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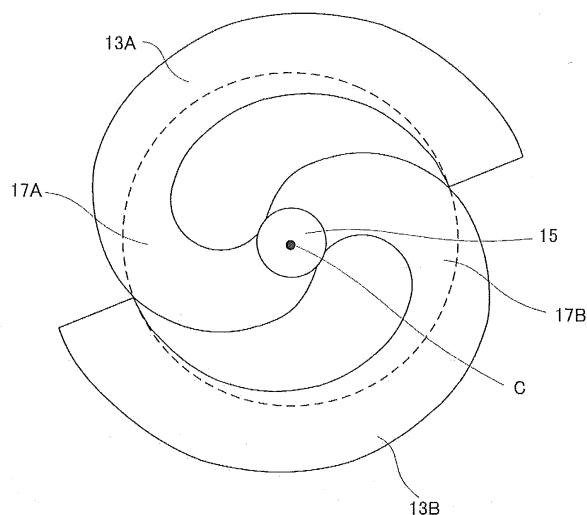
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(54) **PUMP BLADE FOR SUBMERGED PUMP AND SUBMERGED PUMP HAVING SAME**

(57) A pump impeller for a submerged pump capable of removing or reducing the radial load is provided. A non-clogging submerged pump is provided, which includes a substantially cylindrical body, an intake port provided in a center of a lower end surface of the body, a discharge port that is open in a side surface of the body,

and a flow channel passing from the intake port to the discharge port within the body. The flow channel includes a plurality of flow channels, and the flow channels have their size, shape, and position defined such that fluid unbalance is reduced with respect to an axis of rotation.

Figure. 2(B)



Description

TECHNICAL FIELD

[0001] The present invention relates to a pump impeller for a submerged pump, and in particular to a pump impeller for a submerged pump for sewage and a submerged pump provided with the impeller.

BACKGROUND ART

[0002] There has traditionally been a submerged pump for sewage such as that illustrated in Figure 10. A pump impeller 111 as illustrated in Figure 9 is used within the submerged pump (see Patent Literature 1). The pump impeller 111 is generally in a cylindrical shape, which includes an intake port 129 formed at one end and a discharge port 134 formed laterally on the side of the other end, and a spiral flow channel 135 partitioned and formed therein, connecting the intake port 129 with the discharge port 134. The pump impeller 111 further includes a flange portion 140 that protrudes outward along the circumferential surface of the pump impeller 111 from a portion closer to the intake port than the discharge port 134 on the circumferential surface and separates the intake port side from the discharge port side.

[0003] The pump impeller 111 is contained in a pump casing 112 and connected to a closed-type submerged motor 113 for rotatably driving the pump impeller 111. The submerged motor 113 includes a motor 116 having a stator 114 and a rotor 115 and a motor casing 117 that covers the motor 116. A driving shaft 118 extending vertically is provided at the center portion of the rotor 115. The driving shaft 118 is rotatably supported by bearings 119 and 120 at the upper end portion and an intermediate portion on the lower side, respectively. The pump impeller 111 is then connected to the lower end portion of the driving shaft 118.

[0004] A pump chamber 126, which is partitioned by an inner wall 125 that is recessed in a semicircular shape in its cross section, is formed within the pump casing 112. A discharge portion 138 of the pump impeller 111 is contained in the pump chamber 126. An intake portion 121 that protrudes downward is formed in the lower portion of the pump casing 112. An intake port 122 that is open downward is formed in the intake portion 121. A discharge portion 123 that protrudes laterally is formed on the side portion of the pump casing 112. The discharge portion 123 includes a discharge port 124 formed therein, which is open laterally.

[0005] The pump impeller 111 is provided with an intake portion 127 and a discharge portion 128 axially from the lower side toward the upper side in this order. The intake portion 127 and the discharge portion 128 are both formed generally in a cylindrical shape, and the discharge portion 128 is constructed to have a diameter larger than the intake portion 127. The discharge portion 128 is separated from the intake portion 127 by the flange portion

140 that protrudes outward from the circumferential surface of the pump impeller 111. An intake port 129 that is open downward is formed at the lower end of the intake portion 127 of the pump impeller 111. The upper side of the discharge portion 128 is covered by an upper end wall. In other words, the upper side of the pump impeller 111 is hermetically closed by the upper end wall. A hole is provided at the center portion of the upper end wall for inserting a distal end of the driving shaft 118, and a periphery of the hole constitutes a mounting portion 131 for mounting the driving shaft 118. Additionally, the reference numeral 137 denotes a secondary flow channel and the reference numeral 138 denotes a secondary blade.

15 CITATION LIST

PATENT LITERATURE

[0006] Patent Literature 1: Japanese Patent No. 4713066

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0007] The prior art described above, however, has an inevitable problem: when a conventional pump impeller rotates, a large radial load may be generated. In this respect, description will be made in detail.

[0008] In the pump impeller 111 according to the invention disclosed in Patent Literature 1, one flow channel continues from the intake port 129 to the discharge port 134. In other words, the pump impeller 111 is adapted to take in sewage from the intake port 129 that is open downward in coaxial with the driving shaft 118, and the sewage is drained from the discharge port 134 through the one spiral flow channel. In this case, the area where the spiral flow channel is formed is weightless because it is hollow space. On the other hand, the area forming the wall of the pump impeller 111 has weight. For this reason, the weight of the pump impeller 111 is significantly eccentrically distributed in the circumference direction with respect to the axis (center of rotation) of the driving shaft 118. When such pump impeller 111 rotates, the deviation of the weight of fluid also increases with respect to the center of rotation, which is likely to cause a radial load.

[0009] In view of the above problem, it is conceivable to stabilize the weight balance (dynamic balance) of the pump impeller and then add a weight for cancelling the radial load. Specifically, in order to remove unbalance of the weight in the circumference direction of the pump impeller, part of the wall of the pump impeller is thinned or conversely the wall is thickened to correct the balance, and then a weight for cancelling the radial load is added in the opposite direction. Such an effort, however, is limited per se. The reason is that because sewage flows in the spiral flow channel of the pump impeller and the

weight of the sewage itself is added to the pump impeller, the radial load associated with rotation varies, which cannot be cancelled by a mass calculated with fresh water. In addition, even if the weight of the sewage itself is previously taken into consideration, the mixing ratio of sewage flowing from time to time varies, and thus it is impossible for a conventional pump impeller having only one spiral flow channel to remove or reduce the radial load. In view of the problem described above, it is desirable to stabilize the fluid balance.

[0010] The above-mentioned "dynamic balance" is defined herein as displacement of the center of gravity and the center of moment with respect to the axis of rotation when an impeller is rotated in the atmosphere. The dynamic balance can be removed by a correction such as thinning of the wall as described above. The fluid balance refers to balance in the case where a fluid is flowing in a channel while a pump impeller is rotating. Even if the dynamic balance is optimized (zero weight unbalance), the area of water (sewage) in the pump impeller is eccentric with respect to the axis of rotation when the pump impeller is rotated under water. This causes fluid unbalance and a force (which is referred to as a radial load) is applied to the pump impeller via the wall pressure. A large radial load may cause vibration, and thus efforts have been made to cancel the load, such as by applying a weight. In this respect, a multi-channel pump impeller such as that in the present invention can significantly reduce the radial load because the mass distribution of the water area is less likely to be nonaxisymmetric as compared to a single-channel pump impeller. In view of the above description, a specific solution to the problem is as described below.

SOLUTION TO PROBLEM

[0011] The present invention, which has been made in view of the above problem, provides in a first aspect a pump impeller for a non-clogging submerged pump including a generally cylindrical body, an intake port provided in a center of a lower end surface of the body, a discharge port that is open in a side surface of the body, and a flow channel passing from the intake port to the discharge port within the body. The flow channel includes a plurality of flow channels, and the flow channels have their size, shape, and position defined such that fluid unbalance is reduced with respect to an axis of rotation.

[0012] According to the configuration, sewage taken in from the intake port is divided and flows into each of the flow channels. At this time, fluid unbalance is less likely to occur with respect to the axis of rotation because the flow channels are designed to reduce the fluid unbalance, and thus the occurrence of radial load associated with rotation of the pump impeller can significantly be suppressed.

[0013] In a second aspect, the flow channel includes two or more flow channels. According to the configuration, sewage is drained more than once per revolution of

the pump impeller, and thus pressure variation during drainage can be suppressed.

[0014] In a third aspect, a cross-sectional area of the flow channel varies between the intake port and the discharge port. In the pump impeller according to the present invention, when sewage separates from a surface of the flow channel near the discharge port, sewage may be prevented from being taken in from the intake port. Accordingly, the varying cross-sectional area is provided in some positions in order to maintain the pressure above a predetermined level.

[0015] In a fourth aspect, a cross-sectional shape of the flow channel varies between the intake port and the discharge port. Furthermore, in a fifth aspect, the cross-sectional shape of the flow channel changes from circular to generally rectangular or elliptic from the intake port toward the discharge port. The intake port is circular and an upstream portion of the flow channel is also circular; while the circumferential surface of the pump impeller has a shape similar to that of a circumferential surface of a cylinder. Accordingly, the cross-sectional shape needs to be changed near the discharge port in order to secure a constant cross-sectional area.

[0016] In a sixth aspect, an inner wall surface of the flow channel is formed of a continuous curved surface. According to the configuration, foreign matters in sewage flow smoothly in the flow channel so that the occurrence of clogging or the like due to the foreign matters can be prevented.

[0017] In a seventh aspect, inner walls close to a junction of at least two of the flow channels have a surface roughness different from each other. In such a configuration, elongated fibrous foreign matters may be divided and flow into two flow channels at a junction close to the intake port. With a surface roughness different from one flow channel to another, however, the frictional resistance is lower on the side of a flow channel having a smoother surface, so that the foreign matters are likely to flow in the side of the flow channel.

[0018] In an eighth aspect, all of the flow channels have the same size and shape, and are disposed at an equal angular interval with respect to the axis of rotation. According to the configuration, sewage taken in from the intake port is divided and flows into each of the flow channels. At this time, since the flow channels have the same size and shape, and are disposed in positions located at an equal angular interval with respect to the axis of rotation, no weight unbalance with respect to the axis of rotation occurs, and thus the occurrence of radial load associated with rotation of the pump impeller can be minimized.

[0019] Furthermore, a submerged pump is characterized by including a pump impeller according to any one of the first to eighth aspects, a pump casing that contains the pump impeller; and a motor that drives the pump impeller. According to the configuration, a pump having a good fluid balance can be realized when assembled and operated as a pump, without problems such as noise and

vibration.

ADVANTAGEOUS EFFECTS OF INVENTION

[0020] According to the present invention, as an example, the following advantages can be attained by adopting aspects as described above.

1. An average radial load can be reduced in operation because the fluid balance of the pump impeller can be achieved with respect to the axis of rotation.
2. Along with the reduction in the radial load, noise and vibration can be reduced. In addition, the bearing can be replaced with one that has a smaller capacity, and even when a conventional bearing is still used, the rated number of revolution of the pump impeller can be increased.
3. Since a plurality of discharge ports are provided and sewage is drained more than once per revolution of the pump impeller, the variation in drainage pressure can be reduced.
4. Since an intake flow channel near the intake port is a straight flow channel coincident with the axis of rotation, the flow channel length in an entrance portion is reduced. This allows the flow to enter smoothly, so that the loss is reduced and the hydraulic efficiency is expected to be improved.

BRIEF DESCRIPTION OF DRAWINGS

[0021]

Figure 1(A) illustrates one flow channel, and is a perspective view illustrating the shape of the flow channel.

Figure 1(B) illustrates one flow channel, and is a plan view.

Figure 2(A) illustrates two flow channels used in a pump impeller according to an embodiment of the preset invention, and is a perspective view illustrating the shape of the flow channels.

Figure 2(B) illustrates two flow channels used in a pump impeller according to an embodiment of the preset invention, and is a plan view.

Figure 3(A) illustrates a pump impeller provided with the flow channels disclosed in Figures 2(A) and 2(B), and is a perspective view seen from the intake port side.

Figure 3(B) illustrates a pump impeller provided with the flow channels disclosed in Figures 2(A) and 2(B), and is a side view.

Figure 4(A) illustrates the pump impeller disclosed in Figures 3(A) and 3(B), and is a plan view.

Figure 4(B) illustrates the pump impeller disclosed in Figures 3(A) and 3(B), and is a side view.

Figure 4(C) illustrates the pump impeller disclosed in Figures 3(A) and 3(B), and is a bottom view (intake port side).

Figure 5(A) is a sectional view of the pump impeller disclosed in Figures 4(A), 4(B) and 4(C), taken along the line 5A-5A in Figure 4(A).

Figure 5(B) is a sectional view of the pump impeller disclosed in Figures 4(A), 4(B) and 4(C), taken along the line 5B-5B in Figure 4(B).

Figure 6(A) illustrates three flow channels used in a pump impeller according to a second embodiment of the preset invention, and is a perspective view illustrating the shape of the flow channels.

Figure 6(B) illustrates three flow channels used in a pump impeller according to a second embodiment of the preset invention, and is a plan view.

Figure 7 is a sectional view of the pump impeller disclosed in Figure 6.

Figure 8(A) is a sectional view illustrating a pump impeller with flow channels each having a different size and shape, which is a combination of one thin flow channel and two thick flow channels.

Figure 8(B) is a sectional view illustrating a pump impeller with flow channels each having a different size and shape, in which angular intervals are different for each flow channel.

Figure 9 is a sectional view illustrating an example configuration for a submerged pump provided with a pump impeller according to an embodiment of the preset invention.

Figure 10 is a side view illustrating a conventional pump impeller.

Figure 11 is a sectional view illustrating a submerged pump provided with the pump impeller disclosed in Figure 10.

DESCRIPTION OF EMBODIMENTS

[0022] A pump impeller according to an embodiment of the preset invention will now be described with reference to Figures 1 to 8.

<General Configuration>

[0023] The pump impeller of the embodiment includes a plurality of flow channels that bring an intake port coaxial with an axis of rotation into communication with a discharge port on an outer circumferential portion and the flow channels are disposed at an equal angular interval with respect to the axis of rotation by logical add. Although the number of flow channels are not limited, Figures 3(A) to 5(B) illustrate an embodiment with two flow channels, and Figures 6(A) to 8(B) illustrate an embodiment with three flow channels. The flow channels are bent in a curved shape between the intake port and the discharge port. As an example, the pump impeller is produced by casting. However, as long as strength or corrosion resistance can be secured, any other metal or non-metal material may be used.

<Flow Channel>

[0024] Figure 1(A) is an image by computer graphics, illustrating a flow channel 3 used in a pump impeller. Referring to the shape of the flow channel 3 from an intake port 5 toward a discharge port 7, the flow channel is coaxial with the axis of rotation C near the intake port 5. In other words, the central axis of the flow channel 3 near the intake port 5 is parallel to and coincident with the axis of rotation C. On the downstream side, the central axis of the flow channel 3 extends downward and then radially outward with respect to the axis of rotation C. A transitional portion from the direction of the axis of rotation to the radially outward direction is formed of a continuous curve.

[0025] While the central axis of the flow channel 3 extends radially outward, it further extends circumferentially with respect to the axis of rotation C. Accordingly, as a result of a combination of the radially outward component with the circumferential component, the central axis of the flow channel 3 extends outward in a spiral manner. Furthermore, the cross-sectional shape of the flow channel 3 is a complete circle near the intake port 5, while it is rectangular near the discharge port 7. Accordingly, a transitional region from the intake port 5 toward the discharge port 7 continuously changes such that a circle gradually turns into a rectangle. Note that even though the term rectangle is used, corner portions do not have right-angled surfaces but are formed of curves of a small radius of curvature. This arrangement is for preventing foreign matters from being accumulated in the corner portions.

[0026] Figure 1(A) illustrates a logical shape of the flow channel 3; when applied to an actual pump impeller, an outer edge of the pump impeller is circular about the axis of rotation C. Specifically, an ellipse illustrated in Figure 1(A) defines the outer edge of the pump impeller. Accordingly, an actual flow channel 3 formed in the pump impeller has a shape as illustrated in Figure 1(B) in which the discharge port 7 is formed over a broad angular range. The shape of the flow channel 3 used in a pump impeller has been described. This description, however, is of a case in which only one flow channel 3 is provided. As described below, the embodiment is characterized by a combination of two flow channels, and thus a specific example thereof will be described.

[0027] Figure 2(A) illustrates a configuration that includes two flow channels 13A and 13B and that has been subjected to logical add with reference to the axis of rotation C (intake port). The flow channels 13A and 13B have completely the same size and shape as each other and are located at point-symmetric positions with respect to the central axis C. In other words, the flow channel 3 in Figures 1(A) and 1(B) is rotationally copied and disposed at an equal angular interval. Accordingly, as illustrated in Figure 2(B), regions where the flow channels 13A and 13B are directed radially outward from an intake port 15 extend in directions mutually spaced by 180° (op-

posite directions). The logical add used herein refers to simply combining two flow channels with a common intake port.

[0028] Figure 2(B) illustrates actual flow channels 13A and 13B by the outer edge of the pump impeller (illustrated by a dotted line), similarly to Figure 1(B). As illustrated, the flow channels 13A and 13B are completely point-symmetric with respect to the axis of rotation C, and form a generally S-shaped flow channel as a whole. Near the outer edge of the pump impeller, discharge ports 17A and 17B are formed over a broad angular range, similarly to the example in Figure 1(B).

[0029] Figures 3 are views of a pump impeller 11 according to the embodiment created by computer graphics. In particular, Figure 3(A) is a view seen obliquely from the intake port 15 side, and Figure 3(B) is a view seen from the side. Flow channels formed inside the pump impeller 11 illustrated in the figure are the flow channels 13A and 13B illustrated in Figure 2(B). As apparent from Figure 3(B), the cross-sectional shape of a flow channel is nearly circular on the right side (upstream side) of the axis of rotation C, while it is in a shape forming a part of a rectangle on the left side (downstream side) of the axis of rotation.

[0030] Figures 4(A), 4(B) and 4(C) illustrate the pump impeller 11 of the embodiment, and are a plan view, a side view, and a bottom view, respectively. As illustrated in Figure 4(A) and 4(B), a cylindrical hub 14 is formed in a region of the central axis C, and the hub 14 is adapted to receive an inserted driving shaft (not illustrated) of a driving motor. For example, the pump impeller 11 is adapted to rotate at the number of revolution on the order of 1500 rpm. However, if efficiency can be improved, the pump impeller may be rotated at any number of revolution that is lower or higher than 1500 rpm.

[0031] Figure 5(A) is a sectional view taken along the line 5A-5A in Figure 4(B). As illustrated, the pump impeller 11 includes an intake port 15 formed therein that is open to one side of the central axis C, and sewage is taken in as the pump impeller 11 rotates. The sewage is then transported from the intake port 15 circumferentially outward along the flow channels 13A and 13B, finally drained from the discharge ports 17A and 17B. As illustrated, although an opening is formed on the other side of the central axis C, a driving shaft is inserted in the opening as described above, and thus the sewage will not leak from the opening.

[0032] Figure 5(B) is a sectional view taken along the line 5B-5B in Figure 4(B). As illustrated, the flow channels 13A and 13B continuing from the intake port 15 extend radially outward in a spiral manner, and provide discharge ports 17A and 17B on the outer edge of the pump impeller 11. Accordingly, other portions than the flow channels are wall portions constituting the pump impeller 11. As apparent from the figure, the discharge ports 17A and 17B of the embodiment are formed in an angular range of approximately 180° with respect to the central axis C. This is based on a basic idea that there are two

flow channels 13A and 13B and that efficiency is improved by forming discharge ports 17A and 17B over as broad angular range as possible. In Figure 5(B), a pump casing 16 is also illustrated for convenience in explanation. Description will be made later as to how the pump impeller 11 and the pump casing 16 are related.

[0033] The intake port 15 is cylindrical and is open so as to be coaxial with the axis of rotation C. Accordingly, the intake port 15 is formed as substantially common one port by logical add. The intake port 15 is disposed so as to be open downward when it is actually installed in a pump. The inner diameter of the intake port 15 is set based on the volume of solid matters contained in sewage handled by the pump impeller 11.

<Junction of Flow Channel>

[0034] As illustrated in Figures 5(A) and 5(B), the flow channels 13A and 13B branch out from one intake port 15 into two flow channels, as described above. The flow channels 13A and 13B have approximately the same cross-sectional area from near the intake port 15 up to the junction. On the other hand, the cross-sectional area is gradually reduced from the junction toward the downstream. This is because if the cross-sectional area of each of the flow channels 13A and 13B is equivalent to the cross-sectional area of the intake port 15 after branching, the sum of the areas doubles and the pressure of sewage decreases, which may cause a separation phenomenon of sewage from an inner surface of the flow channels 13A and 13B. If such a separation phenomenon occurs, the efficiency of the pump decreases, and in some cases, failure to take in sewage from the intake port 15 would be anticipated. For this reason, the cross-sectional area of the flow channels 13A and 13B after branching is reduced relative to the cross-sectional area of the intake port 15, as described above.

[0035] The rate of decrease in the cross-sectional area of the flow channels 13A and 13B after branching varies depending on the nature of sewage handled or parameters such as the number of revolution of the pump impeller 11. For example, when the viscosity of sewage is high, the separation phenomenon is less likely to occur so that the rate of decrease in the cross-sectional area may be small. When the number of revolution of the pump impeller 11 is high, then the separation phenomenon is likely to occur so that the rate of decrease in the cross-sectional area may desirably be increased. As for a specific rate of decrease in the cross-sectional area, for example, the cross-sectional area of the flow channels 13A and 13B after branching is approximately 0.55 (in the case of two flow channels) per unit of the cross-sectional area of the intake port 15.

[0036] The inner wall surfaces of the flow channels 13A and 13B near the junction is formed to have a surface roughness different from each other. This is to address the case in which fibrous objects (elongated string-like objects) are preset in sewage. For example, assume that

a fibrous object on the order of several tens of centimeters long is preset in sewage. In this case, opposite ends of the fibrous object may possibly flow in two flow channels 13A and 13B separately. If such a case happens, the fibrous object sticks to and remains in the junction.

[0037] On the other hand, when the flow channels 13A and 13B near the junction have a surface roughness different from each other, the fibrous object is allowed to flow in one of the flow channels 13A and 13B smoothly. Specifically, the inner surface of one flow channel 13A is smoothened, and the inner surface of the other flow channel 13B is formed in a roughened state (for example, as-cast state). In such a case, the frictional resistance on the fibrous object is lower on the smooth inner surface, and to the contrary, the coefficient of friction is higher on the rough inner surface. Such imbalance in the coefficient of friction allows the fibrous object to flow in the side of the flow channel having the smooth inner surface. In this way, a possible problem that may be associated with two flow channels 13A and 13B can be solved by intentionally altering the surface roughness.

<Operation of Pump Impeller>

[0038] Based on Figure 5(B), operation of the pump impeller 11 according to the embodiment will now be described. The pump impeller 11 rotates clockwise in Figure 5(B). At this time, sewage preset in the (first) flow channel 13A of the pump impeller 11 is subjected to a centrifugal force associated with the rotation. For this reason, the sewage tends to move outward in the radial direction of the pump impeller 11. When the discharge port 17A of the pump impeller 11 faces a drain port 18 of the pump casing 16, the sewage is then delivered to the outside of the pump through the discharge port 17A and the drain port 18.

[0039] When the pump impeller 11 further rotates clockwise, the next discharge port 17B faces the drain port 18 of the pump casing 16. Sewage preset in the (second) flow channel 13B of the pump impeller 11 is also subjected to a centrifugal force associated with the rotation. The sewage is thus delivered to the outside of the pump through the discharge port 17B and the drain port 18, in the same way as described above. This means that the sewage is drained twice per revolution of the pump impeller 11. If the amount of sewage to be drained is the same as that for a conventional pump impeller having only one flow channel, the amount of drain in one turn is halved because the drainage of sewage is divided into two. As a result, pulsation (pressure variation) occurring while the sewage is drained is kept low.

[0040] As described above, when sewage is drained from the pump impeller 11, the flow channels 13A and 13B are subjected to a pressure drop. As a result of the effect of the pressure drop, sewage is taken in from the intake port 15. Accordingly, the cross-sectional area of the flow channels 13A and 13B is defined to prevent sewage from separating from the inner surface of the flow

channels 13A and 13B near the discharge ports 17A and 17B, as described above. Note that the cross-sectional area of the flow channels 13A and 13B may be gradually changed from the intake port 15 toward the discharge ports 17A and 17B, or may be constant in a predetermined section and constant at a different scale in other sections.

[0041] Furthermore, the flow channels 13A and 13B of the embodiment have a cross-sectional shape that changes from circular to rectangular between the intake port 15 and the discharge ports 17A and 17B. However, these cross-sectional shapes are only exemplary. Sequentially from the intake port 15 to discharge ports 17A and 17B, any combination may be made, for example: circular -> a transitional region -> elliptic, or circular -> a transitional region -> elliptic -> a transitional region -> rectangular. In addition, although "rectangular" in the embodiment refers to a square, an oblong cross-sectional shape may be used.

[0042] All inner wall surfaces of the flow channels 13A and 13B are formed of a continuous curved surface. This is to prevent the flow channels 13A and 13B from being clogged with foreign matters. In the embodiment, the cross-sectional shape of the flow channels 13A and 13B is rectangular near the discharge ports 17A and 17B. Corner portions of the cross-section are not completely right-angled but are connected by a continuous curved surface. Furthermore, a longitudinal axis (a line connecting sectional centers from the intake port 15 to the discharge ports 17A and 17B) of the flow channels 13A and 13B is also continuous. In this way, foreign matters are prevented from being caught in the flow channels 13A and 13B while sewage is flowing.

[0043] Figures 6(A), 6(B) and 7 are views for describing a pump impeller 21 with three flow channels according to a second embodiment. In particular, Figure 6(A) corresponds to Figure 2(A) of the first embodiment, Figure 6(B) corresponds to Figure 2(B), and Figure 7 corresponds to Figure 5. Here, Figures 6(A) and 6(B) illustrate three flow channels 23A, 23B and 23C disposed in positions located at an equal angular interval around an intake port 25.

[0044] Similarly to the first embodiment, the flow channels 23A, 23B and 23C have completely the same size and shape as each other and formed by rotationally copying the flow channel in Figures 1(A) and 1(B) and disposing them at an equal angular interval with respect to the central axis C. Accordingly, as illustrated in Figure 6(B), regions where the flow channels 23A, 23B and 23C are directed radially outward from the intake port 25 extend in directions mutually spaced by 120°.

[0045] Figure 6(B) illustrates actual flow channels 23A, 23B and 23C by an outer edge of the pump impeller 23 (illustrated by a dotted line), similarly to Figure 2(B). Near the outer edge of the pump impeller 23, discharge ports 27A, 27B and 27C are formed over a broad angular range (approximately 120°), similarly to the example in Figure 2(B). Figure 7 is a sectional view illustrating a pump im-

peller housed in an actual pump casing 26.

[0046] In the pump impeller 21 according to the embodiment, sewage is drained by one third per rotation from three flow channels 23A, 23B and 23C, respectively. As a result, assuming that the drain flow rate is the same, pressure variation occurring during drainage is kept lower than that of the pump impeller 11 of the first embodiment with two flow channels.

[0047] The description above has been made as to a pump impeller, all flow channels of which have the same size and shape, and are disposed at an equal angular interval about the respective axis of rotation. However, a pump impeller capable of reducing fluid balance is not necessarily limited to the pump impeller of the above configuration. In other words, the fluid balance can be reduced when one flow channel is thinner and the remaining two flow channels are thicker, as illustrated in Figure 8(A). Conversely, a combination of two thinner flow channels and one thicker flow channel is also possible.

[0048] Furthermore, as illustrated in Figure 8(B), the fluid balance can be reduced when angular intervals between flow channels are unequal. In this way, by varying angular intervals, an intermittent flow (pulsation) in a volute can be increased to enhance drainability for foreign matters.

[0049] Figure 9 is a sectional view of a submerged pump 60 provided with the pump impeller 11 according to the embodiment as described above. The pump impeller 11 is contained in a pump casing 62 and connected to a closed-type submerged motor 63 for rotatably driving the pump impeller 11. The submerged motor 63 includes a motor 66 having a stator 64 and a rotor 65, and a motor casing 67 that covers the motor 66. A driving shaft 68 extending vertically is provided at the center portion of the rotor 65. The driving shaft 68 is rotatably supported by bearings 69 and 70 at the upper end portion and an intermediate portion on the lower side, respectively. The pump impeller 11 is then connected to the lower end portion of the driving shaft 68.

[0050] A pump chamber 76, which is partitioned by an inner wall 75 that is recessed in a semicircular shape in its cross section, is formed within the pump casing 62. A discharge portion 68 of the pump impeller 11 is contained in the pump chamber 76. An intake portion 71 that protrudes downward is formed in the lower portion of the pump casing 62. An intake port 72 that is open downward is formed in the intake portion 71. A drain portion 73 that protrudes laterally is formed on the side portion of the pump casing 62. The drain portion 73 includes a drain port 74 formed therein, which is open laterally.

INDUSTRIAL APPLICABILITY

[0051] A pump impeller according to the preset invention can be particularly useful for a submerged pump for sewage.

REFERENCE SIGNS LIST

[0052]

1, 11, 21	pump impeller
3	flow channel
5	intake port
7	discharge port
13A, 13B	flow channel
15	intake port
17A, 17B	discharge port
23A, 23B, 23C	flow channel
25	intake port
26	pump casing
27A, 27B, 27C	discharge port
C	axis of rotation

to 6, wherein inner walls close to a junction of at least two of the flow channels have a surface roughness different from each other.

- 5 **8.** The pump impeller according to any one of claims 1 to 7, wherein all of the flow channels have the same size and shape, and are disposed at an equal angular interval with respect to the axis of rotation.
- 10 **9.** A submerged pump comprising:
- the pump impeller according to any one of claims 1 to 8;
a pump casing that contains the pump impeller;
and
a motor that drives the pump impeller.
- 15

Claims

- 20
- 1.** A pump impeller for a non-clogging submerged pump comprising:
- a substantially cylindrical body;
an intake port provided in a center of a lower end surface of the body;
a discharge port that is open in a side surface of the body; and
a flow channel passing from the intake port to the discharge port within the body,
wherein the flow channel includes a plurality of flow channels, and
the flow channels have their size, shape, and position defined such that fluid unbalance is reduced with respect to an axis of rotation.
- 25
- 2.** The pump impeller according to claim 1, wherein the flow channel includes two or more flow channels.
- 3.** The pump impeller according to claim 1 or 2, wherein a cross-sectional area of the flow channel varies between the intake port and the discharge port.
- 30
- 4.** The pump impeller according to any one of claims 1 to 3, wherein a cross-sectional shape of the flow channel varies between the intake port and the discharge port.
- 35
- 5.** The pump impeller according to claim 4, wherein the cross-sectional shape of the flow channel changes from circular to generally rectangular or elliptic from the intake port toward the discharge port.
- 40
- 6.** The pump impeller according to any one of claims 1 to 5, wherein an inner wall surface of the flow channel is formed of a continuous curved surface.
- 45
- 7.** The pump impeller according to any one of claims 1
- 50
- 55

Figure 1(A)

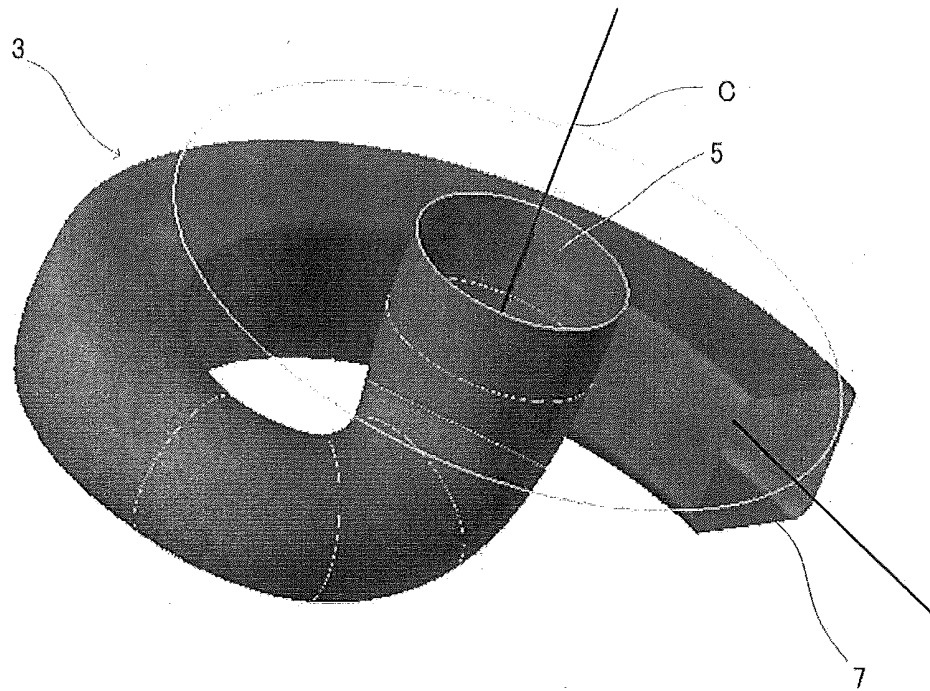


Figure 1(B)

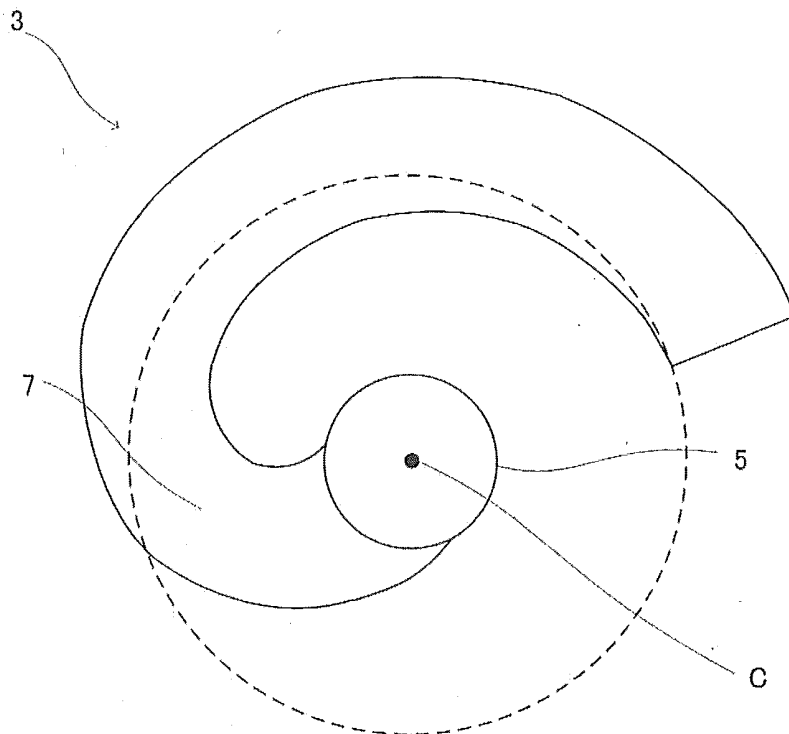


Figure 2(A)

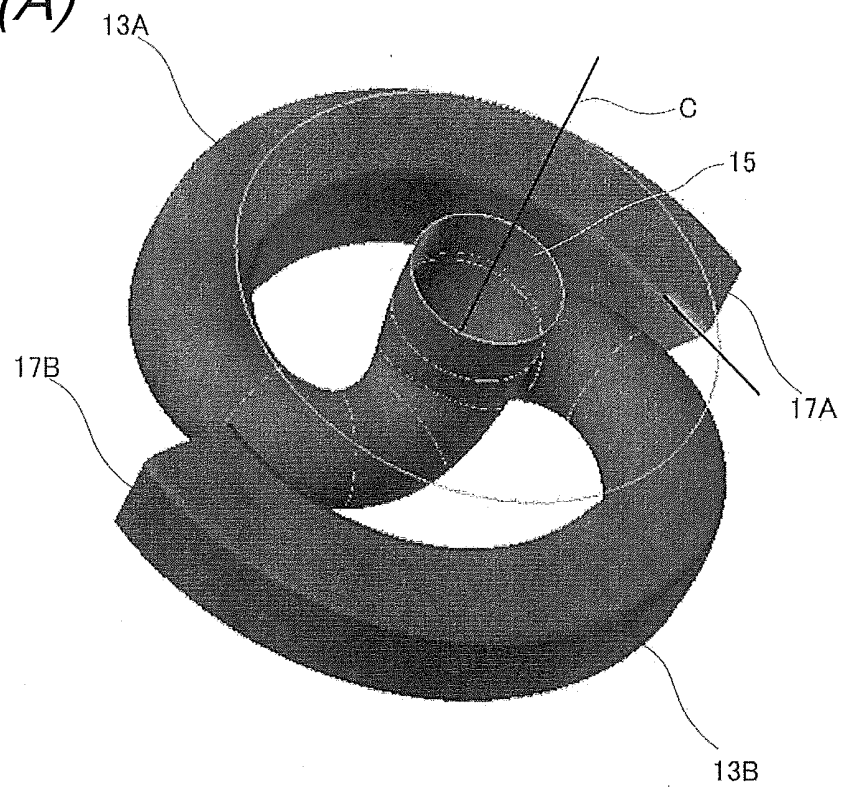


Figure. 2(B)

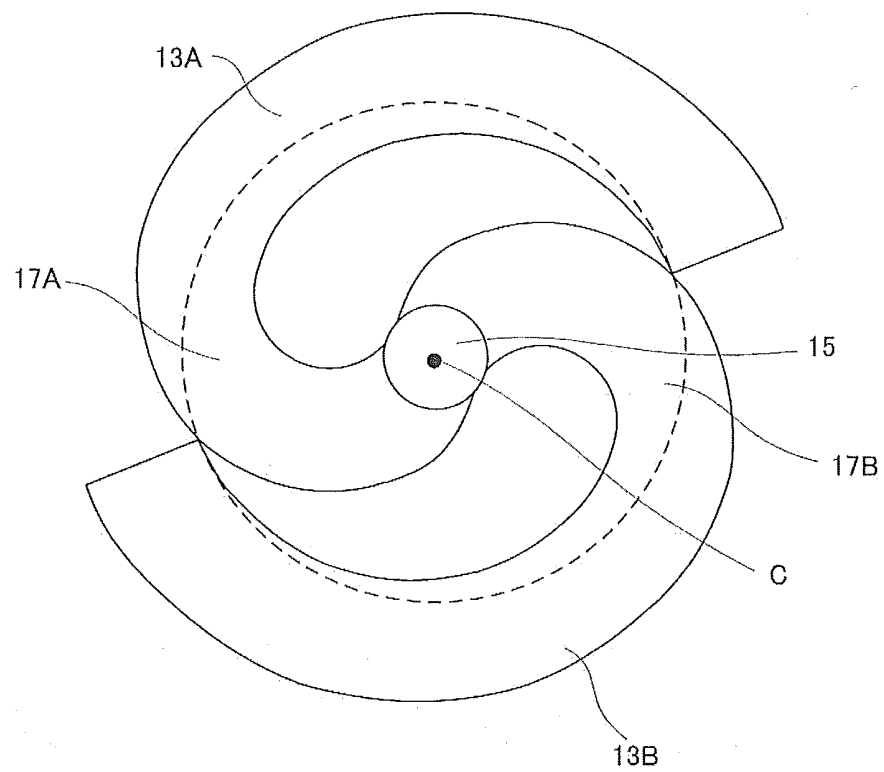


Figure 3(A)

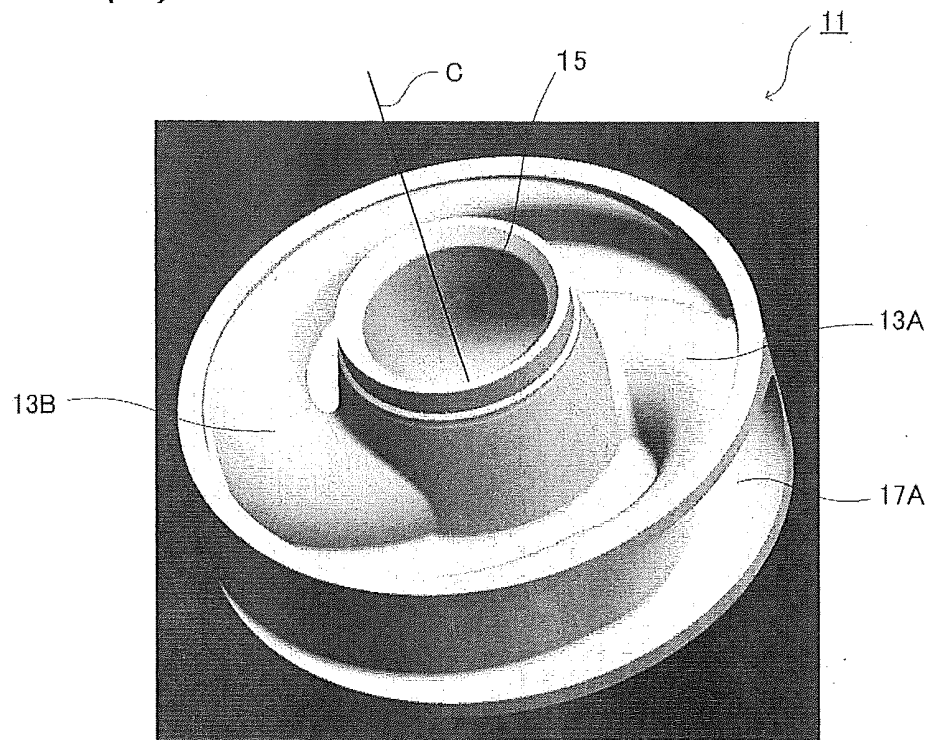


Figure 3(B)

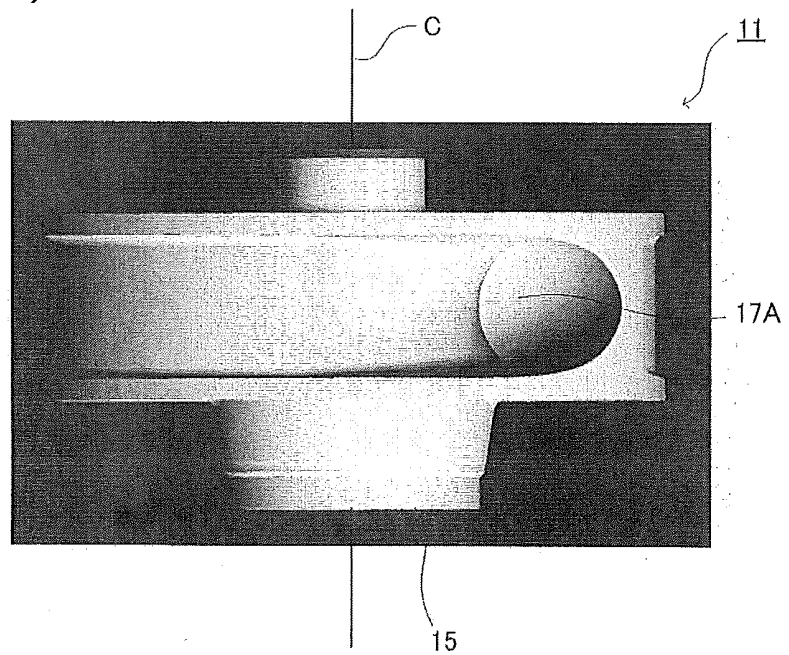


Figure 4(A)

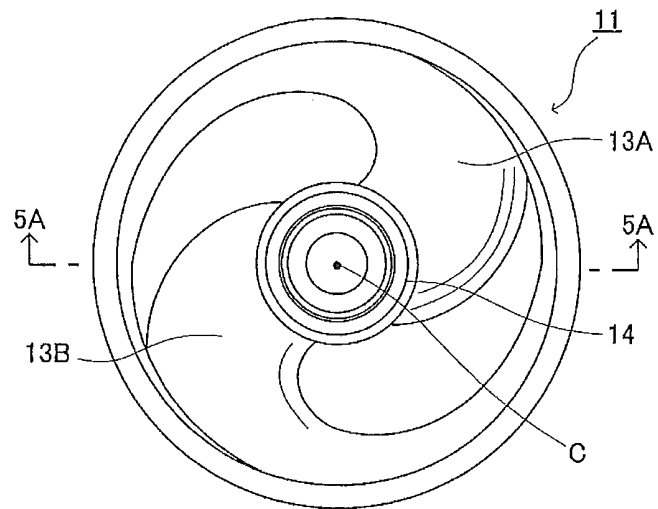


Figure 4(B)

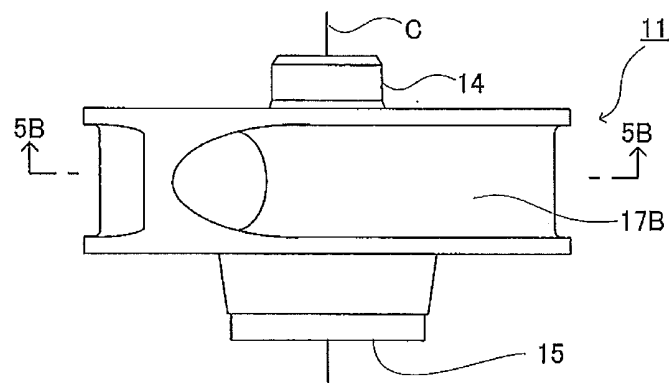


Figure 4(C)

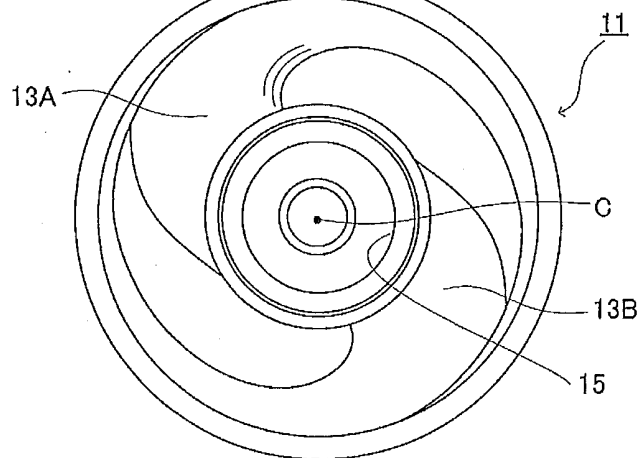


Figure 5(A)

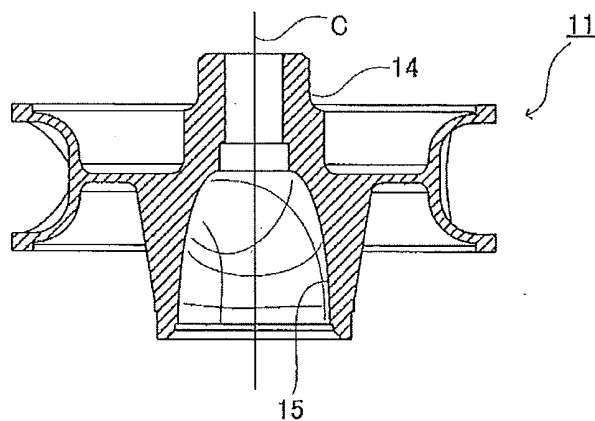


Figure 5(B)

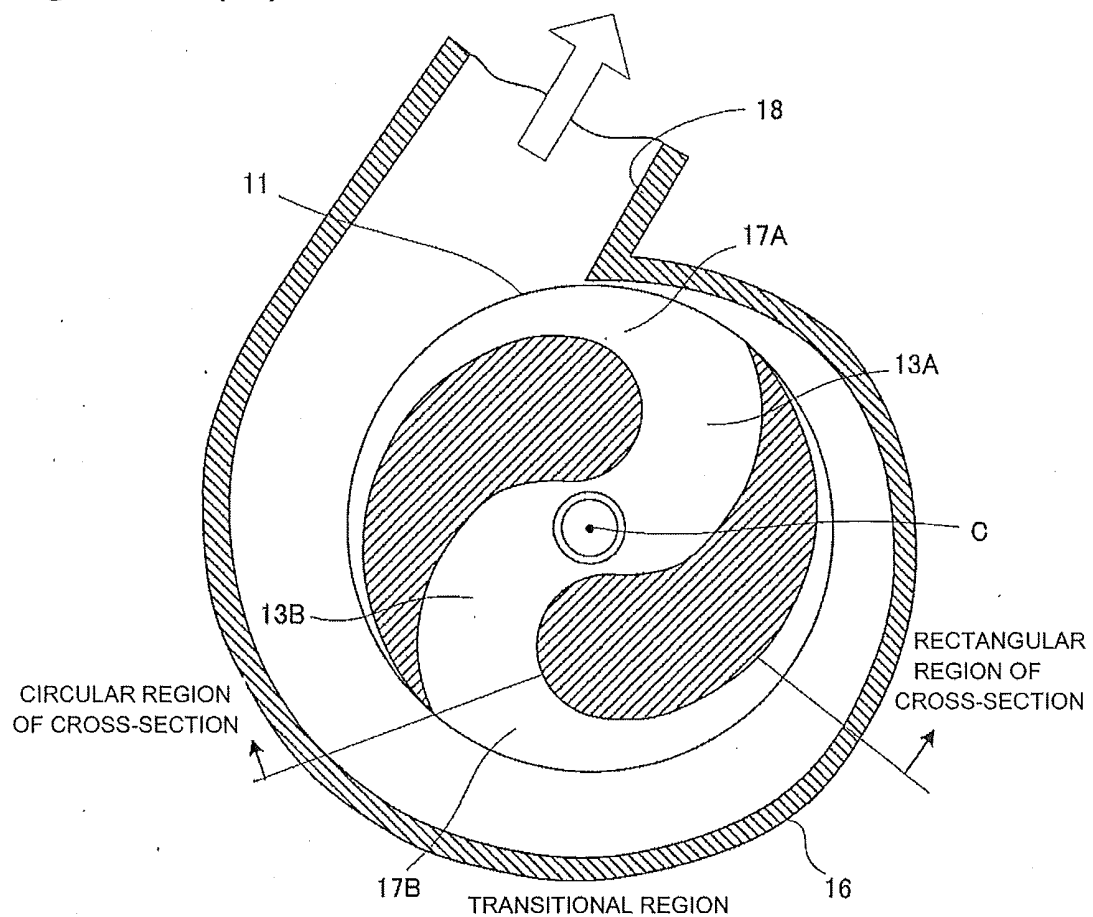


Figure 6(A)

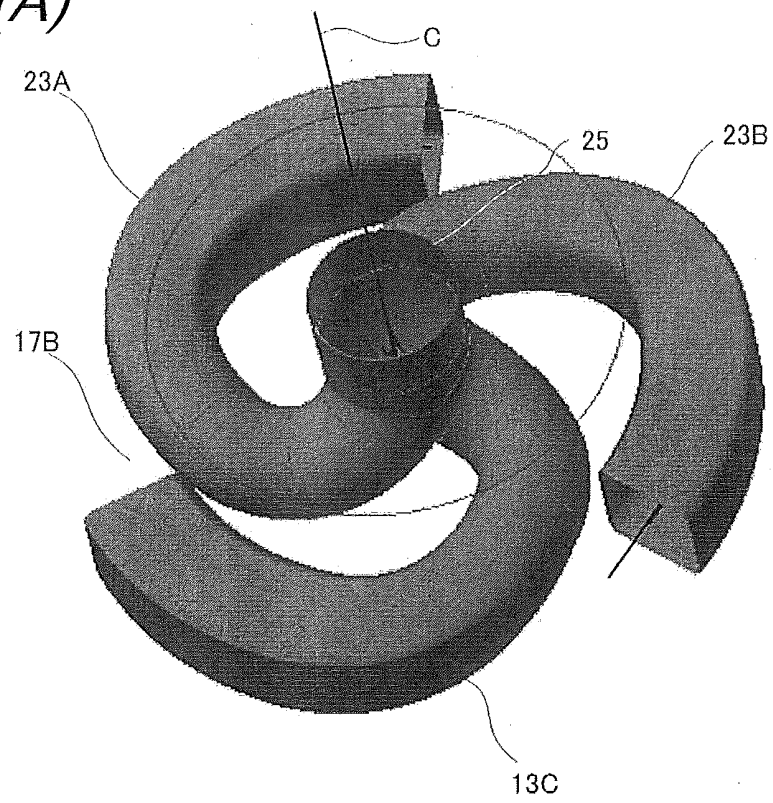


Figure 6(B)

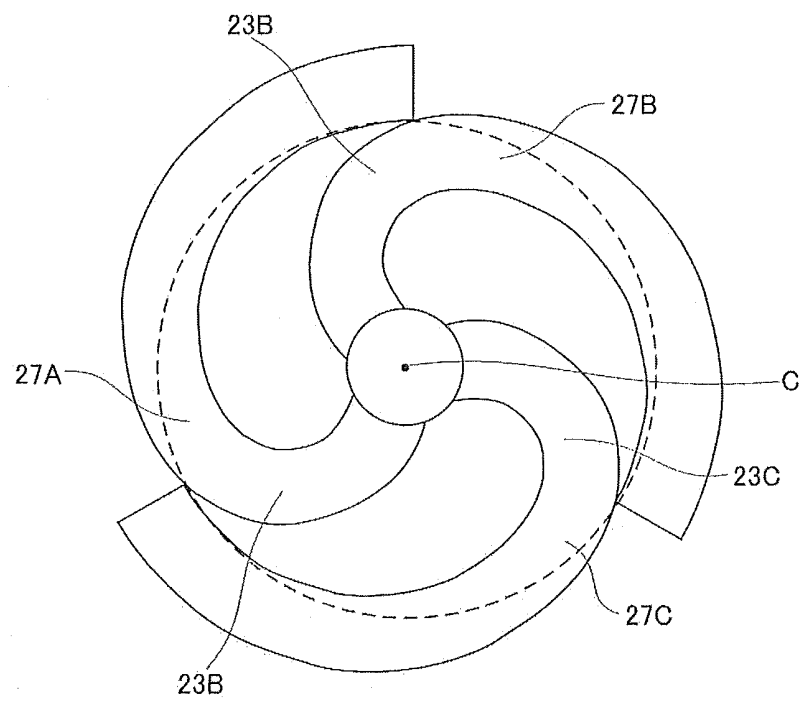


Figure 7

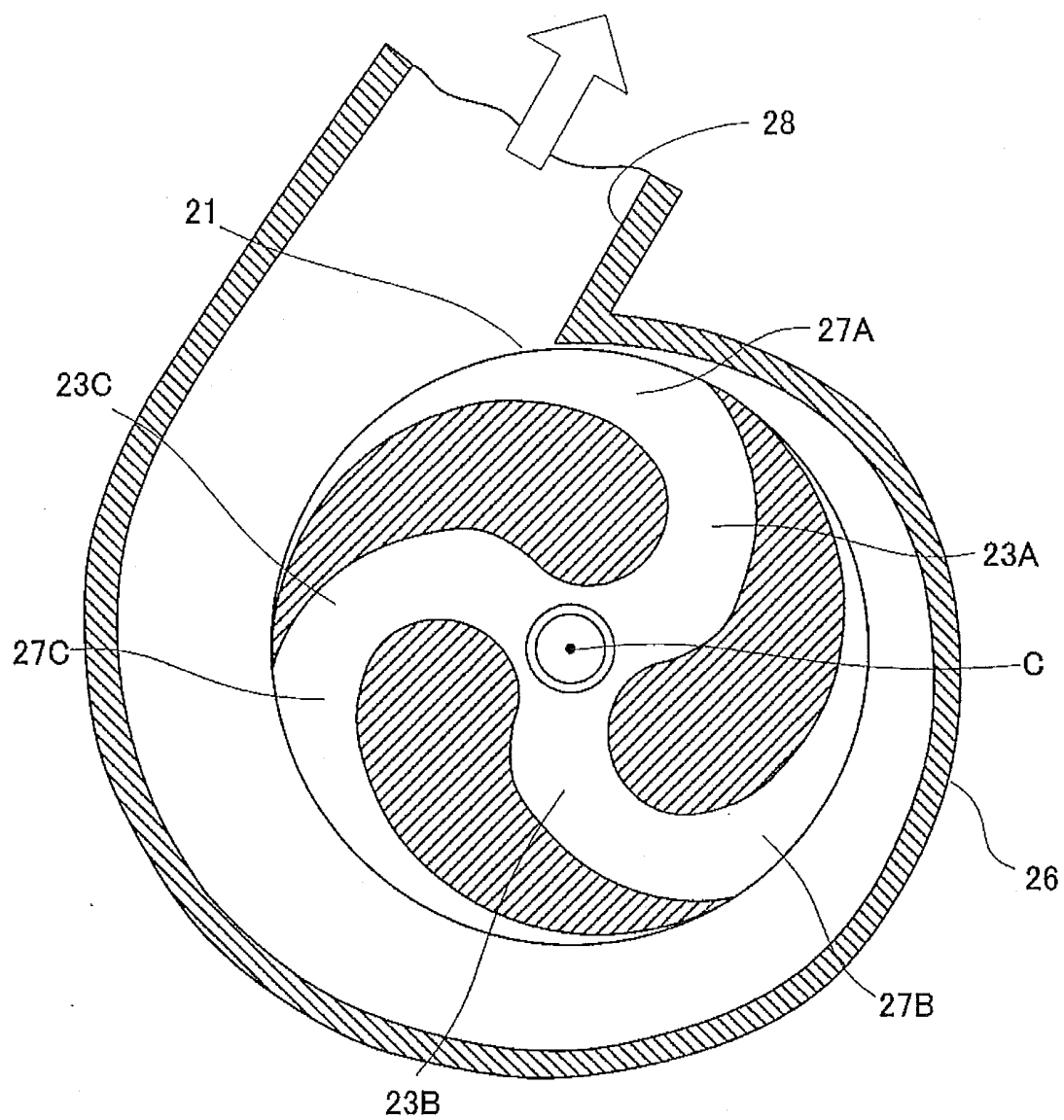


Figure 8(A)

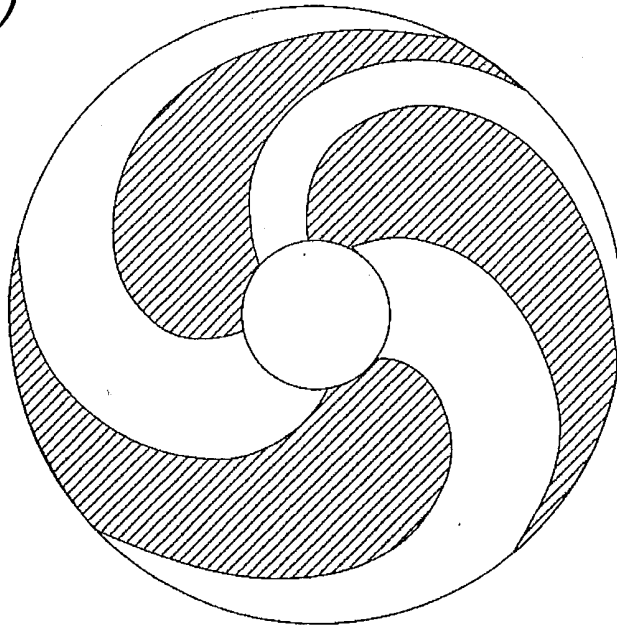


Figure 8(B)

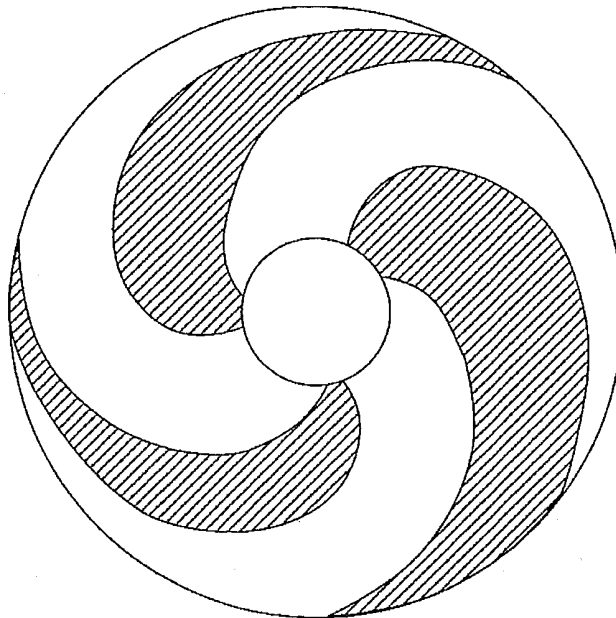


Figure 9

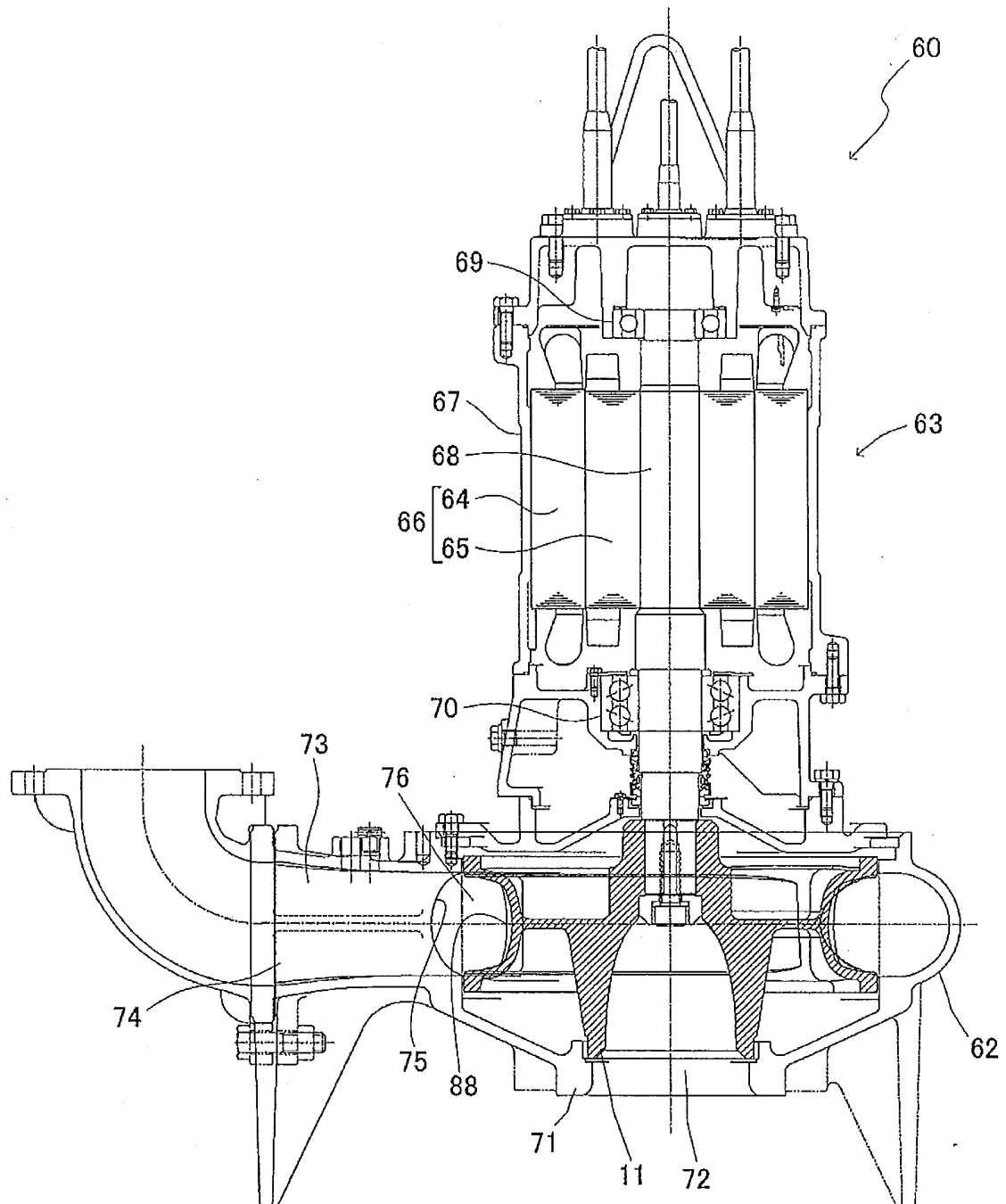


Figure 10

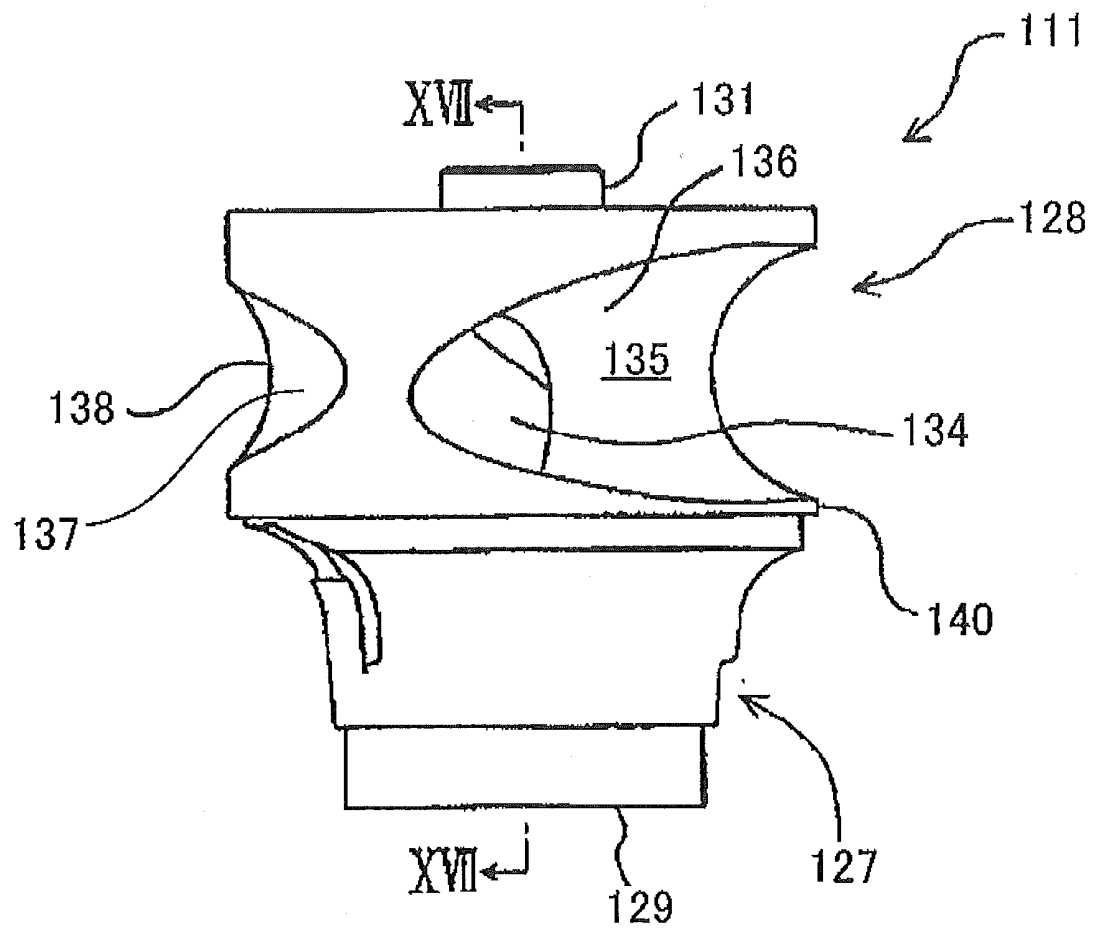
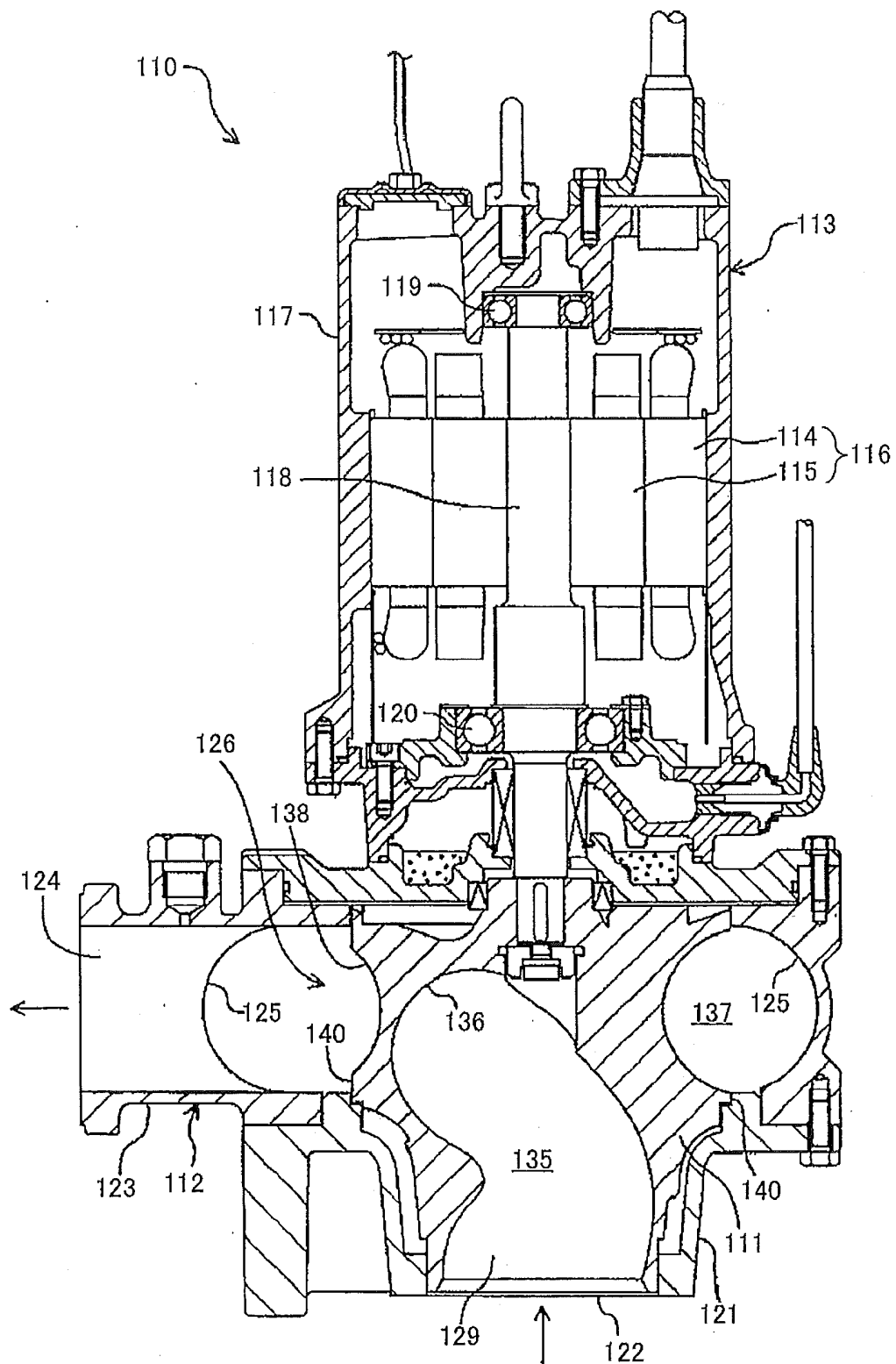


Figure 11



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2014/060657

A. CLASSIFICATION OF SUBJECT MATTER

F04D7/04(2006.01)i, F04D29/22(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)

F04D7/04, F04D29/22

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 1996-2014
 Kokai Jitsuyo Shinan Koho 1971-2014 Toroku Jitsuyo Shinan Koho 1994-2014

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 Y A	JP 9-209963 A (Yoshiyuki NAKASE), 12 August 1997 (12.08.1997), paragraphs [0011] to [0025] (Family: none)	1-3, 6, 8-9 4-5 7
Y	JP 2008-520889 A (ITT Manufacturing Enterprises, Inc.), 19 June 2008 (19.06.2008), paragraphs [0017] to [0022]; fig. 2a & US 2009/0208336 A1 & WO 2006/053831 A1 & KR 10-2007-0086413 A & CN 101061319 A	4-5
Y	JP 2-230999 A (Flygt AB), 13 September 1990 (13.09.1990), page 3, upper left column, line 19 to upper right column, line 4 & US 4981417 A & EP 359731 A1	4-5

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

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&" document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search
10 June, 2014 (10.06.14)Date of mailing of the international search report
24 June, 2014 (24.06.14)Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

Facsimile No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2014/060657

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 55-91797 A (Ebara Corp.), 11 July 1980 (11.07.1980), page 2, upper left column, line 10 to lower right column, line 5 (Family: none)	7
A	JP 52-107605 A (Hitachi, Ltd.), 09 September 1977 (09.09.1977), entire text; all drawings (Family: none)	1-9

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 4713066 B [0006]