



(11) **EP 2 476 783 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
18.07.2012 Bulletin 2012/29

(51) Int Cl.:
C25B 15/02 (2006.01) C25B 1/24 (2006.01)
C25B 9/00 (2006.01)

(21) Application number: **10813517.9**

(86) International application number:
PCT/JP2010/005419

(22) Date of filing: **02.09.2010**

(87) International publication number:
WO 2011/027566 (10.03.2011 Gazette 2011/10)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK SM TR

- **HONGU, Makoto**
Osaka-shi
Osaka 555-0011 (JP)
- **OHKUBO, Hiroshi**
Osaka-shi
Osaka 555-0011 (JP)

(30) Priority: **07.09.2009 JP 2009205491**

(71) Applicant: **Toyo Tanso Co., Ltd.**
Osaka-shi
Osaka 555-0011 (JP)

(74) Representative: **TBK**
Bavariaring 4-6
80336 München (DE)

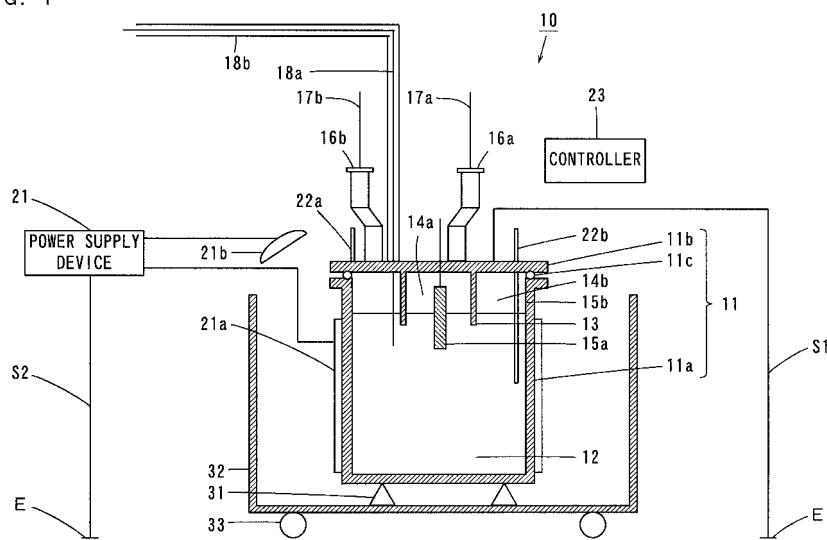
(72) Inventors:
• **YOSHIMOTO, Osamu**
Osaka-shi
Osaka 555-0011 (JP)

(54) **ELECTROLYTIC DEVICE**

(57) 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 elec-

trolyzer. 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.

F I G. 1



Description

[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 NF_3 (nitrogen trifluoride) gas, NeF (neon fluoride) gas, and 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.

[Patent Document 1] JP 2004-244724 A

[Summary of Invention]

[Technical Problem]

[0005] 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.

[0006] 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.

[0007] In order to prevent such electrochemistry corrosion, Patent Document 1 discusses a countermeasure using a piping 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.

[0008] 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]

[0009] (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.

[0010] 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.

[0011] 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.

[0012] 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.

[0013] (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.

[0014] 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.

[0015] (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.

[0016] 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.

[0017] (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.

[0018] 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.

[0019] (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.

[0020] 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.

[0021] (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.

[0022] 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.

[0023] (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.

[0024] 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.

[0025] (8) The electrolytic apparatus may further in-

clude 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.

[0026] 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.

[0027] 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.

[0028] 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.

[0029] (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.

[0030] 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.

[0031] (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]

[0032] 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]

[0033]

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

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

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

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

[FIG. 5] 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.

[FIG. 6] 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]

[0034] 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

[0035] 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.

[0036] 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.

[0037] 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.

[0038] 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.

[0039] 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.

[0040] 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.

[0041] 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.

[0042] 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.

[0043] 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.

[0044] 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.

[0045] 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.

[0046] The electrolyzer 11 includes a heater 21 a and a blower 21 b. 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.

[0047] 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 21 a and the electrolyzer main body 11a increases. The heater 21a heats the electrolyzer 11 with heat conduction.

[0048] 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.

[0049] 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.

[0050] 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.

[0051] 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.

[0052] 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

[0053] An operation for controlling the temperature of the electrolytic bath 12 in the electrolyzer 11 by the controller 23 will be described below.

[0054] 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.

[0055] 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 electrolytic 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.

[0056] 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.

[0057] 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.

[0058] 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 21 a is stopped.

[0059] The controller 23 controls ON and OFF of the heater 21a and the blower 21 b 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.

[0060] Fig. 3 is a flowchart illustrating a control operation of the heater 21a and the blower 21b by the controller 23.

[0061] 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.

[0062] 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.

[0063] In an initial state, the heater 21a is turned on, and the blower 21b is turned off.

[0064] 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).

[0065] 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.

[0066] 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

[0067] 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.

[0068] 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.

[0069] 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.

[0070] 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

[0071] 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.

[0072] 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.

[0073] 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.

[0074] 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.

[0075] 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.

[0076] 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.

[0077] 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

[0078] 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.

[0079] 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.

[0080] 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.

[0081] 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.

[0082] 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.

[0083] 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

[0084] 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.

[0085] 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.

[0086] 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]

[0087] The present invention is effectively applicable to an electrolytic apparatus such as a gas generation apparatus.

Claims

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.

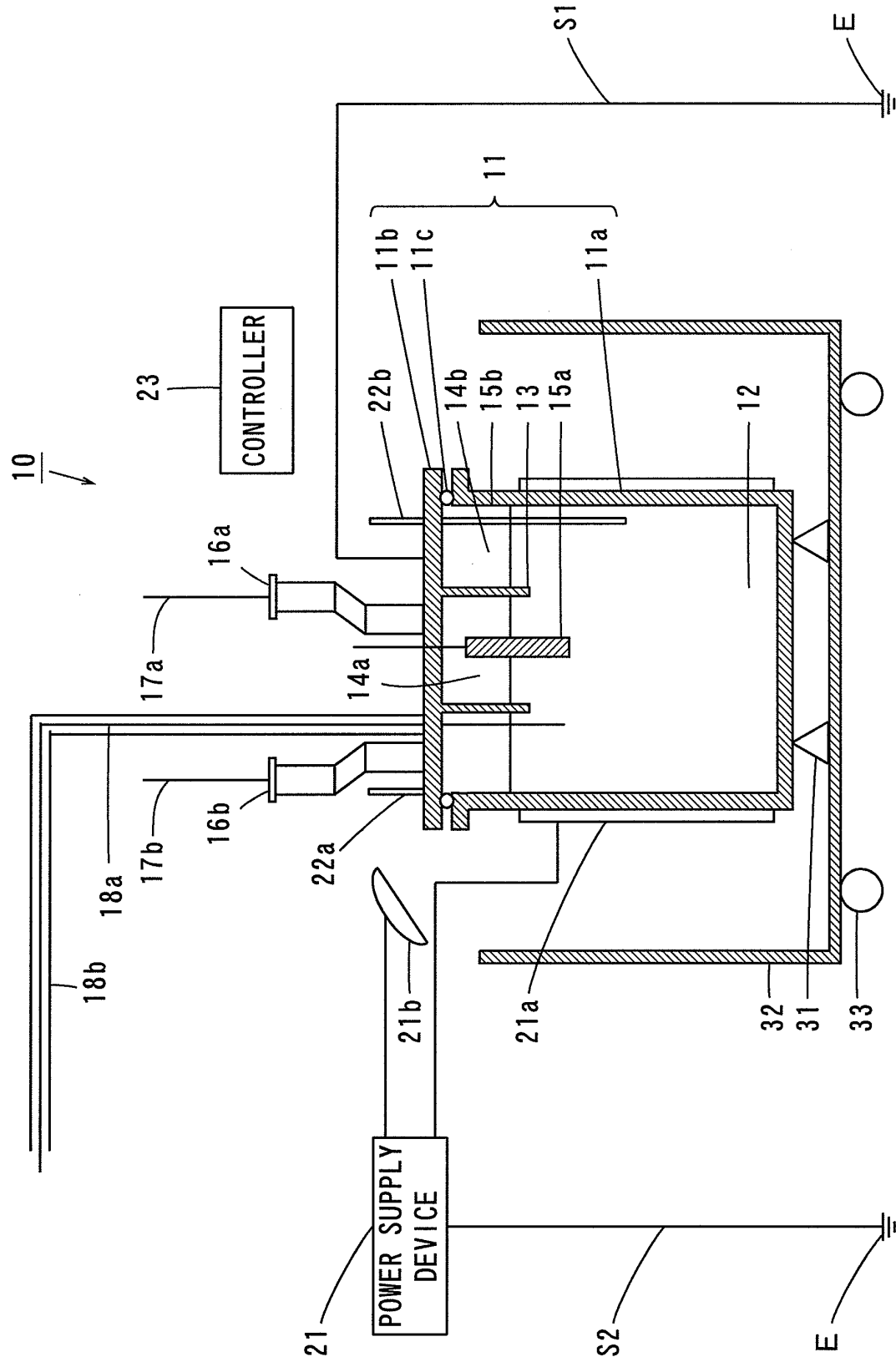
6. The electrolytic apparatus according to claim 1, wherein
a first chamber is provided in said electrolyzer, and
a second chamber is provided between said first chamber and said electrolyzer, and
a first electrode is arranged in said first chamber, and said electrolyzer functions as a second electrode. 5 10
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. 15
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. 20 25 30
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. 35
10. The electrolytic apparatus according to claim 1, wherein said electrolyzer is an electrolyzer for fluorine generation. 40

45

50

55

FIG. 1



F I G. 2

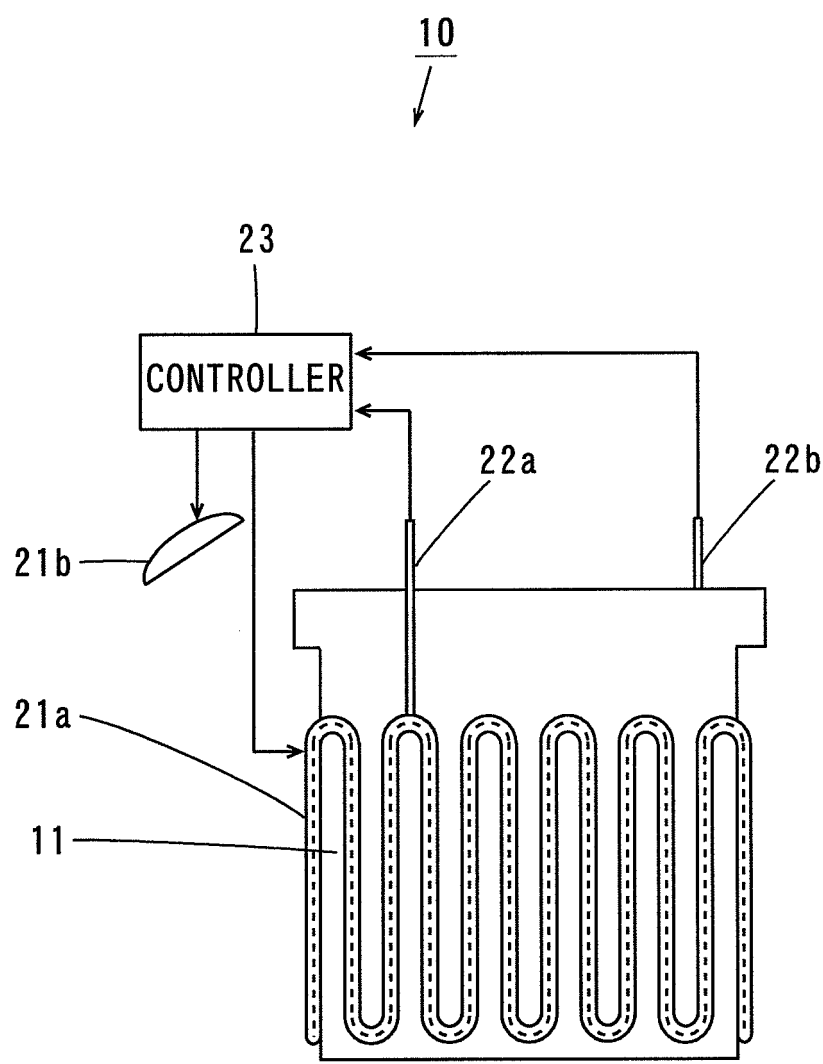


FIG. 3

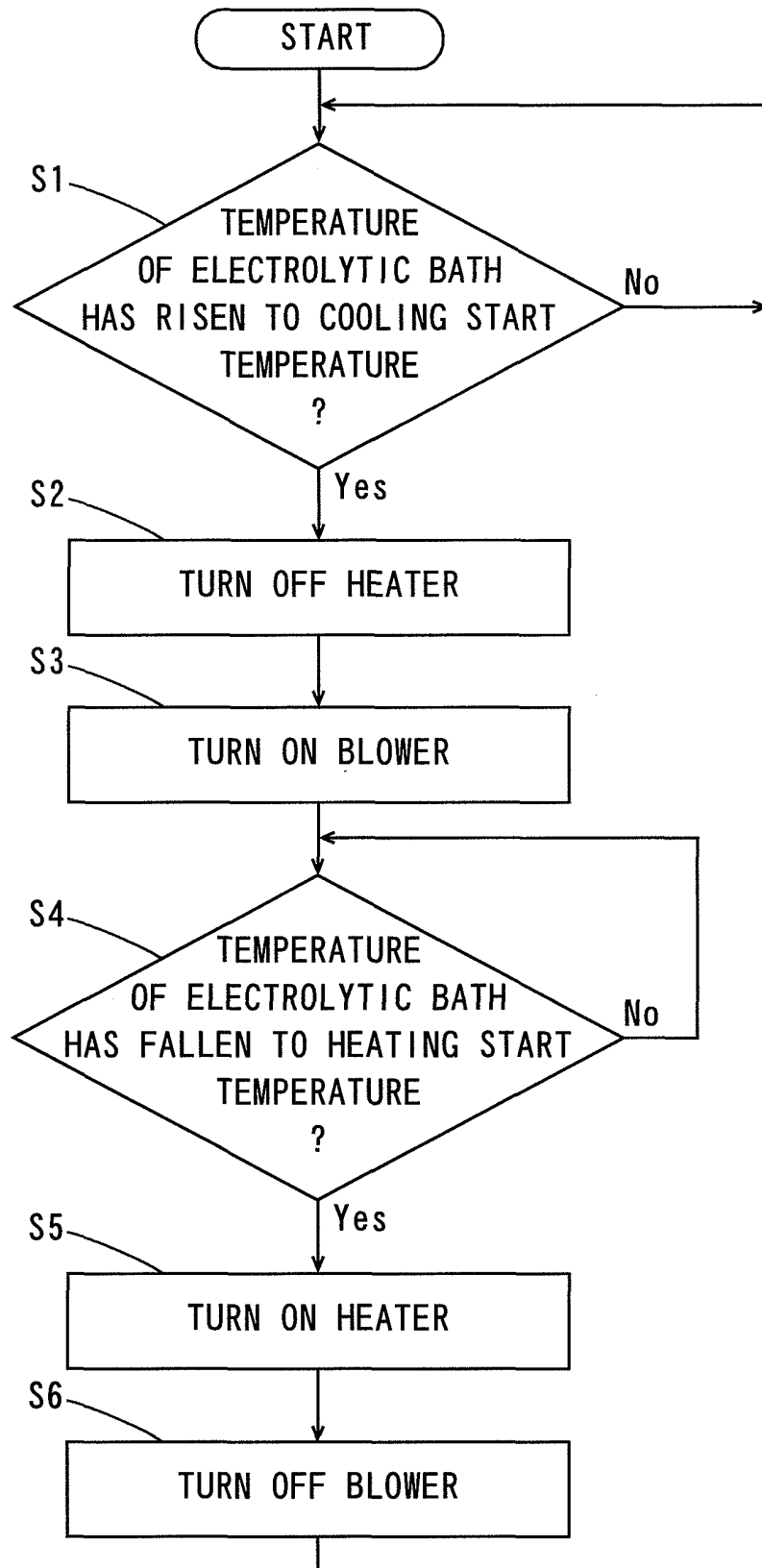


FIG. 4

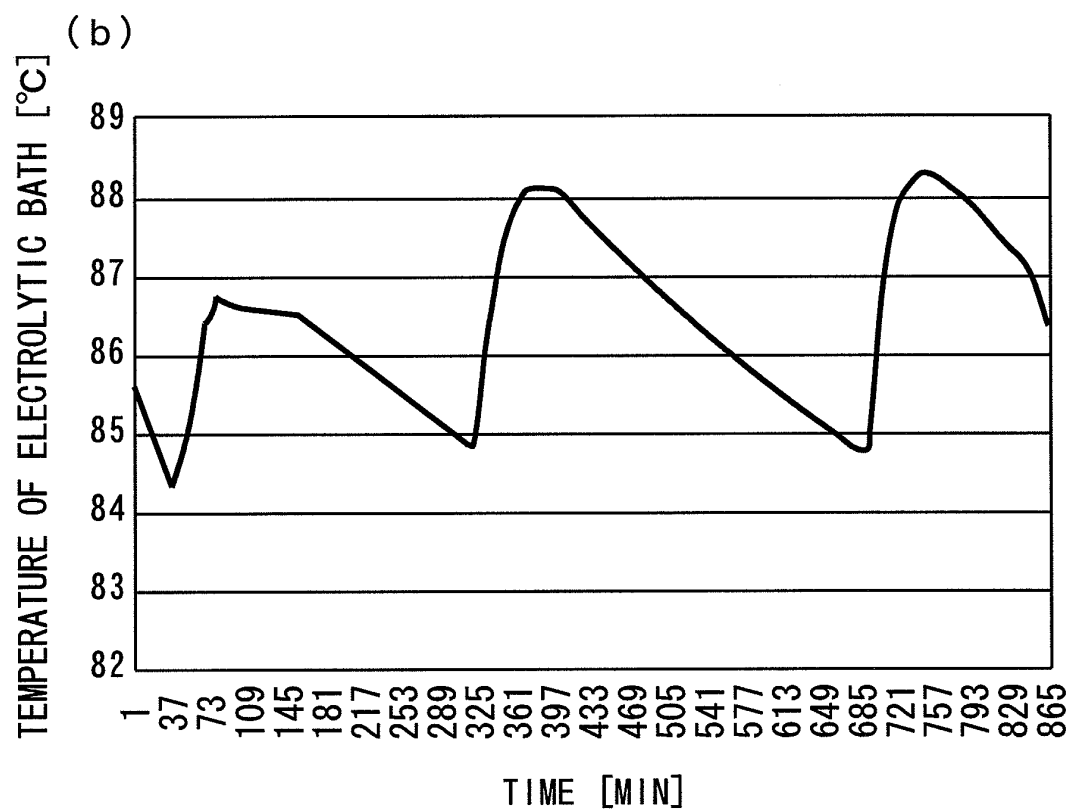
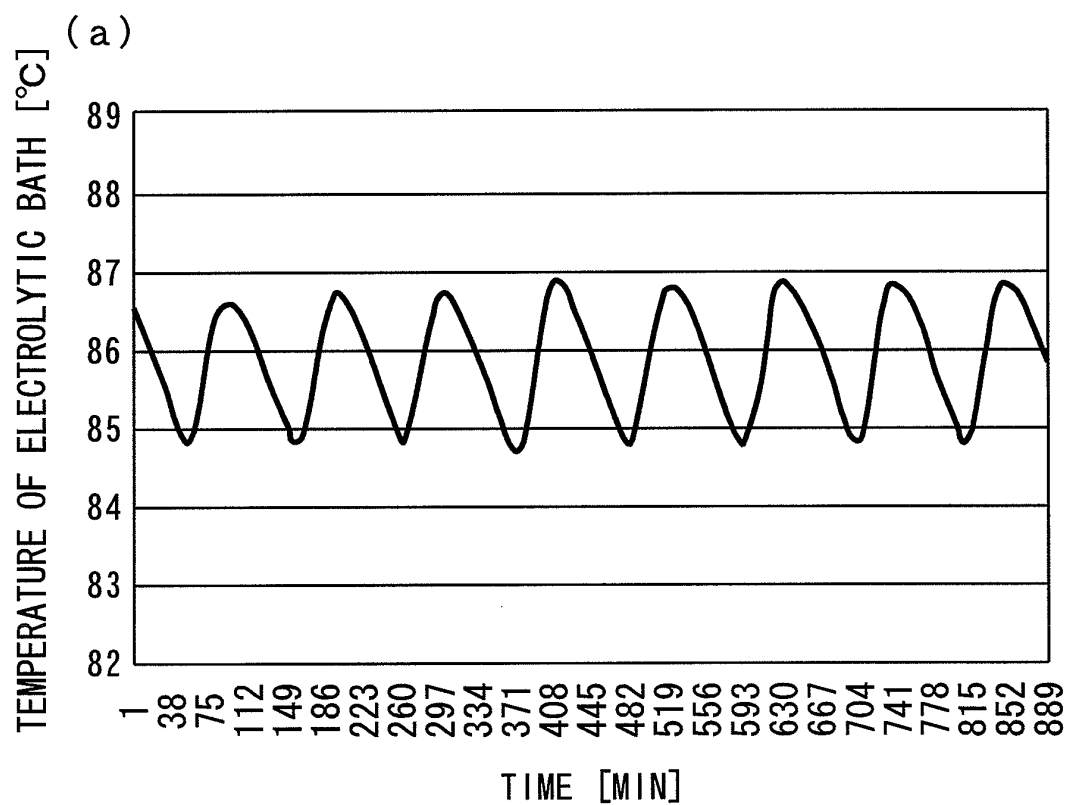


FIG. 5

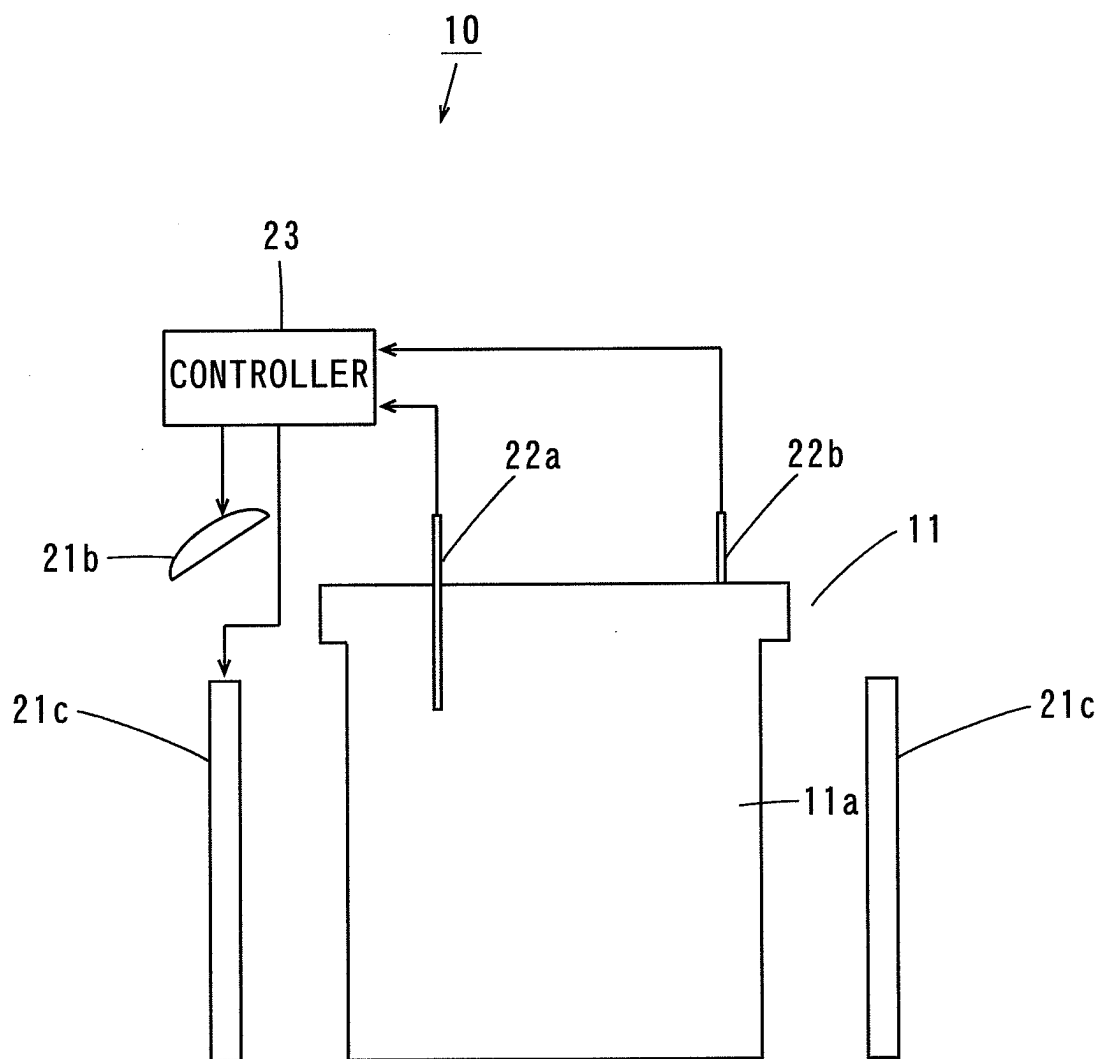
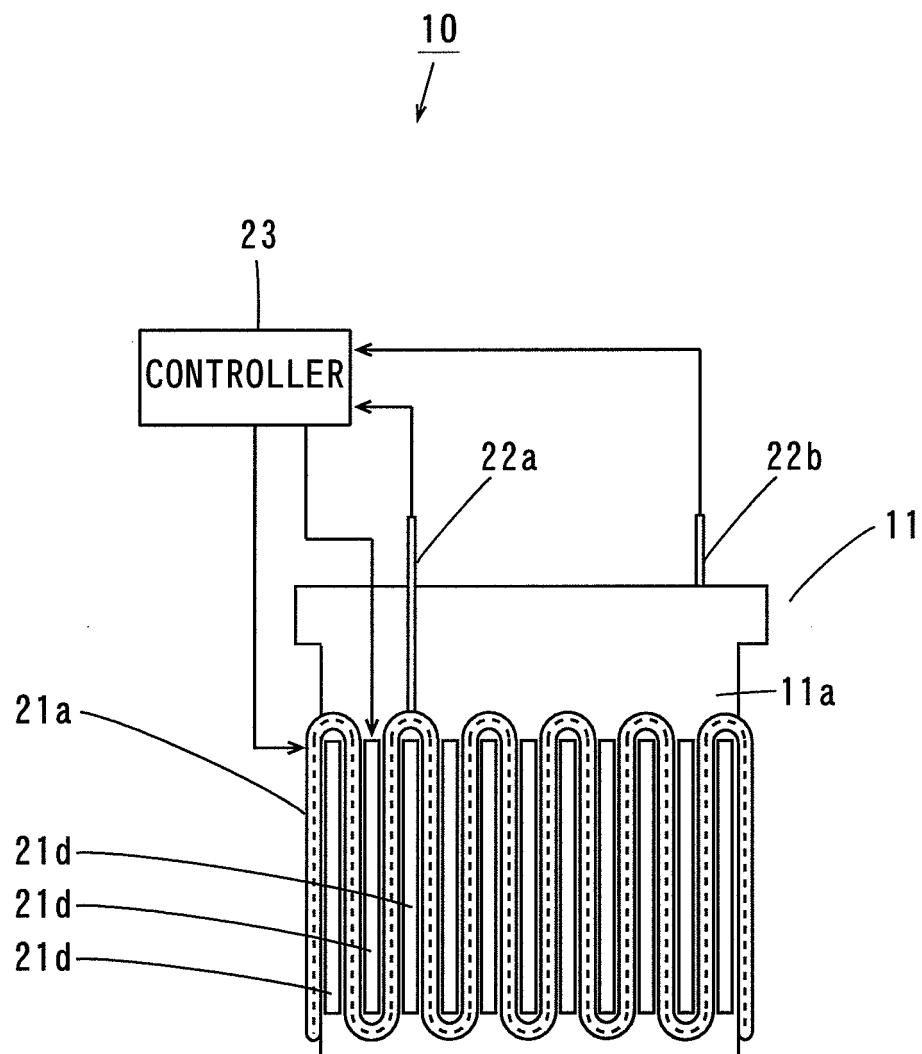


FIG. 6



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2010/005419

A. CLASSIFICATION OF SUBJECT MATTER

C25B15/02(2006.01) i, C25B1/24(2006.01) i, C25B9/00(2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C25B15/02, C25B1/24, C25B9/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2010

Kokai Jitsuyo Shinan Koho 1971-2010 Toroku Jitsuyo Shinan Koho 1994-2010

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2005-048290 A (Toyo Tanso Co., Ltd.), 24 February 2005 (24.02.2005), claims; paragraphs [0004] to [0010]; drawings & US 2004/0149570 A1 & EP 1455004 A1 & KR 10-2004-0067894 A	1-10
Y	JP 2007-046110 A (Honda Motor Co., Ltd.), 22 February 2007 (22.02.2007), claims; paragraph [0021] (Family: none)	1-10

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

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
30 September, 2010 (30.09.10)Date of mailing of the international search report
12 October, 2010 (12.10.10)Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2010/005419

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2004-089702 A (Heraeus Kulzer GmbH & Co. KG.), 25 March 2004 (25.03.2004), claims; drawings & US 2004/0108199 A1 & EP 1384448 A1 & DE 10234285 A & AT 334636 T & DK 1384448 T	1-10
Y	JP 2004-204347 A (Kimu Sannamu), 22 July 2004 (22.07.2004), claims; paragraph [0016]; drawings & KR 10-2004-0055411 A & CN 1510172 A	1-10
Y	JP 2000-042555 A (Sanyo Electric Co., Ltd.), 15 February 2000 (15.02.2000), claims; paragraphs [0010] to [0013] (Family: none)	1-10

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2004244724 A [0004]