(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 4 147 770 A1**

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

(43) Date of publication:
**15.03.2023 Bulletin 2023/11**

(21) Application number: **20934639.4**

(22) Date of filing: **20.08.2020**

(51) International Patent Classification (IPC):
***B01F 1/00*** *(2006.01)* ***B01F 3/04*** *(2006.01)*
***B01F 5/00*** *(2006.01)*

(52) Cooperative Patent Classification (CPC):
**B01F 21/00; B01F 23/20; B01F 25/00**

(86) International application number:
**PCT/JP2020/031529**

(87) International publication number:
**WO 2021/225009 (11.11.2021 Gazette 2021/45)**

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR**
Designated Extension States:
**BA ME**
Designated Validation States:
**KH MA MD TN**

(30) Priority: **08.05.2020 JP 2020082338**

(71) Applicant: **Sanso Electric Co., Ltd.**
**Hyogo 671-2288 (JP)**

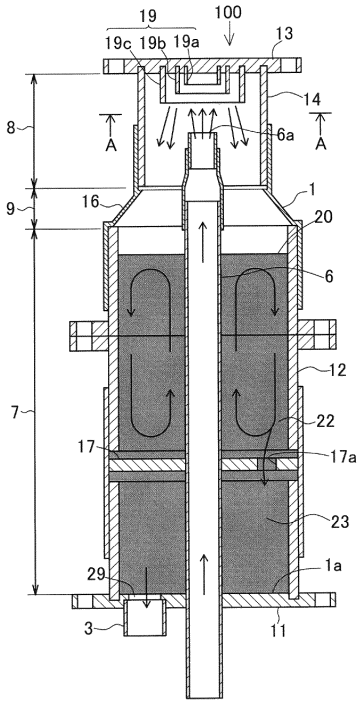
(72) Inventors:
- **CAO Yinchun**
**Himeji-shi Hyogo 671-2288 (JP)**
- **UTSUMI Nobuaki**
**Himeji-shi Hyogo 671-2288 (JP)**

(74) Representative: **Winter, Brandl - Partnerschaft mbB**
**Alois-Steinecker-Straße 22**
**85354 Freising (DE)**

# (54) GAS DISSOLUTION DEVICE

(57) A gas dissolver includes a gas dissolving tank (1) that dissolves gas in liquid inside, a partition (17) dividing an inside of the gas dissolving tank (1) into an upper chamber (22) and a lower chamber (23), an intake tube (6) to introduce a gas-liquid mixture into the gas dissolving tank (1) from outside, and a discharge pipe channel (3) to discharge gas dissolved liquid from the lower chamber (23) of the gas dissolving tank (1). The intake tube (6) has a downstream end (6a) with an opening extending toward a center of a ceiling (13) of the gas dissolving tank (1). The partition (17) includes a connecting path (17a) connecting the upper chamber (22) and the lower chamber (23). The connecting path (17a) is off a center of the partition (17).

Fig. 1




EP 4 147 770 A1

## Description

### FIELD OF INVENTION

**[0001]** The present invention relates to a gas dissolver that dissolves gas in liquid under pressure.

### BACKGROUND ART

**[0002]** A gas dissolver is described in, for example, Patent Literature 1. The gas dissolver described in Patent Literature 1 is a microbubble generator that generates microbubbles in a bath. The gas dissolver in this literature includes a gas dissolving tank (a gas-liquid dissolving tank in Patent Literature 1) that dissolves gas in liquid, a suction pipe channel extending from the bath to a pump for the gas dissolving tank, an intake tube (an inlet pipe channel in Patent Literature 1) extending from the pump into the gas dissolving tank, and a discharge pipe channel extending from the exit of the gas dissolving tank to the bath. A gas intake (a gas intake tube in Patent Literature 1) for introducing gas is located halfway along the suction pipe channel. The gas-liquid dissolving tank is charged with liquid to a predetermined height, thus defining a liquid area and a gas area.

**[0003]** When the pump is driven, the intake tube ejects a gas-liquid mixture in the gas-liquid dissolving tank. The ejected gas-liquid mixture collides with a collision section on the ceiling of the gas-liquid dissolving tank. The collision forms a local high-pressure part, at which the gas dissolves more readily in the liquid. After colliding with the collision section, the gas-liquid mixture falls from the gas area to the liquid area, and air bubbles contained in the gas-liquid mixture enter the liquid area. After entering the liquid area, the air bubbles dissolve in the liquid while being agitated by the flow in the liquid area, and decrease in size. The air bubbles agitated by the flow in the liquid area are discharged partially through the outlet in the gas dissolving tank together with the liquid. The partial air bubbles and the liquid discharged through the outlet flow into the discharge pipe channel.

### CITATION LIST

### PATENT LITERATURE

**[0004]** Patent Literature 1: Japanese Patent No. 4759553

### SUMMARY OF INVENTION

### TECHNICAL PROBLEM

**[0005]** However, the gas dissolving tank in Patent Literature 1 cannot easily increase the dissolved gas concentration due to relatively large air bubbles flowing out in large amounts through the outlet in the gas dissolving tank, and also cannot easily increase the gas dissolving efficiency.

**[0006]** In response to the above issue, one or more aspects of the present invention are directed to a gas dissolver that increases the dissolved gas concentration and the gas dissolving efficiency more easily than known structures.

### SOLUTION TO PROBLEM

**[0007]** A gas dissolver according to a first aspect of the present invention includes a gas dissolving tank that dissolves gas in liquid inside, a partition dividing an inside of the gas dissolving tank into an upper chamber and a lower chamber, an intake tube to introduce a gas-liquid mixture into the gas dissolving tank from outside, and a discharge pipe channel to discharge gas dissolved liquid from the lower chamber of the gas dissolving tank. The intake tube has a downstream end with an opening extending toward a center of a ceiling of the gas dissolving tank. The partition includes a connecting path connecting the upper chamber and the lower chamber. The connecting path is off a center of the partition.

**[0008]** A gas dissolver according to a second aspect of the present invention is the gas dissolver according to the first aspect in which the ceiling may include a collision section defining a protrusion-dent portion, and the intake tube may be located to cause an ejected gas-liquid mixture to collide with the collision section.

**[0009]** A gas dissolver according to a third aspect of the present invention is the gas dissolver according to the second aspect in which the protrusion-dent portion may include protrusions having lower ends extending further downward at positions more outward.

**[0010]** A gas dissolver according to a fourth aspect of the present invention is the gas dissolver according to any one of the first to third aspects in which the lower chamber may have a volume smaller than an effective volume of the upper chamber, where the effective volume of the upper chamber is a part of the upper chamber below the downstream end of the intake tube.

**[0011]** A gas dissolver according to a fifth aspect of the present invention is the gas dissolver according to any one of the first to third aspects in which the discharge pipe channel may be connected to an outlet in a bottom surface of the gas dissolving tank, and the outlet may be off the connecting path as viewed from above.

**[0012]** A gas dissolver according to a sixth aspect of the present invention is the gas dissolver according to any one of the first to fourth aspects in which the intake tube may have a smaller opening area at the downstream end than at an upstream end.

### ADVANTAGEOUS EFFECTS

**[0013]** The gas dissolver according to the above aspects of the present invention increases the dissolved gas concentration and the gas dissolving efficiency easily.

BRIEF DESCRIPTION OF THE DRAWINGS

**[0014]**

FIG. 1 is a sectional view of a gas dissolving tank in one embodiment.
FIG. 2 is a sectional view taken along A-A in FIG. 1.
FIG. 3 is a diagram of a gas dissolver according to the embodiment.
FIG. 4 is a diagram showing a liquid flow in the gas dissolver according to the embodiment.
FIG. 5 is a diagram of a collision section in a modification, corresponding to the sectional view taken along A-A in FIG. 1.

DETAILED DESCRIPTION

**[0015]** A gas dissolver according to one embodiment of the present invention will now be described with reference to the drawings. A gas dissolver 100 according to the present embodiment is a device for dissolving gas in liquid. The gas dissolver 100 includes a gas dissolving tank 1, a suction pipe channel 2, a discharge pipe channel 3, a pump 4, a gas introducer 5, and an intake tube 6. In the present embodiment, the gas is oxygen, and the liquid is water. The gas may be a gas different from oxygen (e.g., air, carbon dioxide, or nitrogen), and the liquid may be a liquid different from water.

**[0016]** The gas dissolving tank 1 dissolves gas in liquid inside under pressure. The inside of the gas dissolving tank 1 illustrated in FIG. 1 includes a first portion 7 that is a substantially cylindrical space having a relatively large diameter, a second portion 8 that is a substantially cylindrical space having a relatively small diameter, and a third portion 9 that is a substantially truncated-cone space defined continuously between the first portion 7 and the second portion 8. The first portion 7 is defined above a bottom plate 11 and inside a large-diameter cylindrical section 12. The second portion 8 is defined below a ceiling 13 and inside a small-diameter cylindrical section 14. The third portion 9 is defined inside a conical cylindrical section 16 tapering from the large-diameter cylindrical section 12 and continuous with the small-diameter cylindrical section 14.

**[0017]** As shown in FIG. 1, the intake tube 6, a partition 17, and a collision section 19 are provided inside the gas dissolving tank 1.

**[0018]** The partition 17 divides the inside of the gas dissolving tank 1 into an upper chamber 22 and a lower chamber 23. In the present embodiment, the partition 17 divides the first portion 7 horizontally. The partition 17 includes at least one connecting path 17a connecting the upper chamber 22 and the lower chamber 23. The one or more connecting paths 17a are formed off the center of the partition 17.

**[0019]** The lower chamber 23 has a smaller volume than the upper chamber 22. With the effective volume of the upper chamber 22 being a part of the upper chamber 22 below a downstream end 6a of the intake tube 6, the volume of the lower chamber 23 is smaller than the effective volume of the upper chamber 22. In the first portion 7 divided horizontally by the partition 17, the part below the partition 17 has a smaller volume than the part above the partition 17. As shown in FIG. 1, the liquid area of the lower chamber 23 is smaller than the liquid area of the upper chamber 22.

**[0020]** The intake tube 6 is located to introduce a gas-liquid mixture into the gas dissolving tank 1 from outside. The intake tube 6 is connected to the downstream end of the suction pipe channel 2 with the pump 4. In the present embodiment, the intake tube 6 extends along the center axis of the gas dissolving tank 1, with an opening in the downstream end 6a opposing the center of the ceiling 13 of the gas dissolving tank 1. The intake tube 6 extends through the center of the bottom (the bottom plate 11) of the gas dissolving tank 1 and the center of the partition 17. To increase the rate of the gas-liquid mixture ejected from the intake tube 6, as shown in FIG. 1, it is desirable that the intake tube 6 has a smaller opening area at the downstream end 6a than at an upstream end 6b (refer to FIG. 4).

**[0021]** The collision section 19 includes a protrusion-dent portion on the ceiling 13. The protrusion-dent portion of the collision section 19 on the ceiling 13 includes protrusions having lower ends extending further downward at positions more outward. In the present embodiment, the collision section 19 includes multiple members that are arranged concentrically, or specifically, a first cylindrical member 19a to a third cylindrical member 19c. In the example shown in FIG. 1, the lower ends of the first cylindrical member 19a to the third cylindrical member 19c are located lower at positions more outward. The area of the ceiling 13 with the collision section 19 (the area inside the outer diameter of the third cylindrical member 19c designated by D in the example shown in FIG. 2) is smaller than the area of a liquid surface 20 in the gas dissolving tank 1. These dimensions allow liquid colliding with the collision section 19 to fall outward in the radial direction of the gas dissolving tank 1, increasing the area of contact between the liquid and the gas and thus improving the gas dissolving efficiency.

**[0022]** The suction pipe channel 2 has an upstream end serving as a suction port for liquid. In the present embodiment, the upstream end of the suction pipe channel 2 is submerged in a liquid 27 stored in a container 26 as shown in FIG. 4.

**[0023]** The pump 4 is located between the downstream end of the suction pipe channel 2 and the upstream end of the intake tube 6. Thus, when the pump 4 is driven, the liquid stored in the container 26 is drawn into the suction pipe channel 2 and pressure-fed through the intake tube 6 into the gas dissolving tank 1. The inside of the gas dissolving tank 1 is pressurized when the pump 4 is driven.

**[0024]** The gas introducer 5 is located halfway along the intake tube 6. The gas introducer 5 mixes com-

pressed gas fed from a compressed-gas source 28 into the liquid flowing in the intake tube 6. The compressed gas is fed from the compressed-gas source 28 at a pressure higher than the pressure in the suction pipe channel 2.

**[0025]** The discharge pipe channel 3 has an upstream end connected to an outlet 29 in a bottom surface 1a of the gas dissolving tank 1. The discharge pipe channel 3 has a downstream end located in the container 26. Liquid is ejected through the downstream end with an increased dissolved gas concentration into the container 26.

**[0026]** In the present embodiment, as shown in FIG. 3, the gas dissolving tank 1 is supported by a gas dissolving tank support 31. The gas dissolving tank support 31 illustrated in this figure includes a housing 33 supporting the gas dissolving tank 1 and also covering the gas dissolving tank 1. In detail, the gas dissolving tank support 31 includes the housing 33 and a mount 34 fixed to the housing 33, and the bottom plate 11 of the gas dissolving tank 1 is, for example, bolted to the mount 34. The housing 33 also includes a top board 33a to which the ceiling 13 of the gas dissolving tank 1 is, for example, bolted. The pipes serving as the intake tube 6 and the discharge pipe channel 3 protrude downward from the mount 34 by predetermined dimensions and extend in different lateral directions through the housing 33 to the outside. In the example shown in FIG. 3, the gas dissolving tank support 31 is movable on casters 32 at the bottom.

**[0027]** When the pump 4 is driven in the gas dissolver 100 with the structure described above, the liquid is drawn from the container 26 into the suction pipe channel 2, and the gas introducer 5 mixes gas into the liquid flowing in the intake tube 6 to form a gas-liquid mixture. The resultant gas-liquid mixture is ejected through the downstream end 6a of the intake tube 6 into the gas dissolving tank 1.

**[0028]** In the gas dissolving tank 1, the gas dissolves in the liquid depending on the area of contact between the liquid and the gas and on the pressure in the gas dissolving tank 1. In the upper chamber 22 of the gas dissolving tank 1, the gas area and the liquid area are defined. The gas-liquid mixture ejected through the downstream end 6a of the intake tube 6 first collides with the collision section 19, forming a local high-pressure part, at which the gas (air bubbles) dissolves efficiently in the liquid. The gas-liquid mixture colliding with the collision section 19 then passes through the gas area and reaches the liquid area. When the gas-liquid mixture falls through the gas area, the area of contact between the liquid and the gas increases, thus promoting the dissolution of the gas in the liquid also in this area.

**[0029]** After the gas-liquid mixture reaches the liquid area, air bubbles contained in the gas-liquid mixture are agitated by the flow in the liquid area (the flow indicated by arrows in FIG. 1) and dissolved in the liquid while decreasing in size. The liquid in the upper chamber 22 moves to the lower chamber 23 through the connecting path 17a in the partition 17. The connecting path 17a, which is off the center of the partition 17, is less likely to allow air bubbles in the upper chamber 22 to move to the lower chamber 23 than in the structure with the connecting path 17a at the center of the partition 17 or at the outer periphery of the partition 17. Thus, most air bubbles are likely to remain in the upper chamber 22, and most air bubbles dissolve in the liquid in the upper chamber 22 until they disappear or dissolve in the liquid as nano-sized air bubbles.

**[0030]** After air bubbles move from the upper chamber 22 to the lower chamber 23 through the connecting path 17a, most of the moved air bubbles are not immediately discharged through the outlet 29 and can again be dissolved in the liquid while being agitated by the flow of the liquid in the lower chamber 23 with the outlet 29 positioned off the connecting path 17a as viewed from above.

**[0031]** This minimizes the amount of air bubbles discharged through the outlet 29 without being dissolved in the liquid, and the gas dissolved liquid fed through the discharge pipe channel 3 to the container 26 has a high dissolved gas concentration. In addition, the reduced amount of gas discharged through the discharge pipe channel 3 allows higher gas dissolving efficiency.

**[0032]** As described above, in the gas dissolver 100 according to the present embodiment, the gas dissolving tank 1 includes the partition 17 with the connecting path 17a. With these components, air bubbles in the liquid area cannot easily be discharged through the outlet 29, and thus a larger amount of gas remains in the gas dissolving tank 1 and dissolves in the liquid. Thus, the gas dissolver 100 according to the present embodiment increases the dissolved gas concentration and the gas dissolving efficiency more easily than a known gas dissolver.

**[0033]** In the gas dissolver 100 according to the present embodiment, the volume of the lower chamber 23 is smaller than the effective volume of the upper chamber 22. Thus, the liquid area in the upper chamber 22 may have larger capacity than the liquid area in the lower chamber 23. To maximize air bubbles held in the gas dissolving tank 1 without being discharged through the outlet 29, it is desirable that the liquid area in the upper chamber 22 containing more air bubbles is larger than the lower chamber 23 containing less air bubbles. In the present embodiment, the liquid area in the upper chamber 22 may have larger capacity than the liquid area in the lower chamber 23, and thus the dissolved gas concentration and also the gas dissolving efficiency are more likely to increase.

Other Embodiments

**[0034]** In the embodiment described above, the collision section 19 includes multiple members that are arranged concentrically, or specifically, the cylindrical members 19a to 19c. In a modification, as shown in FIG. 5, a collision section may include concentrically arranged

curved plates 19Aa to 19Ac having different radiuses and each including two pieces. The curved plates 19Aa to 19Ac also have lower ends extending further downward at positions more outward. The collision section 19 is not limited to these two examples and may have various forms with a protrusion-dent portion on the lower surface of the ceiling 13.

**[0035]** In the embodiment described above, the intake tube 6 extends through the center of the bottom plate 11 of the gas dissolving tank 1 and the center of the partition 17 and along the center axis of the gas dissolving tank 1. However, the intake tube 6 may be located in other forms. For example, as shown in FIG. 5 in Patent Literature 1, an intake tube may extend from the outside through the side of the gas dissolving tank in a lateral direction to the inside, bend upward at the center of the gas dissolving tank, and extend along the center axis.

**[0036]** The present invention may be embodied in various other forms without departing from the spirit or the main features of the present invention. The embodiments described above are thus merely illustrative in all respects and should not be construed to be restrictive.

## INDUSTRIAL APPLICABILITY

**[0037]** The present invention is applicable to, for example, a gas dissolver that dissolves gas in liquid under pressure.

## REFERENCE SIGNS LIST

**[0038]**

| | |
|---|---|
| 1 | gas dissolving tank |
| 3 | discharge pipe channel |
| 6 | intake tube |
| 6a | downstream end of intake tube |
| 13 | ceiling |
| 17 | partition |
| 17a | connecting path |
| 22 | upper chamber |
| 23 | lower chamber |
| 27 | liquid |
| 29 | outlet |
| 100 | gas dissolver |

## Claims

**1.** A gas dissolver, comprising:

a gas dissolving tank configured to dissolve gas in liquid inside;
a partition dividing an inside of the gas dissolving tank into an upper chamber and a lower chamber;
an intake tube configured to introduce a gas-liquid mixture into the gas dissolving tank from outside; and
a discharge pipe channel configured to discharge gas dissolved liquid from the lower chamber of the gas dissolving tank,
wherein the intake tube has a downstream end with an opening extending toward a center of a ceiling of the gas dissolving tank, and
the partition includes a connecting path connecting the upper chamber and the lower chamber, the connecting path being off a center of the partition.

**2.** The gas dissolver according to claim 1, wherein

the ceiling includes a collision section defining a protrusion-dent portion, and
the intake tube is located to cause an ejected gas-liquid mixture to collide with the collision section.

**3.** The gas dissolver according to claim 2, wherein
the protrusion-dent portion includes protrusions having lower ends extending further downward at positions more outward.

**4.** The gas dissolver according to claim 1 to 3, wherein the lower chamber has a volume smaller than an effective volume of the upper chamber, where the effective volume of the upper chamber is a part of the upper chamber below the downstream end of the intake tube.

**5.** The gas dissolver according to any one of claim 1 to 3, wherein

the discharge pipe channel is connected to an outlet in a bottom surface of the gas dissolving tank, and
the outlet is off the connecting path as viewed from above.

**6.** The gas dissolver according to any one of claims 1 to 4, wherein
the intake tube has a smaller opening area at the downstream end than at an upstream end.

Fig. 1

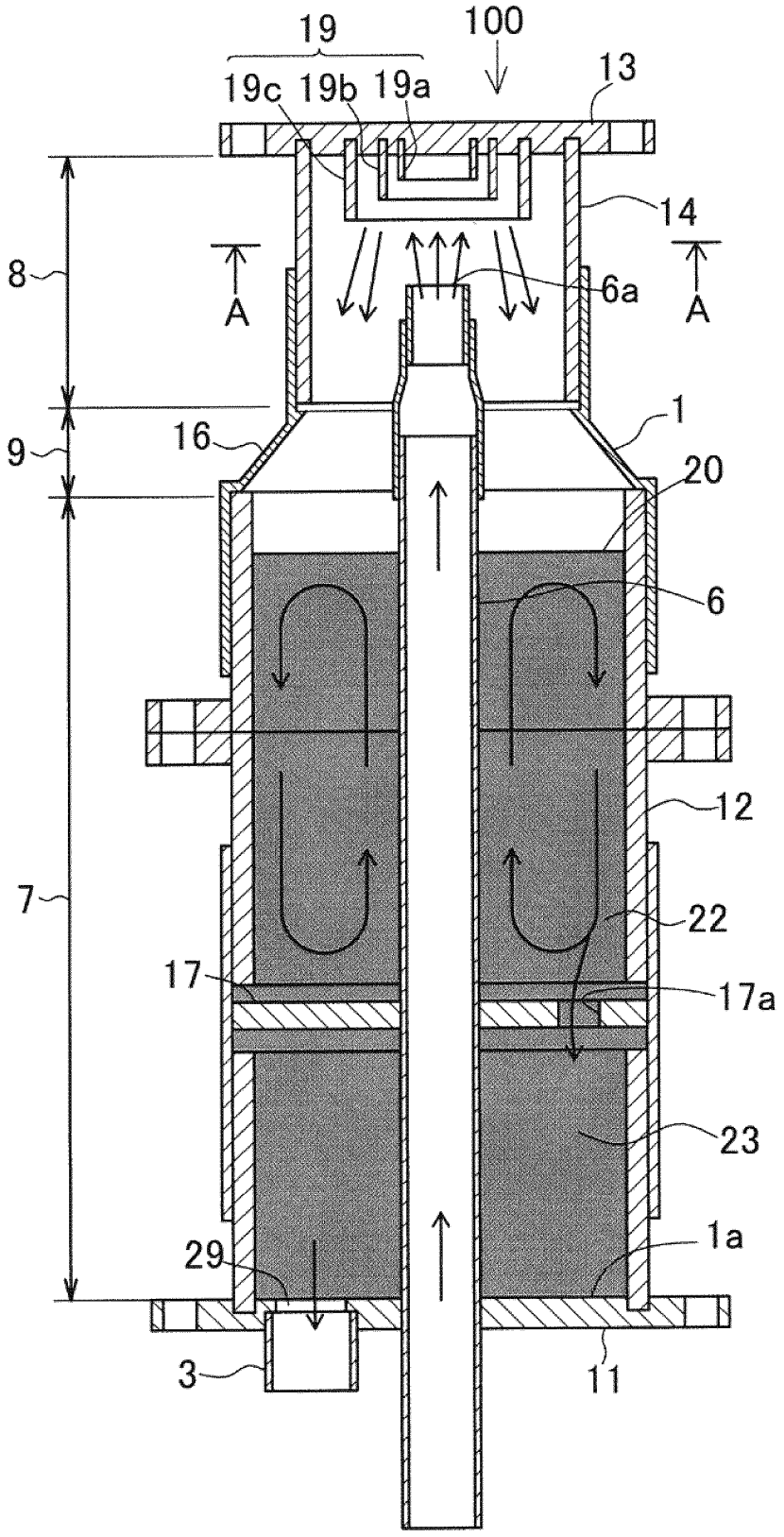


Fig. 2

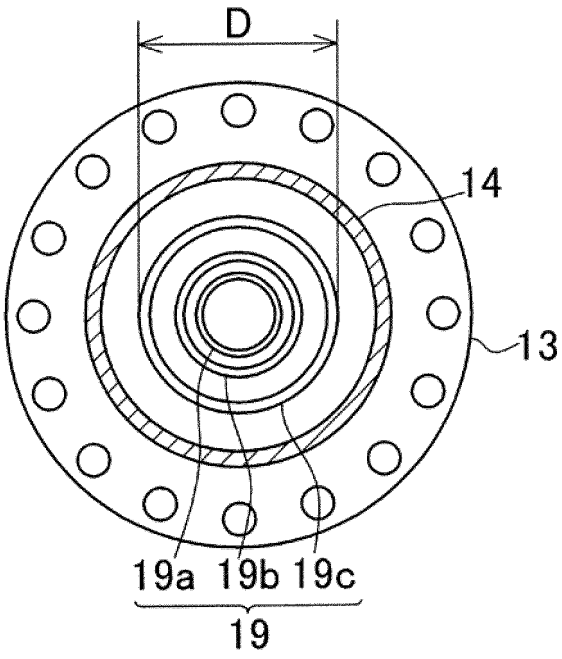


Fig. 3

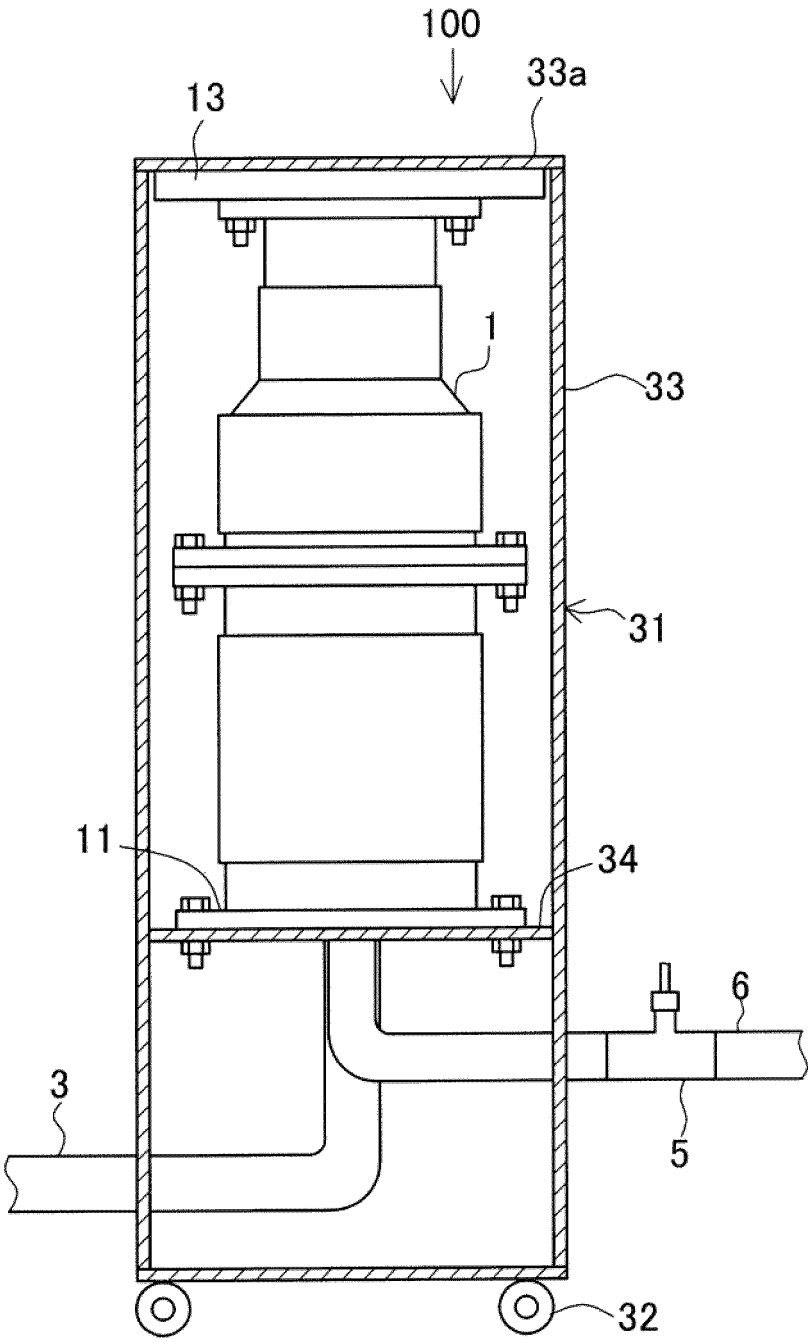


Fig. 4

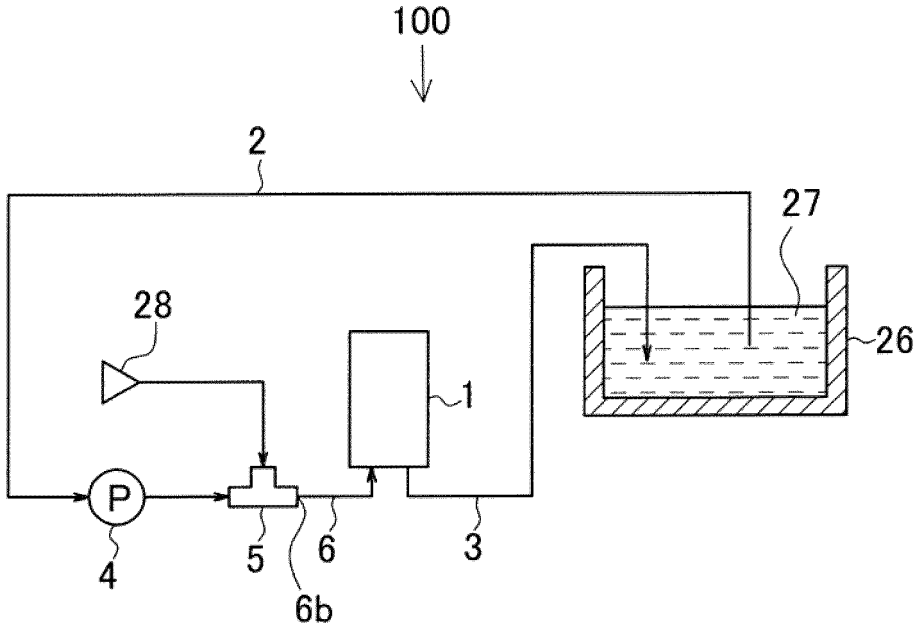
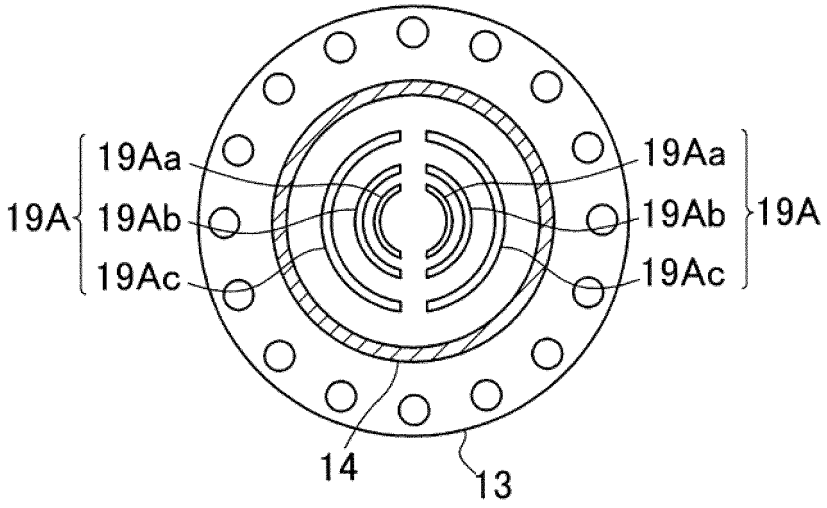

100
2
27
28
26
1
P
4
5
6
6b
3

Fig. 5


19A
19Aa
19Ab
19Ac
19Aa
19Ab
19Ac
19A
14
13

**INTERNATIONAL SEARCH REPORT**

International application No.
PCT/JP2020/031529

A. CLASSIFICATION OF SUBJECT MATTER
Int. Cl. B01F1/00(2006.01)i, B01F3/04(2006.01)i, B01F5/00(2006.01)i
FI: B01F1/00 A, B01F3/04 Z, B01F5/00 D

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)
Int. Cl. B01F1/00, B01F3/04, B01F5/00

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 1971-2020
Registered utility model specifications of Japan 1996-2020
Published registered utility model applications of Japan 1994-2020

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<br>Y | JP 2006-180829 A (SEIWA PRO KK) 13 July 2006, claims, paragraphs [0026]-[0108], fig. 1-12 | 1-2, 6<br>2-6 |
| X<br>Y | JP 2007-75749 A (MATSUE DOKEN KK) 29 March 2007, claims, paragraphs [0001], [0036]-[0062], fig. 1-3, 6-10 | 1, 6<br>2-6 |
| X<br>Y | JP 2014-104373 A (KANKYO SYSTEM KK) 09 June 2014, claims, paragraphs [0001], [0025]-[0048], fig. 1-3 | 1, 6<br>2-6 |
| Y | JP 2009-112909 A (SANSO ELECTRIC CO.,LTD.) 28 May 2009, claims, paragraphs [0021], [0033]-[0044], fig. 5-11 | 2-6 |

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 05.10.2020 | 20.10.2020 |
| Name and mailing address of the ISA/<br>Japan Patent Office<br>3-4-3, Kasumigaseki, Chiyoda-ku,<br>Tokyo 100-8915, Japan | Authorized officer<br><br>Telephone No. |

Form PCT/ISA/210 (second sheet) (January 2015)

**INTERNATIONAL SEARCH REPORT**
Information on patent family members

International application No.
PCT/JP2020/031529

| Patent Documents referred to in the Report | Publication Date | Patent Family | Publication Date |
|---|---|---|---|
| JP 2006-180829 A | 13.07.2006 | (Family: none) | |
| JP 2007-75749 A | 29.03.2007 | (Family: none) | |
| JP 2014-104373 A | 09.06.2014 | KR 10-2014-0066073 A | |
| JP 2009-112909 A | 28.05.2009 | KR 10-2009-0045848 A | |

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

## REFERENCES CITED IN THE DESCRIPTION

*This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.*

### Patent documents cited in the description


- JP 4759553 B **[0004]**