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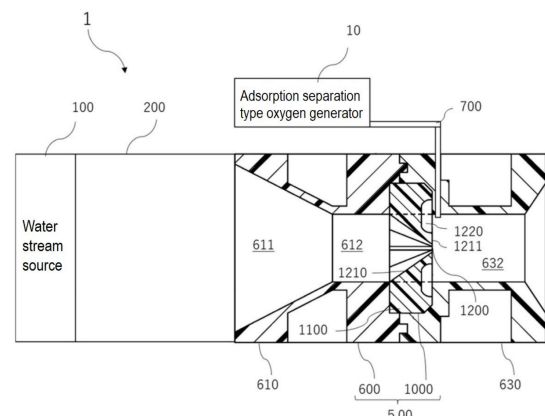
(54) **GAS DISSOLVING METHOD**

(57) In the related art, a gas such as oxygen has been needed to be pressurized to be forcibly dissolved in water, and for example, an oxygen cylinder or the like has been needed to be prepared. For this reason, its apparatus has become complicated, and not only its cost has increased, but also its maintenance has taken time and effort.

A gas dissolving apparatus of the present invention is configured as follows. An apparatus of dissolving a gas into a water stream, the apparatus including: a supply source of the gas; a water stream source; and a dissolving section, the dissolving section including: a tube through which the water stream from the water stream source is allowed to pass; a vertical downstream wall in the tube, the vertical downstream wall facing downstream of the water stream, the water stream flowing around along the downstream wall to create a negative pressure region; and a gas supply passage penetrating from a peripheral wall of the tube to the negative pressure region, the gas supply passage being connected to the source of the gas, wherein a gas of the gas supply source

is supplied to the negative pressure region through the gas supply passage due to negative pressure in the negative pressure region.

FIG. 1



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Description

TECHNICAL FIELD

5 **[0001]** The present invention relates to a method of dissolving a gas in a water stream.

BACKGROUND ART

10 **[0002]** A useful gas such as carbon dioxide gas is dissolved into a water stream, thereby increasing its concentration.
[0003] For example, as for a gas dissolving apparatus described in Patent Literature 1, it is disclosed that carbon dioxide gas stored in a gas cylinder is supplied to a collision portion where fine bubbles are generated.
[0004] Patent Literature 2 discloses a method of pressurizing a gas and dissolving the gas into water.
[0005] In each of the gas dissolving methods described in these prior art documents, a pressurized gas is supplied to a water stream.
15 **[0006]** As for the gas dissolving apparatus described in Patent Literature 1, the mixing of the gas with water progresses remarkably in a strong stirring region downstream of the collision portion, and the dissolution of the gas is efficiently carried out (see Patent Literature 1, page 21, paragraphs 2 and 3).
[0007] In addition, please refer to Patent Literature 3 and Patent Literature 4.

20 CITATIONS LIST

PATENT LITERATURE

25 **[0008]**
Patent Literature 1: JP 6182715 B2
Patent Literature 2: JP 5762210 B2
Patent Literature 3: JP 6279179 B2, paragraph 0040, paragraph 0041
Patent Literature 4: JP 6978793 B2

30 SUMMARY OF INVENTION

TECHNICAL PROBLEMS

35 **[0009]** There is an increasing demand for forcibly dissolving a useful gas into water to enhance the function of water. For example, it is known that live fish can be kept alive for a long period of time by increasing the amount of oxygen dissolved in water in a live fish tank of a truck for transporting live fish.
[0010] On the other hand, gas such as oxygen has been needed to be pressurized to be forcibly dissolved into water, and for example, an oxygen cylinder or the like has been needed to be prepared. For this reason, its apparatus has become
40 complicated, and not only its cost has increased, but also its maintenance has taken time and effort.

SOLUTIONS TO PROBLEMS

45 **[0011]** The present invention has been made to solve the above-mentioned problems, and a first aspect thereof is defined as follows. That is,

a method of dissolving a gas in a water stream,
the method comprising: creating a negative pressure region in a part of water included in the water stream; and
50 sucking the gas due to negative pressure in the negative pressure region, thereby entraining the gas into the water stream and generating fine bubbles.

[0012] According to the gas dissolving method of the first aspect defined as described above, a gas from a gas supply source is sucked due to negative pressure in the negative pressure region, and this gas is entrained in the water stream. In other words, even if the gas to be introduced is not pressurized at all, a sufficient amount of the gas is sucked into the
55 negative pressure region. When the gas to be introduced is pressurized, gas suction efficiency is improved.

[0013] A part of the water is gasified (vaporized) in the negative pressure region of the water stream. When the gas is introduced into the negative pressure region, the gas and water vapor in the negative pressure region are mixed. Then, with an increase of the pressure of a part of the water stream that has flown out from the negative pressure region, the water

vapor condenses and turns back to water. At this time, the gas is drawn into water and becomes in a state of being dissolved in water.

[0014] Even if the water in the negative pressure region is not gasified, the vapor pressure decreases and the bond between water molecules is reduced in strength, and hence the introduced gas becomes easier to enter between the water molecules.

[0015] Moreover, since fine bubbles are generated, the gas is also present in the fine bubbles, which prevents a decrease in the concentration of the gas dissolved in water.

[0016] In the present invention, gas suction is caused by negative pressure in the negative pressure region. Therefore, there is no need for an external pressure device for feeding gas.

[0017] A second aspect of the present invention is defined as follows. That is, in the method of the first aspect, the gas in a state at atmospheric pressure is sucked into the negative pressure region.

[0018] To produce oxygen industrially at a low cost, an adsorption separation method is generally employed, and oxygen produced by such a production method is not in a pressurized state. In other words, according to the second aspect, even unpressurized oxygen, which is taken out from an adsorption separation device as an oxygen supply source, can be directly dissolved in water, that is, oxygen in a state at atmospheric pressure can be dissolved in water.

[0019] A third aspect of the present invention is defined as follows. That is, in the gas dissolving method of the first aspect, the water stream flows through a tube, a vertical downstream wall facing downstream of the water stream is provided in the tube, and the water stream flows along the downstream wall to create the negative pressure region.

[0020] According to the gas dissolving method of the third aspect defined as described above, the water stream flowing around along the downstream wall moves away from the center of the tube, and creates the negative pressure region on the outer peripheral side of the tube. It becomes easier to supply the gas into such a negative pressure region from outside the tube.

[0021] Patent Literature 4 states that water is caused to pass through a tube having a vertical downstream wall and thereby fine bubbles including nano-order ultrafine bubbles are created in water (see Figs. 4 and 5).

[0022] A small-diameter portion (an orifice) is preferably provided in the tube, and a vertical downstream wall is preferably formed at an outlet of the small-diameter portion.

[0023] A fourth aspect of the present invention is defined as follows. That is, in the gas dissolving method of the third aspect, a recess is formed in the downstream wall, and a part of the water stream that has flown into the recess is vaporized due to negative pressure in the recess.

[0024] The negative pressure is extremely great in the recess formed in the downstream wall. According to the study of the present inventors, in this recess, the pressure varies (oscillates), and the water is almost completely vaporized in the state at the maximum negative pressure.

[0025] At the time when the gas supplied to the negative pressure region is introduced into the water stream and reaches the recess, the gas is drawn into the recess by the great negative pressure in the recess and is mixed with water vapor in the recess.

[0026] At the time when the oscillating negative pressure in the recess decreases (at the time when water vapor turns back to water), the gas together with water vapor is drawn into water.

[0027] The gas can be supplied directly to the recess.

[0028] Since the pressure oscillations in the recess also have an agitation effect of the water stream, in terms of this, the gas dissolving effect is also improved.

[0029] A fifth aspect of the present invention is defined as follows. That is,

in the gas dissolving method defined in the fourth aspect, the recess penetrates into a peripheral wall of the tube, and the gas is supplied through a gas supply passage penetrating from the peripheral wall of the tube to the recess.

[0030] In the gas dissolving method of the fifth aspect defined as described above, the recess penetrates into the peripheral wall of the tube, so that a part of the recess is in a state of being covered with a lid from the wall. According to the study of the present inventors, vaporization of water is promoted in the recess of the portion covered with the lid.

[0031] A seventh aspect of the present invention is defined as follows. That is, an apparatus through which a gas is dissolved into a water stream from a water stream source, the apparatus comprising: a supply source of the gas; and a dissolving section, the dissolving section comprising:

a tube through which a water stream from the water stream source is allowed to pass;
a vertical downstream wall in the tube, the vertical downstream wall facing downstream of the water stream, the water stream flowing along the downstream wall to create a negative pressure region; and
a gas supply passage that penetrates from a peripheral wall of the tube to the negative pressure region, the gas supply passage being connected to the supply source,

wherein a gas of the supply source is supplied to the negative pressure region through the gas supply passage due to negative pressure in the negative pressure region.

[0032] According to the gas dissolving apparatus of the seventh aspect defined as described above, the gas of the supply source of the gas is supplied to the negative pressure region through the gas supply passage due to negative pressure in the negative pressure region, and thus no gas pressurizing device (including a pump) is required. Therefore, the number of components in the entirety of the apparatus is reduced, and an inexpensive apparatus becomes available. Moreover, according to the gas dissolving apparatus including the dissolving section, fine bubbles are also generated in the dissolving section.

[0033] Note that, in a case where the target gas is the atmospheric air, there is no need for a tank or the like that serves as a gas supply source, and the atmosphere itself is the gas supply source. Therefore, the end portion of the gas supply passage on the side of the gas supply source is in a state of being open to the atmosphere.

[0034] The water stream having passed through the gas dissolving apparatus can be fed back to the water stream source. That is, water in a tank is circulated, and the circulating water stream is allowed to pass through the dissolving section. It has been found that the temperature of the circulating water is not increased at all when this gas dissolving apparatus is applied to such a circulation system. This is thought to be because no mechanical external force such as agitation is applied to the water stream, in addition to that the gas does not need to be pressurized at all as dissolving the gas.

[0035] To produce enhanced negative pressure in the negative pressure region, a recess can be formed in the downstream wall. A part of the water stream flowing into the recess is vaporized due to negative pressure in the recess (an eighth aspect).

[0036] In this eighth aspect of the present invention, a gas supply passage has an opening in the recess. Since enhanced negative pressure is generated in the recess, the gas can be efficiently sucked from the outside. In addition, since water vaporization is promoted due to the enhanced negative pressure, the gas is entrained in water when the water vapor turns back to water, so that the gas is dissolved at a high concentration.

[0037] The gas supply passage preferably has an opening at a position opposing this recess (an eleventh aspect).

[0038] The recess can be penetrated into the peripheral wall of the tube (a tenth aspect). When the recess is penetrated into the peripheral wall of the tube, a part of the recess is in a state of being covered with a lid. According to the study of the present inventors, water vaporization is promoted in the recess of the portion covered with the lid.

[0039] It is to be noted that fine bubbles are efficiently generated in the water stream when such a recess is provided as stated in Patent Literature 4. In this specification, fine bubbles include nano-order ultrafine bubbles.

[0040] The gas that can be selected is one type or two or more types selected from an inorganic gas such as atmospheric air, oxygen, ozone, ammonia, or nitrogen, or an organic gas such as carbon dioxide or ethane.

BRIEF DESCRIPTION OF DRAWINGS

[0041]

Fig. 1 is a schematic view illustrating a gas dissolving apparatus according to a first embodiment of the present invention.

Fig. 2 is a front view of a bubble generator employed in the gas dissolving apparatus of Fig. 1.

Fig. 3 is a schematic view illustrating a gas dissolving apparatus according to another embodiment.

Fig. 4 is a schematic view illustrating a gas dissolving apparatus according to another embodiment.

Fig. 5 is a schematic view illustrating a gas dissolving apparatus according to another embodiment.

Fig. 6 is a graph showing characteristics of a gas dissolving apparatus of an example.

Fig. 7 shows changes in oxygen concentration over time.

Fig. 8 is a graph showing results of another example.

DESCRIPTION OF EMBODIMENTS

(First embodiment)

[0042] A gas dissolving apparatus 1 according to a first embodiment of the present invention is described below.

[0043] The gas dissolving apparatus 1 comprises a gas supply source 10, a water stream source 100, and a dissolving section 500.

[0044] As the gas supply source 10, an adsorption separation type oxygen generator was employed. The oxygen output from this oxygen generator is in a state at atmospheric pressure.

[0045] As the type of gas that the gas supply source 10 supplies, any gas to be dissolved in the water stream can be

selected. A tank or cylinder of such a gas can be used as the gas supply source 10.

[0046] The atmosphere can also be used as the gas supply source.

[0047] A general-purpose pump can be used as the water stream source 100. The pressure of the water stream and the amount of water delivered by the pump can be set freely.

[0048] A tap can be directly used as the water stream source.

[0049] The dissolving section 500 comprises a tubular portion 600 and a bubble generator 1000. Note that this bubble generator 1000 is described in Patent Literature 3 (JP 6279179 B2), and the description thereof is incorporated herein by reference.

[0050] The tubular portion 600 is divided into parts in axial direction (water stream direction). An upstream part 610 thereof is connected to the water stream source 100 through a conduit 200. An inlet of the water stream comprises: a funnel-shaped part 611 whose diameter decreases in the water stream direction; and an inlet-side orifice 612. An outlet-side orifice 632 is formed in a downstream part 630. The two orifices 612 and 632 have the same diameter.

[0051] The bubble generator 1000 is sandwiched between the upstream part 610 and the downstream part 630 and incorporated therein. Fig. 2 is a front view of the bubble generator 1000. Fig. 1 is a cross section taken along line A-A in Fig. 2.

[0052] This bubble generator 1000 comprises a main body 1100 and a bubble generating part 1200.

[0053] The main body 1100 is formed into a tubular shape. A part of the outer peripheral surface of this main body 1100 is cut out to form a flat portion 1110. This flat portion prevents unnecessary rotation and is used for positioning. The main body 1100 does not need to have a cylindrical shape, and can have any shape. For example, it may have a rectangular tubular shape. It may also be radically divided into parts. It may also have a tapered shape whose diameter becomes smaller toward the downstream in the water stream direction.

[0054] The bubble generating part 1200 has a columnar portion 1210, which protrudes from an inner peripheral surface of the main body 1100 and is formed integrally with the main body 1100. In this example, six columnar portions 1210 are included. Each of slits 1300 is formed between the columnar portions 1210.

[0055] The slits 1300 are formed radially in a plan view. In this example, the center of radiation coincides with the central axis of the main body 1100. The center of radiation does not need to coincide with the central axis of the main body 1100. The slits 1300 are formed on one virtual transverse plane in the main body 1100. In other words, in each of the columnar portions 1210, a part most protruding from the inner peripheral surface of the main body 1100 is formed on the virtual transverse plane. This most protruding part preferably coincides with the peripheral edge of a bottom surface 1211 of the columnar portion 1210.

[0056] This bottom surface 1211 is, in its most protruding part, preferably formed perpendicularly or at an acute angle with respect to the water stream direction. This is because a greater change in flow velocity can be produced to generate negative pressure there.

[0057] Recesses 1220 are formed in the bottom surface 1211. The water stream passed through the slits 1300 and flown over the bottom surface side is affected sucking by the recesses 1220 so that the negative pressure generation on the bottom surface 1211 is promoted.

[0058] To uniformly generate the negative pressure, the recesses 1220 are preferably arranged evenly and radially from the center of the slits 1300, that is, from the central axis of the main body 1100.

[0059] Each of the recesses 1220 is extended to the main body 1100. The portion of the recess 1220 existing in the main body 1100 serves as a cavity during use. Water about to flow into the recess 1220 interferes with water already existing in the recess 1220, but the interference is buffered by this cavity. Therefore, the negative pressure creating effect is enhanced.

[0060] In this example, each of the slits 1300 is formed to have the same width, but a change in width can be allowed. The change in width mentioned here means that the widths of the slits are different from each other, and means that a change in width is allowed in one slit.

[0061] The cross-sectional area of the columnar portion 1210 becomes gradually smaller from the bottom surface 1211 toward the upstream side. Then, the cross-sectional area becomes zero on its upstream side surface. As a result, the resistance of the columnar portion to the water stream can be reduced. In addition, by adopting such a structure, pulling out of a mold can be performed without any resistance during mold forming.

[0062] The columnar portion 1210 in this example has a pyramid shape whose bottom surface 1211 is a surface defined by each of edges 1310 of the slit 1300. The ridgeline of the columnar portion 1210 is defined as follows. That is, one terminal point of the ridgeline is defined at cross point of the adjacent edges 1310 and 1310. The other terminal point of the ridgeline is defined at the point where the most upstream point of the inner peripheral surface of the main body 1100 crossing the virtual bisecting surface of the edges 1310 and 1310.

[0063] A gas supply passage 700 is disposed between the gas supply source 10 and the orifice 632. This gas supply passage 700 is formed of a pipe, one end of which is connected to the gas supply source 10, and the other end of which is open to the orifice 632.

[0064] The other end of the gas supply passage 700 can be open to and face the recess 1220. This makes it possible to

efficiently supply the gas to the water stream that flows into the recess 1220.

[0065] Furthermore, as illustrated in Fig. 3, the other end of the gas supply passage 700 can be open in the recess 1220 (a gas dissolving apparatus 2).

[0066] The water stream supplied from the water stream source 100 through the conduit 200 to the dissolving section 500 is compressed at the funnel-shaped part 611 and the water stream is enhanced. This water stream is further compressed at the columnar portion 1210 of the bubble generating part 1200. After having passed through the slit 1300, such a water stream creates a negative pressure region in the orifice 632 on the downstream side and creates small bubbles. As a result, fine bubbles are generally formed in the negative pressure region (a cavitation effect). Since a part of the water stream having passed through the slit 1300 flows along the vertical bottom surface (the downstream wall) of the columnar portion 1210, a negative pressure region is also created in a region close to the bottom surface 1211 in an outer region (a region close to the peripheral wall of the tubular portion) of the orifice 632 on the downstream side.

[0067] Through the gas supply passage 700 having an opening here, this negative pressure region can suck the gas from the gas supply source 10. The gas sucked into the negative pressure region is drawn into water in the negative pressure region.

[0068] The water stream flows along the bottom surface 1211, and thus also flows into the recesses 1220, where the negative pressure is further enhanced. Therefore, the gas supply passage 700 preferably has an opening facing and opposing to at least one of the recesses 1220. This is for the purpose of efficiently supplying the gas to the recess 1220 with an enhanced negative pressure.

[0069] Fig. 4 illustrates a gas dissolving apparatus 3 according to another embodiment. Note that the same elements as those in Fig. 1 are denoted by the same reference numerals, and the description thereof will be omitted.

[0070] A dissolving section 2100 of this gas dissolving apparatus 3 includes an introduction part 2210, an orifice 2220, and an enlarged diameter part 2230, which are sequentially formed in a tubular main body 2200, from the upstream thereof. Note that the dissolving section 2100 is described in JP 6978793 B2 (Patent Literature 4), and therefore the description thereof is incorporated herein by reference.

[0071] The outlet of the orifice 2220 has an opening, and a downstream wall 2240 defining the enlarged diameter part 2230 stands vertically to the water stream. Four recesses 2250 are formed at intervals of 90 degrees in the downstream wall 2240. A circumferential recess 2231 is formed in the enlarged diameter part 2230.

[0072] Here, the orifice 2220 refers to a reduced diameter portion of the same diameter in the tubular main body. The diameter can be changed and/or a groove can be formed on the peripheral wall of the orifice to the extent that no disturbance occurs in the water stream.

[0073] The configuration of the dissolving section 2100 generates fine bubbles as disclosed in JP 2021-20153 A by the present applicant. That is, a negative pressure region is created in the enlarged diameter part 2230 and in the recess 2250.

[0074] Since fine bubbles are generated even without the recess 2250 of the downstream wall 2240 or the recess 2231 of the enlarged diameter part 2230 as disclosed in JP 2021-20153 A, an adequate negative pressure region is created as long as the downstream wall stands vertically in the tubular main body including the orifice 2220, and the negative pressure can draw in the gas from the gas supply source 10 through the gas supply passage 700.

[0075] In the example of Fig. 4, the other end of the gas supply passage 700 is open to the enlarged diameter part 2230.

[0076] As illustrated in Fig. 5, the gas supply passage 700 may have an opening in the recess 2250 (a gas dissolving apparatus 4).

EXAMPLES

[0077] An oxygen gas dissolution test was performed by using the gas dissolving apparatus 1 illustrated in Fig. 1.

[0078] Tap water (at water temperature of 20.0°C) in an opened tank was introduced at an amount of water (8 L/min) and a water pressure of 0.3 MPa into the gas dissolving apparatus 1. An adsorption separation type oxygen generator (Originator 601 manufactured by Kinkisan Co., Ltd.) was used as the oxygen gas supply source 10, and oxygen gas not pressurized at all in a state at atmospheric pressure was enabled to be supplied to the gas supply passage 700.

[0079] Fig. 6 shows the relationship between the oxygen gas supply flow rate and the dissolved oxygen concentration when the supply flow rate of the oxygen gas was changed under the aforementioned conditions.

[0080] It can be seen from Fig. 6 that the supply flow rate of the oxygen gas is preferably from 1 L/min to 2 L/min under the aforementioned conditions.

[0081] In other words, the oxygen gas supply capacity of the oxygen gas supply source is preferably adjusted so as to correspond to the inflection point of the oxygen gas supply flow rate-dissolved oxygen concentration curve shown in Fig. 6.

[0082] Fig. 7 shows the changes in the dissolved oxygen concentration over time in the water with dissolved oxygen obtained in this way.

[0083] The results in Fig. 7 show oxygen concentration decrease behavior equivalent to that of water with dissolved oxygen produced by a traditional gas dissolving apparatus that involves pressurization. Here, it can be seen that the oxygen dissolving apparatus of the present invention does not need external energy for pressurization, agitation, and the

like when dissolving oxygen (other than energy for delivering water), and hence is suitable for energy conservation.

[0084] Tap water in a 500-L tank was used as a target to be treated, while the tap water in the tank was circulated at a water amount (8 L/min) and a water pressure of 0.3 MPa with a circulation device equipped with a pump, a pipe, and a valve, the circulating water stream was caused to pass through the gas dissolving apparatus 1.

[0085] The results are shown in Table 1.

[Table 1]

Circulation time (min)	Circulation number (times)	DO value (mg/L)	Water temperature (°C)
0	0	10.8	23.1
5	0.08	11.9	22.8
10	0.16	14.01	22.3
20	0.32	17.85	22.4
30	0.48	21.13	22.5
60	0.96	28.8	22.9
120	1.92	37.9	23.6

[0086] The dissolved oxygen concentration in the tap water in the tank before circulation was 10.8 mg/L. The dissolved oxygen concentration in the tap water in the tank after circulation for 60 minutes (480 L circulation) was 28.8 mg/L, and the dissolved oxygen concentration in the tap water in the tank after circulation for 120 minutes (960 L circulation) was 37.9 mg/L. It can be seen from this that the dissolved oxygen concentration in the tap water increased by approximately four times higher than that before circulation.

[0087] Note that, no change in water temperature in the tank was observed between before circulation and after circulation for 120 minutes. The tank is in a state of being left in a room, and is not subjected to any temperature control from the outside.

[0088] In contrast, in a general-purpose gas dissolving apparatus, the temperature of water in the tank increases because the gas is dissolved with a high pressure. Therefore, it has been common to cool by adding ice or the like.

[0089] The dissolved oxygen concentration was measured with Model No.: HI98198 manufactured by Hanna Instruments.

[0090] Fig. 8 shows the relationship between water pressure and the dissolved oxygen concentration when the oxygen supply device 10 was removed, the gas supply passage 700 was open to the atmosphere, and the water pressure was varied in the apparatus of Fig. 1. It should be noted that fine bubbles were generated at each water pressure.

[0091] It should be noted that self-supply amounts of the atmospheric air when varying the water pressure was as shown in Table 2.

[Table 2]

	Feed water pressure			
	0.2 MPa	0.3 MPa	0.5 MPa	0.75 MPa
Atmospheric air self-supply amount (L/min)	1.01	1.35	2.07	3.14

[0092] It can be seen from the results in Fig. 8 that according to the gas dissolving apparatus of Examples, the oxygen concentration in water can be increased by using the atmospheric air.

[0093] The present invention is not limited in any way to the description of the foregoing embodiments and examples of the invention. The present invention also includes various modifications that can be easily conceived by those skilled in the art without departing from the scope of the claims.

REFERENCE SIGNS LIST

[0094]

1, 2, 3, 4 Gas dissolving apparatus
10 Gas supply source
100 Water stream source

500, 2100	Dissolving section
700	Gas supply passage
1211, 2240	Downstream wall
1220, 2250	Recess

Claims

1. A method of dissolving a gas in a water stream,
the method comprising: creating a negative pressure region in a part of water included in the water stream; and
sucking the gas due to negative pressure in the negative pressure region, thereby entraining the gas into the water
stream and generating fine bubbles.
2. The method according to claim 1, wherein the gas in a state at atmospheric pressure is sucked into the negative
pressure region.
3. The method according to claim 1, wherein the water stream flows through a tube, a vertical downstream wall facing
downstream of the water stream is provided in the tube, and the water stream flows along the downstream wall to
create the negative pressure region.
4. The method according to claim 3, wherein a recess is formed in the downstream wall, and a part of the water stream
flowing into the recess is vaporized due to negative pressure in the recess.
5. The method according to claim 4, wherein the recess penetrates into a peripheral wall of the tube, and
the gas is supplied through a gas supply passage that penetrates from the peripheral wall of the tube to the recess.
6. The method according to claim 1, wherein the gas is one type or two or more types selected from inorganic gases such
as atmospheric air, oxygen, ozone, ammonia, nitrogen, hydrogen, and argon, and organic gases such as carbon
dioxide, and ethane.
7. An apparatus of dissolving a gas into a water stream from a water stream source, the apparatus comprising:
a supply source of the gas; and a dissolving section, the dissolving section comprising:
a tube through which a water stream from the water stream source is allowed to pass;
a vertical downstream wall in the tube, the vertical downstream wall facing downstream of the water stream, the
water stream flowing along the downstream wall to create a negative pressure region; and
a gas supply passage that penetrates from a peripheral wall of the tube to the negative pressure region, the gas
supply passage being connected to the supply source of the gas,
wherein a gas of the supply source of the gas is supplied to the negative pressure region through the gas supply
passage due to negative pressure in the negative pressure region.
8. The apparatus according to claim 7, wherein a recess is formed in the downstream wall, and a part of the water stream
flowing into the recess is vaporized due to negative pressure in the recess.
9. The apparatus according to claim 8, wherein the gas supply passage has an opening in the recess.
10. The apparatus according to claim 9, wherein the gas supply passage penetrates into a peripheral wall of the tube.
11. The apparatus according to claim 7, wherein the gas supply passage has an opening opposing the recess.
12. The apparatus according to claim 7, wherein the supply source of the gas is an adsorbent-type oxygen gas generator,
and oxygen gas supplied from the gas generator is not pressurized at all and is supplied to the gas supply passage.
13. The apparatus according to claim 7, wherein the supply source of the gas is an atmosphere, and the gas supply
passage is open to the atmosphere.
14. The apparatus according to claim 7, wherein the dissolving section generates fine bubbles in the water stream.
15. A gas dissolving apparatus configured to dissolve a gas into water in a tank, the apparatus comprising:

a supply source of the gas; the tank; a dissolving section; and a circulation device of water in the tank, the dissolving section comprising:

5 a tube through which a water stream from the tank by the circulation device is allowed to pass;
a vertical downstream wall in the tube, the vertical downstream wall facing downstream of the water stream,
the water stream flowing along the downstream wall to create a negative pressure region; and
a gas supply passage penetrating from a peripheral wall of the tube to the negative pressure region, the gas
supply passage being connected to the supply source of the gas,
10 wherein a gas from the supply source of the gas is supplied to the negative pressure region through the gas
supply passage due to negative pressure in the negative pressure region and generates fine bubbles.

16. A gas dissolving method using the gas dissolving apparatus according to claim 15, wherein water in the tank is not cooled.

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FIG. 1

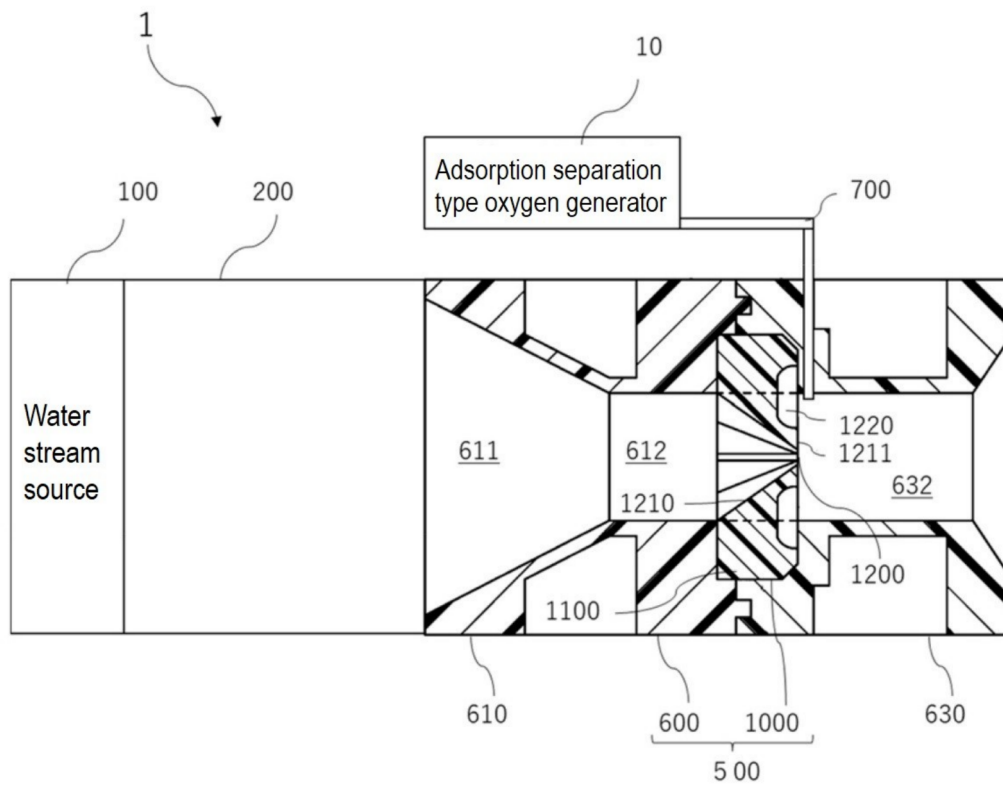


FIG. 2

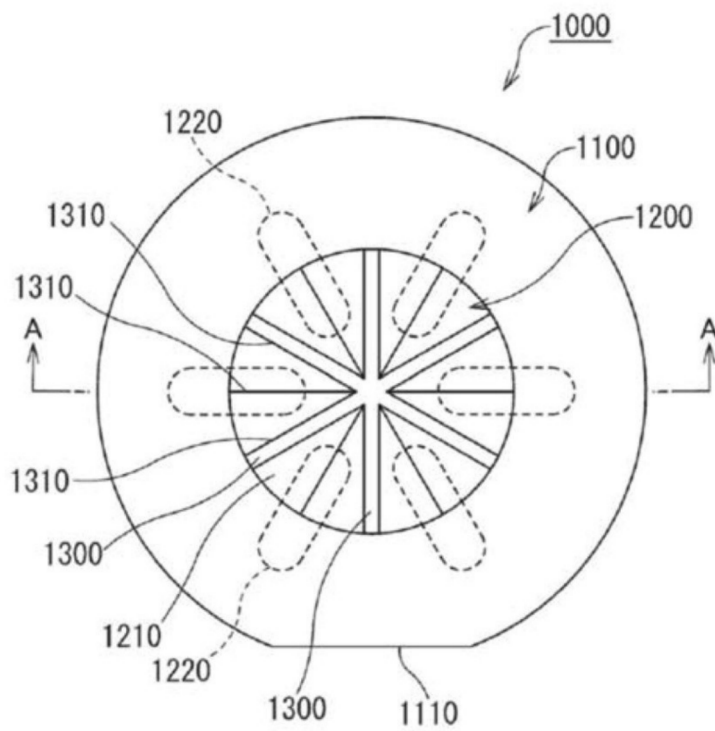


FIG. 3

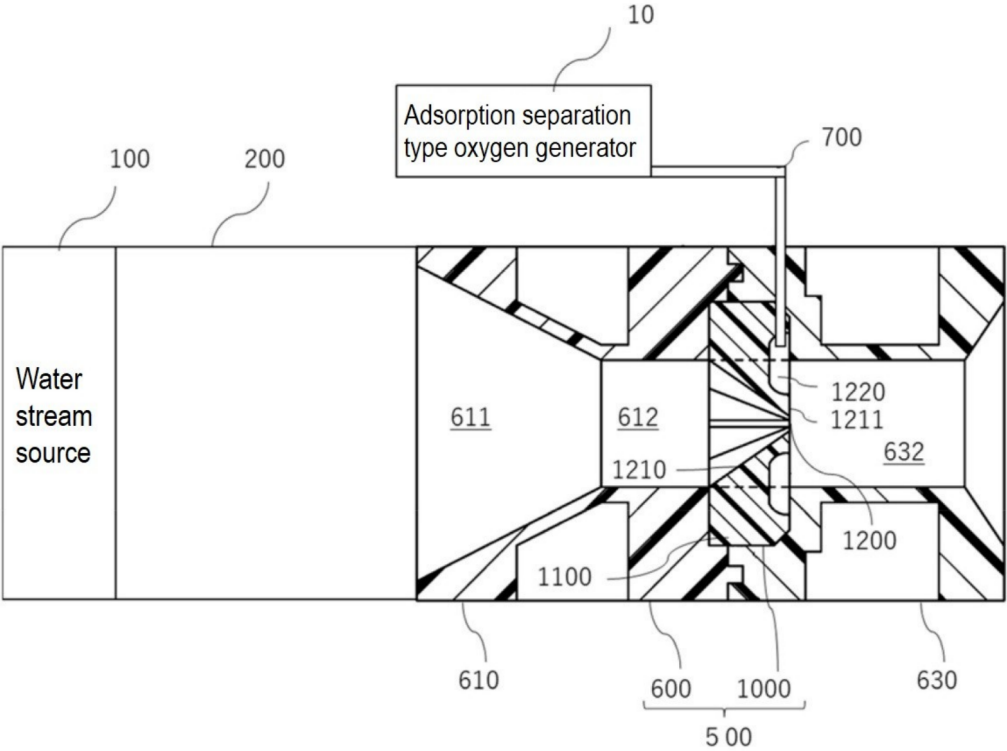


FIG. 4

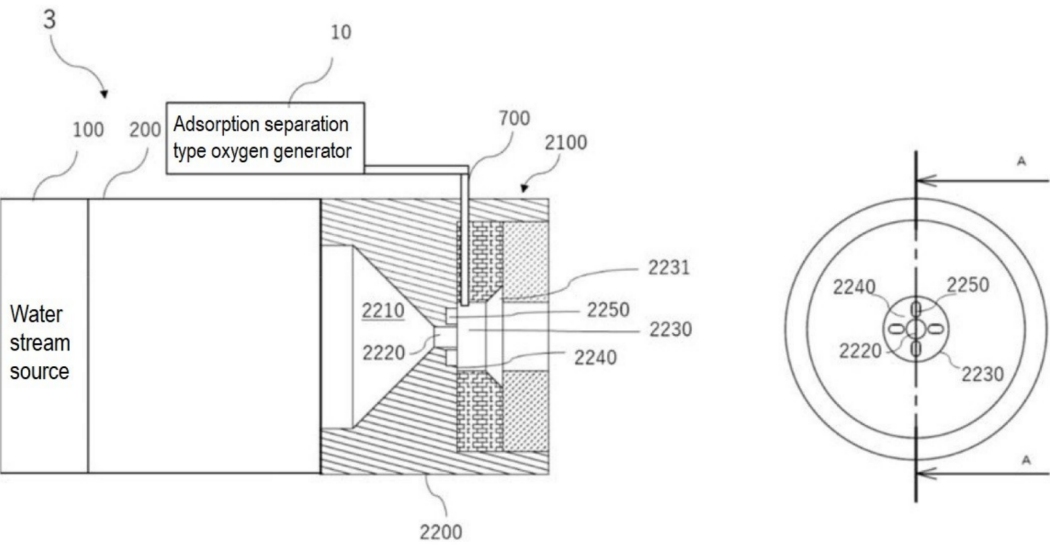


FIG. 5

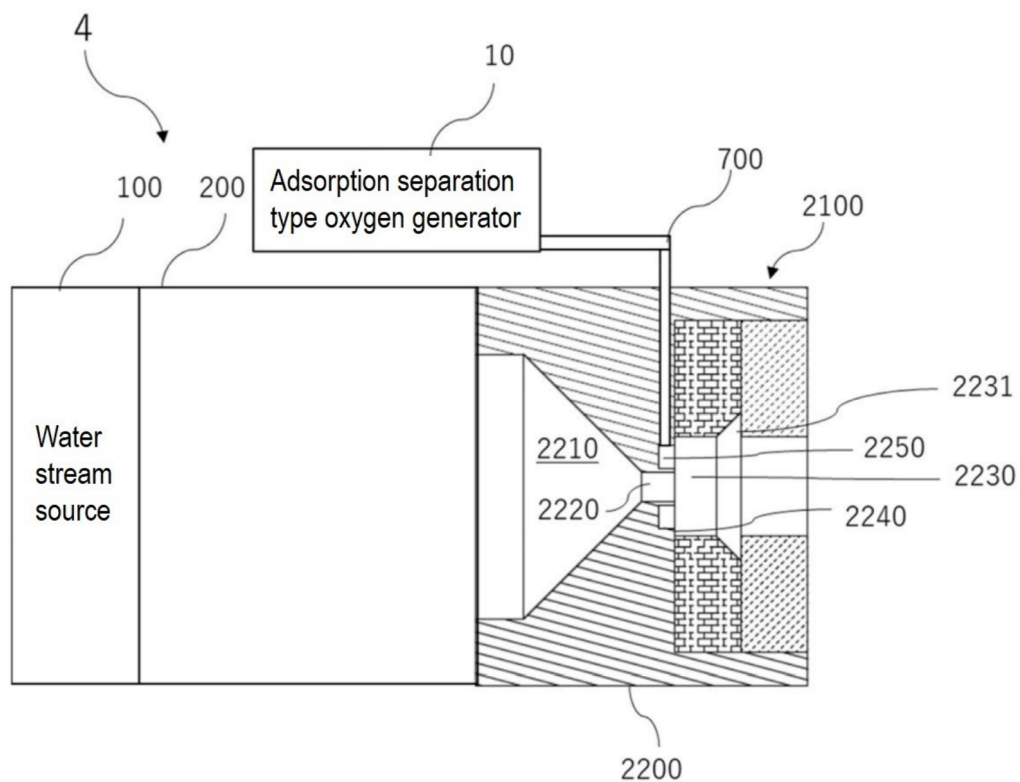


FIG. 6

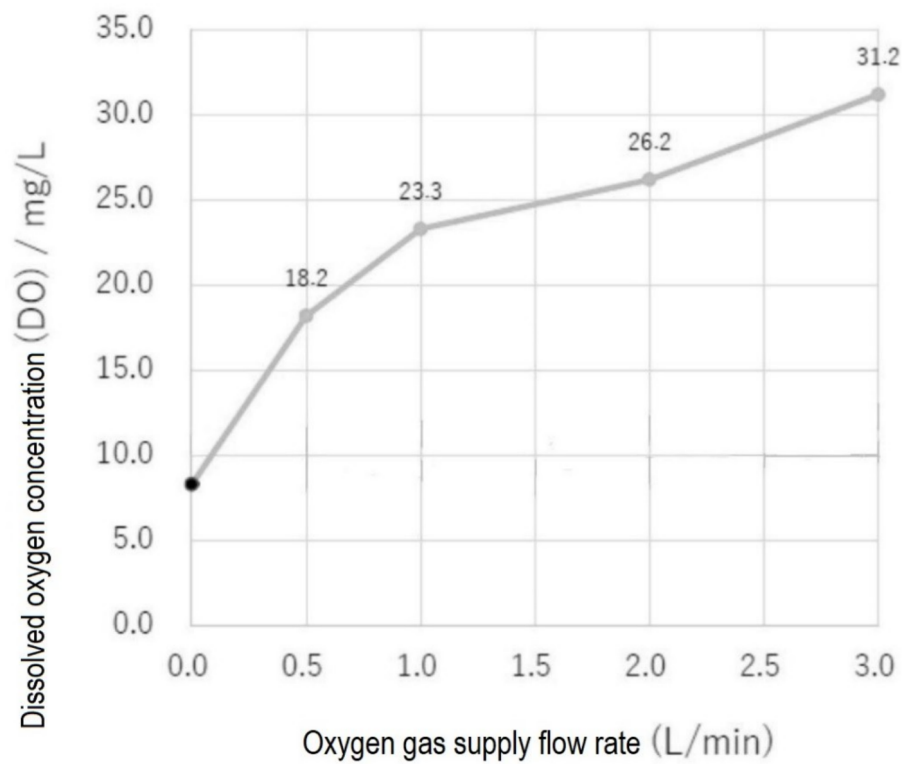


FIG. 7

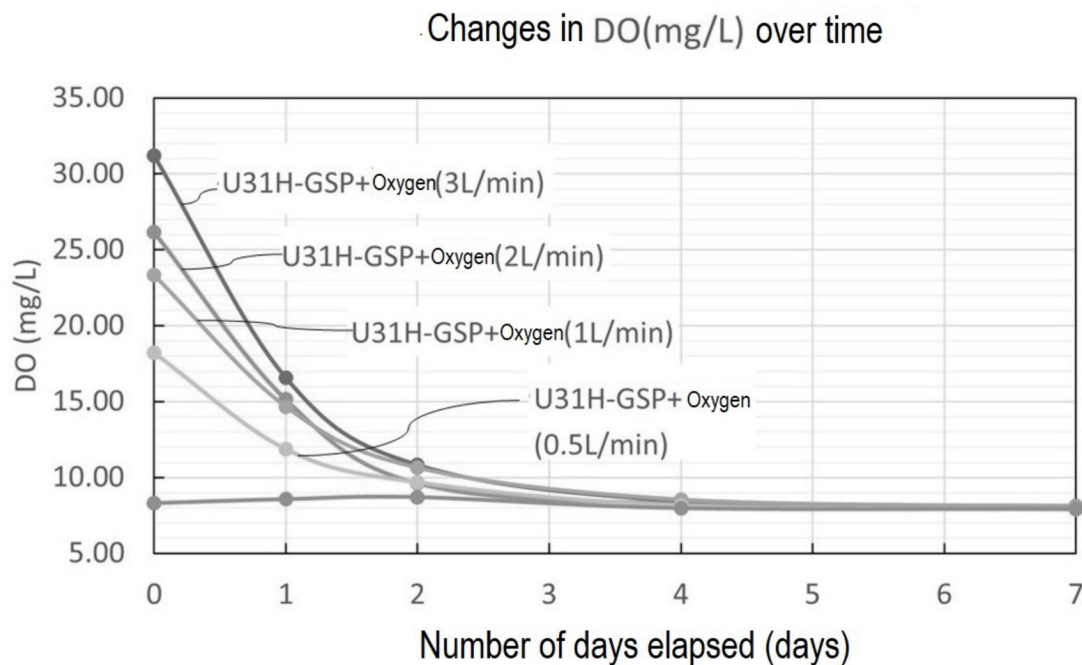
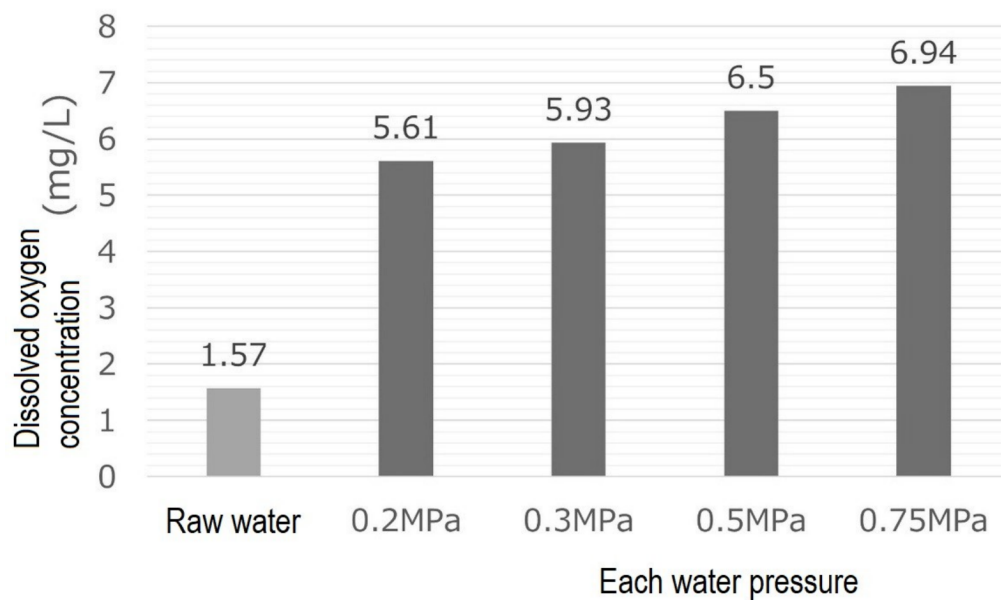


FIG. 8



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2024/026520

A. CLASSIFICATION OF SUBJECT MATTER

B01F 23/2326(2022.01)i; **B01F 21/20**(2022.01)i; **B01F 23/23**(2022.01)i; **B01F 23/2375**(2022.01)i; **B01F 25/51**(2022.01)i; **B01F 25/314**(2022.01)i; **B01F 35/71**(2022.01)i; **B01F 101/48**(2022.01)n

FI: B01F23/2326; B01F25/314; B01F23/2375; B01F25/51; B01F23/23; B01F35/71; B01F21/20; B01F101/48

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)

B01F23/2326; B01F21/20; B01F23/23; B01F23/2375; B01F25/51; B01F25/314; B01F35/71; B01F101/48

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 1971-2024
Registered utility model specifications of Japan 1996-2024
Published registered utility model applications of Japan 1994-2024

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.
X	WO 2019/106908 A1 (TOSHIBA LIFESTYLE PRODUCTS & SERVICES CORPORATION) 06 June 2019 (2019-06-06) claim 1, paragraphs [0043]-[0061], [0164]	1-6
Y		1-6
A		7-16
X	JP 2019-48274 A (OJI HOLDINGS CORPORATION) 28 March 2019 (2019-03-28) claims 1, 7, paragraphs [0015], [0017], examples	1
Y		1-6
A		7-16
X	JP 2012-96216 A (SAKAMOTO, Yasutaka) 24 May 2012 (2012-05-24) claims 1, 17, paragraphs [0100], [0107]	1
Y		1-6
A		7-16



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Date of the actual completion of the international search

04 October 2024

Date of mailing of the international search report

15 October 2024

Name and mailing address of the ISA/JP

**Japan Patent Office (ISA/JP)
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Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2024/026520

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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A	US 5211475 A (MCDERMOTT, M.) 18 May 1993 (1993-05-18)	7-15
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/JP2024/026520

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JP 2019-48274 A	28 March 2019	(Family: none)	
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WO 2016/178436 A2	10 November 2016	(Family: none)	
WO 2018/021330 A1	01 February 2018	US 2019/0176100 A1 US 2021/0331124 A1 US 2023/0372882 A1 EP 3488920 A1 EP 3892365 A1 EP 3915672 A1 CN 109475829 A CN 113648858 A	
US 5211475 A	18 May 1993	EP 408360 A2	
JP 2024-87168 A	01 July 2024	WO 2024/135639 A1	

Form PCT/ISA/210 (patent family annex) (July 2022)

REFERENCES CITED IN THE DESCRIPTION

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- JP 5762210 B [0008]
- JP 6279179 B [0008] [0049]
- JP 6978793 B [0008] [0070]
- JP 2021020153 A [0073] [0074]