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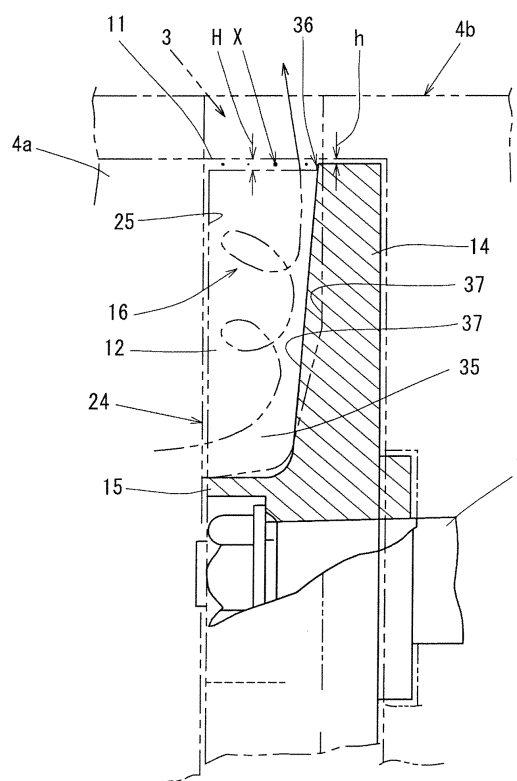
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(71) Applicant: **YONEHARA GIKEN CO., LTD.**
Taisha-cho
Izumo-shi
Shimane 699-0722 (JP)

(72) Inventor: **YONEHARA, Ryoichi**
Hikawa-gun
Shimane 699-0722 (JP)
(74) Representative: **Johnstone, Douglas Ian et al**
Baron Warren Redfern
19 South End
Kensington
London
W8 5BU (GB)

(54) **PRESSURIZING CENTRIFUGAL PUMP**

(57) [PROBLEMS] To solve the problems of a conventional pressurizing centrifugal pump that an inner peripheral wall, the edge of an outlet, blades, etc. are damaged when a foreign substance is included into a subject fluid and that intense cavitation and a big noise such as a draining sound occurring at the tips of the blades and lowering of pump performance are caused by moving of the fluid through a small gap between the inner peripheral wall and the tips of the blades. [MEANS FOR SOLVING PROBLEMS] In the pressurizing centrifugal pump, the tip of a blade (12) is formed to be low by providing a level difference (36) in the direction of the center from the outer periphery of a blade plate (14) to make the outer periphery of the blade plate (14) close to the inner peripheral wall (11) of a case (4) to form a fluid control space (h) for controlling moving of the fluid to the rear side of the blade and to form a fluid passage space (H) accelerating the passage of the foreign substance (X) included in the fluid between the inner peripheral wall (11) and the tip of the blade (12).

FIG.8



Description

TECHNICAL FIELD

[0001] The present invention relates to a pressurizing centrifugal pump for rotating an impeller in a pump case to absorb and then deliver a liquid or the like.

BACKGROUND ART

[0002] A pressurizing centrifugal pump for absorbing, pressurizing and delivering a fluid such as water, oil, air or the like is conventionally known as shown in Patent Document 1 describing a proposal by the present applicant.

Such a pressurizing centrifugal pump includes a drum-like case having an absorption opening and a delivery opening. In the case, an impeller having blades radially projected on a side surface thereof faces a pressurizing surface which is a part of a pressurizing chamber converging from the absorption opening toward the delivery opening, and also faces a pressurizing section having a pressurizing partition wall which is provided close to a side surface of the blades to prevent the leak of the fluid from a blade chamber. A fluid which is absorbed from the absorption opening is pressurized in a pump chamber including the impeller and the pressurizing section and is delivered from the delivery opening.

Patent Document 1: Japanese Laid-Open Patent Publication No. 2004-60470

DISCLOSURE OF THE INVENTION

Problems to be Solved by the Invention

[0003] In the pressurizing centrifugal pump described in Patent Document 1 mentioned above, the blades projected on a side surface of a blade plate, radially from a boss section, each have a forward inclining angle (scraping angle). This provides an advantage that an outer end of the blade, which precedes the rest of the blade, promotes the scraping of the fluid from the pressurizing chamber into the blade chamber. However, the blades formed to be flat with such a forward inclining angle pressurize the fluid scraped into the blade chamber while allowing the fluid to be leaked sideways freely. This provides a disadvantage that a vigorous turbulence is caused at the border between the side surface of the impeller and the pressurizing chamber. The blade plate couples a front surface of a blade and a rear surface of another blade adjacent thereto via a flat blade trough surface on the side of the blade plate. This provides a disadvantage that the fluid scooped by the front surface of the blade and is about to form a whirlpool around the blade chamber causes a turbulence at a corner of the base of the blade and thus spoils the pumping efficiency.

[0004] Each blade projected from the impeller is

formed to have a diameter which is the same as that of the blade plate. Therefore, when an outer circumferential surface of the blade plate is made close to an inner circumferential surface of the pump case to form a fluid control space of, for example, about 0.3 mm for controlling the leak of the fluid to the rear side of the blade plate, tips of the blades also form a space of the same size as that of the fluid control space.

[0005] In the pump structured as above, when the fluid is contaminated with a foreign substance of, for example, about 0.3 mm or greater, the foreign substance moves along the blades toward the tips thereof and vigorously collides against the inner circumferential wall or moves while being caught in the fluid control space. This provides a disadvantage that the inner circumferential wall, an edge of the delivery opening, the blade plate, etc. is likely to be damaged. In addition, since the fluid is moved in a small space between the tips of the blades and the inner circumferential wall, there are problems that intense cavitation, water draining or the like caused at the tips of the blades is noisy, the pumping efficiency is reduced, and the like.

Means for Solving the Problems

[0006] In order to solve the above-described problems, a pressurizing centrifugal pump according to the present invention are characterized by the following. First, the pressurizing centrifugal pump comprises a drum-like case (4) having an absorption opening (2) and a delivery opening (3); and an impeller (5) rotatable in the case (4), the impeller having a plurality of blades (12) projected on a side surface of a blade plate (14), radially from a boss section (15), each of the blades (12) having an angle extending rearward in a rotation direction. In an inner surface of the case (4), a pressurizing surface (27) which faces the blades (12) and is a part of a pressurizing chamber (24) converged from the absorption opening (2) toward the delivery opening (3), and a pressurizing section (22) having a pressurizing partition wall (25), provided close to a side surface of the blades (12), for preventing a fluid in blade chambers (16) from leaking, are provided; a pump chamber (9) is provided in which the impeller (5) faces the pressurizing surface (27) and the pressurizing section (22); tips of the blades (12) are provided at a level lower than that of an outer circumferential surface of a blade plate (14) by a level difference (36) provided from the outer circumferential surface toward a central position of the blade plate (14); the outer circumferential surface of the blade plate (14) is provided close to an inner circumferential wall (11) of the case (4) to form a fluid control space (h) for controlling movement of the fluid toward a rear side of the blades; and a fluid passage space (H) for promoting passage of a foreign substance (X) in the fluid is formed between the inner circumferential wall (11) and the tips of the blades (12).

[0007] Second, the blade chambers (16) formed of the blades (12) projected from the blade plate (14) with a

predetermined interval between each two adjacent blades (12) are each formed of an arched blade front surface (33) curved to protrude toward an upstream direction in the rotation direction; a blade rear surface (35) formed of a curved surface which is generally along a shape of the blade front surface (33); and an arched blade trough surface (37) for connecting the blade front surface (33) of a blade (12) and the blade rear surface (35) of another blade (12) adjacent thereto, the blade trough surface (37) being curved to protrude toward the blade plate (14).

[0008] Third, troughs of the blade chambers (16) are made gradually deeper from a bottom toward a tip thereof.

[0009] Fourth, troughs of the blade chambers (16) are made gradually deeper from a bottom to a middle point before a tip thereof and are made generally constant in depth from the middle point to the tip.

[0010] Fifth, a pressurizing guide surface (27b) generally parallel to a side surface of the impeller (5) is provided on the side of a start point of the pressurizing surface (27) continued to the absorption opening (2).

Effect of the Invention

[0011] A pressurizing centrifugal pump according to the present invention structured as described above has the following effects.

Since the level of the tips of the blades is made lower than that of the outer circumferential surface of the blade plate by providing a level difference inward from the outer circumferential surface, the outer circumferential surface of the blade plate can be made as close as possible to the inner circumferential wall. Thus, the movement of the fluid from the fluid control space to the rear side of the blades can be controlled and so the pumping efficiency can be improved. In addition, owing to the fluid passage space formed between the inner circumferential wall and the tips of the blades, the passage of the foreign substance (X) mixed to contaminate the fluid can be promoted and noise can be reduced.

[0012] The fluid supplied from the absorption opening by the rotation is introduced, as being scooped, into the blade chamber along the shape of the blade front surface. Also, the fluid sequentially introduced from the pressurizing chamber via the pressurizing surface is guided along the blade front surface and the blade trough surface, and so a whirlpool is formed smoothly in the blade chamber to carry the fluid to the delivery opening. Therefore, the pump pressure can be increased by a centrifugal force and a kicking action of the blades and the fluid can be released vigorously.

[0013] The fluid is guided from the bottom toward the tip of the blade chamber along the blade front surface and the blade trough surface, and thus an orderly whirlpool is formed while preventing generation of a turbulence. Thus the pressure in the blade chamber is increased. When the fluid reaches the delivery opening

and is released from the tip thereof by the centrifugal force and the kicking action of the blades, a circulating flow directed from the bottom of the blade chamber toward the delivery opening is formed in an orderly manner. Therefore, the fluid can be vigorously delivered from the delivery opening.

[0014] The troughs of the blade chambers are made gradually deeper from the bottom to a middle point before the tip thereof and are made generally constant in depth from the middle point to the tip. Owing to this, the trough surface can be inclined with respect to the delivery opening, without decreasing the depth of the troughs on the bottom side of the blade chamber, and the fluid can be directed toward the delivery opening without fail.

[0015] The fluid supplied from the absorption opening is directed toward the impeller via the pressurizing guide surface, and the fluid is guided parallel along the impeller from the start of the absorption operation. Therefore, the fluid can be supplied in correspondence with the absorption by the impeller without causing any negative pressure to the fluid, and so the pumping efficiency can be improved.

BRIEF DESCRIPTION OF DRAWINGS

[0016]

[FIG. 1] FIG. 1 is a partially cross-sectioned left side view of a pressurizing centrifugal pump according to the present invention.

[FIG. 2] FIG. 2 is a cross-sectional view showing a structure of a pump chamber shown in FIG. 1.

[FIG. 3] FIG. 3 is a developed cross-sectional view showing the structure of the pump chamber shown in FIG. 1 in a developed manner.

[FIG. 4] FIG. 4 is a front view showing a structure of a pressurizing case.

[FIG. 5] FIG. 5 is a cross-sectional view taken along line A-A in FIG. 4.

[FIG. 6] FIG. 6 is a cross-sectional view taken along line B-B in FIG. 4.

[FIG. 7] FIG. 7 is a partial front view of an impeller.

[FIG. 8] FIG. 8 is a side cross-sectional view showing a structure of the impeller shown in FIG. 7.

[FIG. 9] FIG. 9 is a plan view showing a shape of blades and blade chambers in the impeller shown in FIG. 7.

[FIG. 10] FIG. 10 is a cross-sectional view taken along line A-A in FIG. 7.

[FIG. 11] FIG. 11 is a cross-sectional view taken along line B-B in FIG. 7.

Description of the Reference Numerals

[0017]

- | | |
|---|--------------------------------------|
| 1 | Pump (pressurizing centrifugal pump) |
| 2 | Absorption opening |

3	Delivery opening
4	Case
4a	Pressurizing case
4b	Impeller case
5	Impeller
11	Inner circumferential wall
14	Blade plate
15	Boss section
12	Blade
24	Pressurizing chamber
27	Pressurizing surface
16	Blade chamber
22	Pressurizing section
33	Blade front surface
35	Blade rear surface
36	Level difference
37	Blade trough surface
H	Fluid passage space
h	Fluid control space
X	Foreign substance
27b	Pressurizing guide surface

BEST MODE FOR CARRYING OUT THE INVENTION

[0018] An embodiment of the present invention will be described with reference to the drawings. In FIG. 1, FIG. 2 and FIG. 4, reference numeral 1 represents a pressurizing centrifugal pump. The pump 1 includes a drum-shaped case 4 having an absorption opening 2 and a delivery opening 3, and an impeller 5 axially supported to be rotatable in the case 4. When necessary, a gas supply section 6 for supplying a gas such as air or like is installed in the case 4.

[0019] The pump 1 operates as follows. One side of a pump shaft 7 provided with the impeller 5 is driven from the side of a motor to rotate the impeller 5 in a direction of the arrow shown in FIG. 1. Thus, an arbitrary fluid such as water, oil or the like and an arbitrary gas such as air, another type of gas or the like or a powder such as a medicine or the like are absorbed from the absorption opening 2 into a pump chamber 9 in the case 4. While the gas or the like is stirred to be mixed with the fluid, the resultant mixture is pressurized and urged to be delivered from the delivery opening 3.

[0020] Hereinafter, a structure, a function and the like of each element will be described in detail. In this embodiment, the fluid is water and the gas to be mixed is air. The case 4 shown in the figure as an example includes a pressurizing case 4a having the absorption opening 2 and an impeller case 4b having the delivery opening 3 as a pair of left and right cases. The pressurizing case 4a and the impeller case 4b are separably coupled to each other to form the pump chamber 9, which is air-tight.

[0021] The impeller case 4b is bowl-shaped, and the impeller 5 and a pressurizing section 22, described later, of the pressurizing case 4a are accommodated in, and fit to, the impeller case 4b. In a cylindrical inner circum-

ferential wall 11 of the impeller case 4b, the delivery opening 3 having a predetermined length covering a plurality of blades 12 projected from a side surface of the impeller 5 is formed at a delivery position facing the width of the blade. At the delivery opening 3, a delivery pipe 13 curved to protrude toward a delivery direction of the fluid is integrally connected.

The impeller case 4b has an integral support section, in another portion of the inner circumferential wall 11, for axially supporting the pump shaft 7 at a central position of the pump chamber 9.

[0022] The pump shaft 7 separably attaches and fixes the impeller 5, having the plurality of blades 12 projected therefrom, at an end of the shaft in the pump chamber 9 by an attaching screw and a nut, etc. The impeller 5 is provided such that a side surface of a blade plate 14 different from a side surface from which the blades 12 are projected is made close to a side wall of the impeller case 4b and such that the blades 12 are away from the inner circumferential wall 11 by a fluid passage space H described later.

[0023] As shown in FIG. 2, the impeller 5 has an integral cylindrical boss section 15 also acting as an attaching section to the pump shaft 7. The boss section 15 extends from a central position of the blade plate 14, which acts as a side wall of the blades and is disc-shaped. A side end of the boss section 15 and a side end of blades 12 in the impeller 5 are substantially flush with each other. Thus, when the impeller 5 is put attached to the impeller case 4b, an end surface of the boss section 15 is close to an end surface of a flat pressurizing partition wall 25 (see FIG. 4) described later, which is formed in a central section of the pressurizing case 4a.

[0024] Owing to this, in the impeller 5, the blades 12 are projected on the blade plate 14, radially from the boss section 15 with a predetermined interval between each two adjacent blades 12. A space made of each adjacent blades 12, the blade plate 14 and the boss section 15 acts as a blade chamber 16 (see FIG. 3) for accommodating the fluid. The blade chambers 16, with the blades 12 formed as described later with reference to FIG. 7 through FIG. 11, improves the pumping efficiency.

[0025] Now, with reference to FIG. 2 through FIG. 6, the pressurizing case 4a will be described. The pressurizing case 4a integrally has a case lid 21 having an absorption pipe 19 and the pressurizing section 22. The pressurizing section 22 is inserted into an opening of the inner circumferential wall 11 of the impeller case 4b provided with the blades 5, and the pressurizing case 4a and the impeller case 4b are fixed to each other by a bolt. Thus, the case 4 can be put into a closed state. Owing to this, the pump chamber (pressurizing chamber) 9 for pressurizing the fluid scooped from the absorption opening 2 and delivering the fluid from the delivery opening 3 by the impeller 5 is formed between the pressurizing section 22 and the impeller 5.

[0026] As shown in FIG. 3, the pump chamber 9 includes an absorption chamber 23 for promoting the ab-

sorption of the fluid and a pressurizing chamber 24 communicated thereto for pressurizing the fluid. Between an end of the pressurizing chamber 24 and the absorption opening 2, the pressurizing partition wall 25 is formed close to the side surface of the plurality of blades 12 for controlling the leak of the fluid from the blade chambers 16. The pressurizing partition wall 25 is flat and flush with a central partition wall 26.

Owing to this, the absorption chamber 23, the pressurizing chamber 24 and the pressurizing partition wall 25 are continuously provided around the central partition wall 26 which faces the end surface of the boss section 15 of the impeller 5.

[0027] A pressurizing surface 27 formed to be mildly inclining from the absorption opening 2 to the pressurizing partition wall 25 converges the pressurizing chamber 24 such that the pressurizing chamber 24 gradually approaches the blades 12 from the side of the absorption chamber 23. Owing to this, the fluid absorbed from the absorption opening 2 into the pump chamber 9 is gradually pressurized by the plurality of blades 12 while passing the pressurizing chamber 24, which is a long pathway, in the state of being scraped by the rotation of the impeller 5 and sequentially held in the blade chambers 16.

[0028] The pressurizing surface 27 is formed up to a pressurization end point 29, which is a start point of the pressurizing partition wall 25. The fluid moving downstream from the absorption chamber 23 is pressurized and guided along the inclining pressurizing surface 27 into the blade chambers 16. Owing to the pressurizing surface 27, the fluid can be pressurized without any drastic pressure change in the pump chamber 9 and is efficiently pushed out from the delivery opening 3 while having the highest possible pressure at the pressurization end point 29.

[0029] As shown in FIG. 3 through FIG. 6, the pressurizing surface 27 in this embodiment has a stepped direction-change pressurizing surface 31 for promoting the direction change of the pressurized fluid toward the corresponding blade chambers 16. The direction-change pressurizing surface 31 is provided in the vicinity of a position which is upstream with respect to the pressurization end point 29 and corresponds to a start point of the delivery opening 3. Thus, a second pressurizing surface 27a is formed between the direction-change pressurizing surface 31 and the pressurization end point 29.

[0030] It is desirable that the direction-change pressurizing surface 31 is formed from the vicinity of a position which is upstream with respect to the pressurization end point 29 and is downstream with respect to the start point of the delivery opening 3. The direction of the fluid in the pressurizing chamber 24 is changed immediately before the second pressurizing surface 27a toward the delivery opening 3 via the corresponding blade chambers 16. Thus, the pressurization of the fluid is promoted and the pressure reduction which may otherwise be caused by the delivery is prevented at a position of the pump chamber 9 corresponding to the delivery opening 3.

[0031] Owing to this structure, the fluid is stirred around by the blades 12 in the pressurizing chamber 24 having a converged shape while being sequentially pressurized along the pressurizing surface 27 to form a vigorous whirlpool. In the case where the pump is for mixing air with the fluid, air bubbles of the mixed air are made progressively reduced in size in the pressurized whirlpool. The advancing direction of the fluid and the air bubbles moving downstream is changed in the middle of the pressurizing surface 27 toward the inside of the blade chambers 16 by the shape of the direction-change pressurizing surface 31 without causing any big contact resistance. Also, the air bubbles can be pressurized and discharged promptly. For providing air or the like to the pump chamber 9, air may be mixed with the liquid in the absorption opening 2 by the gas supply apparatus 6 having a structure which is substantially the same as that of the conventional art.

[0032] As represented with the chained line in FIG. 3, the absorption chamber 23 of the pump 1 in this embodiment forms a pressurizing guide surface 27b, which is generally parallel to the side surface of the impeller 5, on the side of the start point of the pressurizing surface 27 continuous to the absorption opening 2. Owing to this, in response to the absorption capability which is provided by the shape improvement of the blade chambers 16 described later, the supply of the fluid from the absorption opening 2 can be promoted without causing any negative pressure to the fluid in the absorption chamber 23. Thus, the absorption performance can be improved.

[0033] More specifically, unlike the inclining surface of the conventional shape which is formed from the start point of the pressurizing surface 27 represented with the solid line in FIG. 3, the pressurizing guide surface 27b extends flat and generally parallel to the side surface of the blades 12 of the impeller 5 after being curved at the corner at which the pressurizing guide surface 27b is projected so as to converge an end portion of the absorption opening 2. Then, the pressurizing guide surface 27b is continued to the inclining surface of the pressurizing surface 27.

[0034] Owing to this, the pump 1 can allow the fluid supplied from the absorption opening 2 to be vigorously directed toward the impeller 5 by the start corner of the pressurizing guide surface 27b, and also can guide the fluid by the pressurizing guide surface 27b toward the impeller 5 from the start of the absorption operation of the fluid. The fluid supplied in correspondence with the absorption by the impeller 5 can be prevented from having a negative pressure at a start point of the absorption chamber 23. Therefore, the pumping efficiency can be higher than that of the conventional art and the cavitation can be suppressed. Thus, the pump can be made more tranquil.

[0035] The delivery opening 3 in the impeller case 4b is formed in the inner circumferential wall 11 thereof so as to have a lengthy shape in correspondence with the width of the blades, at a position facing the second pres-

surizing surface 27a and the pressurization partition wall 25 on the side of the end of the pressurizing chamber 24. In the middle of the delivery opening 3 in the length direction thereof, a plate-like guide member 32 having a predetermined guide angle is installed for guiding and delivering the fluid.

[0036] Now, a structure of the blades 12 and the blade chambers 16 in the impeller 5 will be described. As shown in FIG. 1, FIG. 7 and FIG. 8, the blades 12 are projected on one side surface of the disc-shaped blade plate 14, radially from the boss section 15 in an upstream direction in the impeller rotation direction (hereinafter, referred to simply as "upstream"). When seen from the front, each blade is smoothly bent in the middle to incline rearward.

[0037] Owing to such a shape of the blades, the impeller 5 scrapes the fluid from the absorption opening 2 while rotating, and holds the fluid inside the blade chambers 16. When facing the delivery opening 3, each blade 12 adds a centrifugal force to the fluid by the shape of the blade inclining rearward and thus forming the blade chamber 16, while pushing out, as if kicking, and thus urging the fluid. Thus, the pressure of the fluid in the centrifugation direction is increased.

[0038] As shown in FIG. 7 and FIG. 8, in the impeller 5, the diameter of the rotating track of the tip of each blade 12 is smaller than the diameter of the blade plate 14 to make the size of the space between the blade 12 and the inner circumferential wall 11 different from the size of the space between the blade plate 14 and the inner circumferential wall 11. The blade chamber 16 between each two adjacent blades 12 is formed to be circular or elliptical when seen in a plane. Owing to these, the pumping efficiency is improved, the noise is reduced, and the durability of the blades is improved.

[0039] More specifically, each blade 12 of the pump 1 shown here has the following size. For example, where twelve blades 12 having a tip thickness of about 3 mm are projected at an equal interval on the boss section 15 having a diameter of 55 mm and the blade plate 14 having an outer diameter of 125 mm, the interval between the base sections of each adjacent blades 12 is about 10 mm. In addition, the bending on the side of the base sections of the blades is controlled such that the interval between the base sections of each adjacent blades 12 is not made too small, and thus the fluid accommodating volume of each blade chamber 16 is increased so as to prevent the fluid from entering the base sections.

[0040] As shown in FIG. 9, each blade 12 has a flat surface 5a approaching the pressurizing partition wall 25 to be parallel thereto from the side of an arched blade front surface 33 and a chamfer-like inclining surface 5b reaching a blade rear surface 35, within a thickness of an outer end portion of the blade. In the case where the thickness of the blade 12 is about 3 mm, the flat surface 5a desirably has a width of about 1 mm for forming the inclining surface 5b. The inclining surface 5b may be formed by curving the blade rear surface 35 which is shaped to be generally along the shape of the blade front

surface 33. When necessary, the blades 12 are surface-treated by an anti-abrasion material such as titanium or the like or by a surface-smoothing material.

[0041] In the impeller 5 of the pump 1 shown in the figures as an example, the level of the tip of each blade 12 is made lower than that of the outer circumferential surface of the blade plate 14 by providing a level difference 36 from the outer circumferential surface toward a central position of the blade plate 14. Such a structure is adopted in order to make the rotating diameter of the tip of the blade smaller than the diameter of the blade plate 14 by about several millimeter. In the case where the pump is for clean (normal) water, it is desirable that where a fluid control interval h formed by the cylindrical inner circumferential wall 11 and the outer circumferential surface of the blade plate 14 is about 0.05 mm, the fluid passage space H formed by the inner circumferential wall 11 and the tip of the blade 12 is set to be about 0.35 mm.

[0042] Owing to the level difference 36, the pump 1 can form the fluid passage space H between the tip of the blade 12 and the inner circumferential wall 11 while the outer circumferential surface of the blade plate 14 is as close as possible to the inner circumferential wall 11. Thus, the leak of the fluid from the fluid control space h caused by the pressure in the pump chamber 9 can be controlled, and the pressure loss can be suppressed.

[0043] Through the fluid passage space H formed to be larger than the fluid control space h , small particle powder (foreign substance X) of about 0.3 mm mixed to contaminate the fluid, for example, minerals such as sand or the like, organic substances or the like can easily pass.

[0044] Therefore, disadvantages of the conventional art that, for example, the foreign substance (X) vigorously collides against the inner circumferential wall 11, or is caught or rotated while being caught between the tip of the blade and an edge of the delivery opening 3 can be solved. Owing to this, the impeller 5 can smoothly move the foreign substance (X) in the pump chamber 9 through the fluid passage space H and discharge the foreign substance (X) from the delivery opening 3 without the inner circumferential wall 11, the blades 12 or the like being damaged. The fluid passage space H has such a size as to allow the foreign substance (X) to pass. Therefore, features that, for example, the pumping efficiency is not significantly spoiled are provided. As long as such functions are provided, the level difference 36 does not need to be a "level difference" in a precise sense.

[0045] Owing to the fluid passage space H formed by the level difference 36 to lower the level of the tips of the blades 12 rotatable at a high speed, a great amount of the fluid can be accommodated and smoothly moved throughout the circumference of the impeller and thus delivered from the delivery opening 3.

At this point, cavitation, which is likely to occur between the tips of the blades and the inner circumferential wall 11, is suppressed and the fluid is moved in the large space between the tips of the blades and the inner circumferential wall 11. Therefore, noise of, for example,

draining water at the tips of the blades can also be reduced.

In the case where the pump is for pumping a large particle foreign substance (X) together with the fluid, as well as for the normal water, the fluid passage space H may have a size corresponding to the size of the foreign substance (X).

[0046] Now, with reference to FIG. 7 through FIG. 11, the blades 12 and the blade chambers 16 in this embodiment will be described.

The blades 12 projected from the blade plate 14 with a predetermined blade pitch and a predetermined blade width each include the arched blade front surface 33 curved to protrude in an upstream direction in the rotation direction, and the blade rear surface 35 formed of a curved surface generally along the shape of the blade front surface 33. The impeller 5 includes an arched blade trough surface 37 which smoothly connects the blade front surface 33 and the blade rear surface 35 of two adjacent blades 12 and is curved to protrude toward the blade plate 14.

[0047] The blade chambers 16 each formed of the blade front surface 33, the rear front surface 35 and the blade trough surface 37 which are continuously provided have the following shape. The width of the blades 12 (projecting length) is made gradually shorter from the width of the blade tip, which is substantially the same as the length of the delivery opening 3, toward the bottom of the blade chambers 16. Accordingly, the troughs of the blade chambers 16 are made gradually deeper from the bottom thereof toward the tip thereof. As shown in FIG. 9, FIG. 10 and FIG. 11, the blade chambers 16 are formed such that the cross-section thereof at certain positions are generally similar.

[0048] The impeller 5 having the above-described structure introduces, as if scooping, the fluid supplied from the absorption opening 2 by the rotation of the impeller 5 into each blade chamber 16 along the shape of the blade front surface 3. By the fluid sequentially introduced from the pressurizing chamber 24 via the pressurizing surface 27, a whirlpool can be formed around a central position of the cross-section of the blade chamber along the blade front surface 33 and the blade trough surface 37 in an orderly and accelerating manner as shown with the arrows in FIG. 9 while preventing the generation of a turbulence. Thus, the pressure in the blade chamber can be increased.

[0049] The trough of each blade chamber 16 is formed to become gradually deeper from the bottom thereof toward the tip thereof. Therefore, when the fluid pressurized in the blade chamber 16 reaches the delivery opening 3 and is released from the tip thereof by the centrifugal force and the kicking action of the blade 12, a circulating flow directed from the bottom of the blade chamber 16 toward the delivery opening 3 in an orderly manner can be formed. Therefore, the fluid is delivered vigorously and smoothly from the delivery opening 3 while the pressurizing energy thereof is increased.

[0050] The blades 12 formed as described above may each have a thick outer tip owing to the flat surface 5a instead of a thin and pointed outer tip. The base section of the blade 12 is thick owing to the curving of the blade trough surface 37. Therefore, the blades 12 are strong and durable, and so can be provided close to the pressurizing partition wall 25. Therefore, the outer tips of the blades 12 can be provided close to the pressurizing partition wall 25. This suppresses the leak of the fluid, air bubbles and the like from the space between the blades 12 and the pressurizing partition wall 25. The fluid vigorously flowing out from the space although being in a small amount flows into the next blade chamber 16 and is scooped by the blade front surface 33 while forming a whirlpool along the inclining surface 5b and the blade rear surface 35. Therefore, the pressurization can be promoted without causing a significant turbulence.

[0051] As represented with the solid line in FIG. 9, the blade rear surface 35 and the blade front surface 33 can be continuously formed with a curve larger than the curve represented with the chained line. In this case also, it is desirable that the level difference 36 is formed on a tangential line extending from the trough of the blade chamber 16.

[0052] Referring to FIG. 8, the trough surface is not limited to inclining from the bottom toward the tip of the blade chamber 16. The trough surface may include a non-inclining portion from a position at about half of the trough in a length direction thereof to the delivery opening 3 (see chained line 37).

In this case, regardless of the size of the delivery opening 3 provided at a predetermined position of the impeller case 4b, the trough surface can be inclined without decreasing the depth of the trough on the bottom side of the blade chamber 16. Therefore, the fluid can be directed toward the delivery opening 3 without fail. Such a blade chamber 16 may be chosen in correspondence with the usage of the pump 1. This provides an advantage that, for example, the blade chamber 16 can be easily adapted to any of various pump specifications.

[0053] The pump 1 structured as described above operates as follows. When the impeller 5 is driven to rotate, each blade 12 scrapes and absorbs the fluid into the blade chamber 16 from the absorption opening 2 via the absorption chamber 23, while the fluid accommodated in each blade chamber 16 is continuously carried around in the pump chamber 9 to reach the delivery opening 3 and is delivered from the delivery pipe 13.

[0054] The level of the tip of each blade 12 of the impeller 5 is made lower than the level of the outer circumferential surface of the blade plate 14 by the level difference 36 which is provided inward from the outer circumferential surface. Therefore, the foreign substance (X) mixed to contaminate the fluid is allowed to pass the large fluid passage space H between the inner circumferential wall 11 and the tips of the blades 12 and to escape in the circumferential direction. Thus, the collision of the foreign substance (X) against the inner circumferential wall 11

is buffered. In addition, the tips of the blades 12 are prevented from moving while catching the foreign substance (X). Therefore, the pump is made highly durable, and the cavitation, water-draining noise and the like caused at the tips of the blades can be reduced by the fluid passage space H.

[0055] The impeller 5 allows the fluid control space h to be narrowed substantially to the limit of the tolerable processing precision while securing the fluid passage space H. This provides advantages that, for example, even where the fluid pressure in the pressurizing chamber 24 is increased, the movement of the fluid to the rear side of the blade plate 14 can be controlled and the pumping efficiency can be improved.

[0056] At this point, air mixed with the fluid in the pressurizing chamber 24 in correspondence with a certain usage is pressurized along the pressurizing surface 27 while being formed into small bubbles by the blades 12 and uniformly dispersed in the fluid passage space H. The air bubbles reach the pressurizing partition wall 25, and are smoothly delivered at the most pressurized state from the delivery opening 3 while being supplied with a pushing force and a centrifugal force by the rotation of the blades 12.

[0057] Owing to this, various processing including washing with a fluid mixed with air, water cleaning with an aeration action and the like can be performed at a high performance. The gas to be mixed in the pump 1 is not limited to air, and any of various types of gas or powder can be used. Any liquid such as a liquid medicine, a fire extinguishing liquid, a fertilizing liquid or the like can also be used. Thus, the convenience is increased and the usage of the pump can be broadened.

Claims

1. A pressurizing centrifugal pump, comprising:

a drum-like case (4) having an absorption opening (2) and a delivery opening (3); and
an impeller (5) rotatable in the case (4), the impeller having a plurality of blades (12) projected on a side surface of a blade plate (14), radially from a boss section (15), each of the blades (12) having an angle extending rearward in a rotation direction;
wherein:

in an inner surface of the case (4), a pressurizing surface (27) which faces the blades (12) and is a part of a pressurizing chamber (24) converged from the absorption opening (2) toward the delivery opening (3), and a pressurizing section (22) having a pressurizing partition wall (25), provided close to a side surface of the blades (12), for preventing a fluid in blade chambers (16) from

leaking, are provided;

a pump chamber (9) is provided in which the impeller (5) faces the pressurizing surface (27) and the pressurizing section (22); tips of the blades (12) are provided at a level lower than that of an outer circumferential surface of a blade plate (14) by a level difference (36) provided from the outer circumferential surface toward a central position of the blade plate (14);

the outer circumferential surface of the blade plate (14) is provided close to an inner circumferential wall (11) of the case (4) to form a fluid control space (h) for controlling movement of the fluid toward a rear side of the blades; and

a fluid passage space (H) for promoting passage of a foreign substance (X) in the fluid is formed between the inner circumferential wall (11) and the tips of the blades (12).

2. A pressurizing centrifugal pump according to claim 1, wherein the blade chambers (16) formed of the blades (12) projected from the blade plate (14) with a predetermined interval between each two adjacent blades (12) are each formed of:

an arched blade front surface (33) curved to protrude toward an upstream direction in the rotation direction;

a blade rear surface (35) formed of a curved surface which is generally along a shape of the blade front surface (33); and

an arched blade trough surface (37) for connecting the blade front surface (33) of a blade (12) and the blade rear surface (35) of another blade (12) adjacent thereto, the blade trough surface (37) being curved to protrude toward the blade plate (14).

3. A pressurizing centrifugal pump according to claim 1 or 2, wherein troughs of the blade chambers (16) are made gradually deeper from a bottom toward a tip thereof.

4. A pressurizing centrifugal pump according to claim 1 or 2, wherein troughs of the blade chambers (16) are made gradually deeper from a bottom to a middle point before a tip thereof and are made generally constant in depth from the middle point to the tip.

5. A pressurizing centrifugal pump according to claim 1 or 2, wherein a pressurizing guide surface (27b) generally parallel to a side surface of the impeller (5) is provided on the side of a start point of the pressurizing surface (27) continued to the absorption opening (2).

FIG.1

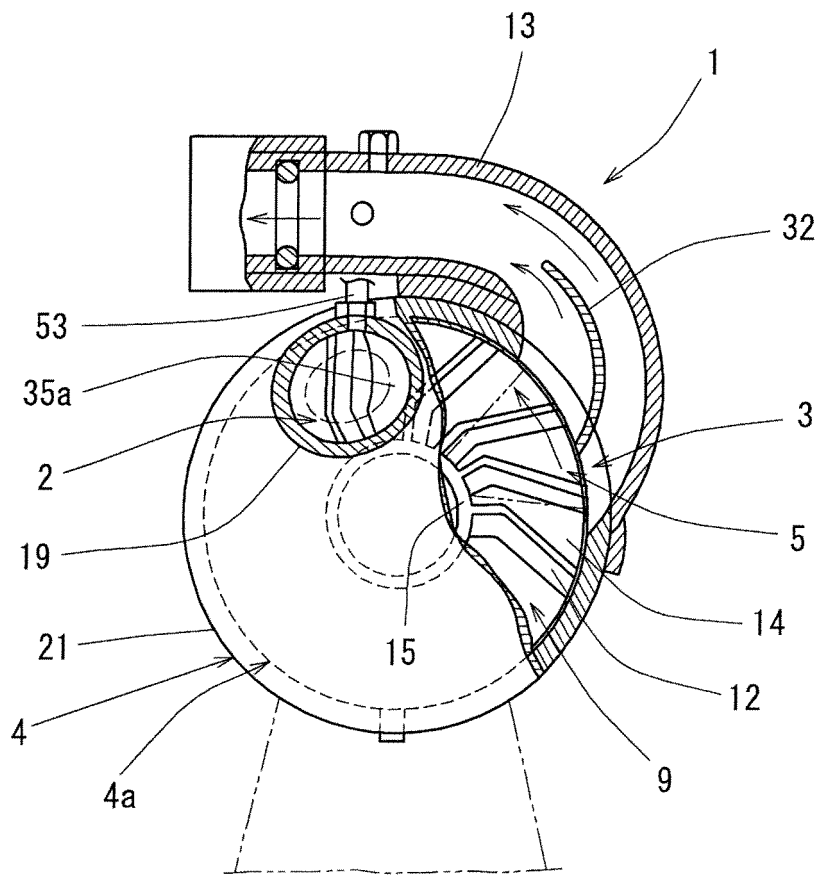


FIG.2

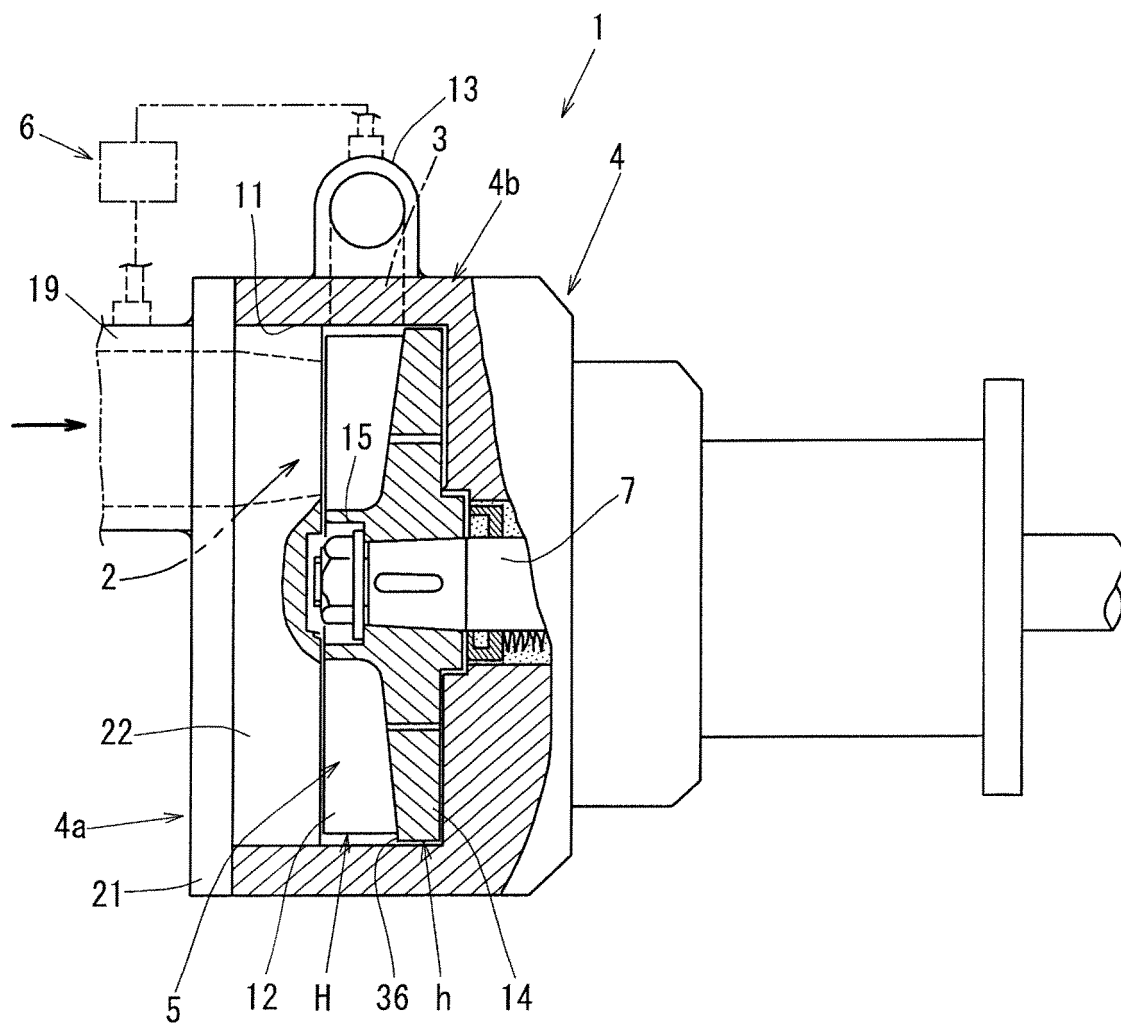


FIG.3

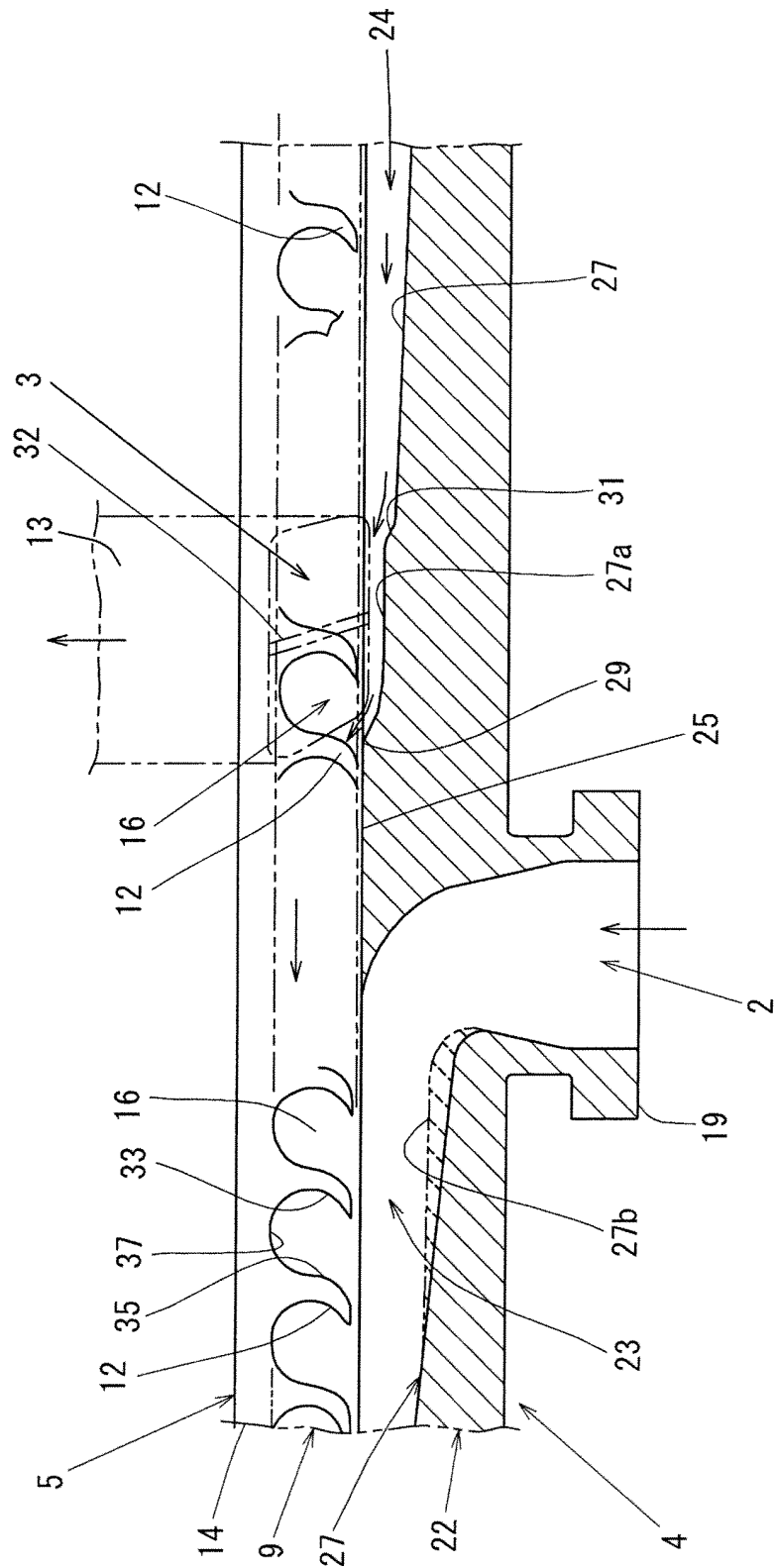


FIG.4

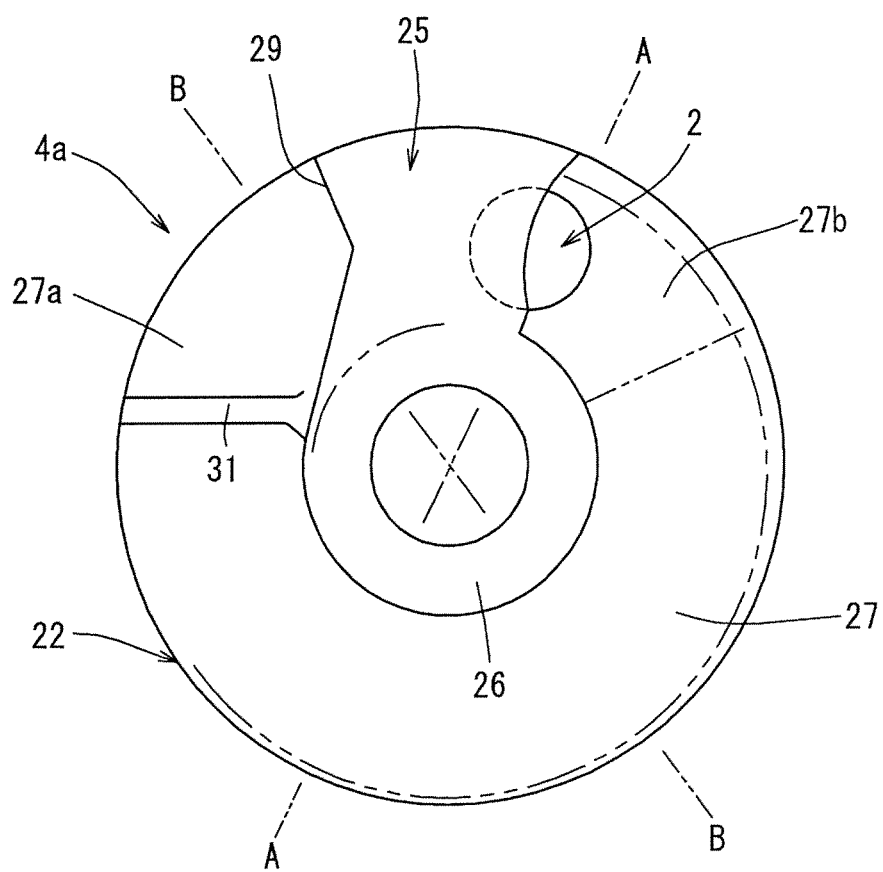


FIG.5

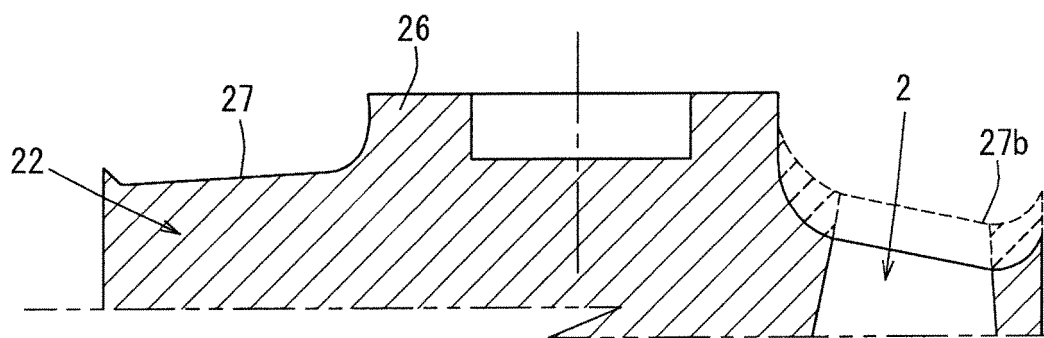


FIG.6

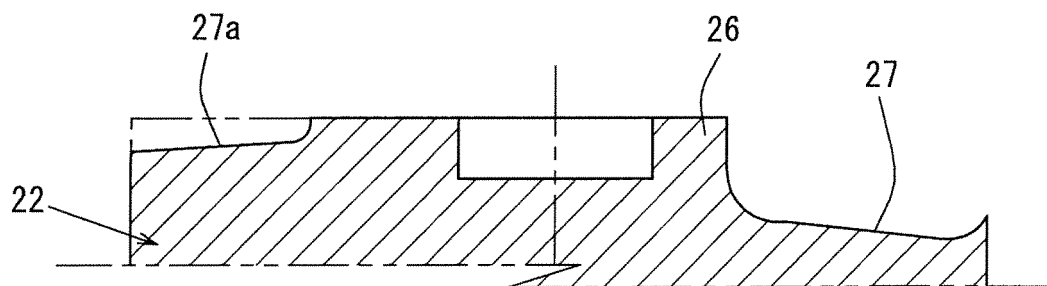


FIG.7

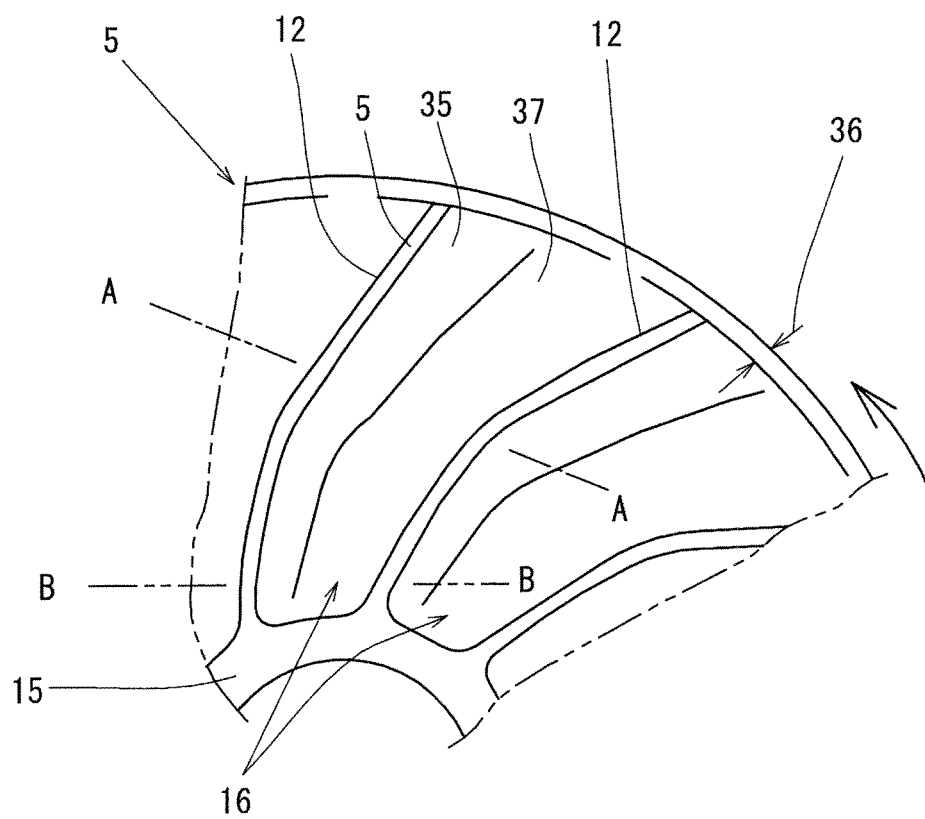


FIG.8

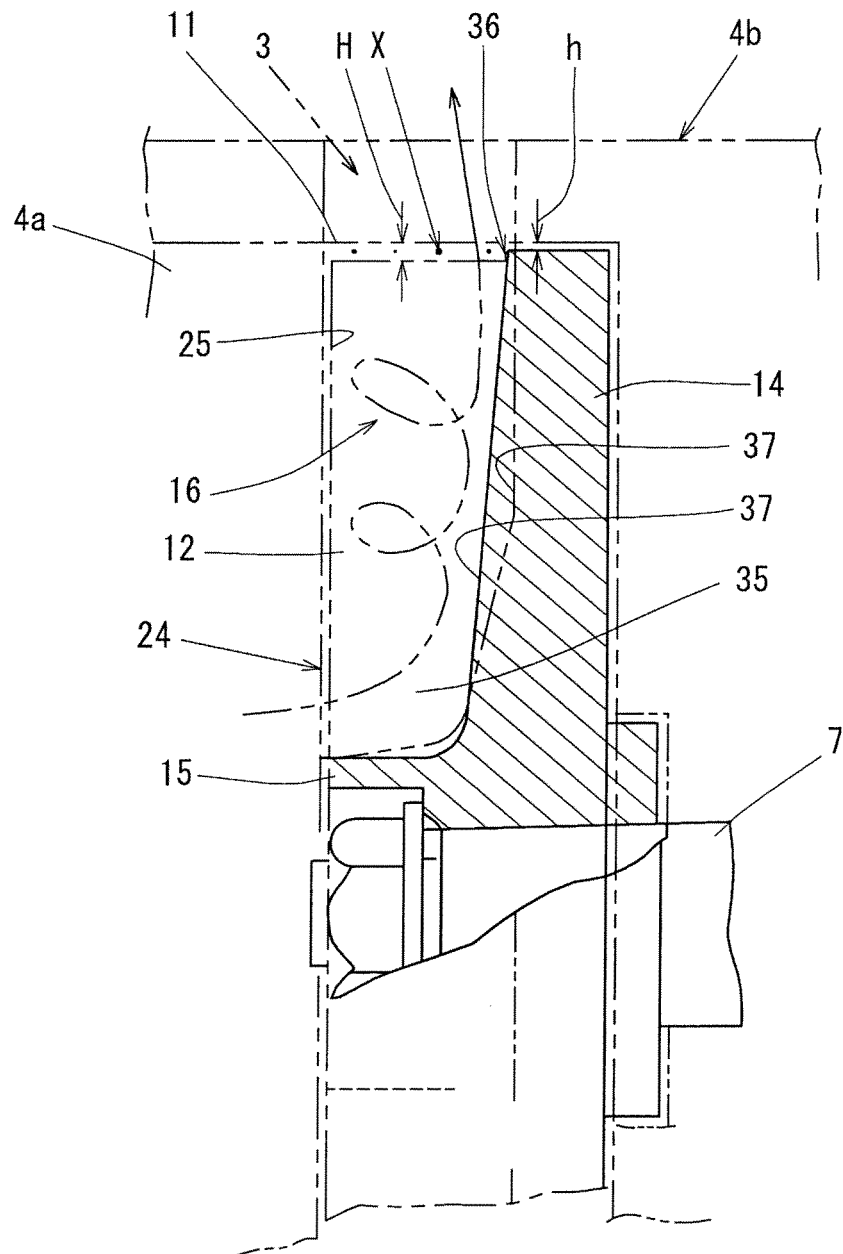


FIG.9

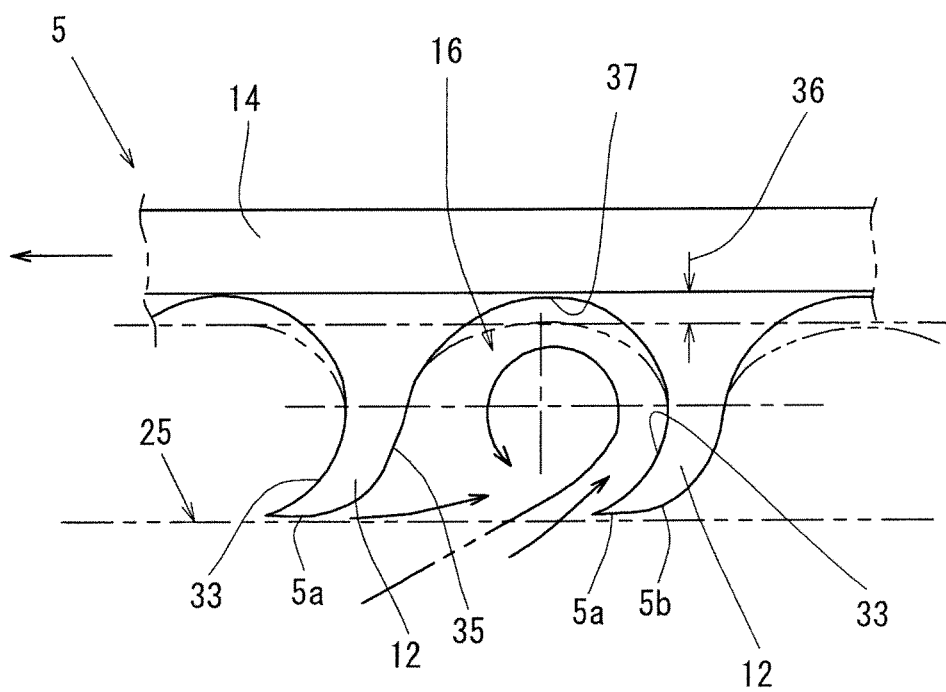


FIG.10

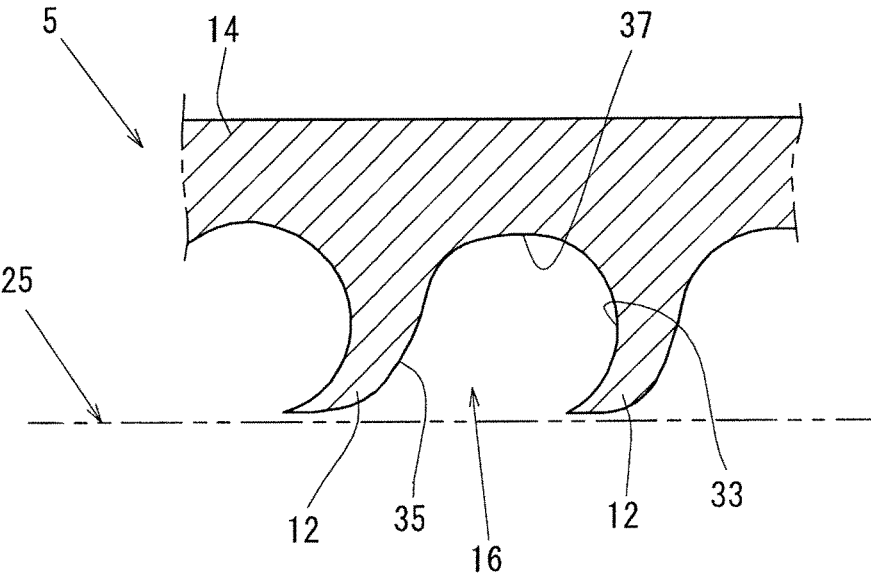
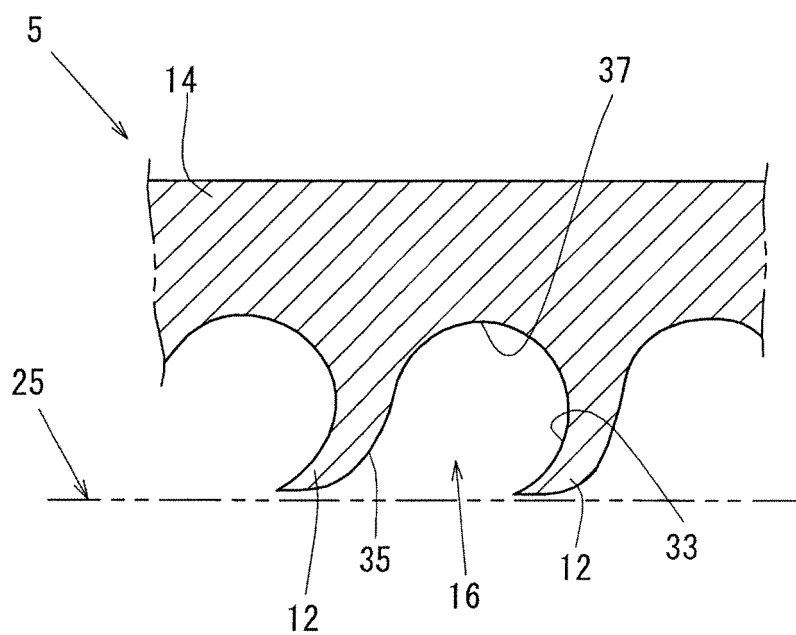


FIG.11



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2007/074642

A. CLASSIFICATION OF SUBJECT MATTER

F04D29/24(2006.01)i, F04D5/00(2006.01)i, F04D7/04(2006.01)i, F04D29/42(2006.01)i, F04D29/66(2006.01)i, F04D31/00(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)

F04D29/24, F04D5/00, F04D7/04, F04D29/42, F04D29/66, F04D31/00

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 1996-2008

Kokai Jitsuyo Shinan Koho 1971-2008 Toroku Jitsuyo Shinan Koho 1994-2008

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.
Y	WO 2005/098239 A1 (Yonehara Giken Co., Ltd.), 20 October, 2005 (20.10.05), Par. Nos. [0022] to [0061]; Figs. 1 to 11 (Family: none)	1-5
Y	JP 2005-240628 A (Tsurumi Manufacturing Co., Ltd.), 08 September, 2005 (08.09.05), Par. No. [0007]; Fig. 1 (Family: none)	1-5
Y	JP 63-138199 A (Nikko Consulting Engineering Co., Ltd.), 10 June, 1988 (10.06.88), Page 3, upper right column, line 5 to lower right column, line 15; Fig. 1 (Family: none)	2-5

☒ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

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Date of the actual completion of the international search
03 March, 2008 (03.03.08)

Date of mailing of the international search report
18 March, 2008 (18.03.08)

Name and mailing address of the ISA/
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INTERNATIONAL SEARCH REPORT

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PCT/JP2007/074642

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2006-307859 A (Sulzer Pumpen AG.), 09 November, 2006 (09.11.06), Fig. 3 & US 2006/263200 A1 & EP 1717449 A2	3
Y	JP 9-177693 A (Asmo Co., Ltd.), 11 July, 1997 (11.07.97), Fig. 1 (Family: none)	3
Y	JP 2005-270245 A (Hitachi Home & Life Solution, Inc.), 06 October, 2005 (06.10.05), Fig. 1 (Family: none)	4
Y	JP 2000-240584 A (Ebara Corp.), 05 September, 2000 (05.09.00), Fig. 5 (Family: none)	4
Y	JP 4-159493 A (Hitachi, Ltd.), 02 June, 1992 (02.06.92), Page 3, upper left column, line 4 to page 4, upper left column, line 16; Figs. 1 to 8 & EP 477650 A2	5
A	JP 2005-240629 A (Tsurumi Manufacturing Co., Ltd.), 08 September, 2005 (08.09.05), Par. No. [0007]; Figs. 1 to 6 (Family: none)	1-5

Form PCT/ISA/210 (continuation of second sheet) (April 2007)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2004060470 A [0002]