

LIQUID TREATMENT APPARATUS

BACKGROUND

5 1. Technical Field

[0001] The present disclosure relates to a liquid treatment apparatus which electrochemically treats a liquid, and an apparatus which is capable of growing a plant with sterilized water by supplying the treated liquid.

10 2. Description of the Related Art

[0002] Fig. 15 illustrates an example of a conventional liquid treatment apparatus. A liquid treatment apparatus in which first electrode 801 and second electrode 802 are disposed in liquid 803 (for example, water), a high voltage pulse is applied between first electrode 801 and second electrode 802
15 from pulse power source 804 such that liquid 803 is vaporized, plasma 805 is generated, a plasma treatment is performed on liquid 803, and the liquid is sterilized with a component having oxidizing power such as hydroxyl radical (OH radical) or hydrogen peroxide. In particular, it is known that OH radicals have high oxidizing power, and these components are said to have a high
20 sterilization action, for example, against bacteria. In addition, it is known that when plasma 805 is generated in liquid 803, plasma 805 is covered with liquid 803, and a liquid-derived component is likely to be generated. For example, it is known that OH radicals or hydrogen peroxide is likely to be generated by generating plasma 805 in water.

25 **[0003]** However, in a case of the conventional liquid treatment apparatus, not only a high applied voltage is required for vaporizing liquid 803, but also the generation efficiency of plasma 805 is low, and it takes a long time to

sterilize liquid 803, which were problems.

5 [0004] Therefore, in order to improve the generation efficiency of the plasma while lowering the applied voltage, a liquid treatment apparatus in which a gas introduced from the outside is interposed between both electrodes is known (refer to Japanese Patent No. 4041224). In the liquid treatment apparatus (Fig. 16) disclosed in Japanese Patent No. 4041224, a pulse voltage is applied between anode electrode 901 and cathode electrode 902 while interposing target treatment liquid 903 and gas 904 (for example, oxygen) between anode electrode 901 and cathode electrode 902. The plasma is generated in gas 904 by applying the pulse voltage, and a plasma treatment is performed on liquid 803 to sterilize the liquid. According to the liquid treatment apparatus disclosed in Japanese Patent No. 4041224, it is possible to decrease the applied voltage as compared with the case where the gas is not interposed, and to efficiently generate plasma to sterilize target treatment liquid 903.

[0005] If a treatment liquid treated with such a liquid treatment apparatus is supplied to a tank or the like containing a culture liquid for plant cultivation, an apparatus which is capable of growing a plant with sterilized water can be considered.

20 SUMMARY

[0006] According to an aspect of the present disclosure, there is provided a liquid treatment apparatus including a treatment tank which generates a gas phase in the vicinity of a rotating center of a rotating flow of a liquid by generating the rotating flow by rotating the liquid introduced from an introduction portion around a central axis, and includes a discharging portion for discharging the liquid introduced from the introduction portion as a treatment liquid, after rotating the liquid between the introduction portion and

the discharging portion to generate the rotating flow; a first electrode in which at least a portion is disposed in the treatment tank so as to be in contact with the liquid in the treatment tank; a second electrode which is disposed so as to be in contact with the liquid in the treatment tank; a power source which
5 applies a voltage between the first electrode and the second electrode, generates a plasma in the gas phase, sterilizes the liquid so as to form the treatment liquid, and generates a modifying component in the treatment liquid; a microbubble generator which includes a microbubble generating chamber having a longitudinal sectional area larger than an opening of the
10 discharging portion of the treatment tank, generates microbubbles or nanobubbles by discharging the treatment liquid from the discharging portion of the treatment tank in the microbubble generating chamber, and diffuses the generated microbubbles or nanobubbles in the treatment liquid; a target treatment tank which holds a culture liquid for plant cultivation, sterilizes the
15 culture liquid with the treatment liquid supplied from the microbubble generator, and discharges sterilized target treatment water to the treatment tank as at least a portion of the liquid; a liquid supplier which is capable of circulating the liquid introduced in the treatment tank from the introduction portion of the treatment tank via the microbubble generator, between the
20 treatment tank and the target treatment tank, in which the plasma is generated in the gas phase of the rotating flow formed between the introduction portion and the discharging portion with the liquid, the liquid is sterilized, the modifying component is generated, the generated modifying component is dissolved in the treatment liquid to be dispersed in the treatment liquid, the
25 treatment liquid is introduced to the target treatment tank via the microbubble generator, and the target treatment water discharged after the discharged culture liquid is sterilized is introduced to the treatment tank as at least a

portion of the liquid by the liquid supplier.

[0007] In the liquid treatment apparatus according to the aspect of the disclosure, the liquid is vaporized in the rotating flow, the pulse voltage is applied to the generated gas phase to generate plasma, so that the liquid can be
5 sterilized, and the treatment liquid containing the modifying component having a sterilization action can be generated. Since it is unnecessary to vaporize the liquid by application of voltage, it is possible to efficiently generate the plasma with low electric power, efficiently and quickly sterilize the liquid and the target treatment water, and shorten the treatment time, thereby increasing
10 sterilization capacity. In addition, since the sterilization treatment of the liquid and the target treatment water is performed without introducing air from the outside, the discharging of electricity is stabilized and generation of nitrous acid, which is a harmful substance, can be suppressed.

15 BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. 1 is a side sectional view illustrating a configuration of a liquid treater of a liquid treatment apparatus according to an Embodiment 1 of the disclosure;

FIG. 2 is a side sectional view of an apparatus main body;

20 FIG. 3 is a diagram seen from a cross-section taken along line in 3-3 of FIG. 2;

FIG. 4 is a side sectional view illustrating a state where a rotating flow is generated in a treatment tank, and a voltage is not applied;

FIG. 5 is a diagram seen from a cross-section taken along line in 5-5 of
25 FIG. 4;

FIG. 6A is a side sectional view illustrating a state where a rotating flow is generated in a treatment tank, and a voltage is applied;

FIG. 6B is a partially enlarged view of a state in which plasma is generated in a gas phase of FIG. 6A;

FIG. 6C is a side sectional view of a state where microbubbles are generated in a microbubble generator of the liquid treatment apparatus;

5 FIG. 6D is a diagram illustrating an entire configuration of the liquid treatment apparatus;

FIG. 6E is a diagram illustrating an entire configuration of a liquid treatment apparatus according to Embodiment 2 of the disclosure;

10 FIG. 6F is a diagram illustrating an entire configuration of a liquid treatment apparatus according to Embodiment 3 of the disclosure;

FIG. 6G is a diagram illustrating an entire configuration of a liquid treatment apparatus according to Embodiment 4 of the disclosure;

FIG. 7 is a side sectional view illustrating a modification example of the apparatus main body;

15 FIG. 8 is a side sectional view illustrating the modification example of the apparatus main body;

FIG. 9A is a side sectional view illustrating the modification example of the apparatus main body;

20 FIG. 9B is a side sectional view illustrating the modification example of the apparatus main body which is different from FIG. 9A;

FIG. 10 is a side sectional view illustrating the modification example of the apparatus main body;

FIG. 11 is a side sectional view illustrating the modification example of the apparatus main body;

25 FIG. 12 is a side sectional view illustrating the modification example of the apparatus main body;

FIG. 13 is a side sectional view illustrating the modification example of

the apparatus main body;

FIG. 14A is a side sectional view illustrating the modification example of the apparatus main body;

FIG. 14B is a side sectional view in which a copper material is disposed
5 in a part of the microbubble generator in the modification example of the apparatus main body;

FIG. 15 is a schematic configuration diagram of a conventional liquid treatment apparatus; and

FIG. 16 is a schematic configuration diagram of a conventional liquid
10 treatment apparatus including a gas introduction device.

DETAILED DESCRIPTIONS

[0009] Prior to detailed description, problems in the related art will be briefly described.

15 **[0010]** In the conventional liquid treatment apparatus, the generation efficiency of the plasma is low, it takes a long time to treat the liquid, purification capacity, in other words, sterilization capacity is weakened, and the discharging of electricity is not stabilized due to the introduction of air.

[0011] The disclosure has been made in view of the above circumstances,
20 and an object of the disclosure is to provide a liquid treatment apparatus that efficiently generates plasma to quickly sterilize the liquid, and shortens the treatment time of the liquid, and thereby the sterilization capacity is improved, and the discharging of electricity is not stabilized with no air introduction required.

25 Embodiment 1

[0012] Liquid treatment apparatus 101 including liquid treater 100 according to the embodiment of the disclosure will be specifically described with

reference to the drawings.

In the drawings, the same or corresponding parts are denoted by the same reference numerals, and description thereof will not be repeated. For ease of explanation, in the drawings referred to below, the configuration is simplified or schematically shown, and some constituent members are omitted. In addition, the dimensional ratio between the constituent members shown in each drawing does not necessarily indicate the actual size ratio.

Entire configuration

[0013] Liquid treatment apparatus 101 is provided with liquid treater 100 including at least microbubble generator 90, and target treatment tank 41 which holds culture liquid for plant cultivation 42 (refer to FIG. 6D). Liquid treater 100 functions as a device for performing a sterilization treatment and generating treatment liquid L2 used in the sterilization treatment in target treatment tank 41.

[0014] First, an entire configuration of liquid treater 100 of liquid treatment apparatus 101 according to Embodiment 1 will be described. FIG. 1 is a side sectional view illustrating a configuration of liquid treater 100 according to Embodiment 1 of the disclosure. In the following drawings, arrow F indicates a forward direction of liquid treater 100, and arrow B indicates a backward direction. Arrow U indicates an upward direction, and arrow D indicates a downward direction. Arrow R is a right direction when seen from the backward direction, and arrow L indicates a left direction when seen from the backward direction.

[0015] Liquid treater 100 sterilizes a liquid and generates a modifying component by discharging electricity in the liquid, and thereby a treatment liquid is generated by dispersing the generated modifying component in the liquid. In Embodiment 1, a case where the target sterilization treatment of

target treatment water L1, described below as an example of the liquid, discharged from target treatment tank 41 is performed, and target treatment water L1 is modified so as to be used for the sterilization treatment in target treatment tank 41, and thereby treatment liquid L2 containing the modifying component such as OH radicals or hydrogen peroxide as a modifying component is generated will be described. Here, target treatment water L1 is a liquid discharged from target treatment tank 41 by sterilizing culture liquid 42 held by target treatment tank 41 described below with treatment liquid L2, and a liquid containing culture liquid 42, treatment liquid L2, and the like, which is a liquid introduced to treatment tank 12 by liquid supplier 50 through circulation pipe 81 and pipe 51.

[0016] Liquid treater 100 is provided with at least treatment tank 12, first electrode 30, second electrode 31, and power source 60. More specifically, liquid treater 100 is provided with apparatus main body 10, liquid supplier 50, microbubble generator 90, and power source 60. Apparatus main body 10 is provided with treatment tank 12, introduction portion 15, discharging portion 17, first electrode 30, and second electrode 31.

[0017] Treatment tank 12 is a portion which sterilizes target treatment water L1 introduced in the inside by the plasma and generates the modifying component so as to generate treatment liquid L2. The material of treatment tank 12 may be an insulator, or a conductor. In a case where the material is a conductor, it is necessary to interpose an insulator between treatment tank 12 and first electrode 30, and between treatment tank 12 and second electrode 31. When the modifying component is discharged to microbubble generator 90, the modifying component is dispersed to target treatment water L1, and thereby treatment liquid L2 is generated.

[0018] Treatment tank 12 includes a treatment chamber which is formed

into a circular shape with a circular cross-section in the front surface. Introduction portion 15 is disposed in one end of treatment tank 12, and introduces target treatment water L1 to treatment tank 12 from a tangential direction of a circular cross-sectional shape orthogonal to central axis X1 of treatment tank 12. Introduction portion 15 communicates with liquid supplier 50 via pipe 51. Discharging portion 17 is disposed at the other end of treatment tank 12, and discharges target treatment water L1 introduced to treatment tank 12 and the modifying component generated in treatment tank 12 to microbubble generator 90 from treatment tank 12. In Embodiment 1, discharging portion 17 is connected to treatment liquid supplying port 91 of microbubble generator 90.

[0019] First electrode 30 is disposed inside at one end of treatment tank 12. First electrode 30 is disposed to protrude from the center of the inner wall at one end of treatment tank 12 into treatment tank 12 along the longitudinal direction.

[0020] Second electrode 31 is disposed on the outside of the wall at the other end of treatment tank 12, and is disposed in the vicinity of discharging portion 17.

[0021] First electrode 30 is connected to power source 60, and second electrode 31 is ground. A high pulse voltage is applied to first electrode 30 and second electrode 31 by power source 60. As a material of first electrode 30, for example, tungsten is used.

[0022] As an example, liquid supplier 50 is a pump for supplying target treatment water L1 into treatment tank 12. Liquid supplier 50 is connected to pipe 51. One end of pipe 51 is connected to introduction portion 15 as an inner opening disposed in the vicinity of the inner wall at one end of treatment tank 12, the other end of pipe 51 is connected to a liquid supply source (not shown,

for example, water tank 80) or target treatment tank 41, target treatment water L1 from target treatment tank 41 containing treatment liquid L2 of microbubble generator 90 is connected in a form that can be circulated between treatment tank 12 and target treatment tank 41 via microbubble generator 90.

5 **[0023]** Power source 60 applies a high pulse voltage between first electrode 30 and second electrode 31. Power source 60 can apply a so-called bipolar pulse voltage that alternately applies a positive pulse voltage and a negative pulse voltage.

10 **[0024]** Microbubble generator 90 is a bath that shears the modifying component discharged from liquid treater 100 in microbubble generating chamber 90f, generates microbubbles or nanobubbles containing the modifying component, and diffuses the microbubbles or nanobubbles into water. Specifically, microbubble generator 90 includes microbubble generating chamber 90f having a cross-sectional area larger than that of an opening of
15 discharging portion 17 of treatment tank 12, the modifying component discharged into microbubble generator 90 from discharging portion 17 is sheared by microbubble generator 90, microbubbles containing the modifying component, or microbubbles and nanobubbles are generated in microbubble generator 90, and the generated microbubbles or nanobubbles are diffused into
20 water. Accordingly, microbubble generator 90 functions as a microbubble generating tank. Regarding microbubble generator 90, at least the inner diameter or one side which is twice or more the inner diameter dimension of the opening of discharging portion 17 of treatment tank 12 is secured, whereby treatment liquid L2 which can surely perform the sterilization is generated in
25 microbubble generator 90 can be reliably generated.

[0025] As illustrated in FIG. 6D, for example, the microbubble generator 90 has treatment liquid supplying port 91 disposed at the center of the side wall on

the treatment tank side and connected to discharging portion 17 of treatment tank 12, and treatment liquid discharging port 90b disposed at the center similarly to treatment liquid supplying port 91 on the side wall on the side opposite to the treatment tank side. Microbubble generating chamber 90f has
5 a longitudinal sectional area which is larger than at least an opening of discharging portion 17 of treatment tank 12. Here, the longitudinal sectional area means a cross-section perpendicular to central axis X1 (for example, refer to FIG. 2). Further, preferably, microbubble generating chamber 90f is made smaller than the longitudinal sectional area of the treatment chamber
10 treatment tank 12 so that treatment liquid L2 can be quickly supplied from microbubble generator 90 to target treatment tank 41. In FIGS. 1 to 6C and the like, for ease of understanding, the size of microbubble generator 90 is exaggerated relative to treatment tank 12, but actual size ratios are as illustrated in FIGS. 6D to 6F, and in other drawings, the size of microbubble
15 generator 90 is illustrated in an expanding manner.

[0026] In such microbubble generator 90, plasma P is generated in gas phase G of treatment tank 12 so as to sterilize target treatment water L1 and generate a modifying component. The generated modifying component is dissolved and dispersed in the liquid so as to generate treatment liquid L2,
20 generated treatment liquid L2 discharged into microbubble generator 90 from discharging portion 17 of treatment tank 12 via treatment liquid supplying port 91 of microbubble generator 90, and then is discharged from treatment liquid discharging port 90b of microbubble generator 90.

[0027] In FIG. 6D, pipe 51 is connected to target treatment tank 41 so as to
25 form a portion of circulation pipe 81. Target treatment water L1 of target treatment tank 41 is supplied into treatment tank 12 from introduction portion 15 via circulation pipe 81 and liquid supplier 50, treatment liquid L2

discharged from discharging portion 17 of treatment tank 12, discharged treatment liquid L2 is introduced to microbubble generator 90 from treatment liquid supplying port 91, and treatment liquid L2 is further discharged from treatment liquid discharging port 90b of microbubble generator 90, is supplied
5 to target treatment tank 41, and is further discharged from target treatment tank 41 to be introduced to treatment tank 12 via liquid supplier 50, and thereby a configuration in which the liquid is circulated between treatment tank 12, microbubble generator 90, and target treatment tank 41 is realized.

[0028] Target treatment tank 41 holds culture liquid 42 for culturing a
10 plant so that treatment liquid L2 is supplied from microbubble generator 90 to sterilize culture liquid 42.

Apparatus main body

[0029] Next, apparatus main body 10 will be specifically described. FIG. 2 is a side sectional view of apparatus main body 10.

[0030] Treatment tank 12 includes first inner wall 21, second inner wall 22, and third inner wall 23. First inner wall 21 is a cylindrical wall. Second inner wall 22 is provided at a left end in FIG. 2 of first inner wall 21. Third inner wall 23 is provided at a right end in FIG. 2 of first inner wall 21. Second inner wall 22 and third inner wall 23 are substantially circular in a side view.
15 Substantially cylindrical accommodating space 83 is configured to include first inner wall 21, second inner wall 22, and third inner wall 23 in the inside of treatment tank 12. A central axis of first inner wall 21, that is, an imaginary central axis of substantially columnar accommodating space 83 configured inside treatment tank 12 is defined as a central axis X1.

[0031] On second inner wall 22, cylindrical electrode supporting cylinder 24 protruding into accommodating space 83 is provided at the center. Electrode supporting cylinder 24 is cylindrical and extends rightward. Electrode
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supporting cylinder 24 is disposed such that the central axis coincides with central axis X1. On the inner side of electrode supporting cylinder 24, first electrode 30 is supported via insulator 53. First electrode 30 has a rod shape and insulator 53 is disposed around first electrode 30. First electrode 30 is
5 disposed so that the longitudinal axis coincides with central axis X1. The inner side end face of right end 301 of first electrode 30, the inner side end face of insulator 53, and inner side end face 241 of electrode supporting cylinder 24 are arranged on substantially the same plane.

[0032] Introduction portion 15 penetrates apparatus main body 10, and one
10 opening end 151 is formed on first inner wall 21. In the side view, introduction portion 15 is disposed at a position adjacent to second inner wall 22. FIG. 3 is a diagram seen from a cross-section taken along line in 3-3 of FIG. 2. Introduction portion 15 is disposed on the wall surface of first inner wall 21.

[0033] Discharging portion 17 penetrates a central part of third inner wall
15 23. Discharging portion 17 is formed such that the central axis coincides with central axis X1.

[0034] Second electrode 31 is a plate-shaped metal member, and opening
20 311 is formed at the central part. Opening 311 is formed into a circular shape such that the central axis coincides with central axis X1.

Operation

[0035] Next, an operation of liquid treater 100 will be described.
Hereinafter, for the sake of convenience of explanation, a state in which a gas
phase is generated inside treatment tank 12 (FIGS. 4 and 5) and a state in
25 which a pulse voltage is applied to generated gas phase G to generate plasma P (FIG. 6A and FIG. 6B) will be described separately. FIG. 4 is a side sectional view illustrating a state where rotating flow F1 is generated in treatment tank

12, and a pulse voltage is not applied.

[0036] First, as illustrated in FIG. 4, target treatment water L1 of target treatment tank 41 is suctioned by using a pump, and target treatment water L1 is introduced to treatment tank 12 from introduction portion 15 at a
5 predetermined pressure. Then, target treatment water L1 moves along first inner wall 21 toward the right side in FIG. 4 from introduction portion 15 while generating rotating flow F1. Rotating flow F1 that has moved to the right side in FIG. 4 while rotating moves toward discharging portion 17.

[0037] With rotating flow F1, the pressure in the vicinity of central axis X1
10 is decreased to equal to or lower than a saturated water vapor pressure, and vaporized water is generated by a part of target treatment water L1, so that gas phase G is generated in the vicinity of central axis X1. Gas phase G is generated in the vicinity of the rotating center, specifically, from right end 301 of first electrode 30 to the vicinity of opening 311 of second electrode 31 along
15 central axis X1. Gas phase G rotates in the same direction as that of rotating flow F1 by rotating flow F1 being in contact with gas phase G. Rotated gas phase G is sheared into microbubbles or nanobubbles by receiving the resistance of water in microbubble generator 90 in the vicinity of discharging portion 17, and then is diffused to microbubble generator 90 via treatment
20 liquid supplying port 91 of microbubble generator 90 connected to discharging portion 17 from discharging portion 17.

[0038] FIG. 5 is a diagram seen from a cross-section taken along line in 5-5 of FIG. 4. As illustrated in FIG. 4, when target treatment water L1 is introduced to treatment tank 12 from introduction portion 15 at a
25 predetermined pressure, target treatment water L1 generates rotating flow F1 clockwise along first inner wall 21 in FIG. 5. When target treatment water L1 rotates inside treatment tank 12, the pressure in the vicinity of the center of

rotating flow F1, that is, the pressure in the vicinity of central axis X1 is decreased to equal to or lower than a saturated water vapor pressure, and vaporized water is generated by a part of target treatment water L1 in the vicinity of central axis X1, so that gas phase G is generated.

5 **[0039]** FIG. 6A and FIG. 6B are side sectional views illustrating a state where rotating flow F1 is generated in treatment tank 12, and a pulse voltage is applied. As illustrated in FIG. 6A, a high pulse voltage is applied between first electrode 30 and second electrode 31 by power source 60 in a state in which gas phase G in which the target treatment water L1 is vaporized is generated
10 from the vicinity of first electrode 30 to the vicinity of second electrode 31. FIG. 6B is an enlarged view illustrating a state in which plasma P is generated in gas phase G. When the high pulse voltage is applied between first electrode 30 and second electrode 31, plasma P is generated in gas phase G, so that target treatment water L1 is sterilized, and water-derived radicals (OH radical
15 or the like), a compound (hydrogen peroxide or the like), or ions are generated as a modifying component. Gas phase G containing the modifying component rotates in the same direction as that of rotating flow F1 by surrounding rotating flow F1. When gas phase G containing the modifying component rotates, a part of the modifying component is dissolved into rotating flow F1
20 side, and the modifying component is dispersed in target treatment water L1. Additionally, gas phase G containing the modifying component in the vicinity of discharging portion 17 is sheared by receiving the resistance of treatment liquid L2 in microbubble generator 90 so as to generate bubble BA containing the modifying component. When the treatment liquid is supplied into
25 microbubble generator 90, air is prevented from being mixed into gas phase G which is a negative pressure. In this way, treatment liquid L2 is supplied into microbubble generator 90 in a state where the modifying component generated

by plasma P is dissolved in a bubble or in treatment liquid L2.

[0040] Treatment liquid L2 supplied to microbubble generator 90 is supplied to target treatment tank 41.

[0041] When treatment liquid L2 comes into contact with culture liquid 42
5 in target treatment tank 41, culture liquid 42 is sterilized by the OH radical or the hydrogen peroxide in treatment liquid L2. A portion of sterilized culture liquid 42, treatment liquid L2, or the like is discharged from target treatment tank 41, is introduced, as target treatment water L1, to treatment tank 12 via liquid supplier 50, and, as a treatment liquid, is circulated again in treatment
10 tank 12 from treatment tank 12 via microbubble generator 90 and target treatment tank 41.

[0042] Note that, liquid treatment apparatus 101 in FIG. 6D is further provided with liquid measurement sensor 49 and treatment liquid controller 48.

15 [0043] Liquid measurement sensor 49 is a sensor which is disposed between target treatment tank 41 and treatment tank 12, specifically, between target treatment tank 41 and liquid supplier 50, and measures the liquid amount or the liquid pressure of target treatment water L1 to be introduced into treatment tank 12 from target treatment tank 41.

20 [0044] Treatment liquid controller 48 independently controls power source 60 and liquid supplier 50 based on the measurement result of liquid measurement sensor 49 so as to achieve the above operation. With treatment liquid controller 48, it is possible to perform control so as to perform the discharging of electricity after the entire treatment tank 12 is filled with liquid
25 and not to discharge the electricity in a state where the entire treatment tank 12 is filled with liquid. With this, it possible to more reliably achieve stabilization of the discharging of electricity.

[0045] According to Embodiment 1 described above, target treatment water L1 is vaporized in rotating flow F1, and a pulse voltage is applied to generated gas phase G to generate plasma P, so that target treatment water L1 which is a liquid is sterilized, and treatment liquid L2 containing a modifying component
5 is generated from the liquid. Therefore, gas phase G has a negative pressure as compared to the gas phase formed by the gas vaporized by Joule heat or the gas introduced from the outside, and plasma P can be generated at a small voltage (that is, low power), so that the sterilization treatment of the liquid in the treatment tank can be efficiently performed. Furthermore, since water is
10 not vaporized by Joule heat, the energy to be input is reduced. In addition, since gas is not introduced from the outside, a gas supply device is unnecessary, and liquid treatment apparatus 101 is easily downsized.

[0046] In addition, it is difficult to hold gas phase G formed by the gas evaporated by Joule heat or the gas introduced from the outside at a certain
15 shape or a fixed position by buoyancy. However, in gas phase G according to Embodiment 1, a force is applied in the direction of gathering on central axis X1 by the surrounding rotating flow F1, and thus constant gas phase G can be generated in the vicinity of right end 301 of first electrode 30. Therefore, the amount of gas generated between first electrode 30 and second electrode 31
20 varies little over time, and the power required for plasma P is hardly changed, and thus plasma P can be stably generated, and it is possible to efficiently and quickly sterilize the liquid in the treatment tank containing target treatment water L1, shorten the treatment time of the liquid, and improve the sterilization capacity.

25 [0047] Since the volume of plasma P is equal to or less than the volume of the gas phase in the vicinity of the cathode electrode, but the shape of gas phase G formed by the gas vaporized by Joule heat or the gas introduced from the

outside is a bubble shape, if the volume is equal to or greater than a certain level, the gas phase splits, and thus it is difficult to generate plasma P having a certain volume or more. However, in gas phase G of Embodiment 1, if it is possible to secure the rotating speed of rotating flow F1, it is easy to enlarge the volume in the direction of central axis X1, and thus the volume of plasma P is easily increased. Therefore, it is easy to increase the sterilization treatment amount of the liquid and the generation amount of the modifying component, so that the liquid can be quickly sterilized.

[0048] Also, since the volume expands when the liquid is vaporized, cavitation that generates shock waves and destroys surrounding objects is known. In Embodiment 1, the reason why the destruction by cavitation is most intensified is discharging portion 17 that has the smallest inner diameter of treatment tank 12 and the fastest rotating speed of rotating flow F1. Therefore, since right end 301 of first electrode 30 of gas phase G is far from the portion where the destruction of the cavitation is the strongest, the influence on first electrode 30 due to the cavitation becomes small and plasma P can be stably generated.

[0049] In addition, since a treatment of target treatment water L1 is performed without introducing air from the outside, it is possible to stabilize the discharging of electricity and suppress generation of harmful nitrous acid generated in the plasma utilizing the gas phase in which a gas containing a nitrogen component such as air is introduced. Further, it is possible to generate treatment liquid L2 containing bubbles BA containing OH radicals, hydrogen peroxide, or the like.

Embodiment 2

[0050] As illustrated in FIG. 6E, as liquid treatment apparatus 102 of Embodiment 2, fertilizing device 45 is additionally provided to liquid treatment

apparatus 101 of Embodiment 1.

[0051] Fertilizing device 45 is disposed between microbubble generator 90 and target treatment tank 41, and gives a fertilizing device component such as potassium to treatment liquid L2 supplied to target treatment tank 41.

5 **[0052]** In this way, when fertilizing device 45 is disposed on the downstream side of treatment tank 12 and microbubble generator 90, it is possible to prevent a balance of the fertilizing device component applied to treatment liquid L2 or a plurality of the fertilizing device components from being broken due to the discharging the electricity in treatment tank 12. That
10 is, since the discharging of electricity is performed on the upstream side of fertilizing device 45, the influence of the discharging of electricity to the fertilizing device component can be suppressed.

Embodiment 3

[0053] As illustrated in FIG. 6F, as liquid treatment apparatus 103 of
15 Embodiment 3, electrical characteristic measuring device 46 and fertilization controller 47 are additionally provided to liquid treatment apparatus 102 of Embodiment 2.

[0054] Electrical characteristic measuring device 46 is disposed between microbubble generator 90 and fertilizing device 45, and measures pH or electric
20 conductivity of treatment liquid L2 supplied from microbubble generator 90. The reason why the pH or the electric conductivity of treatment liquid L2 is measured by electrical characteristic measuring device 46 is that the component changes due to the discharging of electricity and thus, the measurement is performed immediately before fertilizing device 45 and based
25 on the measurement result, fertilization controller 47 determines and fertilizes the fertilizing device component to be added by fertilizing device 45.

[0055] Fertilization controller 47 controls a fertilizing operation of

fertilizing device 45 based on the measurement result of electrical characteristic measuring device 46.

[0056] According to such a configuration, when the pH or the electric conductivity of treatment liquid L2 is measured by the electrical characteristic measuring device 46, the fertilizing device component is monitored, and fertilizing device 45 is controlled, it is possible to further stabilize the fertilizing device component.

Embodiment 4

[0057] As illustrated in FIG. 6G, as liquid treatment apparatus 104 of Embodiment 4, hydrogen peroxide removing device 55, hydrogen peroxide removal controlling device 56, hydrogen peroxide concentration measuring device 57, oxygen supplier 70, and oxygen gas pipe 82 are further provided to liquid treatment apparatus 103 of Embodiment 3. As an example, hydrogen peroxide concentration measuring device 57, hydrogen peroxide removing device 55, and oxygen supplier 70 are linearly arranged in circulation pipe 81 between fertilizing device 45 to target treatment tank 41. Hydrogen peroxide removal controlling device 56 is connected to hydrogen peroxide removing device 55. Oxygen gas pipe 82 is disposed in parallel with circulation pipe 81 between hydrogen peroxide removing device 55 and oxygen supplier 70.

[0058] Although it is known that the hydrogen peroxide can be sterilized by oxidizing power, in a case where the hydrogen peroxide is contained in treatment liquid L2 at a high concentration, the oxidizing power also adversely affects the roots of the plant and inhibits plant growth, and thereby the hydrogen peroxide in treatment liquid L2 is removed by hydrogen peroxide removing device 55. The oxygen gas which is generated by decomposing the removed hydrogen peroxide is supplied into circulation pipe 81 via oxygen gas pipe 82 and oxygen supplier 70. As a result, by introducing the oxygen gas

into treatment liquid L2, the dissolved oxygen of treatment liquid L2 is increased, which can lead to the promotion of the plant growth.

[0059] As a hydrogen peroxide removing method by hydrogen peroxide removing device 55, the hydrogen peroxide may be removed by reacting
5 hydrogen peroxide with manganese dioxide or activated carbon as a catalyst. Although it is possible to decompose hydrogen peroxide using a reducing agent such as sodium sulfite, the composition of treatment liquid L2 is changed by adding the reducing agent, and thus it is preferable to use a catalyst. Hydrogen peroxide removing device 55 is disposed between treatment tank 12
10 and target treatment tank 41.

[0060] Hydrogen peroxide concentration measuring device 57 is disposed between hydrogen peroxide removing device 55 and treatment tank 12. Hydrogen peroxide concentration measuring device 57 measures the concentration of the hydrogen peroxide of treatment liquid L2 supplied from
15 microbubble generator 90 via circulation pipe 81. In a case where hydrogen peroxide removal controlling device 56 determines that a measured value obtained by measuring with hydrogen peroxide concentration measuring device 57 is larger than the value of the concentration of the hydrogen peroxide set in advance, hydrogen peroxide removal controlling device 56 controls the
20 operation of hydrogen peroxide removing device 55 so as to remove the hydrogen peroxide from treatment liquid L2. With such a configuration, it is possible to adjust the concentration of the hydrogen peroxide of treatment liquid L2 flowing through circulation pipe 81. As an example, in a case where hydrogen peroxide removal controlling device 56 determines that the
25 concentration of the hydrogen peroxide of treatment liquid L2, that is, the measured value obtained by measuring with hydrogen peroxide concentration measuring device 57 is larger than 1.0 ppm, it is desired that hydrogen

peroxide removal controlling device 56 controls hydrogen peroxide removing device 55 so as to remove the hydrogen peroxide.

5 [0061] Oxygen gas pipe 82 is disposed between hydrogen peroxide removing device 55 and oxygen supplier 70. The oxygen generated by decomposing and removing hydrogen peroxide by hydrogen peroxide removing device 55 is introduced into oxygen supplier 70 through oxygen gas pipe 82.

[0062] In oxygen supplier 70, the oxygen is dissolved in treatment liquid L2, and the dissolved oxygen concentration of treatment liquid L2 is increased. Oxygen supplier 70 causes a rotating flow in treatment liquid L2, and the
10 oxygen gas generated by decomposing and removing the hydrogen peroxide by hydrogen peroxide removing device 55 can be introduced into treatment liquid L2 at a negative pressure generated by the rotating flow. In this way, it is possible to increase the dissolved oxygen concentration of treatment liquid L2 without newly installing a pump for charging the oxygen gas.

15 [0063] Oxygen supplier 70 may supply the oxygen as fine bubbles using, for example, a micro-nanobubble generator or an air stone. Particularly, it is known that fine bubbles having a bubble diameter of equal to or less than 1 μm exist in a solution for several months, and it is possible to increase the dissolved oxygen concentration of treatment liquid L2 during the cultivation period for a
20 long period of time, thereby promoting plant growth.

[0064] With such a configuration, the hydrogen peroxide concentration of treatment liquid L2 is monitored, and it is possible to increase the dissolved oxygen concentration of treatment liquid L2 with respect to liquid treatment apparatus 103, thereby promoting plant growth.

25 Modification Example

[0065] The configuration of liquid treater 100 described in Embodiments 1 to 4 is an example, and can be variously modified. For example, an internal

structure of treatment tank 12 or a position of first electrode 30 or second electrode 31 is not limited to the structures of Embodiments 1 to 4.

[0066] In Embodiments 1 to 4, treatment tank 12 is a simple cylindrical shape, but is a cylindrical treatment tank having a circular cross-sectional shape, and can have various shapes as long as it includes a discharging portion having a hole shape narrowed on the central axis or in the vicinity of the central axis of the treatment tank at one end of the treatment tank. For example, as illustrated in FIG. 7, the same effect can be obtained even in treatment tank 121 combining cylinders having different radii. In FIG. 7, the radius on the introduction portion side is larger than the radius on the discharging portion side. Alternatively, the same effect can be obtained even in treatment tank 122 having a conical shape as illustrated in FIG. 8. Preferably, in order to prevent rotating flow F1 from sliding in forward direction F, as illustrated in FIG. 8, a conical shape in which the inner diameter of the cross-section is continuously decreased is preferable.

[0067] In Embodiments 1 to 4, the shape of first electrode 30 is a rod electrode, but is not limited thereto as long as it has a shape that concentrates electrolysis on right end 301 of first electrode 30. For example, as illustrated in FIG. 9A, plate-shaped first electrode 32 having a pointed conical shape toward the discharging portion side may be used. As illustrated in FIG. 9B, instead of the conical shape, plate-like first electrode 32A which includes, in the central part, mountain-shaped convex 32B protruding so as to curve toward the discharging portion side may be used. In first electrode 32A, since the central part closest to plasma P to be generated tends to wear out, it is preferable to use an electrode having mountain-shaped convex 32B which allows the central part to protrude into treatment tank 12 has a long life as compared to a simple flat electrode. More preferably, instead of the plate-shaped first electrode 32,

a rod electrode may be used which facilitates the transfer of electrodes into treatment tank 12 when the electrode is worn out.

[0068] As illustrated in FIG. 10, the same effect can be obtained even with a structure in which first electrode 30 and insulator 53 are attached to second inner wall 22 without using electrode supporting cylinder 24 of first electrode 30. In order to suppress the electrolysis of water or the generation of Joule heat, areas except for a connection area between right end 301 of first electrode 30 and power source 60 which is necessary for plasma generation may be covered with an insulator.

[0069] In Embodiments 1 to 4, the material of first electrode 30 is tungsten as an example, but is not particularly limited as long as it is a material having the conductivity. It is preferable to use a metal material capable of exhibiting a high sterilization effect by causing a Fenton reaction when being in contact with hydrogen peroxide in water. For example, a stainless steel (SUS), copper, or copper tungsten is preferable.

[0070] In Embodiments 1 to 4, second electrode 31 is disposed in discharging portion 17, but is not limited as long as at least a part of second electrode grounded in treatment tank 12 is disposed. For example, as for the disposition location, as illustrated in FIG. 11, the same effect can be obtained by disposing as rod-shaped second electrode 33 on the side of central axis X1 of first inner wall 21. As illustrated in FIG. 12, rod-shaped second electrode 33 may be disposed in microbubble generator 90 outside treatment tank 12 or in the vicinity of treatment liquid supplying port 91 of microbubble generator 90. As illustrated in FIG. 13, cylindrical second electrode 34 may be disposed inside first inner wall 21. Although opening 311 has a circular shape, it may be a polygonal shape, or the second electrode may be formed by combining a plurality of divided metal members. In order not to disturb rotating flow F1, it

is preferable to have a plate shape or a cylindrical shape having a round hole. The shorter the distance between gas phase G and the second electrode is, the smaller the resistance of water is, and thereby the Joule heat can be suppressed. Therefore, the second electrode may be disposed in discharging
5 portion 17 where the space between gas phase G and the second electrode is short, or in the vicinity the discharging portion 17.

[0071] The flow rate of target treatment water L1 introduced into treatment tank 12 is set to the flow rate at which gas phase G occurs in rotating flow F1 in accordance with the shape and the like of treatment tank 12. In a
10 case where the pulse voltage is applied to first electrode 30 and second electrode 31 by monopolar instead of bipolar, the pulse voltage or a voltage, a pulse width, a frequency, or the like can be appropriately set to a value capable of generating plasma P in gas phase G generated in rotating flow F1.

[0072] Power source 60 may be a high-frequency power source other than
15 the pulse power source as long as the effect of the present disclosure can be obtained. Preferably, since the pH between the electrodes is biased due to the electrolysis of water, bipolar application may be used so that the cathode and the anode can be exchanged.

[0073] Microbubble generator 90 is set as a tank, but is not limited thereto
20 as long as it can hold water in microbubble generator 90 in order to shear rotating flow F1. For example, it may be a pipe for transporting the treatment liquid. Preferably, as illustrated in FIG. 14A, apparatus main body 10 discharges the treatment liquid upward and microbubble generator 90 is on the top of apparatus main body 10 in order to fill discharging portion 17 with target
25 treatment water L1 and prevent the air from being mixed into treatment tank 12.

[0074] A material constituting microbubble generator 90 is not limited as

long as it is a material that does not permeate water. For example, as illustrated in FIG. 14B, it is possible to use plate member 92 containing copper or iron capable of exhibiting a high sterilization effect by causing a Fenton reaction with hydrogen peroxide water, which is one of the modifying components, and a portion or the entire of microbubble generator 90. Plate member 92 may be disposed in microbubble generator 90 as a member different from microbubble generator 90.

In short, when plate member 92 comes into contact with the treatment liquid in microbubble generator 90, the Fenton reaction with hydrogen peroxide solution which is one of the modifying components is caused, and thereby it is possible to develop a high sterilization effect.

[0075] While Embodiments 1 to 4 of the present disclosure have been described above, Embodiments 1 to 4 are merely examples for implementing the disclosure. Therefore, the disclosure is not limited to Embodiments 1 to 4 described above, and the above-described Embodiments 1 to 4 can be appropriately modified and implemented without departing from the spirit of the disclosure.

[0076] That is, it is possible to achieve each of the effects by combining the above-described embodiments, optional embodiments among the various embodiments, or modification examples as appropriate. In addition, combinations of the embodiments or combinations of the embodiments or combinations of the embodiments and the examples are possible and combinations of features in different embodiments or examples are also possible.

25 Conclusion

[0077] The liquid treatment apparatus according to one embodiment of the disclosure is provided with treatment tank 12, first electrode 30, second

electrode 31, power source 60, microbubble generator 90, target treatment tank 41, and liquid supplier 50. Treatment tank 12 generates a gas phase in the vicinity of a rotating center of a rotating flow of a liquid by generating the rotating flow by rotating the liquid introduced from introduction portion 15 around central axis X1, and includes discharging portion 17 for discharging the liquid introduced from introduction portion 15 as a treatment liquid, after rotating the liquid between introduction portion 15 and discharging portion 17 to generate the rotating flow. At least a portion of first electrode 30 is disposed in treatment tank 12 and comes into contact with the liquid in treatment tank 12. Second electrode 31 is disposed so as to be in contact with the liquid in treatment tank 12. Power source 60 applies a voltage between first electrode 30 and second electrode 31 to generate a plasma in the gas phase, so that the liquid is sterilized so as to form the treatment liquid, and the modifying component is generated in the treatment liquid. Microbubble generator 90 includes microbubble generating chamber 90f having a longitudinal sectional area larger than an opening of discharging portion 17 of treatment tank 12, generates microbubbles or nanobubbles by discharging the treatment liquid from discharging portion 17 of treatment tank 12 in microbubble generating chamber 90f, and diffuses the generated microbubbles or nanobubbles into the treatment liquid. Target treatment tank 41 holds a culture liquid for plant cultivation, sterilizes the culture liquid with the treatment liquid supplied from microbubble generator 90, and discharges sterilized target treatment water to treatment tank 12 as at least a portion of the liquid. Liquid supplier 50 which is capable of circulating the liquid introduced in treatment tank 12 from introduction portion 15 of treatment tank 12 via microbubble generator 90 between treatment tank 12 and target treatment tank 41. The liquid treatment apparatus generates the plasma in

the gas phase of the rotating flow formed between introduction portion 15 and discharging portion 17 with the liquid, sterilizes the liquid, generates the modifying component, dissolves the generated modifying component in the treatment liquid to be dispersed in the treatment liquid, introduces the treatment liquid to target treatment tank 41 via microbubble generator 90, and introduces the target treatment water discharged after sterilizing the culture liquid to treatment tank 12 as at least a portion of the liquid by liquid supplier 50.

[0078] Liquid treatment apparatus may be further provided with fertilizing device 45 which is disposed between microbubble generator 90 and target treatment tank 41, and performs fertilization on the treatment liquid supplied to target treatment tank 41.

[0079] Liquid treatment apparatus may further include electrical characteristic measuring device 46 which is disposed between microbubble generator 90 and fertilizing device 45, and measures pH or electric conductivity of treatment liquid supplied from microbubble generator 90, and fertilization controller 47 which controls a fertilizing operation of fertilizing device 45 based on the measurement result of electrical characteristic measuring device 46.

[0080] Liquid treatment apparatus may be further provided with hydrogen peroxide concentration measuring device 57 which is disposed between treatment tank 12 and target treatment tank 41 and measures the concentration of the hydrogen peroxide of the treatment liquid supplied from microbubble generator 90, hydrogen peroxide removing device 55 which is disposed on the downstream side of hydrogen peroxide concentration measuring device 57 in a flow path of the treatment liquid, and removes the hydrogen peroxide from the treatment liquid, hydrogen peroxide removal controlling device 56 which is connected to hydrogen peroxide removing device

55, and controls an operation of removing the hydrogen peroxide based on the measurement result of the concentration of the hydrogen peroxide measured by hydrogen peroxide concentration measuring device 57, and oxygen supplier 70 which introduces oxygen generated from the hydrogen peroxide removed by
5 hydrogen peroxide removing device 55 to the treatment liquid.

[0081] The liquid treatment apparatus may be further provided with liquid measurement sensor 49 which is disposed between target treatment tank 41 and treatment tank 12, and measures a liquid amount or a liquid pressure of the liquid to be introduced into treatment tank 12, and treatment liquid
10 controller 48 which controls power source 60 based on the measurement result obtained by liquid measurement sensor 49.

[0082] First electrode 30 may be disposed so as to be in contact with gas phase generated in the vicinity of the rotating center of the rotating flow of the liquid, or disposed so as to be positioned in the vicinity of the gas phase.

15 **[0083]** The liquid introduced from introduction portion 15 of treatment tank 12 may contain the target treatment water discharged from target treatment tank 41.

[0084] Treatment tank 12 includes cylindrical or truncated conical first inner wall 21 which rotates the liquid supplied from introduction portion 15 to
20 generate a rotating flow, and first electrode 30 may be disposed on central axis X1 of first inner wall 21 or the vicinity of central axis X1.

[0085] First electrode 30 may be disposed on one end side of central axis X1 or the vicinity of central axis X1, second electrode 31 may be disposed on central axis X1 or the other end side in the vicinity of central axis X1,
25 introduction portion 15 may be disposed on one end side of central axis X1, and discharging portion 17 may be disposed on the other end side of central axis X1.

[0086] Second electrode 31 may be a plate-shaped electrode disposed so as

to surround at least a portion around central axis X1 of first inner wall 21 on the other end side of first inner wall 21.

[0087] Second electrode 31 may be disposed on the side of central axis X1 of first inner wall 21 on the other end side of first inner wall 21.

5 **[0088]** Second electrode 31 is a cylindrical electrode disposed so as to surround at least a portion around central axis X1 of first inner wall 21 on the other end side of first inner wall 21.

[0089] The liquid treatment apparatus according to the above-described aspect of the disclosure can generate a plasma in a liquid, sterilize the liquid,
10 and generate a treatment liquid containing a modifying component (a liquid-derived radical or a compound or the like) from the liquid so as to sterilize a culture liquid even with the modifying component of the generated treatment liquid. Therefore, the liquid treatment apparatus according to the above-described aspect of the disclosure can be used for a plant growth
15 apparatus or the like in hydroponic culture.

WHAT IS CLAIMED IS:

1. A liquid treatment apparatus comprising:

5 a treatment tank which generates a gas phase in a vicinity of a rotating center of a rotating flow of a liquid by generating the rotating flow by rotating the liquid introduced from an introduction portion around a central axis, and includes a discharging portion for discharging the liquid introduced from the introduction portion as a treatment liquid, after rotating the liquid between the introduction portion and the discharging portion to generate the rotating flow;

10 a first electrode in which at least a portion is disposed in the treatment tank so as to be in contact with the liquid in the treatment tank;

a second electrode which is disposed so as to be in contact with the liquid in the treatment tank;

15 a power source which applies a voltage between the first electrode and the second electrode, generates a plasma in the gas phase, sterilizes the liquid so as to form the treatment liquid, and generates a modifying component in the treatment liquid;

20 a microbubble generator which includes a microbubble generating chamber having a longitudinal sectional area larger than an opening of the discharging portion of the treatment tank, generates microbubbles or nanobubbles by discharging the treatment liquid from the discharging portion of the treatment tank in the microbubble generating chamber, and diffuses the generated microbubbles or nanobubbles in the treatment liquid;

25 a target treatment tank which holds a culture liquid for plant cultivation, sterilizes the culture liquid with the treatment liquid supplied from the microbubble generator, and discharges sterilized target treatment water to the treatment tank as at least a portion of the liquid; and

a liquid supplier which is capable of circulating the liquid introduced in the treatment tank from the introduction portion of the treatment tank via the microbubble generator, between the treatment tank and the target treatment tank,

5 wherein the plasma is generated in the gas phase of the rotating flow formed between the introduction portion and the discharging portion with the liquid, the liquid is sterilized, the modifying component is generated, the generated modifying component is dissolved in the treatment liquid to be dispersed in the treatment liquid, the treatment liquid is introduced to the
10 target treatment tank via the microbubble generator, and the target treatment water discharged after the discharged culture liquid is sterilized is introduced to the treatment tank as at least a portion of the liquid by the liquid supplier.

2. The liquid treatment apparatus of Claim 1, further comprising:

15 a fertilizing device which is disposed between the microbubble generator and the target treatment tank, and performs fertilization on the treatment liquid to be supplied to the target treatment tank.

3. The liquid treatment apparatus of Claim 2, further comprising:

20 an electrical characteristic measuring device which is disposed between the microbubble generator and the fertilizing device, and measures pH or electric conductivity of the treatment liquid supplied from the microbubble generator; and

 a fertilization controller which controls the fertilization of the fertilizing
25 device based on a measurement result obtained by the electrical characteristic measuring device.

4. The liquid treatment apparatus of Claim 3, further comprising:

a hydrogen peroxide concentration measuring device which is disposed between the treatment tank and the target treatment tank, and measures a concentration of hydrogen peroxide of the treatment liquid supplied from the microbubble generator;

a hydrogen peroxide removing device which is disposed downstream of a flow path of the treatment liquid than the hydrogen peroxide concentration measuring device, and removes the hydrogen peroxide from the treatment liquid;

a hydrogen peroxide removal controlling device which is connected to the hydrogen peroxide removing device, and controls the removing of the hydrogen peroxide based on the measurement result of the concentration of the hydrogen peroxide measured by the hydrogen peroxide concentration measuring device; and

an oxygen supplier which introduces oxygen generated from the hydrogen peroxide removed by the hydrogen peroxide removing device to the treatment liquid.

5. The liquid treatment apparatus of Claim 1, further comprising:

a liquid measurement sensor which is disposed between the target treatment tank and the treatment tank, and measures a liquid amount or a liquid pressure of the liquid to be introduced into the treatment tank; and

a treatment liquid controller which controls the power source based on a measurement result obtained by the liquid measurement sensor.

6. The liquid treatment apparatus of Claim 1,

wherein the first electrode is disposed so as to be in contact with the gas

phase generated in the vicinity of the rotating center of the rotating flow of the liquid, or disposed so as to be positioned in a vicinity of the gas phase.

7. The liquid treatment apparatus of Claim 1,
5 wherein the liquid introduced from the introduction portion of the treatment tank contains the target treatment water discharged from the target treatment tank.

8. The liquid treatment apparatus of Claim 7,
10 wherein the treatment tank includes a cylindrical or truncated conical first inner wall which causes rotating the liquid supplied from the introduction portion to generate the rotating flow, and
wherein the first electrode is disposed on a central axis of the first inner wall or a vicinity of the central axis.

15 9. The liquid treatment apparatus of Claim 8,
wherein the first electrode is disposed on one end side of the central axis or the vicinity of central axis,

wherein the second electrode is disposed on the other end side of the
20 central axis or the vicinity of central axis,

wherein the introduction portion is disposed on one end side of the central axis, and

wherein the discharging portion is disposed on the other end side of the central axis.

25 10. The liquid treatment apparatus of Claim 9,
wherein the second electrode is a plate-shaped electrode disposed so as

to surround at least a portion around the central axis of the first inner wall on the other end side of the first inner wall.

11. The liquid treatment apparatus of Claim 9,
5 wherein the second electrode is disposed on the side of the central axis of the first inner wall on the other end side of the first inner wall.

12. The liquid treatment apparatus of Claim 9,
wherein the second electrode is a cylindrical electrode disposed so as to
10 surround at least a portion around the central axis of the first inner wall on the other end side of the first inner wall.