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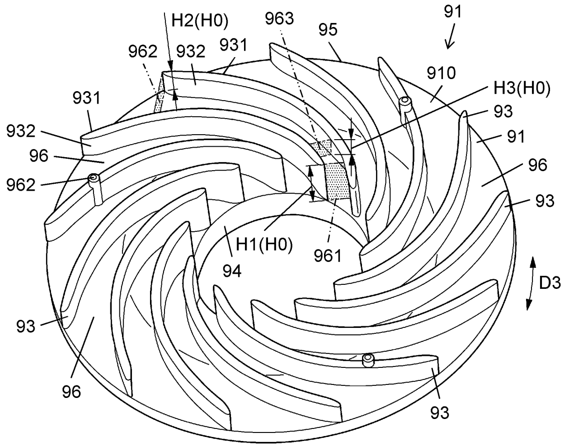
(54) PUMP

(57) The present disclosure provides a pump that suppresses occurrence of cavitation. The pump according to the present disclosure includes an impeller and a driver. The impeller includes a plurality of blades (93) each having a plate shape and facing each other in a rotation direction. The driver rotates the impeller to cause a liquid to flow. The impeller has flow path (96). Flow path (96) is formed between a pair of adjacent blades of the plurality of blades (93). In flow path (96), the liquid flows from inlet port (961) positioned at inner edge portion (94) of the impeller toward outlet port (962) positioned at outer edge portion (95) of the impeller. Flow path (96) throttle (963) having a cross-sectional area smaller than a cross-sectional area of inlet port (961) and a cross-sectional area of outlet port (962).

FIG. 6



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Description

TECHNICAL FIELD

[0001] The present disclosure relates generally to a pump, and more particularly to a pump including an impeller.

BACKGROUND ART

[0002] The pump impeller described in PTL 1 includes a first impeller body, a second impeller body, a discharge flow path, and a collar. The pump impeller described in PTL 1 is operated by being implemented on a pump, and thus, a liquid is drawn from an inflow hole of a first impeller body by a centrifugal force and flows outward through a discharge flow path. In the pump impeller described in PTL 1, a cross-sectional area of the discharge flow path decreases from the inner end thereof toward the outer end thereof.

Citation List

Patent Literature

[0003] PTL 1: Japanese Utility Model Registration No. 3168366

SUMMARY OF THE INVENTION

Technical problem

[0004] In the pump impeller described in PTL 1 and the pump including the same, cavitation may occur in the discharge flow path.

[0005] The present disclosure has been made in view of the above circumstances, and an object of the present disclosure is to provide a pump in which occurrence of cavitation can be suppressed.

Solution to problem

[0006] A pump according to an aspect of the present disclosure includes an impeller and a driver. The impeller includes a plurality of blades each having a plate shape and facing each other in a rotation direction. The driver rotates the impeller to cause a liquid to flow. The impeller has a flow path. The flow path is formed between a pair of adjacent blades of the plurality of blades. In the flow path, the liquid flows from an inlet port positioned at an inner edge portion of the impeller toward an outlet port positioned at an outer edge portion of the impeller. The flow path includes a throttle having a cross-sectional area smaller than a cross-sectional area of the inlet port and a cross-sectional area of the outlet port between the inlet port and the outlet port.

Advantageous effect of invention

[0007] In the present disclosure, it is possible to provide the pump in which the occurrence of cavitation can be suppressed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008]

Fig. 1 is a cross-sectional view of a pump according to a first exemplary embodiment.
Fig. 2 is an enlarged cross-sectional view of main parts of the pump according to the first exemplary embodiment.
Fig. 3 is a perspective view of a positioning member of the pump according to the first exemplary embodiment.
Fig. 4 is a perspective view of the positioning member in the first exemplary embodiment as viewed from another angle.
Fig. 5 is a schematic view of main parts of the pump according to the first exemplary embodiment.
Fig. 6 is a perspective view of main parts of an impeller of the pump according to the first exemplary embodiment.
Fig. 7 is a plan view of main parts of the impeller in the first exemplary embodiment.
Fig. 8 is a cross-sectional view of main parts of the impeller in the first exemplary embodiment.
Fig. 9 is a graph showing a relationship between a cross-sectional area and a position in a flow path of the impeller in the first exemplary embodiment.
Fig. 10 is a perspective view of a positioning member of a pump according to a first modification.
Fig. 11 is a schematic view of main parts of a pump according to a second modification.
Fig. 12 is a perspective view of a positioning member of the pump according to the second modification.
Fig. 13 is a perspective view of the positioning member in the second modification as viewed from another angle.
Fig. 14 is a perspective view of a positioning member of a pump according to a third modification.
Fig. 15 is a schematic view of main parts of the pump according to the third modification.
Fig. 16 is a schematic view of main parts of a pump according to a second exemplary embodiment.

DESCRIPTION OF EMBODIMENT

[0009] Hereinafter, preferred exemplary embodiments of the present disclosure will be described in detail with reference to the drawings. Note that, in the exemplary embodiments to be described below, elements common to each other are denoted by the same reference marks, and redundant description of the common elements may be omitted. The following exemplary embodiments are merely some of various exemplary embodiments of the present disclosure. The exemplary embodiments can be variously changed in accordance with the design and the like as long as the object of the present disclosure can be achieved.

[0010] The drawings described in the exemplary embodiments are schematic views, and ratios of sizes and thicknesses of the elements in the drawings do not necessarily reflect actual dimensional ratios. Note that, arrows indicating directions are merely examples, and are not intended to define directions when a pump is used. In addition, the indicating the directions in the drawings are merely illustrated for description, and are unsubstantial.

[0011] Note that, the term "orthogonal (that is, vertical)" used in the present disclosure includes not only a state where an angle between two elements is strictly 90° but also a state where two elements are substantially orthogonal to each other within a certain range of error. That is, the angle between two orthogonal elements is within a certain range of error (for example, less than or equal to 10°) with respect to 90°.

[0012] In the following description, in the illustration of values of a distance, an area, and the like, the expression "less than or equal to" may be the expression "less than". That is, when two values are compared, since whether a case where two values are equal is included or not can be arbitrarily changed depending on how a reference value or the like is set, there is no technical difference between the expression "less than or equal to" and the expression "less than". Similarly, the expression "more than or equal to" may be the expression "exceed".

(First exemplary embodiment)

(1) Overview

[0013] First, an overview of pump 1 according to a first exemplary embodiment will be described with reference to Figs. 1 to 6.

[0014] Fig. 1 is a cross-sectional view of pump 1 according to the first exemplary embodiment. Fig. 6 is a perspective view of main parts of impeller 9 of pump 1 according to the first exemplary embodiment. As illustrated in Fig. 1, pump 1 includes driver 3 and impeller 9.

[0015] Driver 3 rotates impeller 9 to cause a liquid to flow. Specifically, driver 3 changes a magnetic field to rotate impeller 9. Driver 3 rotates impeller 9. Thus, pump 1 sucks a liquid such as water from suction portion 22 into pump chamber SP3, and discharges the liquid from discharge portion 24 to an outside of pump 1.

[0016] Impeller 9 is housed in pump chamber SP3. Impeller 9 has front shroud 91 (that is, an example of a first shroud) and rear shroud 92 (that is, an example of a second shroud).

[0017] As illustrated in Fig. 6, front shroud 91 is formed in an annular shape. A plurality of blades 93 are formed in front shroud 91. In Fig. 6, 13 blades 93 are formed. In other words, impeller 9 has the plurality of blades 93.

[0018] The plurality of blades 93 are formed in plate shapes facing each other in the rotation direction. A plurality of (for example, 13) flow paths 96 are formed between the plurality of blades 93. In other words, impeller 9 has the plurality of flow paths 96.

[0019] Flow path 96 is formed between two adjacent blades 93. In addition, flow path 96 is formed from inner edge portion 94 to outer edge portion 95 of front shroud 91 (that is, one element of impeller 9). When impeller 9 is rotated, in flow path 96, a liquid flows from inlet port 961 positioned at inner edge portion 94 toward outlet port 962 positioned at outer edge portion 95. Flow path 96 has throttle 963.

[0020] Throttle 963 is formed between inlet port 961 and outlet port 962 in flow path 96. Throttle 963 has a cross-sectional area smaller than a cross-sectional area of inlet port 961 and a cross-sectional area of outlet port 962.

[0021] Since the cross-sectional area of throttle 963 is smaller than the cross-sectional area of inlet port 961 and the cross-sectional area of outlet port 962, throttle 963 pressurizes a liquid passing through throttle 963. Since throttle 963 pressurizes the liquid, pump 1 of the first exemplary embodiment can suppress occurrence of cavitation.

(2) Details

[0022] Hereinafter, details of pump 1 according to the first exemplary embodiment will be described with reference to Figs. 1 to 9. Note that, in the following description, extending direction D1 of axis Ax1 of rotating shaft 6 is defined as a "front-rear direction". Further, an orientation from rotating shaft 6 toward tubular portion 21 of pump case 2 is defined as "forward", and an orientation from tubular portion 21 toward rotating shaft 6 is defined as "rearward".

[0023] Pump 1 is, for example, a pump used in water. As illustrated in Fig. 1, pump 1 includes pump case 2, driver 3, rotating shaft 6, bearing 7, rotor 8, impeller 9, receiving plate 100, positioning member 200, elastic member 300, and plate 400.

(2.1) Pump case

[0024] Pump case 2 has tubular portion 21, suction portion 22, base portion 23, and discharge portion 24.

[0025] A shape of base portion 23 is a bottomed tubular shape. Base portion 23 forms first space SP1 for housing impeller 9. First space SP1 is at least a part of pump chamber SP3. That is, base portion 23 (that is, one element of pump case 2) forms at least a part of pump chamber SP3. Base portion 23 has first opening 231 and second opening 232.

[0026] First opening 231 is formed at a bottom portion of base portion 23 along extending direction D1 of rotating shaft 6 (that is, in the front-back direction). A shape of first opening 231 of the first exemplary embodiment is a circular shape in plan view along extending direction D1. However, the shape of first opening 231 is not limited to the circular shape, and the shape of first opening 231 may be, for example, a polygonal shape.

[0027] Second opening 232 is formed in a side peripheral portion of base portion 23. A shape of second opening 232 is a circular shape in plan view along radial direction D2. However, the shape of second opening 232 is not limited to the circular shape, and may be, for example, a polygonal shape. Radial direction D2 is a direction orthogonal to extending direction D1 of rotating shaft 6, and is a direction along a diameter of a virtual circle having axis Ax1 of rotating shaft 6 as a center.

[0028] Suction portion 22 protrudes forward from an edge of first opening 231 of base portion 23. A shape of suction portion 22 is a cylindrical shape. However, the shape of suction portion 22 is not limited to the cylindrical shape, and may be, for example, a tubular shape having a polygonal cross-sectional shape. When impeller 9 is operated, suction portion 22 sucks a liquid such as water from the outside of pump 1.

[0029] Discharge portion 24 protrudes from the side peripheral portion of base portion 23. A shape of discharge portion 24 of the first exemplary embodiment is a cylindrical shape. However, the shape of discharge portion 24 is not limited to the cylindrical shape, and may be, for example, a tubular shape having a polygonal cross-sectional shape. An internal space of discharge portion 24 and first space SP1 are connected to each other through second opening 232. When impeller 9 is operated, discharge portion 24 discharges the liquid in pump chamber SP3 (that is, a part of first space SP1) to the outside of pump 1.

[0030] Tubular portion 21 is supported by base portion 23 so as to be positioned in front of rotating shaft 6 in extending direction D1 and inside inner edge portion 921 of rear shroud 92 in radial direction D2. Tubular portion 21 is formed in a bottomed tubular shape. Fig. 2 is an enlarged cross-sectional view of main parts of pump 1 according to the first exemplary embodiment. As illustrated in Fig. 2, tubular portion 21 has bottom portion 211 and side peripheral portion 212. A shape of bottom portion 211 is a circular shape. Side peripheral portion 212 protrudes rearward from an edge of bottom portion 211. A shape of side peripheral portion 212 is a cylindrical shape. Note that, the shape of tubular portion 21 is not limited to the bottomed cylindrical shape, and may be a bottomed rectangular cylindrical shape, a bottomed elliptical cylindrical shape, or a bottomed cylindrical shape in which a part of side peripheral portion 212 is missing. Tubular portion 21 that is a part of pump case 2 is formed such that first end portion 61 of rotating shaft 6 (that is, one end of rotating shaft 6) is inserted thereto.

(2.2) Driver

[0031] Driver 3 illustrated in Fig. 1 rotates impeller 9 about rotating shaft 6 as a rotation center to cause the liquid to flow. Driver 3 has mold portion 4 and separation plate 5.

(2.2.1) Mold portion

[0032] Mold portion 4 is formed by resin-molding each portion for driving rotor 8. A shape of mold portion 4 is a bottomed tubular shape. Mold portion 4 forms second space SP2 for housing rotor 8. Second space SP2 is at least a part of pump chamber SP3. That is, mold portion 4 (that is, one element of driver 3) forms at least a part of pump chamber SP3.

[0033] Mold portion 4 has bottom portion 45 and side peripheral portion 46. A shape of bottom portion 45 is a circular shape. Side peripheral portion 46 protrudes forward from an edge of bottom portion 45. A shape of side peripheral portion 46 is a cylindrical shape. However, the shape of bottom portion 45 is not limited to the circular shape, and may be, for example, a polygonal shape. The shape of side peripheral portion 46 is not limited to the cylindrical shape, and may be, for example, a rectangular cylindrical shape.

[0034] Mold portion 4 has a stator having a plurality of teeth 41 and a plurality of coils 42, controller 43, and connection portion 44. Note that, in the following description, each of the plurality of teeth 41 may be referred to as "tooth 41". In addition, each of the plurality of coils 42 may be referred to as "coil 42".

[0035] Connection portion 44 is exposed from bottom portion 45 of mold portion 4. Connection portion 44 electrically connects controller 43 and the plurality of coils 42 to an external device such as a power supply that supplies power to controller 43 and the plurality of coils 42.

[0036] The plurality of teeth 41 and the plurality of coils 42 are provided in side peripheral portion 46. Coil 42 is wound around tooth 41. Coil 42 is energized, and thus, a magnetic field is generated.

[0037] Controller 43 is provided in bottom portion 45. Controller 43 changes a magnetic field by performing energization control of the plurality of coils 42. More specifically, controller 43 changes the magnetic field such that rotor 8 rotates by performing the energization control of the plurality of coils 42.

(2.2.2) Separation plate

[0038] Separation plate 5 covers a front surface of bottom portion 45 of mold portion 4 and a front surface and an inner peripheral surface of side peripheral portion 46. Separation plate 5 is disposed between mold portion 4 and pump chamber SP3. In other words, separation plate 5 partitions mold portion 4 and pump chamber SP3. Separation plate 5 covers the front surface of bottom portion 45 of mold portion 4 and the front surface and the inner peripheral surface of side peripheral portion 46 to prevent water from entering mold portion 4 from pump chamber SP3.

[0039] Separation plate 5 has bottom portion 51, side peripheral portion 52, flange portion 53, and tubular portion 54. Bottom portion 51 covers the front surface of bottom portion 45 of mold portion 4. A shape of bottom portion 51 is a circular shape. Side peripheral portion 52 protrudes forward from an edge of bottom portion 51. A shape of side peripheral portion 52 is a cylindrical shape. Side peripheral portion 52 covers the inner peripheral surface of side peripheral portion 46 of mold portion 4. Flange portion 53 protrudes from a front end of side peripheral portion 52 along radial direction D2. A shape of flange portion 53 is an annular shape. Flange portion 53 covers the front surface of side peripheral portion 46 of mold portion 4.

[0040] Tubular portion 54 protrudes toward a front surface from a center of bottom portion 51. A shape of tubular portion 54 is a cylindrical shape. Second end portion 62 (see Fig. 2), which will be described later, of rotating shaft 6 is inserted into tubular portion 54.

(2.3) Rotating shaft

[0041] Rotating shaft 6 is positioned inside pump chamber SP3. Rotating shaft 6 is made of, for example, ceramic. As illustrated in Fig. 2, rotating shaft 6 has base portion 60, first end portion 61, and second end portion 62.

[0042] A shape of base portion 60 is a columnar shape. Note that, the shape of base portion 60 may be a cylindrical shape. Axis Ax1 of rotating shaft 6 is a center of base portion 60.

[0043] First end portion 61 protrudes forward from a front end of base portion 60. A shape of first end portion 61 is a columnar shape having a semicircular cross-sectional shape. Note that, the shape of first end portion 61 may be a polygonal columnar shape or an elliptical columnar shape. First end portion 61 is one end of rotating shaft 6, and is inserted into tubular portion 21 that is a part of pump case 2. In addition, first end portion 61 of the first exemplary embodiment is inserted into tubular portion 21 that is a part of pump case 2 via positioning member 200.

[0044] Second end portion 62 protrudes rearward from a rear end of base portion 60. A shape of second end portion 62 is a columnar shape having a semicircular cross-sectional shape. Note that, the shape of second end portion 62 may be a polygonal columnar shape or an elliptical columnar shape. Second end portion 62 is the other end of rotating shaft 6, and is inserted into tubular portion 54 that is a part of separation plate 5.

(2.4) Bearing

[0045] Bearing 7 is positioned between plate 400 and receiving plate 100 in extending direction D1. A shape of bearing 7 is a cylindrical shape. Rotating shaft 6 passes through bearing 7. Bearing 7 is configured to be movable between plate 400 and receiving plate 100 along extending direction D1.

[0046] As illustrated in Fig. 1, bearing 7 of the first exemplary embodiment is provided in rotor 8 to operate integrally with rotor 8, and rotates around base portion 60 of rotating shaft 6. Bearing 7 is made of, for example, a resin in which a carbon material such as graphite is mixed. As illustrated in Fig. 2, bearing 7 has facing surface 71 facing receiving plate 100 in extending direction D1. A normal line of facing surface 71 is along extending direction D1.

(2.5) Rotor

[0047] As illustrated in Fig. 1, rotor 8 has base portion 81, magnet 82 having a plurality of magnetic poles, first coupling portion 83, and second coupling portion 84.

[0048] A shape of base portion 81 is a cylindrical shape. Base portion 81 holds magnet 82. Magnet 82 is a permanent magnet such as a neodymium magnet.

[0049] A shape of first coupling portion 83 is a cylindrical shape. In plan view along extending direction D1, first coupling portion 83 surrounds receiving plate 100, positioning member 200, and tubular portion 21 of pump case 2. A part of an outer peripheral surface of first coupling portion 83 is connected to an inner peripheral surface of a front end of base portion 81. A rear end of first coupling portion 83 is positioned behind the front end of base portion 81, and a front end of first coupling portion 83 is positioned in front of the front end of base portion 81. The front end of first coupling portion 83 is connected to inner edge portion 921 of rear shroud 92. In other words, first coupling portion 83 protrudes rearward from inner edge portion 921 of rear shroud 92.

[0050] Second coupling portion 84 protrudes rearward from an inner peripheral surface of the rear end of first coupling portion 83. A shape of second coupling portion 84 is a cylindrical shape. A diameter of an inner peripheral surface of second coupling portion 84 is substantially equal to a diameter of an outer peripheral surface of bearing 7. Second coupling portion 84 and bearing 7 are coupled to each other. Since second coupling portion 84 and bearing 7 are coupled to each other, rotor 8 and bearing 7 operate integrally.

[0051] Rotor 8 rotates by an interaction between a magnetic field generated by a current flowing through the plurality of coils 42 of the stator and a magnetic field generated by magnet 82 of rotor 8.

(2.6) Receiving plate

[0052] As illustrated in Fig. 2, receiving plate 100 is positioned in front of bearing 7. More specifically, receiving plate 100 is positioned between bearing 7 and tubular portion 21 that is a part of pump case 2 in extending direction D1. More specifically, receiving plate 100 is positioned between bearing 7 and positioning member 200 in extending direction D1. First end portion 61 of rotating shaft 6 passes through hole 103 of receiving plate 100. A shape of hole 103 has a circular shape. Hole 103 is configured such that receiving plate 100 does not rotate with respect to first end portion 61 (that is, one end of rotating shaft 6) in a state where first end portion 61 of rotating shaft 6 passes through hole 103. Receiving plate 100 is made of, for example, ceramic. Receiving plate 100 is configured to be movable between bearing 7 and positioning member 200 along extending direction D1.

[0053] Receiving plate 100 is a circular (that is, annular shape) flat plate having hole 103. Front surface 102 and rear surface 101 of receiving plate 100 are parallel to each other, and normal lines of front surface 102 and rear surface 101 are along extending direction D1. Rear surface 101 of receiving plate 100 comes into contact with facing surface 71 of bearing 7 when impeller 9 is rotated.

(2.7) Plate

[0054] Plate 400 is positioned behind bearing 7. More specifically, plate 400 is positioned between bearing 7 and tubular portion 54 that is a part of separation plate 5 in extending direction D1. Second end portion 62 of rotating shaft 6 passes through hole 401 of plate 400. A shape of hole 401 is a circular shape. Hole 401 is configured such that plate 400 does not rotate with respect to second end portion 62 (that is, the other end of rotating shaft 6) in a state where second end portion 62 of rotating shaft 6 passes through hole 401. Plate 400 is made of, for example, ceramic.

(2.8) Positioning member

[0055] Positioning member 200 is positioned in front of receiving plate 100. More specifically, positioning member 200 is positioned between receiving plate 100 and tubular portion 21 that is a part of pump case 2 in extending direction D1. Positioning member 200 of the first exemplary embodiment is formed in a bottomed tubular shape. Fig. 3 is a perspective view of positioning member 200 of pump 1 according to the first exemplary embodiment. Fig. 4 is a perspective view of positioning member 200 in the first exemplary embodiment as viewed from another angle. As illustrated in Figs. 3 and 4, positioning member 200 of the first exemplary embodiment has side peripheral portion 201, rear surface 202, bottom portion 203 having a circular shape, and edge portion 204.

[0056] Edge portion 204 protrudes forward from an edge of bottom portion 203. A shape of edge portion 204 is a cylindrical shape. In plan view along extending direction D1, edge portion 204 surrounds elastic member 300 (see Fig. 2).

[0057] Side peripheral portion 201 protrudes rearward from the edge of bottom portion 203. A shape of side peripheral portion 201 is a tubular shape having a D-shaped cross-sectional shape. As illustrated in Fig. 4, an inner peripheral surface of side peripheral portion 201 has flat surface 205 and circumferential surface 206. In pump 1 of the first exemplary embodiment, first end portion 61 of rotating shaft 6 is inserted into the inner peripheral surface of side peripheral portion 201, and the inner peripheral surface of side peripheral portion 201 and an outer peripheral surface of the semicircular shape of first end portion 61 are fitted to each other. That is, positioning member 200 of the first exemplary embodiment covers first end portion 61 of rotating shaft 6 (that is, one end of rotating shaft 6). Positioning member 200 is fixed to rotating shaft 6 by fitting the inner peripheral surface of side peripheral portion 201 and the outer peripheral surface of first end portion 61 to each other. First end portion 61 of rotating shaft 6 is fitted into positioning member 200, and thus, positioning member 200 can be more firmly fixed to rotating shaft 6.

[0058] As shown in Fig. 2, rear surface 202 is a flat portion at a rear end of side peripheral portion 201. A normal line of rear surface 202 is along extending direction D1. Rear surface 202 comes into contact with front surface 102 of receiving plate 100 when pump 1 is operated. That is, when pump 1 is operated, positioning member 200 defines a position of receiving plate 100 in extending direction D1.

[0059] Positioning member 200 defines the position of receiving plate 100 in extending direction D1, and thus, for example, contact between receiving plate 100 and tubular portion 21 can be suppressed. For example, even in a case where rotating shaft 6 is attached to be inclined with respect to tubular portion 21 (that is, one element of pump case 2), receiving plate 100 and tubular portion 21 are prevented from coming into contact with each other, and thus, it is possible to suppress the inclination of receiving plate 100 with respect to rotating shaft 6. The inclination of receiving plate 100 with respect to rotating shaft 6 is suppressed, and thus, it is possible to stabilize contact between facing surface 71 of bearing 7 and rear surface 101 of receiving plate 100 and to suppress generation of vibration and noise when pump 1 is operated.

[0060] In addition, rear surface 202 of positioning member 200 comes into contact with front surface 102 of receiving plate 100 when pump 1 is operated, and thus, positioning member 200 defines intersection angle $\theta 1$ (see Fig. 5, which will be described later) between the flat portion (that is, rear surface 101) of receiving plate 100 and rotating shaft 6. For example, positioning member 200 defines intersection angle $\theta 1$ between the flat portion of receiving plate 100 and rotating shaft 6 by preventing receiving plate 100 and tubular portion 21 from coming into contact with each other. Intersection angle $\theta 1$ between the flat portion of receiving plate 100 and rotating shaft 6 defined by positioning member 200 is preferably in a range of 85° to 95°. In addition, intersection angle $\theta 1$ between the flat portion of receiving plate 100 and rotating shaft 6 defined by positioning member 200 is more preferably in a range of 88° to 92°. Positioning member 200 defines intersection angle $\theta 1$ between rear surface 101 of receiving plate 100 and rotating shaft 6, and thus, it is possible to further suppress the inclination of receiving plate 100 with respect to rotating shaft 6.

[0061] In addition, intersection angle θ2 between rear surface 202 of positioning member 200 of the first exemplary embodiment and rotating shaft 6 (see Fig. 5, which will be described later) is 90° (that is, vertical). That is, in positioning member 200 of the first exemplary embodiment, intersection angle θ1 between the flat portion (that is, rear surface 101) of receiving plate 100 and rotating shaft 6 is defined as 90° (that is, vertical). For example, positioning member 200 defines intersection angle θ1 between the flat portion of receiving plate 100 and rotating shaft 6 as being vertical by preventing receiving plate 100 and tubular portion 21 from coming into contact with each other. Intersection angle θ1 between the flat portion of receiving plate 100 and rotating shaft 6 is defined as being vertical, and thus, it is possible to further stabilize the contact between facing surface 71 of bearing 7 and rear surface 101 (that is, the flat portion) of receiving plate 100.

[0062] In addition, positioning member 200 of the first exemplary embodiment defines the position of receiving plate 100 such that rear surface 101 (that is, the flat portion) of receiving plate 100 and facing surface 71 of bearing 7 are brought into surface contact with each other. For example, positioning member 200 prevents receiving plate 100 and tubular portion 21 from coming into contact with each other, and thus, the flat portion of receiving plate 100 and facing surface 71 of bearing 7 come into surface contact with each other. Here, the term "surface contact" used in the present disclosure refers to a state where surfaces parallel to each other or surfaces regarded as parallel to each other come into contact with each other in a surface shape. The position of receiving plate 100 is defined such that rear surface 101 of receiving plate 100 and facing surface 71 of bearing 7 come into surface contact with each other, and thus, it is possible to suppress generation of vibration and noise when pump 1 is operated.

[0063] Fig. 5 is a schematic view of main parts of pump 1 according to the first exemplary embodiment. As illustrated in Fig. 5, in pump 1 of the first exemplary embodiment, gap SP4 is formed between positioning member 200 and tubular portion 21. More specifically, gap SP4 is formed between side peripheral portion 201 of positioning member 200 and side peripheral portion 212 of tubular portion 21. In addition, gap SP4 is formed between bottom portion 203 of positioning member 200 and bottom portion 211 of tubular portion 21.

[0064] Fig. 5 illustrates a state where rotating shaft 6 is assembled to be inclined with respect to tubular portion 21. Even in a case where rotating shaft 6 is assembled so as to be inclined with respect to tubular portion 21, gap SP4 is present between positioning member 200 and tubular portion 21, and thus, positioning member 200 is inclined with respect to tubular portion 21 in accordance with an inclination angle of rotating shaft 6. Positioning member 200 is inclined with respect to tubular portion 21 in accordance with the inclination angle of rotating shaft 6, and thus, intersection angle θ2 between rear surface 202 of positioning member 200 and rotating shaft 6 is maintained at a vertical angle.

[0065] Intersection angle θ2 between rear surface 202 of positioning member 200 and rotating shaft 6 is maintained at the vertical angle, and thus, intersection angle θ1 between the flat portion (that is, rear surface 101) of receiving plate 100 and rotating shaft 6 can be maintained at a vertical angle. Accordingly, the contact between facing surface 71 of bearing 7 and rear surface 101 (that is, the flat portion) of receiving plate 100 can be further stabilized.

(2.9) Elastic member

[0066] Elastic member 300 is positioned between positioning member 200 and tubular portion 21 that is a part of pump case 2 in extending direction D1. More specifically, elastic member 300 is positioned between bottom portion 203 of positioning member 200 and bottom portion 211 of tubular portion 21 in extending direction D1.

[0067] A shape of elastic member 300 of the first exemplary embodiment is a columnar shape. Elastic member 300 is made of, for example, rubber or the like, and functions as a displacement absorbing material of at least one of tubular portion 21 of pump case 2 and positioning member 200. Pump 1 includes elastic member 300, and thus, it is possible to suppress propagation of vibration generated when impeller 9 is rotated to tubular portion 21 of pump case 2.

(2.10) Impeller

[0068] As illustrated in Fig. 1, impeller 9 of the first exemplary embodiment is formed integrally with rotor 8. Impeller 9 is positioned in front of rotor 8. Impeller 9 is positioned within first space SP1 of pump chamber SP3.

[0069] Impeller 9 has front shroud 91 (that is, an example of a first shroud) and rear shroud 92 (that is, an example of a second shroud). As illustrated in Fig. 1, front shroud 91 and rear shroud 92 are side by side in extending direction D1. More specifically, rear surface 910 of front shroud 91 and front surface 923 of rear shroud 92 face each other in extending direction D1.

[0070] Rear shroud 92 is formed in an annular shape having inner edge portion 921 and outer edge portion 922.

[0071] Front shroud 91 is positioned in front of rear shroud 92. Front shroud 91 is formed in an annular shape having inner edge portion 94 and outer edge portion 95.

[0072] As illustrated in Fig. 6, the plurality of blades 93 facing each other in the rotation direction (that is, circumferential direction D3) are formed in front shroud 91. In Fig. 6, thirteen blades 93 are formed. In other words, impeller 9 has the plurality of blades 93. In the following description, each of the plurality of blades 93 may be referred to as "blade 93".

[0073] Blade 93 protrudes rearward from rear surface 910 of front shroud 91 along extending direction D1 (see Fig. 1). In other words, blade 93 protrudes toward front surface 923 of rear shroud 92 along extending direction D1. Height H0 of blade 93 of the first exemplary embodiment along extending direction D1 substantially corresponds to a distance along extending direction D1 between rear surface 910 of front shroud 91 and front surface 923 of rear shroud 92.

[0074] In plan view along extending direction D1, blade 93 is formed in an arc plate shape from inner edge portion 94 to outer edge portion 95. Blade 93 has first surface 931 and second surface 932. Impeller 9 of the first exemplary embodiment rotates in an orientation from second surface 932 toward first surface 931 along circumferential direction D3 of front shroud 91.

[0075] The plurality of flow paths 96 are formed between the plurality of blades 93. In Fig. 6, thirteen flow paths 96 are formed. In other words, impeller 9 has the plurality of flow paths 96. In the following description, each of the plurality of flow paths 96 may be referred to as "flow path 96".

[0076] Flow path 96 is formed between two adjacent blades 93. More specifically, flow path 96 is formed between first surface 931 of one blade 93 of two blades 93 adjacent to each other and second surface 932 of other blade 93 of two blades 93 adjacent to each other. That is, flow path 96 is formed between certain first surface 931 and second surface 932 facing certain first surface 931. In addition, flow path 96 is formed from inner edge portion 94 to outer edge portion 95 of front shroud 91 (that is, one element of impeller 9). When impeller 9 is rotated, in flow path 96, a liquid flows from inlet port 961 positioned at inner edge portion 94 toward outlet port 962 positioned at outer edge portion 95.

[0077] In addition, flow path 96 of the first exemplary embodiment is formed by the plurality of blades 93 and a pair of members (that is, front shroud 91 and rear shroud 92) covering both sides of the plurality of blades 93. More specifically, flow path 96 is formed so as to be sandwiched between two blades 93 adjacent to each other in circumferential direction D3, and is sandwiched between rear surface 910 of front shroud 91 and front surface 923 of rear shroud 92 in extending direction D1. Flow path 96 of the first exemplary embodiment is partitioned from pump chamber SP3 in extending direction D1 and circumferential direction D3.

[0078] Fig. 9 is a graph showing a relationship between a cross-sectional area of flow path 96 and a position of flow path 96 between inlet port 961 and outlet port 962 in the first exemplary embodiment.

[0079] The term "cross-sectional area of flow path 96" used in the present disclosure can include an area of a section of flow path 96 intersecting a flow direction of a flowing liquid when pump 1 is operated (that is, when impeller 9 is rotated). Fig. 7 is a plan view of main parts of impeller 9 in the first exemplary embodiment. Fig. 8 is a cross-sectional view of main parts of impeller 9 in the first exemplary embodiment. As illustrated in Figs. 6 to 8, the cross-sectional area of flow path 96 of the first exemplary embodiment is an area of a section in which a distance (that is, a height of blade 93) from rear surface 910 of front shroud 91 to a rear end of blade 93 along extending direction D1 is height H0, and a length of a vertical line from second surface 932 to first surface 931 facing second surface 932 is width W0. Note that, width W0 may be a length of a vertical line from first surface 931 to second surface 932 facing first surface 931. Note that, in the present disclosure, the cross-sectional area of flow path 96 is expressed with the cross-sectional area of inlet port 961 as 100%.

[0080] Note that, in Fig. 6, a section of inlet port 961, a section of outlet port 962, and a section of throttle 963 are illustrated as dotted regions. As illustrated in Fig. 7, in the first exemplary embodiment, width W1 of the section of inlet port 961 is a length of a vertical line from a portion closest to inner edge portion 94 of first surface 931 to second surface 932 facing first surface 931. In addition, as illustrated in Figs. 6 and 8, height H1 of the section of inlet port 961 is a length along extending direction D1 of the portion closest to inner edge portion 94 of first surface 931 (that is, one element of blade 93). In addition, as illustrated in Fig. 7, in the first exemplary embodiment, width W2 of the section of outlet port 962 is a length of a vertical line from first surface 931 to a portion closest to outer edge portion 95 of second surface 932 facing first surface 931. In addition, as illustrated in Fig. 6, height H2 of the section of outlet port 962 is a length along extending direction D1 of the portion closest to outer edge portion 95 of second surface 932 (that is, one element of blade 93).

[0081] As illustrated in Fig. 7, in the present disclosure, the "position of flow path 96" is indicated by a ratio (that is, second distance L2/first distance L1 [%]) of second distance L2 from inlet port 961 to a certain position with respect to first distance L1 in a case where first distance L1 from inlet port 961 to outlet port 962 is 100%. In addition, first distance L1 is defined by, for example, a length of first surface 931 or second surface 932 from inlet port 961 to outlet port 962 in plan view along extending direction D1. First distance L1 of the first exemplary embodiment is a length of first surface 931 from inlet port 961 to outlet port 962. In addition, second distance L2 is defined by, for example, a length of first surface 931 or second surface 932 from inlet port 961 to throttle 963 in plan view along extending direction D1. Second distance L2 of the first exemplary embodiment is a length of first surface 931 from inlet port 961 to throttle 963.

[0082] Flow path 96 has throttle 963. As an example, second distance L2 of throttle 963 of the first exemplary embodiment is 19% of first distance L1. As illustrated in Fig. 9, since the cross-sectional area of throttle 963 in which second distance L2 is 19% of first distance L1 is a smallest cross-sectional area, the cross-sectional area of throttle 963 is smaller than the cross-sectional area of inlet port 961 and the cross-sectional area of outlet port 962.

[0083] Since the cross-sectional area of throttle 963 is smaller than the cross-sectional area of inlet port 961 and the cross-sectional area of outlet port 962, throttle 963 pressurizes the liquid passing through throttle 963. Since throttle 963 pressurizes the liquid, pump 1 of the first exemplary embodiment can suppress occurrence of cavitation. When cavitation occurs in the flow path, a range in which the liquid flows is narrowed, and work efficiency of the pump decreases. However, pump 1 of the first exemplary embodiment suppresses the occurrence of cavitation, and thus, a decrease in work efficiency is suppressed. In addition, by suppressing the occurrence of cavitation, pump 1 of the first exemplary embodiment can suppress generation of vibration and noise when pump 1 is operated.

[0084] In addition, as illustrated in Fig. 7, second distance L2 (for example, 19%) between inlet port 961 and throttle 963 of the first exemplary embodiment is shorter than third distance L3 (for example, 81%) between outlet port 962 and throttle 963. Note that, third distance L3 is defined by, for example, a length of first surface 931 or second surface 932 from outlet port 962 to throttle 963 in plan view along extending direction D1. Third distance L3 of the first exemplary embodiment is a length of first surface 931 from outlet port 962 to throttle 963. Since second distance L2 is shorter than third distance L3, the occurrence of cavitation can be further suppressed. In other words, between inlet port 961 and outlet port 962, throttle 963 is present close to inlet port 961. Thus, the occurrence of cavitation can be further suppressed.

[0085] In addition, second distance L2 (for example, 19%) between inlet port 961 and throttle 963 of the first exemplary embodiment is preferably more than or equal to 10% of first distance L1 between inlet port 961 and outlet port 962. Second distance L2 is more than or equal to 10% of first distance L1, and thus, the occurrence of cavitation can be further suppressed. Note that, second distance L2 between inlet port 961 and throttle 963 is preferably 10% to 30% of first distance L1. In addition, second distance L2 between inlet port 961 and throttle 963 is more preferably 15% to 25% of first distance L1. Further, similarly to the case of throttle 963 of the first exemplary embodiment, second distance L2 between inlet port 961 and throttle 963 is more preferably 18% to 22% of first distance L1. Further, second distance L2 between inlet port 961 and throttle 963 is more preferably 20% of first distance L1. Note that, the throttle is not limited to having one section in flow path 96 as the throttle, and may be formed to have a predetermined length in a length direction of flow path 96.

[0086] In addition, as illustrated in Fig. 9, the cross-sectional area of flow path 96 of the first exemplary embodiment gradually decreases from inlet port 961 toward throttle 963. Since the cross-sectional area of flow path 96 gradually decreases from inlet port 961 to throttle 963, the liquid can smoothly flow through flow path 96.

[0087] In addition, as illustrated in Figs. 6 and 8, height H0 of the plurality of blades 93 of the first exemplary embodiment gradually decreases from inlet port 961 toward throttle 963. Height H0 of the plurality of blades 93 gradually decreases from inlet port 961 toward throttle 963, and thus, the cross-sectional area of flow path 96 can be reduced without narrowing width W0 of flow path 96. Note that, the cross-sectional area of flow path 96 may be reduced by changing a thickness of blade 93 to gradually narrow width W0 of flow path 96 from inlet port 961 toward throttle 963.

[0088] In addition, in throttle 963 of the first exemplary embodiment, height H3 of throttle 963 is lower than height H1 of inlet port 961. Height H3 of throttle 963 is set to be lower than height H1 of inlet port 961, and thus, the cross-sectional area of flow path 96 can be reduced without narrowing width W0 (for example, width W3) of flow path 96.

[0089] As illustrated in Fig. 9, the cross-sectional area of throttle 963 of the first exemplary embodiment in which second distance L2 is 19% of first distance L1 is less than or equal to 85% of the cross-sectional area of inlet port 961 or outlet port 962. The cross-sectional area of throttle 963 is set to be less than or equal to 85% of the cross-sectional area of inlet port 961 or outlet port 962, and thus, the occurrence of cavitation can be further suppressed. In addition, the cross-sectional area of throttle 963 is preferably less than or equal to 75% of the cross-sectional area of inlet port 961 or outlet port 962. The cross-sectional area of throttle 963 is set to be less than or equal to 75% of the cross-sectional area of inlet port 961 or outlet port 962, and thus, the occurrence of cavitation can be further suppressed. Further, the cross-sectional area of throttle 963 is more preferably 70% of the cross-sectional area of inlet port 961 or outlet port 962.

[0090] In addition, as illustrated in Fig. 9, as an example, the cross-sectional area of throttle 963 of the first exemplary embodiment in which second distance L2 is 19% of first distance L1 is more than or equal to 55% of the cross-sectional area of inlet port 961 or outlet port 962. The amount of liquid flowing through flow path 96 is maintained at a certain level or more, the work efficiency of pump 1 can be maintained at a certain level or more. In addition, the cross-sectional area of throttle 963 is preferably more than or equal to 65% of the cross-sectional area of inlet port 961 or outlet port 962. Further, the cross-sectional area of throttle 963 is more preferably 70% of the cross-sectional area of inlet port 961 or outlet port 962.

(3) Operation of pump

[0091] Next, an operation of pump 1 will be described with reference to Figs. 1 and 2.

[0092] First, controller 43 of driver 3 performs the energization control of the plurality of coils 42. Rotor 8 is rotated by an interaction between the magnetic field generated by the current flowing through the plurality of coils 42 and the magnetic field of magnet 82 having the plurality of magnetic poles included in rotor 8. When rotor 8 rotates, impeller 9 integrally formed with rotor 8 rotates.

[0093] Impeller 9 rotates, and thus, a centrifugal force is generated. The liquid within pump chamber SP3 is discharged from discharge portion 24 by the centrifugal force, and the liquid is sucked into pump chamber SP3 through suction portion 22. That is, impeller 9 is rotated, and thus, pump 1 sucks and discharges the liquid.

[0094] In addition, when impeller 9 is rotated, thrust acts on impeller 9 in an orientation approaching suction portion 22 (that is, forward) along extending direction D1. Impeller 9, rotor 8, bearing 7, and receiving plate 100 are integrally moved forward by the thrust. As illustrated in Fig. 2, front surface 102 of receiving plate 100 comes into contact with rear surface 202 of positioning member 200, and thus, the positions of impeller 9, rotor 8, bearing 7, and receiving plate 100 in extending direction D1 are determined. Bearing 7 rotates in a state where facing surface 71 of bearing 7 comes into contact with rear surface 101 of receiving plate 100.

[0095] Controller 43 of driver 3 performs control to stop the supply of power to the plurality of coils 42, and thus, the rotation of rotor 8 is stopped. Accordingly, operation of pump 1 is stopped.

(4) Modifications

[0096] The first exemplary embodiment is merely one of various exemplary embodiments of the present disclosure. The first exemplary embodiment can be variously changed in accordance with design and the like as long as the object of the present disclosure can be achieved.

[0097] Hereinafter, modifications of the first exemplary embodiment will be listed. The modifications to be described below can be applied in appropriate combination with the first exemplary embodiment.

(4.1) First modification

[0098] Fig. 10 is a perspective view of positioning member 200a of pump 1 according to a first modification. As illustrated in Fig. 10, pump 1 may include positioning member 200a instead of positioning member 200.

[0099] Positioning member 200a has a plurality of retaining portions 207. In Fig. 10, positioning member 200a has two retaining portions 207.

[0100] The plurality of retaining portions 207 protrude from flat surface 205 along a direction orthogonal to extending direction D1. Positioning member 200a has the plurality of retaining portions 207, and thus, it is possible to prevent rotating shaft 6 from coming off from positioning member 200a.

(4.2) Second modification

[0101] Fig. 11 is a schematic view of main parts of pump 1 according to a second modification. As illustrated in Fig. 11, pump 1 may include positioning member 200b instead of positioning member 200, and may include elastic member 300a instead of elastic member 300. As will be described later, elastic member 300a has an annular shape.

[0102] Fig. 12 is a perspective view of positioning member 200b of pump 1 according to the second modification. As illustrated in Fig. 12, positioning member 200b has protrusion 208.

[0103] Protrusion 208 protrudes from bottom portion 203 toward tubular portion 21 of pump case 2 (that is, forward) along extending direction D1. Protrusion 208 has a columnar shape with a rounded front surface. In addition, protrusion 208 is formed in bottom portion 203, and thus, a groove having an annular shape is formed between protrusion 208 and edge portion 204.

[0104] Fig. 13 is a perspective view of positioning member 200b in the second modification as viewed from another angle. As illustrated in Fig. 13, side peripheral portion 201 of positioning member 200b is thicker than side peripheral portion 201 (see Fig. 4) of positioning member 200. In addition, side peripheral portion 201 of positioning member 200b has a bottomed tubular shape.

[0105] Positioning member 200b has a plurality of groove portions 209. In Fig. 13, positioning member 200b has two groove portions 209. The plurality of groove portions 209 are formed on the inner peripheral surface of side peripheral portion 201 along extending direction D1. More specifically, the plurality of groove portions 209 are formed at both ends of flat surface 205. Positioning member 200b has the plurality of groove portions 209, and thus, it is possible to prevent the inner peripheral surface of side peripheral portion 201 from being elastically bent and rotating shaft 6 from coming off in a case where rotating shaft 6 is inserted.

[0106] As illustrated in Fig. 11, a shape of elastic member 300a is an annular shape. Elastic member 300a is disposed to be fitted in the annular groove formed between protrusion 208 and edge portion 204 of positioning member 200b. In addition, elastic member 300a protrudes forward from protrusion 208 in a state of being positioned in the annular groove formed between protrusion 208 and edge portion 204 of positioning member 200b. Pump 1 includes elastic member 300a, and thus, it is possible to suppress propagation of vibration generated when impeller 9 is rotated to tubular portion 21 of pump case 2.

(4.3) Third modification

[0107] Fig. 14 is a perspective view of positioning member 200c of a pump 1 according to a third modification. As illustrated in Fig. 14, pump 1 may include positioning member 200c instead of positioning member 200b.

[0108] Positioning member 200c does not have edge portion 204 of positioning member 200b according to the second modification. In addition, bottom portion 203 of positioning member 200 is formed so as to protrude rearward near an outer edge as approaching the outer edge.

[0109] Fig. 15 is a schematic view of main parts of pump 1 according to the third modification. As illustrated in Fig. 15, in pump 1 according to the third modification, elastic member 300a is fitted around protrusion 208 of positioning member 200c. Elastic member 300a is fitted around protrusion 208, and thus, elastic member 300a comes into contact with tubular portion 21 in extending direction D1 and radial direction D2 within tubular portion 21 of pump case 2. Accordingly, it is possible to suppress propagation of vibration generated when impeller 9 is rotated to tubular portion 21 of pump case 2.

(4.4) Other modifications

[0110] The plurality of blades 93 may be formed on rear shroud 92 instead of front shroud 91. In addition, the plurality of blades 93 may be formed to be dispersed on front shroud 91 and rear shroud 92.

[0111] Driver 3 may have a mechanism for rotating a plurality of driving magnets around separation plate 5 along circumferential direction D3 instead of mold portion 4.

[0112] In the first exemplary embodiment, although it has been described that driver 3 has separation plate 5, pump case 2 may have separation plate 5 instead of driver 3. In addition, at least one of pump case 2 and mold portion 4 may have a shape having a function of separation plate 5 instead of driver 3 having separation plate 5. For example, an inner peripheral portion of mold portion 4 may be resin-molded to prevent water from entering mold portion 4 from pump chamber SP3.

(Second exemplary embodiment)

[0113] Fig. 16 is a schematic view of main parts of pump 1 according to a second exemplary embodiment. As illustrated in Fig. 16, pump 1 according to the second exemplary embodiment is different from pump 1 according to the first exemplary embodiment in that positioning member 200d is provided instead of positioning member 200 and elastic member 300b is provided instead of elastic member 300.

[0114] Rotating shaft 6 of the second exemplary embodiment has groove portion 63. Groove portion 63 is formed over the entire circumference along a circumferential direction of first end portion 61.

[0115] Positioning member 200d is positioned between receiving plate 100 and tubular portion 21 that is a part of pump case 2 in extending direction D1. Gap SP4 is formed between positioning member 200d and a rear end of side peripheral portion 212 of tubular portion 21. Due to the presence of gap SP4, even in a case where rotating shaft 6 is assembled to be inclined with respect to tubular portion 21, positioning member 200d is inclined with respect to tubular portion 21 in accordance with the inclination angle of rotating shaft 6.

[0116] Positioning member 200d is a flat plate-shaped member. Positioning member 200d of the second exemplary embodiment is a flat plate having an annular shape and having through-hole 210 through which first end portion 61 of rotating shaft 6 passes. A shape of through-hole 210 is a circular shape. Through-hole 210 is configured such that positioning member 200d does not rotate with respect to first end portion 61 (that is, one end of rotating shaft 6) in a state where first end portion 61 of rotating shaft 6 passes through through-hole 210.

[0117] In addition, through-hole 210 of the second exemplary embodiment is formed to be fitted in groove portion 63 of rotating shaft 6. That is, positioning member 200d is formed to be fitted in groove portion 63 of rotating shaft 6. Positioning member 200d is fixed to rotating shaft 6, and positioning member 200d does not move along extending direction D1. Accordingly, gap SP4 between positioning member 200d and the rear end of side peripheral portion 212 of tubular portion 21 is maintained.

[0118] Since pump 1 of the second exemplary embodiment includes flat plate-shaped positioning member 200d, for example, manufacturing cost can be suppressed as compared with the case of including bottomed tubular positioning member 200.

[0119] Elastic member 300b is positioned between first end portion 61 of rotating shaft 6 and tubular portion 21 that is a part of pump case 2. Pump 1 includes elastic member 300b, and thus, it is possible to suppress propagation of vibration generated when impeller 9 is rotated to tubular portion 21 that is a part of pump case 2.

[0120] The second exemplary embodiment is merely one of various exemplary embodiments of the present disclosure. The second exemplary embodiment can be variously changed in accordance with design and the like as long as the object of the present disclosure can be achieved.

[0121] For example, positioning member 200d may be a member configured to be fixed to rotating shaft 6 by an elastic force toward axis Ax1 of rotating shaft 6 along radial direction D2 in a state where rotating shaft 6 passes through through-hole 210. Positioning member 200d may be a so-called e-ring or the like. That is, positioning member 200d may be a C-shaped member in plan view. More specifically, positioning member 200d may be a flat plate-shaped member having a C-shape in plan view. The term "C-shape in plan view" used in the present disclosure may have a shape in which a part of an annular ring having a through-hole (for example, through-hole 210) is missing. In addition, through-hole 210 (that is, a space) through which rotating shaft 6 passes includes a space in which the entire periphery of rotating shaft 6 is surrounded and a space in which a part of the periphery of rotating shaft 6 is missing.

[0122] Various configurations (including the modification) described in the second exemplary embodiment can be used by appropriately combining with various configurations (including the modification) described in the first exemplary embodiment.

(Conclusion)

[0123] As described above, pump (1) according to a first aspect includes impeller (9) and driver (3). Impeller (9) includes a plurality of blades (93) each having a plate shape and facing each other in a rotation direction. Driver (3) rotates impeller (9) to cause a liquid to flow. Impeller (9) has flow path (96). Flow path (96) is formed between a pair of adjacent blades of the plurality of blades (93). In flow path (96), the liquid flows from inlet port (961) positioned at inner edge portion (94) of impeller (9) toward outlet port (962) positioned at outer edge portion (95) of impeller (9). Flow path (96) has throttle (963) having a cross-sectional area smaller than a cross-sectional area of inlet port (961) and a cross-sectional area of outlet port (962) between inlet port (961) and outlet port (962).

[0124] In this aspect, since the cross-sectional area of throttle (963) is smaller than the cross-sectional area of inlet port (961) and the cross-sectional area of outlet port (962), throttle (963) pressurizes the liquid passing through throttle (963). Since throttle (963) pressurizes the liquid, pump (1) can suppress occurrence of cavitation.

[0125] In pump (1) according to a second aspect, in the first aspect, a distance (that is, second distance L2) between inlet port (961) and throttle (963) is shorter than a distance (that is, third distance L3) between outlet port (962) and throttle (963).

[0126] In this aspect, since the distance (that is, second distance L2) between inlet port (961) and throttle (963) is shorter than the distance (that is, third distance L3) between outlet port (962) and throttle (963), the occurrence of cavitation can be further suppressed.

[0127] In pump (1) according to a third aspect, in the second aspect, the distance (that is, second distance L2) between inlet port (961) and throttle (963) is more than or equal to 10% of a distance (that is, first distance L1) between inlet port (961) and outlet port (962).

[0128] In this aspect, since the distance (that is, second distance L2) between inlet port (961) and throttle (963) is more than or equal to 10% of the distance (that is, first distance L1) between inlet port (961) and outlet port (962), the occurrence of cavitation can be further suppressed.

[0129] In pump (1) according to a fourth aspect, in any one of the first to third aspects, the cross-sectional area of flow path (96) gradually decreases from inlet port (961) toward throttle (963).

[0130] In this aspect, since the cross-sectional area of flow path (96) gradually decreases from inlet port (961) to throttle (963), the liquid can smoothly flow through flow path (96).

[0131] In pump (1) according to a fifth aspect, in the fourth aspect, each of heights (H0) of the plurality of blades (93) gradually decreases from inlet port (961) toward throttle (963).

[0132] In this aspect, height (H0) of the plurality of blades (93) gradually decreases from inlet port (961) toward throttle (963), and thus, the cross-sectional area of flow path (96) can be reduced without narrowing width (W0) of flow path (96).

[0133] In pump (1) according to a sixth aspect, in any one of the first to fifth aspects, the cross-sectional area of throttle (963) is less than or equal to 85% of the cross-sectional area of inlet port (961) or outlet port (962).

[0134] In this aspect, the occurrence of cavitation can be further suppressed.

[0135] In pump (1) according to a seventh aspect, in any one of the first to sixth aspects, the cross-sectional area of throttle (963) is more than or equal to 55% of the cross-sectional area of inlet port (961) or outlet port (962).

[0136] In this aspect, the amount of liquid flowing through flow path (96) can be maintained at a certain level or more.

[0137] In pump (1) according to an eighth aspect, in any one of the first to seventh aspects, flow path (96) is formed by the plurality of blades (93) and a pair of members (that is, front shroud 91 and rear shroud 92) covering both sides of the plurality of blades (93).

[0138] In this aspect, for example, flow path (96) surrounded by the plurality of blades (93) and the pair of members (that is, front shroud 91 and rear shroud 92) covering both sides of the plurality of blades (93) is formed, and thus, the occurrence of cavitation can be further suppressed.

[0139] In pump (1) according to a ninth aspect, in any one of the first to eighth aspects, in throttle (963), height (H3) of throttle (963) is lower than height (H1) of inlet port (961).

[0140] In this aspect, height (H3) of throttle (963) is set to be lower than height (H1) of inlet port (961), the cross-sectional area of flow path (96) can be reduced without narrowing width (W0) of flow path (96).

[0141] Configurations other than the first aspect are not essential for pump (1), and can be omitted as appropriate.

INDUSTRIAL APPLICABILITY

[0142] As an example, a pump according to the present disclosure is used by being incorporated in

(i) a hot water circulation device such as a heat pump water heater and room heater or a gas boiler water heater and room heater,
(ii) a cooling water circulation device such as a server cooling device, or
(iii) a bathtub water circulation device.

REFERENCE MARKS IN THE DRAWINGS

[0143]

1	pump
2	pump case
21	tubular portion
211	bottom portion
212	side peripheral portion
22	suction portion
23	base portion
231	first opening
232	second opening
24	discharge portion
3	driver
4	mold portion
41	tooth
42	coil
43	controller
44	connection portion
45	bottom portion
46	side peripheral portion
5	separation plate
51	bottom portion
52	side peripheral portion
53	flange portion
54	tubular portion
6	rotating shaft
60	base portion
61	first end portion
62	second end portion
63	groove portion
7	bearing
71	facing surface
8	rotor
81	base portion
82	magnet
83	first coupling portion
84	second coupling portion
9	impeller
91	front shroud
910	rear surface
92	rear shroud
921	inner edge portion
922	outer edge portion
923	front surface
93	blade
931	first surface
932	second surface
94	inner edge portion
95	outer edge portion
96	flow path
961	inlet port
962	outlet port
963	throttle
100	receiving plate
101	rear surface
102	front surface
103	hole
200	positioning member
200a	positioning member
200b	positioning member
200c	positioning member
200d	positioning member
201	side peripheral portion
202	rear surface
203	bottom portion
204	edge portion
205	flat surface
206	circumferential surface
207	retaining portion
208	protrusion
209	groove portion
210	through-hole
300	elastic member
300a	elastic member
300b	elastic member
400	plate
401	hole
Ax1	axis
D1	extending direction
D2	radial direction
D3	circumferential direction
H0	height
H1	height
H2	height
H3	height
L1	first distance
L2	second distance
L3	third distance
SP1	first space
SP2	second space
SP3	pump chamber
SP4	gap
W0	width
W1	width
W2	width
W3	width
$\theta1$	intersection angle
$\theta2$	intersection angle

Claims

1. A pump comprising:

an impeller having a plurality of blades each having a plate shape and facing each other in a rotation direction; and
a driver that rotates the impeller to cause a liquid to flow,
wherein
the impeller comprises a flow path that is formed between a pair of adjacent blades of the plurality of blades, the liquid flowing from an inlet port positioned at an inner edge portion of the impeller through the flow path toward an outlet port positioned at an outer edge portion of the impeller, and
the flow path comprises a throttle having a cross-sectional area smaller than a cross-sectional

area of the inlet port and a cross-sectional area of the outlet port between the inlet port and the outlet port.

2. The pump according to Claim 1, wherein
a distance between the inlet port and the throttle is shorter than a distance between the outlet port and the throttle.

3. The pump according to Claim 2, wherein
the distance between the inlet port and the throttle is more than or equal to 10% of a distance between the inlet port and the outlet port.

4. The pump according to any one of Claims 1 to 3, wherein
the cross-sectional area of the flow path gradually decreases from the inlet port toward the throttle.

5. The pump according to Claim 4, wherein
each of heights of the plurality of blades gradually decreases from the inlet port toward the throttle.

6. The pump according to any one of Claims 1 to 5, wherein
the cross-sectional area of the throttle is less than or equal to 85% of the cross-sectional area of the inlet port or the outlet port.

7. The pump according to any one of Claims 1 to 6, wherein
the cross-sectional area of the throttle is more than or equal to 55% of the cross-sectional area of the inlet port or the outlet port.

8. The pump according to any one of Claims 1 to 7, wherein
the flow path is formed by the plurality of blades and a pair of members covering both sides of the plurality of blades.

9. The pump according to any one of Claims 1 to 8, wherein
in the throttle, a height of the throttle is lower than a height of the inlet port.

FIG. 1

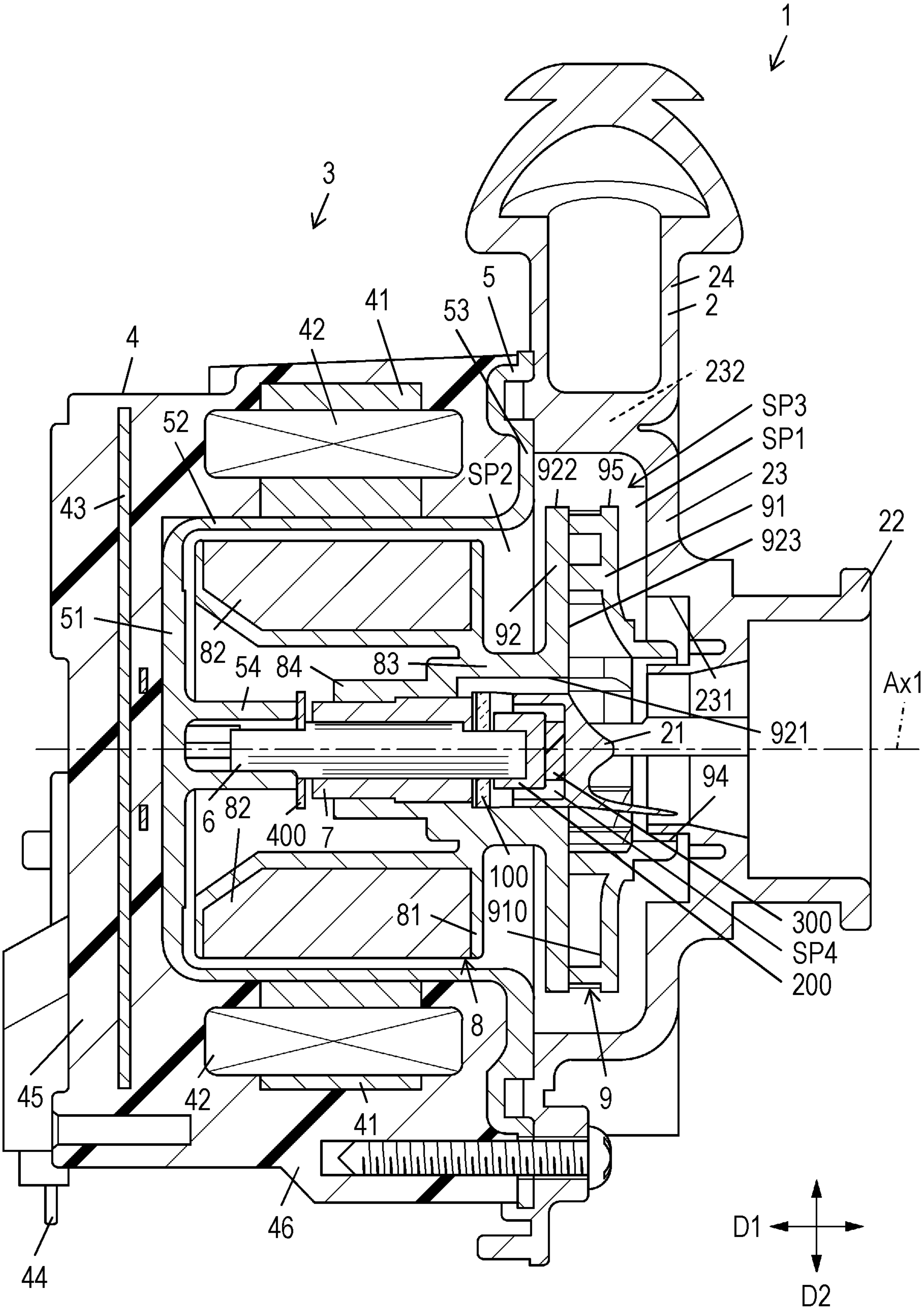
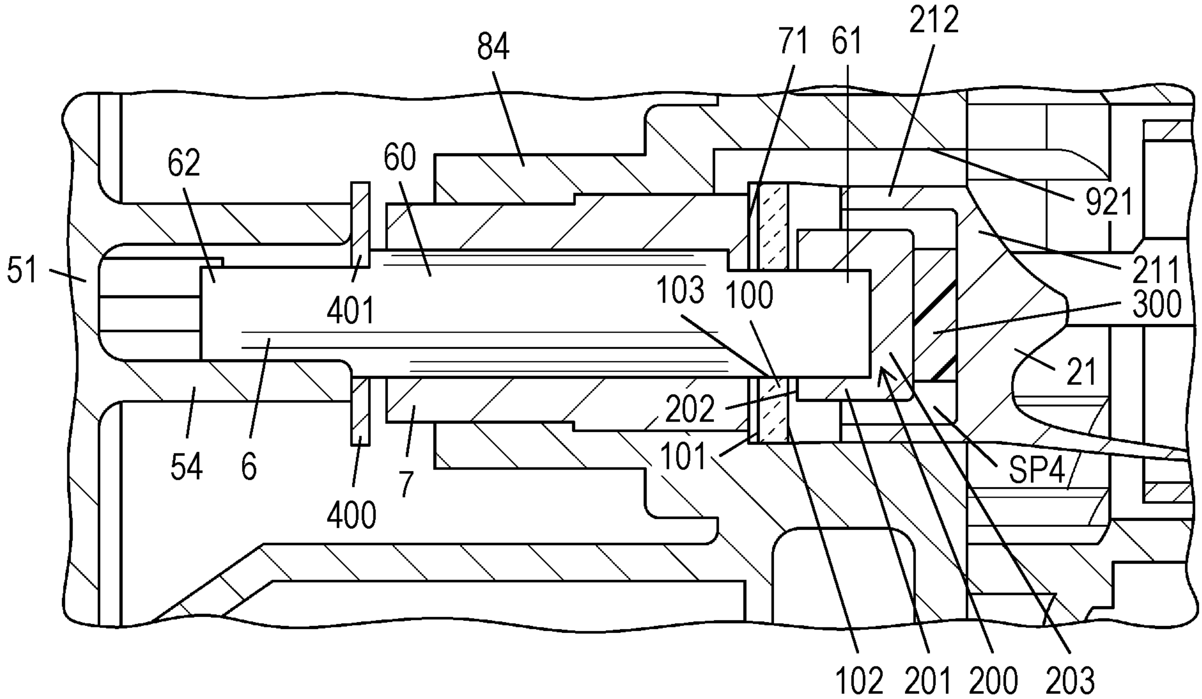

1
3
5
24
2
41
53
42
4
232
SP3
SP1
52
922
95
23
SP2
43
91
923
22
51
92
82
83
84
54
231
Ax1
921
21
6
82
400
7
94
100
300
910
81
SP4
200
8
45
42
9
41
46
44
D1
D2

FIG. 2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SP4
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201
200
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FIG. 3

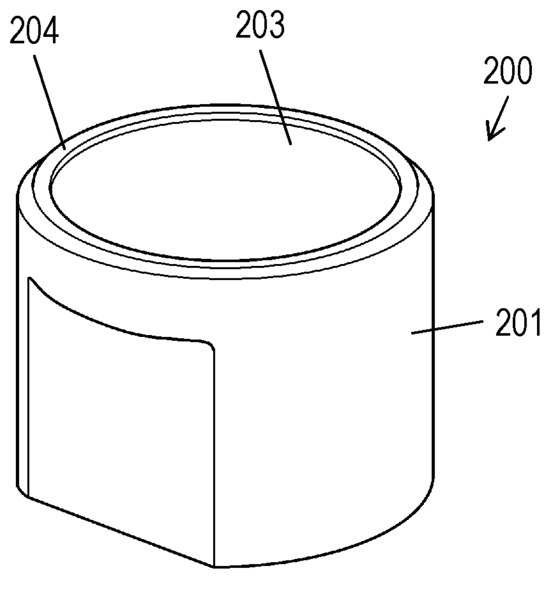
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FIG. 4

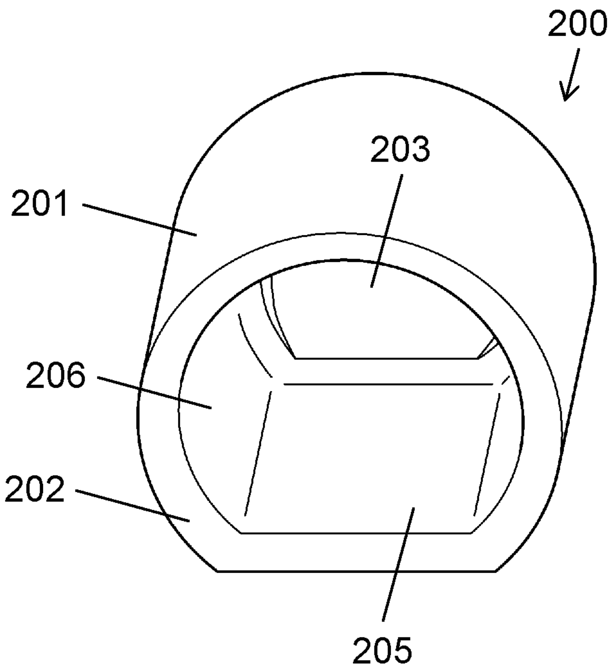
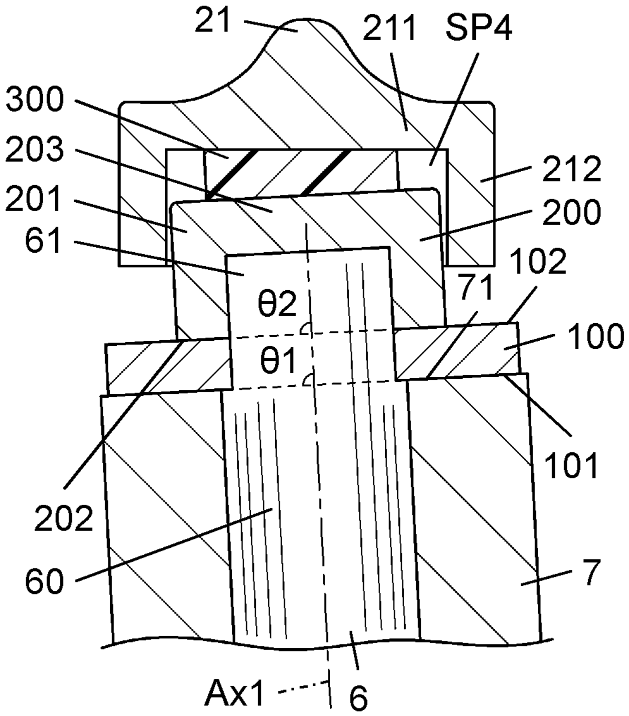


FIG. 5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θ2
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θ1
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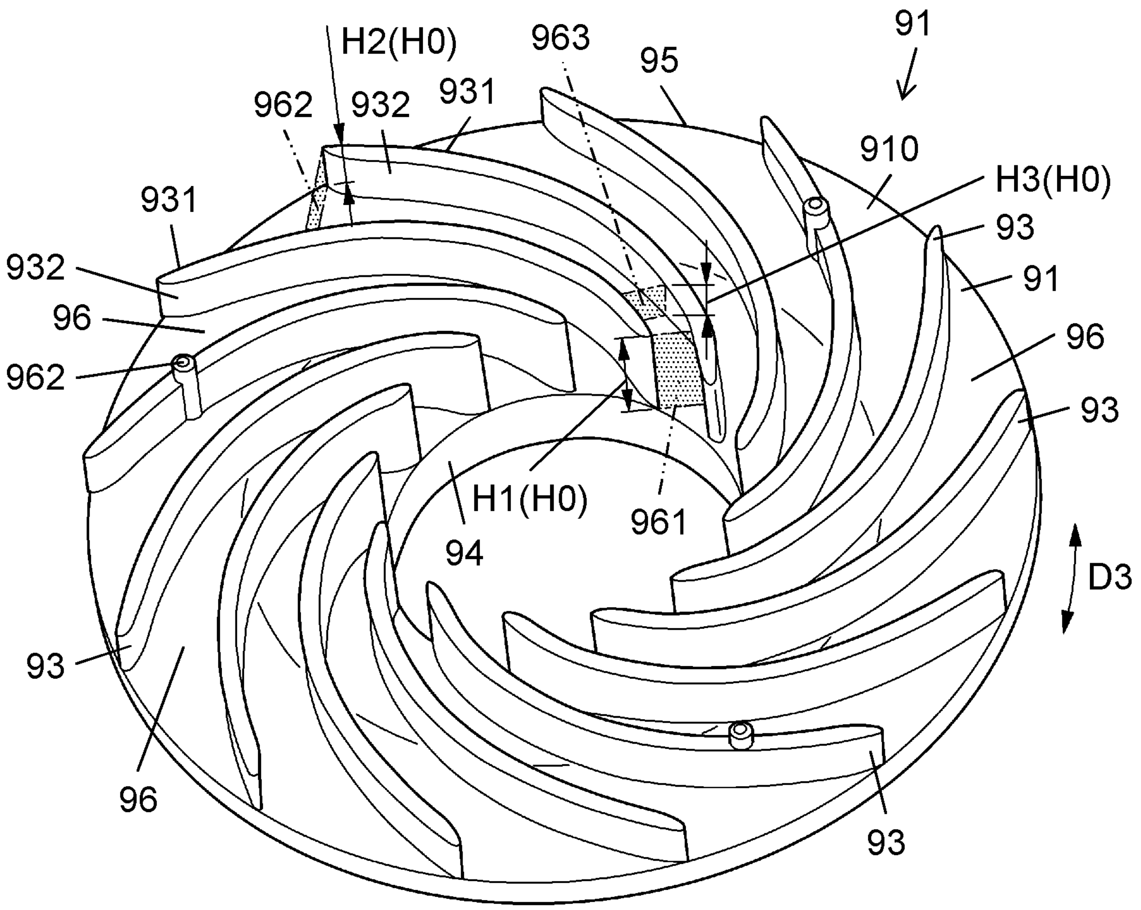
7
Ax1
6

FIG. 6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91
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962
932
931
910
H3(H0)
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932
91
96
96
962
93
H1(H0)
961
94
D3
93
96
93

FIG. 7

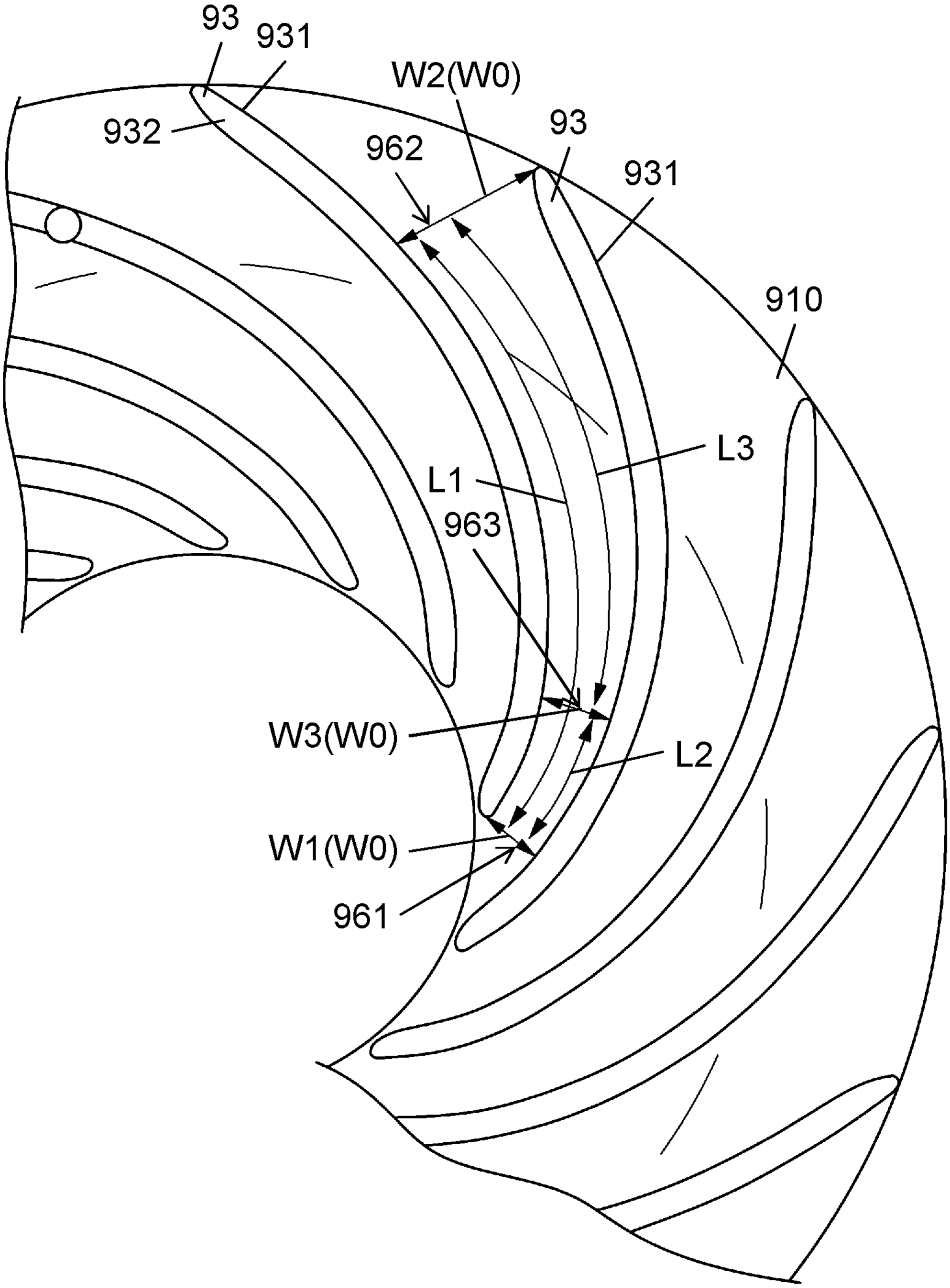


FIG. 8

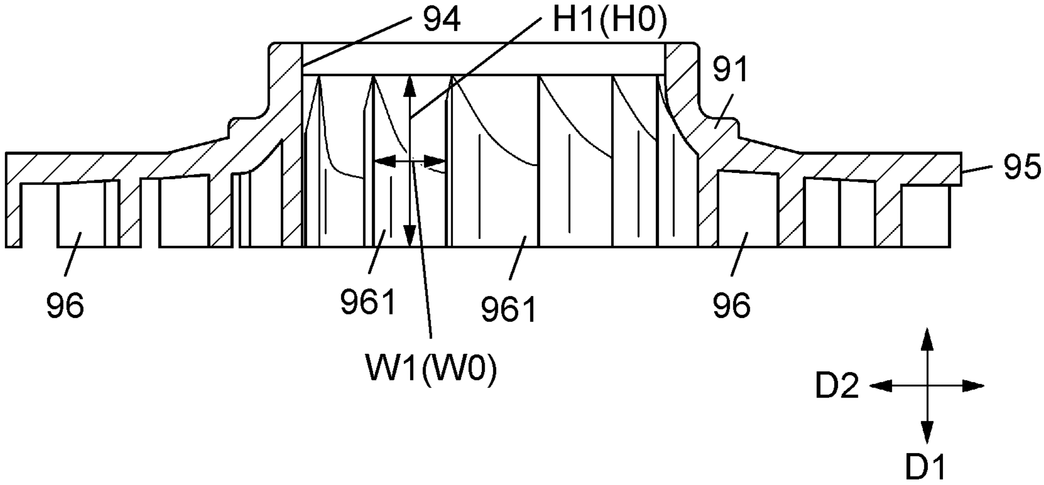


FIG. 9

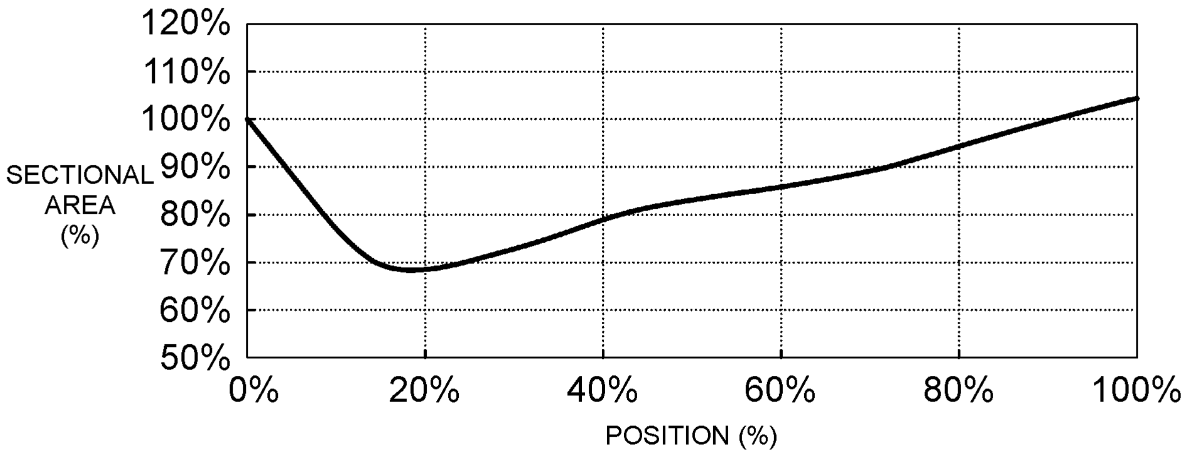


FIG. 10

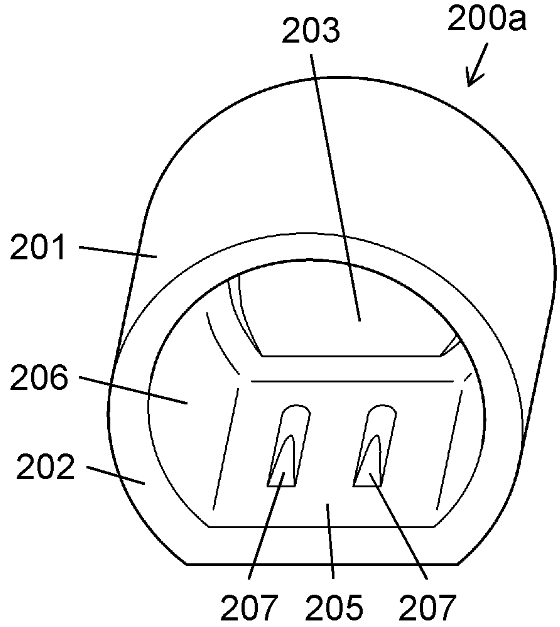
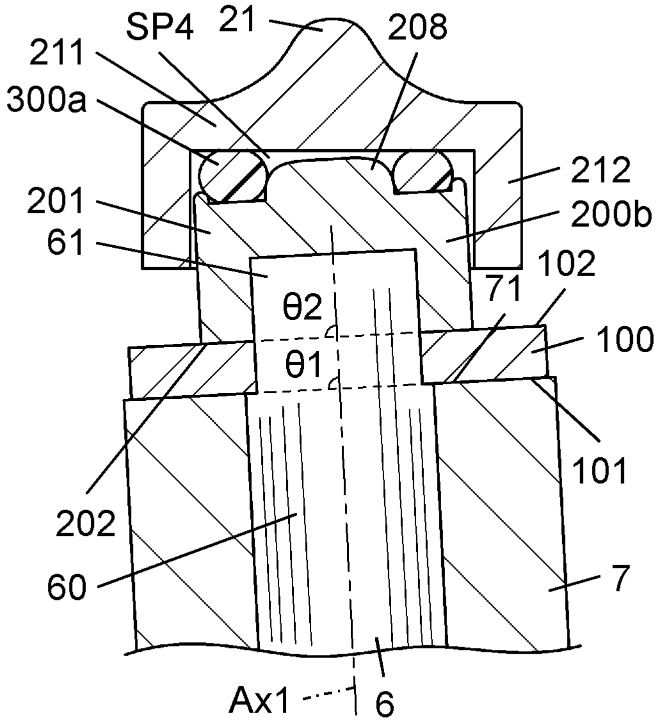


FIG. 11


SP4
21
208
211
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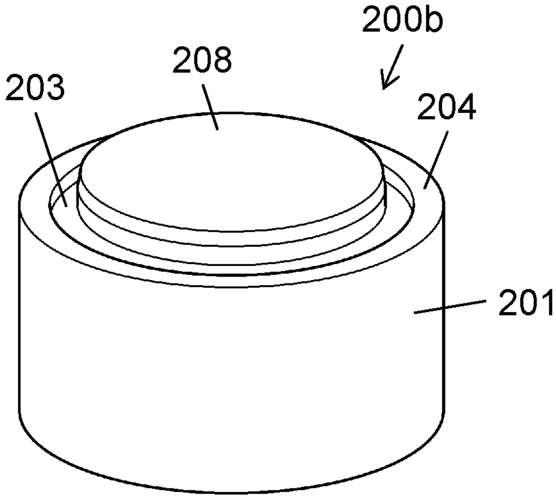
212
201
200b
61
102
71
θ2
100
θ1
101
202
7
60
Ax1
6

FIG. 12


200b
208
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204
201

FIG. 13

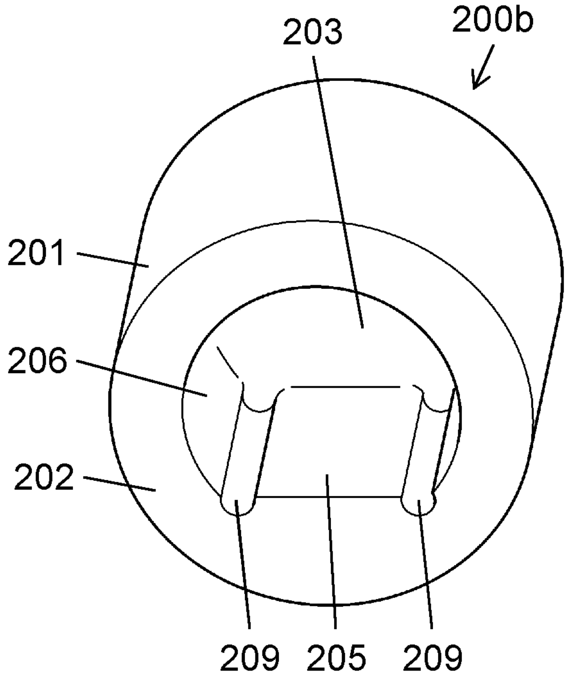


FIG. 14

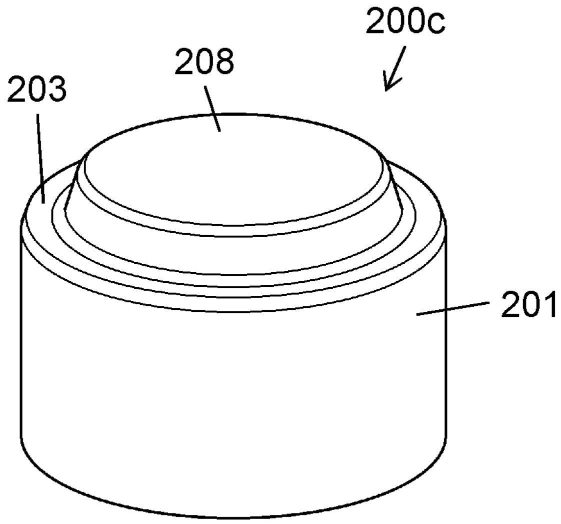
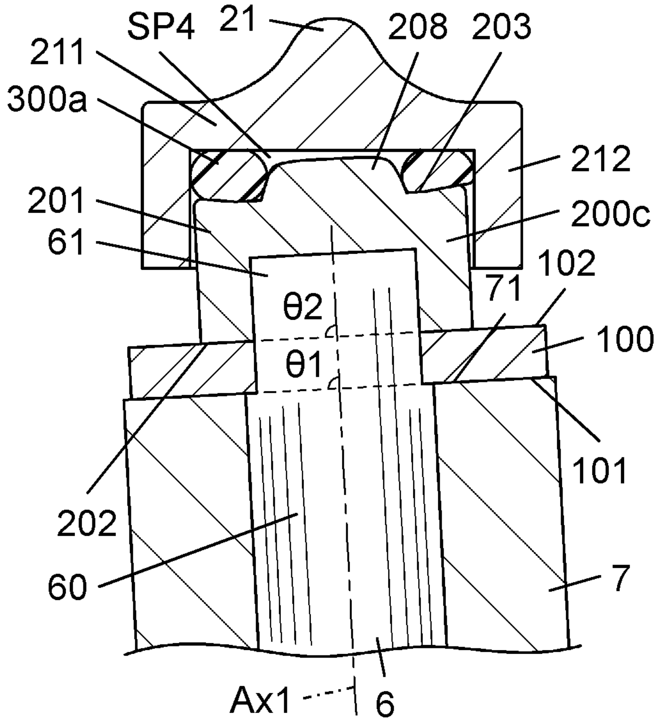


FIG. 15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θ2
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θ1
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202
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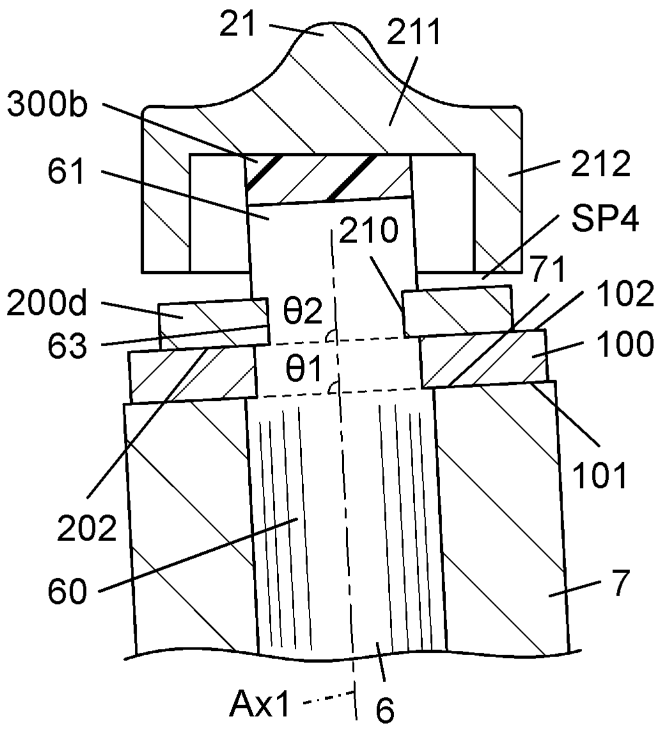
Ax1
6

FIG. 16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θ1
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Ax1
6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2023/002772

A. CLASSIFICATION OF SUBJECT MATTER

F04D 29/22(2006.01)i; ***F04D 13/06***(2006.01)i
FI: F04D29/22 F; F04D13/06 D; F04D29/22 A

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)

F04D29/22; F04D13/06

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 1971-2023
Registered utility model specifications of Japan 1996-2023
Published registered utility model applications of Japan 1994-2023

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	US 2074650 A (HOLDAWAY, William S.) 23 March 1937 (1937-03-23) p. 1, left column, line 31 to p. 2, left column, line 44, fig. 1-4	1-9
X	DE 1042384 B1 (ETA-CORPORATION G.M.B.H.) 30 October 1958 (1958-10-30) column 1, line 1 to column 3, line 35, fig. 1-4	1-9
A	US 2014/0064947 A1 (ERIKSSON, Ola) 06 March 2014 (2014-03-06) entire text, all drawings	1-9
A	US 2046226 A (THE CLEVELAND BRASS MANUFACTURING COMPANY) 30 June 1936 (1936-06-30) entire text, all drawings	1-9

☐ 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
15 March 2023	**28 March 2023**
Name and mailing address of the ISA/JP **Japan Patent Office (ISA/JP)** **3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915** **Japan**	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2023/002772

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
US 2074650 A	23 March 1937	(Family: none)	
DE 1042384 B1	30 October 1958	(Family: none)	
US 2014/0064947 A1	06 March 2014	WO 2012/154118 A1	
		AU 2012254210 A1	
		CA 2833860 A1	
		BR 112013028697 A2	
		SE 1150409 A1	
US 2046226 A	30 June 1936	(Family: none)	

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

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 3168366 U **[0003]**