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(54) **ELECTROLYTIC DEVICE**

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(75) Inventors: **Osamu Yoshimoto**, Kagawa (JP);  
**Makoto Hongu**, Osaka (JP);  
**Hiroshi Ohkubo**, Kagawa (JP)

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(73) Assignee: **TOYO TANSO CO., LTD.**,  
Osaki-shi (JP)

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(57) **ABSTRACT**

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An electrolytic apparatus includes an electrolyzer, a heater, and a blower. The electrolyzer accommodates an electrolytic bath. The heater is provided in the electrolyzer while being electrically insulated from the electrolyzer. Similarly, the blower is provided in the electrolyzer while being electrically insulated from the electrolyzer. The heater is turned on so that a temperature of the electrolyzer rises. The heater is turned off and the blower is turned on so that a temperature of the electrolyzer falls. The heater and the blower are switched between ON and OFF so that the temperature of the electrolyzer is kept constant.

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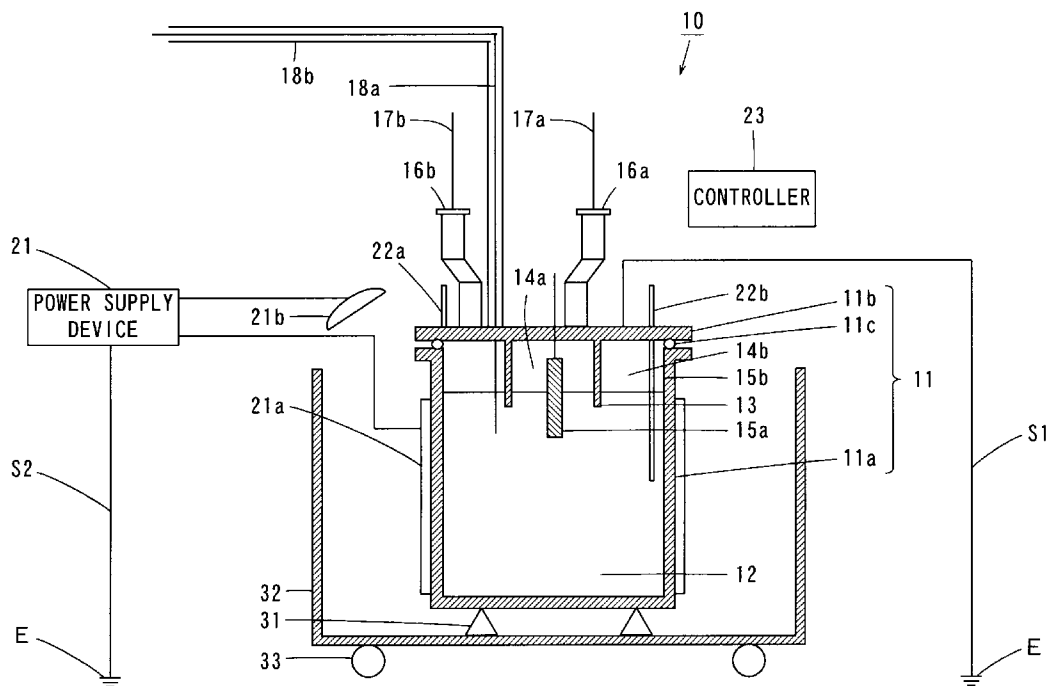


FIG. 1

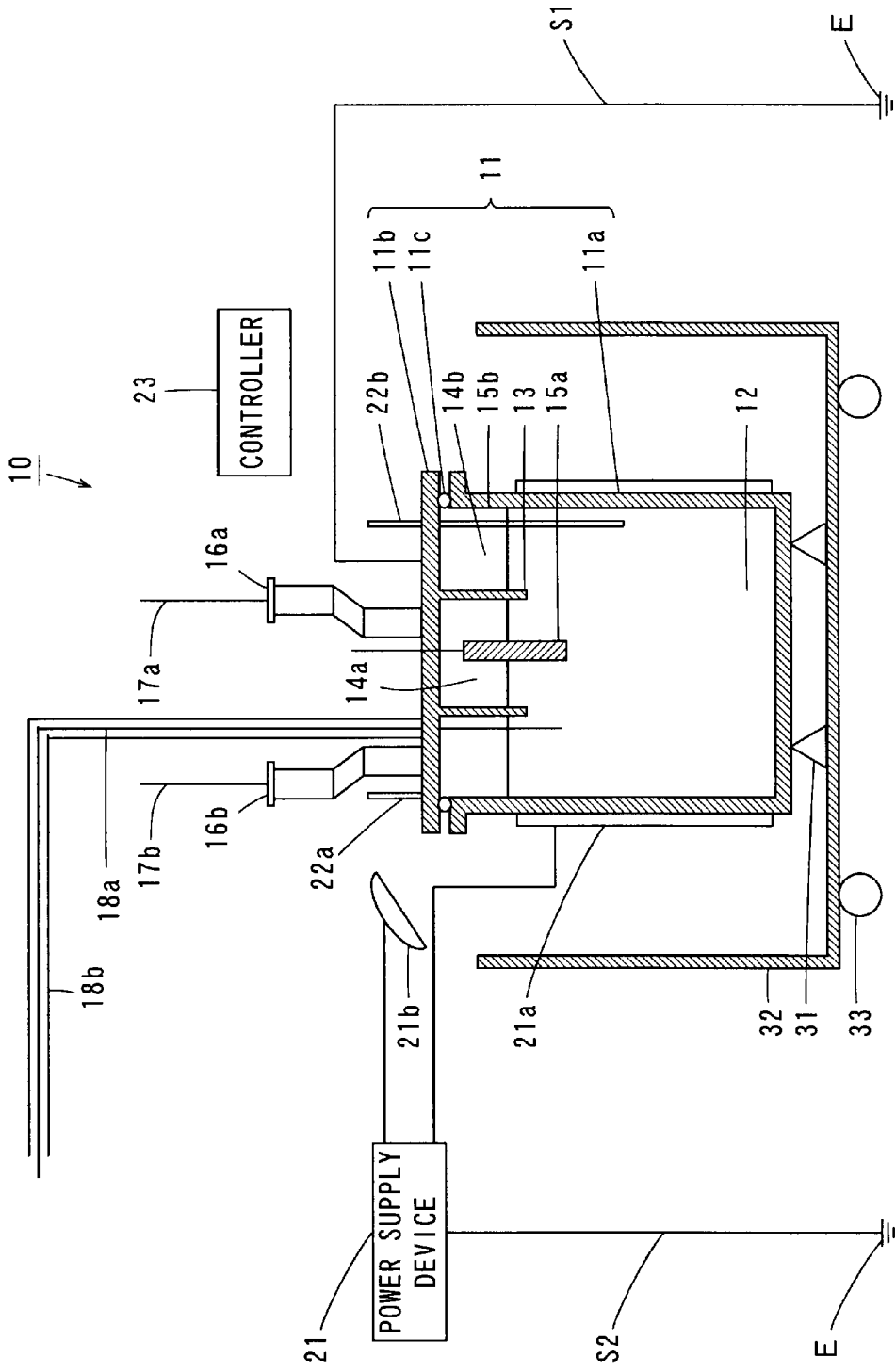


FIG. 2

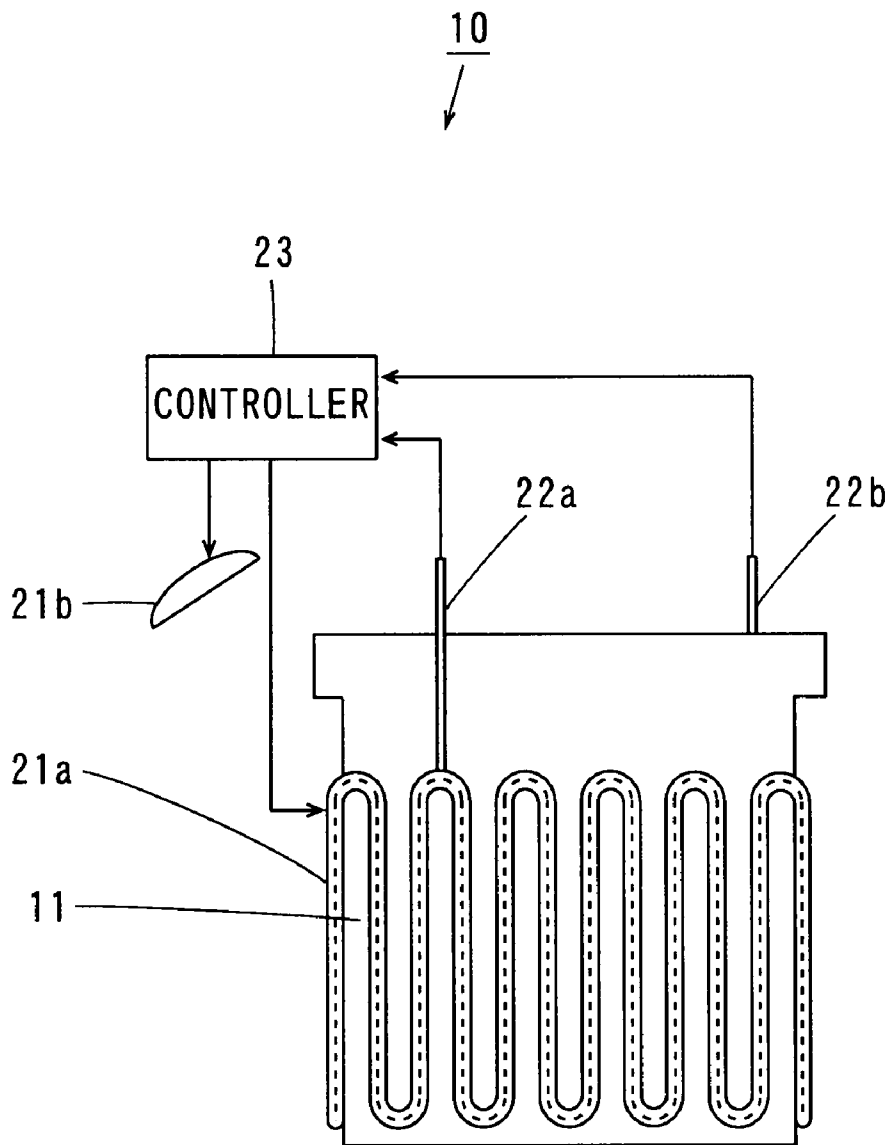


FIG. 3

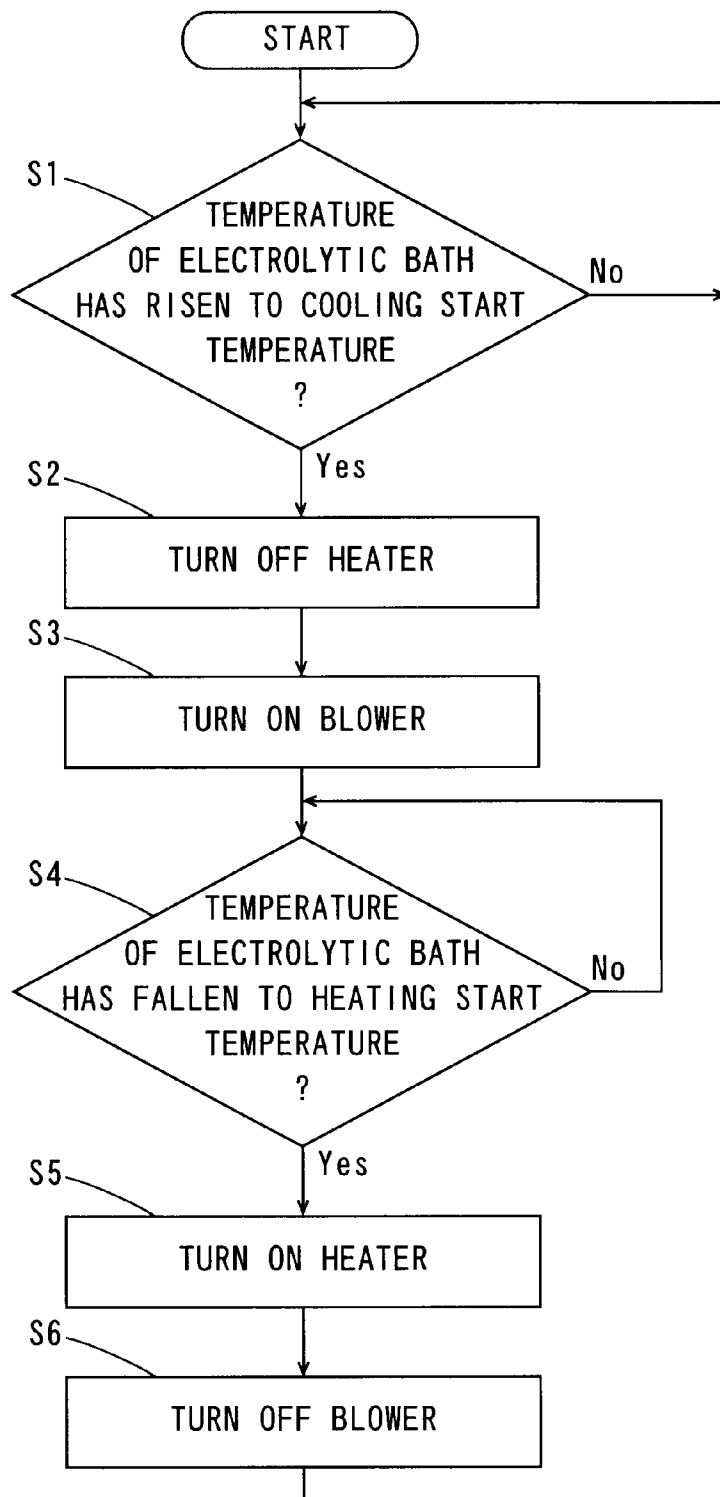


FIG. 4

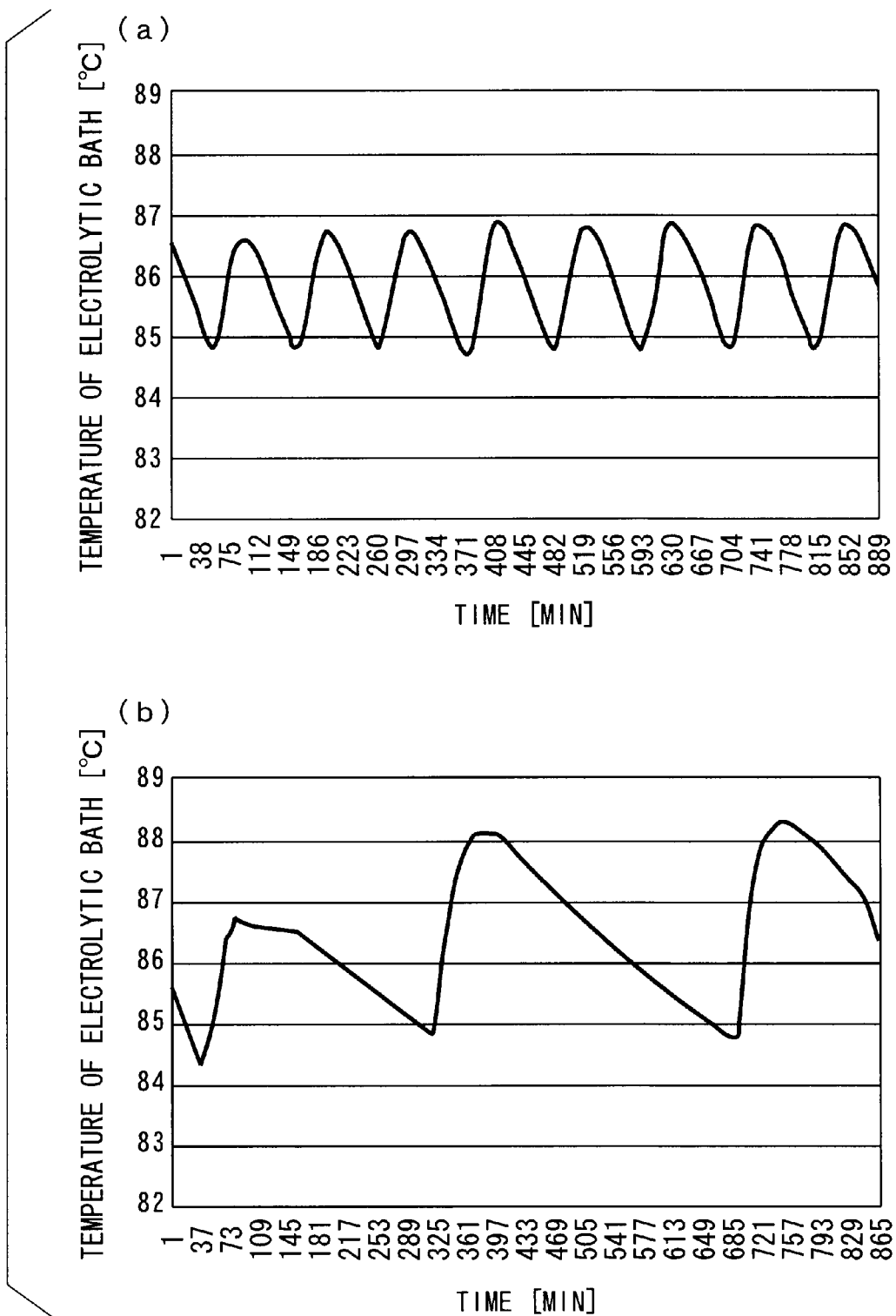


FIG. 5

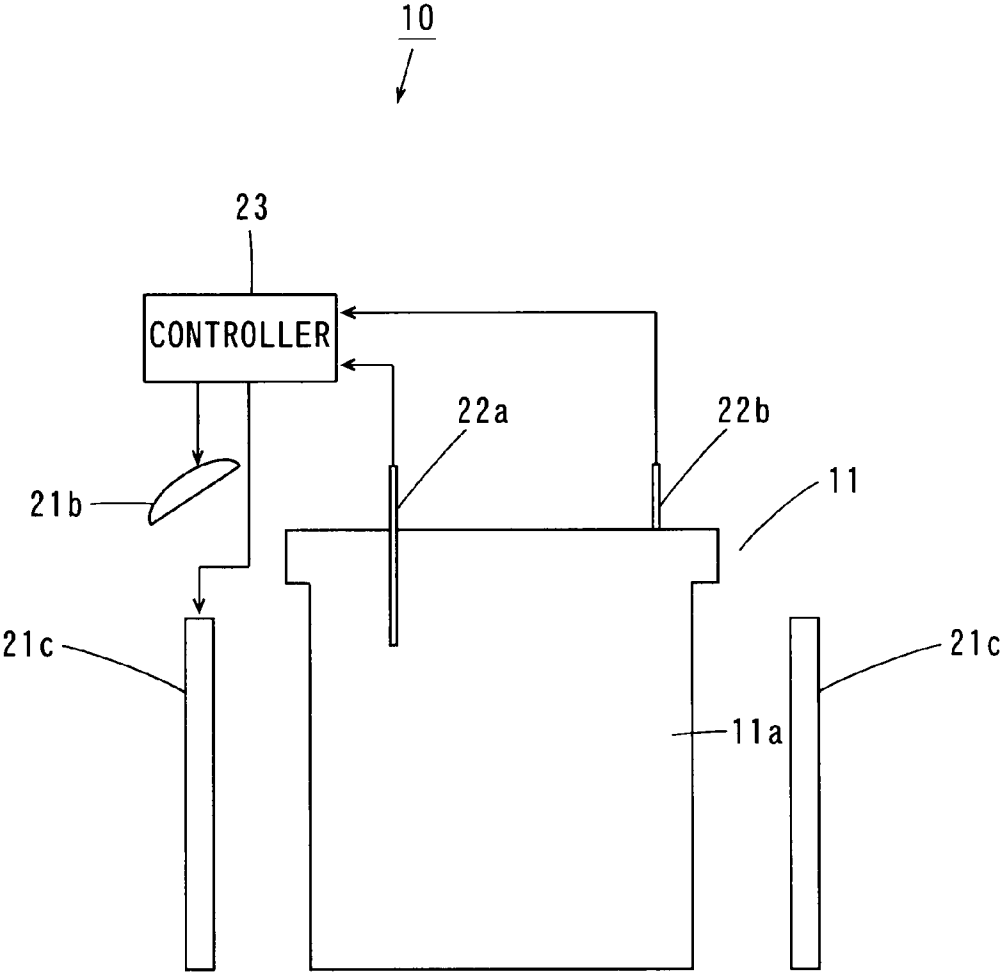
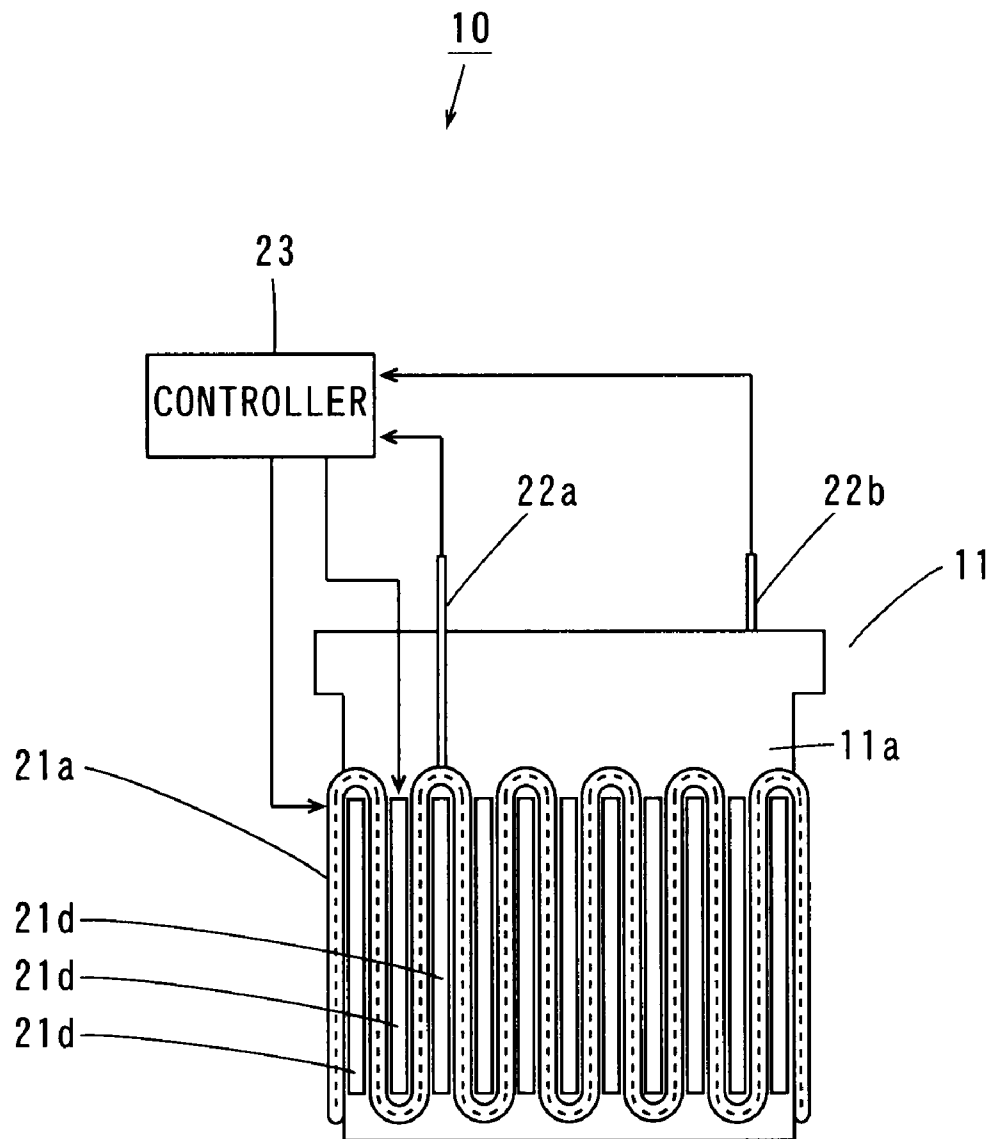


FIG. 6



## ELECTROLYTIC DEVICE

### TECHNICAL FIELD

**[0001]** The present invention relates to an electrolytic apparatus including an electrolyzer.

### BACKGROUND ART

**[0002]** Conventionally, in processes for manufacturing semiconductors, fluorine gases have been used in various applications such as material cleaning and surface modification. In this case, the fluorine gases themselves may be used. Various fluoride-based gases such as  $\text{NF}_3$  (nitrogen trifluoride) gas,  $\text{NeF}$  (neon fluoride) gas, and  $\text{ArF}$  (argon fluoride) gas that are synthesized based on the fluorine gases may be used.

**[0003]** Electrolytic apparatuses that generate fluorine gases by electrolyzing HF (hydrogen fluoride) have generally been used to stably supply the fluorine gases. In such electrolytic apparatuses, electrolytic baths composed of KF—HF (potassium-hydrogen fluoride) based mixed molten salts are formed in electrolyzers. The electrolytic baths in the electrolyzers are electrolyzed so that fluorine gases are generated. In this case, temperatures of the electrolytic baths in the electrolyzers are required to be kept in predetermined ranges to make electrolytic conditions of the electrolytic apparatuses constant.

**[0004]** In a molten salt electrolytic apparatus discussed in Patent Document 1, for example, a hot water jacket is provided on a side surface on the outer periphery of an electrolyzer. The hot water jacket includes a hot water pipe and a heat insulating layer. The hot water pipe is provided to surround the side surface on the outer periphery of the electrolyzer. In the hot water pipe, a heat medium heated by a hot water heating device is circulated. In the electrolyzer, a thermometer is provided. The hot water heating device heats a heat medium based on a temperature measured by the thermometer, to keep the electrolytic bath in the electrolyzer at a predetermined temperature.

**[0005]** [Patent Document 1] JP 2004-244724 A

### SUMMARY OF INVENTION

#### Technical Problem

**[0006]** In an electrolyzer in an electrolytic apparatus, at least a cover portion is required to be grounded to a ground having a reference potential in preparation for discharges in the electrolyzer by electric leakage and static electricity. In a hot water heating device, electric power with large current is handled. Therefore, the hot water heating device is required to be grounded to a ground having a reference potential to ensure safety.

**[0007]** In this case, the cover portion of the electrolyzer is electrically connected to the electrolyzer through an electrolytic bath. When a heat medium has conductivity, a closed circuit including the cover portion of the electrolyzer, the electrolytic bath, the electrolyzer, the heat medium having conductivity, the hot water heating device, and the ground is formed. When electrolyzation is started using the electrolyzer forming the closed circuit, a current due to a potential difference in the electrolyzer flows in the closed circuit, and electrochemistry corrosion occurs in a metal portion included in the closed circuit.

**[0008]** In order to prevent such electrochemistry corrosion, Patent Document 1 discusses a countermeasure using a pip-

ing at least a part of which is insulated and a heat medium having high insulation properties. However, a heat medium being an insulating solvent (e.g., a fluorine-based solvent) and having such a large heat capacity that a temperature of the electrolyzer can be adjusted does not exist. Therefore, an example of the heat medium having a relatively high electrical resistance and having a large heat capacity is pure water. However, the pure water slightly has electric conductivity. Therefore, the above-mentioned electrochemistry corrosion in the metal portion is not completely prevented.

**[0009]** An object of the present invention is to provide an electrolytic apparatus capable of ensuring a heat capacity in which a temperature of an electrolyzer can be sufficiently adjusted while reliably preventing electrochemistry corrosion due to a potential difference.

#### Solution to Problem

**[0010]** (1) According to an aspect of the present invention, an electrolytic apparatus includes an electrolyzer that accommodates an electrolytic bath, a heating unit that heats the electrolyzer using its heat source electrically insulated from the electrolyzer, and a cooling unit that cools the electrolyzer using its heat dissipation source electrically insulated from the electrolyzer.

**[0011]** In the electrolytic apparatus according to the aspect of the present invention, the heat source of the heating unit is electrically insulated from the electrolyzer, and the heat dissipation source of the cooling unit is electrically insulated from the electrolyzer. In this state, the electrolyzer is heated by the heat source of the heating unit, and is cooled by the heat dissipation source of the cooling unit.

**[0012]** In this case, the electrolyzer is directly heated and cooled by the heat source and the heat dissipation source, unlike that in heat exchange using a heat medium. Thus, a temperature of the electrolyzer can be sufficiently adjusted.

**[0013]** A potential is not fed to the electrolyzer via the heat source and the heat dissipation source. Therefore, electrochemistry corrosion in the electrolytic apparatus due to the potential difference in the electrolyzer can be reliably prevented.

**[0014]** (2) The heating unit may include a heater having a heating element that is coated with an insulating film as the heat source, and the heater may be provided in contact with an outer surface of the electrolyzer.

**[0015]** In this case, the heating element of the heater is provided in contact with the outer surface of the electrolyzer with the insulating film interposed therebetween. Therefore, the electrolyzer is directly heated by heat conduction from the heating element of the heater to the electrolyzer. Thus, the electrolyzer can be heated with high responsiveness.

**[0016]** (3) The heating unit may include an infrared heating device that radiates infrared rays as the heat source, and the infrared heating device may be spaced apart from the electrolyzer so as to be insulated therefrom.

**[0017]** In this case, the infrared rays are radiated from the infrared heating device spaced apart from the electrolyzer to the electrolyzer. Thus, the electrolyzer is directly heated by heat radiation. The infrared heating device is reliably insulated from the electrolyzer.

**[0018]** (4) The cooling unit may include a blower that blows air to the electrolyzer as the heat dissipation source, and the blower may be spaced apart from the electrolyzer so as to be insulated therefrom.

[0019] In this case, the blower spaced apart from the electrolyzer blows air to the electrolyzer. Thus, the electrolyzer is directly cooled by air circulation. The blower is reliably insulated from the electrolyzer.

[0020] (5) The cooling unit may include a cooling device having a cooling element that is coated with an insulating film as the heat dissipation source, and the cooling device may be provided in contact with an outer surface of the electrolyzer.

[0021] In this case, the cooling element is provided in contact with the outer surface of the electrolyzer with the insulating film interposed therebetween. Thus, the electrolyzer is directly cooled by absorption of heat from the electrolyzer to the cooling device. Thus, the electrolyzer can be cooled with high responsiveness.

[0022] (6) A first chamber may be provided in the electrolyzer, and a second chamber may be provided between the first chamber and the electrolyzer, and a first electrode may be arranged in the first chamber, and the electrolyzer may function as a second electrode.

[0023] In this case, the electrolyzer electrically insulated from an installation surface, the heat source, and the heat dissipation source functions as a second electrode. Therefore, a stable and accurate voltage can be applied between the first electrode and the second electrode.

[0024] (7) The electrolytic apparatus may further include a controller that controls the heating unit and the cooling unit so that a temperature of the electrolytic bath in the electrolyzer is maintained within a predetermined target temperature range.

[0025] In this case, the controller controls heating of the electrolyzer by the heating unit and cooling of the electrolyzer by the cooling unit. Thus, a temperature in the electrolyzer can be stably and reliably kept within the target temperature range.

[0026] (8) The electrolytic apparatus may further include a detector that detects a temperature of the electrolytic bath in the electrolyzer, and the controller may stop an operation of the heating unit while operating the cooling unit when the temperature detected by the detector rises to a first temperature lower than an upper-limit value of the target temperature range, and may operate the heating unit while stopping an operation of the cooling unit when the temperature detected by the detector falls to a second temperature higher than a lower-limit value of the target temperature range.

[0027] In this case, when the temperature of the electrolyzer rises to the first temperature lower than the upper-limit value of the target temperature range, the operation of the heating unit is stopped while the cooling unit operates. Thus, the temperature of the electrolyzer can be prevented from exceeding the upper-limit value of the target temperature range due to overshoot.

[0028] When the temperature of the electrolyzer falls to the second temperature higher than the lower-limit value of the target temperature range, the heating unit operates while the operation of the cooling unit is stopped. Thus, the temperature of the electrolyzer can be prevented from being the lower-limit value or less of the target temperature range due to undershoot.

[0029] Further, the heating unit is stopped while the cooling unit operates, and the heating unit operates while the cooling unit is stopped. Thus, an overshoot amount and an undershoot amount at the temperature of the electrolyzer can be reduced.

As a result, the target temperature range can be reduced, and the temperature of the electrolyzer can be kept substantially constant.

[0030] (9) The controller may control the heating unit and the cooling unit so that a difference between the upper-limit value and the lower-limit value of the target temperature range is within two degrees.

[0031] In this case, the temperature of the electrolyzer is kept substantially constant. Therefore, an electrolyzation condition is kept substantially constant. Thus, more stable electrolyzation can be performed.

[0032] (10) The electrolyzer may be an electrolyzer for fluorine generation. Vapor pressure of a fluorine compound used as the electrolytic bath greatly changes with temperature. In such a case, the temperature of the electrolytic bath is also controlled stably and with high accuracy. Therefore, a vapor of a fluorine compound can be prevented from being released from the electrolytic bath in the electrolyzer.

#### ADVANTAGEOUS EFFECTS OF INVENTION

[0033] According to the present invention, there can be provided an electrolytic apparatus that controls a temperature of an electrolytic bath in an electrolyzer stably and with high accuracy in a low-cost and simple configuration.

#### BRIEF DESCRIPTION OF DRAWINGS

[0034] FIG. 1 is a schematic sectional view of an electrolytic apparatus according to an embodiment of the present invention.

[0035] FIG. 2 is a schematic view on the outer side of mainly an electrolyzer in the electrolytic apparatus illustrated in FIG. 1.

[0036] FIG. 3 is a flowchart illustrating a control operation of a heater and a blower by a controller.

[0037] FIG. 4 illustrates results of temperatures of electrolytic baths in an inventive example and a comparative example.

[0038] FIG. 5 is a schematic view on the outer side of mainly an electrolyzer in an electrolytic apparatus according to another embodiment of the present invention.

[0039] FIG. 6 is a schematic view on the outer side of mainly an electrolyzer in an electrolytic apparatus according to still another embodiment of the present invention.

#### DESCRIPTION OF EMBODIMENTS

[0040] The embodiments of the present invention will be described in detail referring to the drawings. The embodiments below describe an electrolytic apparatus.

##### (1) Configuration of Electrolytic Apparatus

[0041] FIG. 1 is a schematic sectional view of an electrolytic apparatus according to an embodiment of the present invention. FIG. 2 is a schematic view on the outer side of mainly an electrolyzer in the electrolytic apparatus illustrated in FIG. 1.

[0042] The electrolytic apparatus 10 illustrated in FIG. 1 is a gas generation apparatus that generates a fluorine gas. The electrolytic apparatus 10 includes an electrolyzer 11. The electrolyzer 11 includes an electrolyzer main body 11a, an upper cover 11b, and an insulating member 11c.

[0043] The electrolyzer main body 11a and the upper cover 11b are formed of a metal such as Ni (Nickel), Monel, pure iron, or stainless steel or its alloy, for example.

[0044] The electrolyzer main body **11a** has a bottom portion and four side portions, and has an opening in its upper part. The insulating member **11c** is provided along upper end surfaces of the side portions. The insulating member **11c** is formed of an insulating material such as resin. The upper cover **11b** is arranged on the insulating member **11c** to close the opening of the electrolyzer main body **11a**. Thus, the insulating member **11c** electrically insulates the electrolyzer main body **11a** and the upper cover **11b** from each other.

[0045] In the electrolyzer **11**, electric power with large current is handled. Discharges in the electrolyzer **11** by static electricity are required to be prevented. Therefore, a ground wire **S1** grounds the upper cover **11b** in the electrolyzer **11** to a ground **E**. Thus, an electric shock or the like by electric leakage from the electrolyzer **11** is prevented.

[0046] A plurality of supporting members **31** composed of an insulating material support the electrolyzer **11** in a housing **32** composed of a conductive material. The supporting member **31** is formed of Bakelite, for example. Wheels **33** composed of an insulating material are attached to a bottom surface of the housing **32**. In this manner, the electrolyzer **11** is electrically insulated from the housing **32**, and the housing **32** is electrically insulated from an installation surface.

[0047] An electrolytic bath **12** composed of a KF—HF (potassium-hydrogen fluoride) based mixed molten salt is formed in the electrolyzer **11**. A cylindrical partition wall **13** is provided integrally with the upper cover **11b** so that its part is immersed in the electrolytic bath **12**. The partition wall **13** is composed of Ni or Monel, for example. In the electrolyzer **11**, an anode chamber **14a** is formed inside the partition wall **13**, and a cathode chamber **14b** is formed outside the partition wall **13**.

[0048] An anode **15a** is arranged to be immersed in the electrolytic bath **12** within the anode chamber **14a**. A low-polarizable carbon electrode, for example, is preferably used as a material for the anode **15a**. A cathode **15b** is formed on an inner surface of the electrolyzer main body **11a**. A hydrogen gas is mainly generated in the cathode chamber **14b**. Ni, for example, is preferably used as a material for the cathode **15b**.

[0049] An HF supply line **18a** for supplying HF is connected to the upper cover **11b**. The HF supply line **18a** is covered with a temperature adjustment heater **18b**. Thus, HF is prevented from being liquefied in the HF supply line **18a**. A liquid level detection device (not illustrated) detects the height of a liquid level of the electrolytic bath **12**. When the height of the liquid level detected by the liquid level detection device becomes lower than a predetermined value, HF is supplied to the electrolyzer **11** through the HF supply line **18a**.

[0050] The electrolytic apparatus **10** includes a controller **23**. The controller **23** applies a voltage between the anode **15a** and the cathode **15b**. Thus, the electrolytic bath **12** in the electrolyzer **11** is electrolyzed. Thus, a fluorinate gas is mainly generated in the anode chamber **14a**.

[0051] The upper cover **11b** is provided with gas exhaust ports **16a** and **16b**. An exhaust pipe **17a** is connected to the gas exhaust port **16a**, and an exhaust pipe **17b** is connected to the gas exhaust port **16b**. The gas exhaust port **16a** communicates with the anode chamber **14a**, and the gas exhaust port **16b** communicates with the cathode chamber **14b**. A gas generated by the anode chamber **14a** is discharged from the gas exhaust port **16a** through the exhaust pipe **17a**, and a gas generated by the cathode chamber **14b** is discharged from the gas exhaust port **16b** through the exhaust pipe **17b**.

[0052] The electrolyzer **11** includes a heater **21a** and a blower **21b**. In the present embodiment, a sheathed heater is used as the heater **21a**. The sheathed heater has a configuration in which an electrically-heated wire is coated with an insulating film. The sheathed heater can obtain a desired heat capacity using the electrically-heated wire. The electrolyzer **11** can be quickly heated by providing the heater **21a** in contact with the electrolyzer **11**. The heater **21a** is electrically insulated from the electrolyzer **11**, although provided in contact with the electrolyzer **11**.

[0053] As illustrated in FIG. 2, the heater **21a** is attached to outer surfaces of the side portions of the electrolyzer main body **11a** so as to have a meander shape. Thus, a contact area between the heater **21a** and the electrolyzer main body **11a** increases. The heater **21a** heats the electrolyzer **11** with heat conduction.

[0054] The blower **21b** is spaced apart from the electrolyzer **11** so as to be insulated therefrom, and blows air to the electrolyzer **11**. Thus, the blower **21b** cools the electrolyzer **11** with air circulation in the state of being electrically insulated from the electrolyzer **11**.

[0055] The heater **21a** and the blower **21b** operate by electric power supplied from a power supply device **21**. The power supply device **21** is grounded to the ground **E** via a ground wire **S2** to ensure safety.

[0056] In the present embodiment, the insulating film provided in the sheathed heater serving as the heater **21a** electrically insulates the heater **21a** and the electrolyzer **11** from each other. Air serving as an insulator electrically insulates the blower **21b** and the electrolyzer **11** from each other. In this case, if the upper cover **11b** and a power supply device **21** are grounded to the ground **E**, to form a closed circuit, a current due to a potential difference in the electrolyzer **11** does not flow through a metal portion of the electrolytic apparatus. Thus, electrochemistry corrosion in a metal portion of the electrolytic apparatus is prevented.

[0057] The electrolytic apparatus **10** is provided with a temperature sensor **22a** that detects a temperature of the heater **21a** and a temperature sensor **22b** that detects a temperature of the electrolytic bath **12** in the electrolyzer main body **11a**. In the present embodiment, the temperature sensors **22a** and **22b** are composed of a thermocouple.

[0058] The controller **23** controls the heater **21a** and the blower **21b** based on a temperature of the electrolyzer **11** detected by the temperature sensor **22a** and a temperature of the electrolytic bath **12** detected by the temperature sensor **22b**.

## (2) Temperature Control Operation

[0059] An operation for controlling the temperature of the electrolytic bath **12** in the electrolyzer **11** by the controller **23** will be described below.

[0060] The electrolytic bath **12** in the electrolyzer **11** assumes a solid state at room temperature and under atmospheric pressure. Therefore, the electrolytic bath **12** is required to be heated to not less than 80° C. nor more than 90° C. and dissolved in a liquid state to electrolyze the electrolytic bath **12**.

[0061] When a current flows through the anode **15a**, the cathode **15b**, and the electrolytic bath **12** during the electrolyzation, Joule heat due to electric resistances of the anode **15a**, the cathode **15b**, and the electrolytic bath **12** is generated. When the electrolytic bath **12** is dissolved, heat of dissolution is generated. Thus, the temperature of the electro-

lytic bath 12 excessively rises. As a result, vapor pressure of HF in the electrolytic bath 12 increases so that HF is released from the electrolytic bath 12. In this case, the purity of a fluorine gas taken out of the exhaust pipe 17a may decrease, and the electrolyzation efficiency of HF may decrease. Therefore, the temperature of the electrolytic bath 12 is required to be maintained in an appropriate temperature range.

[0062] First, the controller 23 turns on the heater 21a. Thus, the temperature of the electrolyzer 11 rises, and the temperature of the electrolytic bath 12 in the electrolyzer 11 also rises. The controller 23 controls ON and OFF of the heater 21a based on the temperature detected by the temperature sensor 22a until the electrolytic bath 12 is dissolved. The temperature of the electrolyzer 11 (hereinafter referred to as a lower-limit electrolyzer temperature) obtained when the electrolytic bath 12 is dissolved is previously measured.

[0063] The controller 23 turns off the heater 21a when the temperature detected by the temperature sensor 22a becomes an upper-limit value (hereinafter referred to as an upper-limit electrolyzer temperature) previously set to prevent the temperature of the electrolyzer 11 from excessively rising.

[0064] When the electrolytic bath 12 is dissolved, the temperature sensor 22b can detect the temperature of the electrolytic bath 12. When electrolyzation is started, Joule heat or the like is generated so that an amount of heat larger than an amount of heat lost by natural heat dissipation is put into the electrolytic bath 12. Thus, the temperature of the electrolytic bath 12 rises even in a state where the heater 21a is stopped.

[0065] The controller 23 controls ON and OFF of the heater 21a and the blower 21b based on the temperature detected by the temperature sensor 22b when the temperature detected by the temperature sensor 22a becomes the lower-limit electrolyzer temperature or more.

[0066] FIG. 3 is a flowchart illustrating a control operation of the heater 21a and the blower 21b by the controller 23.

[0067] Hereinafter, an upper-limit value of a temperature range of an electrolytic bath most suitable for electrolyzation is referred to as a target upper-limit temperature, and a lower-limit value of the temperature range of the electrolytic bath most suitable for electrolyzation is referred to as a target lower-limit temperature.

[0068] A temperature at which the heater 21a is turned off and the blower 21b is turned on so that the temperature of the electrolytic bath does not exceed the target upper-limit temperature is referred to as a cooling start temperature, and a temperature at which the heater 21a is turned on and the blower 21b is turned off so that the temperature of the electrolytic bath does not decrease beyond the target lower-limit temperature is referred to as a heating start temperature. The cooling start temperature is set to a value lower by a predetermined temperature (e.g., one degree) than the target upper-limit temperature, and the heating start temperature is set to a value higher by a predetermined temperature (e.g., one degree) than the target lower-limit temperature.

[0069] In an initial state, the heater 21a is turned on, and the blower 21b is turned off.

[0070] The controller 23 determines whether the temperature of the electrolytic bath 12 detected by the temperature sensor 22b rises to the cooling start temperature (step S1). If the temperature of the electrolytic bath 12 does not rise to the cooling start temperature, the controller 23 waits until the temperature of the electrolytic bath 12 reaches the cooling start temperature. If the temperature of the electrolytic bath

12 rises to the cooling start temperature, the controller 23 turns off the heater 21a (step S2), and turns on the blower 21b (step S3).

[0071] The controller 23 then determines whether the temperature of the electrolytic bath 12 detected by the temperature sensor 22b falls to the heating start temperature (step S4). If the temperature of the electrolytic bath 12 does not fall to the heating start temperature, the controller 23 waits until the temperature of the electrolytic bath 12 reaches the heating start temperature. If the temperature of the electrolytic bath 12 falls to the heating start temperature, the controller 23 turns on the heater 21a (step S5), and turns off the blower 21b (step S6), and the processing returns to step S1.

[0072] In this manner, the temperature of the electrolytic bath 12 is kept between a target upper-limit temperature higher by a predetermined temperature than the cooling start temperature and a target lower-limit temperature lower by a predetermined temperature than the heating start temperature.

### (3) Effects of Embodiment

[0073] In the electrolytic apparatus 10 according to the present embodiment, the electrolyzer 11 is supported by the supporting member 31 to be electrically insulated from the housing 32. The heater 21a and the blower 21b are electrically insulated from the electrolyzer 11. In this state, the electrolyzer 11 is heated by heat conduction from the heater 21a, and is cooled by air circulation from the blower 21b.

[0074] In this case, a potential is not applied to the electrolyzer 11 via the heater 21a and the blower 21b. Therefore, the corrosion in the electrolyzer 11 can be prevented by applying a stable anticorrosion voltage to the electrolyzer 11. Thus, the maintenance cost of the electrolyzer 11 can be reduced.

[0075] The electrolyzer 11 is heated by heat conduction, and is cooled by air circulation. In this case, a heat medium having insulation properties for heating and cooling the electrolyzer 11 is not required. Therefore, the electrolyzer 11 can be heated and cooled in a low-cost and simple configuration.

[0076] Further, the electrolyzer 11 is directly heated and cooled by heat conduction from the heater 21a and air circulation from the blower 21b, unlike that in heat exchange using a heat medium. Thus, the temperature of the electrolytic bath 12 in the electrolyzer 11 can be controlled stably and with high accuracy.

### (4) Examples

[0077] In an inventive example and a comparative example, described below, the electrolytic apparatus 10 illustrated in FIGS. 1 and 2 was used, to control the temperature of the electrolytic bath 12. An electrolytic apparatus used in the comparative example had the same configuration as that of the electrolytic apparatus 10 illustrated in FIGS. 1 and 2 except that the blower 21b was not attached thereto.

[0078] In the inventive example and the comparative example, the heating start temperature and the cooling start temperature of the electrolytic bath 12 were respectively set to 85° C. and 86° C.

[0079] In the inventive example, when the temperature of the electrolytic bath 12 detected by the temperature sensor 22b rose to 86° C., the heater 21a was turned off while the blower 21b was turned on so that the electrolytic bath 12 was forcedly cooled by air blowing. When the temperature of the electrolytic bath 12 detected by the temperature sensor 22b

fell to 85° C., the heater **21a** was turned on while the blower **21b** was turned off so that the electrolytic bath **12** was heated.

**[0080]** On the other hand, in the comparative example, when the temperature of the electrolytic bath **12** detected by the temperature sensor **22b** rose to 86° C., the heater **21a** was turned off while the electrolytic bath **12** was naturally cooled. When the temperature of the electrolytic bath **12** detected by the temperature sensor **22b** fell to 85° C., the heater **21a** was turned on, and the electrolytic bath **12** was heated.

**[0081]** FIGS. **4 (a)** and **4 (b)** are diagrams respectively illustrating results of the temperatures of the electrolytic bathes **12** in the inventive example and the comparative example. In FIG. **4**, the horizontal axis indicates time, and the vertical axis indicates the temperature of the electrolytic bath **12**.

**[0082]** As illustrated in FIG. **4 (a)**, in the inventive example, a variation in the temperature of the electrolytic bath **12** was controlled within a range of two degrees for a period of 889 minutes. On the other hand, in the comparative example, a variation in the temperature of the electrolytic bath **12** was four degrees or more for a period of 865 minutes.

**[0083]** As apparent from the results of the inventive example and the comparative example, the heater **21a** as well as the blower **21b** was used so that the variation in the temperature of the electrolytic bath **12** could be kept approximately constant.

#### (5) Another Embodiment

**[0084]** FIG. **5** is a schematic view on the outer side of mainly an electrolyzer in an electrolytic apparatus according to another embodiment of the present invention.

**[0085]** An electrolytic apparatus **10** illustrated in FIG. **5** differs from the electrolytic apparatus **10** illustrated in FIGS. **1** and **2** in that a plurality of infrared heating devices **21c** are arranged around an electrolyzer **11** in place of the heater **21a**.

**[0086]** The plurality of infrared heating devices **21c** are spaced apart from the electrolyzer **11**, to radiate infrared rays to the electrolyzer **11**. Thus, the plurality of infrared heating devices **21c** heat the electrolyzer **11** by heat radiation in the state of being electrically insulated from the electrolyzer **11**.

**[0087]** FIG. **6** is a schematic view on the outer side of mainly an electrolyzer in an electrolytic apparatus according to still another embodiment of the present invention.

**[0088]** An electrolytic apparatus **10** illustrated in FIG. **6** differs from the electrolytic apparatus **10** illustrated in FIGS. **1** and **2** in that a plurality of cooling devices **21d** are attached thereto in a distributed manner in contact with outer surfaces of side portions of an electrolyzer main body **11a** in place of the blower **21b**. The cooling device **21d** has a configuration in which a Peltier element is insulated by being coated with a ceramic material, an insulating film and the like. Thus, a plurality of cooling devices **21d** cool the electrolyzer **11** by performing a heat absorption operation in the state of being electrically insulated from the electrolyzer **11**.

**[0089]** The plurality of infrared heating devices **21c** may be provided in place of the heater **21a** illustrated in FIGS. **1** and **2**, and the plurality of cooling devices **21d** may be provided in place of the blower **21b**.

#### (6) Correspondences between Elements in the Claims and Parts in Embodiments

**[0090]** In the following paragraphs, non-limiting examples of correspondences between various elements recited in the

claims below and those described above with respect to various preferred embodiments of the present invention are explained.

**[0091]** The heater **21a** and the infrared heating device **21c** are examples of a heat source and a heating unit, the blower **21b** and the cooling device **21d** are examples of a heat dissipation source and a cooling unit, the electrically-heated wire of the sheathed heater is an example of a heating element, the heater **21a** is an example of a heater, the Peltier element is an example of a cooling element, the anode chamber **14a** is an example of a first chamber, the cathode chamber **14b** is an example of a second chamber, the anode **15a** is an example of a first electrode, the cathode **15b** is an example of a second electrode, the controller **23** is an example of a controller, and the temperature sensor **22b** is an example of a detector.

**[0092]** As each of various elements recited in the claims, various other elements having configurations or functions described in the claims can be also used.

### INDUSTRIAL APPLICABILITY

**[0093]** The present invention is effectively applicable to an electrolytic apparatus such as a gas generation apparatus.

1. An electrolytic apparatus comprising:  
an electrolyzer that accommodates an electrolytic bath;  
a heating unit that heats said electrolyzer using its heat source electrically insulated from said electrolyzer; and  
a cooling unit that cools said electrolyzer using its heat dissipation source electrically insulated from said electrolyzer.
2. The electrolytic apparatus according to claim 1, wherein said heating unit includes a heater having a heating element that is coated with an insulating film as said heat source, and said heater is provided in contact with an outer surface of said electrolyzer.
3. The electrolytic apparatus according to claim 1, wherein said heating unit includes an infrared heating device that radiates infrared rays as said heat source, and said infrared heating device is spaced apart from said electrolyzer so as to be insulated therefrom.
4. The electrolytic apparatus according to claim 1, wherein said cooling unit includes a blower that blows air to said electrolyzer as said heat dissipation source, and said blower is spaced apart from said electrolyzer so as to be insulated therefrom.
5. The electrolytic apparatus according to claim 1, wherein said cooling unit includes a cooling device having a cooling element that is coated with an insulating film as said heat dissipation source, and said cooling device is provided in contact with an outer surface of said electrolyzer.
6. The electrolytic apparatus according to claim 1, wherein a first chamber is provided in said electrolyzer, and a second chamber is provided between said first chamber and said electrolyzer, and a first electrode is arranged in said first chamber, and said electrolyzer functions as a second electrode.
7. The electrolytic apparatus according to claim 1, further comprising a controller that controls said heating unit and

said cooling unit so that a temperature of the electrolytic bath in said electrolyzer is maintained within a predetermined target temperature range.

**8.** The electrolytic apparatus according to claim 7, further comprising a detector that detects a temperature of the electrolytic bath in said electrolyzer,

wherein said controller stops an operation of said heating unit while operating said cooling unit when the temperature detected by said detector rises to a first temperature lower than an upper-limit value of said target temperature range, and operates said heating unit while stopping an operation of said cooling unit when the temperature

detected by said detector falls to a second temperature higher than a lower-limit value of said target temperature range.

**9.** The electrolytic apparatus according to claim 8, wherein said controller controls said heating unit and said cooling unit so that a difference between the upper-limit value and the lower-limit value of said target temperature range is within two degrees.

**10.** The electrolytic apparatus according to claim 1, wherein said electrolyzer is an electrolyzer for fluorine generation.

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