



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

(43) Date of publication:
04.04.2012 Bulletin 2012/14

(51) Int Cl.:
C25B 9/00 (2006.01)

(21) Application number: **10780245.6**

(86) International application number:
PCT/JP2010/003470

(22) Date of filing: **24.05.2010**

(87) International publication number:
WO 2010/137284 (02.12.2010 Gazette 2010/48)

(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

(30) Priority: **26.05.2009 JP 2009126622**

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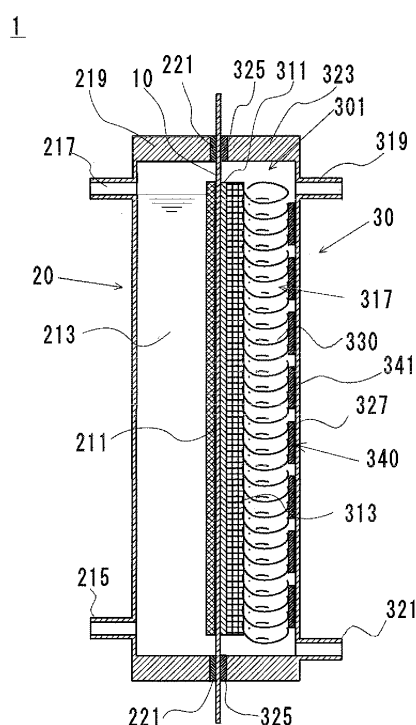
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(54) **GAS DIFFUSION ELECTRODE-EQUIPPED ION-EXCHANGE MEMBRANE ELECTROLYTIC CELL**

(57) Provided is a gas diffusion electrode equipped ion exchange membrane electrolyzer including an anode, an ion-exchange membrane, and a cathode chamber in which a gas diffusion electrode is disposed, wherein in a cathode gas chamber formed between a back plate of the cathode chamber and one side of the gas diffusion electrode opposite to the electrolytic surface, a gas-permeable elastic member is disposed between the gas diffusion electrode and the back plate, and the elastic member forms a conductive connection between the gas diffusion electrode and the back plate by making contact with corrosion-resistant conductive layers formed on the surfaces of a plurality of conductive members which are joined to the back plate.

Fig. 1



Description

Technical Field

[0001] The present invention relates to a gas diffusion electrode equipped ion exchange membrane electrolyzer for use in electrolysis of an alkali metal chloride aqueous solution such as brine and, more particularly, to a gas diffusion electrode equipped ion exchange membrane electrolyzer suitably applied to a two-chamber type gas diffusion electrode equipped ion exchange membrane electrolyzer.

Background Art

[0002] A gas diffusion electrode equipped ion exchange membrane electrolyzer provided with a gas diffusion electrode is utilized as a means for reducing electrolysis voltage by causing a reaction with a gas introduced from outside at the gas diffusion electrode.

In a gas diffusion electrode equipped ion exchange membrane electrolyzer for alkali metal chloride aqueous solution wherein the gas diffusion electrode is used as a cathode, an alkali chloride aqueous solution is supplied to an anode chamber so as to generate a chlorine gas at an anode. On the other hand, an oxygen-containing gas is supplied to a cathode chamber, whereby at the gas diffusion electrode, the oxygen is reduced, and further, an alkali metal hydroxide aqueous solution is generated.

[0003] An electrolyte cannot be made to flow over the entire surface of the gas diffusion electrode unless a state where the gas diffusion electrode is brought into firm and uniform contact to the ion exchange membrane is maintained. If not, a current cannot be made to flow uniformly through the electrolytic surface of the gas diffusion electrode.

To cope with this, there has been proposed an ion exchange membrane electrolyzer in which a gas-permeable elastic member is disposed between a cathode chamber at the back of the gas diffusion electrode and a back plate so as to bring the gas diffusion electrode into firm contact with the ion exchange membrane and to ensure electrical conduction between the back plate of the cathode chamber and gas diffusion electrode.

Since the alkali metal hydroxide aqueous solution and oxygen exist in the cathode chamber, an oxidizing environment is formed along the inner wall surface of the cathode chamber. Therefore, the cathode chamber is made of nickel, a nickel alloy, or the like. However, under such an environment, a passivation film is formed on the surface of the nickel or nickel alloy due to oxidation.

Although progression of metal corrosion can be restrained by the passivation film formed on the nickel or nickel alloy, a large conduction resistance is generated by the passivation film in a conducting circuit through which a current is made to flow by the contact of the elastic member with the back plate of the cathode cham-

ber and the gas diffusion electrode.

To prevent a reduction in the conductivity due to the passivation film, there has been proposed a configuration in which silver plating is applied to the back plate of the cathode chamber and elastic member so as to prevent an increase in the conduction resistance (refer to e.g., Patent Document 1).

Citation List

Patent Document

[0004] Patent Document 1: JP-A-2006-322018

15 Disclosure of the Invention

Problems to be Solved by the Invention

[0005] Although to prevent a reduction in the conductivity and prevent an increase in the conduction resistance by applying silver plating to the back plate of the cathode chamber and elastic member is an effective means for preventing an increase in the voltage of the gas diffusion electrode equipped ion exchange membrane electrolyzer, it has not been possible to avoid the increase in the voltage of the electrolyzer under a long duration of electrolysis.

An object of the present invention is to provide a gas diffusion electrode equipped ion exchange membrane electrolyzer capable of preventing an increase in the voltage of the electrolyzer due to an increase in the conduction resistance in the conducting circuit from the gas diffusion electrode to the back plate of the cathode chamber so as to perform a lower voltage operation which is one of the features of the gas diffusion electrode equipped ion exchange membrane electrolyzer for a long period of time.

Means for Solving the Problems

[0006] According to the present invention, there is provided a gas diffusion electrode equipped ion exchange membrane electrolyzer having an anode, an ion exchange membrane, and a cathode chamber in which a gas diffusion electrode is disposed, **characterized in that** in a cathode gas chamber formed between a back plate of the cathode chamber and one side of the gas diffusion electrode opposite to the electrolytic surface, a gas-permeable elastic member is disposed between the gas diffusion electrode and the back plate, and the elastic member forms a conductive connection between the gas diffusion electrode and the back plate by making contact with corrosion-resistant conductive layers formed on the surfaces of a plurality of conductive members which are joined to the back plate.

The conductive member has a silver or platinum group metal-containing corrosion-resistant conductive layer on a foil or plate made of nickel or a nickel alloy.

The conductive member is obtained by integrating the silver or platinum group metal-containing corrosion-resistant conductive layer by means of plating, cladding or baking coating.

A part of or the entire conductive member is joined to the back plate.

The elastic member forms a corrosion-resistant conductive layer on a conductive contacting surface or the entire surface thereof.

Advantages of the Invention

[0007] The gas diffusion electrode equipped ion exchange membrane electrolyzer according to the present invention has a configuration in which the plurality of conductive members on the surface of each of which the corrosion-resistant conductive layer is formed are disposed on the surfaces contacting the elastic member and back plate of the cathode chamber for electrical conduction to the gas diffusion electrode. As a result, there can be provided a gas diffusion electrode equipped ion exchange membrane electrolyzer in which characteristics of the contact portion with the elastic member for electrical conduction to the gas diffusion electrode are stable, and the voltage of the electrolyzer can stably be kept at a lower level for a long period of time.

Brief Description of the Drawings

[0008]

FIG. 1 is a cross-sectional view for explaining an embodiment of a gas diffusion electrode equipped ion exchange membrane electrolyzer according to the present invention.

FIG. 2 is an exploded perspective view for explaining the embodiment of the gas diffusion electrode equipped ion exchange membrane electrolyzer according to the present invention.

FIGS. 3A and 3B are views for explaining the embodiment of the gas diffusion electrode equipped ion exchange membrane electrolyzer according to the present invention, which illustrate the conductive member, and in which FIG. 3A illustrates an example in which conductive members each having a comparatively large area are mounted to the back plate, and FIG. 3B illustrates an example in which a large number of conductive members each having a comparatively small area are mounted to the back plate. FIG. 4 is a view for explaining Example and Comparative Example of the gas diffusion electrode equipped ion exchange membrane electrolyzer according to the present invention.

FIG. 5 is a view for explaining the embodiment of the gas diffusion electrode equipped ion exchange membrane electrolyzer according to the present invention.

Best Mode for Carrying Out the Invention

[0009] It has been found that partial separation of a coating layer of a material excellent in conductivity such as silver formed on the conduction contacting surface of a back plate of a cathode chamber of a gas diffusion electrode equipped ion exchange membrane electrolyzer is caused by an occurrence of portions different in electrochemical characteristics due to unevenness in the film thickness occurring in the coating layer formed by plating or the like.

That is, the back plate of the cathode chamber is surrounded by a cathode chamber frame, so that it is not possible to avoid an occurrence of a phenomenon in which unevenness occurs in the flow of a plating solution in a plating tank, causing formation of portions different in characteristics such as film thickness. Thus, when electrolysis is performed for a long period of time, a problem such as film separation from the back plate may occur.

[0010] In the present invention, a problem caused by directly plating a conductive layer to the back plate is solved as follows. That is, a plurality of conductive members made of a planar metal foil or metal plate formed by plating a corrosion-resistant conductive layer made of silver or platinum-group metal to the surface thereof are joined to the back plate so as to make the characteristics of the contacting portion to an elastic member uniform, thereby allowing prevention of a phenomenon such as separation of the corrosion-resistant conductive layer contacting the elastic member.

[0011] An embodiment of the present invention will be described with reference to the accompanying drawings. FIG. 1 is a cross-sectional view for explaining an embodiment of a gas diffusion electrode equipped ion exchange membrane electrolyzer according to the present invention.

The following description is made taking a gas diffusion electrode equipped ion exchange membrane electrolyzer for use in electrolysis of brine, in which a single anode chamber and a single cathode chamber are stacked through an ion exchange membrane.

FIG. 1 is a cross-sectional view obtained by cutting the gas diffusion electrode equipped ion exchange membrane electrolyzer along a plane orthogonal to an electrode surface.

A gas diffusion electrode equipped ion exchange membrane electrolyzer 1 has a configuration called a two-chamber type gas diffusion electrode equipped ion exchange membrane electrolyzer, in which an anode chamber 20 and a cathode chamber 30 provided therein are separated by an ion exchange membrane 10.

The anode chamber 20 has an anode 211 and is filled with brine as an anolyte 213. An anolyte inlet 215 is formed at the lower portion of the anode chamber 20.

An outlet 217 for anolyte whose concentration has been decreased by electrolysis and gas is formed at the upper portion of the anode chamber, and an anode chamber

frame 219 is stacked to the ion exchange membrane 10 through an anode chamber side gasket 221.

[0012] The cathode chamber 30 is provided on the opposite side to the anode chamber 20 with respect to the ion exchange membrane 10, and a gas diffusion electrode 313 is provided in the cathode chamber.

A liquid retaining member 311 is disposed between a cathode chamber inner space 301 including the gas diffusion electrode 313 and ion exchange membrane 10.

[0013] On one side of the gas diffusion electrode 313 opposite to the liquid retaining member 311 side, an elastic member 330 which is made of a wire rod and which has inside thereof a space through which a gas can be passed is disposed.

The elastic member 330 brings the gas diffusion electrode 313 and liquid retaining member 311 into firm contact with the ion exchange membrane 10 side to form a cathode gas chamber 317 within the cathode chamber and makes contact with corrosion-resistant conductive layers 341 formed on the surfaces of a plurality of conductive members 340 which are joined to the back plate 327 of the cathode chamber 30 to form a conducting circuit between the gas diffusion electrode 313 and back plate 327.

[0014] When an alkali metal chloride aqueous solution is supplied to the anode chamber 20 of the gas diffusion electrode equipped ion exchange membrane electrolyzer 1 according to the present invention and then current is applied between the anode 211 and gas diffusion electrode 313 while an oxygen-containing gas is supplied to the cathode gas chamber 317 of the cathode chamber 30 through an oxygen inlet 319, the gas diffusion electrode 313 is supplied with the fluid content of an alkali metal hydroxide aqueous solution from the liquid retaining member 311 as well as supplied with the oxygen-containing gas from the cathode gas chamber 317 side, resulting in progress of a generating reaction of the alkali metal hydroxide aqueous solution in the gas diffusion electrode 313.

The generated alkali metal hydroxide aqueous solution is transferred to the liquid retaining member 311 according to the concentration gradient and absorbed/retained by the liquid retaining member 311, as well as flows down along the inside of the liquid retaining member 311 and gas chamber side of the gas diffusion electrode 313 to be discharged from a cathode gas chamber outlet 321.

[0015] Since a high concentration oxygen, a water vapor, and mist of the alkali metal hydroxide aqueous solution exist in the cathode gas chamber 317, and temperature of the cathode gas chamber 317 reaches about 90 °C, the cathode chamber is made of nickel, a nickel alloy, or the like. Further, the elastic member is made of a metal material having a high corrosion resistance and a high conductivity, such as nickel or a high nickel alloy.

[0016] In a conventional gas diffusion electrode equipped ion exchange membrane electrolyzer, a metal having a satisfactory corrosion resistance, such as nickel or a nickel alloy, used as a material of the cathode gas

chamber 317 is oxidized at its surface in the presence of a high concentration oxygen to form a passivation film, impeding electrical conduction, which leads to an increase in the voltage of the electrolyzer.

[0017] To cope with this, in the gas diffusion electrode equipped ion exchange membrane electrolyzer according to the present invention, a plurality of planar conductive members 340 each having a corrosion-resistant conductive layer 341 on the surface thereof are disposed on the back plate 327 of the cathode chamber 30.

Each planar conductive member 340 has the corrosion-resistant conductive layer 341 whose surface characteristics are made uniform by plating, cladding, or baking coating, so that even if the area of the back plate 327 is increased, a surface having uniform characteristics can be obtained in any position.

As a result, in a long period operation, an increase in a contact resistance does not occur at the contacting surfaces of the elastic member 330 forming the conducting circuit between the gas diffusion electrode 313 and back plate 327 due to existence of the corrosion-resistant conductive layers 341, allowing prevention of an increase in the voltage of the electrolyzer.

[0018] As the planar conductive member, it is preferable to use the same material as that of the back plate of the cathode chamber, i.e., a nickel material, the thickness thereof preferably being 0.1 mm to 1.0 mm. The corrosion-resistant conductive layer may be formed of a metal such as silver or platinum group metal and it is particularly preferable to use silver having a satisfactory conductivity. The corrosion-resistant conductive layer can be formed by plating, cladding, baking, or the like.

The thickness of the corrosion-resistant conductive layer is preferably set to 0.5 μm or more. When the thickness falls below 0.5 μm, sufficient characteristics cannot be obtained. On the other hand, the larger the thickness, the more excellent the corrosion resistance and the like become; however, a thickness of about 5 μm will suffice. It is preferable that the planar conductive member is formed in a size of 60 mm × 56 mm to 1220 mm × 500 mm. When the size is smaller than 60 mm × 56 mm, the number of the planar conductive members to be installed is increased to increase the number of spot welding points, which may result in a degradation of the uniformity. On the other hand, when the size is larger than 1220 mm × 500 mm, nonuniformity is likely to occur unfavorably when the corrosion-resistant conductive layer is formed by plating or the like.

[0019] FIG. 2 is a view for explaining the embodiment of the gas diffusion electrode equipped ion exchange membrane electrolyzer according to the present invention and more specifically, an exploded perspective view for explaining the elastic member and conductive member.

The plurality of conductive members 340 are joined to the back plate 327 of a cathode chamber frame 323. In the illustrative example, 12 conductive members 340 are disposed.

The elastic member 330 is disposed such that one surface thereof contacts the conductive members 340 and the other surface thereof contacts one surface of the gas diffusion electrode opposite to the electrolytic surface.

In the example of FIG. 2, the elastic member 330 has eight unit elastic members 333a, 333b, 333c, 333d, 333e, 333f, 333g, and 333h mounted to an elastic member frame 331, each of which is constituted by a hollow spring coil forming a gas passage and is disposed so as to uniformly press the gas diffusion electrode and to allow uniform electrical conduction between the gas diffusion electrode and back plate.

The use of the plurality of unit elastic members can allow the pressure and current distribution uniformly applied to the gas diffusion electrode even when the electrolysis area of the gas diffusion electrode is increased. Further, the number of the unit elastic members 333a to 333h forming the elastic member 330 and the number of the conductive members may appropriately be set in accordance with the size of the electrolysis area or magnitude of the application current density.

[0020] FIG. 3 is a view for explaining the embodiment of the gas diffusion electrode equipped ion exchange membrane electrolyzer according to the present invention, which illustrates the conductive member.

In the example of FIG. 3A, conductive members 340 each having a comparatively large area are mounted to the back plate by a method such as spot welding performed at joining portions 343 and the corrosion-resistant conductive layers 341 formed on the conductive members 340 are disposed on the gas diffusion electrode side.

In the example of FIG. 3B, a large number of conductive members 340 each having a smaller area than the conductive members of FIG. 3A are mounted to the back plate 327 and joined thereto at the joining portions 343, and corrosion-resistant conductive layers 341 are formed respectively on the surface of the mounted conductive members.

The mounting of a large number of the small-area conductive members 340 allows stable electrical conduction between the back plate and gas diffusion electrode for a long period of time.

Hereinafter, the present invention will be described based on Examples and Comparative Examples.

Example

Example 1

[0021] An ion exchange membrane (anode ion exchange membrane F-8020 made by Asahi Glass Co., Ltd) was disposed in an electrolyzer having an effective electrolysis area of 56 mm (height) $\times$ 60 mm (width) so as to contact an anode for brine electrolysis (JP202R made by Permelec Electrode Ltd.). On the opposite side of the anode of the ion exchange membrane, a carbon fiber fabric (made by Zoltek) having a thickness of 0.4 mm that covers the electrolytic surface was stacked as

a liquid retaining member, and further a liquid-permeable gas diffusion electrode (Permelec Electrode Ltd.) was stacked on the liquid retaining member.

A nickel wire coil obtained by winding a nickel wire having a wire diameter of 0.17 mm in a coil shape having a winding diameter of 6 mm was disposed on one side of the gas diffusion electrode opposite to the electrolytic surface.

A conductive member made of a nickel foil (NW2201) of 56 mm (H) $\times$ 60 mm (W) $\times$ 0.2 mm (T) having one surface that has been subjected to silver plating was joined to the back plate of the cathode chamber of the cathode chamber frame by spot welding at six points.

[0022] A voltage measurement terminal was attached to the gas diffusion electrode, and the electrolyzer was operated for 17 days with the current density kept at 3 kA/m², electrolysis temperature kept at 87°C to 89°C, and aqueous sodium hydroxide concentration kept at 30 mass% to 33 mass%.

A potential difference between the gas diffusion electrode and back plate, i.e., voltage drop was measured. The measurement result is shown in FIG. 4. A voltage was not increased but kept at an initial voltage of 0.001 V, that is, operation of the electrolyzer was stable for 17 days.

Example 2

[0023] An ion exchange membrane (anode ion exchange membrane "Aciplex" F-4403 made by Asahi Kasei Chemicals Corporation) was disposed in an electrolyzer having an effective electrolysis area of 620 mm (width) $\times$ 1220 mm (height) so as to contact an anode for brine electrolysis (JP202R made by Permelec Electrode Ltd.). On the opposite side of the anode of the ion exchange membrane, a carbon fiber fabric (made by Zoltek) having a thickness of 0.4 mm that covers the electrolytic surface was stacked as a liquid retaining member, and further a liquid-permeable gas diffusion electrode (Permelec Electrode Ltd.) was stacked on the liquid retaining member.

[0024] Four nickel wire coils each obtained by winding a nickel wire having a wire diameter of 0.17 mm in a coil shape having a winding diameter of 6 mm were disposed on one surface of the gas diffusion electrode opposite to the electrolytic surface.

Two conductive members each made of a nickel foil (NW2201) of 1160 mm (H) $\times$ 310 mm (W) $\times$ 0.2 mm (T) having one surface that has been subjected to silver plating of a 10 μ m thickness were each joined to the back plate of the cathode chamber of the cathode chamber frame by spot welding at 144 points.

Thus obtained electrolyzer was used to perform electrolysis with the current density kept at 3 kA/m², electrolysis temperature kept at 75°C to 85°C, and aqueous sodium hydroxide concentration kept at 30 mass% to 34 mass%. As illustrated in FIG. 5 showing a trend in the voltage of the electrolyzer, an increase in the voltage was not ob-

served.

when the electrolyzer was disassembled after the total operation period of 500 days, no abnormality was observed in the silver plated conductive member.

Comparative Example 1

[0025] An electrolyzer produced in the same manner as Example 1 except that the silver plating was not applied to the conductive member was used to perform electrolysis under the same conditions as those in Example 1, and a potential difference between the gas diffusion electrode and back plate of the cathode chamber was measured in the same manner as Example 1. As illustrated in FIG. 4 showing the measurement result, the potential difference was increased with time. Further, when the electrolyzer was disassembled after stop of the operation, the nickel foil used as the conducting member was turned black due to formation of a passivation film.

Comparative Example 2

[0026] Electrolysis was performed in the same manner as Example 2 except that an electrolyzer has a cathode chamber in which the conductive member was not provided and silver plating of a 10 μm center thickness was applied to the back plate, and a trend in the voltage of the electrolyzer was measured.

A 200 mV voltage increase was observed after 300 days operation. Further, when the electrolyzer was disassembled after stop of the operation, the silver plating at substantially all the conducting portions of the silver plating layer of the back plate contacting the elastic member were separated to expose the nickel material as the underlayer, and further, the nickel material as the underlayer was turned black due to formation of a passivation film.

Industrial Applicability

[0027] The gas diffusion electrode equipped ion exchange membrane electrolyzer according to the present invention has a configuration in which the plurality of conductive members on the surface of each of which the corrosion-resistant conductive layer is formed are disposed on the surfaces contacting the elastic member and back plate of the cathode chamber for electrical conduction to the gas diffusion electrode. As a result, there can be provided a gas diffusion electrode equipped ion exchange membrane electrolyzer in which characteristics of the contact portion with the elastic member for electrical conduction to the gas diffusion electrode are stable, no separation of the corrosion-resistant conductive layer from the surface of the conductive member occurs, voltage drop between the gas diffusion electrode and back plate is small, and performance can be made stable for a long period of time.

Explanation of Symbols

[0028]

- 5 1: Gas diffusion electrode equipped ion exchange membrane electrolyzer
- 10: Ion exchange membrane
- 20: Anode chamber
- 30: Cathode chamber
- 10 211: Anode
- 213: Anolyte
- 215: Anolyte inlet
- 217: Anolyte and gas outlet
- 219: Anode chamber frame
- 15 221: Anode chamber side gasket
- 301: Cathode chamber inner space
- 311: Liquid retaining member
- 313: Gas diffusion electrode
- 317: Cathode gas chamber
- 20 319: Oxygen inlet
- 321: Cathode gas chamber outlet
- 323: Cathode chamber frame
- 325: Cathode chamber side gasket
- 327: Back plate
- 25 330: Elastic member
- 331: Elastic member frame
- 333a, 333b, 333c, 333d, 333e, 333f, 333g, 333h: Unit elastic member
- 340: Conductive member
- 30 341: Corrosion-resistant conductive layer
- 343: Joining portion

Claims

- 35 1. A gas diffusion electrode equipped ion exchange membrane electrolyzer having an anode, an ion exchange membrane, and a cathode chamber in which a gas diffusion electrode is disposed, **characterized in that**
- 40 in a cathode gas chamber formed between a back plate of the cathode chamber and one side of the gas diffusion electrode opposite to the electrolytic surface, a gas-permeable elastic member is disposed between the gas diffusion electrode and the back plate, and the elastic member forms a conductive connection between the gas diffusion electrode and the back plate by making contact with corrosion-resistant conductive layers formed on the surfaces of a plurality of conductive members which are joined to the back plate.
- 45 2. The gas diffusion electrode equipped ion exchange membrane electrolyzer according to claim 1, **characterized in that**
- 50 the conductive member has a silver or platinum group metal-containing corrosion-resistant conductive layer on a foil or plate made of nickel or a nickel
- 55

alloy.

3. The gas diffusion electrode equipped ion exchange membrane electrolyzer according to claim 1 or 2, **characterized in that** the conductive member is obtained by integrating the silver or platinum group metal-containing corrosion-resistant conductive layer by means of plating, cladding or baking coating.
4. The gas diffusion electrode equipped ion exchange membrane electrolyzer according to any one of claims 1 to 3, **characterized in that** a part of or the entire conductive member is joined to the back plate.
5. The gas diffusion electrode equipped ion exchange membrane electrolyzer according to any one of claims 1 to 4, **characterized in that** the elastic member forms a corrosion-resistant conductive layer on a conductive contacting surface or the entire surface thereof.

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Fig. 1

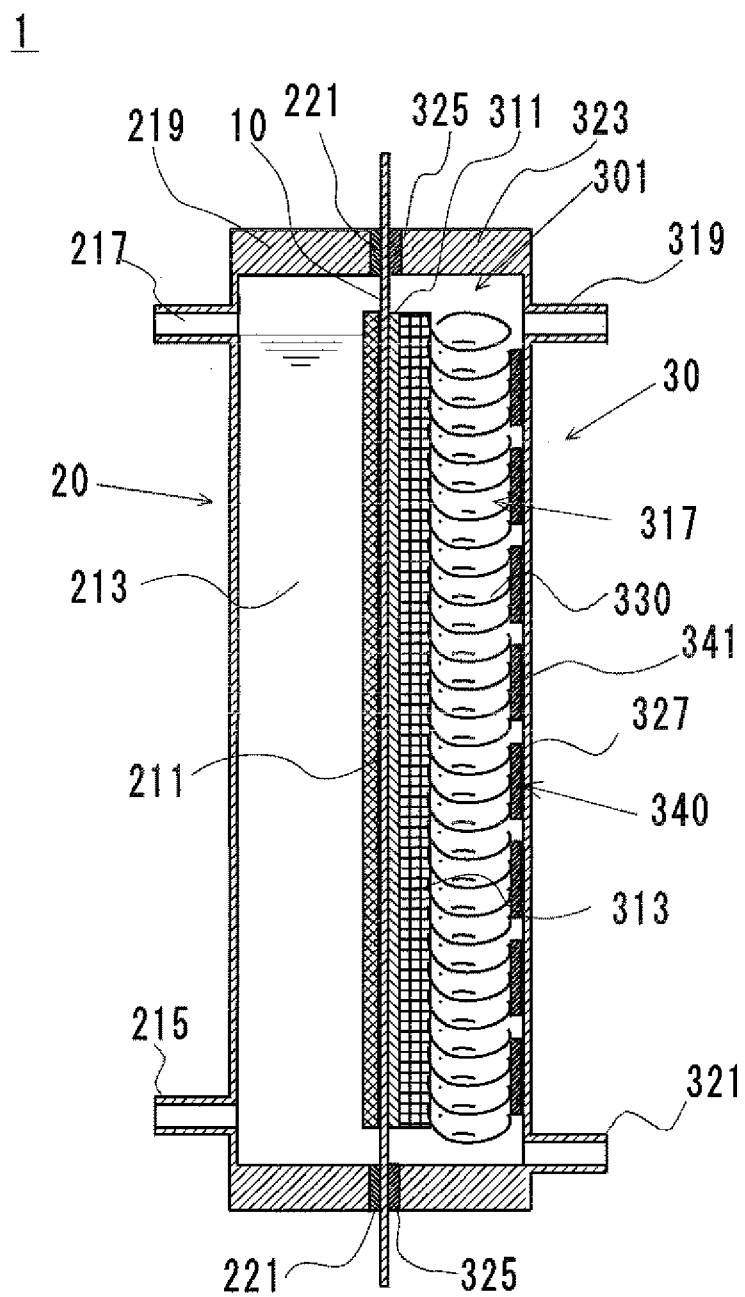


Fig.2

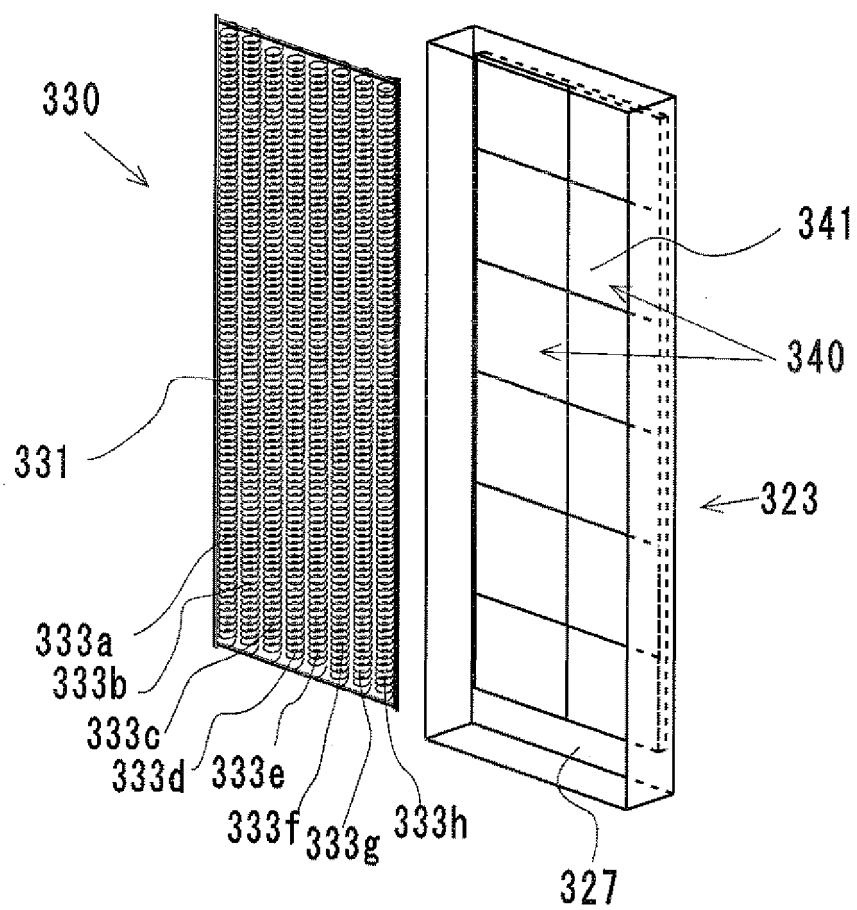


Fig.3

Fig.3A

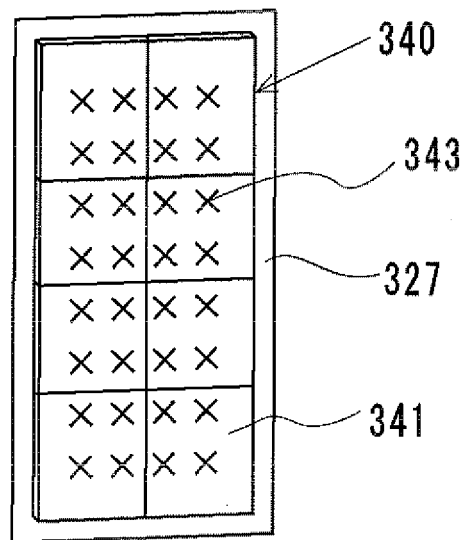


Fig.3B

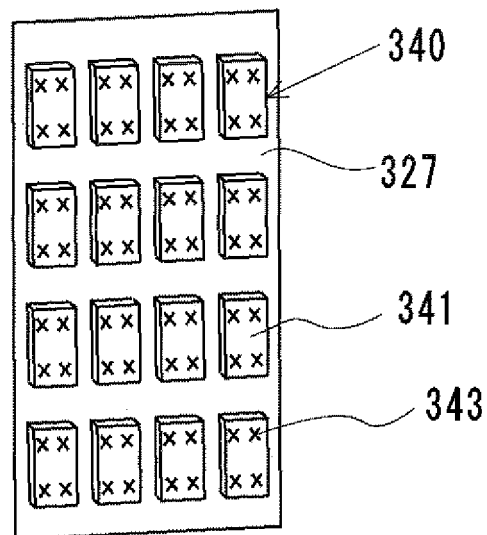


Fig.4

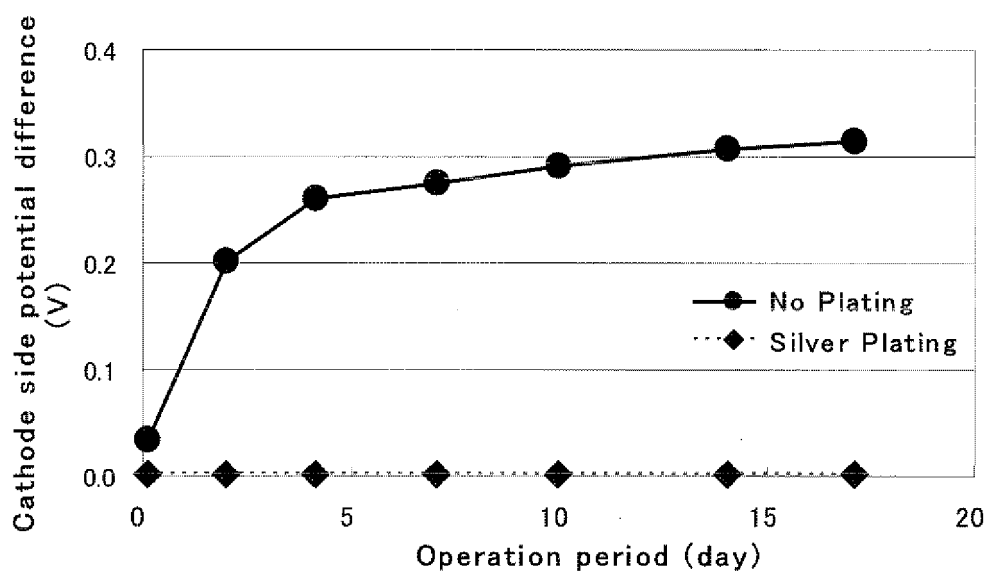
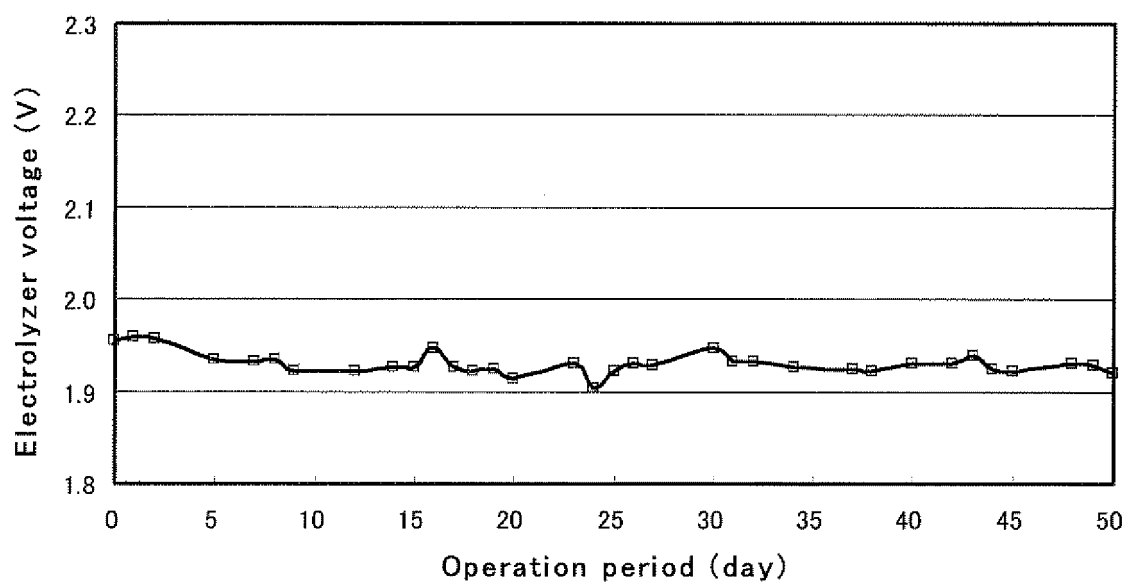


Fig.5



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2010/003470

A. CLASSIFICATION OF SUBJECT MATTER

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)

C25B1/00-9/04, C25B9/10, C25B11/00-11/18, C25B13/00-15/08

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 2006-322018 A (Chlorine Engineers Corp., Ltd., Kaneka Corp., Toagosei Co., Ltd.), 30 November 2006 (30.11.2006), claims; paragraphs [0001], [0011] to [0035]; fig. 4 & US 2009/0071820 A1 & EP 1882758 A1 & WO 2006/123716 A1 & CN 101175871 A	1-5
Y	JP 2001-3189 A (Kaneka Corp., Toagosei Co., Ltd., Mitsui Chemicals, Inc.), 09 January 2001 (09.01.2001), claims; paragraphs [0001], [0007] to [0018] (Family: none)	1-5

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

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Date of the actual completion of the international search
10 June, 2010 (10.06.10)Date of mailing of the international search report
22 June, 2010 (22.06.10)Name and mailing address of the ISA/
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Patent documents cited in the description

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