



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

(43) Date of publication:
11.01.2017 Bulletin 2017/02

(51) Int Cl.:
F04C 2/10 (2006.01) F04C 15/00 (2006.01)

(21) Application number: **15757983.0**

(86) International application number:
PCT/JP2015/055335

(22) Date of filing: **25.02.2015**

(87) International publication number:
WO 2015/133342 (11.09.2015 Gazette 2015/36)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(72) Inventor: **KAWANO Yuji**
Kumagaya-shi
Saitama 360-0831 (JP)

(30) Priority: **06.03.2014 JP 2014043471**

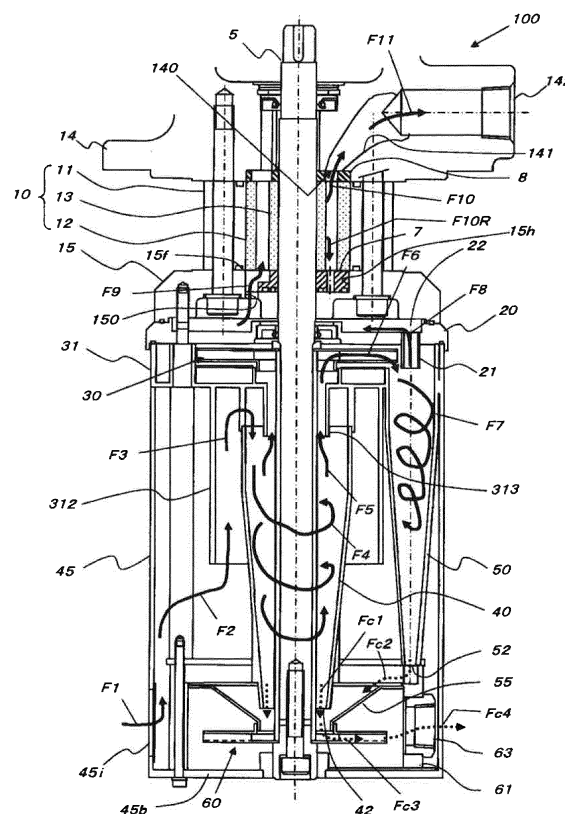
(74) Representative: **Piésold, Alexander James**
Dehns
St Bride's House
10 Salisbury Square
London EC4Y 8JD (GB)

(71) Applicant: **Nippon Oil Pump Co., Ltd.**
Kumagaya-shi, Saitama 360-0831 (JP)

(54) **PUMP DEVICE**

(57) The purpose of the present invention is to suppress the occurrence of unevenness in a rotor of an internal gear pump, suppress the formation of gaps between the end surfaces (side surfaces) of an inner rotor and an outer rotor, and to prevent a decline in volume efficiency. Thus, the pump device of the present invention includes an internal gear pump (10), in which an inner rotor (13) is inscribed to an outer rotor (12), and includes a plate member (7) which is provided to an end surface of the rotors. The plate member (7) is formed of a material having high hardness, has a shape that does not block a suction port (150), has a through-hole (73) formed therein, and has O-ring grooves (71, 72), which each have a continuous shape and house an O-ring formed therein.

Fig 1



Description

TECHNICAL FIELD

[0001] The present invention relates to an internal gear pump.

BACKGROUND ART

[0002] As gear pumps, there are an external gear pump and an internal gear pump (e.g., a trochoid pump: a registered trade mark).

[0003] In conventional examples, the internal gear pump is used in a region with a relatively low pressure as compared with the external gear pump.

[0004] In recent years, an internal gear pump which is applied for a coolant (a cooling liquid or a cutting liquid) as a working fluid has been suggested (see, e.g., Patent Literature 1).

[0005] However, since there are hard foreign substances (particles) are present in the coolant, the hard foreign substances abrade a rotor of the internal gear pump.

[0006] Further, when the rotor is abraded, there arises a problem such as formation of a gap between end surfaces (side surfaces) of an inner rotor and an outer rotor, a decrease in volume efficiency, and a reduction in discharge amount.

[0007] Furthermore, at the present stage, an effective measure for the problem concerning the internal gear pump has not been suggested.

CITATION LIST

PATENT LITERATURE

[0008] Patent Literature 1: International Publication No. 2012/053231

SUMMARY OF INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0009] In view of the problem of the prior art described above, it is an object of the present invention to provide a pump device which can suppress abrasion of rotors of an internal gear pump, suppress formation of a gap between end surfaces (side surfaces) of an inner rotor and an outer rotor, and prevent a decrease in volume efficiency.

SOLUTIONS FOR PROBLEM

[0010] A pump device (100 to 100C, 200 to 200C) according to the present invention is characterized in that the pump device (100 to 100C, 200 to 200C) includes an internal gear pump (10) in which an inner rotor (13, 213) is inscribed to an outer rotor (12, 212), a plate member

(a balance plate 7, 7A, 207, 207A) is provided on end surfaces (suction side end surfaces: end surfaces apart from a drive source) of the rotors (the outer rotor 12, 212 and the inner rotor 13, 213), and the plate member (the balance plate 7, 7A, 207, 207A) is made of a material with high hardness, formed into a shape which does not block a suction port (150, Pi), has a through-hole (a discharge pressure introducing hole 73, 73A) formed therein, and also has O-ring grooves (71, 71A, 72, 72A, 207a, 207b, 207k, 207j) formed thereon which have continuous shapes and in which O-rings are accommodated therein.

[0011] In the present invention, it is preferable that said O-ring grooves (71, 72, 207a, 207b) are formed on a surface of the plate member (the balance plate 7, 207) which is apart from the rotors, and the O-rings are attached in the O-ring grooves (71, 72, 207a, 207b) with a prescribed tightening margin.

[0012] Alternatively, in the present invention, it is preferable that a blind space (a blind hole BH) is formed in the plate member (the balance plate 7A, 207A) on an opposite side of the rotors, and elastic members (9) are accommodated in the blind space.

[0013] In the present invention, it is preferable for a second plate member (a fixing plate 8) to be arranged on end surfaces of the rotors on the opposite side of said plate member (the balance plate 7, 7A, 207, 207A) and to have a shape which does not block a discharge port (140).

[0014] Further, according to the present invention, in the internal gear pump, a suction side and a discharge side for a working fluid may be arranged on different sides along a rotation axis direction of the rotors.

[0015] Alternatively, the suction side and the discharge side of the working fluid may be arranged on the same side along the rotation axis direction of the rotors.

ADVANTAGEOUS EFFECTS of INVENTION

[0016] According to the present invention comprising the above-mentioned construction, since the plate member (the balance plate 7, 7A, 207, 207A) is provided on the end surfaces (the suction-side end surfaces: the end surfaces apart from the drive source) of the rotors (the outer rotor and the inner rotor), the plate member (the balance plate 7, 7A, 207, 207A) is made of the material having high hardness and has a shape which does not block (close) the suction port (150, Pi) and has a the through-hole (the discharge pressure introducing hole 73, 73A) formed therein, a discharge pressure (or the pressurized working fluid) is introduced to the side of the plate member (7, 7A, 207, 207A) apart from the rotors through the gap between the outer rotor (12, 212) and the inner rotor (13, 213) and the through-hole (the discharge pressure introducing hole 73, 73A).

[0017] Here, since the O-ring grooves (71, 71A, 72, 72A, 207a, 207b, 207k, 207j) are formed on the plate member (the balance plate 7, 7A, 207, 207A) and the O-rings are fitted (snapped) therein, the discharge pressure

is introduced to the plate member (7, 7A, 207, 207A), and the O-rings prevent leakage even if the pressurized working fluid is supplied.

[0018] Further, since an area of a region of the plate member (7, 7A, 207, 207A) to which the discharge pressure is introduced is defined (set) so as to be larger than an area of a region to which the discharge pressure in the gap between the outer rotor (12, 212) and the inner rotor (13, 213) where is operated, the plate member (7, 7A, 207, 207A) is pressed toward the rotor side (the discharge side in the first to fourth embodiments: the left side in FIG. 1).

[0019] Even if the discharge pressure becomes zero or a negative pressure, the plate member is pressed by a tightening margin of the O-rings or elastic repulsive force of the elastic member (the spring 9), and hence no gap is formed between the rotors (12, 13, 212, 213) and the plate member (7, 7A, 207, 207A).

[0020] According to the present invention, since the plate member (7, 7A, 207, 207A) is made of the material having high hardness, the plate member is not abraded. On the other hand, although the side surfaces of the rotors (12, 13, 212, 213) are abraded, the plate member (7, 7A, 207, 207A) pressed against the rotors maintains the flat state without being abraded, and hence the side surfaces of the rotors (12, 13, 212, 213) are not abraded into an uneven shape. Furthermore, as regards an abraded amount of the rotors (12, 13, 212, 213), the plate member (7, 7A, 207, 207A) moves to the rotor side in order to reduce a clearance (the gap) (formed due to the abrasion). As a result of reducing the clearance (the gap), according to the pump device of the present invention, the volume efficiency is improved.

[0021] It is to be noted that, since the plate member (7, 7A, 207, 207A) is formed to a shape which does not close (block) the suction port (150, Pi) side, provision of the plate member (7, 7A, 207, 207A) does not inhibit a suction of the working fluid into the internal gear pump.

[0022] Here, since force which presses the plate member (7, 7A, 207, 207A) toward the rotor side is introduced from the discharge pressure of the internal gear pump, the discharge pressure does not operate on the plate member at the time, that is, for example, start-up of the internal gear pump.

[0023] However, in the present invention, mechanical force other than the discharge pressure of the internal gear pump can press the plate member (7, 7A, 207, 207A) toward the rotor side.

[0024] For example, the O-rings are arranged on the plate member (7, 207) on the opposite side of the rotors, the O-rings are disposed in the O-ring grooves (71, 72, 207a, 207b) with a prescribed tightening margin, and the elastic repulsive force of the O-rings operates to the plate member (7, 207), and therefore, the plate member is pressed toward the rotor side.

[0025] Alternatively, since a blind space (a blind hole BH), a space which is not a through-hole, is formed on the end surface of the plate member (7A, 207A) on the

opposite side of the rotors and accommodating the elastic member (9) in the blind space, the elastic repulsive force of the elastic member (9: the spring) operate to the plate member (7A, 207A), and therefore, the elastic repulsive force presses the plate member (7A, 207A) toward the rotor side.

[0026] Consequently, in the present invention, although the pump device thereof is even at the time of startup or the like of an internal gear pump, the plate member (7, 7A, 207, 207A) is pressed toward the rotor side.

[0027] Since the plate member (7, 7A, 207, 207A) made of the material having high hardness maintains a flat state without being abraded as described above, the side surfaces of the rotors (12, 13, 212, 213) pressed against this member is not abraded into an uneven shape. Moreover, the plate member (7, 7A, 207, 207A) moves toward the rotor side depending upon an abraded amount of the rotors (12, 13, 212, 213), a clearance (the gap) (formed due to the abrasion) is reduced, and hence the volume efficiency is improved.

BRIEF DESCRIPTION OF DRAWINGS

[0028]

FIG. 1 is a front cross-sectional view showing a first embodiment according to the present invention;
 FIG. 2 is a side elevation view of rotors of an internal gear pump according to the first embodiment;
 FIG. 3 is a view showing a balance plate according to the first embodiment;
 FIG. 4 is a partially sectional front view showing parts near the balance plate according to the first embodiment;
 FIG. 5 is a view showing a fixing plate according to the first embodiment;
 FIG. 6 is a front cross-sectional view showing a second embodiment according to the present invention;
 FIG. 7 is a front cross-sectional view showing a third embodiment according to the present invention;
 FIG. 8 is a view showing a balance plate according to the third embodiment;
 FIG. 9 is a partially sectional front view showing parts near the balance plate according to the third embodiment;
 FIG. 10 is a front cross-sectional view showing a fourth embodiment according to the present invention;
 FIG. 11 is a front cross-sectional view showing a fifth embodiment according to the present invention;
 FIG. 12 is a side elevation view (a view taken along an arrow Y in FIG. 11) according to the fifth embodiment;
 FIG. 13 is a front cross-sectional view showing a sixth embodiment according to the present invention;
 FIG. 14 is a front cross-sectional view showing a

seventh embodiment according to the present invention; and

FIG. 15 is a front cross-sectional view showing an eighth embodiment according to the present invention.

DESCRIPTIONS OF EMBODIMENTS

[0029] Embodiments according to the present invention will now be described hereinafter with reference to the accompanying drawings.

[0030] A first embodiment according to the present invention will be first described with reference to FIG. 1 to FIG. 5.

[0031] In FIG. 1, a pump device which is denoted as a whole by reference sign 100 has an internal gear pump 10.

[0032] The internal gear pump 10 includes a gear case 11, an outer rotor 12, and an inner rotor 13. In FIG. 1, reference sign 14 denotes a pump housing, and reference sign 15 designates a pump lower end plate (which will be abbreviated as an "end plate" hereinafter). The inner rotor 13 is fixed to a rotary shaft 5 by a non-illustrated key.

[0033] FIG. 2 shows how a pressure of a working fluid is raised by mesh of the outer rotor 12 and the inner rotor 13.

[0034] In FIG. 2, the internal gear pump 10 according to the embodiment rotates in the same direction (arrows R) while seven inner teeth 12t of the outer rotor 12 mesh with six outer teeth 13t of the inner rotor 13.

[0035] The pressure of the working fluid is raised by the mesh of the seven inner teeth 12t of the outer rotor 12 and the six outer teeth 13t of the inner rotor 13.

[0036] In FIG. 2, the pressure of the working fluid in a hatched region E1 is raised.

[0037] The working fluid subjected to the pressure rise in the region E1 (FIG. 2) flows from a discharge port 140 (which is indicated by a broken line in FIG. 2) formed in an end surface on the rotor 12 or 13 side through a discharge flow path 141 of the pump housing 14 (FIG. 1), and is discharged from a discharge opening 142.

[0038] In FIG. 1, the pump device 100 has a primary cyclone 40 provided in a cyclone casing 45 and has a plurality of secondary cyclones 50 provided outside the primary cyclone 40 along a radial direction. Each of the primary cyclone 40 and the secondary cyclones 50 is a tapered member having a diameter contracted toward its lower end (a foreign substance ejection opening 42, 52). An inflow opening 45i from which the working fluid is taken in is formed near a lower end of the cyclone casing 45.

[0039] Further, the pump device 100 also has an impeller 30 (a cyclone relay impeller) accommodated in an impeller housing 31.

[0040] A tapered guide member 55 is arranged below the primary cyclone 40, and a foreign substance ejection impeller 60 is further provided below this member.

[0041] The inner rotor 13, the cyclone relay impeller

30, and the foreign substance ejection impeller 60 are fixed to the rotary shaft 5, and driven to rotate by a non-illustrated electric motor.

[0042] Flows (F1 to F11: Fc1 to Fc4) of the working fluid taken in from the inflow opening 45i of the pump device 100 will now be described.

[0043] The working fluid F1 taken in from the inflow opening 45i flows up in the cyclone casing 45 (an arrow F2), turns back at a ceiling portion of a guide member 312, and flows into the primary cyclone 40 (an arrow F3).

[0044] The working fluid which has flowed into the primary cyclone 40 is dragged by the rotary shaft 5 and vortically flows down (an arrow F4), foreign substances with large specific gravity (e.g., foreign substances such as chips included in the coolant) are ejected from the foreign substance ejection opening 42 (an arrow Fc1 indicated by a dotted line), and the clean working fluid flows up to a position of the cyclone relay impeller 30 (an arrow F5).

[0045] The rotation of the cyclone relay impeller 30 raises the pressure of the working fluid, and the working fluid flows into the secondary impellers 50 (an arrow F6).

[0046] The working fluid which has flowed into the secondary cyclones 50 vortically flows down (an arrow F7), the foreign substances with large specific gravity flow down, are ejected from the foreign substance ejection opening 52, and slide down on the tapered guide member 55 (an arrow Fc2 indicated by a dotted line), and the working fluid which has been cleaned in two stages moves up and flows through a suction pipe 21 provided in a suction plate 20 (an arrow F8).

[0047] The working fluid passes through a flow path 22 of the suction plate 20 and is sucked into the internal gear pump 10 from a suction port 150 of the end plate 15 (an arrow F9). Furthermore, the working fluid is subjected to pressure rising by the internal gear pump 10 and discharged from a discharge opening 142 of the pump housing 14 through the discharge port 140 and the discharge flow path 141 of the pump housing 14 (an arrow F10, an arrow F11). Although particulars will be described later, a part of the working fluid (indicated by an arrow F10R) subjected to the pressure rising by the internal gear pump 10 flows into a discharge pressure introducing hole 73 (FIG. 3) formed in a balance plate 7.

[0048] It is to be noted that the working fluid (arrows Fc1 and Fc2) containing foreign substances ejected from the foreign substance ejection opening 42 of the primary cyclone 40 and the foreign substance ejection opening 52 of the secondary cyclones 50 is provided with a dynamic pressure by the foreign substance ejection impeller 60 (an arrow Fc3), and ejected from a foreign substance discharge opening 63 to the outside of the pump (an arrow Fc4).

[0049] The pump device 100 shown in FIG. 1 is a pump which is a type that a suction side (the end plate 15 side) and a discharge side (the pump housing 14 side) are arranged on different sides along a direction of the rotary shaft 5 (an up-and-down direction in FIG. 1) of the internal

gear pump 10.

[0050] As rules of thumb grasped by the present inventor, in this type of pump device, there occurs a phenomenon that the rotors 12 and 13 of the internal gear pump 10 have higher abrasion losses on the end plate 15 side (the suction side: the lower side in FIG. 1) than on the pump housing 14 side (the discharge side: the upper side in FIG. 1).

[0051] To suppress steps formed by the abrasion of the rotors 12 and 13, the balance plate 7 (see FIG. 3) is arranged on the end plate 15 side (the suction side: the lower side in FIG. 1) in the gear pump 10 of the pump device 100. The balance plate 7 is made of a material with high hardness.

[0052] In FIG. 1, a balance plate attaching hole 15h is formed in a surface 15f of the end plate 15 which is in contact with the rotors 12 and 13, and a depth dimension of the balance plate attaching hole 15h is slightly larger than a thickness dimension of the balance plate 7. Moreover, the balance plate 7 is attached in the balance plate attaching hole 15h.

[0053] As shown in FIG. 3, the balance plate 7 has such a planar shape that bases of two semicircles 7oa (a large semicircle) and 7ob (a small semicircle) having different radii are connected to each other.

[0054] In a portion where the semicircles 7oa and 7ob are connected to each other, the semicircles 7oa and 7ob are smoothly connected to each other through arcs r with small radial dimensions.

[0055] In FIG. 3, the center of curvature of the large semicircle 7oa is denoted by reference sign C1, and the center of curvature of the small semicircle 7ob is denoted by reference sign C2. In FIG. 3, the two centers of curvature C1 and C2 are offset (in the up-and-down direction in FIG. 3).

[0056] O-ring grooves 71 and 72 are formed on a plane of the balance plate 7, and each of the O-ring grooves 71 and 72 is annularly formed as seen from a plane and has a rectangular cross-sectional shape.

[0057] A center C3 of the O-ring groove 72 which is small (in the radial dimension) is placed on a horizontal line Lh (an alternate long and short dash line extended in a left-and-right direction in FIG. 3) running through said center of curvature C1, and is placed to be offset to the left side in FIG. 3 with respect to the center of curvature C1.

[0058] A through-hole 7i is formed in the small O-ring groove 72 in the radial direction. The through-hole 7i is concentric with the O-ring groove 72, and a radius of the through-hole 7i is smaller than a radius of curvature of the small O-ring groove 72. Additionally, the rotary shaft 5 (FIG. 1) is inserted into the through-hole 7i.

[0059] Although not shown in FIG. 1 and FIG. 3, O-rings (elastic members resistant to the working fluid: which are made of, e.g., rubber) are fitted in the O-ring grooves 71 and 72, respectively.

[0060] On a bottom portion of the balance plate attaching hole 15h (see FIG. 1), a region E2 (a hatched region

in FIG. 3) surrounded by the two O-ring grooves 71 and 72 shown in FIG. 3 becomes a sealed space (a hermetically closed space) by the non-illustrated two O-rings.

[0061] In the sealed space (the region E2 surrounded by the O-ring grooves 71 and 72: the hatched region in FIG. 3), two through-holes (discharge pressure introducing holes) 73 extended in a thickness direction of the balance plate 7 are formed, and the working fluid (the working fluid indicated by an arrow F10R) enters via the through-holes 73. The working fluid which has entered said sealed space (the hatched region E2 in FIG. 3) applies pressing force which moves the balance plate 7 upward in FIG. 1, and presses the balance plate 7 against the rotors 12 and 13.

[0062] It is to be noted that the two discharge pressure introducing holes 73 in the balance plate 7 are arranged so that one of them is not closed even if the other one is closed by the inner rotor 13.

[0063] Reference sign 74 in FIG. 3 denotes a pin hole into which a non-illustrated locking pin is inserted. The non-illustrated locking pin prevents the balance plate 7 from rotating (corotation caused by rotation of the rotary shaft 5).

[0064] It is to be noted that the pin hole 74 is a blind hole, and it is opened on a side where the O-ring grooves 71 and 72 are formed.

[0065] In FIG. 1, a fixing plate 8 is arranged on the upper side of the rotors 12 and 13 (the opposite side of the balance plate 7) so that it comes into contact with the rotors 12 and 13. The fixing plate 8 is made of a material with higher hardness than the rotors 12 and 13. Further, the hardness is preferably higher than that of foreign substances which may be mixed into the coolant.

[0066] FIG. 5 shows the detail of the fixing plate 8.

[0067] In FIG. 5, a suction port 82 and a discharge port 81 are formed in the fixing plate 8. However, the suction port 82 of the fixing plate 8 does not have to be formed. It is to be noted that, when the suction port 82 of the fixing plate 8 is not formed, a sealing pressure relieving hole (not shown) must communicate with a suction chamber.

[0068] As the fixing plate (the fixing plate in the first embodiment) 8 in FIG. 5, to commonalize with a fixing plate (commonalize a part) in a pump (FIG. 11 to FIG. 15) in which a suction side and a discharge side for the working fluid are arranged on the same side along a rotary shaft direction of an inner rotor, one having both the suction port 82 and the discharge port 81 formed therein is just illustrated. Here, when a rotating direction differs, the fixing plate in the pump (FIG. 11 to FIG. 15) is turned over and then used.

[0069] Reference sign 84 in FIG. 5 denotes a locking pin attaching hole, and reference sign 8i denotes an insertion hole for the rotary shaft 5.

[0070] In the internal gear pump 10, a gap between the outer rotor 12 and the inner rotor 13 is continuous from the suction side (the lower side in FIG. 1) to the discharge side (the upper side in FIG. 1). Thus, the discharge pressure of the internal gear pump 10 is led to a

lower end surface of the balance plate 7 in FIG. 1 (the bottom portion of the balance plate attaching hole 15h) through the gap between the outer rotor 12 and the inner rotor 13 (the arrow F10R) and the discharge pressure introducing hole 73 formed in the balance plate 7 along the pump rotary shaft direction (the up-and-down direction in FIG. 1), and supplied (applied) to said sealed space (the hatched region E2 in FIG. 3). Further, the discharge pressure presses the balance plate 7 against the rotors 12 and 13 (toward the upper side in FIG. 1).

[0071] On the other hand, in FIG. 2, the hatched region E1 is a gap between the outer rotor 12 and the inner rotor 13 at a given moment, and it represents a region where the discharge pressure operates. Furthermore, the discharge pressure in the hatched region E1 operates to press the balance plate 7 toward the lower side in FIG. 1 (a direction to get away from the rotors 12 and 13).

[0072] As obvious from FIG. 2 and FIG. 3, since the following setting is constructed, a pressure applied to the E2 side with a larger area (the lower side of the balance plate 7 in FIG. 1) is higher than a pressure applied to the E1 side with a smaller region (the upper side of the balance plate 7 in FIG. 1):

$$\text{Area of E1} < \text{Area of E2}$$

Consequently, the balance plate 7 is pressed toward the discharge side (the upper side in FIG. 1: the rotor 12 or 13 side).

[0073] Here, when force which presses the balance plate 7 toward the discharge side (the upper side in FIG. 1) is too strong, the pressure applied to the region E2 side prevents the rotation of the rotors 12 and 13. On the other hand, when the force which presses the balance plate 7 toward the rotor 12 or 13 side (the upper side in FIG. 1) is too weak, the volume efficiency is lowered due to the abrasion at the end portions of the rotors 12 and 13.

[0074] In the first embodiment, positions of the O-rings (i.e., positions of the O-ring grooves 71 and 72) are determined so that this problem does not occur. In other words, the positions of the O-ring grooves 71 and 72 are set to positions which enable assuredly pressing the balance plate 7 toward the rotor 12 or 13 side (the upper side in FIG. 1) and preventing a decrease in volume efficiency caused due to the abrasion at the end portions of the rotors 12 and 13 without interrupting the rotation of the rotors 12 and 13 by the pressure applied to the region E2 side.

[0075] It is to be noted that an actual device is affected by a pressure gradient of the discharge pressure leaking to an outer periphery of the outer rotor 12 and an inner periphery of the inner rotor 13 from the region E1, and hence an area of the region E2 is determined based on experiments.

[0076] In FIG. 3, the region E2 surrounded by the two O-ring grooves 71 and 72 is set so that the suction port (a region whose boundary is indicated by a broken line Li in FIG. 3) side (the lower side in FIG. 3) is extremely

small and the discharge port 140 (a region Lo surrounded by an alternate long and two dashes line in FIG. 3) is large. That is because the pump discharge pressure is higher than a suction pressure, and hence the pump discharge side region Lo where the discharge pressure of the balance plate 7 operates is pressed toward the rotor 12 or 13 side with the large pressure. That is, in the balance plate 7, the two O-ring grooves 71 and 72 are set so that the pump discharge side region Lo which is a region where the discharge pressure operates is pressed toward the rotor 12 or 13 side with the large pressure and an amount of the balance plate 7 pressing the rotors 12 and 13 is uniformized.

[0077] On the other hand, the balance plate 7 is formed into a shape which does not block the suction port 150 (reference sign Li in FIG. 3) side, which is a shape which does not prevent suction of the working fluid into the internal gear pump 10. In other words, on the suction side (the lower side in FIG. 1), a region which is not blocked by the balance plate 7 constitutes the suction port 150 of the internal gear pump 10.

[0078] The balance plate 7 having such a construction presses the end surfaces of the rotors 12 and 13 on the suction side (the lower side in FIG. 1) toward the discharge side (the upper side in FIG. 1) with the use of the discharge pressure of the internal gear pump 10.

[0079] As described above, since the balance plate 7 is made of a material having high hardness, it is not abraded and maintains a flat state. Thus, the side surfaces of the rotors 12 and 13 pressed by the balance plate 7 are not abraded into uneven shapes. Furthermore, the balance plate 7 moves toward the rotors 12 and 13 for abraded amounts of the rotors 12 and 13, and a clearance (the gap) formed due to the abrasion is reduced. Thus, the volume efficiency of the internal gear pump 10 is improved.

[0080] As described above, the force which presses the balance plate 7 against the end surfaces of the rotors 12 and 13 on the suction side (the lower side in FIG. 1) is provided from the discharge pressure of the internal gear pump 10. Thus, at the time of startup of the internal gear pump 10, the discharge pressure does not operate on the balance plate.

[0081] On the other hand, in the first embodiment, since the O-rings each having a cross section whose diametric dimension is larger than a depth dimension of each O-ring groove 71 or 72 are attached in the O-ring grooves 71 and 72 respectively, elastic repulsive force Fr of the O-rings OR operates on the O-ring grooves 71 and 72, and the balance plate 7 is pressed against the lower end surfaces of the rotors 12 and 13 (which are not shown in FIG. 4) by the elastic repulsive force Fr (which operates upward in FIG. 4).

[0082] In other words, an initial pressure which presses the balance plate 7 against the lower end surfaces of the rotors 12 and 13 at the time of, e.g., startup is provided by the elastic repulsive force Fr of the O-rings in the first embodiment. Thus, even at startup when the discharge

pressure of the internal gear pump 10 does not operate on the balance plate 7, the balance plate 7 is pressed against the lower end surfaces of the rotors 12 and 13 in FIG. 4. Here, since the balance plate 7 made of the material with high hardness maintains a flat state without being abraded, the side surfaces of the rotors 12 and 13 pressed by the balance plate 7 are not abraded into uneven shapes, and formation of steps on the side surfaces of the rotors 12 and 13 is suppressed. Moreover, the balance plate 7 moves toward the rotors 12 and 13 for a length corresponding to abraded amounts of the rotors 12 and 13, and a clearance (the gap) formed by the abrasion is reduced. Consequently, the volume efficiency of the internal gear pump 10 is improved.

[0083] A second embodiment according to the present invention will now be described with reference to FIG. 6. In FIG. 6, an entire pump device is denoted by reference sign 100A.

[0084] In the first embodiment shown in FIG. 1 to FIG. 5, the fixing plate 8 (FIG. 5) is provided on the discharge side (above the rotors 12 and 13 in FIG. 1) of the internal gear pump 10.

[0085] On the other hand, in the second embodiment shown in FIG. 6, no fixing plate is provided. Experiments conducted by the present inventor have revealed that abrasion of rotors 12 and 13 on a pump housing 14 side (a discharge side: which is above the rotors 12 and 13 in FIG. 6) is not considerable. Thus, the fixing plate can be omitted depending on a required specification.

[0086] Other structures, operations, and effects in the second embodiment shown in FIG. 6 are the same as those in the first embodiment shown in FIG. 1 to FIG. 5.

[0087] A third embodiment according to the present invention will now be described with reference to FIG. 7 to FIG. 9. In FIG. 7, an entire pump device is denoted by reference sign 100B.

[0088] In the first embodiment and the second embodiment shown in FIG. 1 to FIG. 6, as shown in FIG. 4, at the time of startup of the internal gear pump 10, the initial pressure which presses the balance plate 7 toward the discharge side (the upper side in FIG. 1) (for example, the force which presses the balance plate 7 against the end surfaces of the rotors 12 and 13 at the time of startup: upward force in FIG. 4) is provided by the elastic repulsive force F_r of the O-rings.

[0089] On the other hand, in the third embodiment shown in FIG. 7 to FIG. 9, at the time of startup of an internal gear pump 10, an initial pressure which presses a balance plate 7A toward discharge side (the upper side in FIG. 7) (force which presses a balance plate 7A against end surfaces of rotors 12 and 13: upward force in FIG. 9) is provided by elastic repulsive force of a spring (a coil spring) 9 instead of the elastic repulsive force of the O-rings.

[0090] As obvious from comparison between FIG. 9 and FIG. 4, in the third embodiment, positions of O-ring grooves 71A and 72A or O-rings OR (see FIG. 9) in the balance plate 7A are different from those in the first em-

bodiment and the second embodiment (see FIG. 4).

[0091] In FIG. 4 (the first embodiment, second embodiment), the O-ring grooves 71 and 72 or the O-rings OR on the balance plate 7 are formed on the end surfaces of the balance plate 7 on the suction side (the lower side in FIG. 4).

[0092] On the other hand, in FIG. 9 (the third embodiment), the O-ring grooves 71A and 72A or the O-rings OR on the balance plate 7A are arranged, along the rotation axis direction (the up-and-down direction in FIG. 9), in a region between an end surface of the balance plate 7A on the suction side (a lower side in FIG. 9) and an end surface of the same on the discharge side (an upper side in FIG. 9) and at positions along an outer peripheral surface and an inner peripheral surface of the balance plate 7A. Additionally, an inner O-ring 72A faces a bush BS fitted and fixed in an end plate 15.

[0093] As shown in FIG. 9 (and FIG. 7), a blind hole BH is formed in the end surface of the balance plate 7A on the suction side (the lower side in FIG. 7), and the spring 9 is accommodated in the blind hole BH. This spring 9 is accommodated in a compressed state, and elastic repulsive force operates in a direction along which the spring 9 expands.

[0094] Consequently, the balance plate 7A is pressed toward the discharge side (the upper side in FIG. 7 and FIG. 9) by the elastic repulsive force of the spring 9 (expanding force of the spring 9), and the initial pressure at the time of startup of the internal gear pump 10 (for example, force which presses the balance plate 7A against the end surface of the rotors 12 and 13 at the time of startup) is provided.

[0095] In FIG. 8, reference sign 73A denotes a discharge pressure introducing hole 73, and reference sign 74A designates a locking pin attaching hole.

[0096] Further, circles (alternate long and short dash line) denoted by reference sign G on both left and right ends in FIG. 8 indicate contact positions of the two springs 9 set in balance plate attaching holes 15h.

[0097] It is to be noted that, as a fixing plate in the third embodiment, the fixing plate 8 which is common to the first embodiment is used.

[0098] In the third embodiment which provides the initial pressure at the time of startup of the internal gear pump by the elastic repulsive force of the springs 9, as compared with the first and second embodiment each of which provides the initial pressure by the elastic repulsive force of the O-rings, an amount of pressing the balance plate 7A by the elastic repulsive force (a moving amount) can be set to be larger than that in the first embodiment and the second embodiment.

[0099] Thus, in the third embodiment, even if abrasion losses of the rotors 12 and 13 are considerable, the balance plate 7A which is made of a material with high hardness and maintains a flat state without being abraded is appropriately pressed against side surfaces of the rotors 12 and 13. Thus, formation of steps on the side surface of the rotors 12 and 13 is suppressed. Further, the bal-

ance plate 7 moves toward the rotors 12 and 13 for a length corresponding to the abrasion losses of the rotors 12 and 13 to reduce a clearance (a gap) formed due to the abrasion, and hence volume efficiency is improved.

[0100] Other structures, operations, and effects in the third embodiment shown in FIG. 7 to FIG. 9 are the same as those in the embodiments shown in FIG. 1 to FIG. 6.

[0101] A fourth embodiment according to the present invention will now be described with reference to FIG. 10. In FIG. 10, an entire pump device is denoted by reference sign 100C.

[0102] In the third embodiment shown in FIG. 7 to FIG. 9, the fixing plate 8 (which is the same as that in FIG. 5) is provided on the discharge side (the upper side in FIG. 7) of the internal gear pump. On the other hand, in the fourth embodiment shown in FIG. 10, no fixing plate is provided.

[0103] Other structure, operations, and effects in the fourth embodiment shown in FIG. 10 are the same as those in the third embodiment shown in FIG. 7 to FIG. 9.

[0104] A fifth embodiment according to the present invention will now be described with reference to FIG. 11 to FIG. 14. In FIG. 11, an entire pump device is denoted by reference sign 200.

[0105] In the first to fourth embodiments shown in FIG. 1 to FIG. 10 are all embodiments applied to the pump device which is a type that the suction side and the discharge side for the working fluid are arranged on different sides along the rotary shaft direction of the inner rotor 13.

[0106] On the other hand, in the fifth embodiment shown in FIG. 11 to FIG. 14 is an embodiment applied to a pump device which is a type that a suction side and a discharge side for a working fluid are arranged on the same side along a rotary shaft direction of an inner rotor 213.

[0107] In FIG. 11 and FIG. 12, the pump device denoted as a whole by reference sign 200 has a rotary shaft 205, a gear case 211, an outer rotor 212, an inner rotor 213, a pump housing 214, an end cap 215, and a support member 216. The support member 216, the pump housing 214, the gear case 211, and the end cap 215 are integrally fixed with the use of two through bolts B1 and nuts with washers NW. Further, the support member 216 and the pump housing 214 are fastened by a bolt B2, and the end cap 215, the gear case 211, and the pump housing 214 are fastened by a bolt B3.

[0108] A rotary shaft 205 pierces through the pump housing 214 and the inner rotor 213, and is supported by a bearing BG intermediately installed in the pump housing 214 and a bearing BS intermediately installed in the end cap 215.

[0109] Here, reference sign K denotes a key which fixes the inner rotor 213 to the rotary shaft 205, and reference sign SW denotes a thrust washer, and reference sign MS denotes an oil seal.

[0110] In FIG. 11, a balance plate attaching hole (a blind hole) 215H in which a balance plate 207 is attached is formed in a surface of the end cap 215 which is in

contact with the rotors 212 and 213 (a left end surface of the end cap 215 in FIG. 11).

[0111] On the other hand, a fixing plate attaching hole (a concave portion) 214H in which a fixing plate 8 is attached is formed in a surface of the pump housing 214 which is in contact with the rotors 212 and 213 (a right end surface of the pump housing 214 in FIG. 11).

[0112] In FIG. 12, a working fluid is sucked into a pump device 200 as indicated by an outline arrow Fi, flows through the pump device 200 as indicated by arrows of a broken line, and is discharged from the pump device 200 as indicated by an outline arrow Fo.

[0113] In FIG. 12, reference sign Pi designates a suction port, and reference sign Po designates a discharge port. As shown in FIG. 13, in the fifth embodiment, the suction port Pi is present on the same side as the discharge port Po along a rotary shaft direction. Thus, in FIG. 12, both the suction port Pi and the discharge port Po are shown on the assumption that they are provided on the same side.

[0114] In FIG. 11 and FIG. 12, the outer rotor 212 and the inner rotor 213 rotate in the same direction, the working fluid which has flowed in from the suction port Pi is raised its pressure by a fluctuation in volume of a gap between gears of the rotors 212 and 213, and the working fluid is discharged to the outside of the pump device 200 from a discharge opening 214o of the pump housing 214 (FIG. 12) through the discharge port Po.

[0115] A construction of the balance plate 207 (FIG. 11) in the pump device 200 is common to the balance plate 7 (FIG. 3) in the first embodiment. However, since a rotating direction of the rotor is different, the balance plate 207 has a shape which is axisymmetric to an X-X axis in FIG. 3 with respect to the balance plate shown in FIG. 3.

[0116] The balance plate 207 has an O-ring groove 207a having a large radial dimension and an O-ring groove 207b having a small radial dimension, and O-rings are fitted in the O-ring grooves 207a and 207b, respectively. Further, a through-hole (which is the same as the discharge pressure introducing hole 73 in FIG. 3) is formed in the balance plate 207, and a locking pin hole (which is the same as the pin hole 74 in FIG. 3) is also formed.

[0117] A construction of a fixing plate 8 in the fifth embodiment is common to the fixing plate 8 in the first embodiment. However, when a rotor rotating direction is different, the fixing plate 8 in the fifth embodiment has a construction which is provided by reversing the fixing plate 8 in the first embodiment.

[0118] In the fifth embodiment shown in FIG. 11 and FIG. 12, like the first embodiment shown in FIG. 1 to FIG. 5, the balance plate 207 is pressed against the rotor 212 and 213. Furthermore, an initial pressure is provided from elastic repulsive force of the O-rings.

[0119] Other structures, operations, and effects of the fifth embodiment shown in FIG. 11 and 12 are the same as those in the first embodiment shown in FIG. 1 to FIG. 5.

[0120] A sixth embodiment according to the present invention will now be described with reference to FIG. 13. In FIG. 13, an entire pump device is denoted by reference sign 200A.

[0121] In the fifth embodiment shown in FIG. 11 and FIG. 12, the fixing plate 8 is provided on a drive source side (a left side in FIG. 11) along the rotary shaft direction of the internal gear pump.

[0122] On the other hand, in the sixth embodiment shown in FIG. 13, no fixing plate is provided.

[0123] Other structure, operations, and effects of the sixth embodiment shown in FIG. 13 are the same as those in the fifth embodiment of the fifth embodiment shown in FIG. 11 and FIG. 12.

[0124] A seventh embodiment will now be described with reference to FIG. 14. In FIG. 14, an entire pump device is denoted by reference sign 200B.

[0125] In FIG. 11 to FIG. 13, when the discharge pressure does not operate on the balance plate 207 at the time of, e.g., startup of the internal gear pump, the initial pressure which presses the balance plate 207 toward the drive source side (the left side in FIG. 11) is provided by the elastic repulsive force of the O-rings like the first embodiment and the second embodiment.

[0126] On the other hand, in the seventh embodiment shown in FIG. 14, when a discharge pressure does not operate on a balance plate 207A at the time of, e.g., startup of an internal gear pump, an initial pressure which presses the balance plate 207A toward a drive source side (the left side in FIG. 14) is provided by elastic repulsive force of a spring 209 like the third embodiment and the fourth embodiment.

[0127] A construction of the balance plate 207A (FIG. 14) in the pump device 200B is common to the balance plate 7A (FIG. 8 and FIG. 9) in the third embodiment. However, since a rotating direction of the rotors is different, the balance plate 207A has a shape which is axisymmetric to an X-X axis in FIG. 8 with respect to the balance plate 7A in FIG. 8.

[0128] Moreover, in the pump device 200B, likewise, even if abrasion losses of rotors 212 and 213 increase, since the balance plate 207A which is made of a material with high hardness and maintains a flat state without being abraded is appropriately pressed against side surfaces of the rotors 212 and 213, formation of steps on the side surfaces of the rotors 212 and 213 is suppressed. Moreover, the balance plate 207A moves toward the rotor 212 or 213 side for a length corresponding to abrasion losses of the rotors 212 and 213 to reduce a clearance (a gap) formed due to abrasion, and hence volume efficiency is improved.

[0129] Other structures, operations, and effects of the seventh embodiment in FIG. 14 are the same as those in the embodiments shown in FIG. 11 to FIG. 13.

[0130] An eighth embodiment according to the present invention will now be described with reference to FIG. 15. In FIG. 15, an entire pump device is denoted by reference sign 200C.

[0131] In the seventh embodiment shown in FIG. 14, the fixing plate 8 is provided on the drive source side (a left side in FIG. 14) along a rotary shaft direction.

[0132] On the other hand, in the eighth embodiment shown in FIG. 15, no fixing plate is provided.

[0133] Other structures, operations, and effects of the eighth embodiment shown in FIG. 15 are the same as those in the seventh embodiment shown in FIG. 14.

[0134] It is additionally noted that the illustrated embodiments are just illustrative examples and they are not descriptions which restrict a technical scope of the present invention.

[0135] For example, in the illustrated embodiments, the balance plate is provided on the suction side (the right side in FIG. 1) only, and it is not provided on the discharge side (the left side in FIG. 1). On the other hand, the balance plate can be provided on the discharge side (the left side in FIG. 1) only. In such a case, a shape of the port must be changed from that in the illustrated embodiments.

REFERENCE SYMBOLS LIST

[0136]

5 ...	rotary shaft
7 ...	balance plate
8 ...	fixing plate
9 ...	spring
10 ...	internal gear pump
11 ...	gear case
12 ...	outer rotor
13 ...	inner rotor
14 ...	pump housing
15 ...	end plate
20 ...	suction plate
30 ...	cyclone relay impeller
40 ...	primary cyclone
45 ...	cyclone casing
50 ...	secondary cyclone
60 ...	foreign substance ejection impeller

Claims

1. A pump device **characterized in that** the pump device comprises an internal gear pump in which an inner rotor is inscribed to an outer rotor, wherein a plate member is provided on end surfaces of the rotors, and the plate member is made of a material with high hardness, formed into a shape which does not block a suction port, has a through-hole formed therein, and also has O-ring grooves formed thereon which have continuous shapes and in which O-rings are accommodated therein.
2. The pump device according to claim 1, wherein, in the present invention, said O-ring grooves are

formed on a surface of the plate member which is apart from the rotors, and the O-rings are attached in the O-ring grooves with a prescribed tightening margin.

5

3. The pump device according to claim 1, wherein a blind space is formed in the plate member on an opposite side of the rotors, and elastic members are accommodated in the blind space.

10

15

20

25

30

35

40

45

50

55

Fig 1

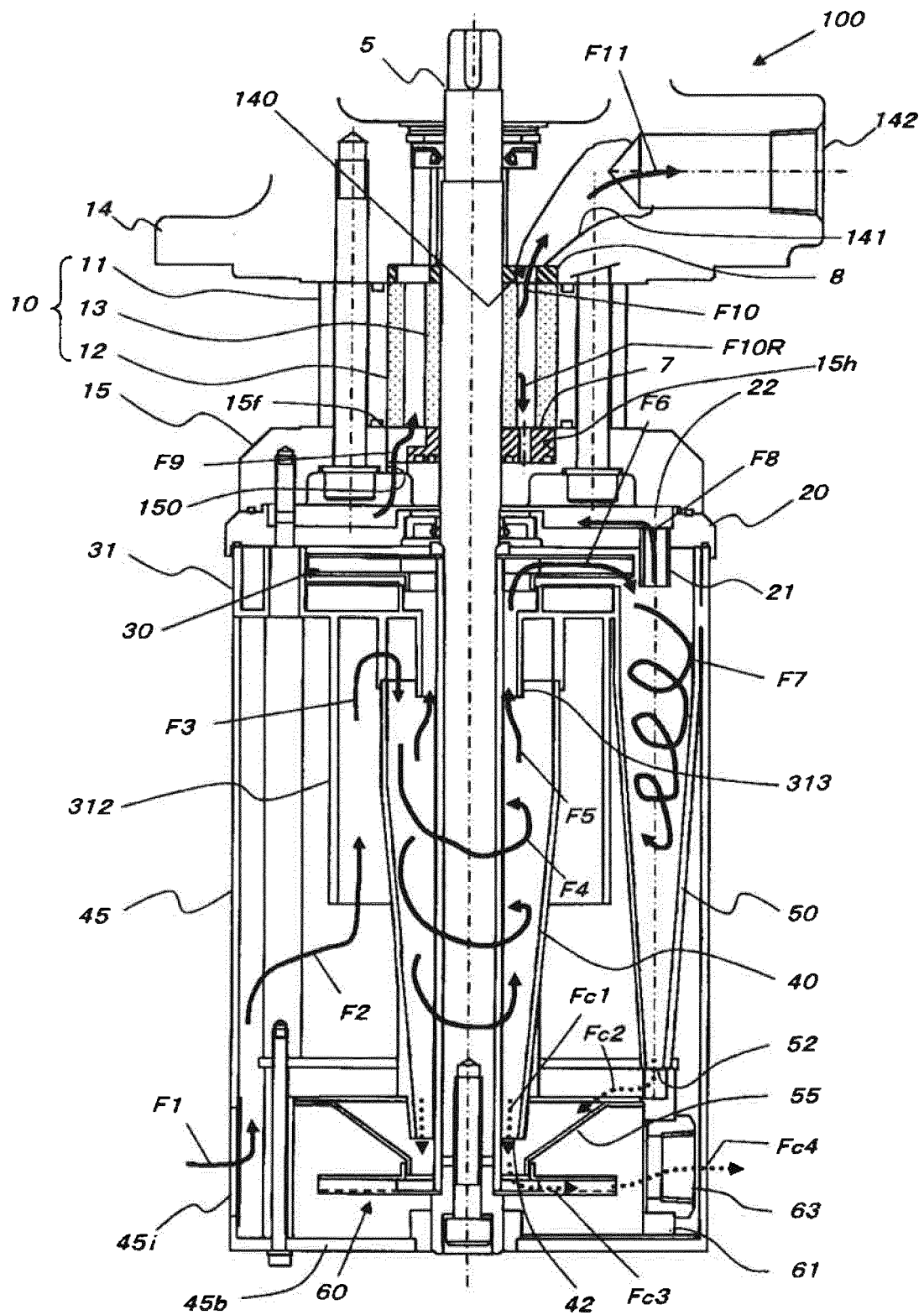


Fig 2

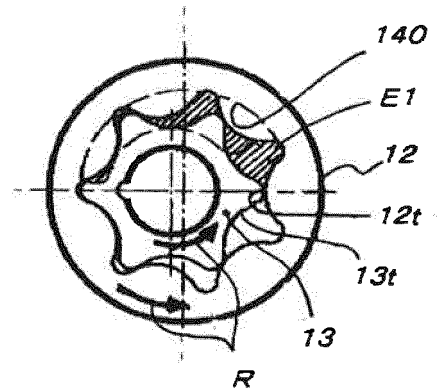


Fig 3

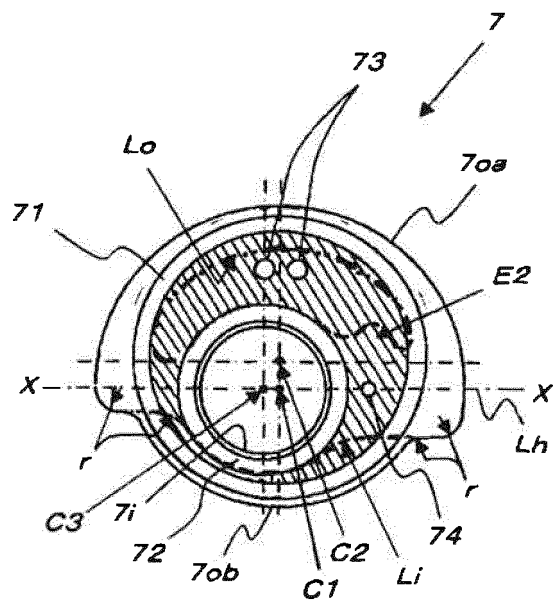


Fig 4

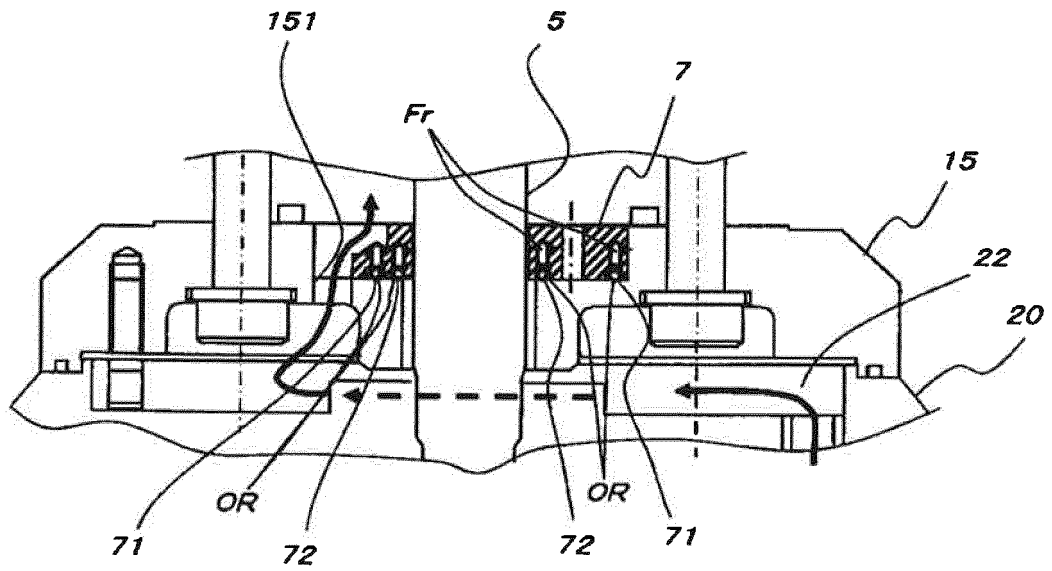


Fig 5

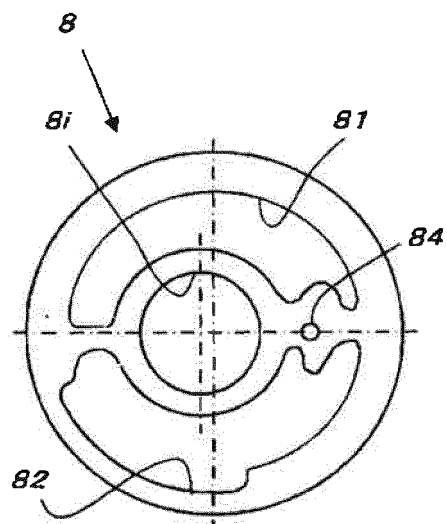


Fig 6

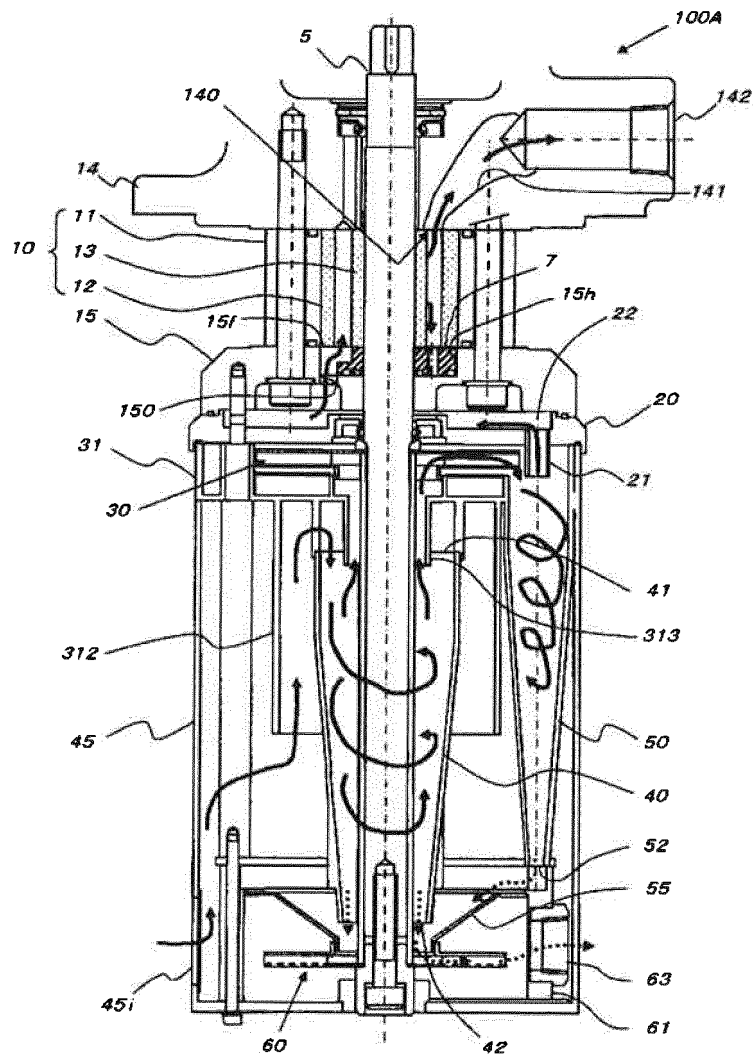


Fig 7

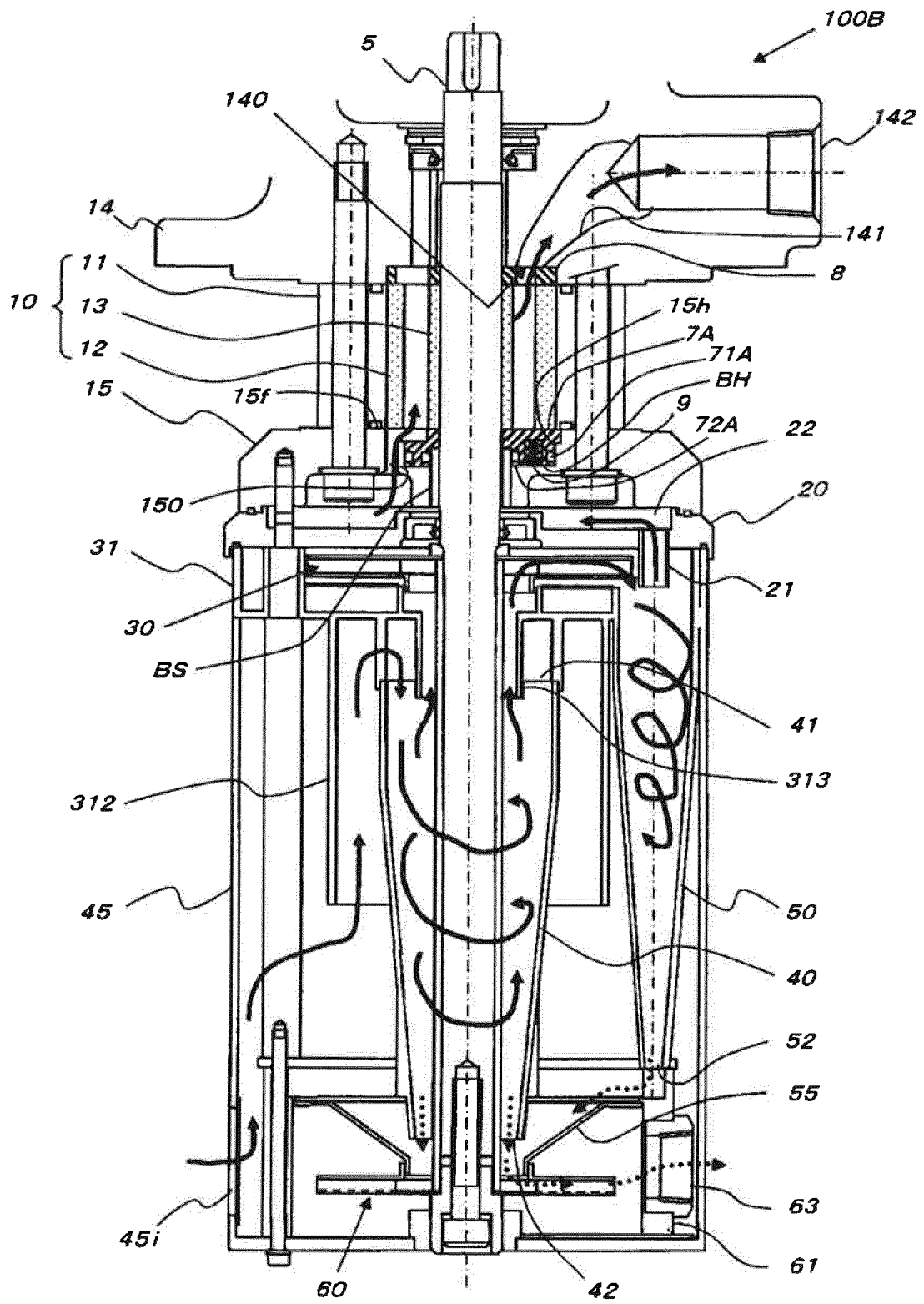


Fig 8

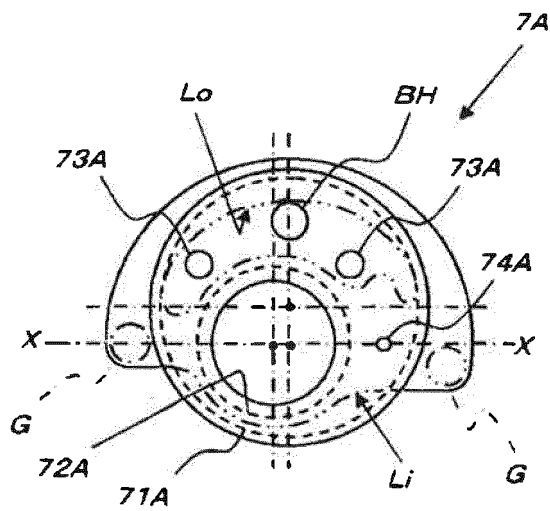


Fig 9

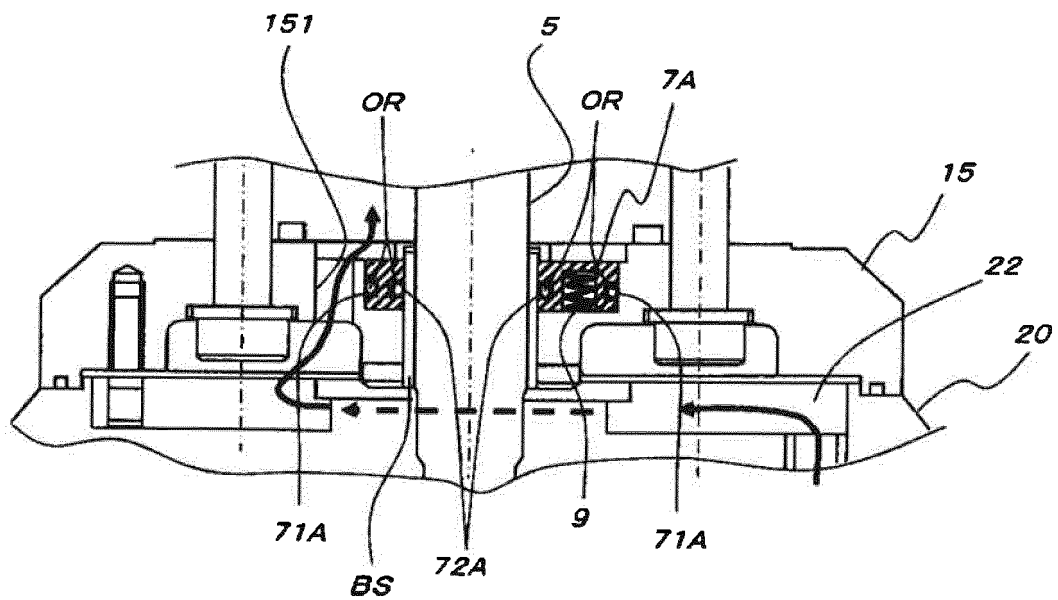


Fig 10

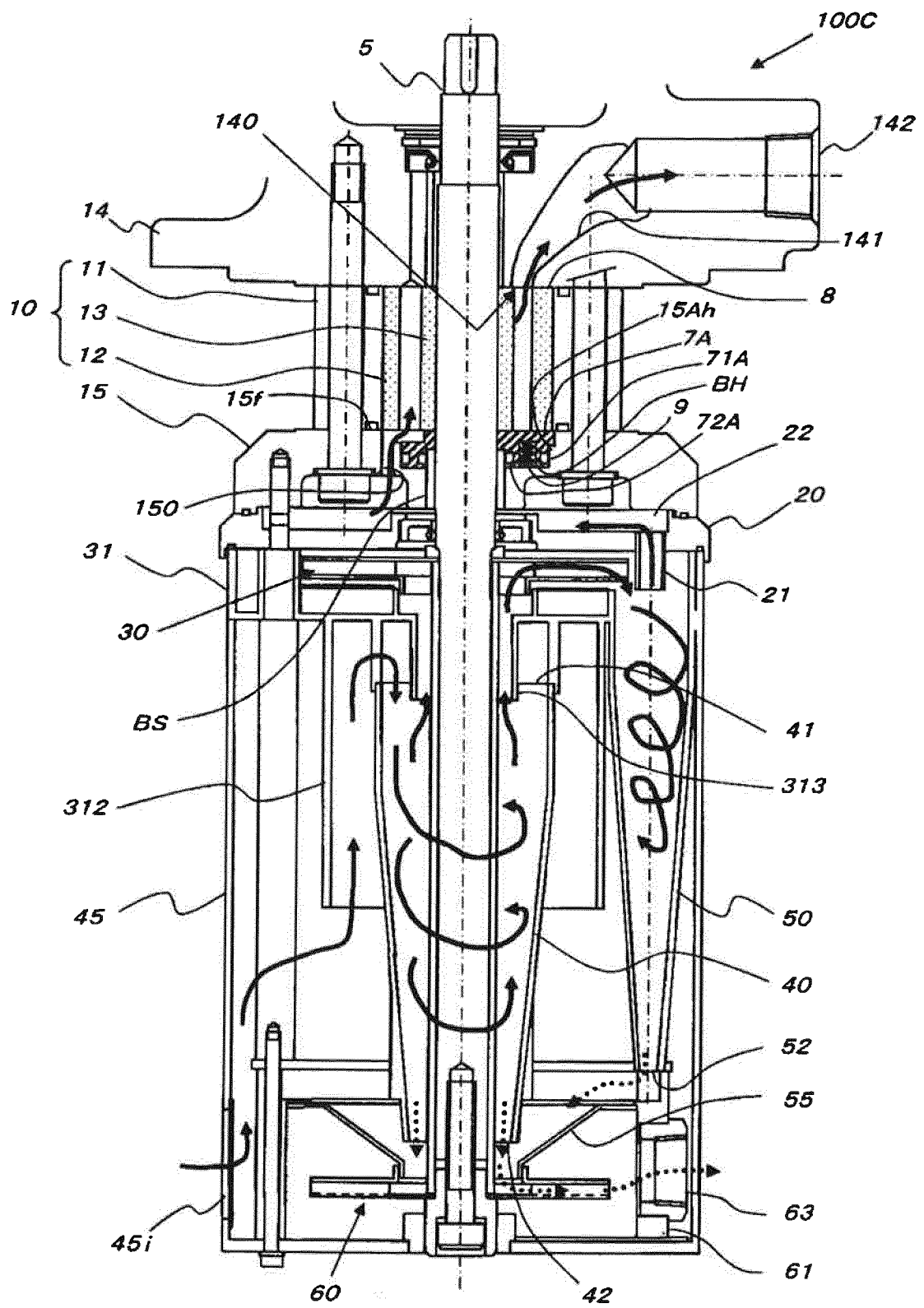


Fig 11

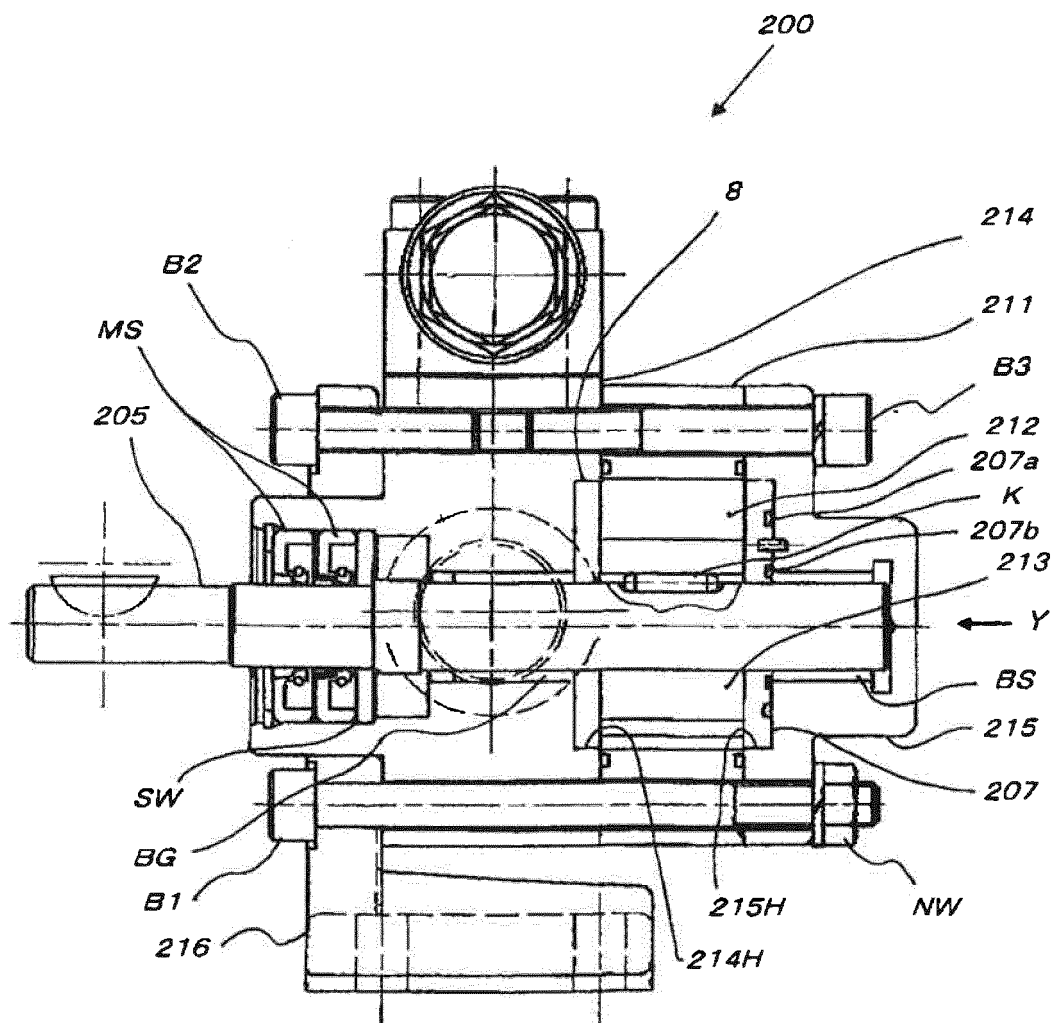


Fig 12

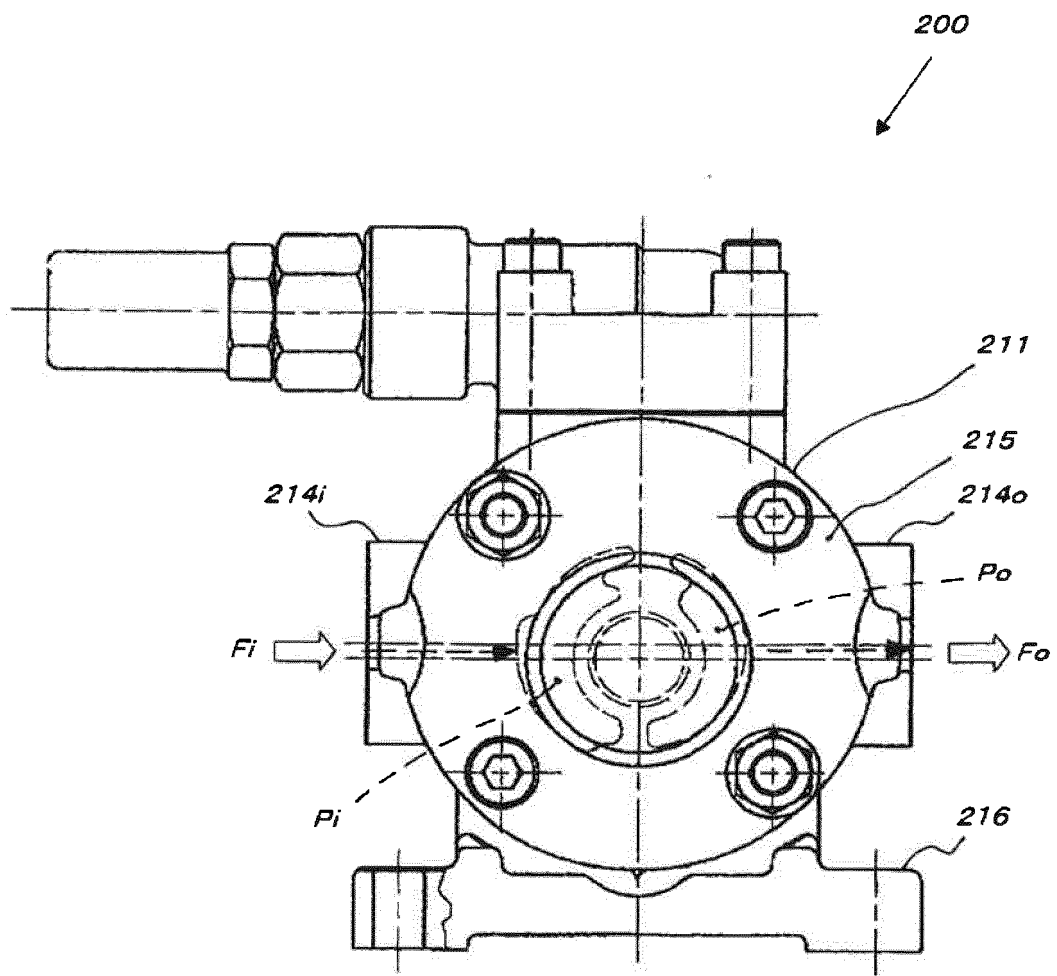


Fig. 13

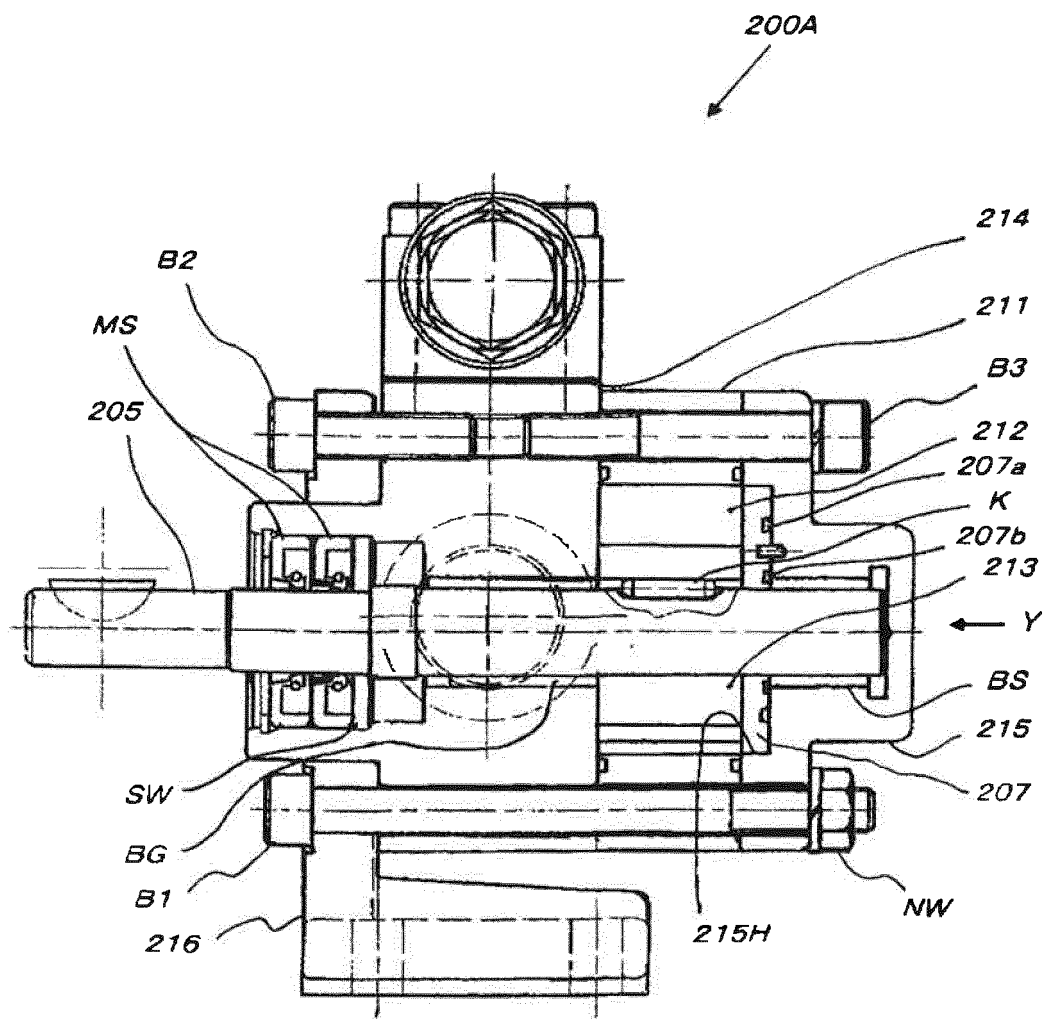


Fig 14

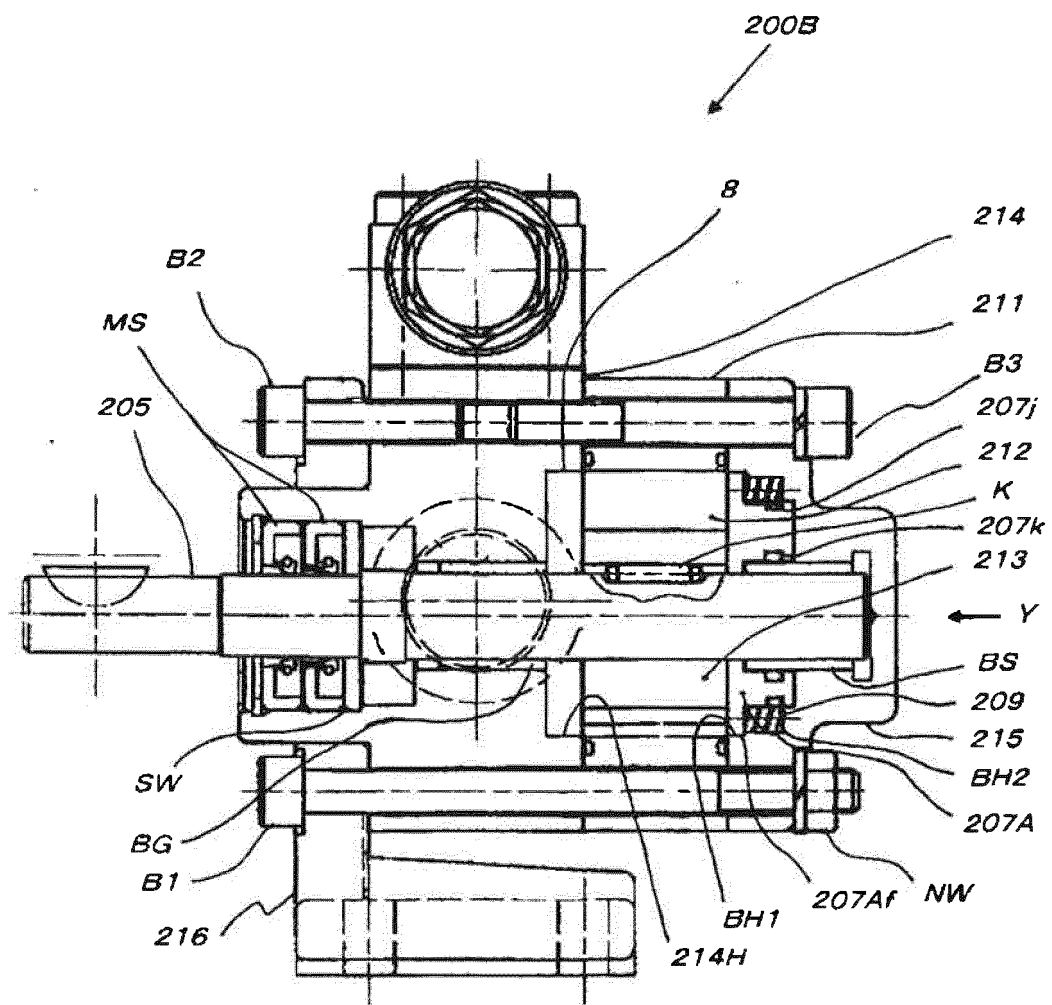
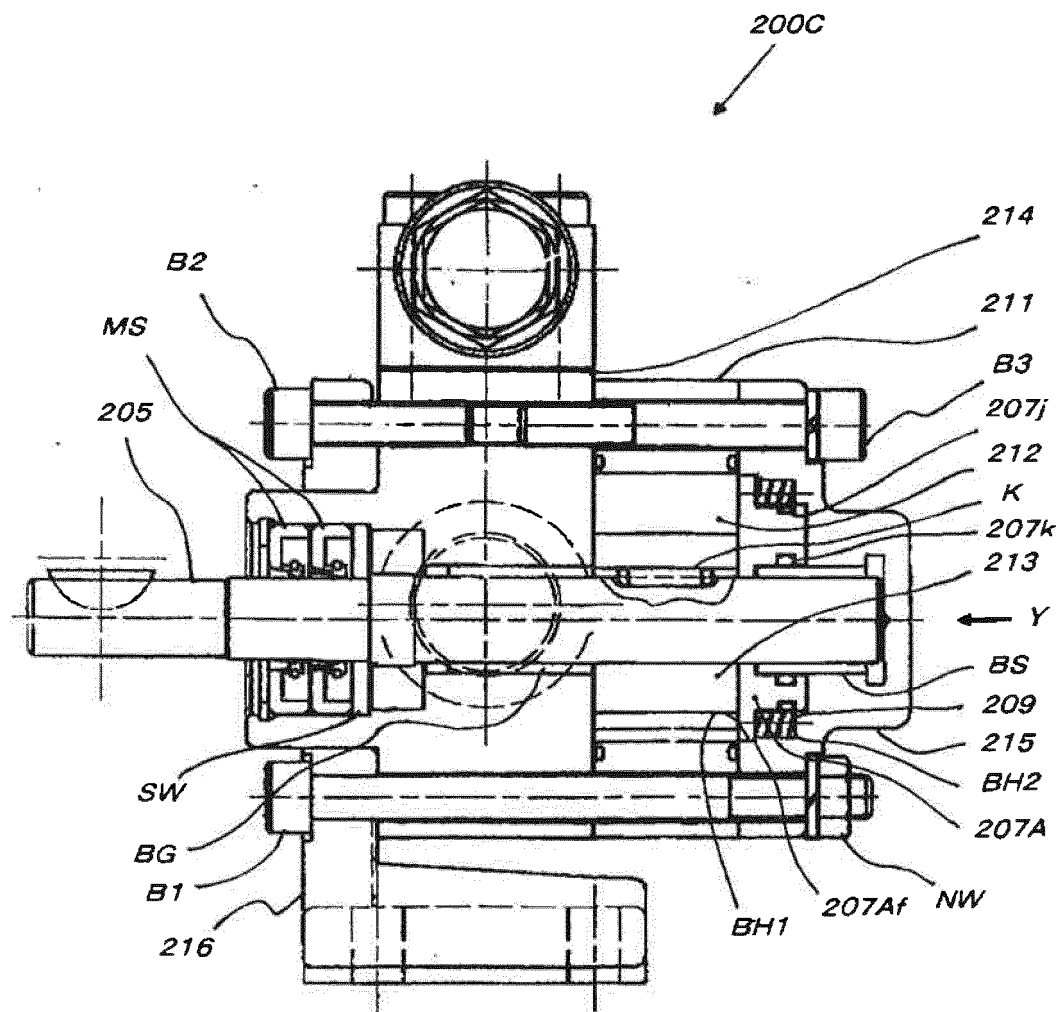


Fig 15



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/055335

A. CLASSIFICATION OF SUBJECT MATTER

F04C2/10(2006.01)i, F04C15/00(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F04C2/10, F04C15/00

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

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2012/079982 A2 (ROBERT BOSCH GMBH), 21 June 2012 (21.06.2012), page 4, line 28 to page 8, line 6; fig. 1 to 3 & JP 2014-506969 A & US 2014/0030129 A1 & DE 102010063313 A1 & KR 10-2013-0141595 A	1-3
Y	JP 55-60681 A (Pierburg Luftfahrtgerate Union GmbH), 07 May 1980 (07.05.1980), page 9, upper right column, line 6 to lower left column, line 17; fig. 11 to 13 & US 4344745 A & GB 2032526 A & DE 2846547 A1 & FR 2439885 A1	1, 2

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

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"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)

"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

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
18 May 2015 (18.05.15)Date of mailing of the international search report
02 June 2015 (02.06.15)
 Name and mailing address of the ISA/
 Japan Patent Office
 3-4-3, Kasumigaseki, Chiyoda-ku,
 Tokyo 100-8915, Japan

Authorized officer

Telephone No.

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

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/055335

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 3641962 B2 (Toyota Motor Corp.), 27 April 2005 (27.04.2005), paragraphs [0089] to [0094]; fig. 8 (Family: none)	3
A	US 2006/0051229 A1 (Reinhardt THOMS et al.), 09 March 2006 (09.03.2006), entire text; all drawings (Family: none)	1-3

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

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- WO 2012053231 A [0008]