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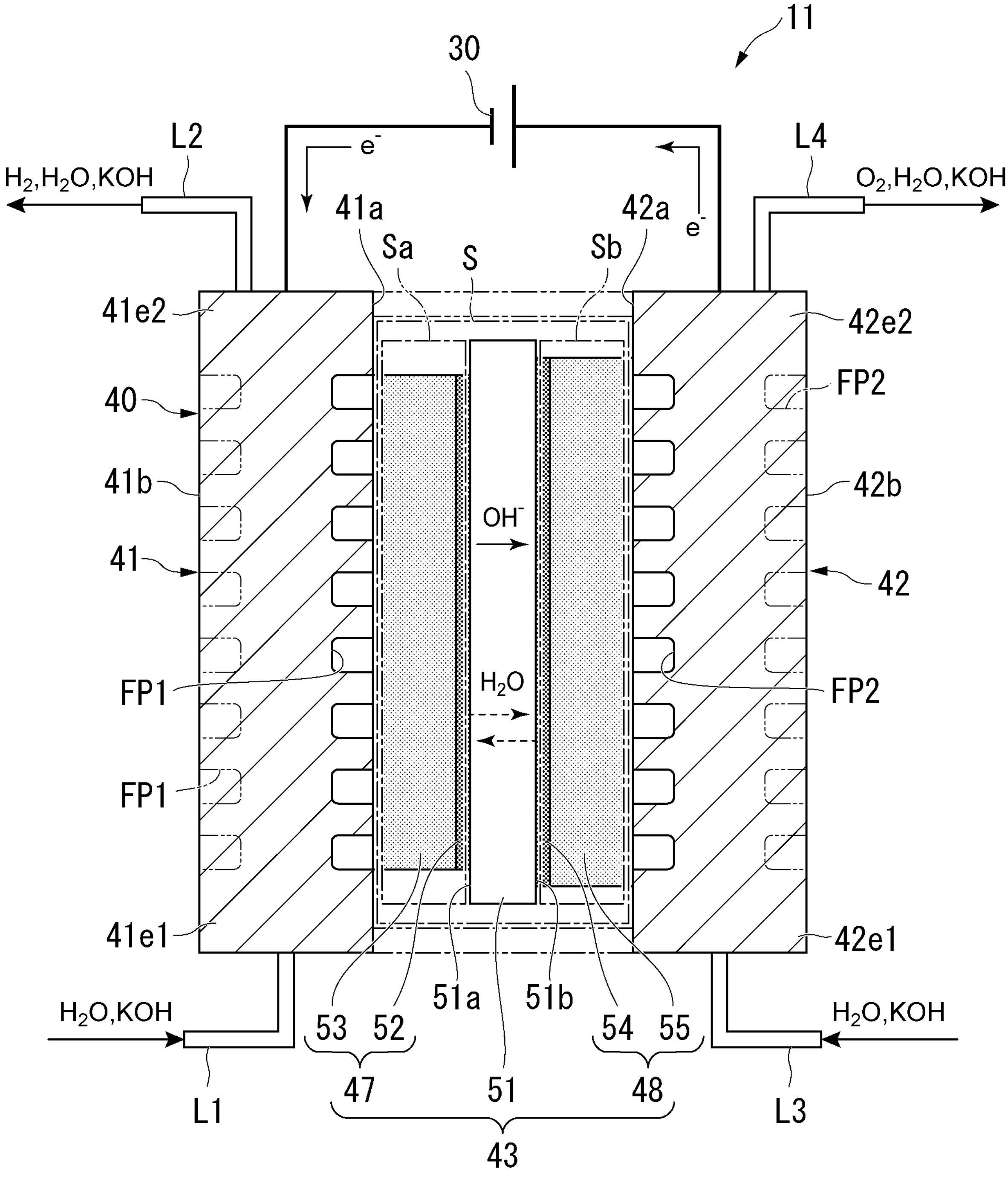
(54) ELECTROLYTIC CELL AND ELECTROLYZER

(57) An electrolytic cell of the present disclosure includes a first separator, a second separator, an ion exchange membrane configured to be disposed between the first separator and the second separator, and an anion exchange membrane with hydroxide ion conductivity, a cathode configured to be disposed between the first separator and the ion exchange membrane, and an anode configured to be disposed between the second separator and the ion exchange membrane. In a case of being viewed in a first direction in which the ion exchange membrane, the cathode, and the anode overlap each other, an area of the anode is larger than an area of the cathode.

FIG. 2


11
30
L2
H2,H2O,KOH
e-
L4
O2,H2O,KOH
41a
42a
Sa
S
Sb
41e2
42e2
40
FP2
41b
42b
OH-
41
42
H2O
FP1
FP2
FP1
41e1
42e1
H2O,KOH
H2O,KOH
53
52
51a
51b
54
55
47
51
48
L1
L3
43

Description

TECHNICAL FIELD

[0001] The present disclosure relates to an electrolytic cell and an electrolysis device.
[0002] Priority is claimed on Japanese Patent Application No. 2022-90936, filed on June 3, 2022, the content of which is incorporated herein by reference.

BACKGROUND ART

[0003] Patent Document 1 discloses a membrane electrode assembly used in polymer electrolyte membrane (PEM)-type water electrolysis. In order to improve pressure stability and airtightness at a high differential pressure, in the membrane electrode assembly, a first gas diffusion layer disposed on the front surface side of an ion conductive membrane has a smaller area than the ion conductive membrane, and a second gas diffusion layer disposed on the rear surface side of the ion conductive membrane has the same area as the ion conductive membrane (semi-coherent design).

Citation List

Patent Documents

[0004] [Patent Document 1] Published Japanese Translation No. 2009-513820 of the PCT International Publication

SUMMARY OF INVENTION

Technical Problem

[0005] Incidentally, as the deterioration when the electrolytic cell is used, the deterioration of an anode may significantly progress as compared with the deterioration of a cathode, and as a result, the performance of the electrolytic cell may decrease.
[0006] The present disclosure has been made in order to solve the above-described problems, and an object thereof is to provide an electrolytic cell and an electrolysis device, which can improve performance.

Solution to problem

[0007] In order to solve the above-described problems, an electrolytic cell according to the present disclosure includes a first separator, a second separator, an ion exchange membrane configured to be disposed between the first separator and the second separator, and an anion exchange membrane with hydroxide ion conductivity, a cathode configured to be disposed between the first separator and the ion exchange membrane, and an anode configured to be disposed between the second separator and the ion exchange membrane. In a case of being viewed in a first direction in which the ion exchange membrane, the cathode, and the anode overlap each other, an area of the anode is larger than an area of the cathode.
[0008] In order to solve the above-described problems, an electrolysis device according to the present disclosure includes an electrolytic cell, an electrolyte supply unit configured to supply an electrolyte to the electrolytic cell; and a power supply unit configured to apply a voltage to the electrolytic cell. The electrolytic cell includes a first separator, a second separator, an ion exchange membrane configured to be disposed between the first separator and the second separator, and an anion exchange membrane with hydroxide ion conductivity, a cathode configured to be disposed between the first separator and the ion exchange membrane, and an anode configured to be disposed between the second separator and the ion exchange membrane. In a case of being viewed in a first direction in which the ion exchange membrane, the cathode, and the anode overlap each other, an area of the anode is larger than an area of the cathode. Advantageous Effects of Invention
[0009] According to the electrolytic cell and the electrolysis device of the present disclosure, it is possible to improve the performance.

BRIEF DESCRIPTION OF DRAWINGS

[0010]

[FIG. 1] A schematic configuration diagram representing an overall configuration of an electrolysis device according to a first embodiment of the present disclosure.

[FIG. 2] A cross-sectional view schematically representing an electrolytic cell according to the first embodiment of the present disclosure.

[FIG. 3] An exploded perspective view representing the electrolytic cell according to a first embodiment of the present disclosure.

[FIG. 4] A cross-sectional view representing the electrolytic cell according to the first embodiment of the present disclosure.

[FIG. 5] A graph describing an action of the electrolytic cell according to the first embodiment of the present disclosure.

[FIG. 6] A graph describing an action of the electrolytic cell according to the first embodiment of the present disclosure.

[FIG. 7] A cross-sectional view representing an electrolytic cell according to a second embodiment of the present disclosure.

[FIG. 8] A table representing results of examining a state of deterioration of an anode after a predetermined time has elapsed in a plurality of electrolytic cell specimens using the electrolysis device according to the first embodiment of the present disclosure.

DESCRIPTION OF EMBODIMENTS

[0011] Hereinafter, an electrolytic cell and an electrolysis device according to the embodiment of the present disclosure will be described with reference to the drawings. In the following description, the same reference signs are assigned to configurations having the same or similar functions. In the present disclosure, "face each other" means that two members overlap each other when viewed in a certain direction and may also include a case where another member (for example, another layer) is present between the two members.

[0012] First, a Z direction, an X direction, and a Y direction are defined with reference to FIG. 4. The Z direction is a direction from a first separator 41 to a second separator 42 described later. The X direction is a direction intersecting (for example, orthogonal to) the Z direction and is a direction from a central portion C of an ion exchange membrane 51 described later toward one end portion of the ion exchange membrane 51. The Y direction is a direction intersecting (for example, orthogonal to) the Z direction and the X direction and is, for example, a depth direction of the paper surface in FIG. 4. In the present disclosure, the term of "area" means an area in a case of being viewed in the Z direction (that is, an area extending in the X direction and the Y direction). In addition, in the present disclosure, the term of "external size" means an external size in the case of being viewed in the Z direction. That is, the terms of "external size" and "area" may mean substantially the same thing and may be appropriately interpreted with each other.

(First Embodiment)

< 1. Configuration of Electrolysis Device>

[0013] FIG. 1 is a schematic configuration diagram showing an overall configuration of an electrolysis device 1 according to a first embodiment. For example, the electrolysis device 1 is a device that generates hydrogen by electrolyzing water contained in an electrolyte. For example, the electrolysis device 1 is an anion exchange membrane (AEM)-type electrolytic device. However, the electrolysis device 1 is not limited to the above example and may be an electrolysis device having a different type, such as a device for electrolytic reduction of carbon dioxide.

[0014] For example, the electrolysis device 1 is provided with an electrolytic cell stack 10, an electrolyte supply unit 20, and a power supply unit 30.

(Electrolytic Cell Stack)

[0015] The electrolytic cell stack 10 is an assembly of a plurality of electrolytic cells 11. For example, the electrolytic cell stack 10 is formed by arranging the plurality of electrolytic cells 11 in one direction. Each electrolytic cell 11 includes a cathode chamber Sa and an anode chamber Sb. The electrolytic cell 11 will be described later in detail.

(Electrolyte Supply Unit)

[0016] The electrolyte supply unit 20 is a supply unit that supplies an electrolyte to each electrolytic cell 11. For example, the electrolyte is pure water or an alkaline aqueous solution. The electrolyte supply unit 20 includes a cathode-side supply unit 20a and an anode-side supply unit 20b.

[0017] The cathode-side supply unit 20a is a supply unit that supplies an electrolyte to the cathode chamber Sa of each electrolytic cell 11. For example, the cathode-side supply unit 20a includes a hydrogen gas-liquid separation device 21, a first pump 22, a hydrogen recovery unit 23, a first electrolyte supply unit 24, and piping lines L1 and L2.

[0018] The hydrogen gas-liquid separation device 21 stores the electrolyte. A supply port of the hydrogen gas-liquid separation device 21 is connected to the cathode chamber Sa of the electrolytic cell 11 via the piping line L1. The first pump 22 is provided in the middle of the piping line L1 and sends the electrolyte stored in the hydrogen gas-liquid separation device 21 toward the cathode chamber Sa of the electrolytic cell 11.

[0019] The return port of the hydrogen gas-liquid separation device 21 is connected to the cathode chamber Sa of the electrolytic cell 11 via the piping line L2. An electrolyte containing hydrogen generated in the electrolytic cell 11 flows into the hydrogen-gas-liquid separation device 21 from the electrolytic cell 11. The hydrogen gas-liquid separation device 21 has a gas-liquid separation unit that separates hydrogen contained in the electrolyte. The hydrogen separated from the electrolyte by the hydrogen gas-liquid separation device 21 is recovered by the hydrogen recovery unit 23. The hydrogen gas-liquid separation device 21 is replenished with the electrolyte from the first electrolyte supply unit 24.

[0020] On the other hand, the anode-side supply unit 20b is a supply unit that supplies an electrolyte to the anode chamber Sb of each electrolytic cell 11. For example, the anode-side supply unit 20b includes an oxygen gas-liquid separation device 26, a second pump 27, an oxygen recovery unit 28, a second electrolyte supply unit 29, and piping lines L3 and L4.

[0021] The oxygen gas-liquid separation device 26 stores the electrolyte. A supply port of the oxygen gas-liquid separation device 26 is connected to the anode chamber Sb of the electrolytic cell 11 via the piping line L3. The second pump 27 is provided in the middle of the piping line L3 and sends the electrolyte stored in the oxygen gas-liquid separation device 26 toward the anode chamber Sb of the electrolytic cell 11.

[0022] The return port of the oxygen gas-liquid separation device 26 is connected to the anode chamber Sb of the electrolytic cell 11 via the piping line L4. An electrolyte containing oxygen generated in the electrolytic cell 11 flows into the oxygen gas-liquid separation device 26 from the electrolytic cell 11. The oxygen gas-liquid separation device 26 has a gas-liquid separation unit that separates oxygen contained in the electrolyte. Oxygen separated from the electrolyte by the oxygen gas-liquid separation device 26 is recovered by the oxygen recovery unit 28. The oxygen gas-liquid separation device 26 is replenished with the electrolyte from the second electrolyte supply unit 29.

(Power Supply Unit)

[0023] The power supply unit 30 is a direct current power supply device that applies a voltage to the electrolytic cell 11. The power supply unit 30 applies a direct current voltage desired for the electrolysis of the electrolyte between the anode and the cathode of the electrolytic cell 11.

<2. Configuration of Electrolytic Cell>

<2. 1 Basic Structure of Electrolytic Cell>

[0024] Next, the electrolytic cell 11 will be described in detail.

[0025] FIG. 2 is a cross-sectional view schematically showing the electrolytic cell 11. For example, the electrolytic cell 11 includes a first separator 41, a second separator 42, and a membrane electrode assembly 43.

(First Separator)

[0026] The first separator 41 is a member that defines one surface of an internal space S of the electrolytic cell 11. The internal space S is a space including the cathode chamber Sa and the anode chamber Sb described later. For example, the first separator 41 has a rectangular plate shape and includes a metal member. For example, a negative voltage is applied to the first separator 41 from the power supply unit 30 via a first current collector 61 (refer to FIG. 3) described later.

[0027] The first separator 41 has a first end portion 41el (for example, a lower end portion) and a second end portion 41e2 (for example, an upper end portion) located on a side opposite to the first end portion 41e1. The above-described piping line L1 is connected to the first end portion 41e1 of the first separator 41. The above-described piping line L2 is connected to the second end portion 41e2 of the first separator 41. The first separator 41 has a first inner surface 41a that faces the cathode chamber Sa described later. A first flow path FP1 through which the electrolyte supplied from the piping line L1 flows is formed on the first inner surface 41a. For example, the first flow path FP1 is a groove provided in the first inner surface 41a. The electrolyte that has flowed through the first flow path FP1 is discharged to the outside of the electrolytic cell 11 through the piping line L2. Each structure (for example, a flow path structure) shown in FIG. 2 is merely an example and does not limit the content of the present embodiment. For example, various structures can be used as the flow path structure depending on the size, purpose, and use environment of the device. The same applies to each structure shown in other drawings.

(Second Separator)

[0028] The second separator 42 is a member that is disposed with an internal space S between the second separator 42 and at least part of the first separator 41 and that defines the other surface of the internal space S. For example, the second separator 42 has a rectangular plate shape and includes a metal member. A positive voltage is applied to the second separator 42 from the power supply unit 30 via a second current collector 62 (refer to FIG. 3) described later. The first separator 41 and the second separator 42 included in the same electrolytic cell 11 form an electrolyzer 40 of the electrolytic cell 11 as a pair of separators.

[0029] The second separator 42 has a first end portion 42e1 (for example, a lower end portion) and a second end portion 42e2 (for example, an upper end portion) located on a side opposite to the first end portion 42e1. The above-described piping line L3 is connected to the first end portion 42e1 of the second separator 42. The above-described piping line L4 is connected to the second end portion 42e2 of the second separator 42. The second separator 42 has a second inner surface 42a that faces the anode chamber Sb described later. A second flow path FP2 through which the electrolyte supplied from the piping line L3 flows is formed on the second inner surface 42a. For example, the second flow path FP2 is a groove provided in the second inner surface 42a. The electrolyte that has flowed through the second flow path FP2 is discharged to the outside of the electrolytic cell 11 through the piping line L4.

[0030] Here, for convenience of description, a configuration in which the first inner surface 41a of the first separator 41 has a groove for a flow path (first flow path FP1) and the second inner surface 42a of the second separator 42 has a groove for a flow path (second flow path FP2) is described. However, for example, the first separator 41 of the electrolytic cell 11 included in the electrolytic cell stack 10 (refer to FIG. 1) may be a bipolar plate having the same groove for a flow path (first flow path FP1, shown by a two-dot chain line in FIG. 2) on a surface 41b opposite to the first inner surface 41a in addition to the first inner surface 41a. In addition, the second separator 42 of the electrolytic cell 11 included in the electrolytic cell stack 10 may be a bipolar plate having the same groove for a flow path (second flow path FP2, shown by a two-dot chain line in FIG. 2) on a surface 42b opposite to the second inner surface 42a in addition to the second inner surface 42a. The grooves for flow paths provided on both surfaces of the first separator 41 may have different shapes and dispositions. In addition, the grooves for flow paths provided on both surfaces of the second separator 42 may have different shapes and dispositions.

[0031] A membrane electrode assembly (MEA) 43 is a structure in which an ion exchange membrane, a catalyst, and a power supply body are assembled. The membrane electrode assembly 43 is disposed between the first separator 41 and the second separator 42 and is located in the internal space S. For example, the membrane electrode assembly 43 includes an ion exchange membrane 51, a cathode catalyst layer 52, a cathode power supply body 53, an anode catalyst layer 54, and an anode power supply body 55.

(Ion Exchange Membrane)

[0032] The ion exchange membrane 51 is a membrane that selectively allows ions to permeate. For example, the ion exchange membrane 51 is a solid polymer electrolyte membrane. For example, the ion exchange membrane 51 is an anion exchange membrane (AEM) having hydroxide ion conductivity. However, the ion exchange membrane 51 is not limited to the above-described example and may be an ion exchange membrane having a type different from the above-described example. For example, the ion exchange membrane 51 has a rectangular sheet shape. The external size of the ion exchange membrane 51 is smaller than the external size of the first separator 41 or the second separator 42. The ion exchange membrane 51 is disposed between the first separator 41 and the second separator 42 and is located in the above-described internal space S.

[0033] The ion exchange membrane 51 has a first surface 51a facing the first inner surface 41a of the first separator 41 and a second surface 51b located on a side opposite to the first surface 51a and facing the second inner surface 42a of the second separator 42. In the internal space S, the cathode chamber Sa is defined between the first surface 51a of the ion exchange membrane 51 and the first inner surface 41a of the first separator 41. In the internal space S, the anode chamber Sb is defined between the second surface 51b of the ion exchange membrane 51 and the second inner surface 42a of the second separator 42.

[0034] In the cathode chamber Sa, in a case where a voltage is applied to the electrolytic cell 11, the following chemical reaction occurs, and hydrogen is generated from the electrolyte. In the present application, the phrase that "XX is generated" may also include a case where another substance is simultaneously generated in association with the generation of XX. The hydroxide ions generated in the cathode chamber Sa pass through the membrane electrode assembly 43 and move from the cathode chamber Sa to the anode chamber Sb.

$$2H_2O + 2e^- \rightarrow H_2 + 2OH^-$$

[0035] In the anode chamber Sb, in a case where a voltage is applied to the electrolytic cell 11, the following chemical reaction occurs, and oxygen is generated from the electrolyte.

$$2OH^- \rightarrow 1/2O_2 + H_2O + 2e^-$$

[0036] As a result, in a case of being viewed in the electrolytic cell 11 as a whole, the following chemical reaction occurs.

$$H_2O \rightarrow H_2 + 1/2O_2$$

(Cathode Catalyst Layer)

[0037] The cathode catalyst layer 52 is a layer that accelerates the chemical reaction in the cathode chamber Sa described above. For example, the cathode catalyst layer 52 has a rectangular sheet shape. In the present embodiment, the external size of the cathode catalyst layer 52 is smaller than the external size of the ion exchange membrane 51. The cathode catalyst layer 52 is disposed in the cathode chamber Sa and is adjacent to the ion exchange membrane 51. In the present application, the term of "adjacent" is not limited to a case where two members are independently adjacent to each other and may also include a case where at least part of one member of the two members enters the other member. For example, part of the cathode catalyst layer 52 may enter a surface portion of the ion exchange membrane 51. In the present embodiment, the cathode catalyst layer 52 is provided on the first surface 51a of the ion exchange membrane 51. For example, the cathode catalyst layer 52 is formed by applying a material of the cathode catalyst layer 52 to the first surface 51a of the ion exchange membrane 51. A negative voltage is applied to the cathode catalyst layer 52 from the power supply unit 30 via the first separator 41 and the cathode power supply body 53, and the cathode catalyst layer 52 functions as part of the cathode 47 of the electrolytic cell 11.

[0038] As a material of the cathode catalyst layer 52, any material that accelerates the chemical reaction in the cathode chamber Sa described above may be used, and various materials can be used. For example, the cathode catalyst layer 52 contains one or more nickel, a nickel alloy, a cerium oxide, a lanthanum oxide, or platinum. In the present disclosure, the term of "XX oxide" may contain another material other than XX and oxygen. In addition, the cathode catalyst layer 52 may include another material such as carbon in addition to the above-described material. "XX" is any material.

(Cathode Power Supply Body)

[0039] The cathode power supply body 53 is an electrical connection portion that transmits a voltage applied to the first separator 41 to the cathode catalyst layer 52. The cathode power supply body 53 is disposed in the cathode chamber Sa. The cathode power supply body 53 is located between the first inner surface 41a of the first separator 41 and the cathode catalyst layer 52 and is in contact with each of the first inner surface 41a of the first separator 41 and the cathode catalyst layer 52. At least part of the cathode power supply body 53 may overlap at least part of at least one of the first separator 41 or the cathode catalyst layer 52. The cathode power supply body 53 has a structure in which an electrolyte and gas can pass through the inside. For example, the cathode power supply body 53 is made of a metal mesh structure, a sintered body, a fiber, or the like. In the present embodiment, the external size of the cathode power supply body 53 is the same as the external size of the cathode catalyst layer 52. In the present embodiment, the cathode 47 of the electrolytic cell 11 includes the cathode catalyst layer 52 and the cathode power supply body 53.

(Anode Catalyst Layer)

[0040] The anode catalyst layer 54 is a layer that accelerates the chemical reaction in the anode chamber Sb described above. For example, the anode catalyst layer 54 has a rectangular sheet shape. In the present embodiment, the external size of the anode catalyst layer 54 is smaller than the external size of the ion exchange membrane 51.

[0041] The anode catalyst layer 54 is disposed in the anode chamber Sb and is adjacent to the ion exchange membrane 51. For example, part of the anode catalyst layer 54 may enter the surface portion of the ion exchange membrane 51. In the present embodiment, the anode catalyst layer 54 is provided on the second surface 51b of the ion exchange membrane 51. For example, the anode catalyst layer 54 is formed by applying a material of the anode catalyst layer 54 to the second surface 51b of the ion exchange membrane 51. A positive voltage is applied to the anode catalyst layer 54 from the power supply unit 30 via the second separator 42 and the anode power supply body 55, and the anode catalyst layer 54 functions as part of the anode 48 of the electrolytic cell 11.

[0042] As a material of the anode catalyst layer 54, any material that accelerates the chemical reaction in the above-described anode chamber Sb may be used, and various materials can be used. For example, the anode catalyst layer 54 contains one or more nickel, a nickel alloy, a nickel oxide, a copper oxide, an iridium oxide, a niobium oxide, a lead oxide, or a bismuth oxide. As described above, the term of "XX oxide" in the present disclosure may contain another material other than XX and oxygen. For example, the term of "nickel oxide" may contain another material such as iron or cobalt in addition to nickel and oxygen. In addition, the term of "copper oxide" may contain another material such as cobalt in addition to copper and oxygen. The term of "iridium oxide" may contain another material such as ruthenium in addition to iridium and oxygen. The term of "lead oxide" may contain another material such as ruthenium in addition to lead and oxygen. The term of "bismuth oxide" may contain another material such as ruthenium, in addition to bismuth and oxygen.

(Anode Power Supply Body)

[0043] The anode power supply body 55 is an electrical connection portion that transmits the voltage applied to the second separator 42 to the anode catalyst layer 54. The anode power supply body 55 is disposed in the anode chamber Sb. The anode power supply body 55 is located between the second inner surface 42a of the second separator 42 and the anode catalyst layer 54 and is in contact with each of the second inner surface 42a of the second separator 42 and the anode catalyst layer 54. At least part of the anode power supply body 55 may overlap at least part of at least one of the second separator 42 or the anode catalyst layer 54. The anode power supply body 55 has a structure in which an electrolyte and gas can pass through the inside. For example, the anode power supply body 55 is made of a metal mesh structure, a sintered body, a fiber, or the like. In the present embodiment, the external size of the anode power supply body 55 is the same as the external size of the anode catalyst layer 54. In the present embodiment, the anode 48 of the electrolytic cell 11 includes the anode catalyst layer 54 and the anode power supply body 55.

[0044] FIG. 3 is an exploded perspective view showing the electrolytic cell 11. For example, the electrolytic cell 11 includes the first current collector 61, the second current collector 62, a first insulator 63, a second insulator 64, a first insulating material 65, a second insulating material 66, a first end plate 67, and a second end plate 68, in addition to the above-described configuration. In FIG. 3, for convenience of description, a support portion 70 and a sealing portion 80 described later are not shown.

(First Current Collector)

[0045] The first current collector 61 is an electrical connection portion that transmits the negative voltage applied from the power supply unit 30 to the first separator 41.

[0046] The first current collector 61 is a metal plate member (for example, a copper plate). For example, the first current collector 61 is in contact with the first separator 41 from a side of the electrolytic cell 11 opposite to the internal space S and is electrically connected to the first separator 41. A negative voltage desired for the electrolysis in the electrolytic cell 11 is applied to the first current collector 61 from the power supply unit 30. The first current collector 61 may be shared by two electrolytic cells 11 adjacent to each other in the electrolytic cell stack 10.

(Second Current Collector)

[0047] The second current collector 62 is an electrical connection portion that transmits the positive voltage applied from the power supply unit 30 to the second separator 42. The second current collector 62 is a metal plate member (for example, a copper plate). For example, the second current collector 62 is in contact with the second separator 42 from a side of the electrolytic cell 11 opposite to the internal space S and is electrically connected to the second separator 42. A positive voltage desired for the electrolysis in the electrolytic cell 11 is applied to the second current collector 62 from the power supply unit 30. The second current collector 62 may be shared by two electrolytic cells 11 adjacent to each other in the electrolytic cell stack 10.

(First Insulator)

[0048] The first insulator 63 is a member that insulates an outer peripheral portion of the first separator 41 and an outer peripheral portion of the second separator 42. The first insulator 63 is a frame-shaped sheet member that is larger than the outer shape of the cathode catalyst layer 52 and the outer shape of the cathode power supply body 53 by one size. The first insulator 63 is attached to the first inner surface 41a of the first separator 41 and covers an end portion of the first inner surface 41a. The material of the first insulator 63 is not particularly limited as long as the material is an insulating material, and is, for example, a sheet-like resin such as polytetrafluoroethylene (PTFE).

(Second Insulator)

[0049] The second insulator 64 is a member that insulates the outer peripheral portion of the first separator 41 and the outer peripheral portion of the second separator 42, similarly to the first insulator 63. The second insulator 64 is a frame-shaped sheet member that is larger than the outer shape of the anode catalyst layer 54 and the outer shape of the anode power supply body 55 by one size. The second insulator 64 is attached to the second inner surface 42a of the second separator 42 and covers an end portion of the second inner surface 42a. The material of the second insulator 64 is not particularly limited as long as the material is an insulating material and is, for example, a sheet-like resin such as PTFE. In addition, the first insulator 63 and the second insulator 64 can also be used as an integrated insulator.

(First Insulating Material)

[0050] The first insulating material 65 is located between the first current collector 61 and the first end plate 67. For example, the external size of the first insulating material 65 is the same as the external size of the first current collector 61 or larger than the external size of the first current collector 61.

(Second Insulating Material)

[0051] The second insulating material 66 is located between the second current collector 62 and the second end plate 68. For example, the external size of the second insulating material 66 is the same as the external size of the second current collector 62 or larger than the external size of the second current collector 62.

(First End Plate)

[0052] The first end plate 67 is located on a side opposite to the first insulating material 65 with respect to the internal space S of the electrolytic cell 11. For example, the external size of the first end plate 67 is larger than the external size of the first insulating material 65.

(Second End Plate)

[0053] The second end plate 68 is located on a side opposite to the second insulating material 66 with respect to the internal space S of the electrolytic cell 11. For example, the external size of the second end plate 68 is larger than the external size of the second insulating material 66.

[0054] The electrolytic cell 11 is not limited to the above-described configuration. For example, in a case where a plurality of the electrolytic cells 11 are disposed side by side in the electrolytic cell stack 10, two adjacent electrolytic cells 11 among the plurality of electrolytic cells 11 may share the first separator 41 or the second separator 42, each of which is a bipolar plate. In this case, the current collector (the first current collector 61 or the second current collector 62), the insulator (the first insulator 63 or the second insulator 64), the insulating material (the first insulating material 65 or the second insulating material 66), and the end plate (the first end plate 67 or the second end plate 68) may not be present between the two adjacent electrolytic cells 11.

<2. 2 Structure of Outer Peripheral Portion of Electrolytic Cell>

[0055] FIG. 4 is a cross-sectional view showing the electrolytic cell 11. In the present embodiment, the external size of the ion exchange membrane 51 is larger than each of the external size of the cathode catalyst layer 52 and the external size of the cathode power supply body 53. In other words, the area of the ion exchange membrane 51 is larger than each of the area of the cathode catalyst layer 52 and the area of the cathode power supply body 53. The ion exchange membrane 51 protrudes outside (on the outer peripheral side) the cathode catalyst layer 52 and the cathode power supply body 53 in a direction (for example, the X direction or the Y direction) orthogonal to the thickness direction (Z direction) of the membrane electrode assembly 43. In the present disclosure, the term of "outside" or "outer peripheral side" means a side away from the central portion C of the ion exchange membrane 51 in a direction (for example, the X direction or the Y direction) orthogonal to the thickness direction (Z direction) of the membrane electrode assembly 43.

[0056] Similarly, the external size of the ion exchange membrane 51 is larger than each of the external size of the anode catalyst layer 54 and the external size of the anode power supply body 55. In other words, in the case of being viewed in the thickness direction (Z direction) of the membrane electrode assembly 43, the area of the ion exchange membrane 51 is larger than each of the area of the anode catalyst layer 54 and the area of the anode power supply body 55. The ion exchange membrane 51 protrudes on the outer peripheral side of the anode catalyst layer 54 and the anode power supply body 55 in a direction (for example, the X direction or the Y direction) orthogonal to the thickness direction (Z direction) of the membrane electrode assembly 43.

[0057] For example, as shown in FIG. 4, the electrolytic cell 11 includes a support portion 70 and a sealing portion 80. The support portion 70 is a member that supports the membrane electrode assembly 43 inside the electrolytic cell 11. The sealing portion 80 is a member that closes the internal space S between the first separator 41 and the second separator 42. Hereinafter, these members will be described.

(Support Portion)

[0058] The support portion 70 is disposed between the first separator 41 and the second separator 42. The support portion 70 is located inside (on the inner peripheral side) an outer edge portion 51e of the ion exchange membrane 51 and supports the ion exchange membrane 51. In the present disclosure, the term of "outer edge portion" means an edge portion that is separated from the central portion C of the ion exchange membrane 51 in a direction (for example, the X direction or the Y direction) orthogonal to the thickness direction (Z direction) of the membrane electrode assembly 43. In addition, in the present disclosure, the term of "inside" or "inner peripheral side" means an inside (a side close to the central portion C) as viewed from the central portion C of the ion exchange membrane 51. In the present embodiment, for example, the support portion 70 includes a first support portion 71 and a second support portion 72.

(First Support Portion)

[0059] The first support portion 71 is a support portion on the cathode side. The first support portion 71 is disposed between the first inner surface 41a of the first separator 41 and the first surface 51a of the ion exchange membrane 51. The first support portion 71 is located inside (on the inner peripheral side) the outer edge portion 51e of the ion exchange membrane 51. The first support portion 71 is sandwiched between the first inner surface 41a (or the first insulator 63) of the first separator 41 and the first surface 51a of the ion exchange membrane 51 at a position outside (on the outer peripheral side) the cathode catalyst layer 52 and the cathode power supply body 53 and supports the ion exchange membrane 51 with respect to the first inner surface 41a of the first separator 41. The first support portion 71 is formed in an annular shape (for example, a frame shape) along the outer edge portion 51e of the ion exchange membrane 51, and in an annular shape that is smaller than the outer edge portion 51e of the ion exchange membrane 51 by one size.

(Second Support Portion)

[0060] The second support portion 72 is a support portion on the anode side. The second support portion 72 is disposed between the second inner surface 42a of the second separator 42 and the second surface 51b of the ion exchange membrane 51. The second support portion 72 is located inside (on the inner peripheral side) the outer edge portion 51e of the ion exchange membrane 51. The second support portion 72 is sandwiched between the second inner surface 42a of the second separator 42 and the second surface 51b of the ion exchange membrane 51 at a position outside (on the outer peripheral side) the anode catalyst layer 54 and the anode power supply body 55 and supports the ion exchange membrane 51 with respect to the second inner surface 42a of the second separator 42. The second support portion 72 is formed in an annular shape (for example, a frame shape) along the outer edge portion 51e of the ion exchange membrane 51, and in an annular shape that is smaller than the outer edge portion 52e of the ion exchange membrane 51 by one size.

(Sealing Portion)

[0061] The sealing portion 80 is disposed between the first separator 41 and the second separator 42. The sealing portion 80 is located outside (on the outer peripheral side) the outer edge portion 51e of the ion exchange membrane 51 and seals the internal space S of the electrolytic cell 11. In the present embodiment, the sealing portion 80 includes a first sealing portion 81 and a second sealing portion 82. However, the first sealing portion 81 and the second sealing portion 82 may be formed integrally. That is, the first sealing portion 81 and the second sealing portion 82 may be one member. In addition, the sealing portion 80 may be formed integrally with at least one of the first insulator 63 and the second insulator 64 described above.

(First Sealing Portion)

[0062] The first sealing portion 81 is a sealing portion on the cathode side. The first sealing portion 81 is located outside (on the outer peripheral side) the outer edge portion 51e of the ion exchange membrane 51. The first sealing portion 81 is sandwiched between the first inner surface 41a of the first separator 41 and the second sealing portion 82 and seals part of the outer peripheral side of the internal space S. The first sealing portion 81 is formed in an annular shape (for example, a frame shape) along the outer edge portion 51e of the ion exchange membrane 51, and in an annular shape that is larger than the outer edge portion 51e of the ion exchange membrane 51 by one size.

(Second Sealing Portion)

[0063] The second sealing portion 82 is a sealing portion on the anode side. The second sealing portion 82 is located outside the outer edge portion 51e of the ion exchange membrane 51. The second sealing portion 82 is sandwiched between the second inner surface 42a of the second separator 42 and the first sealing portion 81 and seals part of the outer peripheral side of the internal space S. The second sealing portion 82 is formed in an annular shape (for example, a frame shape) along the outer edge portion 51e of the ion exchange membrane 51, and in an annular shape that is larger than the outer edge portion 51e of the ion exchange membrane 51 by one size.

<3. Area Ratio of Cathode and Anode>

[0064] Next, the area ratio of the cathode and the anode will be described. In the present embodiment, the area of the anode 48 is larger than the area of the cathode 47. For example, the area of the anode catalyst layer 54 is larger than the area of the cathode catalyst layer 52. The area of the anode power supply body 55 is larger than the area of the cathode power supply body 53.

[0065] In the present embodiment, the area ratio of the anode 48 to the cathode 47 is more than 1.0 and 2.0 or less. In addition, from another viewpoint, in the present embodiment, the area ratio of the anode 48 to the cathode 47 is set such that a rate of increase in the overvoltage of the anode 48 due to the progress of deterioration is less than 2 times (more preferably less than 1.5 times) as compared with a rate of increase in the overvoltage of the cathode 47. Hereinafter, these contents will be described in detail.

[0066] FIG. 5 is a graph describing the action of the electrolytic cell 11. FIG. 5 is a graph showing test results of the current-voltage characteristics in the electrolytic cell of the comparative example in which the area of the anode and the area of the cathode are the same. In FIG. 5, the term of "cycle" means a predetermined period set in advance. As shown in FIG. 5, it is found that the overvoltage increases as the number of cycles increases (that is, as the use time increases) in the electrolytic cell of the comparative example.

[0067] FIG. 6 is another graph describing the action of the electrolytic cell 11. FIG. 6 is a graph showing the test results of a relationship between the number of cycles and the reaction resistance in the electrode in the above comparative example. As shown in FIG. 6, the reaction resistance in the anode 48 has an absolute value larger than the reaction resistance in the cathode 47. Furthermore, a rate of increase in the reaction resistance in the anode 48 due to the progress of deterioration is larger than a rate of increase in the reaction resistance in the cathode 47 due to the progress of deterioration. For example, the rate of increase in reaction resistance in the anode 48 is 2 times or more as compared with the rate of increase in reaction resistance in the cathode 47. This is because an oxidation reaction occurs at the anode 48, and the deterioration of the anode 48 is larger than the deterioration of the cathode 47.

[0068] Therefore, in the present embodiment, the area of the anode 48 is formed larger than the area of the cathode 47. According to such a configuration, the oxidation reaction in the anode 48 can be dispersed over a wide area of the anode 48. As a result, it is possible to suppress the deterioration of the anode 48 from being larger than that of the cathode 47, as compared with the comparative example. When it is possible to suppress the deterioration of the anode 48 from being larger than that of the cathode 47, it is possible to suppress an increase in the overvoltage and to improve the performance and the life of the electrolytic cell 11A.

[0069] According to another viewpoint, in each of the cathode catalyst layer 52 and the anode catalyst layer 54, the current is likely to flow around at an end portion of the catalyst layer, and the current density is likely to increase at the end portion of the catalyst layer. Therefore, in a case where the areas of the cathode catalyst layer and the anode catalyst layer are the same as in the comparative example, since the end portions of the catalyst layers having a high current density face each other, local deterioration is likely to increase at the end portion of each catalyst layer.

[0070] On the other hand, in the present embodiment, since the anode catalyst layer 54 is larger than the cathode catalyst layer 52, the end portions of each catalyst layer having a high current density are shifted from each other. As a result, the deterioration is unlikely to increase at the end portion of each catalyst layer. From this viewpoint as well, it is possible to suppress an increase in the overvoltage and to improve the performance and the life of the electrolytic cell 11.

[0071] As shown in FIG. 6, in the test results of the relationship between the number of cycles and the reaction resistance in the electrode in the comparative example, the rate of increase in the reaction resistance in the anode 48 is 2 times or more as compared with the rate of increase in the reaction resistance in the cathode 47. In the present embodiment, the area ratio of the anode 48 to the cathode 47 is set based on the rate of increase in reaction resistance in the anode 48 and the rate of increase in reaction resistance in the cathode 47. That is, the area ratio of the anode 48 to the cathode 47 is adjusted and determined such that a difference between the rate of increase in the reaction resistance of the anode 48 and the rate of increase in the reaction resistance of the cathode 47 is equal to or less than a predetermined standard (for example, less than 2 times, and more preferably less than 1.5 times).

[0072] In the present embodiment, the catalyst carrying amount of the anode catalyst layer 54 is 1 times or more as compared with the catalyst carrying amount of the cathode catalyst layer 52. In the present disclosure, the term of "catalyst carrying amount" means the weight of the catalyst per unit area [mg/cm^2].

(Second Embodiment)

[0073] Next, a second embodiment will be described. The second embodiment is different from the first embodiment in that the thickness of the anode catalyst layer 54 is larger than the thickness of the cathode catalyst layer 52.

[0074] Configurations other than those described below are the same as the configurations of the first embodiment.

[0075] FIG. 7 is a cross-sectional view showing an electrolytic cell 11A of a second embodiment. In the present embodiment, the area of the anode catalyst layer 54 is larger than the area of the cathode catalyst layer 52, and the thickness of the anode catalyst layer 54 is thicker than the thickness of the cathode catalyst layer 52. The catalyst carrying amount of the anode catalyst layer 54 is 1 times or more as compared with the catalyst carrying amount of the cathode catalyst layer 52.

[0076] In the present embodiment, the volume ratio (or the catalyst carrying amount ratio) of the anode catalyst layer 54 to the cathode catalyst layer 52 is set such that the rate of increase in the overvoltage of the anode 48 due to the progress of deterioration is less than 2 times (more preferably less than 1.5 times) as compared with the rate of increase in the overvoltage of the cathode 47. In other words, the volume ratio of the anode 48 to the cathode 47 is adjusted and determined such that a difference between the rate of increase in the reaction resistance of the anode 48 and the rate of increase in the reaction resistance of the cathode 47 is equal to or less than a predetermined standard (for example, less than 2 times, and more preferably less than 1.5 times).

[0077] According to such a configuration, it is possible to suppress the deterioration of the anode 48 from being larger than that of the cathode 47. Therefore, it is possible to suppress an increase in the overvoltage and to improve the performance and the life of the electrolytic cell 11B.

[0078] The embodiments of the present disclosure have been described above in detail with reference to the drawings. However, the specific configurations are not limited to the embodiments and include a design modification or the like within a scope that does not depart from the gist of the present disclosure.

<Appendix>

[0079] The electrolytic cells 11 and 11A and the electrolysis device 1 described in each embodiment are grasped as follows, for example.

(1) The electrolytic cells 11 and 11A according to a first aspect include the first separator 41, the second separator 42, the ion exchange membrane 51 configured to be disposed between the first separator 41 and the second separator 42 and an anion exchange membrane having hydroxide ion conductivity, the cathode 47 configured to be disposed between the first separator 41 and the ion exchange membrane 51, and the anode 48 configured to be disposed between the second separator 42 and the ion exchange membrane 51. In a case of being viewed in the first direction (Z direction) in which the ion exchange membrane 51, the cathode 47, and the anode 48 overlap each other, the area of the anode 48 is larger than the area of the cathode 47. According to such a configuration, it is possible to suppress the deterioration of the anode 48 from being larger than that of the cathode 47, as compared with a case where the area of the cathode 47 and the area of the anode 48 are the same. As a result, it is possible to suppress a large increase in the overvoltage at the anode 48 and to improve the performance and the life of the electrolytic cells 11 and 11A.

(2) The electrolytic cells 11 and 11A according to a second aspect are the electrolytic cells 11 and 11A according to the first aspect, in which the area of the ion exchange membrane 51 is larger than the area of the anode 48 in the case of being viewed in the first direction (Z direction). According to such a configuration, the support structure (for example, the support portion 70) that supports the ion exchange membrane 51 can be provided by using the outer peripheral portion of the ion exchange membrane 51 formed larger than the anode 48. As a result, it is possible to provide the electrolytic cells 11 and 11A that can more stably support the ion exchange membrane 51.

(3) The electrolytic cells 11 and 11A according to a third aspect are the electrolytic cells 11 and 11A according to the first aspect or the second aspect, in which the area ratio of the anode 48 to the cathode 47 in the case of being viewed in the first direction (Z direction) is more than 1.0 and 2.0 or less. According to such a configuration, it is possible to improve the performance and the life of the electrolytic cells 11 and 11A within a range in which the electrolytic cells 11 and 11A do not become excessively large. In other words, it is possible to improve the performance and the life of the electrolytic cells 11 and 11A while reducing the size of the electrolytic cells 11 and 11A.

(4) The electrolytic cell 11 according to a fourth aspect is the electrolytic cell 11 according to any one of the first to third aspects, in which the area ratio of the anode 48 to the cathode 47 in the case of being viewed in the first direction (Z direction) is set such that the rate of increase of the overvoltage of the anode 48 due to the progress of deterioration is less than 2 times as compared with the rate of increase of the overvoltage of the cathode 47. According to such a configuration, the sizes of the cathode 47 and the anode 48 can be set in an appropriate range based on the area ratio.

(5) The electrolytic cell 11A according to a fifth aspect is any one of the electrolytic cells 11 and 11A according to the first to fourth aspects, in which the cathode 47 includes the cathode catalyst layer 52 configured to overlap the ion

exchange membrane 51, and the cathode power supply body 53 configured to be disposed between the cathode catalyst layer 52 and the first separator 41, the anode 48 includes the anode catalyst layer 54 configured to overlap the ion exchange membrane 51, and the anode power supply body 55 configured to be disposed between the anode catalyst layer 54 and the second separator 42, and the catalyst carrying amount of the anode catalyst layer 54 is 1 times or more as compared with the catalyst carrying amount of the cathode catalyst layer 52. According to such a configuration, it is easy to secure the catalyst carrying amount of the anode catalyst layer 54. As a result, it is possible to further suppress the deterioration of the anode 48 from being larger than that of the cathode 47 at a higher level. As a result, it is possible to further improve the performance and the life of the electrolytic cells 11 and 11A.

(6) The electrolytic cell 11A according to a sixth aspect is the electrolytic cell 11A according to the fifth aspect, in which the volume ratio of the anode catalyst layer 54 to the cathode catalyst layer 52 is set such that the rate of increase of the overvoltage of the anode 48 due to the progress of deterioration is less than 2 times as compared with the rate of increase of the overvoltage of the cathode 47. According to such a configuration, the sizes of the cathode 47 and the anode 48 can be set in an appropriate range based on the volume ratio.

(7) The electrolytic cells 11 and 11A according to a seventh aspect include the first separator 41, the second separator 42, the ion exchange membrane 51 configured to be disposed between the first separator 41 and the second separator 42, the cathode 47 configured to be disposed between the first separator 41 and the ion exchange membrane 51, and the anode 48 configured to be disposed between the second separator 42 and the ion exchange membrane 51. The cathode 47 includes the cathode catalyst layer 52 configured to overlap the ion exchange membrane 51 and the cathode power supply body 53 configured to be disposed between the cathode catalyst layer 52 and the first separator 41, and the anode 48 includes the anode catalyst layer 54 configured to overlap the ion exchange membrane 51 and the anode power supply body 55 configured to be disposed between the anode catalyst layer 54 and the second separator 42. The volume ratio of the anode catalyst layer 54 to the cathode catalyst layer 52 is set such that the rate of increase in the overvoltage of the anode 48 due to the progress of deterioration is less than 2 times as compared with the rate of increase in the overvoltage of the cathode 47. According to such a configuration, the sizes (catalyst carrying amounts) of the cathode 47 and the anode 48 can be set in an appropriate range from the viewpoint of the volume ratio based on the degree of progress of deterioration. According to such a configuration, it is possible to suppress the deterioration of the anode 48 from being larger than that of the cathode 47, as compared with a case where the area of the cathode 47 and the area of the anode 48 are the same. As a result, it is possible to suppress a large increase in the overvoltage at the anode 48, and to improve the performance and the life of the electrolytic cells 11 and 11A.

(8) An electrolysis device 1 according to an eighth aspect includes the electrolytic cells 11 and 11A according to any one of the first to seventh aspects, the electrolyte supply unit 20 configured to supply the electrolyte to the electrolytic cells 11 and 11A, and the power supply unit 30 configured to apply the voltage to the electrolytic cells 11 and 11A. According to such a configuration, it is possible to improve the performance and the life structure of the electrolysis device 1.

(9) An electrolysis device 1 according to a ninth aspect is the electrolysis device 1 according to the eighth aspect, the device further includes the electrolytic cell stack 10 configured to have the plurality of electrolytic cells having the electrolytic cells 11 and 11A, in which two adjacent electrolytic cells among the plurality of electrolytic cells share the first separator 41 or the second separator 42 which is the bipolar plate. According to such a configuration, it is possible to improve the performance and the life structure of the electrolytic cell stack 10 of the electrolysis device 1.

Examples

[0080] In the present disclosure, in the electrolytic cell, deterioration progresses according to the time when a direct current voltage is applied, but deterioration progresses faster in the anode than in the cathode. The progress of deterioration causes an increase in resistance value and is manifested as an increase in voltage in a case where the current density is kept constant. Hereinafter, a plurality of specimens of electrolytic cells having different area ratios of the anode to the cathode were produced, and evaluation experiments were performed to examine the increase in voltage of the anode in the electrolytic cell after a predetermined time had elapsed.

[0081] First, as the electrolytic cell in the related art to be compared, a specimen A in which the area of the anode and the area of the cathode were equal was produced. Furthermore, as the electrolytic cell of the present disclosure, specimens B, C, and D in which the area of the anode 48 was larger than the area of the cathode 47 were produced. The dimensions of the anode and the cathode and the area ratio of the anode to the cathode in the specimens A, B, C, and D are as follows.

[0082] The dimensions of the anode and the cathode in the specimen A are both 45 mm in height × 45 mm in width, and thus the area ratio of the anode to the cathode in the specimen A is 1. On the other hand, all the specimens B, C, and D have the same size, the dimensions of the anode are 50 mm in height × 50 mm in width, the dimensions of the cathode are 41 mm in height × 41 mm in width, and thus the area ratio of the anode to the cathode of the specimens B, C, and D is 1.5. The catalyst carrying amount ratio is also 1.5.

[0083] In the electrolysis device 1 of the first embodiment, the specimens A, B, C, and D were individually installed at the positions of the electrolytic cell 11, and the energization test was performed four times. In each energization test, the power supply unit 30 was driven, a direct current voltage was applied between the anode 48 and the cathode 47 of the electrolytic cell 11 such that the current density was constant (2 amperes/cm^2), and the increases in voltage of the anode 48 in a period from 100 hours after the start of the voltage application to 400 hours after the start of the voltage application were examined.

[0084] FIG. 8 shows evaluation values of the increase in voltage of the anode 48 in the specimens B, C, and D after the above test period has elapsed. In a case where the increase in voltage (the difference in voltage value) of the specimen A to be compared was set to 100, the increase in voltage of the specimen B with respect to the increase in voltage of the specimen A was 63, the increase in voltage of the specimen C with respect to the increase in voltage of the specimen A was 88, and the increase in voltage of the specimen D with respect to the increase in voltage of the specimen A was 25.

[0085] It is found that, in all the specimens B, C, and D in which the dimensions of the anode were larger than the dimensions of the cathode and the area of the anode was larger than the area of the cathode, the values of the increase in voltage are all smaller than that of the specimen A, as compared with the specimen A in which the dimensions of the anode and cathode are the same and the area ratio of the anode to the cathode is 1. As a result, it was found that the deterioration of the specimens B, C, and D of the electrolytic cells of the present disclosure in which the area of the anode was larger than the area of the cathode was unlikely to progress than the specimen A of the electrolytic cell in the related art in which the areas of the anode and the cathode were the same. That is, when the electrolytic cell according to the present disclosure is adopted, since the deterioration of the anode is suppressed, improvement in the performance of the electrolysis device and the long life of the device including the electrolytic cell can be expected.

INDUSTRIAL APPLICABILITY

[0086] The present disclosure relates to an electrolytic cell and an electrolysis device in which the progress of deterioration is slow and a performance deterioration is unlikely to occur.

REFERENCE SIGNS LIST

[0087]

1 Electrolysis device
10 Electrolytic cell stack
11, 11A Electrolytic cell
20 Electrolyte supply unit
30 Power supply unit
40 Electrolyzer
41 First separator
42 Second separator
43 Membrane electrode assembly
47 Cathode
48 Anode
51 Ion exchange membrane
52 Cathode catalyst layer
53 Cathode power supply body
54 Anode catalyst layer
55 Anode power supply body

Claims

1. An electrolytic cell comprising:

a first separator;
a second separator;
an ion exchange membrane configured to be disposed between the first separator and the second separator, and an anion exchange membrane with hydroxide ion conductivity;
a cathode configured to be disposed between the first separator and the ion exchange membrane; and
an anode configured to be disposed between the second separator and the ion exchange membrane,

wherein in a case of being viewed in a first direction in which the ion exchange membrane, the cathode, and the anode overlap each other, an area of the anode is larger than an area of the cathode.

2. The electrolytic cell according to Claim1, wherein in the case of being viewed in the first direction, an area of the ion exchange membrane is larger than the area of the anode.

3. The electrolytic cell according to Claim 1, wherein an area ratio of the anode to the cathode in the case of being viewed in the first direction is more than 1.0 and 2.0 or less.

4. The electrolytic cell according to Claim 1, wherein an area ratio of the anode to the cathode in the case of being viewed in the first direction is set such that a rate of increase of an overvoltage of the anode due to progress of deterioration is less than 2 times as compared with a rate of increase of an overvoltage of the cathode.

5. The electrolytic cell according to Claim 1,

wherein the cathode includes a cathode catalyst layer configured to overlap the ion exchange membrane and a cathode power supply body configured to be disposed between the cathode catalyst layer and the first separator,
the anode includes an anode catalyst layer configured to overlap the ion exchange membrane and an anode power supply body configured to be disposed between the anode catalyst layer and the second separator, and
a catalyst carrying amount of the anode catalyst layer is 1 time or more as compared with a catalyst carrying amount of the cathode catalyst layer.

6. The electrolytic cell according to Claim 5, wherein a volume ratio of the anode catalyst layer to the cathode catalyst layer is set such that a rate of increase of an overvoltage of the anode due to progress of deterioration is less than 2 times as compared with a rate of increase of an overvoltage of the cathode.

7. An electrolytic cell comprising:

a first separator;
a second separator;
an ion exchange membrane configured to be disposed between the first separator and the second separator;
a cathode configured to be disposed between the first separator and the ion exchange membrane; and
an anode configured to be disposed between the second separator and the ion exchange membrane,
wherein the cathode includes a cathode catalyst layer configured to overlap the ion exchange membrane and a cathode power supply body configured to be disposed between the cathode catalyst layer and the first separator,
the anode includes an anode catalyst layer configured to overlap the ion exchange membrane and an anode power supply body configured to be disposed between the anode catalyst layer and the second separator, and
a volume ratio of the anode catalyst layer to the cathode catalyst layer is set such that a rate of increase of an overvoltage of the anode due to progress of deterioration is less than 2 times as compared with a rate of increase of an overvoltage of the cathode.

8. An electrolysis device comprising:

the electrolytic cell according to any one of Claims 1 to 7;
an electrolyte supply unit configured to supply an electrolyte to the electrolytic cell; and
a power supply unit configured to apply a voltage to the electrolytic cell.

9. The electrolysis device according to Claim 8, further comprising:

an electrolytic cell stack that has a plurality of electrolytic cells having the electrolytic cell,
wherein two adjacent electrolytic cells among the plurality of electrolytic cells share the first separator or the second separator, which is a bipolar plate.

FIG. 1

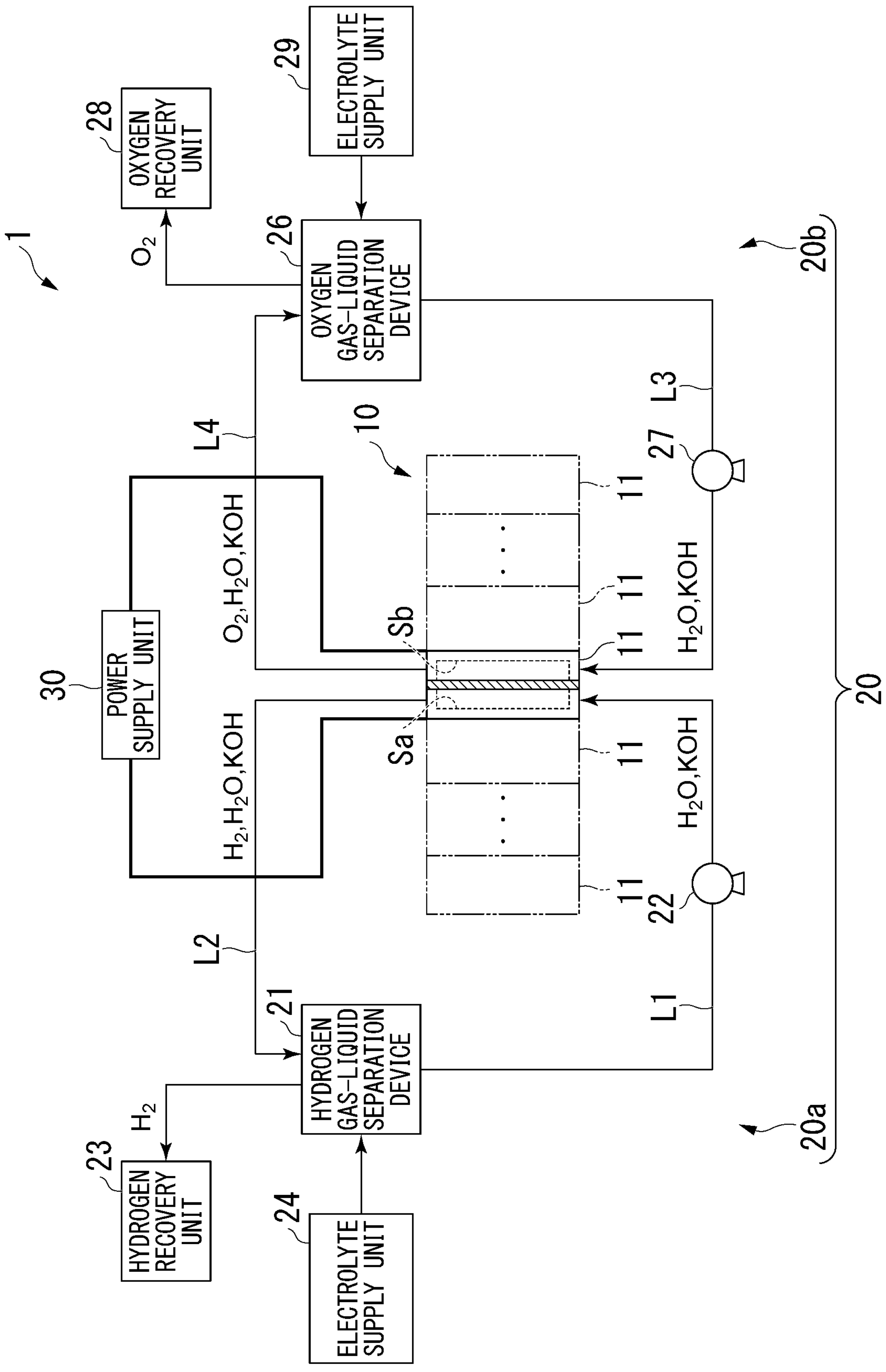

1
10
11
20
20a
20b
21
HYDROGEN GAS-LIQUID SEPARATION DEVICE
22
23
HYDROGEN RECOVERY UNIT
24
ELECTROLYTE SUPPLY UNIT
26
OXYGEN GAS-LIQUID SEPARATION DEVICE
27
28
OXYGEN RECOVERY UNIT
29
ELECTROLYTE SUPPLY UNIT
30
POWER SUPPLY UNIT
L1
L2
L3
L4
Sa
Sb
H_2
O_2
H_2,H_2O,KOH
O_2,H_2O,KOH
H_2O,KOH
H_2O,KOH

FIG. 2

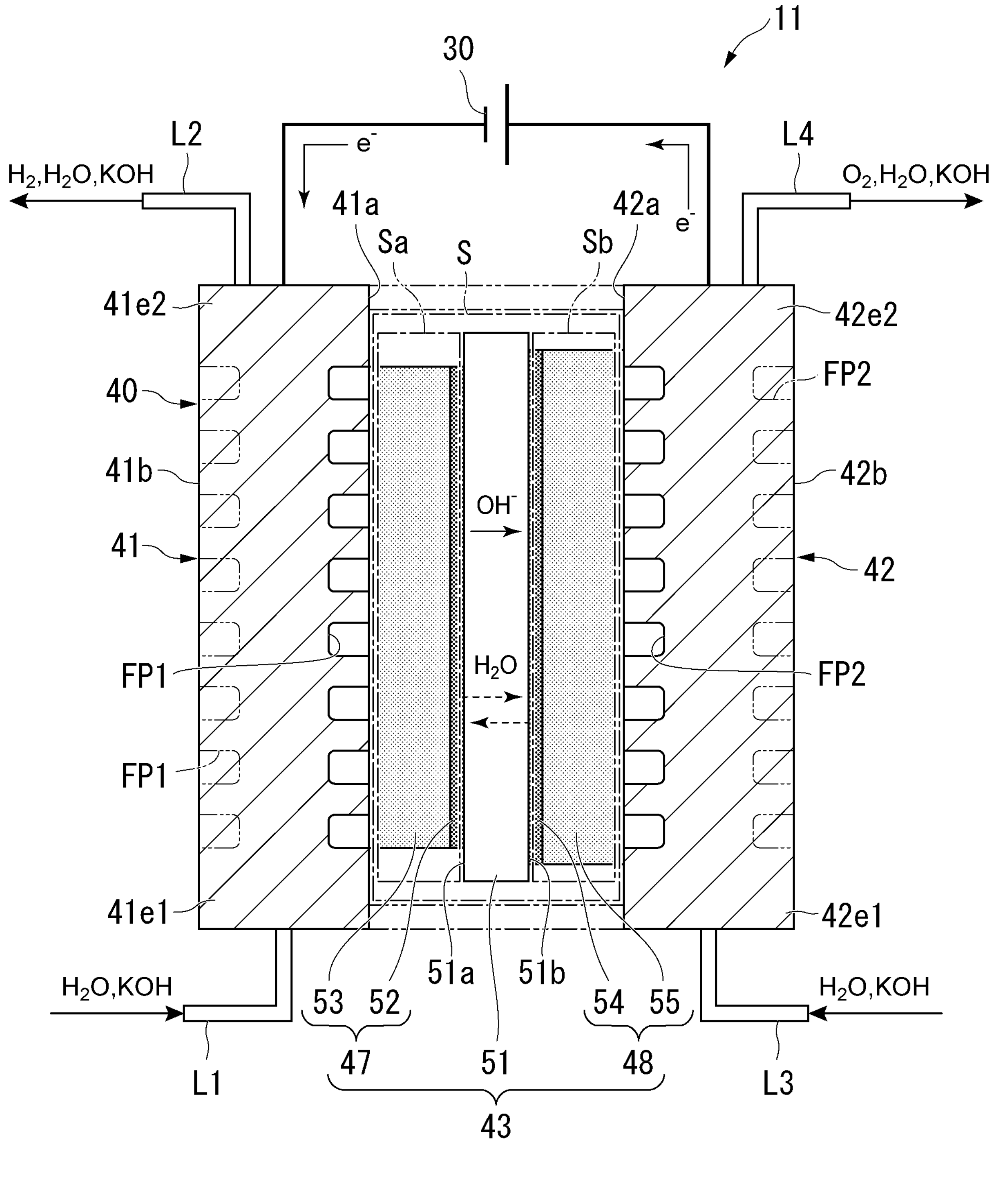

11
30
L2
L4
H_2,H_2O,KOH
O_2,H_2O,KOH
e-
e-
41a
42a
Sa
S
Sb
41e2
42e2
40
FP2
41b
42b
OH-
41
42
FP1
H2O
FP2
FP1
41e1
42e1
51a
51b
H2O,KOH
H2O,KOH
53
52
54
55
L1
47
51
48
L3
43

FIG. 3

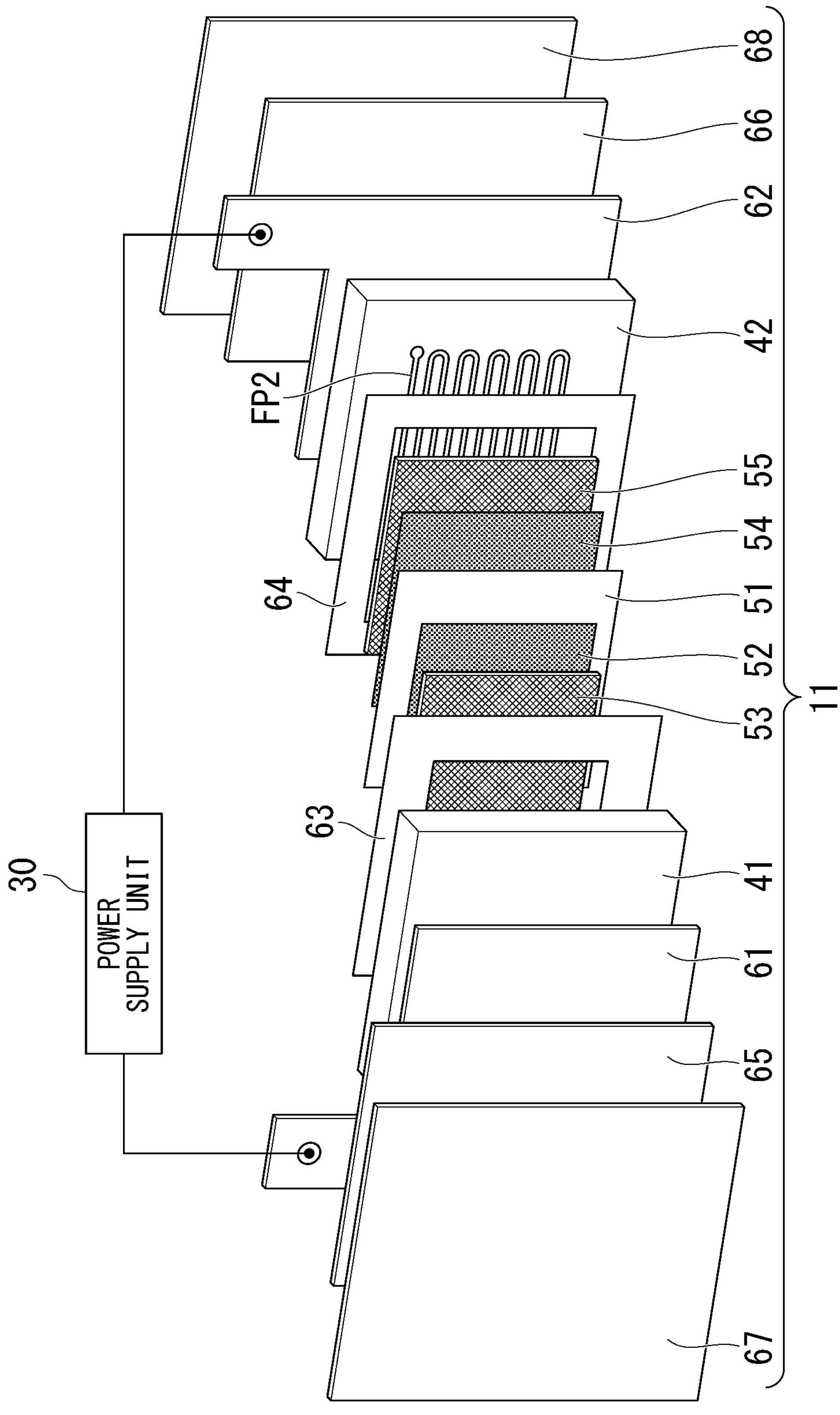

POWER SUPPLY UNIT
30
68
66
62
42
FP2
55
54
64
51
52
53
11
63
41
61
65
67

FIG. 4

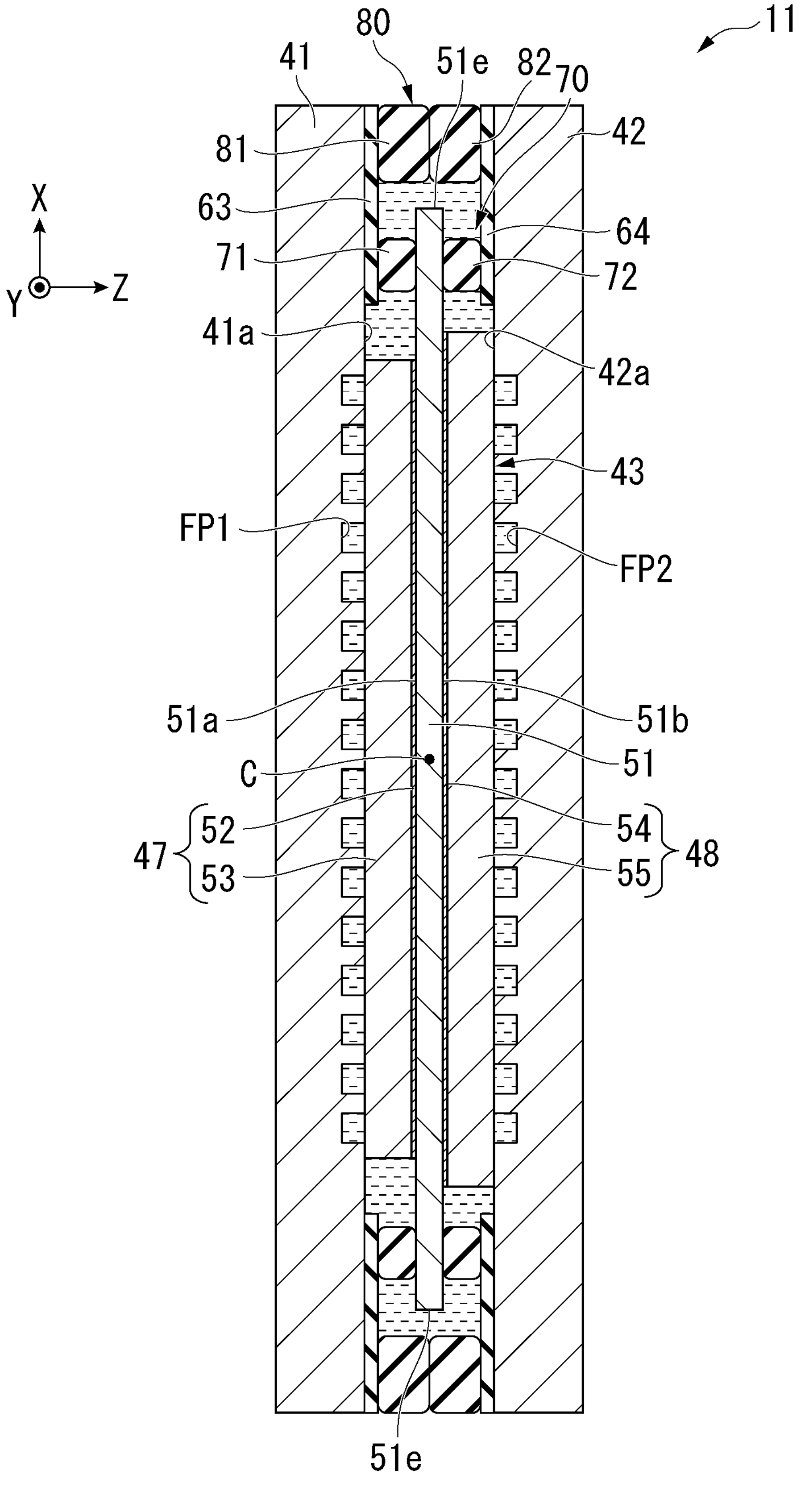

80
41
51e
82
70
11
42
81
63
64
X
71
72
Y
Z
41a
42a
43
FP1
FP2
51a
51b
51
C
52
54
47
48
53
55
51e

FIG. 5

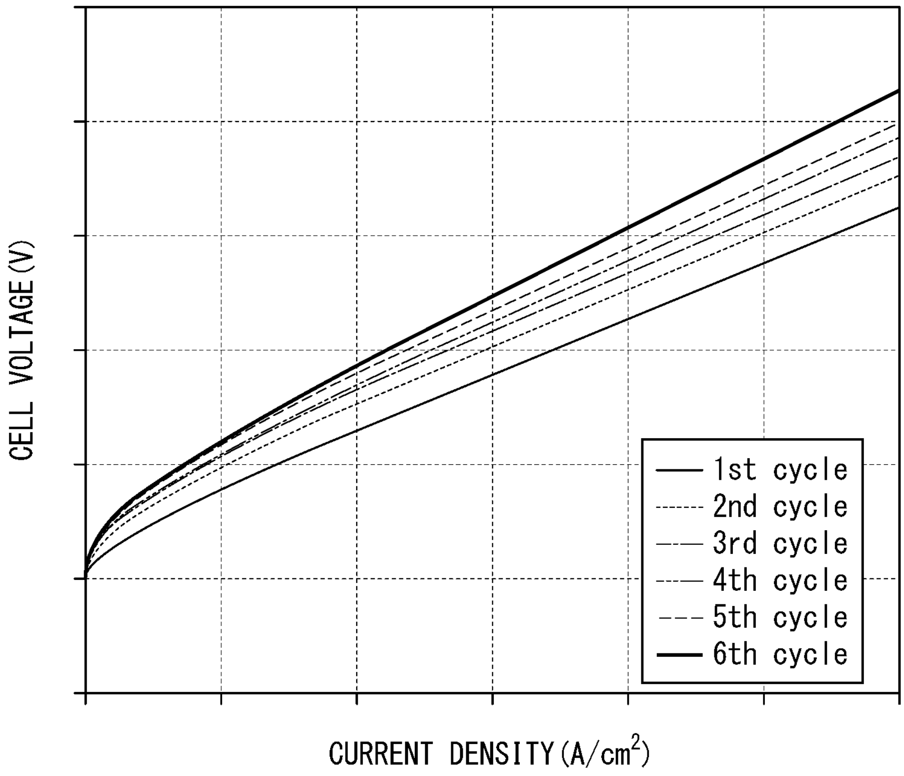

CELL VOLTAGE (V)
CURRENT DENSITY (A/cm2)
1st cycle
2nd cycle
3rd cycle
4th cycle
5th cycle
6th cycle

FIG. 6

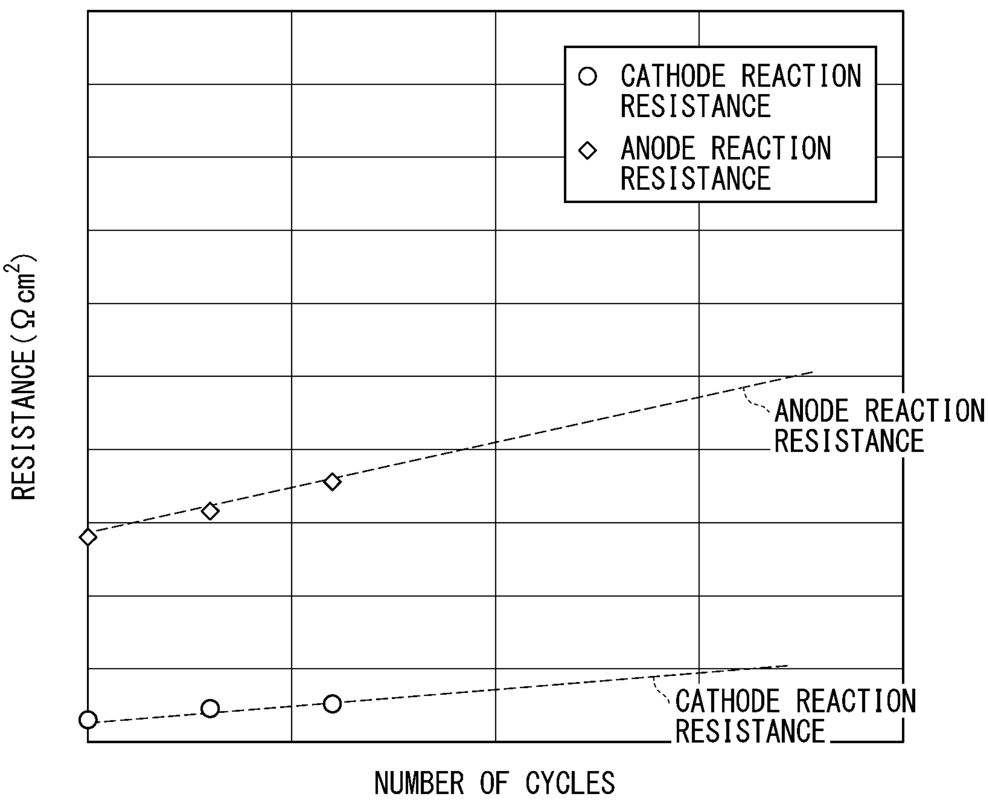
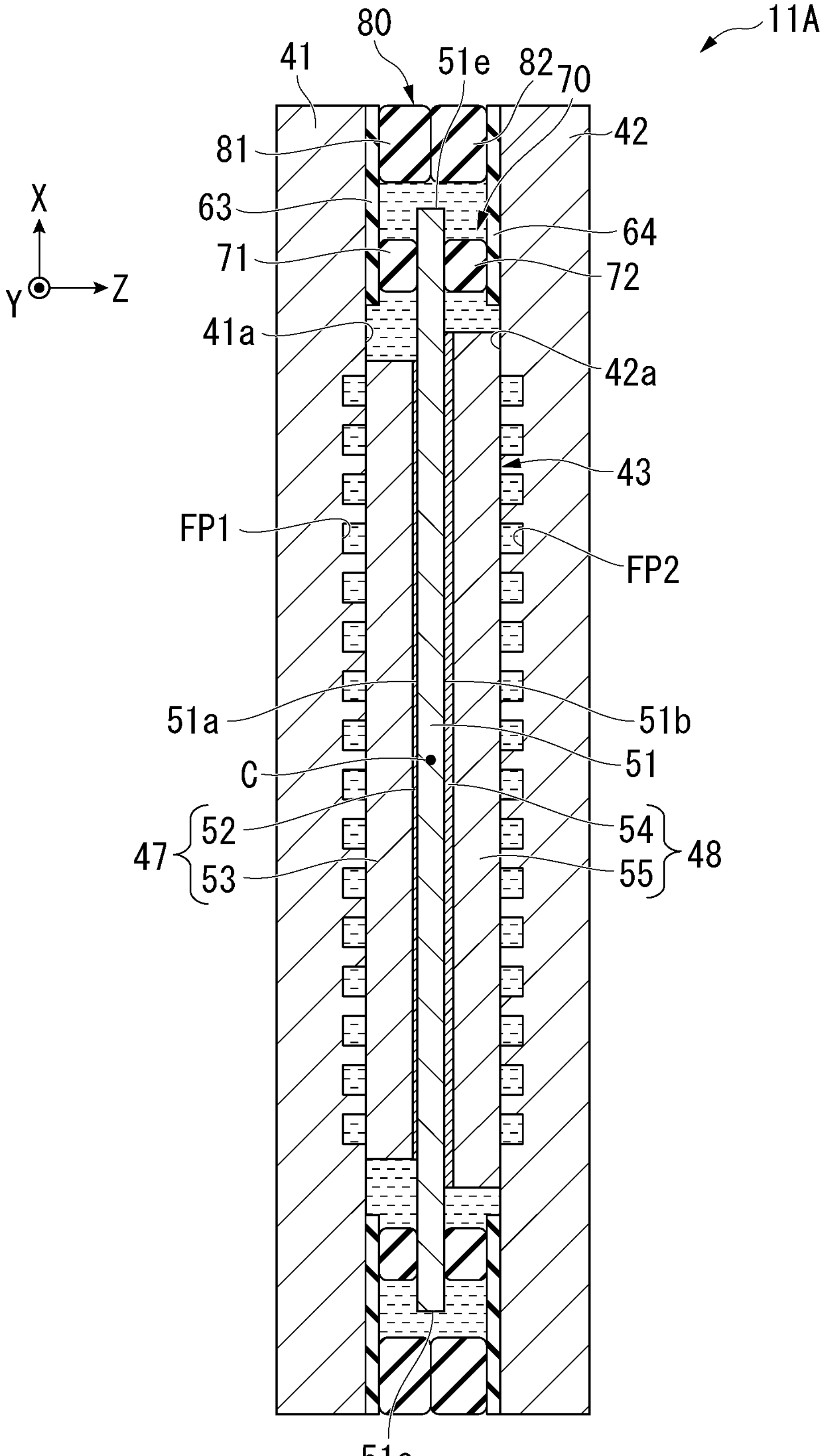

RESISTANCE (Ωcm2)
NUMBER OF CYCLES
CATHODE REACTION RESISTANCE
ANODE REACTION RESISTANCE
ANODE REACTION RESISTANCE
CATHODE REACTION RESISTANCE

FIG. 7



11A
80
41
51e
82
70
42
81
63
64
71
72
41a
42a
43
FP1
FP2
51a
51b
51
C
52
54
47
48
53
55
51e
X
Y
Z

FIG. 8

	SPECIMEN	INCREASE IN VOLTAGE DURING EVALUATION PERIOD
1	A	100
2	B	63
3	C	88
4	D	25

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2023/020234

A. CLASSIFICATION OF SUBJECT MATTER

C25B 9/23(2021.01)i; ***C25B 1/04***(2021.01)i; ***C25B 9/00***(2021.01)i; ***C25B 9/60***(2021.01)i; ***C25B 9/65***(2021.01)i; ***C25B 9/75***(2021.01)i; ***C25B 9/77***(2021.01)i
FI: C25B9/23; C25B9/00 A; C25B1/04; C25B9/60; C25B9/65; C25B9/75; C25B9/77

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)

C25B9/23; C25B1/04; C25B9/00; C25B9/60; C25B9/65; C25B9/75; C25B9/77

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

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2023
Registered utility model specifications of Japan 1996-2023
Published registered utility model applications of Japan 1994-2023

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 2012-117140 A (TAKASAGO THERMAL ENG. CO., LTD.) 21 June 2012 (2012-06-21) claims, paragraphs [0022], [0034], [0048], [0065], fig. 1, 2	1-9
Y	JP 2022-029892 A (HONDA MOTOR CO., LTD.) 18 February 2022 (2022-02-18) paragraphs [0001], [0018]	1-9
Y	JP 2021-195596 A (ASAHI KASEI CORP.) 27 December 2021 (2021-12-27) paragraphs [0024], [0074]	1-9
Y	WO 2017/069083 A1 (MITSUBISHI HEAVY INDUSTRIES ENVIRONMENTAL & CHEMICAL ENGINEERING CO., LTD.) 27 April 2017 (2017-04-27) paragraphs [0001]-[0003]	1-9
Y	WO 2019/111832 A1 (TOKUYAMA CORP.) 13 June 2019 (2019-06-13) paragraphs [0031], [0032], [0042], [0048], fig. 3, 6	1-9

☑ 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
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"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	Date of mailing of the international search report
10 August 2023	**22 August 2023**

Name and mailing address of the ISA/JP	Authorized officer
Japan Patent Office (ISA/JP) **3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915** **Japan**	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2023/020234

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y		5-9
A		1-4

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2023/020234

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 2012-117140 A	21 June 2012	(Family: none)	
JP 2022-029892 A	18 February 2022	US 2022/0042192 A1 paragraphs [0002], [0019] CN 114059092 A	
JP 2021-195596 A	27 December 2021	(Family: none)	
WO 2017/069083 A1	27 April 2017	US 2018/0305828 A1 paragraphs [0003]-[0005] EP 3348672 A1 CN 108138341 A	
WO 2019/111832 A1	13 June 2019	US 2020/0340130 A1 paragraphs [0104], [0105], [0117], [0123], fig. 3, 6 EP 3722463 A1 CN 111433391 A KR 10-2020-0095533 A	
JP 2018-076576 A	17 May 2018	(Family: none)	

Form PCT/ISA/210 (patent family annex) (January 2015)

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