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

(11) EP 3 088 075 A1

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

(43) Date of publication:
02.11.2016 Bulletin 2016/44

(21) Application number: **14874879.1**

(22) Date of filing: **04.11.2014**

(51) Int Cl.:
B01F 7/26 (2006.01)

(86) International application number:
PCT/JP2014/079194

(87) International publication number:
WO 2015/098290 (02.07.2015 Gazette 2015/26)

(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

(30) Priority: **26.12.2013 JP 2013270311**

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(54) STIRRING BLADE AND STIRRING DEVICE

(57) Provided is a stirring impeller that is attached to a stirring shaft provided in a stirring device. The stirring impeller includes a plate-shaped support part that is attached to the stirring shaft, and a plurality of blade units that are arranged on an outer peripheral edge side of the support part. Each blade units includes a first blade part that protrudes from one of the support part, a second blade part that protrudes from the other one of the support part and that is asymmetrical to the first blade part, and an opening that is formed in at least one of the first blade part and the second blade part.

Fig . 2(a)

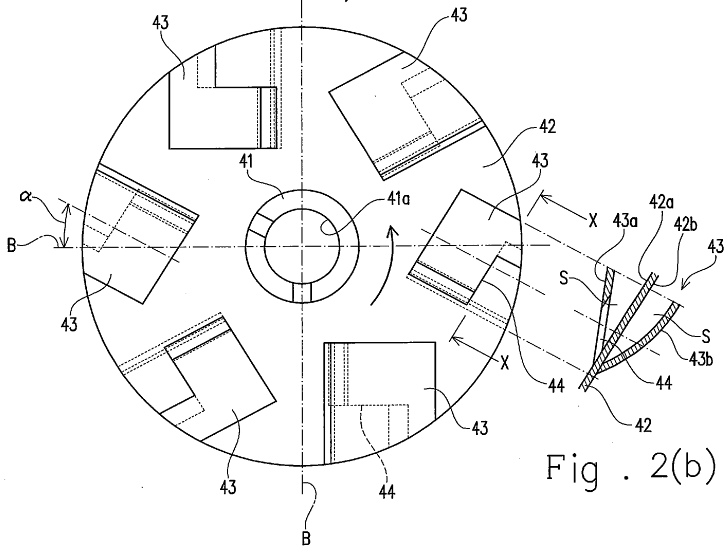

Fig . 2(b)

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Description

Incorporation by Reference

[0001] Priority is claimed to Japanese Patent Application No. 2013-270311, filed December 26, 2013, the entire content of which is incorporated herein by reference.

Technical Field

[0002] The present invention relates to a stirring impeller intended for mixing and a stirring device including the same.

Background Art

[0003] In the related art, for example, a stirring device including a cylindrical stirred tank, a stirring shaft disposed at a central part of the stirred tank, and a stirring impeller attached to a lower part side of the stirring shaft is known as a stirring device that stirs an object to be stirred.

[0004] Additionally, a stirring impeller including a plate-shaped member attached to the stirring shaft and a plurality of flat plate-shaped blade parts fixed to an outer peripheral side of the plate-shaped member is known as a stirring impeller provided in this type of stirring device. According to this stirring device, if the stirring shaft rotates around an axis center, the stirring impeller rotates together with the stirring shaft, and the object to be stirred is stirred and mixed by this rotation.

[0005] However, in a case where the object to be stirred is stirred using such a stirring impeller, a lot of cavities maybe generated on back sides of the flat plate-shaped blade parts (cavitation) . In that case, there is a concern that stirring efficiency may degrade.

[0006] Thus, a stirring impeller configured so that a longitudinal section of each blade part has a shape that is curved or bent in a direction opposite to the rotational direction of the blade part is suggested (refer to Japanese Unexamined Patent Application Publication No. 2004-35724). According to this stirring impeller, cavitation is suppressed.

Citation List

Patent Literature

[0007] [PTL 1] Japanese Unexamined Patent Application Publication No. 2004-35724

Summary of Invention

Technical Problem

[0008] However, also in the stirring impeller as illustrated in the Japanese Unexamined Patent Application Publication No. 2004-35724, cavitation occurs on the back side of the blade part. For this reason, it cannot still be said that suppression of cavitation is sufficient. Additionally, since the resistance that the stirring impeller receives from the object to be stirred is relatively strong, a large driving force is required in an amount equal to the resistance. In this way, it cannot be said that the above stirring impeller has sufficient stirring efficiency, and a stirring impeller with further improved stirring efficiency is desired.

[0009] An object of the invention is to provide a stirring impeller with improved stirring efficiency and a stirring device including the same, in view of the above problems.

Solution to Problem

[0010] A stirring impeller related to the invention is a stirring impeller to be attached to a stirring shaft provided in a stirring device. The stirring impeller includes a plate-shaped support part that is attached to the stirring shaft; and a plurality of blade units that are disposed on an outer peripheral edge side of the support part. The support part includes a first surface and a second surface. Each of the blade units includes a first blade part that protrudes from one of the first surface and the second surface in the support part, a second blade part that protrudes from the other one of the first surface and the second surface in the support part and is made unsymmetrical to the first blade part, and an opening that is formed in at least one of the first blade part and the second blade part.

[0011] Additionally, in the stirring impeller of the above configuration, the support part may be formed in a circular shape. The plurality of blade units may be provided at predetermined intervals along a circumferential direction of the support part. The first blade part in one of two blade units adjacent to each other in the circumferential direction of the support part may be provided on the first surface of the support part, the first blade part in the other one of the two adjacent blade units may be provided on the second surface of the support part, the second blade part of the one blade unit may be provided on the second surface of the support part, and the second blade part of the other blade unit may be provided on the first surface of the support part.

[0012] Additionally, regarding the first blade part and the second blade part that are made asymmetrical to each other, for example, a configuration in which the first blade part is formed in a linear shape and the second blade part is formed in a curved shape may be adopted.

Brief Description of Drawings

[0013]

Fig. 1 is a schematic longitudinal sectional view of a stirring device including a stirring impeller related to a first embodiment of the invention.

Fig. 2 (a) is a top view of the stirring impeller related

to the present embodiment. Fig. 2 (b) is a sectional view as seen in the direction of arrow X-X of Fig. 2(a).
Fig. 3 is a partial side view illustrating an example of a blade unit in the stirring impeller related to the present embodiment.
Fig. 4(a) is a top view of the stirring impeller related to the present embodiment provided for a performance test. Fig. 4(b) is a sectional view as seen in the direction of arrow X-X of Fig. 4(a).
Fig. 5 illustrates test data of the performance test. An upper graph is a graph illustrating the relationship between ventilation volume and kLa (overall mass transfer capacity coefficient). A lower graph is a graph illustrating the relationship between the ventilation volume and power (per unit volume) transmitted to liquid.

Description of Embodiments

[0014] Hereinafter, a stirring impeller related to a first embodiment of the invention together with a stirring device including this stirring impeller will be described referring to Figs. 1 to 3. In addition, in Fig. 1, the stirring impeller 4 is schematically illustrated by a dashed line, and the stirring impeller 4 is illustrated in detail in Figs. 2 and 3.

[0015] A stirring device 1 including the stirring impeller 4 of the present embodiment is a vertical stirring device. The stirring device 1 includes a stirred tank 2 that contains an object (liquid L) to be stirred, a stirring shaft 3 that is rotatably attached within the stirred tank 2, the stirring impeller 4 that is attached to the stirring shaft 3, and a driving unit 5 that rotates the stirring shaft 3. Additionally, the stirring device 1 further includes a gas supply unit 6 that supplies another object (gas G) to be stirred into the stirred tank 2 from a bottom part 22 of the stirred tank 2. In addition, in the present embodiment, objects to be stirred that are contained in the stirred tank 2 are the liquid L and the gas G. Although a case where the gas G is dispersed in liquid is described below as an example, the kind of object to be stirred is not particularly limited. Additionally, the liquid L also includes liquid or the like with higher viscosity and lower flowability other than liquid with lower viscosity and higher flowability.

[0016] The stirred tank 2 is formed in a cylindrical shape that is long in a longitudinal direction. Specifically, the stirred tank 2 includes a cylindrical body part 21, a bottom part 22 that is attached to a lower end of the body part 21 and is semi-elliptical, dish-shaped, or the like in sectional shape, and a top part 23 that is attached to an upper end of the body part 21 and is semi-elliptical, dish-shaped, or the like in sectional shape. Additionally, the stirred tank 2 holds the stirring shaft 3 so that an axial center direction A of the stirring shaft 3 coincides with a vertical direction (upward-downward direction of Fig. 1).

[0017] The stirring shaft 3 is disposed at a central part of the stirred tank 2. A lower end part of the stirring shaft 3 is supported via a bearing (not illustrated) provided at the bottom part 22 of the stirred tank 2. Meanwhile, an upper end part of the stirring shaft 3 extends above the top part 23 of the stirred tank 2, and is connected to the driving unit 5 (here, for example referred to as a motor M.) disposed above the top part 23. The stirring shaft 3 rotates under the driving of the driving unit 5. In addition, a configuration in which the lower end part of the stirring shaft 3 is not supported at all may be adopted as the stirring shaft 3. Additionally, a configuration in which the lower end part of the stirring shaft 3 extends below the bottom part 22 and is connected to the driving unit 5 disposed below the bottom part 22 may be adopted.

[0018] As illustrated in Figs. 2 and 3, the stirring impeller 4 includes a cylindrical boss 41 that is attached to the stirring shaft 3, a tabular or circular (disk-shaped or doughnut-shaped) support part 42 that extends in a radial direction B of the stirring shaft 3 from the boss 41, and a plurality of blade units 43 that are attached to a peripheral edge part (outer peripheral edge side) of the support part 42. The support part 42, the boss 41, and the blade units 43 are fixed by welding or the like, respectively.

[0019] As illustrated in Fig. 2 (a), the boss 41 has a through-hole 41a inserted through the stirring shaft 3. As for the stirring impeller 4, the stirring shaft 3 is inserted through the through-hole 41a of the boss 41. The stirring impeller 4 is attached to the stirring shaft 3 by the boss 41 and the stirring shaft 3 being screw-fastened, welded, or the like.

[0020] The support part 42 is formed to protrude to the outer peripheral side in the radial direction B from an outer peripheral surface of the boss 41 so that the boss 41 is located at the center thereof. Additionally, the support part 42 is fixed to the boss 41 so as to be orthogonal to the axial center direction A of the stirring shaft 3. The length of the support part 42 in the radial direction B of the boss 41 can be appropriately designed according to the radius of the stirred tank 2, or the like, and can be, for example, about 20 to 50% of the diameter of the stirred tank 2, although not particularly limited.

[0021] As illustrated in Fig. 2(a), the plurality of blade units 43 (six in the illustrated example) are arranged at predetermined intervals along a circumferential direction of the support part 42. Each blade unit 43 is arranged so as not to jump out outward in the radial direction from the outer peripheral edge of the support part 42. In the present embodiment, an outer peripheral edge of each blade unit 43 and the outer peripheral edge of the support part 42 coincide with each other in a plan view. As illustrated in Fig. 2(b), the blade unit 43 has a first blade part 43a that protrudes from an upper surface (first surface) 42a that is one surface of the support part 42 and is formed in a linear shape viewed in the radial direction, and a second blade part 43b that protrudes from a lower surface (second surface) 42b that is the other surface of the support part 42 and is formed in a curved shape viewed in the radial direction. Additionally, one end of the blade unit 43 is fixed to the support part 42, and the other end of the blade unit 43 is arranged at a certain distance from the support part 42. The support part 42 is rotated toward a side where the blade unit 43 is released.

[0022] Since the first blade part 43a is formed in a linear shape viewed in the radial direction and the second blade part 43b is formed in a curved shape viewed in the radial direction, both of the blade parts 43a and 43b have asymmetrical shapes on the basis of the support part 42. The first blade part 43a is fixed to one surface of the support part 42 in a thickness direction. The second blade part 43b is fixed to the other surface of the support part 42.

[0023] The first blade part 43a has an opening 44 at apart thereof. The opening 44, as illustrated in Fig. 2, is formed such that predetermined regions on a root side and a radial outer side of the first blade part 43a are cut off in a linear shape, and has a space through which an object to be stirred passes. In addition, the opening 44 may be formed in the second blade part 43b. That is, the opening 44 may be formed in at least one (one or both) of the first blade part 43a and the second blade part 43b. The second blade part 43b is formed in a circular-arc curved shape viewed in the radial direction. This curved shape is not limited to a circular-arc shape, and may be, for example, a shape in which a plurality of linear portions are connected.

[0024] The circular-arc curved shape of the second blade part 43b is, specifically, a shape that is indicated in Fig. 2(a) and that is cured with a constant curvature radius (for example, a curvature radius m5 illustrated in Fig. 4(b)) between two end edges having a parallel relationship with a one-dot chain line showing a receding angle α. In addition, although the second blade part 43b of the present embodiment is curved with the constant curvature radius m5, the invention is not limited to this, and the second curved part may be formed, for example, in a shape that is curved with different curvature radii depending on portions. Specifically, the second blade part has a shape of which the curvature radius is made different partially from the side of the second blade part 43b fixed to the support part 42 toward an end part of the second blade part 43b.

[0025] Additionally, although the second blade part 43b of the present embodiment is formed with the same curvature radius in a direction along a one-dot chain line showing the receding angle α, the invention is not limited to this, and the second blade part may have different curvature radii in this direction. Specifically, the curvature radius of the second blade part 43b may also be changed from the outer peripheral side of the support part 42 toward the center side of the support part 42.

[0026] Additionally, the center side of the curvature radius in the second blade part 43b, as illustrated in Fig. 4, is located on the first blade part 43a, that is, on the support part 42 side. That is, the second blade part 43b has a shape that becomes concave with respect to the support part 42. Since the second blade part 43b is formed so that the center side of the curvature radius becomes the support part 42 side and the curved surface of the second blade part 43b protrudes in a direction away from the support part 42, the separation vortex of an object to be stirred that passes through an outer peripheral part of the first blade part 43a is not easily generated when the supporting part 42 has rotated in the direction (in the direction of the end part of the second blade part 43b) of an illustrated arrow.

[0027] As for a blade unit 43 and another blade unit 43 adjacent thereto in the circumferential direction in Fig. 2(b), the position of the first blade part 43a and the position of the second blade part 43b are reversed. More specifically, as for one blade unit 43 (the blade unit 43 illustrated in Fig. 2(b)) of two adjacent blade units 43, the first blade part 43a is formed on the first surface 42a of the support part 42. However, in the case of the other blade unit 43, the second blade part 43b is formed on the first surface 42a of the support part 42. Similarly, the second blade part 43b of one blade unit 43 is formed on the second surface 42b of the support part 42. However, in the case of the other blade unit 43, the first blade part 43a is formed on the second surface 42b of the support part 42.

[0028] Additionally, the arrangement and the size of the opening 44 between the first blade part 43a or the second blade part 43b are not particularly limited, and may be appropriately set so that suppression of cavitation and suppression of the strength reduction of the blade unit 43 are achieved. For example, the opening 44 may be formed on a tip side in the first blade part 43a or the second blade part 43b, or may be formed on a radial inner side. Moreover, although the opening 44 is formed so as to be cut off in a linear shape in the present embodiment, the opening may be formed so as to be cut off in a curved shape. Additionally, the opening 44 may be formed as a hole of which the periphery is surrounded. Moreover, in the present embodiment, one opening 44 is formed per one first blade part 43a, and a plurality of the openings may be formed. Additionally, openings 44 may be formed in a lattice or in a net. In addition, the driving force (drive torque) of the stirring impeller 4 can be further reduced if a larger opening 44 is formed.

[0029] The blade unit 43 is disposed so as to incline to a downstream side in a rotational direction with respect to the radial direction B of the support part 42. The angle of such inclination to the downstream side, that is, an angle (receding angle) α at which the inner peripheral side of the blade unit 43 retreats may be set to, for example, 10 degrees to 40 degrees. In addition, a configuration in which the blade unit 43 is not made to incline with respect to the radial direction may be adopted, or a configuration in which the inner peripheral side of the blade unit 43 advances may be adopted.

[0030] Subsequently, the operation of the stirring device 1 including the stirring impeller 4 of the present embodiment will be described. First, if the driving unit 5 of the stirring device 1 is driven to rotate the stirring shaft 3 in a direction (the counterclockwise direction of Fig. 2(a)) in which a side where the first and second blade parts 43a and 43b protrude inclinedly becomes a downstream side, the stirring impeller 4 rotates together with the stirring shaft 3 around the stirring shaft 3 within the stirred tank 2. If the stirring impeller 4 rotates, the liquid L and the gas G are mixed while being sheared by the first blade part 43a and the second blade part 43b.

[0031] In a case where the stirring impeller 4 rotates in this way, the liquid L and the gas G (objects to be stirred) pass through the opening 44 toward the upstream side (rear side) from the downstream side (front side) in the rotational direction of the blade unit 43. Additionally, after an object to be stirred in a gap portion S between the first blade part 43a and the second blade part 43b, and the support part 42 has moved to the opening 44 with a centrifugal force, this object to be stirred joins the object to be stirred that passes through the above opening 44 and is dispersed further to the outer peripheral side than the blade unit 43. As mentioned above, since the objects to be stirred are made to join each other after the movement caused by the centrifugal force, it is preferable that the opening 44 is formed in a predetermined region on the radial outer side of the blade unit 43.

[0032] As above, the stirring impeller 4 of the present embodiment includes the support part 42 and the blade unit 43. The blade unit 43 has the first blade part 43a, the second blade part 43b, and the opening 44.

[0033] According to this configuration, as described above, cavitation is suppressed because the blade unit 43 of the stirring impeller 4 has the opening 44. In addition, since the driving force required for the driving of the stirring shaft 3 is reduced due to such an improvement in stirring efficiency, it is also possible to make the stirring shaft 3 relatively slim or and make the driving unit 5 relatively small. Additionally, cost is also reduced. Additionally, operation at a lower torque and at higher-speed rotation than ever before is also possible.

[0034] Additionally, in the present embodiment, the first blade part 43a and the second blade part 43b are asymmetrically formed viewed in the radial direction. Moreover, the first blade part 43a in one blade unit 43 of two blade units 43 adjacent to each other in the circumferential direction is provided on the first surface 42a of the support part 42, the first blade part 43a of the other blade unit 43 is provided on the second surface 42b of the support part 42, the second blade part 43b of the one blade unit 43 is provided on the second surface 42b of the support part 42, and the second blade part 43b of the other blade unit 43 is provided on the first surface 42a of the support part 42. The opening 44 is formed in each first blade part 43a.

[0035] According to this configuration, even if a cavity is generated under the presence of a large amount of gas, gas reservoirs (cavities) on back sides of the blade units 43 adjacent to each other are not easily combined. Accordingly, for example, in a case where gas is present in large quantities in liquid, it is possible to suppress a reduction of power and degradation of stirring performance.

[0036] Additionally, by providing the above configuration, the opening 44 is formed in an upper first blade part 43a in one blade unit 43 of two blade units 43 adjacent to each other, and the opening 44 is formed in a lower first blade part 43a of the other blade unit 43. In this way, since the openings 44 are alternately arranged up and down, it is possible to decentralize gas reservoirs generated near the blade units 43 in an upward-downward direction. Accordingly, flooding does not easily occur. The flooding is a phenomenon in which the gas reservoirs adjacent to each other near the blade units 43 are combined together and the function of the blade units 43 degrades markedly.

[0037] Additionally, by alternately arranging the openings 44 up and down, it is possible to decentralize the flow of a fluid without being centralized on one point. Accordingly, velocity distribution in a heat transfer surface can be further equalized, and an improvement in heat transfer performance is achieved. Additionally, in a case where the invention is applied to an apparatus with high corrosiveness, induction of erosion caused by the centralization of the flow of a fluid on one point can be prevented.

[0038] Next, since the inventor performed a performance test regarding the stirring impeller 4 of the present embodiment, test data is illustrated below.

[0039] The test conditions are as follows.

Test tank: transparent acrylics tank (internal diameter of tank: 310 mm, 2:1 semi-elliptical bottom)
Impeller type: stirring impeller of the present embodiment, general-purpose (target to be compared) disk turbine impeller diameter
Impeller diameter: 124 mm (impeller diameter ratio: 40%, refer to the following for details)
Liquid type: water (density: 1000 kg/m3, viscosity: 1 cP) Water temperature: 12°C
Liquid volume: 26.1 L
Internal: baffle plate-four flat plates (width: 24.8 mm), one ventilation nozzle
Power: 1.0 kW/m3 (at the time of non-ventilation)
Number of rotations: stirring impeller of the present embodiment: 627 rpm (constant), general-purpose disk turbine impeller: 350 rpm (constant)
Ventilation gas: ambient air in testing place Ventilation volume: 0 vvm to 3 vvm

[0040] The stirring impeller 4 of the present embodiment provided for the performance test is made of stainless steel (SUS304), and has shapes illustrated in Fig. 2(a), Fig.2(b), and Fig. 3. The sizes of main parts are as follows, and the positions of dimensions (m1 to m7) of respective parts are illustrated in Fig. 4(a) and Fig. 4(b).

- Diameter of support part 42 (m1): 124 mm
- Plate thickness of support part 42 (m2): 2 mm
- Receding angle of first blade part 43a and second blade part 43b (α) : 30°
- Axial dimension from distal end of first blade part 43a

to distal end of second blade part 43b (m3): 22.5 mm

- Dimension between one-dot chain lines from root to distal end illustrated in Fig. 2 (b) in first blade part 43a and second blade part 43b (m4): 31.8 mm
- Curvature radius to surface of second blade part 43b on support part 42 side (m5): 49.2 mm
- Dimension along direction of receding angle α from outer peripheral edge of support part 42 to radial-inner-side end edge of each of blade parts 43a and 43b (m6): 31.9 mm
- Dimension along direction of receding angle α from outer peripheral edge of support part 42 to radial-inner-side end edge of opening 44 (m7): 13.5 mm

[0041] Additionally, a general-purpose disk turbine impeller used as a target to be compared is an oblong plate-shaped disk in which the diameter of a disk having a disk shape is 99 mm, and blades are arranged along a radial direction of the disk. In this turbine impeller, six blades are arranged at regular intervals in a circumferential direction of the disk, the diameter dimension of a blade tip is 124 mm, and each blade has a vertical dimension of 25 mm and a horizontal dimension of 30 mm.

[0042] The performance test was performed by changing the ventilation volume from 0 vvm to 3 vvm after the power at the time of non-ventilation was set to 1.0 kW/m3 in both of the impellers. An upper graph illustrated in Fig. 5 is a graph illustrating the relationship between the ventilation volume and kLa (overall mass transfer capacity coefficient). kLa shows that more gas is dissolved in liquid as the numerical value of kLa is larger. Additionally, a lower graph illustrated in Fig. 5 is a graph illustrating the relationship between the ventilation volume and power (per unit volume of liquid) transmitted to the liquid. As is clear from each graph, in a case where the ventilation volume is the same, it is clear that the stirring impeller 4 (a line connecting circle plots) of the present embodiment has larger kLa and the power transmitted to the liquid is larger (that is, reduction of power is smaller), compared to the general-purpose disk turbine impeller (a line connecting square plots on the graph) that is a target to be compared.

[0043] From the above, it was proved by the performance test that the stirring impeller 4 of the present embodiment is superior to the general-purpose disk turbine impeller.

[0044] Although the stirring impeller 4 and the stirring device 1 related to the present embodiment are as above, the stirring impeller and the stirring device related to the invention are not limited to the above embodiment, and various changes can be made without departing from the scope of the invention. Additionally, the effects of the stirring impeller 4 and the stirring device 1 related to the invention are not limited to the above-described effects.

[0045] In the above embodiment, an example in which six blade units 43 are provided at regular intervals in the circumferential direction has been mentioned as the stirring impeller 4. However, the invention is not limited to this. In addition to this, the number of blade units 43 may be appropriately set to, for example, 4 to 8 at regular intervals. Additionally, the intervals between the blade units 43 may be appropriately set to different intervals.

[0046] Additionally, in the above embodiment, an example in which the stirring shaft 3 and the stirring impeller 4 rotate in the counterclockwise direction viewed from the top part 23 side to the bottom part 22 side has been mentioned. In addition to this, however, an aspect in which the stirring shaft 3 and the stirring impeller 4 rotate in the clockwise direction may be adopted. In this case, flow reverse to that of the above embodiment is obtained as the flow of an object to be stirred.

[0047] Additionally, applications to which the stirring impeller and the stirring device related to the invention are applied are not particularly limited. For example, the stirring impeller and the stirring device of the invention are used for a reaction operation accompanied by the mass transfer of gas and liquid. As this reaction operation, a gas absorption reaction operation in a hydrogenation reaction tank, an oxidation reaction tank, or the like is mentioned. In addition, a reaction operation under the presence of steam in a solvent removing agent reaction tank, a flash crystallization reaction tank, or the like after rubber polymerization is mentioned. Moreover, the stirring impeller and the stirring device of the invention are also used for a separation/extraction operation.

[0048] The present embodiment is described together. The stirring impeller 4 related to the present embodiment is the stirring impeller 4 attached to the stirring shaft 3 provided in the stirring device 1, and includes the plate-shaped support part 42 that is attached to the stirring shaft 3, and the plurality of blade units 43 that are disposed on the outer peripheral edge side of the support part 42, the support part 42 has the first surface and the second surface, and each of the blade units 43 includes the first blade part 43a that protrudes from one of the first surface and the second surface of the support part 42, the second blade part 43b that protrudes from the other one of the first surface and the second surface in the support part 42 and is made asymmetrical to the first blade part 43a, and the opening 44 that is formed in at least one of the first blade part 43a and the second blade part 43b.

[0049] According to this configuration, after an object to be stirred in the gap portion (S) between the first and second blade parts 43a and 43b and the support part 42 has moved to the opening 44 with a centrifugal force, this object to be stirred joins the object to be stirred that passes through the above opening 44 and is dispersed further to the outer peripheral side than the blade unit 43. Since gathering and stagnation in the object to be stirred in the gap portion between the first and second blade parts 43a and 43b and the support part 42 are suppressed by virtue of such a flow of the object to be stirred, cavitation can be suppressed. Since the resistance that the blade unit 43 receives decreases as much as the object to be stirred passes through the opening 44, the driving force of the stirring impeller 4 can be reduced.

[0050] Additionally, in the stirring impeller 4 of the above configuration, the support part 42 may be formed in a circular shape, the plurality of blade units 43 may be provided at predetermined intervals along the circumferential direction of the support part 42, the first blade part 43a of one blade unit 43 of two blade units 43 and 43 adjacent to each other in the circumferential direction of the support part 42 may be provided on the first surface of the support part 42, the first blade part 43a of the other blade unit 43 may be provided of the second surface of the support part 42, the second blade part 43b of the one blade unit 43 may be provided on the second surface of the support part 42, and the second blade part of the other blade unit may be provided on the first surface of the support part.

[0051] According to this configuration, even if a cavity is generated under the presence of a large amount of gas, gas reservoirs (cavities) on back sides of the blade units 43 and 43 adjacent to each other are not easily combined. As a result, for example, in a case where gas is present in large quantities in liquid, it is possible to suppress a reduction of power and degradation of stirring performance.

[0052] Additionally, regarding the first blade part 43a and the second blade part 43b that are made asymmetrical to each other, for example, a configuration in which the first blade part 43a is formed in a linear shape and the second blade part 43b is formed in a curved shape may be adopted.

[0053] As described above, according to the present embodiment, the stirring impeller 4 with improved stirring efficiency and the stirring device 1 including the stirring impeller 4 are provided.

Reference Signs List

[0054]

- 1: STIRRING DEVICE
- 2: STIRRED TANK
- 3: STIRRING SHAFT
- 4: STIRRING IMPELLER
- 41: BOSS PART
- 41a: THROUGH-HOLE
- 42: SUPPORT PART
- 43: BLADE UNIT
- 43a: FIRST BLADE PART
- 43b: SECOND BLADE PART
- 44: OPENING
- α: INCLINATION ANGLE
- L: LIQUID (OBJECT TO BE STIRRED)
- G: GAS (OBJECT TO BE STIRRED)
- A: AXIS CENTER DIRECTION
- B: RADIAL DIRECTION

Claims

1. A stirring impeller to be attached to a stirring shaft provided in a stirring device, the stirring impeller comprising:

a plate-shaped support part that is attached to the stirring shaft; and
a plurality of blade units that are disposed on an outer peripheral edge side of the support part,
wherein the support part includes a first surface and a second surface,
wherein each of the blade units includes
a first blade part that protrudes from one of the first surface and the second surface in the support part,
a second blade part that protrudes from the other one of the first surface and the second surface in the support part and is made unsymmetrical to the first blade part, and
an opening that is formed in at least one of the first blade part and the second blade part.

2. The stirring impeller according to Claim 1, wherein the support part is formed in a circular shape,
wherein the plurality of blade units are provided at predetermined intervals along a circumferential direction of the support part, and
wherein the first blade part in one of two blade units adjacent to each other in the circumferential direction of the support part is provided on the first surface of the support part, the first blade part in the other one of the two adjacent blade units is provided on the second surface of the support part, the second blade part of the one blade unit is provided on the second surface of the support part, and the second blade part of the other blade unit is provided on the first surface of the support part.

3. The stirring impeller according to Claim 1 or 2, wherein the first blade part is formed in a linear shape viewed in a radial direction, and the second blade part is formed in a curved shape viewed in the radial direction.

4. A stirring device comprising:

the stirring impeller according to any one of Claims 1 to 3.

Fig . 1

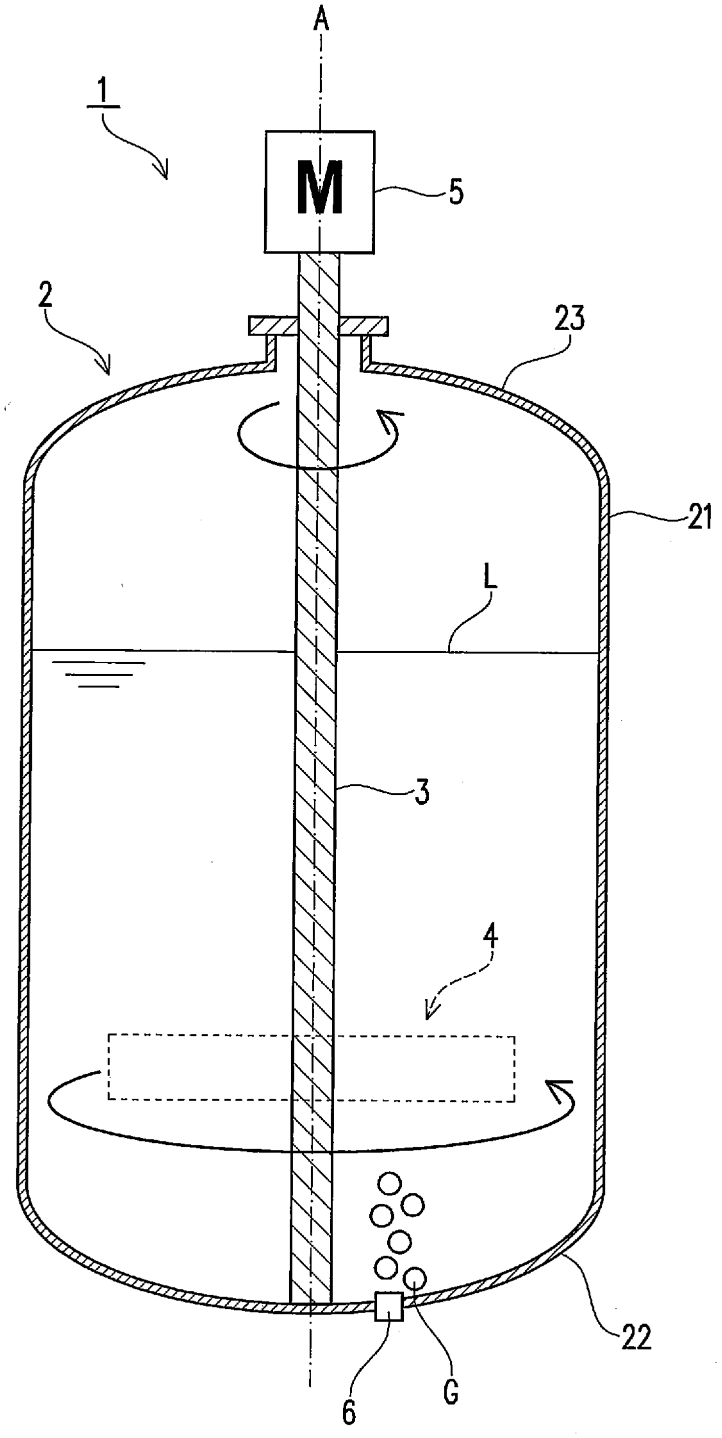


Fig . 2(a)

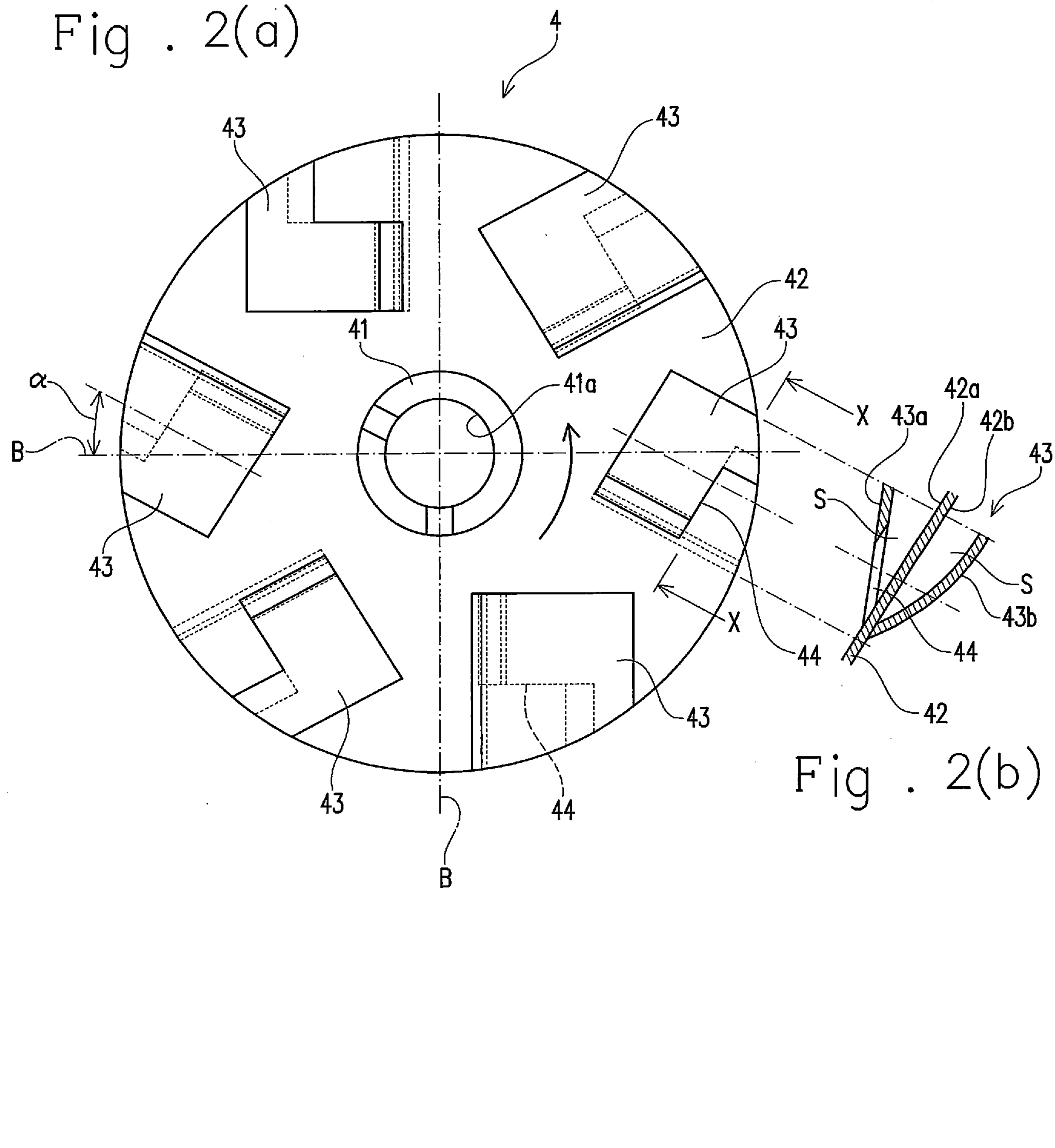


Fig . 2(b)

Fig . 3

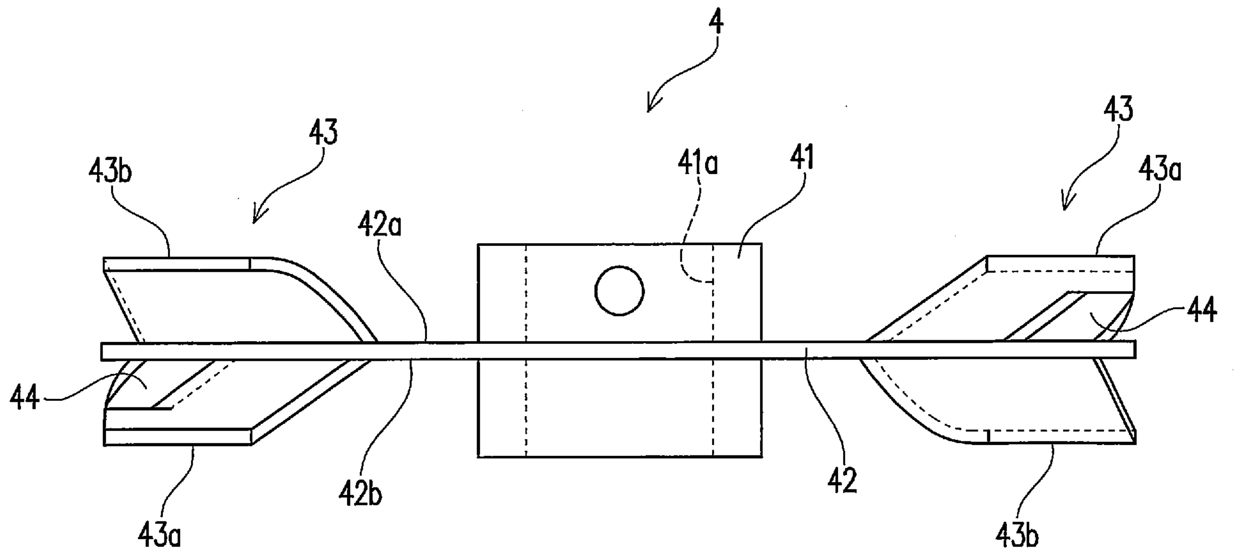


Fig . 4(a)

Fig . 4(b)

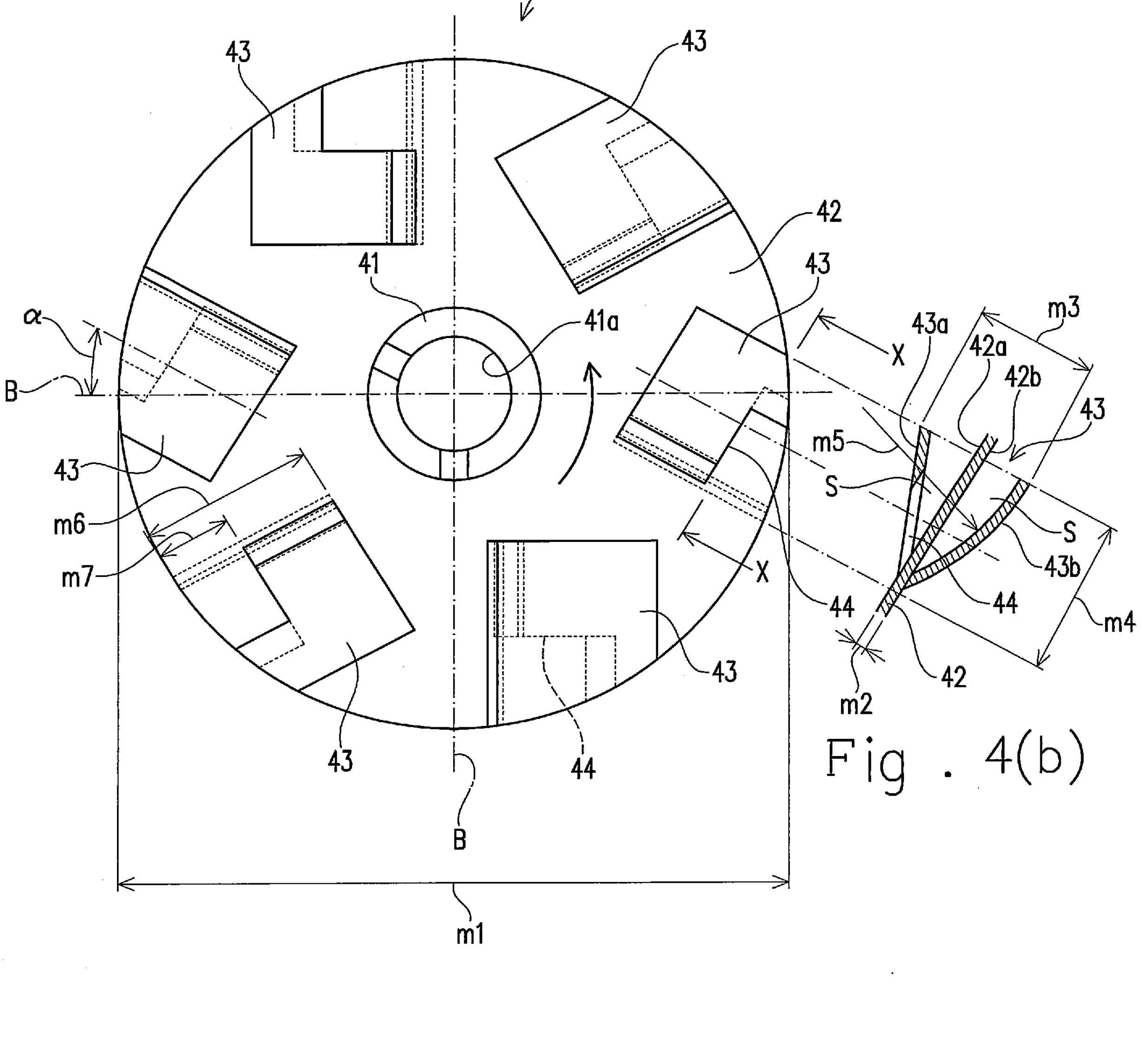
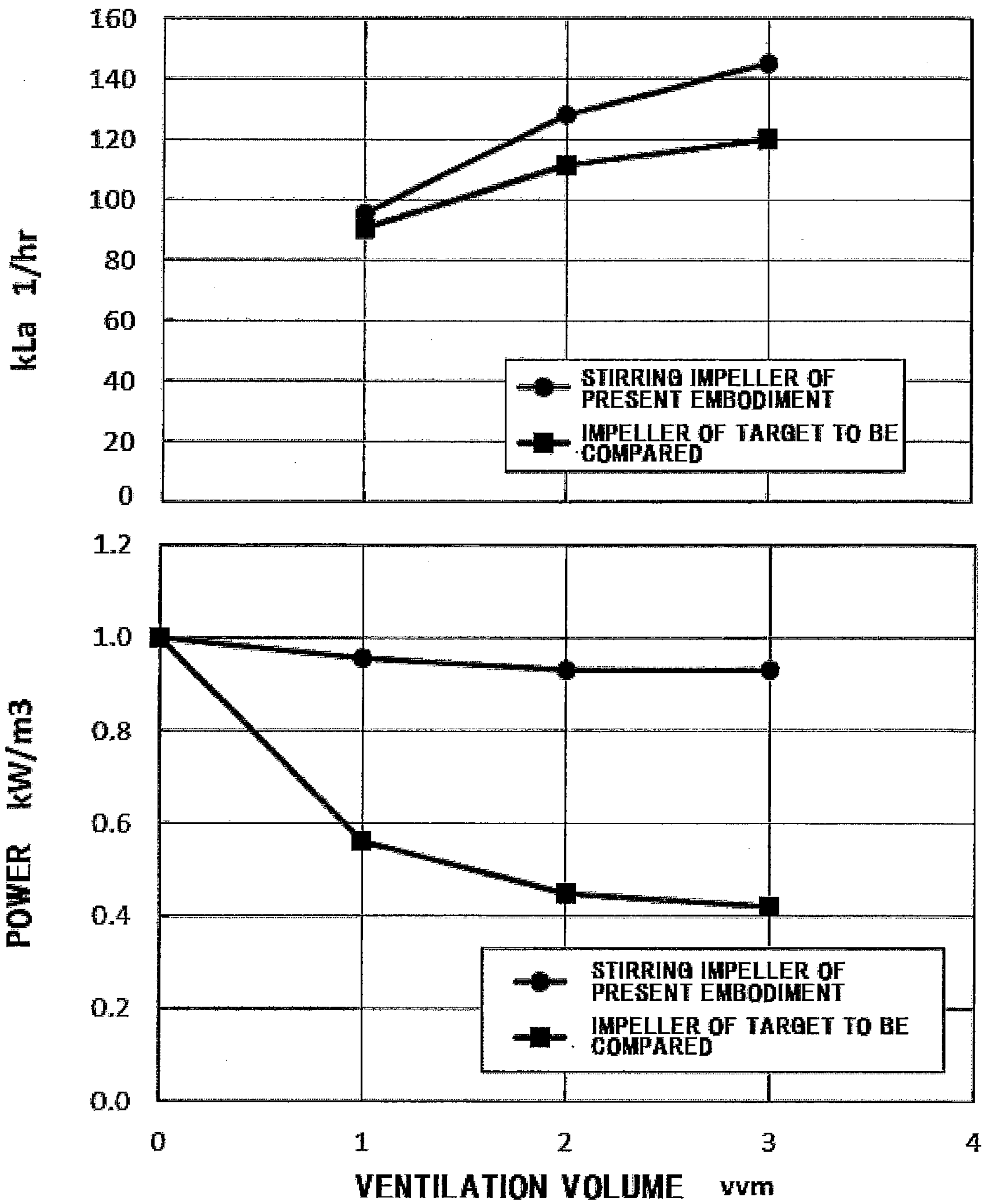

4
43
43
42
41
43
41a
α
B
X
43a
m3
42a
42b
43
m5
S
S
43b
43
m6
m7
X
44
44
m4
44
42
m2
43
43
44
B
m1

Fig . 5


160
140
120
100
80
60
40
20
0
kLa 1/hr
STIRRING IMPELLER OF PRESENT EMBODIMENT
IMPELLER OF TARGET TO BE COMPARED
1.2
1.0
0.8
0.6
0.4
0.2
0.0
POWER kW/m3
STIRRING IMPELLER OF PRESENT EMBODIMENT
IMPELLER OF TARGET TO BE COMPARED
0
1
2
3
4
VENTILATION VOLUME vvm

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2014/079194

A. CLASSIFICATION OF SUBJECT MATTER

B01F7/26(2006.01)i

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)
B01F7/26

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2015
Kokai Jitsuyo Shinan Koho	1971-2015	Toroku Jitsuyo Shinan Koho	1994-2015

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 A	US 2008/0199321 A1 (SPX Corp.), 21 August 2008 (21.08.2008), paragraphs [0001], [0023] to [0034]; fig. 1 to 4 & GB 2446924 A & DE 102008008507 A1 & FR 2912669 A1 & CA 2620485 A1 & CN 101306333 A	1,3-4 2
Y A	US 6770207 B1 (Outokumpu Oyj), 03 August 2004 (03.08.2004), column 3, lines 11 to 26; fig. 1 to 3 & JP 2003-507158 A & WO 2001/012307 A1	1,3-4 2

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

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- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 January 2015 (21.01.15)	03 February 2015 (03.02.15)

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

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INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2014/079194

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 47-29281 A (Poru Rorufu Suteningu), 04 November 1972 (04.11.1972), page 11, lower left column, line 14 to upper right column, line 5; fig. 7 (Family: none)	1,3-4 2
Y	JP 49-48964 B1 (Eastman Kodak Co.), 24 December 1974 (24.12.1974), column 6, lines 34 to 38; fig. 6 & GB 1323464 A & DE 2043392 A1 & FR 2060748 A5 & CH 526131 A	1,3-4
Y	JP 3-72933 A (Hitachi, Ltd.), 28 March 1991 (28.03.1991), page 2, lower right column, lines 12 to 15; fig. 2 (Family: none)	1,3-4
A	JP 63-59341 A (Toyoda Gosei Co., Ltd.), 15 March 1988 (15.03.1988), page 3, upper right column, lines 5 to 12; fig. 5 (Family: none)	1-4

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- JP 2013270311 A **[0001]**
- JP 2004035724 A **[0006] [0007] [0008]**