Claims

[Claim 1]

A water treatment apparatus including a plurality of electric deionized water production apparatuses, wherein

two or more of the electric deionized water production apparatuses are provided,

each electric deionized water production apparatus has a demineralization chamber between a positive electrode and a negative electrode, wherein the demineralization chamber is defined by an anion exchange membrane that is positioned on a side of the positive electrode and a cation exchange membrane that is positioned on a side of the negative electrode and that is filled with ion exchangers,

the demineralization chambers of the plurality of electric deionized water production apparatuses communicate in series,

the plurality of demineralization chambers which communicate in series allows water to be treated that includes boron to flow therethrough and allows treated water to flow out therefrom,

a farthest upstream part of a first stage demineralization chamber into which the water to be treated flows first and a farthest downstream part of a final stage demineralization chamber from which the treated water flows out are only filled with anion exchangers,

a portion which is a part of the plurality of demineralization chambers and which is located between the farthest upstream part of the first stage demineralization chamber and the farthest downstream part of the final stage demineralization chamber is filled with at least cation exchangers,

wherein a ratio of a volume of anion exchangers that fill the farthest upstream part of the first stage demineralization chamber alone to a volume of the first stage demineralization chamber, and a ratio of a volume of anion exchangers that fill the farthest downstream part of the final stage demineralization chamber alone to a volume of the final stage demineralization chamber are 10% or larger,

wherein at least one of the plurality of demineralization chambers has an intermediate ion exchange membrane that is positioned between the anion exchange membrane and the cation exchange membrane, a first small demineralization chamber that is defined by the anion exchange membrane and the intermediate ion exchange membrane, a second small demineralization chamber that is defined by the cation exchange membrane and the

intermediate ion exchange membrane, and the first small demineralization chamber and the second small demineralization chamber communicate in series,

wherein each of the first stage demineralization chamber and the final stage demineralization chamber has the intermediate ion exchange membrane, the first small demineralization chamber and the second small demineralization chamber, and

in the first stage demineralization chamber and the final stage demineralization chamber, the first small demineralization chambers are positioned upstream of the second small demineralization chambers, the first small demineralization chambers are filled with anion exchangers in a single bed form, the farthest upstream parts of the second small demineralization chambers are only filled with cation exchangers, and areas of the second small demineralization chambers other than the farthest upstream parts are filled with anion exchangers.

[Claim 2]

The water treatment apparatus of claim 1, wherein

the first stage demineralization chamber or the final stage demineralization chamber is filled with anion exchangers in a single bed form.

[Claim 3]

A water treatment apparatus including a plurality of electric deionized water production apparatuses, wherein

two or more of the electric deionized water production apparatuses are provided,

each electric deionized water production apparatus has a demineralization chamber between a positive electrode and a negative electrode, wherein the demineralization chamber is defined by an anion exchange membrane that is positioned on a side of the positive electrode and a cation exchange membrane that is positioned on a side of the negative electrode and that is filled with ion exchangers,

the demineralization chambers of the plurality of electric deionized water production apparatuses communicate in series,

the plurality of demineralization chambers which communicate in series allows water to be treated that includes boron to flow therethrough and allows treated water to flow out therefrom,

a farthest upstream part of a first stage demineralization chamber into which the water to be treated flows first and a farthest downstream part of a final stage demineralization chamber from which the treated water flows out are only filled with anion exchangers,

a portion which is a part of the plurality of demineralization chambers and which is located between the farthest upstream part of the first stage demineralization chamber and the farthest downstream part of the final stage demineralization chamber is filled with at least cation exchangers,

wherein a ratio of a volume of anion exchangers that fill the farthest upstream part of the first stage demineralization chamber alone to a volume of the first stage demineralization chamber, and a ratio of a volume of anion exchangers that fill the farthest downstream part of the final stage demineralization chamber alone to a volume of the final stage demineralization chamber are 10% or larger,

wherein at least one of the plurality of demineralization chambers has an intermediate ion exchange membrane that is positioned between the anion exchange membrane and the cation exchange membrane, a first small demineralization chamber that is defined by the anion exchange membrane and the intermediate ion exchange membrane, a second small demineralization chamber that is defined by the cation exchange membrane and the intermediate ion exchange membrane, and the first small demineralization chamber and the second small demineralization chamber communicate in series,

wherein each of the first stage demineralization chamber and the final stage demineralization chamber has the intermediate ion exchange membrane, the first small demineralization chamber and the second small demineralization chamber,

in the first stage demineralization chamber, the first small demineralization chamber is positioned upstream of the second small demineralization chamber, the first small demineralization chamber is filled with anion exchangers in a single bed form, the farthest upstream part of the second small demineralization chamber is only filled with cation exchangers, and an area of the second small demineralization chamber other than the farthest upstream part is only filled with anion exchangers, and

in the final demineralization chamber, the first small demineralization chamber is positioned downstream of the second small demineralization chamber, the first small

demineralization chamber is filled with anion exchangers in a single bed form, and the second small demineralization chamber is filled with cation exchangers in a single bed form.

[Claim 4]

The water treatment apparatus according to any one of claims 1 to 3, wherein a reverse osmosis membrane device is provided upstream of the first stage demineralization chamber.

[Claim 5]

The water treatment apparatus according to any one of claims 1 to 4, wherein a decarboxylation membrane device is provided upstream of the first stage demineralization chamber.

[Claim 6]

A water treatment method using a water treatment apparatus including a plurality of electric deionized water production apparatuses each having a demineralization chamber between a positive electrode and a negative electrode, wherein the demineralization chamber is defined by an anion exchange membrane that is positioned on a side of the positive electrode and a cation exchange membrane that is positioned on a side of the negative electrode and that is filled with ion exchangers, wherein the demineralization chambers of the plurality of electric deionized water production apparatuses communicate in series, the plurality of demineralization chambers which communicate in series allows water to be treated that includes boron to flow therethrough and allows treated water to flow out therefrom, a farthest upstream part of a first stage demineralization chamber into which the water to be treated flows first and a farthest downstream part of a final stage demineralization chamber from which the treated water flows out are only filled with anion exchangers, and a portion which is a part of the plurality of demineralization chambers and which is located between the farthest upstream part of the first stage demineralization chamber and the farthest downstream part of the final stage demineralization chamber is filled with at least cation exchangers,

wherein the water to be treated flows through the plurality of demineralization chambers which communicate in series when a DC voltage is applied between the positive electrode and the negative electrode, whereby the water to be treated is treated and flows out,

wherein a ratio of a volume of anion exchangers that fill the farthest upstream part of the first stage demineralization chamber alone to a volume of the first stage demineralization chamber, and a ratio of a volume of anion exchangers that fill the farthest downstream part of the final stage demineralization chamber alone to a volume of the final stage demineralization chamber are 10% or larger,

wherein at least one of the plurality of demineralization chambers has an intermediate ion exchange membrane that is positioned between the anion exchange membrane and the cation exchange membrane, a first small demineralization chamber that is defined by the anion exchange membrane and the intermediate ion exchange membrane, a second small demineralization chamber that is defined by the cation exchange membrane and the intermediate ion exchange membrane, and the first small demineralization chamber and the second small demineralization chamber communicate in series,

wherein each of the first stage demineralization chamber and the final stage demineralization chamber has the intermediate ion exchange membrane, the first small demineralization chamber and the second small demineralization chamber, and

in the first stage demineralization chamber and the final stage demineralization chamber, the first small demineralization chambers are positioned upstream of the second small demineralization chambers, the first small demineralization chambers are filled with anion exchangers in a single bed form, the farthest upstream parts of the second small demineralization chambers are only filled with cation exchangers, and areas of the second small demineralization chambers other than the farthest upstream parts are filled with anion exchangers;

wherein two or more of the electric deionized water production apparatuses are provided.

[Claim 7]

The water treatment method according to claim 6, wherein

a silica concentration in water to be treated that flows into the first stage electric deionized water production apparatus is 100μg SiO_2/L or less.

[Claim 8]

The water treatment method according to claim 6 or 7, wherein

a boron concentration in water to be treated that flows into the first stage electric deionized water production apparatus is 100μg B/L or less.

[Claim 9]

The water treatment method according to any one of claims 6 to 8, wherein

a carbonic acid concentration in water to be treated that flows into the first stage electric deionized water production apparatus is 5mg CO_2/L or less.