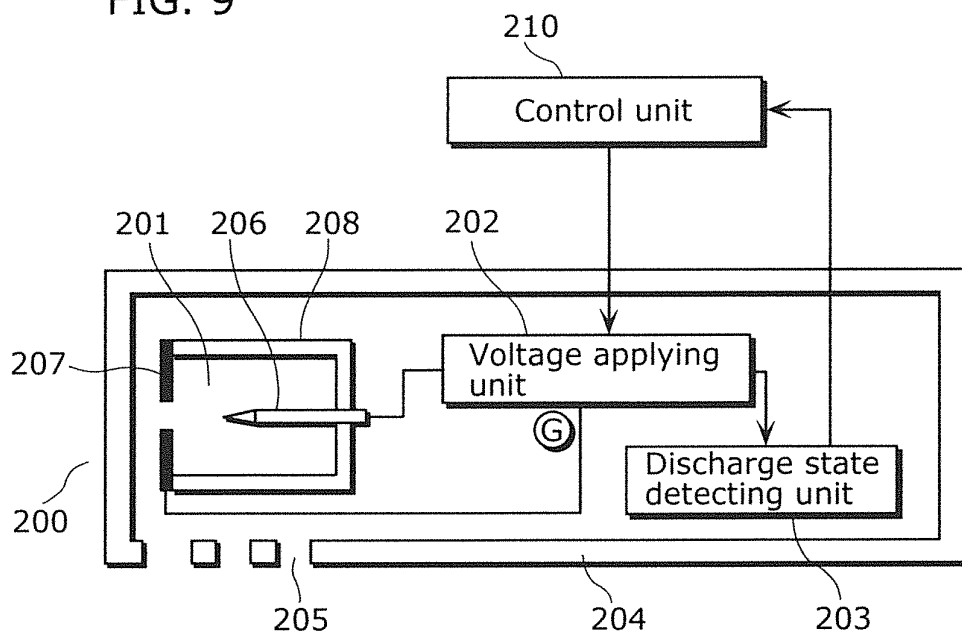


FIG. 10

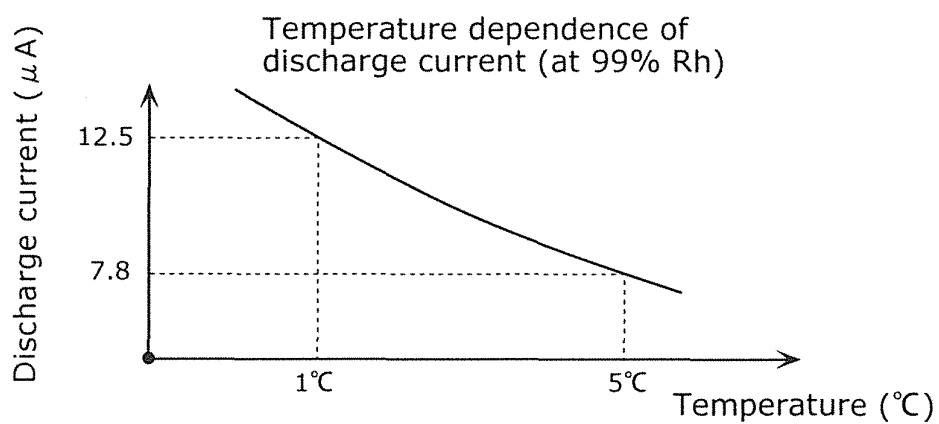


FIG. 11

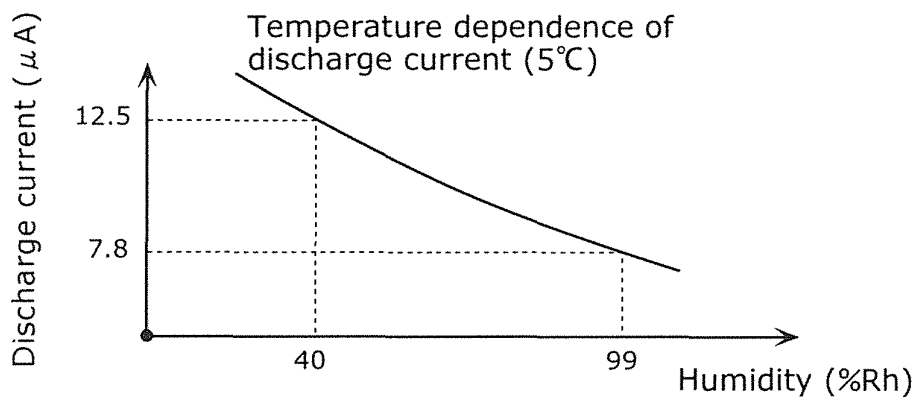


FIG. 12

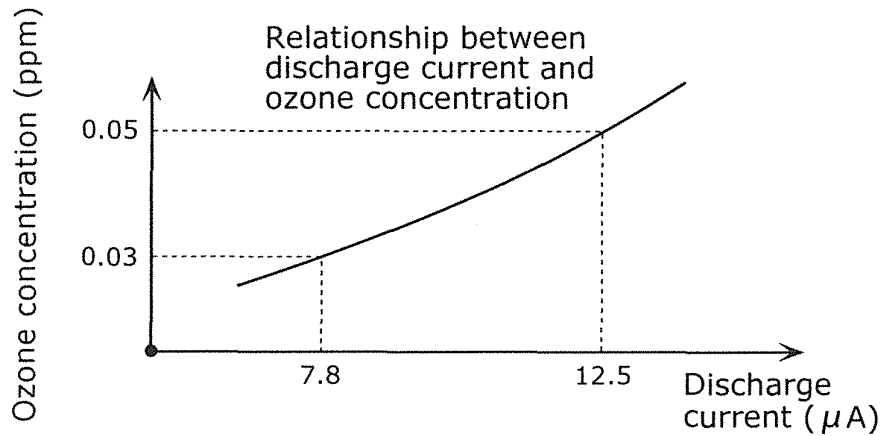


FIG. 13

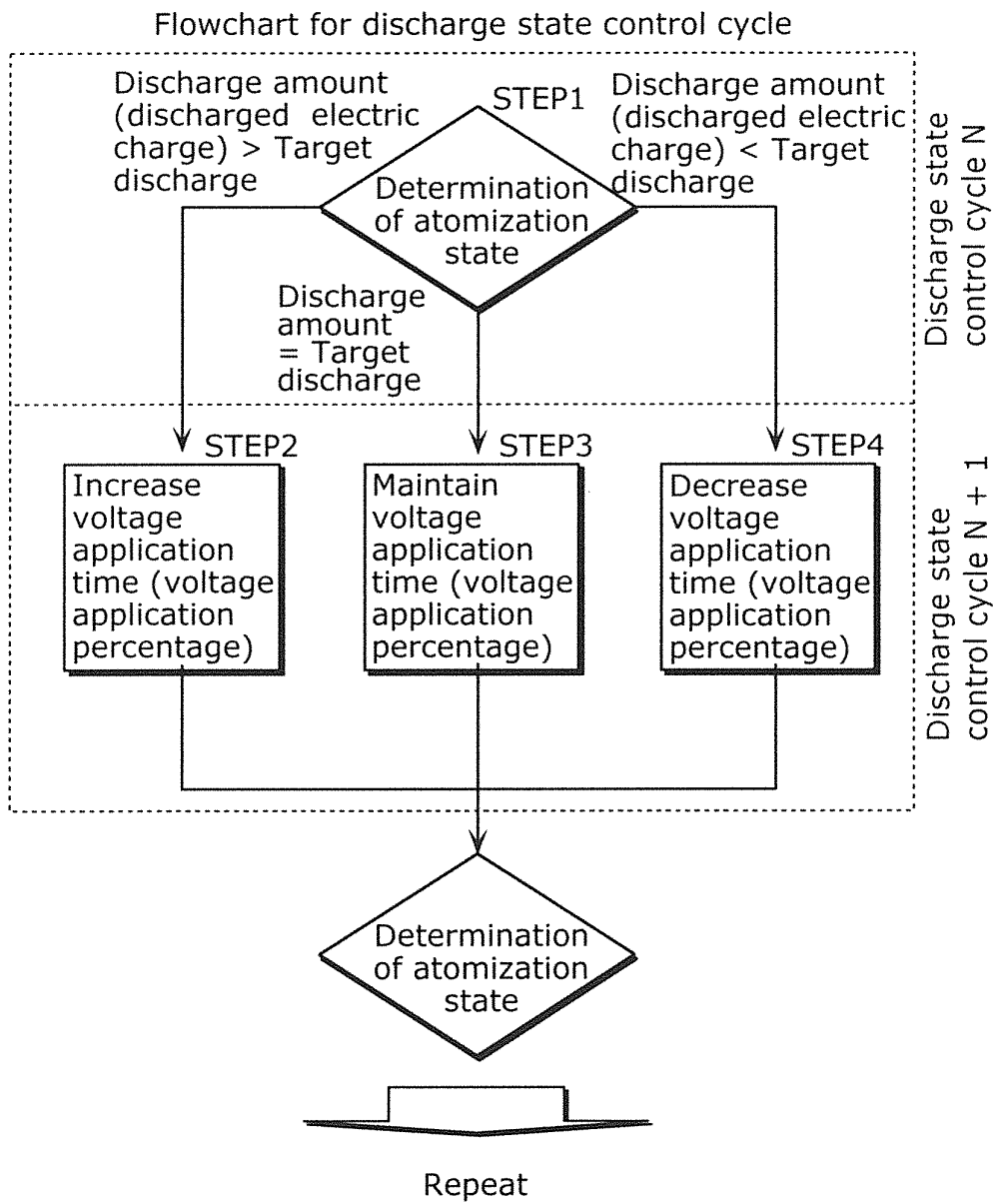


FIG. 14

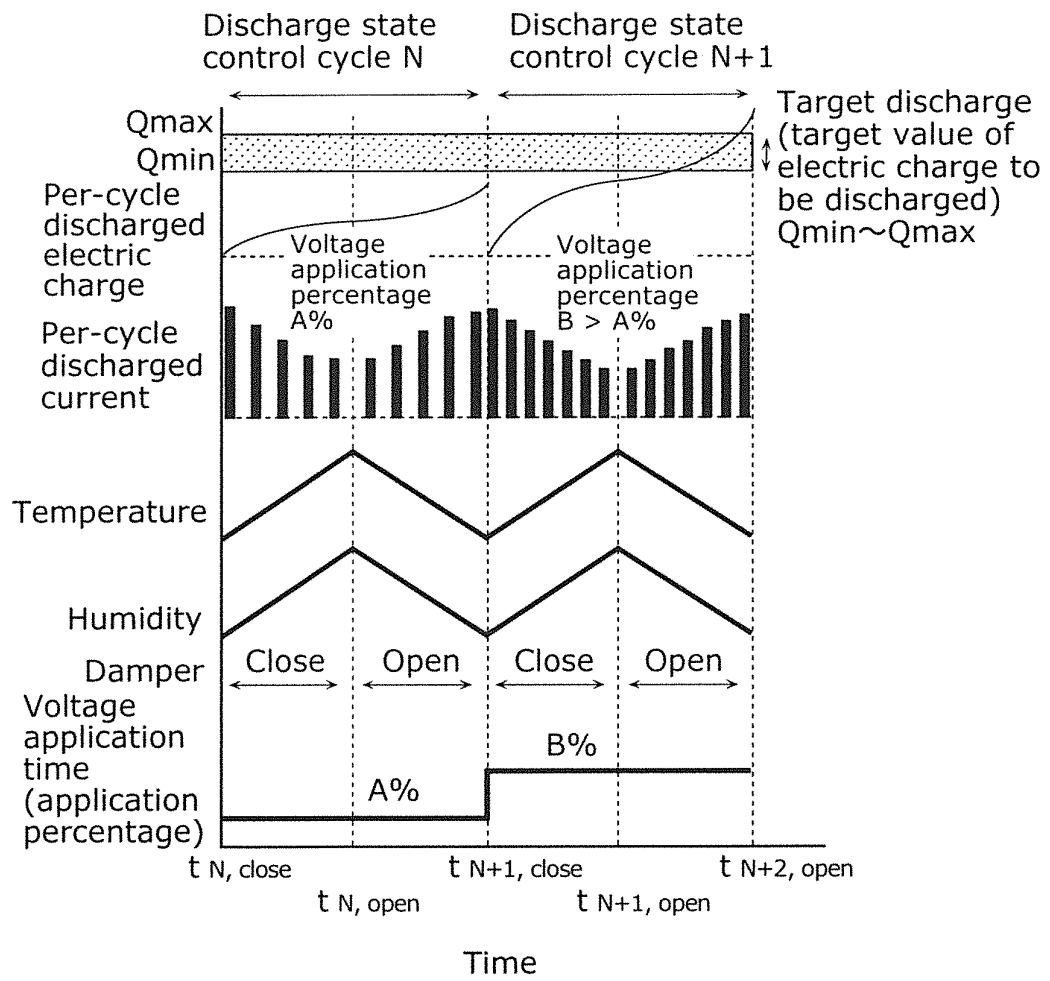


FIG. 15

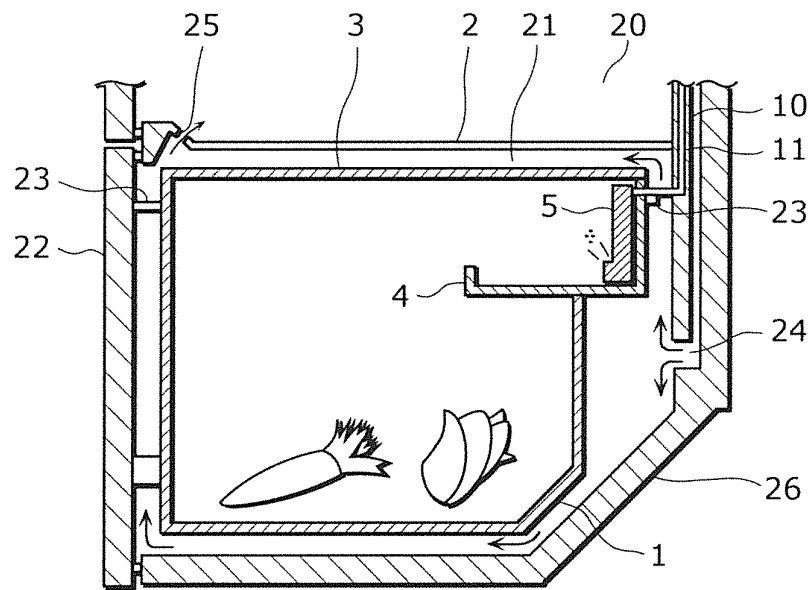
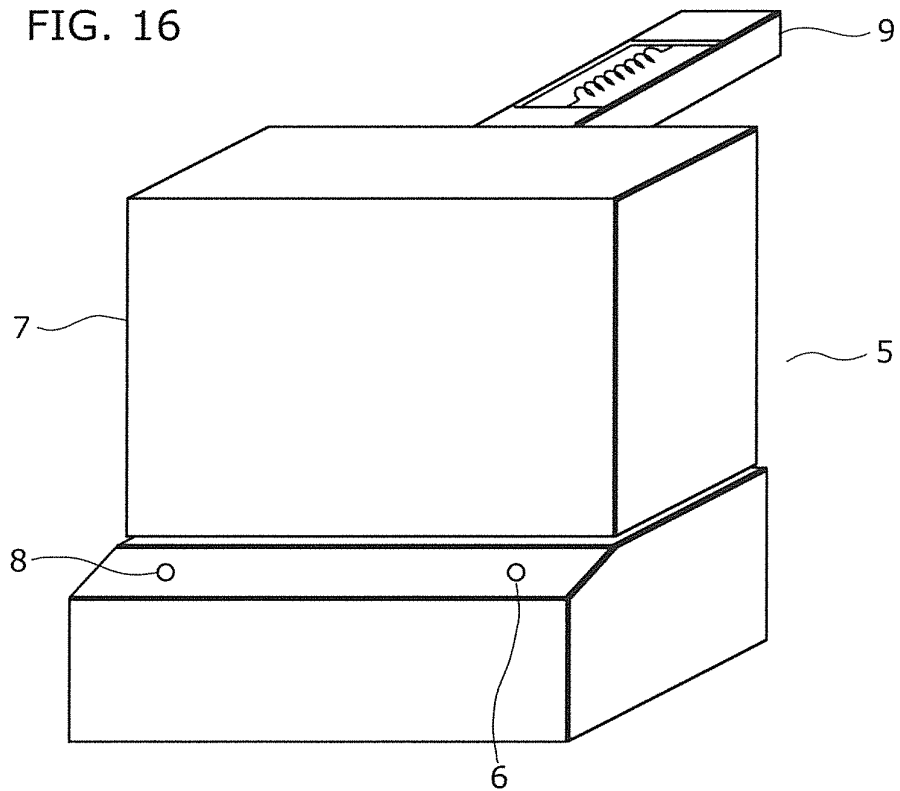


FIG. 16



REFERENCES CITED IN THE DESCRIPTION

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