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(71) Applicant: **AISIN SEIKI KABUSHIKI KAISHA**
Kariya-shi
Aichi-ken, 448-8650 (JP)

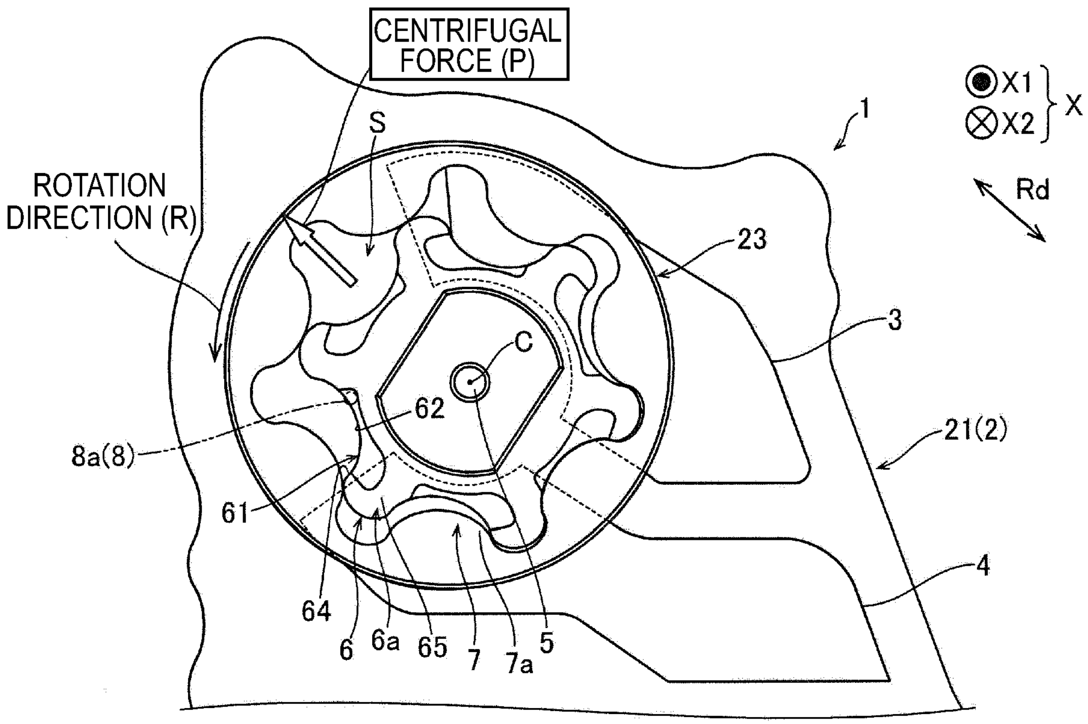
(72) Inventor: **UNO, Yoshito**
KARIYA-SHI, AICHI-KEN, 448-8650 (JP)

(74) Representative: **Cabinet Beau de Loménie**
158, rue de l'Université
75340 Paris Cedex 07 (FR)

(54) INTERNAL GEAR OIL PUMP

(57) An oil pump (1) includes: an inner rotor (6) having external teeth (6a); an outer rotor (7) having internal teeth (7a) engaging with the external teeth; a housing (2) that houses the inner and outer rotors; a suction port (3) formed in the housing and guiding oil into a pump chamber (S); a discharge port (4) formed in the housing and guiding the oil to outside the pump chamber; and a discharge passage (8) through which the pump chamber and an outside area communicate with each other and that discharges a bubble in the oil inside the pump chamber to the outside area. A bubble accommodation portion (61) having a recess shape is formed in a side surface portion (64) of each of the external teeth on a side opposite to a rotation direction of the inner rotor.

FIG.2



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Description

TECHNICAL FIELD

[0001] This disclosure relates to an oil pump, and particularly relates to an oil pump including an inner rotor and an outer rotor.

BACKGROUND DISCUSSION

[0002] In the related art, an oil pump including an inner rotor and an outer rotor is known (for example, refer to JP 2008-308991A).

[0003] JP 2008-308991A discloses a pump (oil pump) including a driving motor (inner rotor) and a driven motor (outer rotor). The pump disclosed in JP 2008-308991A includes a housing that houses the driving motor and the driven motor. Here, the pump disclosed in JP 2008-308991A is located at a position eccentric as much as a predetermined amount from the driving motor.

[0004] The pump disclosed in JP 2008-308991A includes a plurality of external teeth and a recessed groove formed in a tooth bottom between the plurality of external teeth. The pump disclosed in JP 2008-308991A includes a plurality of internal teeth which respectively engage with the plurality of external teeth. The pump disclosed in JP 2008-308991 A has an inter-tooth space formed by the plurality of external teeth and the plurality of internal teeth. The housing disclosed in JP 2008-308991A has a suction port that supplies oil to the inter-tooth space and a discharge port that discharges the oil of the inter-tooth space outside the inter-tooth space. In the housing disclosed in JP 2008-308991A, a through-hole through the recessed groove of the inter-tooth space and an outside area of the housing communicate with each other is formed closer to the discharge port side than a maximum volume position of the inter-tooth space disposed between the suction port and the discharge port.

[0005] The pump disclosed in JP 2008-308991A is configured so that a bubble contained in the oil inside the inter-tooth space is discharged outside the housing by the recessed groove and the through-hole. In detail, according to the pump disclosed in JP 2008-308991A, a centrifugal force generated by rotating the driving motor is used so that the bubble contained in the oil is collected on a tooth bottom portion side of the inter-tooth space. According to the pump disclosed in JP 2008-308991A, a volume of the inter-tooth space is reduced than a volume at the maximum volume position of the inter-tooth space, and the inter-tooth space is set to have positive pressure. In this manner, the bubble contained in the oil collected on the tooth bottom side of the inter-tooth space is discharged outside the housing after passing passes through the recessed groove and the through-hole. According to the pump disclosed in JP 2008-308991A, the inter-tooth space has negative pressure at the maximum volume position of the inter-tooth space.

[0006] Here, according to the pump disclosed in JP 2008-308991A, the inter-tooth space at the maximum volume position of the inter-tooth space has the negative pressure. Accordingly, the oil flows toward the inter-tooth space at the maximum volume position from the inter-tooth space closer to the suction port side than the maximum volume position. According to the pump disclosed in JP 2008-308991A, the inter-tooth space at the maximum volume position has the negative pressure, and the inter-tooth space closer to the discharge port side than the maximum volume position has the positive pressure. Accordingly, the oil flowing from the inter-tooth space closer to the discharge port side than the maximum volume position flows toward the inter-tooth space at the maximum volume position.

[0007] According to the pump disclosed in JP 2008-308991A, due to the oil flowing toward the inter-tooth space at the maximum volume position, the bubble collected inward in a radial direction of the driving motor inside the inter-tooth space at the maximum volume position is diffused (scattered). In this case, the bubble collected inward in the radial direction is less likely to be discharged outside the housing. Therefore, according to the pump disclosed in JP 2008-308991A, it is desirable to improve bubble removal capability inside the inter-tooth space (pump chamber) as follows. The bubble in the inter-tooth space at the maximum volume position needs to be prevented from being diffused. The bubble contained in the oil collected on the tooth bottom portion side of the inter-tooth space needs to be easily discharged outside the housing from the recessed groove and the through-hole.

[0008] Thus, a need exists for an oil pump capable of improving the bubble removal capability inside the pump chamber.

SUMMARY

[0009] An oil pump according to an aspect of this disclosure includes an inner rotor having a plurality of external teeth, an outer rotor having a plurality of internal teeth that engage with the plurality of external teeth of the inner rotor, a housing that houses the inner rotor and the outer rotor, a suction port that is formed in the housing and guides oil into a pump chamber formed by the plurality of external teeth and the plurality of internal teeth, a discharge port that is formed in the housing and guides the oil to outside the pump chamber, and a discharge passage through which the pump chamber and an outside area of the housing communicate with each other and that discharges a bubble contained in the oil inside the pump chamber to the outside area of the housing. A bubble accommodation portion having a recess shape recessed to a side in a rotation direction of the inner rotor is formed in a side surface portion of each of the plurality of external teeth on a side in an opposite direction of the rotation direction of the inner rotor.

[0010] In the oil pump according to the aspect of this disclosure, as described above, the bubble accommodation portion having the recess shape recessed to the side in the rotation direction of the inner rotor is formed in the side surface portion of each of the plurality of external teeth on the side in the opposite direction of the rotation direction of the inner rotor. Here, when the inner rotor and the outer rotor rotationally move the pump chamber, the oil having higher specific gravity than the bubble inside the pump chamber is moved outward in the radial direction of the inner rotor due to a centrifugal force. Accordingly, the bubble contained in the oil is collected inward the radial direction of the inner rotor inside the pump chamber. The oil vigorously and linearly flows into the pump chamber at a maximum volume position from the positive pressure pump chamber closer to the discharge port side than the maximum volume position. In this manner, a flow of the oil flowing from the negative pressure pump chamber closer to the suction port side than the maximum volume position diverges into an outward flow of the oil and an inward flow of the oil in the radial direction of the rotor along an inner surface of the pump chamber. Out of these flows, the inward flow of the oil in the radial direction of the inner rotor is used. The bubble collected inward in the radial direction of the inner rotor inside the pump chamber can be accommodated and stored in the bubble accommodation portion disposed on a side surface on the side in the opposite direction of the rotation direction of the external teeth. As a result, the bubble can be prevented from being diffused (scattered) in the pump chamber by accommodating and storing the bubble in the bubble accommodation portion at the maximum volume position. Accordingly, bubble removal capability inside the pump chamber can be improved, compared to a case where the bubble is diffused in the pump chamber.

[0011] In the oil pump according to the aspect, it is preferable that the discharge passage includes a discharge hole disposed in a tooth bottom portion between the external teeth of the inner rotor or in a portion of the housing which corresponds to the tooth bottom portion, and the bubble accommodation portion is disposed to extend to a position at which the bubble accommodation portion communicates with the discharge hole in a radial direction of the inner rotor.

[0012] According to this configuration, the bubble accommodation portion and the discharge hole can directly communicate with each other. Accordingly, the bubble contained in the oil inside the pump chamber can be smoothly discharged outside the housing via the discharge hole. As a result, the bubble removal capability inside the pump chamber can be further improved.

[0013] In this case, it is preferable that, in an extending direction of a rotation axis of the inner rotor, a depth of the bubble accommodation portion on a discharge hole side is shallower than a depth of the bubble accommodation portion on a side opposite to the discharge hole.

[0014] According to this configuration, the bubble inside the bubble accommodation portion can be easily guided to a region close to the discharge hole by a shallow portion of the bubble accommodation portion on the discharge hole side. As a result, the bubble contained in the oil inside the pump chamber can be efficiently discharged outside the housing via the discharge hole. Accordingly, the bubble removal capability inside the pump chamber can be further improved.

[0015] In the oil pump including the bubble accommodation portion that communicates with the discharge hole, it is preferable that the discharge hole is disposed in a portion of the housing which corresponds to the tooth bottom portion, when viewed in the rotation direction of the inner rotor, the bubble accommodation portion is configured to close a portion of the side surface portion of the external teeth on a side opposite to the discharge hole, and open a portion of the side surface portion of the external teeth on the discharge hole side, and the bubble accommodation portion and the discharge hole communicate with each other in an extending direction of a rotation axis of the inner rotor.

[0016] According to this configuration, out of the side surface portion of the external teeth, the portion on the side opposite to the discharge hole is closed. In this manner, it is possible to secure a thickness in the rotation direction in the external teeth of the inner rotor. In this manner, strength of the external teeth can be prevented from being weakened due to the bubble accommodation portion disposed in the external teeth. Out of the side surface portion of the external teeth, the portion on the discharge hole side is opened. In this simple manner, the bubble accommodation portion and the discharge hole can communicate with each other in the extending direction of the rotation axis of the inner rotor. As a result, the strength of the external teeth can be prevented from being weakened due to the bubble accommodation portion disposed in the external teeth, and a simple configuration enables the bubble accommodation portion and the discharge hole to communicate with each other.

[0017] In this case, it is preferable that, in the radial direction of the inner rotor, an end portion of the bubble accommodation portion on the discharge hole side is flush with an end portion of the discharge hole on the rotation axis side, or is located closer to the rotation axis side than the end portion of the discharge hole on the rotation axis side.

[0018] According to this configuration, a whole opening of the discharge hole on the bubble accommodation portion side can communicate with the bubble accommodation portion. Accordingly, the bubble contained in the oil inside the pump chamber can be smoothly discharged outside the housing via the discharge hole.

[0019] In the oil pump according to the aspect, it is preferable that, the bubble accommodation portion is disposed at a position of the side surface portion of each of the external teeth of the inner rotor, which is capable of accommodating the bubble flowing due to a flow of the oil leaking and flowing in the rotation direction from an inter-tooth space between the internal teeth of the outer rotor and the external teeth of the inner rotor.

[0020] According to this configuration, the bubble accommodation portion can be disposed at a more optimal position. Accordingly, a larger amount of the bubbles can be accommodated in the bubble accommodation portion by using the flow of the oil inside the pump chamber at the maximum volume position formed by the flow of the oil of the pump chamber closer to the suction port side than the maximum volume position and the flow of the oil of the pump chamber closer to the discharge port side than the maximum volume position.

[0021] According to the aspect of this disclosure, it is conceivable that the oil pump according to the aspect adopts the following configuration.

Supplementary Configuration 1

[0022] That is, in the oil pump according to the aspect, the outer end portion of the bubble accommodation portion is located inward of each outer end portion of the plurality of external teeth in the radial direction of the inner rotor.

[0023] According to this configuration, the bubble flowing to the pump chamber from the bubble accommodation portion can be blocked by the outer end portion of the bubble accommodation portion in the radial direction of the inner rotor. Accordingly, a larger amount of the bubbles can be collected inside the bubble accommodation portion.

[0024] In the oil pump according to the aspect, when viewed in the extending direction of the rotation axis of the inner rotor, the bubble accommodation portion has an arc recess shape.

[0025] According to this configuration, the bubble can smoothly flow along an arc-shaped surface from the bubble accommodation portion to the discharge hole. Accordingly, the bubble contained in the oil inside the pump chamber can be smoothly discharged outside the housing via the discharge hole.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] The foregoing and additional features and characteristics of this disclosure will become more apparent from the following detailed description considered with the reference to the accompanying drawings, wherein:

- Fig. 1 is a perspective view illustrating a state where a cover is removed from an oil pump according to a first embodiment;
- Fig. 2 is a plan view illustrating a state where the cover is removed from the oil pump according to the first embodiment;
- Fig. 3 is an enlarged view illustrating a state of a first closing process in the oil pump according to the first embodiment;
- Fig. 4 is a sectional view in which a cross section taken along line 100-100 in Fig. 3 is partially omitted;
- Fig. 5 is an enlarged view illustrating a state of a compression process in the oil pump according to the first embodiment;
- Fig. 6 is an enlarged view illustrating a state of a bubble discharge process in the oil pump according to the first embodiment;
- Fig. 7 is sectional view in which a cross section taken along line 110-110 in Fig. 6 is partially omitted;
- Fig. 8A is a plan view of a suction process of the oil pump according to the first embodiment;
- Fig. 8B is a plan view illustrating the first closing process of the oil pump according to the first embodiment;
- Fig. 9A is a plan view illustrating the compression process of the oil pump according to the first embodiment;
- Fig. 9B is a plan view illustrating the bubble discharge process of the oil pump according to the first embodiment;
- Fig. 10A is a plan view illustrating a second closing process of the oil pump according to the first embodiment;
- Fig. 10B is a plan view illustrating a discharge process of the oil pump according to the first embodiment;
- Fig. 11 is a plan view illustrating a state where a cover is removed from an oil pump according to a second embodiment;
- Fig. 12 is an enlarged view illustrating a state of a bubble discharge process in the oil pump according to the second embodiment;
- Fig. 13 is a sectional view in which a cross section taken along line 200-200 in Fig. 12 is partially omitted;
- Fig. 14A is a plan view of a suction process of the oil pump according to the second embodiment;
- Fig. 14B is a plan view illustrating a first closing process of the oil pump according to the second embodiment;
- Fig. 15A is a plan view illustrating the compression process of the oil pump according to the first embodiment;
- Fig. 15B is a plan view illustrating the bubble discharge process of the oil pump according to the first embodiment;
- Fig. 16A is a plan view illustrating the second closing process of the oil pump according to the first embodiment;
- Fig. 16B is a plan view illustrating the discharge process of the oil pump according to the first embodiment;
- Fig. 17A is a sectional view corresponding to the cross section taken along line 110-110 in Fig. 6 in an oil pump according to a first modification example;
- Fig. 17B is a sectional view corresponding to the cross section taken along line 110-110 in Fig. 6 in the oil pump according to the first modification example;
- Fig. 18A is a sectional view corresponding to the cross section taken along line 110-110 in Fig. 6 in an oil pump according to a second modification example;

Fig. 18B is a sectional view corresponding to the cross section taken along line 110-110 in Fig. 6 in the oil pump according to the second modification example; and

Fig. 19 is a sectional view corresponding to the cross section taken along line 200-200 in Fig. 12 in an oil pump according to a third modification example.

DETAILED DESCRIPTION

[0027] Hereinafter, embodiments disclosed here will be described with reference to the drawings.

First Embodiment

[0028] Referring to Figs. 1 to 7, a configuration of a vehicle oil pump 1 according to a first embodiment will be described.

Configuration of Oil Pump

[0029] As illustrated in Fig. 1, the oil pump 1 is mounted on an automobile (not illustrated) including an engine. The oil pump 1 is configured so that oil A (lubricating oil) inside an oil pan is drawn to be supplied (pumped) to a periphery of a piston of the engine, a movable unit (sliding unit) such as a crankshaft, and a hydraulic device (hydraulic drive unit) such as a variable valve mechanism. The oil pump 1 is an inscribed gear type pump (trochoidal type pump).

[0030] The oil pump 1 includes a housing 2, a suction port 3, a discharge port 4, a shaft 5, an inner rotor 6, an outer rotor 7, and a discharge passage 8 (refer to Fig. 2). Here, an extending direction of a rotation axis C of the shaft 5 will be referred to as an X-direction, one side in the X-direction will be referred to as an X1-direction, and the other side in the X-direction will be referred to as an X2-direction. A rotation direction around a rotation axis of the shaft 5 will be referred to as a rotation direction R. A radial direction of the inner rotor 6 will be referred to as a radial direction Rd.

[0031] The housing 2 is configured to house the inner rotor 6 and the outer rotor 7. Specifically, the housing 2 includes a body 21 and a cover 22. The body 21 and the cover 22 are arranged adjacent to each other in the X-direction. Specifically, the body 21 and the cover 22 are assembled to be in surface contact with each other in the X-direction. The oil pump 1 has a rotor housing space 23 for housing the inner rotor 6 and the outer rotor 7, which is formed by assembling the body 21 and the cover 22 to each other.

[0032] A suction port 3 is formed in the housing 2, and is configured to guide the oil A into a pump chamber S formed by a plurality of external teeth 6a (to be described later) and a plurality of internal teeth 7a (to be described later). That is, the suction port 3 has a function as a guidance passage for guiding the oil A suctioned into the oil pump 1 to the pump chamber S. A discharge port 4 is formed in the housing 2, and is configured to guide the oil A outside the pump chamber S. That is, the discharge port 4 has a function as a deriving passage for guiding the oil A inside the pump chamber S outside the oil pump 1. Both the suction port 3 and the discharge port 4 are disposed across the body 21 and the cover 22.

[0033] The shaft 5 is rotatably attached to the housing 2 in the rotation direction R. The shaft 5 has a cylindrical shape extending in the X-direction. The shaft 5 is rotationally driven by receiving a rotational driving force (torque) from a crankshaft via a belt (not illustrated) attached to any end portion of the shaft 5 in the X-direction, thereby rotationally driving the inner rotor 6. The shaft 5 is inserted (fitted) into the inner rotor 6 by means of press fitting, and rotates the inner rotor 6 in synchronization therewith.

Configuration of Inner Rotor and Outer Rotor

[0034] As illustrated in Fig. 2, the inner rotor 6 is configured to rotate the outer rotor 7 by rotating around a rotation center axis C eccentric from a rotation center axis of the outer rotor 7. That is, a portion of the inner rotor 6 engages with a portion of the outer rotor 7. Specifically, the inner rotor 6 includes the plurality of external teeth 6a. The outer rotor 7 has the plurality of internal teeth 7a respectively engaging with the plurality of external teeth 6a of the inner rotor 6. The external teeth 6a of the inner rotor 6 are arranged inside the outer rotor 7 so as to internally engage with the internal teeth 7a of the outer rotor 7. The number of the external teeth 6a in the inner rotor 6 is one less than the number of the internal teeth 7a in the outer rotor 7.

[0035] If the inner rotor 6 is rotated in the rotation direction R, the outer rotor 7 is rotated in the same direction. During the rotation, the external teeth 6a of the inner rotor 6 and the internal teeth 7a of the outer rotor 7 mesh with each other on a side where a distance is short between the inner rotor 6 and the outer rotor 7. The number of the external teeth 6a is one less than the number of the internal teeth 7a. Accordingly, on a side where the distance is long, the external teeth 6a and the internal teeth 7a do not mesh with each other, thereby forming a gap (pump chamber S) between the external teeth 6a and the internal teeth 7a.

[0036] The inner rotor 6 and the outer rotor 7 fulfill a pump function by rotationally moving the pump chamber S in the rotation direction R to expand and contract the pump chamber S. Therefore, the oil A flows into the pump chamber S from the suction port 3, as a volume of the pump chamber S expands. In this case, pressure inside the pump chamber S decreases (has negative pressure). The oil A flows out to the discharge port 4 from the pump chamber S, as the volume of the pump chamber S contracts. In this case, the pressure inside the pump chamber S increases (has positive pressure). Here, in the pump, as the volume of the pump chamber S expands or contracts, a plurality of processes are performed from a suction process (Fig. 8A) in which the oil A is suctioned into the pump chamber S to a discharge process (Fig. 10B) in which the oil A inside the pump chamber S is discharged.

[0037] The plurality of processes include a suction process (refer to Fig. 8A), a first closing process (refer to Fig. 8B), a compression process (refer to Fig. 9A), a bubble discharge process (refer to Fig. 9B), a second closing process (refer to Fig. 10A), and a discharge process (refer to Fig. 10B). In the suction process and the first closing process, the pressure inside the pump chamber S is the negative pressure. In the compression process, the bubble discharge process, the second closing process, and the discharge process, the pressure inside the pump chamber S is the positive pressure.

[0038] When the inner rotor 6 and the outer rotor 7 rotationally move the pump chamber S in the rotation direction R, the oil A having a higher specific gravity than the bubble B (air) is moved outward in the radial direction Rd due to a centrifugal force P, inside the pump chamber S. That is, when the oil pump 1 is driven, the bubble B contained in the oil A is collected inward (on the shaft 5 side) in the radial direction Rd inside the pump chamber S.

Bubble Accommodation Portion and Discharge Hole

[0039] As illustrated in Fig. 3, the inner rotor 6 according to the first embodiment is configured to collect the bubble B contained in the oil A by using a flow of the oil A inside the pump chamber S during a first closing process (process between the suction process and the compression process).

[0040] The flow of the oil A inside the pump chamber S in the first closing process will be described.

[0041] In the oil pump 1, pressure inside the pump chamber S at a first closing position W2 is negative pressure. Here, the first closing position W2 is a maximum volume position of the pump chamber S. Therefore, the oil A inside the pump chamber S (pump chamber S at a suction position W1) closer to the suction port 3 side than the first closing position W2 flows into the pump chamber S at the first closing position W2 from a gap between the internal teeth 7a and the external teeth 6a on the suction port 3 side in the pump chamber S at the first closing position W2. The oil A inside the pump chamber S (pump chamber S at compression position W3) closer to the discharge port 4 side than the first closing position W2 flows into the pump chamber S at the first closing position W2 from a gap between the internal teeth 7a and the external teeth 6a on the discharge port 4 side in the pump chamber S at the first closing position W2. Here, the pump chamber S on the discharge port 4 side has positive pressure. Accordingly, the oil A flowing from the pump chamber S closer to the discharge port side than the first closing position W2 is ejected. As a result, due to the oil A ejected from the pump chamber S closer to the discharge port side than the first closing position W2, the oil A flowing from the pump chamber S closer to the suction port 3 side than the first closing position W2 diverges into an outward diverging flow F1 and an inward diverging flow F2.

[0042] That is, in the first closing process, the inner rotor 6 is configured so that the bubble B contained in the oil A collected inward (on the shaft 5 side) in the radial direction Rd inside the pump chamber S is not diffused by the inward diverging flow F2. Here, the inward diverging flow F2 is the flow of the oil A inside the pump chamber S for collecting the bubble B contained in the oil A.

[0043] Specifically, a bubble accommodation portion 61 having a recess shape recessed to a side in the rotation direction R of the inner rotor 6 is formed in a side surface portion 64 (hereinafter, referred to as a first side surface portion 64) of the plurality of external teeth 6a on a side in an opposite direction of the rotation direction R of the inner rotor 6. The bubble accommodation portion 61 is formed in a pocket shape for collecting the bubble B contained in the oil A. Specifically, the bubble accommodation portion 61 has an arc recess shape when viewed in an extending direction (X-direction) of the rotation axis C of the inner rotor 6. Here, an outer end portion 61a of the bubble accommodation portion 61 in the radial direction Rd extends from the first side surface portion 64 along the rotation direction R. The inner side of the outer end portion 61a in the radial direction Rd is curved toward a side in the opposite direction of the rotation direction R as the inner side faces inward in the radial direction Rd.

[0044] The bubble accommodation portion 61 is disposed at a position of the first side surface portion 64 of the inner rotor 6, which is capable of accommodating the bubble B flowing due to the oil A leaking and flowing along the rotation direction R from an inter-tooth space between the internal teeth 7a of the outer rotor 7 and the external teeth 6a of the inner rotor 6. That is, the bubble accommodation portion 61 is disposed in a bubble collection region CR capable of collecting the bubble B contained in the oil A flowing due to the inward diverging flow F2. Specifically, the outer end portion 61a in the radial direction Rd is located inside each outer end portion 63 of the plurality of external teeth 6a. An inner end portion in the radial direction Rd is located inside each tooth bottom portion 62 of the plurality of external teeth 6a in the radial direction Rd. It is more preferable that the outer end portion 61a in the radial direction Rd of the external teeth 6a of the inner rotor 6 is located inside each central position in the radial direction Rd of the plurality of external teeth 6a.

[0045] The bubble accommodation portion 61 is configured to block the bubble B flowing due to the inward diverging flow F2. That is, the bubble accommodation portion 61 is configured to collect the bubble B internally flowing due to the inward diverging flow F2. Specifically, the bubble accommodation portion 61 is formed in a blind alley (tapered) shape in a flowing direction of the inward diverging flow F2. In this way, the bubble accommodation portion 61 has a structure in which the bubble B can be collected on a rear side of the blind alley shape by causing the inward diverging flow F2 to driving the bubble B into the bubble accommodation portion 61.

[0046] The bubble accommodation portion 61 has a volume capable of discharging a desired amount of the bubbles B from the discharge hole 8a out of the bubbles B contained in the oil A inside the pump chamber S. That is, the bubble accommodation portion 61 has a volume capable of accommodating a desired amount of the bubbles B out of the bubbles B contained in the oil A inside the pump chamber S. Here, the bubble accommodation portion 61 has a volume having a predetermined proportion with respect to a volume of the pump chamber S at the first closing position W2. The volume of the bubble accommodation portion 61 is smaller than the volume of the pump chamber S at the first closing position W2.

[0047] As illustrated in Fig. 4, the external teeth 6a of the inner rotor 6 are configured so that the outer rotor 7 can be rotated by the inner rotor 6 even if the bubble accommodation portion 61 having the recess shape is formed. That is, the bubble accommodation portion 61 is formed by partially cutting out the external teeth 6a of the inner rotor 6 in the extending direction of the rotation axis C. Specifically, when viewed in the rotation direction R of the inner rotor 6, the bubble accommodation portion 61 is configured to close a portion on a side opposite to the discharge hole 8a out of a side surface portion 65 (hereinafter, referred to as a second side surface portion 65) of the external teeth 6a, and to open a portion on the discharge hole 8a side. Here, the second side surface portion 65 is a side surface portion in a direction perpendicular to the rotation direction R of the inner rotor 6. In this way, the thickness in the rotation direction R is secured. Accordingly, strength of the external teeth 6a of the inner rotor 6 can be prevented from being weakened due to the bubble accommodation portion 61 disposed in the external teeth 6a.

[0048] The bubble accommodation portion 61 has a shape corresponding to each of the inward diverging flow F2 (refer to Fig. 3) and the discharge flow F3 (refer to Fig. 7). That is, the bubble accommodation portion 61 has a shape that collects a larger amount of the bubbles B flowing through the inward diverging flow F2 and more easily discharges the bubble B through the discharge flow F3. Specifically, in the extending direction of the rotation axis C of the inner rotor 6, a depth D2 of the bubble accommodation portion 61 on the discharge hole 8a side is shallower than a depth D1 on a side opposite to the discharge hole 8a.

[0049] Therefore, in the bubble accommodation portion 61, the depth D2 of the portion of the bubble accommodation portion 61 on the discharge hole 8a side is shallower than the depth D1 on the side opposite to the discharge hole 8a so that the bubble B can be easily collected in the discharge hole 8a by using the discharge flow F3. In the bubble accommodation portion 61, the depth D1 of the portion of the bubble accommodation portion 61 on the discharge hole 8a side is deeper so that the bubble B can easily stay in the bubble accommodation portion 61 by using the inward diverging flow F2.

[0050] In the extending direction of the rotation axis C of the inner rotor 6, the portion of the bubble accommodation portion 61 opposite to the discharge hole 8a is curved to the discharge hole 8a as the portion faces inward in the radial direction Rd. That is, in the bubble accommodation portion 61, the depth of the bubble accommodation portion 61 in the extending direction of the rotation axis C gradually decreases as the bubble accommodation portion 61 is closer to the discharge hole 8a. The bubble accommodation portion 61 has a flat surface portion 61b connected to the discharge hole 8a in the inner end portion in the radial direction Rd.

[0051] As illustrated in Fig. 5, during the compression process, the oil pump 1 is configured so that the pressure inside the pump chamber S is pressurized and changed from the negative pressure to the positive pressure by reducing the volume inside the compression chamber S. That is, the oil pump 1 is configured so that the flow of the oil A generated in the pump chamber S having the negative pressure at the first closing position W2 is prevented by changing the pressure inside the pump chamber S to the positive pressure.

[0052] Specifically, in the oil pump 1, the pump chamber S at the compression position W3 internally has the positive pressure. Therefore, the oil A inside the pump chamber S (pump chamber S at the suction position W1) closer to the suction port 3 side than the compression position W3 is prevented from flowing into the pump chamber S at the compression position W3 from the gap between the internal teeth 7a and the external teeth 6a on the suction port 3 side in the pump chamber S at the compression position W3. The oil A inside the pump chamber S (pump chamber S at the discharge position W6) closer to the discharge port 4 side than the compression position W3 is prevented from flowing into the pump chamber S at the compression position W3 from the gap between the internal teeth 7a and the external teeth 6a on the discharge port 4 side in the pump chamber S at the compression position W3. As a result, the outward diverging flow F1 and the inward diverging flow F2 which are generated at the first closing position W2 are less likely to be generated at the compression position W3.

[0053] During the compression process, the oil pump 1 is configured to collect the bubble B contained in the oil A again inward (to the shaft 5 side) in the radial direction Rd inside the pump chamber S. That is, the oil pump 1 is configured as follows. In a state of preventing the flow of the oil A which is generated in the pump chamber S at the first closing position W2, the bubble B contained in the oil A is collected inward in the radial direction Rd inside the pump chamber S by using the centrifugal force P when the inner rotor 6 and the outer rotor 7 rotationally move the pump chamber S in the rotation direction R.

[0054] In this way, the oil pump 1 is configured so that the flow of the oil A inside the pump chamber S is further stabilized than that at the first closing position W2, while the first closing process is changed to the bubble discharge process.

[0055] As illustrated in Figs. 6 and 7, the oil pump 1 is configured as follows. During the bubble discharge process (process between the first closing process and the discharge process), the pump chamber S is internally pressurized. In this manner, the bubble B contained in the oil A collected inward in the radial direction Rd inside the chamber S is discharged outside the housing 2 via the discharge hole 8a. That is, during the bubble discharge process, the oil pump 1 is configured so that the bubble B is discharged using the discharge flow F3 generated from the inside the pump chamber S toward the discharge hole 8a by internally pressurizing the pump chamber S.

[0056] Here, the discharge hole 8a is configured so that the pump chamber S and the outside area of the housing 2 are caused to communicate with each other to discharge the bubble B contained in the oil A inside the pump chamber S to the outside area of the housing 2. Specifically, the discharge hole 8a is disposed in a portion of the housing 2 corresponding to the tooth bottom portion 62 between the external teeth 6a of the inner rotor 6. The discharge hole 8a penetrates the cover 22 in the X-direction in the extending direction of the rotation axis C.

Relationship between Bubble Accommodation Portion and Discharge Hole

[0057] As illustrated in Fig. 7, in the bubble discharge process, the bubble accommodation portion 61 is configured to cause the collected bubble B to flow in the discharge passage 8 by using the discharge flow F3. That is, the discharge passage 8 includes the discharge hole 8a connected to the bubble accommodation portion 61 in an inner end portion 61c in the radial direction Rd of the bubble accommodation portion 61. Specifically, the bubble accommodation portion 61 is disposed to extend to a position at which the bubble accommodation portion 61 communicates with the discharge hole 8a in the radial direction Rd. The bubble accommodation portion 61 and the discharge hole 8a communicate with each other in the extending direction of the rotation axis C of the inner rotor 6. That is, the end portion 61c of the bubble accommodation portion 61 on the discharge hole 8a side is located to be flush with the end portion 122 on the side in the rotation axis C of the discharge hole 8a in the radial direction Rd.

[0058] As illustrated in Fig. 6, during the bubble discharge process, the bubble accommodation portion 61 and the discharge hole 8a are connected to each other in a central portion in the rotation direction R of the bubble accommodation portion 61. Specifically, the bubble accommodation portion 61 is disposed in the rotation direction R so as to extend to at least a position at which the bubble accommodation portion 61 communicates with the discharge hole 8a. That is, the bubble accommodation portion 61 and the discharge hole 8a overlap each other in the X-direction (extending direction of the rotation axis C).

Operation of Oil Pump

[0059] Hereinafter, referring to Figs. 8A to 10B, an operation of the pump 1 from the suction process to the discharge process will be described.

[0060] First, as illustrated in Fig. 8A, during the suction process, the oil A is supplied from the suction port 3 into the pump chamber S at the suction position W1 having the negative pressure, inside the oil pump 1. In this case, in the oil pump 1, the bubble B contained in the oil A also flows into the pump chamber S at the suction position W1. However, due to the centrifugal force P applied to the pump chamber S at the suction position W1, the bubble B is collected inside the pump chamber S at the suction position W1. In the oil pump 1, the inner rotor 6 is rotated in the rotation direction R, thereby changing the suction process to the first closing process.

[0061] As illustrated in Fig. 8B, during the first closing process, in the oil pump 1, the pump chamber S at the first closing position W2 has a maximum volume. That is, the first closing position W2 is a maximum volume position of the pump chamber S. Here, the pressure inside the pump chamber S at the first closing position W2 is the negative pressure lower than the pressure inside the pump chamber S at the suction position W1. In this case, in the oil pump 1, the bubble B contained in the oil A inside the pump chamber S at the first closing position W2 is collected in the bubble accommodation portion 61 by using the inward diverging flow F2 (refer to Fig. 3). In the oil pump 1, the suction process is changed to the compression process by rotating the inner rotor 6 in the rotation direction R.

[0062] As illustrated in Fig. 9A, during the compression process, the oil pump 1 has a smaller volume than the pump chamber S during the first closing process. Here, the pressure inside the pump chamber S at the compression position W3 is the positive pressure higher than the pressure inside the pump chamber S during the first closing process. In this case, in the oil pump 1, in a state of preventing the outward diverging flow F1 (refer to Fig. 3) and the inward diverging flow F2 (refer to Fig. 3) which are generated at the first closing position W2, the bubble B inside the pump chamber S is collected inward in the radial direction Rd by using the centrifugal force P generated when the pump chamber S is rotationally moved in the rotation direction R. In the oil pump 1, the compression process is changed to the bubble discharge process by rotating the inner rotor 6 in the rotation direction R.

[0063] As illustrated in Fig. 9B, during the bubble discharge process, the oil pump 1 has a smaller volume than the pump chamber S during the compression process. Here, the pressure inside the pump chamber S during the bubble discharge process is the positive pressure higher than the pressure inside the pump chamber S in the compression process. In this case, in the oil pump 1, the bubble B is discharged outside the housing 2 from the discharge hole 8a (refer to Fig. 7). In the oil pump 1, the bubble discharge process is changed to the discharge process through the second closing process by rotating the inner rotor 6 in the rotation direction R.

[0064] As illustrated in Figs. 10A and 10B, in the oil pump 1, at the second closing position W5 during the second closing process and at the discharge position W6 during the discharge process, the oil pump 1 further increases the pressure inside the pump chamber S. In this manner, the oil A from which the bubble B is discharged via the discharge hole 8a and which does rarely contain the bubble B is discharged to various engine components (not illustrated) via the discharge port 4. According to the above-described procedure, a series of operations in the oil pump 1 is completed.

Advantageous Effects of First Embodiment

[0065] According to the first embodiment, the following advantageous effects can be achieved.

[0066] According to the first embodiment, as described above, the bubble accommodation portion 61 having the recess shape recessed to the side in the rotation direction of the inner rotor 6 is formed in the first side surface portion 64 on the side in the opposite direction of the rotation direction R of each inner rotor 6 of the plurality of external teeth 6a. Here, when the inner rotor 6 and the outer rotor 7 rotationally move the pump chamber S, the oil A having the higher specific gravity than the bubble B inside the pump chamber S is moved outward in the radial direction Rd due to the centrifugal force P. Accordingly, the bubble B contained in the oil A is collected inward in the radial direction Rd inside the pump chamber S. Due to the flow of the oil A vigorously and linearly ejected to the pump chamber S at the first closing position W2 from the pump chamber S having the positive pressure closer to the discharge port 4 side than the first closing position W2 (maximum volume position), the flow of the oil A flowing from the pump chamber S having the negative pressure closer to the suction port 3 side than the first closing position W2 diverges into the outward diverging flow F1 and the inward diverging flow F2 along the inner surface of the pump chamber S. Out of the flows, the inward diverging flow F2 is used. In this manner, the bubble B collected inward in the radial direction Rd of the inner rotor inside the pump chamber S can be accommodated and stored in the bubble accommodation portion 61 disposed in the first side surface portion 64 on the side in the opposite direction of the rotation direction R of the external teeth 6a. As a result, the bubble B is accommodated and stored in the bubble accommodation portion 61 at the first closing position W2. In this manner, the bubble B of the pump chamber S can be prevented from being diffused. Accordingly, compared to a case where the bubble B is diffused (scattered) in the pump chamber S, the bubble removal capability inside the pump chamber can be improved.

[0067] According to the first embodiment, as described above, the discharge passage 8 has the discharge hole 8a disposed in the tooth bottom portion 62 between the external teeth 6a of the inner rotor 6, or the portion of the housing 2 corresponding to the tooth bottom portion 62. The bubble accommodation portion 61 is disposed to extend to the position at which the bubble accommodation portion 61 communicates with the discharge hole 8a in the radial direction Rd. In this manner, the bubble accommodation portion 61 and the discharge hole 8a can directly communicate with each other. Accordingly, the bubble B contained in the oil A inside the pump chamber S can be smoothly discharged outside the housing 2 via the discharge hole 8a. As a result, the bubble removal capability inside the pump chamber S can be further improved.

[0068] According to the first embodiment, as described above, in the extending direction of the rotation axis C of the inner rotor 6, the depth D2 of the portion of the bubble accommodation portion 61 on the discharge hole 8a side is shallower than the depth D1 on the side opposite to the discharge hole 8a of the bubble accommodation portion 61. In this manner, the bubble B inside the bubble accommodation portion 61 can be easily guided to a region close to the discharge hole 8a by using the portion on the discharge hole 8a side of the bubble accommodation portion 61 having the shallower depth D2. As a result, the bubble B contained in the oil A inside the pump chamber S can be efficiently discharged outside the housing 2 via the discharge hole 8a. Accordingly, the bubble removal capability inside the pump chamber S can be further improved.

[0069] According to the first embodiment, as described above, the discharge hole 8a is disposed in the portion of the housing 2 corresponding to the tooth bottom portion 62. When viewed in the rotation direction R of the inner rotor 6, the bubble accommodation portion 61 is configured to close the portion opposite to the discharge hole 8a out of the second side surface portion 65 and to open the portion on the discharge hole 8a side. The bubble accommodation portion 61 and the discharge hole 8a are disposed to extend to the position where both of these are configured to communicate with each other in the extending direction of the rotation axis C of the inner rotor 6. In this manner, the thickness in the rotation direction R can be secured in the external teeth 6a of the inner rotor 6 by closing the portion on the side opposite to the discharge hole 8a out of the second side surface portion 65. Therefore, the strength of the external teeth 6a can be prevented from being weakened due to the bubble accommodation portion 61 disposed in the external teeth 6a. Out of the second side surface portion 65, the portion on the discharge hole 8a side is opened. In this simple manner, the bubble accommodation portion 61 and the discharge hole 8a can communicate with each other in the extending direction of the rotation axis C of the inner rotor 6. As a result, the strength of the external teeth 6a can be prevented from being weakened due to the bubble accommodation portion 61 disposed in the external teeth 6a, and a simple configuration enables the bubble accommodation portion 61 and the discharge hole 8a to communicate with each other.

[0070] According to the first embodiment, as described above, in the radial direction Rd, the end portion 61c on the discharge hole 8a side of the bubble accommodation portion 61 is located to be flush with the end portion 122 on the side in the rotation axis C of the discharge hole 8a. In this manner, the whole opening of the discharge hole 8a on the bubble accommodation portion 61 side can communicate with the bubble accommodation portion 61. Accordingly, the bubble B contained in the oil A inside the pump chamber S can be smoothly discharged outside the housing 2 via the discharge hole 8a.

[0071] According to the first embodiment, as described above, the bubble accommodation portion 61 is disposed at the position of the first side surface portion 64 of the inner rotor 6, which is capable of accommodating the bubble B flowing due to the oil A leaking and flowing along the rotation direction R from the inter-tooth space between the internal teeth 7a of the outer rotor 7 and the external teeth 6a of the inner rotor 6. In this manner, the bubble accommodation portion 61 can be disposed at a more optimal position. Accordingly, a larger amount of the bubbles B can be accommodated in the bubble accommodation portion 61 by using the inward diverging flow F2.

[0072] According to the first embodiment, as described above, in the radial direction Rd, the outer end portion 61a of the bubble accommodation portion 61 is located inside each outer end portion 63 of the plurality of external teeth 6a. In this manner, the bubble B flowing out from the bubble accommodation portion 61 to the pump chamber S can be blocked by the outer end portion 61a in the radial direction Rd of the bubble accommodation portion 61. Accordingly, a larger amount of the bubbles B can be collected inside the bubble accommodation portion 61.

[0073] According to the first embodiment, as described above, when viewed in the extending direction of the rotation axis C of the inner rotor 6, the bubble accommodation portion 61 is disposed in the arc recess shape. In this manner, the bubble B can smoothly flow from the bubble accommodation portion 61 to the discharge hole 8a along the arc-shaped surface. Accordingly, the bubble B contained in the oil A inside the pump chamber S can be smoothly discharged outside the housing 2 via the discharge hole 8a.

Second Embodiment

[0074] Next, referring to Figs. 11 to 13, a configuration of an oil pump 201 according to a second embodiment of this disclosure will be described. In the second embodiment, unlike the first embodiment in which the discharge passage 8 of the oil pump 1 is formed in the housing 2, an example will be described in which the discharge passage 208 that discharges the bubble B contained in the oil A is formed in a shaft 205. In the second embodiment, the same reference numerals will be given to the same components as those according to the first embodiment, and description thereof will be omitted.

Configuration of Oil Pump

[0075] As illustrated in Fig. 11, the oil pump 201 according to the second embodiment includes a housing 202, the suction port 3, the discharge port 4, the shaft 205, the inner rotor 6, the outer rotor 7, and the discharge passage 208. The shaft 205 includes a rotary shaft 205a and a stationary shaft 205b. The rotary shaft 205a is rotatably attached to the housing 202. On the other hand, the stationary shaft 205b is fixed and attached to the housing 2.

Bubble Accommodation Portion and Discharge Passage

[0076] The first side surface portion 64 of each inner rotor 6 of the plural of external teeth 6a has, the bubble accommodation portion 61 having the recess shape recessed to the side in the rotation direction R of the inner rotor 6. That is, as in the first embodiment, the inner rotor 6 according to the second embodiment is configured to collect the bubble B contained in the oil A by using the flow of the oil A inside the pump chamber S during the first closing process (process between the suction process and the compression process).

[0077] The external teeth 6a of the inner rotor 6 are configured so that the outer rotor 7 is rotated by the inner rotor 6 even if the bubble accommodation portion 61 having the recess shape is formed. Specifically, when viewed in the rotation direction R of the inner rotor 6, the bubble accommodation portion 61 is configured to close a portion on the cover 22 side of the second side surface portion 65 and to open a portion on the body 21 side.

[0078] As illustrated in Figs. 12 and 13, the discharge passage 208 is disposed across the inner rotor 6 and the shaft 205. The discharge passage 208 causes the pump chamber S at a bubble discharge position W4 and the outside area of the housing 202 to communicate with each other. The oil pump 201 is configured to discharge the bubble B contained in the oil A inside the pump chamber S at the bubble discharge position W4 to the outside area of the housing 202 via the discharge passage 208.

[0079] Specifically, the discharge passage 208 includes a first discharge hole 208a disposed in the tooth bottom portion 62 of the inner rotor 6, and a second discharge hole 208b connected to a downstream side end portion of the first discharge hole 208a and disposed in the shaft 205. The first discharge hole 208a is configured to include a through-hole penetrating the shaft 205 side in the radial direction Rd.

[0080] That is, as illustrated in Fig. 11, the first discharge hole 208a is disposed in the inner rotor 6, the rotary shaft 205a, and the stationary shaft 205b. Out of these, a plurality of portions disposed in the inner rotor 6 and the rotary shaft 205a of the first discharge hole 208a are disposed at an equal interval in a circumferential direction of the rotation axis C. The second discharge hole 208b is configured to include a through-hole penetrating the shaft 205 in the extending direction of the rotation axis C. Here, the discharge passage 208 is configured so that the first discharge hole 208a and the second discharge hole 208b communicate with each other at a predetermined rotation angle during the rotation of the inner rotor 6 and the rotary shaft 205a.

[0081] During the bubble discharge process, the oil pump 201 internally pressurizes the pump chamber S. In this manner, the oil pump 201 is configured so that the bubble B contained in the oil A collected inward in the radial direction Rd inside the pump chamber S is discharged outside the housing 202 via the discharge passage 208. That is, during the bubble discharge process, the oil pump 201 is configured so that the bubble B is discharged using the discharge flow F3 generated from the inside of the pump chamber S toward the discharge passage 208 by internally pressurizing the pump chamber S. In this case, in the oil pump 201, the first discharge hole 208a and the second discharge hole 208b communicate with each other.

Operation of Oil Pump

[0082] Hereinafter, referring to Figs. 14A to 16B, an operation of the oil pump 201 from suction process to the discharge process will be described.

[0083] First, as illustrated in Figs. 14A, 14B, and 15A, the oil pump 201 similarly performs the suction process, the first closing process, and the compression process which are respectively illustrated in Figs. 8A, 8B, and 9A.

[0084] As illustrated in Fig. 15B, during the bubble discharge process, the oil pump 201 discharges the bubble B outside the housing 202 from the first discharge hole 208a and the second discharge hole 208b. Thereafter, as illustrated in Figs. 16A and 16B, the oil pump 201 similarly performs the second closing process and the discharge process which are respectively illustrated in Figs. 10A and 10B. According to the above-described procedure, a series of operations in the oil pump 201 is completed. Other configurations according to the second embodiment are the same as those according to the first embodiment.

Advantageous Effects of Second Embodiment

[0085] According to the second embodiment, the following advantageous effects can be achieved.

[0086] According to the second embodiment, as described above, the bubble accommodation portion 61 having the recess shape recessed to the side in the rotation direction R of the inner rotor 6 is formed in the first side surface portion 64 on the side in the rotation direction R of each inner rotor 6 of the plurality of external teeth 6a. In this manner, the inward diverging flow F2 is used so that the bubble B collected inward in the radial direction Rd of the inner rotor inside the pump chamber S can be accommodated and stored in the bubble accommodation portion 61 disposed in the first side surface portion 64 on the side in the opposite direction of the rotation direction R of the external teeth 6a. As a result, the bubble B is accommodated and stored in the bubble accommodation portion 61 at the first closing position W2. In this manner, the bubble B of the pump chamber S can be prevented from being diffused. Accordingly, compared to a case where the bubble B is diffused (scattered) in the pump chamber S, the bubble removal capability inside the pump chamber can be improved.

[0087] According to the second embodiment, as described above, the discharge passage 208 has the discharge hole 8a disposed in the tooth bottom portion 62 between the external teeth 6a of the inner rotor 6. The bubble accommodation portion 61 is disposed to extend to the position at which the bubble accommodation portion 61 communicates with the discharge hole 8a in the radial direction Rd. In this manner, the bubble accommodation portion 61 and the discharge hole 8a can directly communicate with each other. Accordingly, the bubble B contained in the oil A inside the pump chamber S can be smoothly discharged outside the housing 202 via the discharge hole 8a. As a result, the bubble removal capability inside the pump chamber S can be further improved. Other advantageous Effects according to the second embodiment are the same as those according to the first embodiment.

Modification Example

[0088] The embodiments disclosed here should be considered as illustrative in all points and not restrictive. The scope of this disclosure is shown not by the above-described embodiments but by the scope of claims, and further includes meanings equivalent to the scope of claims and all modifications (modification examples) within the scope.

[0089] For example, in the first and second embodiments, an example has been described in which the oil pump 1 (201) is the oil pump using the crankshaft as a drive source. However, this disclosure is not limited thereto. In this disclosure, the oil pump may be an electric oil pump.

[0090] In the above-described first embodiment, an example has been described in which each external teeth 6a of the plurality of inner rotors 6 has only the bubble accommodation portion 61 configured to close the portion on the side opposite to the discharge hole 8a out of the second side surface portion 65 and to open the portion on the discharge hole 8a when viewed in the rotation direction R of the inner rotor 6. However, this disclosure is not limited thereto. According to this disclosure, as in a first modification example illustrated in Figs. 17A and 17B, a discharge hole 322b may be formed not only in a cover 322 but also in a body 321. In order that a bubble accommodation portion 361 alternately communicates with the discharge hole 322a of the cover 322 and the discharge hole 322b of the body 321, closed portions of side surface portions 365 of the plurality of external teeth 306a of the inner rotor 306 may be alternately changed in the extending direction of the rotation axis C in the bubble accommodation portion 361.

[0091] In the above-described first embodiment, an example has been described in which the portion of the bubble accommodation portion 61 opposite to the discharge hole 8a is curved to the discharge hole 8a side in the extending direction of the rotation axis C of the inner rotor 6 as the portion faces inward in the radial direction Rd. However, this disclosure is not limited thereto. According to this disclosure, as in a second modification example illustrated in Fig. 18A, a portion 461c of the bubble accommodation portion 461 opposite to the discharge hole 8a may be inclined to the discharge hole 8a side as the portion 461c faces inward in the radial direction Rd in the extending direction of the rotation axis C of the inner rotor 406. Alternatively, as illustrated in Fig. 18B, a portion 461f of the bubble accommodation portion 461 opposite to the discharge hole 8a may be linearly formed along the radial direction Rd in the extending direction of the rotation axis C of the inner rotor 406.

[0092] In the above-described second embodiment, an example has been described in which the bubble accommodation portion 61 is configured to close the portion on the cover 22 side out of the second side surface portion 65 and to open the portion on the body 21 side. However, this disclosure is not limited thereto. According to this disclosure, as in a third modification example illustrated in Fig. 19, the bubble accommodation portion 561 may be configured to close the portion on the cover 22 side out of the side surface portion 565 of the external teeth 506a and to close the portion on the body 21 side. Here, the bubble accommodation portion 561 and the first discharge hole 208a communicate with each other in a central portion in the extending direction of the rotation axis C.

[0093] In the above-described first and second embodiments, an example has been described in which the outer end portion 61a of the bubble accommodation portion 61 in the radial direction Rd extends from the first side surface portion 64 along the rotation direction R. However, this disclosure is not limited thereto. According to this disclosure, the outer end portion of the bubble accommodation portion in the radial direction may have a return portion protruding inward in the radial direction in order that the bubble collected in the bubble accommodation portion is more likely to stay therein.

[0094] In the above-described first embodiment, an example has been described in which the discharge hole 8a and the portion of the bubble accommodation portion 61 opposite to the discharge hole 8a in the extending direction of the rotation axis C of the inner rotor 6 are connected to each other by the flat surface portion 61b when viewed in the rotation direction R. However, this disclosure is not limited thereto. According to this disclosure, a tip portion of the curved side surface of the bubble accommodation portion opposite to the discharge hole may be directly connected to the discharge hole without using the flat surface portion in the radial direction of the inner rotor.

[0095] In the above-described first embodiment, an example has been described in which the end portion 61c of the bubble accommodation portion 61 on the discharge hole 8a side is located to be flush with the end portion 122 of the discharge hole 8a on the rotation axis C side in the radial direction Rd. However, this disclosure is not limited thereto. According to this disclosure, the end portion of the bubble accommodation portion on the discharge hole side may be located closer to the shaft side than the end portion of the discharge hole on the rotation axis side in the radial direction of the inner rotor.

[0096] The principles, preferred embodiment and mode of operation of the present invention have been described in the foregoing specification. However, the invention which is intended to be protected is not to be construed as limited to the particular embodiments disclosed. Further, the embodiments described herein are to be regarded as illustrative rather than restrictive. Variations and changes may be made by others, and equivalents employed, without departing from the spirit of the present invention. Accordingly, it is expressly intended that all such variations, changes and equivalents which fall within the spirit and scope of the present invention as defined in the claims, be embraced thereby.

Claims

1. An oil pump (1, 201) comprising:

an inner rotor (6, 306, 406) having a plurality of external teeth (6a);
an outer rotor (7) having a plurality of internal teeth (7a) that engage with the plurality of external teeth of the inner rotor;
a housing (2, 202) that houses the inner rotor and the outer rotor;
a suction port (3) that is formed in the housing and guides oil (A) into a pump chamber (S) formed by the plurality of external teeth and the plurality of internal teeth;
a discharge port (4) that is formed in the housing and guides the oil to outside the pump chamber; and
a discharge passage (8, 208) through which the pump chamber and an outside area of the hous-

ing communicate with each other and that discharges a bubble (B) contained in the oil inside the pump chamber to the outside area of the housing, wherein
a bubble accommodation portion (61, 361, 461, 561) having a recess shape recessed to a side in a rotation direction (R) of the inner rotor is formed in a side surface portion (64) of each of the plurality of external teeth on a side in an opposite direction of the rotation direction of the inner rotor.

2. The oil pump according to claim 1, wherein
the discharge passage includes a discharge hole (8a) disposed in a tooth bottom portion (62) between the external teeth of the inner rotor or in a portion of the housing which corresponds to the tooth bottom portion, and
the bubble accommodation portion is disposed to extend to a position at which the bubble accommodation portion communicates with the discharge hole in a radial direction of the inner rotor.

3. The oil pump according to claim 2, wherein
in an extending direction of a rotation axis (C) of the inner rotor, a depth (D2) of the bubble accommodation portion on a discharge hole side is shallower than a depth (D1) of the bubble accommodation portion on a side opposite to the discharge hole.

4. The oil pump according to claim 2 or 3, wherein
the discharge hole is disposed in a portion of the housing which corresponds to the tooth bottom portion,
when viewed in the rotation direction of the inner rotor, the bubble accommodation portion is configured to close a portion of the side surface portion of the external teeth on a side opposite to the discharge hole, and open a portion of the side surface portion of the external teeth on a discharge hole side, and
the bubble accommodation portion and the discharge hole communicate with each other in an extending direction of a rotation axis of the inner rotor.

5. The oil pump according to claim 4, wherein
in the radial direction of the inner rotor, an end portion (61b) of the bubble accommodation portion on the discharge hole side is flush with an end portion (122) of the discharge hole on the rotation axis side, or is located closer to the rotation axis side than the end portion of the discharge hole on the rotation axis side.

6. The oil pump according to any one of claims 1 to 5, wherein
the bubble accommodation portion is disposed at a position of the side surface portion of each of the external teeth of the inner rotor, which is capable of accommodating the bubble flowing due to a flow of the oil leaking and flowing in the rotation direction from an inter-tooth space between the internal teeth of the outer rotor and the external teeth of the inner rotor.

FIG.1

FIRST EMBODIMENT

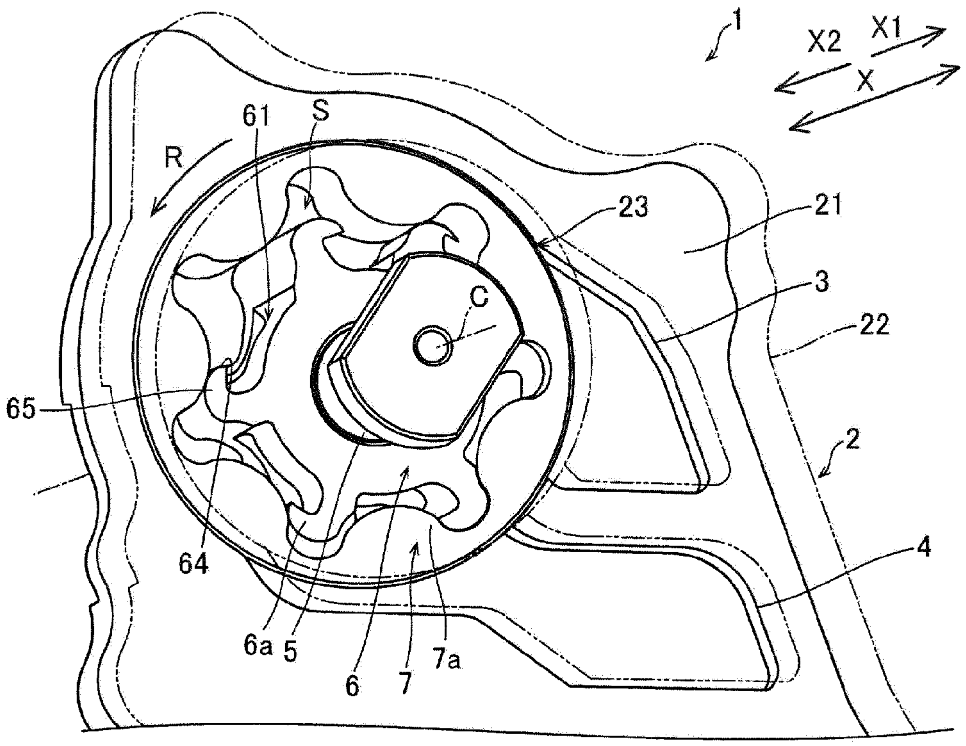


FIG.2

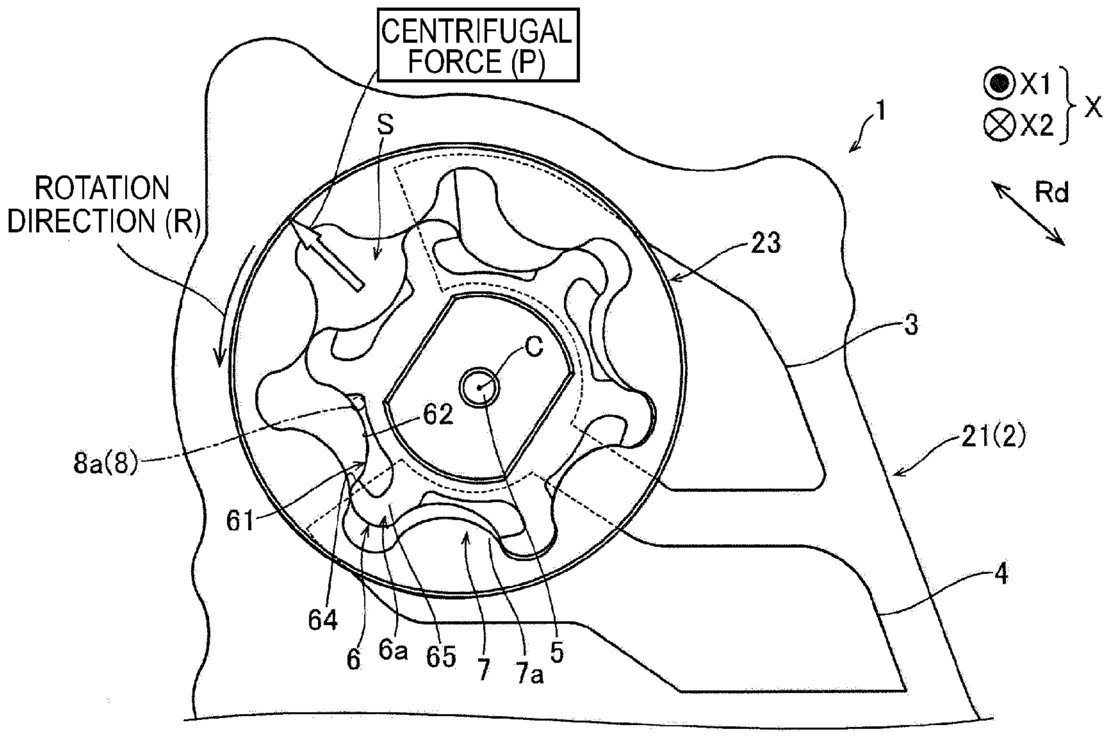


FIG.3

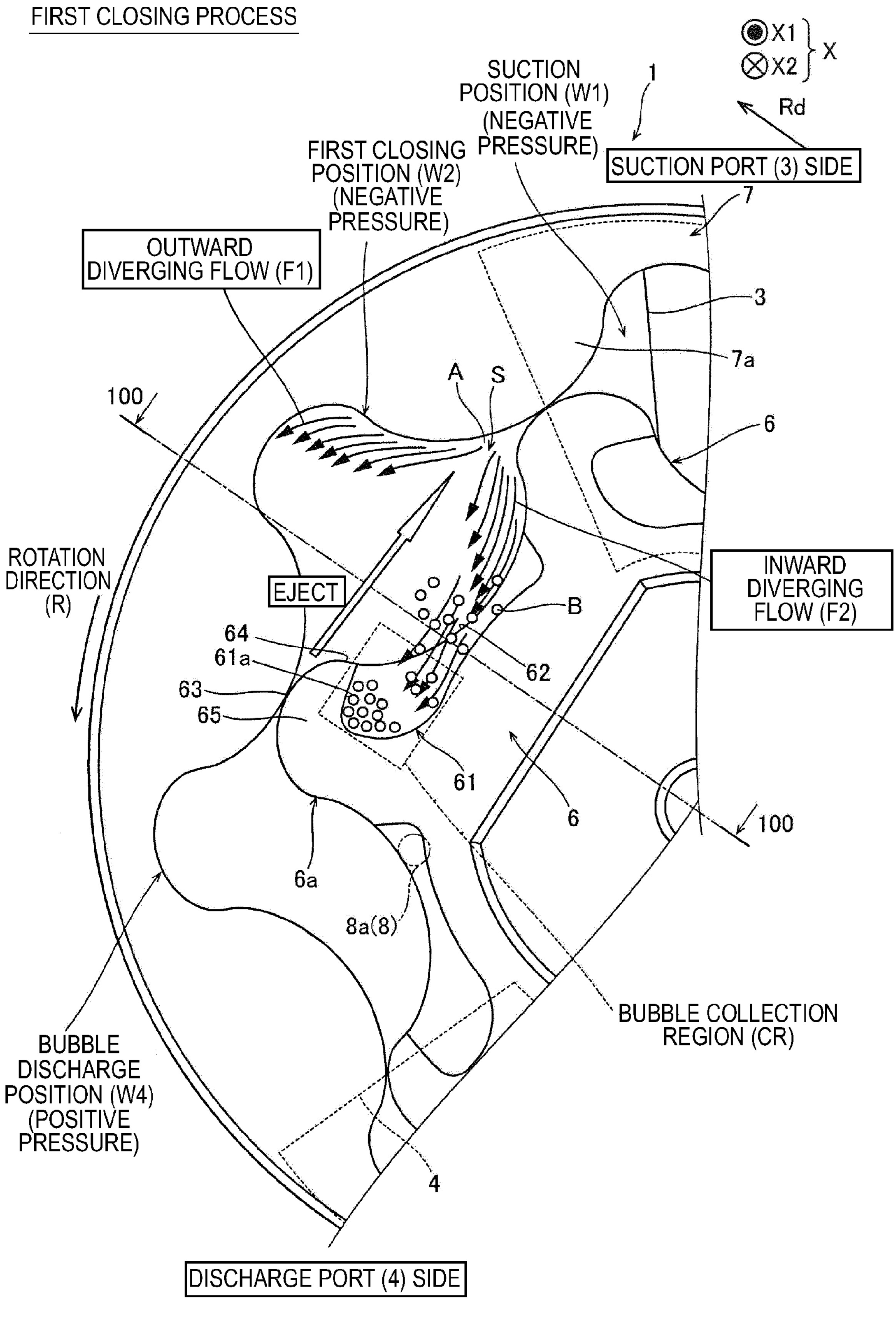

FIRST CLOSING PROCESS
X1
X2
X
Rd
SUCTION POSITION (W1) (NEGATIVE PRESSURE)
1
SUCTION PORT (3) SIDE
FIRST CLOSING POSITION (W2) (NEGATIVE PRESSURE)
7
OUTWARD DIVERGING FLOW (F1)
3
7a
A
S
100
6
ROTATION DIRECTION (R)
EJECT
INWARD DIVERGING FLOW (F2)
B
64
61a
62
63
65
61
6
100
6a
8a(8)
BUBBLE COLLECTION REGION (CR)
BUBBLE DISCHARGE POSITION (W4) (POSITIVE PRESSURE)
4
DISCHARGE PORT (4) SIDE

FIG.4

SECTIONAL VIEW TAKEN ALONG LINE IV-IV (PARTIALLY OMITTED)

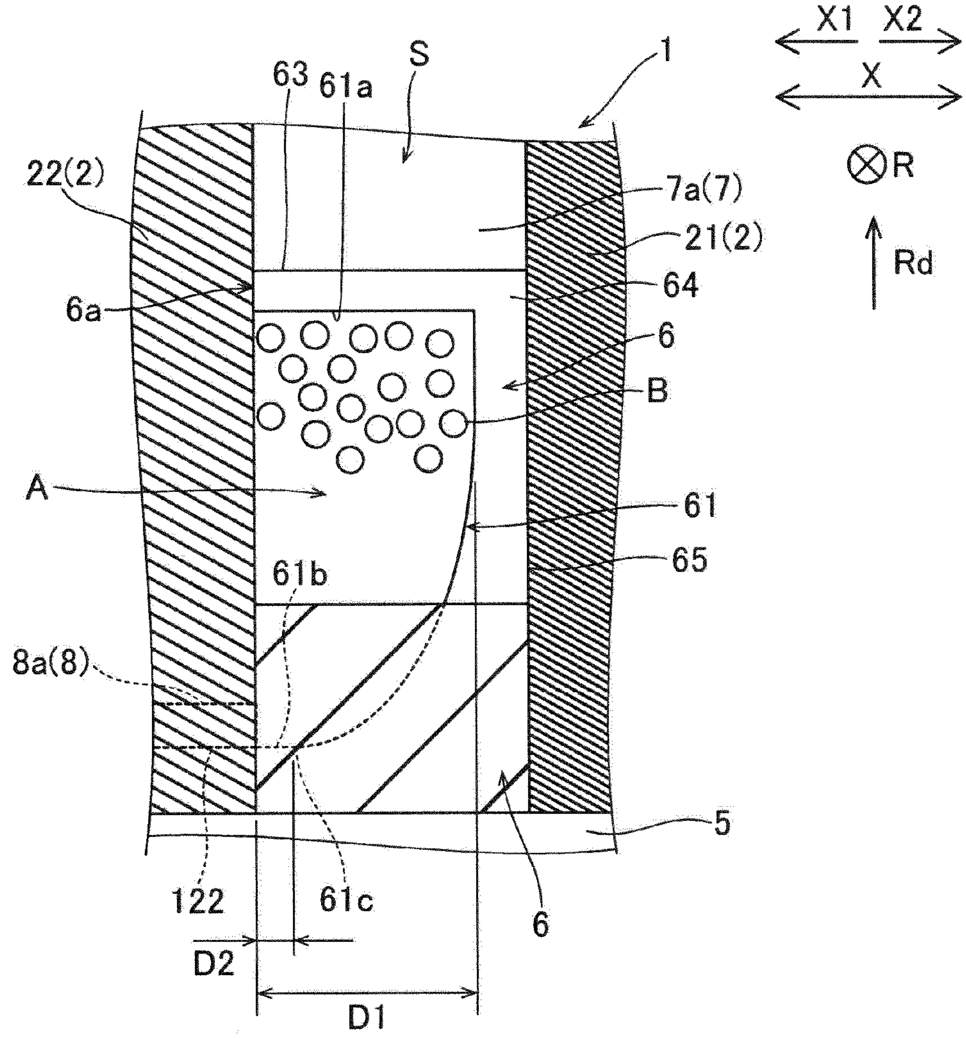


FIG.5

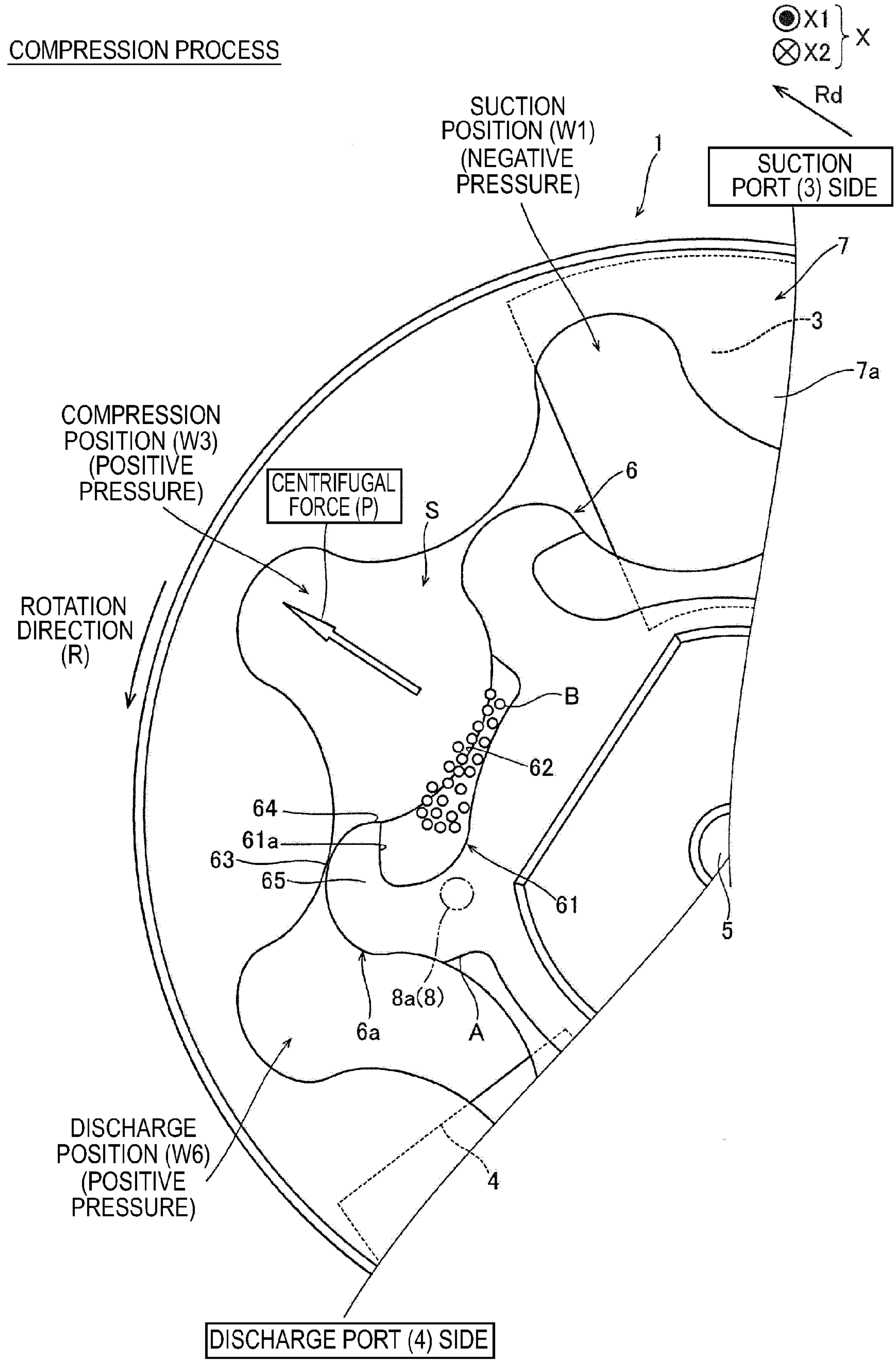

COMPRESSION PROCESS
X1
X2
X
Rd
SUCTION POSITION (W1) (NEGATIVE PRESSURE)
1
SUCTION PORT (3) SIDE
7
3
7a
COMPRESSION POSITION (W3) (POSITIVE PRESSURE)
CENTRIFUGAL FORCE (P)
S
6
ROTATION DIRECTION (R)
B
62
64
61a
63
65
61
5
8a(8)
6a
A
DISCHARGE POSITION (W6) (POSITIVE PRESSURE)
4
DISCHARGE PORT (4) SIDE

FIG.6

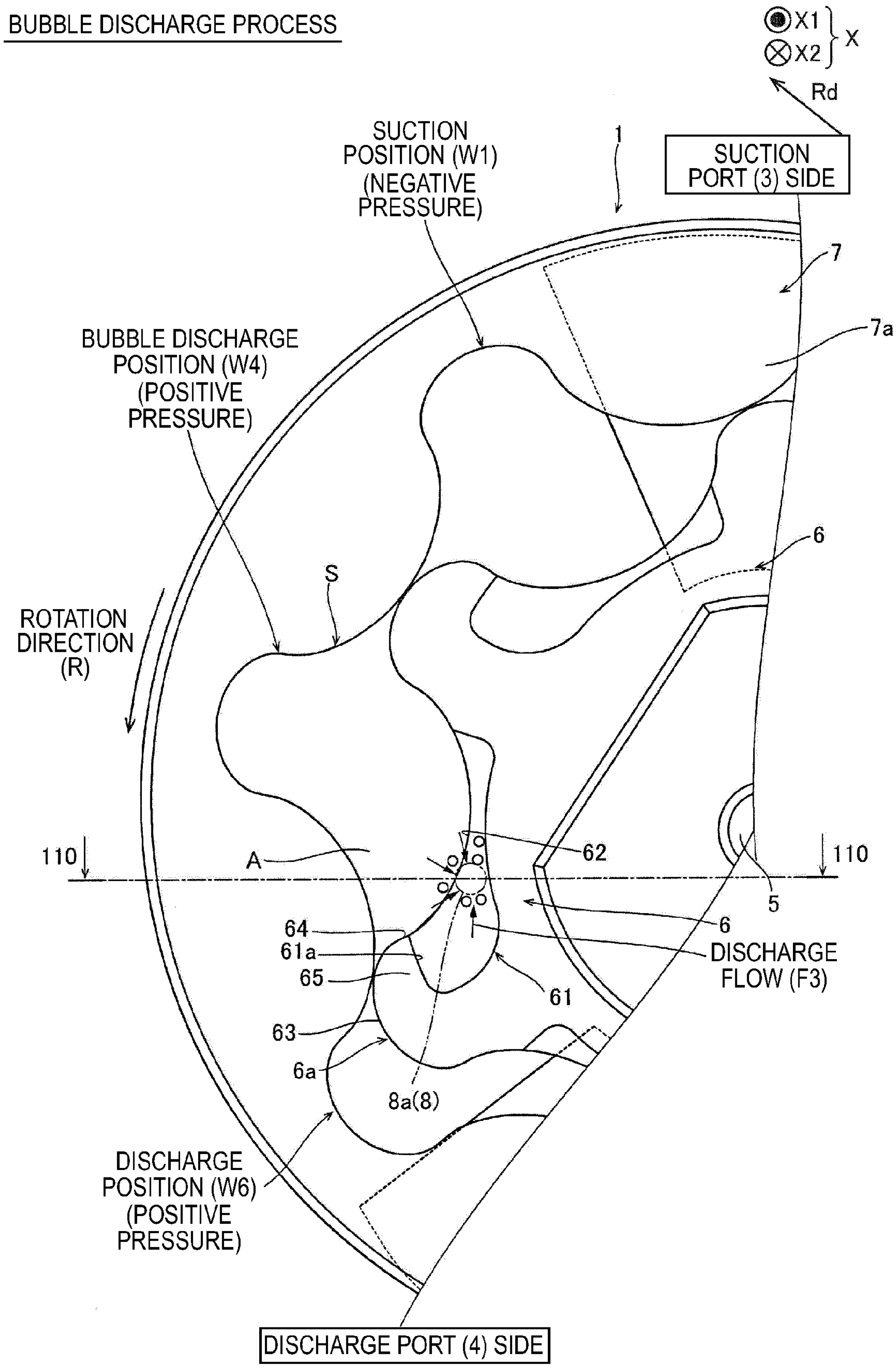

BUBBLE DISCHARGE PROCESS
X1
X2
X
Rd
SUCTION PORT (3) SIDE
SUCTION POSITION (W1) (NEGATIVE PRESSURE)
1
7
7a
BUBBLE DISCHARGE POSITION (W4) (POSITIVE PRESSURE)
6
S
ROTATION DIRECTION (R)
110
A
62
110
5
6
64
61a
65
DISCHARGE FLOW (F3)
61
63
6a
8a(8)
DISCHARGE POSITION (W6) (POSITIVE PRESSURE)
DISCHARGE PORT (4) SIDE

FIG.7

SECTIONAL VIEW TAKEN ALONG LINE VII-VII (PARTIALLY OMITTED)

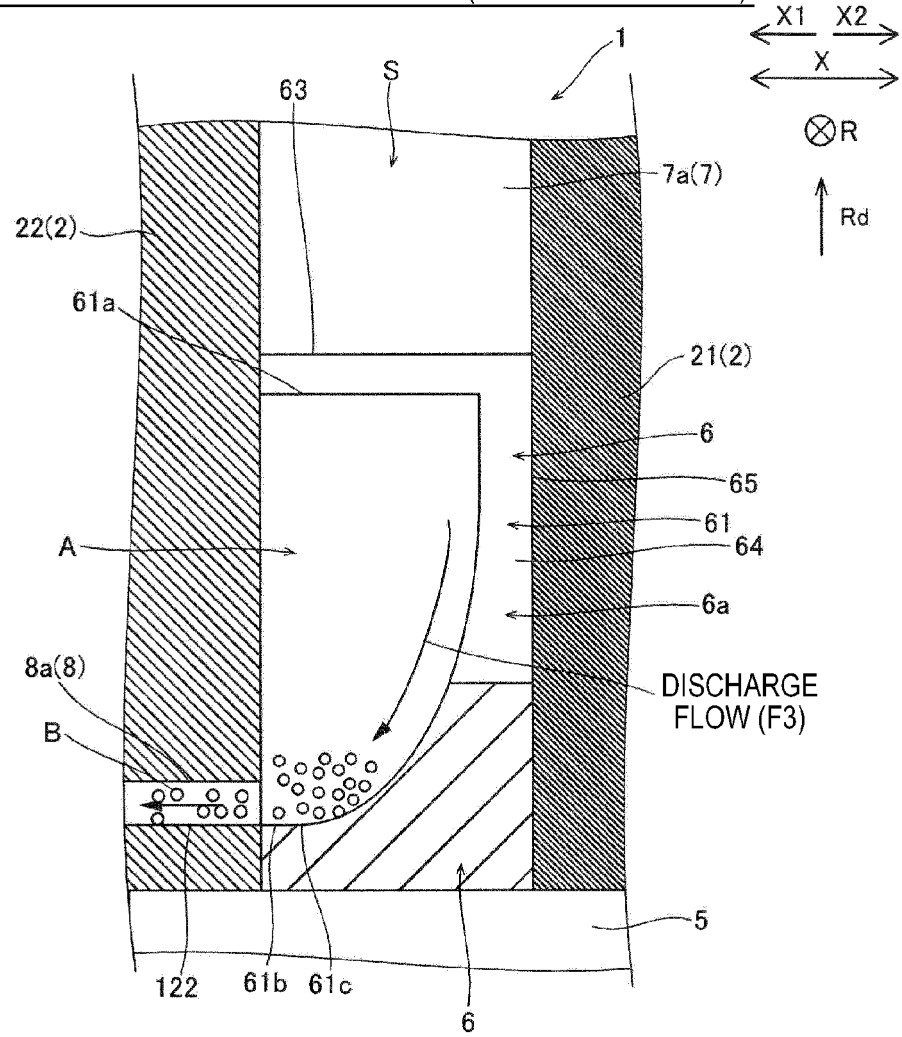


FIG.8A

SUCTION PROCESS

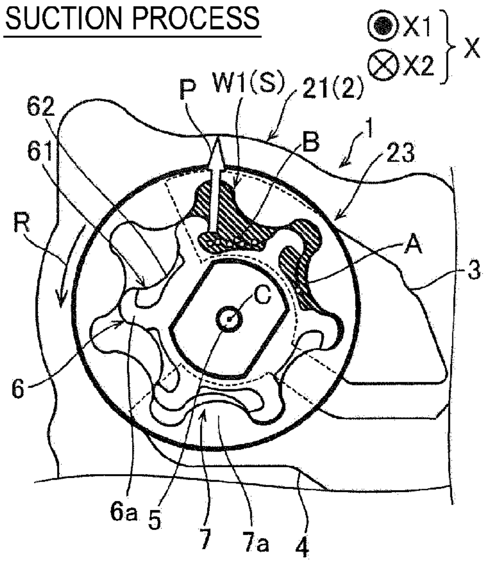


FIG.8B

FIRST CLOSING PROCESS

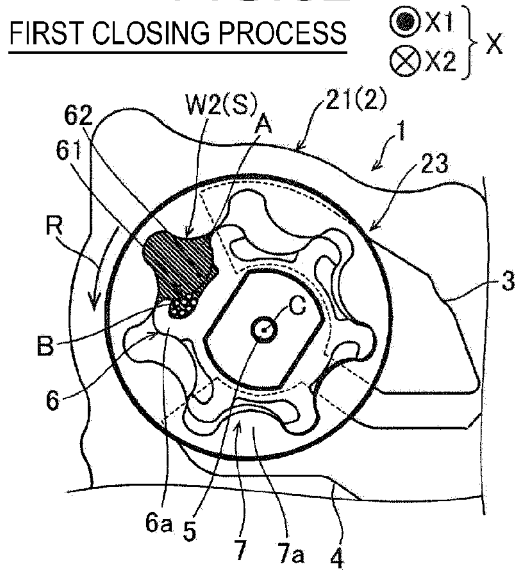


FIG.9A

COMPRESSION PROCESS

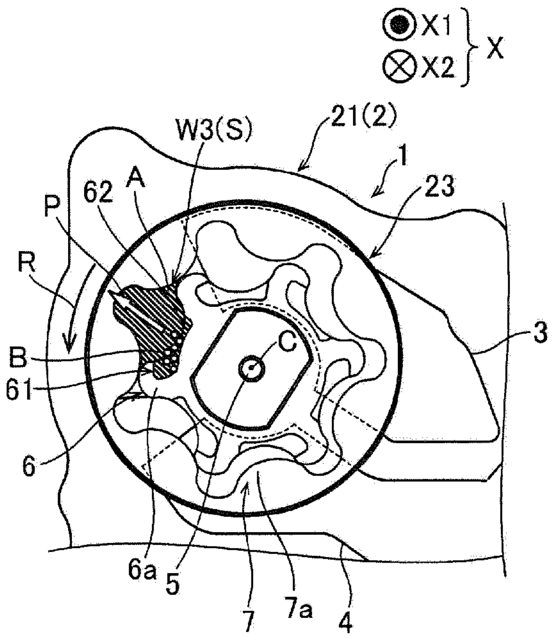


FIG.9B

BUBBLE DISCHARGE PROCESS

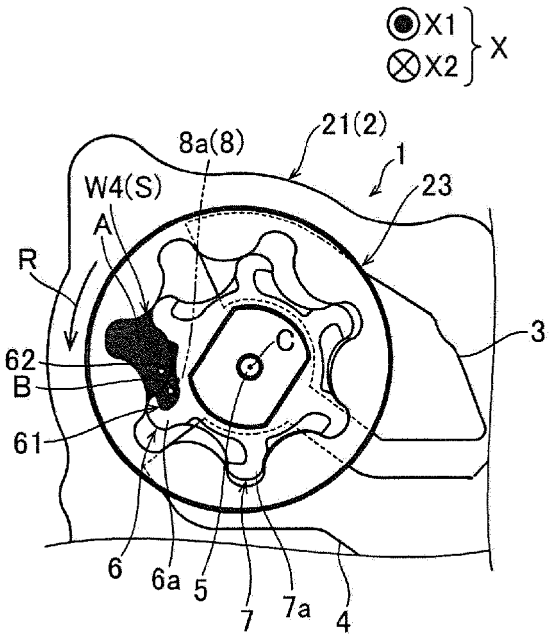


FIG.10A

SECOND CLOSING PROCESS

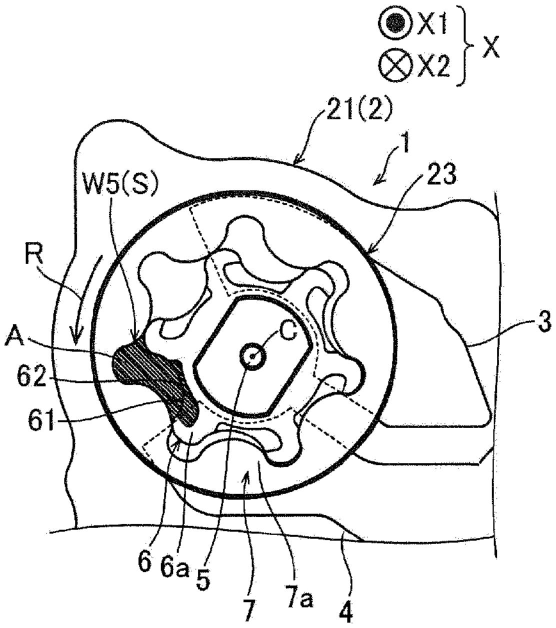


FIG.10B

DISCHARGE PROCESS

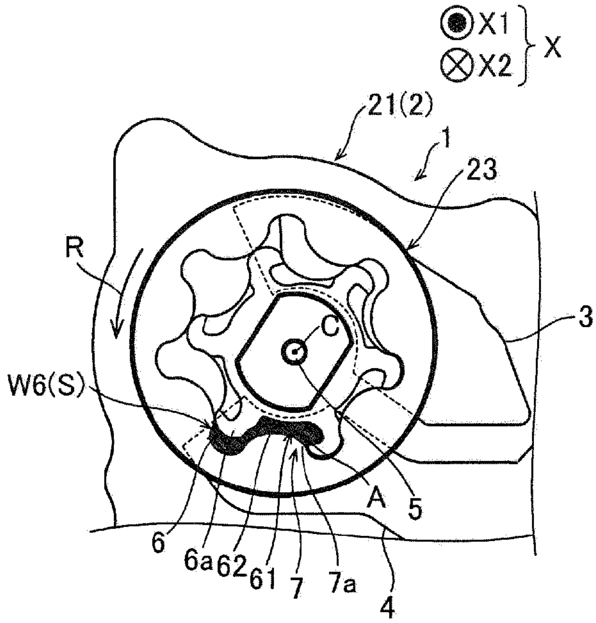


FIG.11

SECOND EMBODIMENT

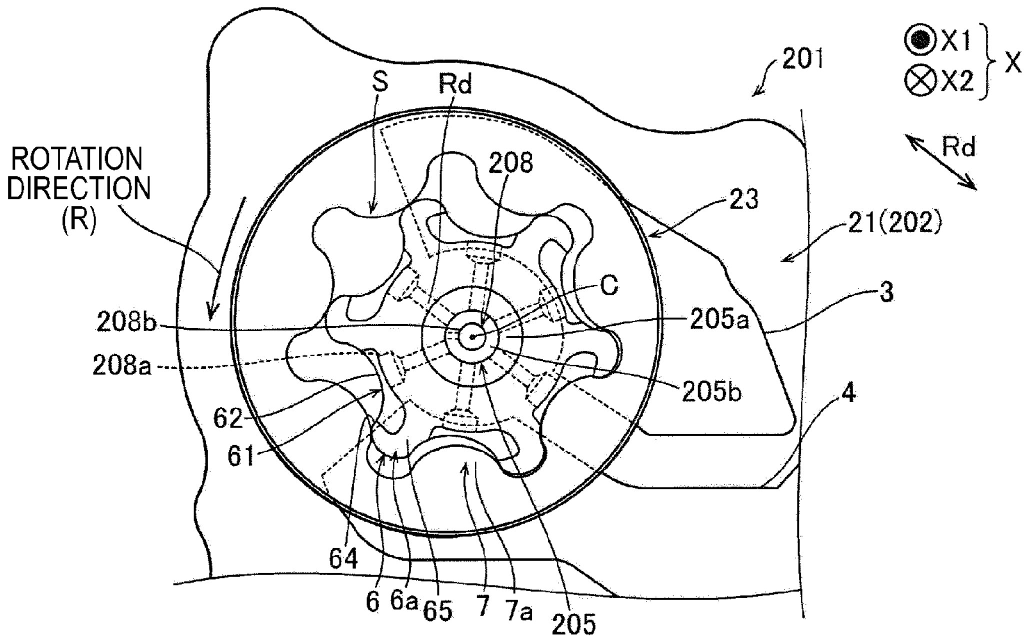


FIG.12

BUBBLE DISCHARGE PROCESS

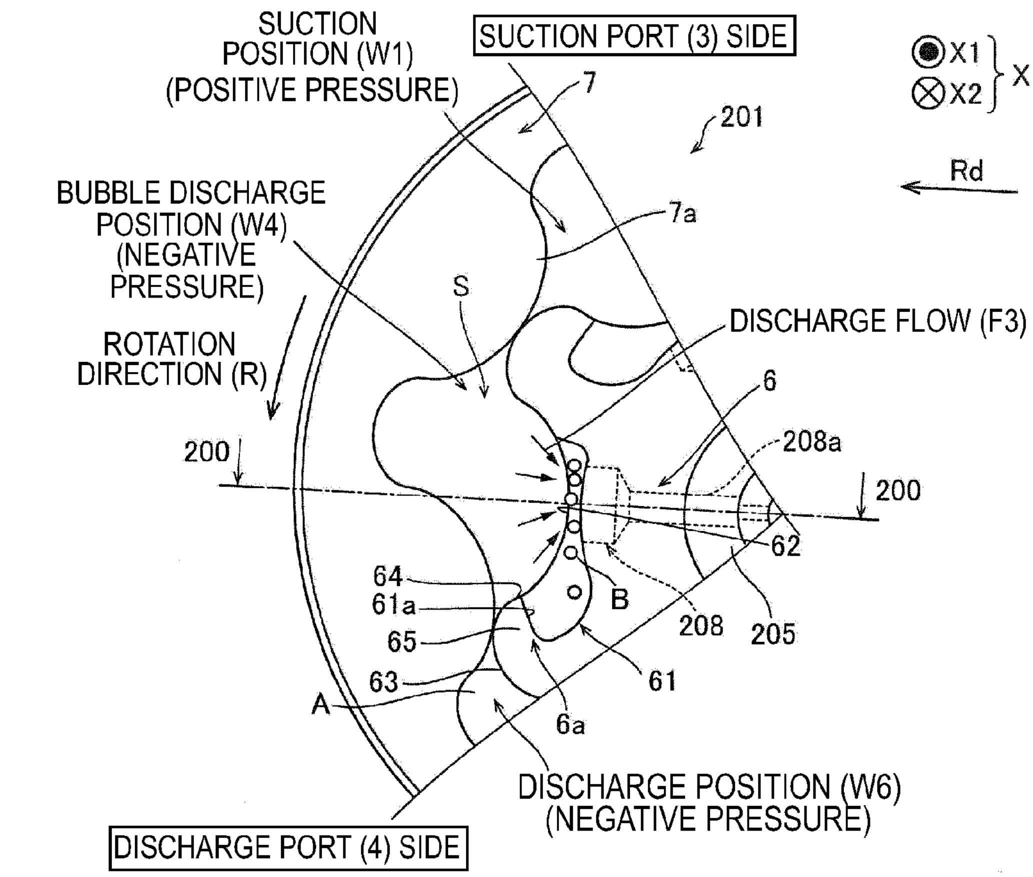


FIG.13

SECTIONAL VIEW TAKEN ALONG LINE XIII-XIII (PARTIALLY OMITTED)

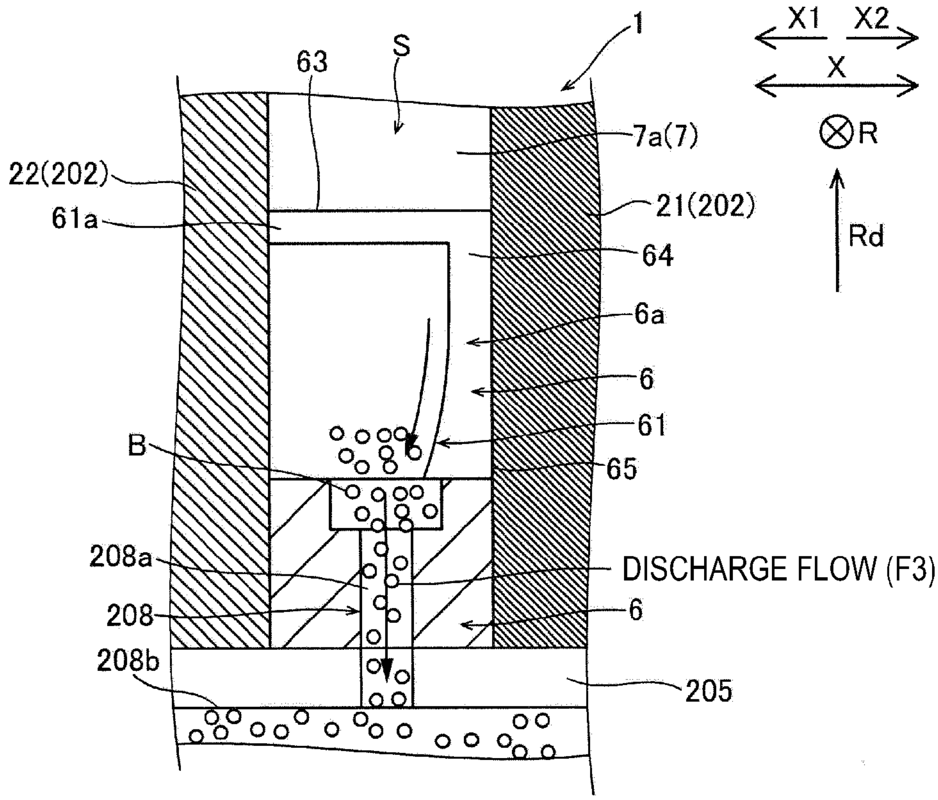


FIG.14A

SUCTION PROCESS

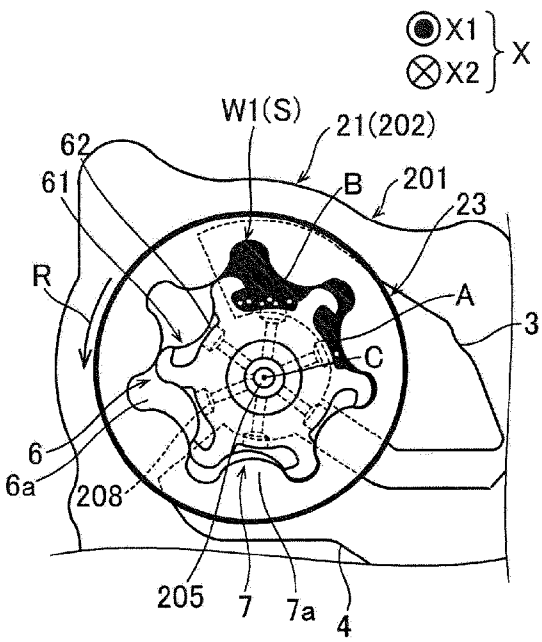


FIG.14B

FIRST CLOSING PROCESS

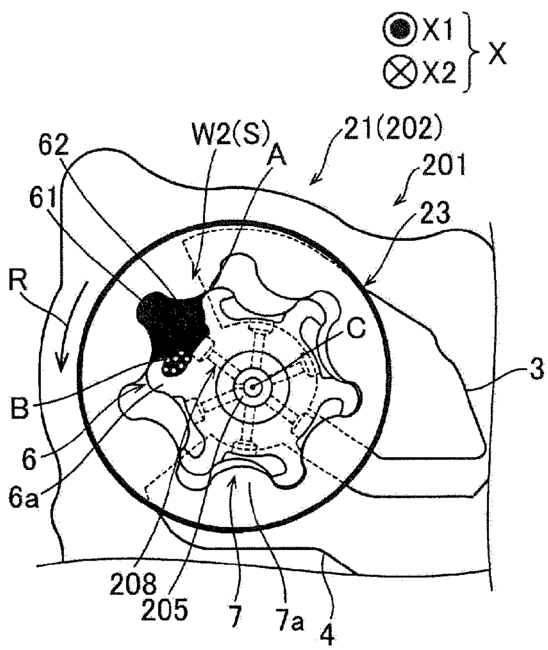


FIG.15A

COMPRESSION PROCESS

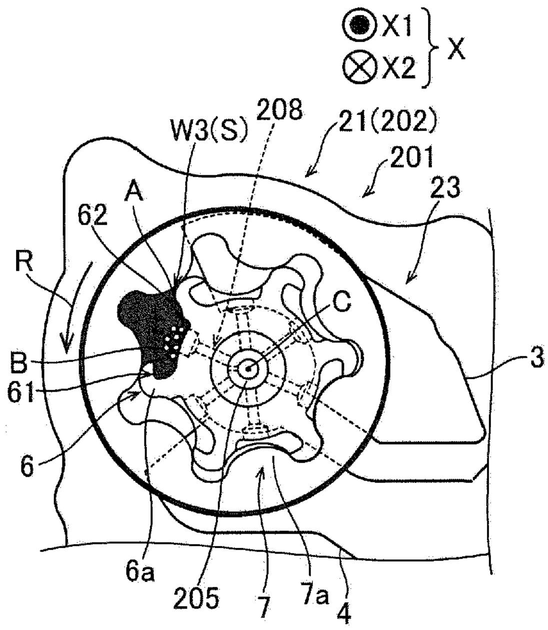


FIG.15B

BUBBLE DISCHARGE PROCESS

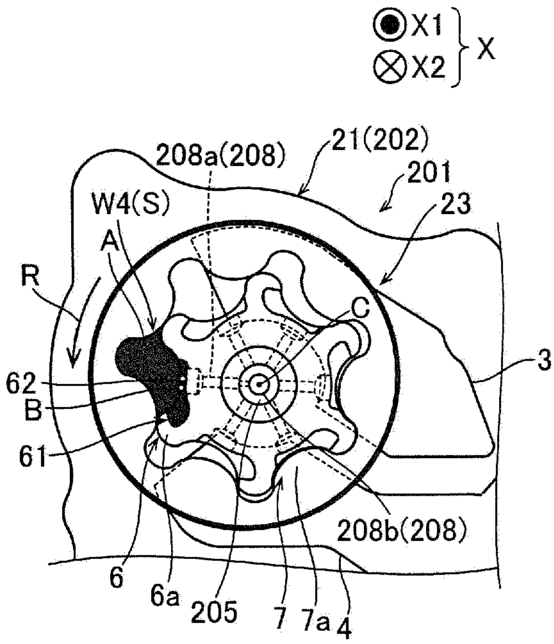


FIG.16A

SECOND CLOSING PROCESS

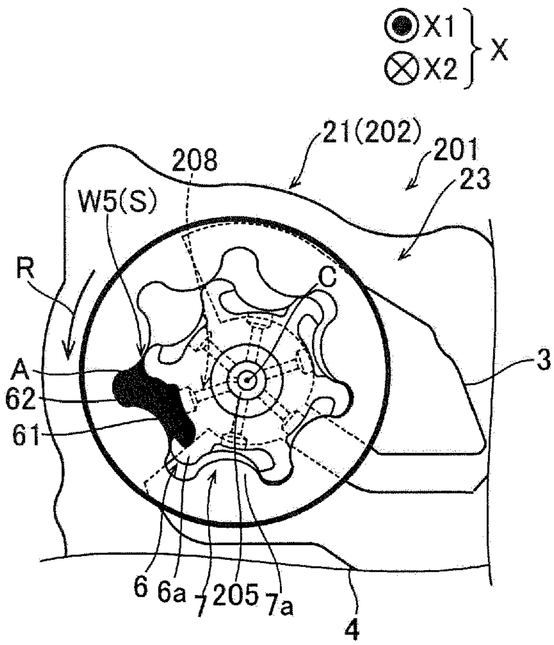
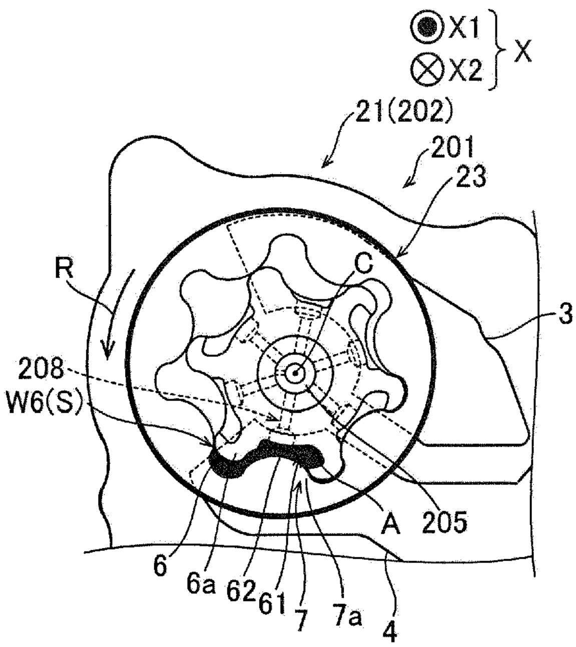


FIG.16B

DISCHARGE PROCESS



FIRST MODIFICATION EXAMPLE

FIG.17A

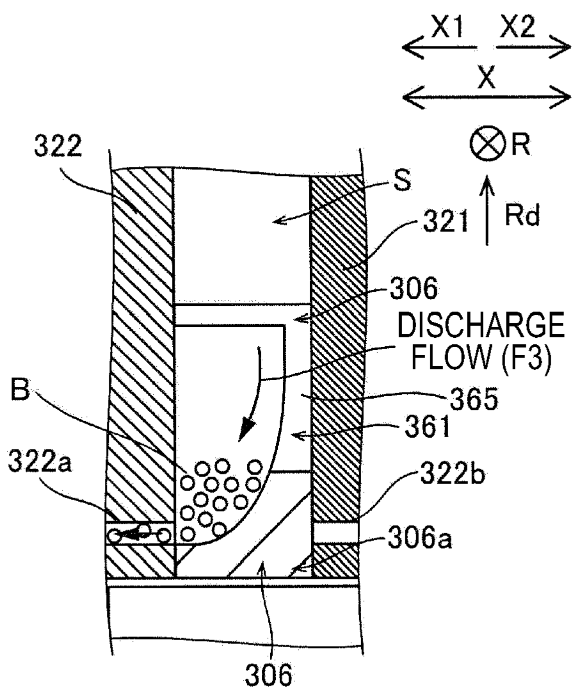
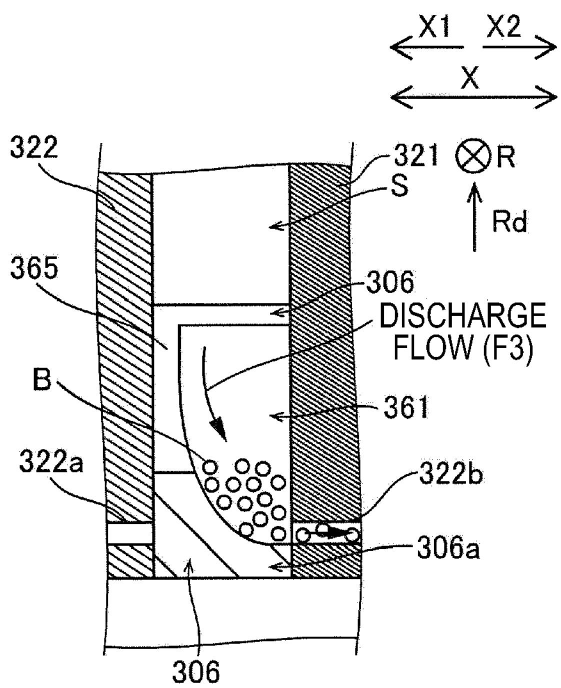


FIG.17B



SECOND MODIFICATION EXAMPLE

FIG.18A

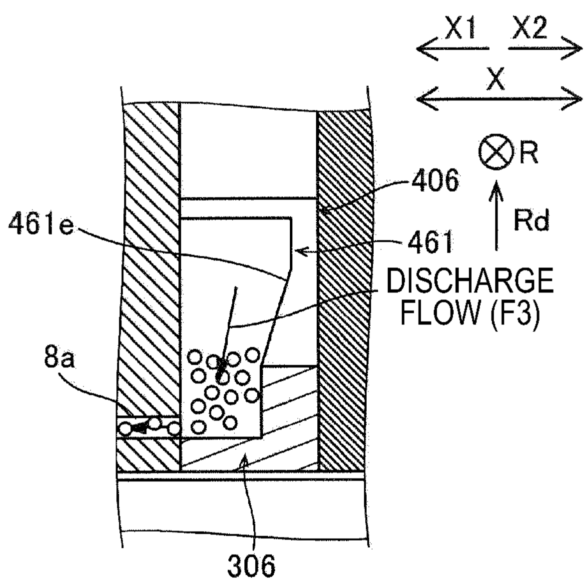


FIG.18B

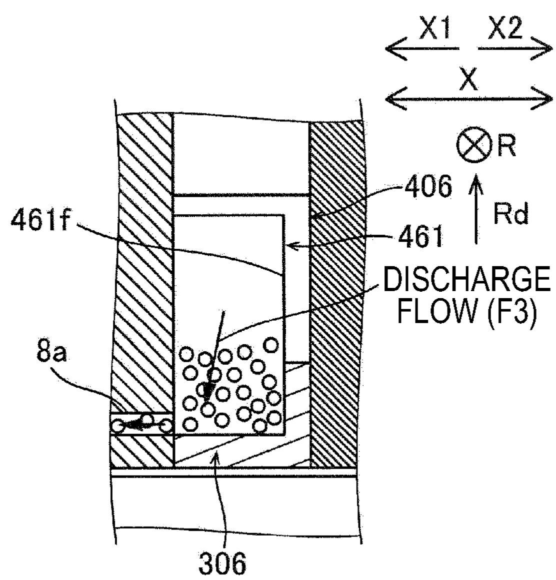
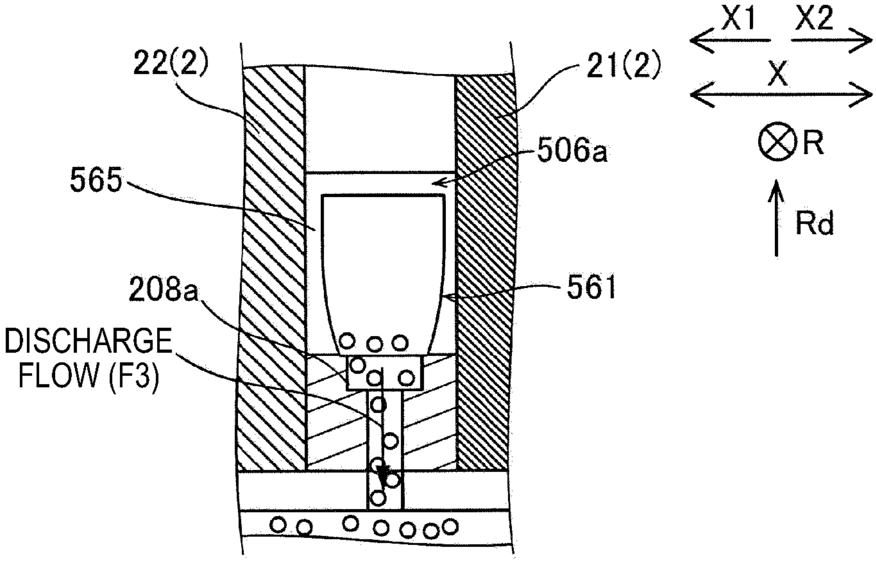


FIG.19

THIRD MODIFICATION EXAMPLE



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EUROPEAN SEARCH REPORT

Application Number
EP 19 21 6072

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	US 2007/092392 A1 (KUROKAWA HIROYUKI [JP]) 26 April 2007 (2007-04-26) * paragraphs [0025], [0028] - [0030], [0045]; figures 10,14 *	1,6 2	INV. F04C2/08 F04C2/10 F04C13/00
Y	JP H05 44651 A (TOYOOKI KOGYO KK) 23 February 1993 (1993-02-23) * paragraph [0008] - paragraph [0010]; figures 1-2 *	2	
A	US 2002/054822 A1 (WATANABE YASUSHI [JP] ET AL) 9 May 2002 (2002-05-09) * abstract; figures 1-3 *	1-6	

TECHNICAL FIELDS SEARCHED (IPC)

F04C

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	9 April 2020	Descoubes, Pierre

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09-04-2020

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