



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
22.11.2017 Bulletin 2017/47

(51) Int Cl.:
F04C 2/18 (2006.01) F04C 15/00 (2006.01)

(21) Application number: **17171019.7**

(22) Date of filing: **15.05.2017**

(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
Designated Validation States:
MA MD

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(30) Priority: **19.05.2016 JP 2016100851**

(54) **GEAR PUMP**

(57) In a gear pump, a gear chamber (4) is defined in a housing hole (2) of a housing (3). A pair of gears (7, 8) is housed in the gear chamber (4). The gears (7, 8) are rotatably supported at support holes (13, 14) of a pair of side plates (5, 6) via support shafts (15, 16). As viewed in an axial direction of the support shafts (15, 16) during rotation of the gears (7, 8), addendum circles (70, 80) of the gears (7, 8) displaced under a differential pressure between a low-pressure chamber (31) and a high-pressure chamber (41) form first contact points (P1) with respect to an inner peripheral surface (2a) that defines a housing hole (2). As viewed in the axial direction of the support shafts (15, 16) during rotation of the gears (7, 8), the first contact points (P1) are covered with the side plates (5, 6) displaced under the differential pressure.

FIG.5A

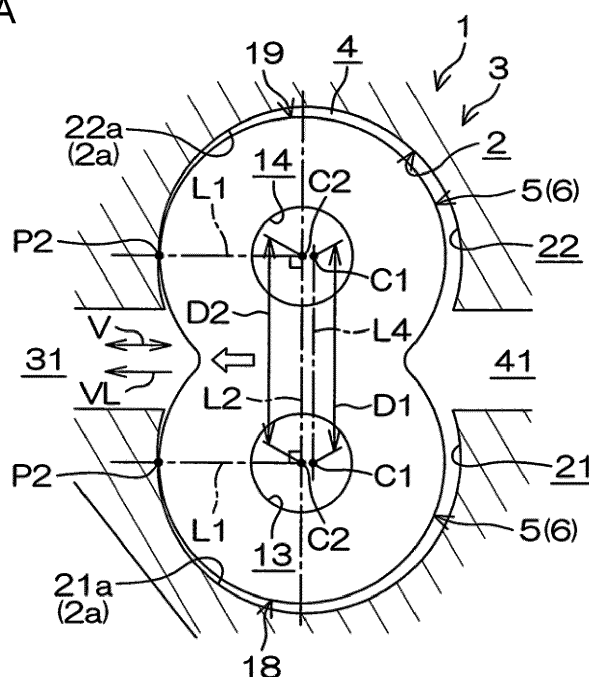
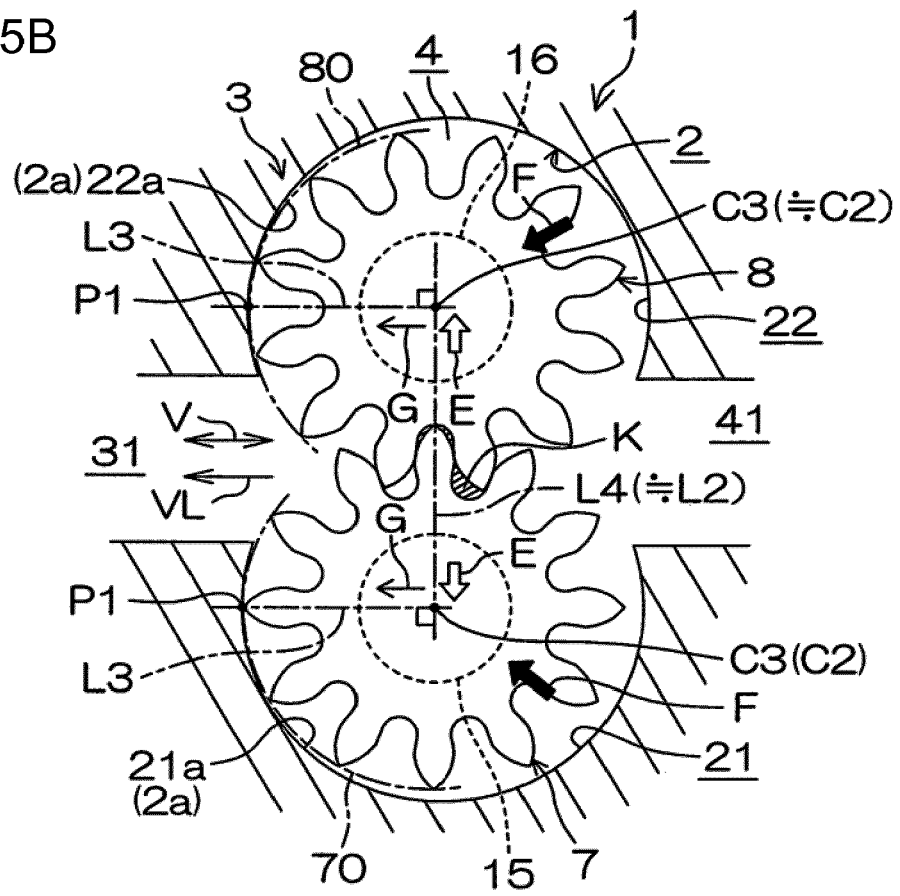


FIG.5B



Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The invention relates to a gear pump.

2. Description of the Related Art

[0002] A commonly-used gear pump has a structure in which a pair of gears meshed with each other is housed in a housing, a gear chamber is defined in a housing hole by a pair of side plates disposed with the gears interposed therebetween in an axial direction, and support shafts of the gears are rotatably supported at support holes provided in the side plates. Refer to, for example, Japanese Patent Application Publication No. H10-122160 (JP H10-122160 A). When the gear pump is viewed in the axial direction of the gears, a low-pressure chamber and a high-pressure chamber are arranged inside the gear chamber, with a meshing position (i.e., a position at which the gears are meshed with each other) interposed between the low-pressure chamber and the high-pressure chamber. The low-pressure chamber is in communication with an inlet port for a working fluid, and the high-pressure chamber is in communication with an outlet port for the working fluid. The side plates are fitted in the housing hole by clearance-fit.

[0003] When the gear pump is in a driving state, a differential pressure between the low-pressure chamber and the high-pressure chamber is applied to the gears and thus the gears are displaced toward the low pressure-side as the center-to-center distance between the gears varies. As illustrated in FIG. 9, an addendum circle 90 of each gear forms a contact point 92 with respect to an inner peripheral surface 91 that defines the housing hole, as illustrated in FIG. 9. The contact point 92 serves as a boundary between the low-pressure chamber and the high-pressure chamber in a circumferential direction of the gear. Meanwhile, the differential pressure is applied to a side plate 93, and thus the side plate 93 is displaced toward the low pressure-side.

[0004] In FIG. 9, a positional relationship between the gear and the side plate is exaggerated. As illustrated in FIG. 9, unlike the side plate 93, the gears are displaced also in a direction Z in which the center-to-center distance between the gears varies. Thus, the contact point 92 of the addendum circle 90 of the gear is not covered with the side plate 93. When the side plate 93 is disposed such that the contact point 92 serving as the boundary between the high pressure-side and the low pressure-side is exposed, internal leakage may occur in a region around the contact point 92 at the axial end (end in the direction perpendicular to the sheet on which FIG. 9 is drawn and toward a person seeing FIG. 9) of the gear. When internal leakage occurs, a fluid leaks from the high-pressure chamber-side to the low-pressure chamber-

side while bypassing the contact point 92. Thus, for example, a decrease in flow rate occurs. This makes the pump performance unstable.

5 SUMMARY OF THE INVENTION

[0005] One object of the invention is to provide a gear pump configured to deliver stable pump performance.

[0006] A gear pump according to an aspect of the invention includes: a housing having a housing hole; a pair of side plates disposed in the housing hole so as to face each other such that a gear chamber is defined between the side plates, each of the side plates having a pair of support holes; and a pair of gears disposed in the gear chamber so as to be meshed with each other, the gears being rotatably supported by the side plates via support shafts inserted into the support holes. When the gear pump is viewed in an axial direction of each of the support shafts during rotation of the gears, a low-pressure chamber and a high-pressure chamber that is higher in pressure than the low-pressure chamber are defined inside the gear chamber, with a meshing position interposed between the low-pressure chamber and the high-pressure chamber. The meshing position is a position at which the gears are meshed with each other. An addendum circle of each of the gears that are displaced under a differential pressure between the low-pressure chamber and the high-pressure chamber forms a first contact point with respect to an inner peripheral surface that defines the housing hole in which the gears are housed. Each of the first contact points is covered with the side plates that are displaced under the differential pressure.

[0007] When the gear pump according to the above aspect is viewed in the axial direction of the support shafts during rotation of the gears, the first contact point of each gear (addendum circle) with respect to the inner peripheral surface that defines the housing hole is covered with the side plates and sealed. Thus, it is possible to suppress the fluid from leaking from the high pressure-side to the low pressure-side while bypassing the first contact points, at an axial end portion of each of the gears. Thus, it is possible to deliver stable pump performance. In the above aspect, each first contact point is a contact point at which the addendum circle is in contact with the inner peripheral surface via a fluid film, such as a thin oil film.

[0008] In the gear pump according to the above aspect, the housing hole may include a pair of cylindrical hole sections in which the gears are respectively housed, each of the side plates may include a pair of disc portions respectively fitted in the cylindrical hole sections, and a first distance and a second distance may be equal to each other. The first distance is a distance between central axes of the cylindrical hole sections of the housing hole, and the second distance is a distance between central axes of the disc portions of each of the side plates.

[0009] The side plates are displaced toward the low pressure-side under the differential pressure. The displacement causes outer peripheral surfaces of the disc

portions of each of the side plates to form contact points (second contact points) with respect to the inner peripheral surfaces that define the cylindrical hole sections of the housing hole. In the gear pump according to the above aspect, the first distance that is a distance between the central axes of the cylindrical hole sections of the housing hole is equal to the second distance that is a distance between the central axes of the disc portions of each side plate. Thus, the straight lines (first straight lines) connecting the second contact points to the central axes of the disc portions corresponding to the second contact points are orthogonal to the straight line (second straight line) connecting the central axes of the cylindrical hole sections of the housing hole. That is, the second contact points are formed on the inner peripheral surface at positions closest to the low-pressure chamber in the direction orthogonal to the second straight line.

[0010] Consequently, even when the positions of the second contact points vary in the circumferential direction of the cylindrical hole section due to variations in the actual dimensions of the housing and the side plates with respect to the dimensional tolerances thereof, the variations in the positions of the second contact points in the direction orthogonal to the second straight line can be kept small. Thus, the displacement of the side plates that are displaced under the differential pressure and the displacement of the gears supported by the side plates can be kept substantially constant. As a result, it is possible to suppress variations in the performance.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The foregoing and further features and advantages of the invention will become apparent from the following description of example embodiments with reference to the accompanying drawings, wherein like numerals are used to represent like elements and wherein:

FIG. 1 is a front sectional view of a gear pump according to an embodiment of the invention, in which hatching representing sections of gears and support shafts of the gears is omitted;

FIG. 2 is a schematic sectional view taken along line II-II in FIG. 1, in which hatching representing sections is omitted;

FIG. 3 is an end view of a tubular main body of a housing;

FIG. 4 is a view of each side plate, illustrating a gear-side side surface thereof as a front side;

FIG. 5A is a schematic sectional view of the gear pump in a driving state, illustrating a displacement state of the side plate;

FIG. 5B is a schematic sectional view of the gear pump in the driving state, illustrating a displacement state of the gears;

FIG. 6 is a sectional view taken along line VI-VI in FIG. 1;

FIG. 7 is a schematic view illustrating a positional

relationship among elements of the gear pump in the driving state;

FIG. 8 is a schematic view illustrating a comparison of a variation state of the position of a second contact point due to variations in the actual dimensions of components with respect to the dimensional tolerances thereof between the gear pump in the embodiment and a conventional gear pump; and

FIG. 9 is a schematic view illustrating a positional relationship among elements of a conventional gear pump in a driving state.

DETAILED DESCRIPTION OF EMBODIMENTS

[0012] Example embodiments of the invention will be described with reference to the accompanying drawings. FIG. 1 is a front sectional view of a gear pump according to an embodiment of the invention. FIG. 2 is a sectional view taken along line II-II in FIG. 1, in which hatching representing sections is omitted. As illustrated in FIG. 1 and FIG. 2, a gear pump 1 includes a housing 3, a pair of side plates 5, 6, and a pair of a drive gear 7 and a driven gear 8. The housing 3 has a housing hole 2. The side plates 5, 6 are disposed in the housing hole 2 so as to face each other. The side plates 5, 6 are disposed apart from each other such that a gear chamber 4 is defined therebetween. The drive gear 7 and the driven gear 8 are disposed in the gear chamber 4 so as to be meshed with each other.

[0013] The housing 3 includes a tubular main body 9 and a pair of cover plates 10, 11. The cover plates 10, 11 are screwed to the tubular main body 9 so as to cover both axial end surfaces of the tubular main body 9. The housing hole 2 is a through-hole that extends through a central portion of the tubular main body 9. Seal members 12 that seal the gear chamber 4 are interposed between the cover plates 10, 11 and the tubular main body 9. Seal members 50 that seal the gear chamber 4 are interposed between the cover plates 10, 11 and the corresponding side plate 5, 6.

[0014] FIG. 3 is an end view of the tubular main body 9 of the housing 3. FIG. 4 is a view of each side plate 5 (6), illustrating a side surface thereof facing the gears 7, 8 as a front side. As illustrated in FIG. 3, the housing hole 2 is in the shape of a figure of eight, and the housing hole 2 has a pair of cylindrical hole sections 21, 22 in which the drive gear 7 and the driven gear 8 are respectively housed. The cylindrical hole section 21 and the cylindrical hole section 22 of the housing hole 2 are cylindrical holes having the same radius R. The cylindrical hole sections 21, 22 respectively have first central axes C1 that are parallel to each other, and the cylindrical hole sections 21, 22 are provided side by side so as to be parallel to each other.

[0015] The cylindrical hole sections 21, 22 are provided such that a first distance D1, which is a distance between the first central axis C1 of the cylindrical hole section 21 and the first central axis C1 of the cylindrical hole section

22, is shorter than a bore diameter (diameter $2R$) of each cylindrical hole section 21 (22) ($D1 < 2R$), and the cylindrical hole section 21 and the cylindrical hole section 22 are communicated with each other. As illustrated in FIG. 4, each of the side plates 5, 6 is in the shape of a figure of eight such that each of the side plates 5, 6 is fitted in the housing hole 2. Each of the side plates 5, 6 includes a pair of disc portions 18, 19 housed respectively in the cylindrical hole sections 21, 22. Outer peripheral surfaces 18a, 19a of the disc portions 18, 19 are fitted to inner peripheral surfaces 21a, 22a that respectively define the cylindrical hole sections 21, 22 by clearance-fit. The disc portions 18, 19 are equal in outside diameter (diameter $2r$) to each other. The outside diameter (diameter $2r$) of each of the disc portions 18, 19 is less than the bore diameter (diameter $2R$) of each of the cylindrical hole sections 21, 22 ($2r < 2R$).

[0016] The disc portions 18, 19 of each of the side plates 5, 6 respectively have second central axes $C2$ that are parallel to each other. Each of the side plate 5, 6 has support holes 13, 14 that are concentric with the corresponding disc portions 18, 19. That is, the second central axes $C2$ of the disc portions 18, 19 respectively coincide with the centers of the support holes 13, 14 of the disc portions 18, 19. The disc portions 18, 19 are provided such that a second distance $D2$, which is a distance between the second central axis $C2$ of the disc portion 18 (the support hole 13) and the second central axis $C2$ of the disc portion 19 (the support hole 14), is shorter than the diameter ($= 2r$) of each disc portion 18 (19) ($D2 < 2r$). The disc portion 18 and the disc portion 19 are integral with each other.

[0017] In the present embodiment, the first distance $D1$ between the first central axes $C1$ illustrated in FIG. 3 is equal to the second distance $D2$ between the second central axes illustrated in FIG. 4 ($D1 = D2$). As illustrated in FIG. 1, opposite end portions of support shafts 15, 16 of the gears 7, 8 are inserted into the corresponding support holes 13, 14 of the side plates 5, 6, and are rotatably supported by the side plates 5, 6. The support shafts 15, 16 are disposed parallel to each other. The opposite end portions of the support shafts 15, 16 may be inserted into the corresponding support holes 13, 14, and supported by the side plates 5, 6 via plain bearings, such as bushings.

[0018] The support shaft 15 extends through the cover plate 10 so as to protrude from the cover plate 10. The support shaft 15 serves as a drive shaft. The support shaft 15 is rotationally driven by a driving force transmitted to an extension end 15a of the support shaft 15 from a power source, such as a motor (not illustrated). The drive gear 7 is fitted to the support shaft 15 such that the drive gear 7 is rotatable together with the support shaft 15 in an integrated manner. An oil seal 17 is disposed at a position at which the support shaft 15 extends through the cover plate 10. The support shaft 16 serves as a driven shaft. The driven gear 8 is fitted to the support shaft 16. The driven gear 8 may be fitted to the support

shaft 16 so as to rotate together with the support shaft 16 in an integrated manner, or so as to be rotatable relative to the support shaft 16. The driven gear 8 is configured such that the driven gear 8 is meshed with the drive gear 7, and is driven to rotate in accordance with the rotation of the drive gear 7 driven by the support shaft 15, along with the support shaft 16 or without causing the rotation of the support shaft 16.

[0019] In FIG. 2, the rotation direction of the drive gear 7 and the rotation direction of the driven gear 8, which is driven in conjunction with the drive gear 7, are represented by arrows. When the gear chamber 4 is viewed in the axial direction of the support shafts 15, 16, a low-pressure chamber 31 and a high-pressure chamber 41 are provided on opposite sides of a position MP at which the gears 7, 8 are meshed with each other (hereinafter, referred to as "meshing position MP between the gears 7, 8") in the gear chamber 4. The low-pressure chamber 31 is in communication with an inlet port 32 for a working fluid, and the high-pressure chamber 41 is in communication with an outlet port 42 for the working fluid. The low-pressure chamber 31 and the high-pressure chamber 41 are connected to a suction portion (not illustrated) and a discharge portion (not illustrated), which are disposed outside the housing 3, via the inlet port 32 and the outlet port 42 configured to open at corresponding positions in the tubular main body 9.

[0020] As illustrated in FIG. 2, when gear pump 1 is in a driving state where both the gears 7, 8 rotate, the working fluid introduced into the low-pressure chamber 31 via the inlet port 32 enters spaces between teeth of the drive gear 7 and teeth of the driven gear 8, the teeth facing the low-pressure chamber 31. The working fluid is transferred due to the rotation of the gears 7, 8 while being sealed in the spaces between the teeth and an inner peripheral surface 2a that defines the housing hole 2, and is then transferred to the high-pressure chamber 41. During the operation of the gear pump 1 performed as described above, a pressure distribution from the low-pressure chamber 31 to the high-pressure chamber 41 is generated inside the gear chamber 4. Mainly a pressing force corresponding to a differential pressure between the low-pressure chamber 31 and the high-pressure chamber 41 acts on the gears 7, 8 and the side plates 5, 6, so that the gears 7, 8 and the side plates 5, 6 are pressed against a low-pressure region of the inner peripheral surface 2a that defines the housing hole 2 (the inner peripheral surfaces 21a, 22a that define the cylindrical hole sections 21, 22).

[0021] First, a displacement state of each side plate 5 (6) will be described. FIG. 5A is a schematic sectional view of the gear pump 1 in the driving state, illustrating the displacement state of each side plate 5 (6) as viewed in the axial direction of the support shafts 15, 16. When the gear pump 1 is in the driving state, the side plate 5 (6) is displaced toward the low-pressure chamber 31 under the differential pressure between the low-pressure chamber 31 and the high-pressure chamber 41. In this

case, a displacement direction (indicated by a blank arrow) of the side plate 5 (6) is a direction toward a low-pressure chamber-side VL in an orthogonal direction V that is orthogonal to a second straight line L2 passing through the second central axes C2 of the side plate 5.

[0022] As viewed in the axial direction of the support shafts 15, 16, a straight line passing through the first central axes C1 of the cylindrical hole sections 21, 22 is defined as a fourth straight line L4. The side plate 5 (6) moves such that the second straight line L2 passing through the second central axes C2 of the side plate 5 (6) is translated with respect to the fourth straight line L4. Each of the side plates 5, 6 displaced toward the low-pressure chamber-side VL in the orthogonal direction V form second contact points P2 on an area of the inner peripheral surface 2a that defines the housing hole 2 (the inner peripheral surfaces 21a, 22a that define the cylindrical hole sections 21, 22), the area being on the low-pressure chamber 31-side. Each second contact point P2 is a contact point at which the side plate 5 (6) is in contact with the inner peripheral surface 2a via a thin film of the working fluid.

[0023] The positions of the second contact points P2 are adjusted as follows. The first distance D1 between the first central axes C1 is equal to the second distance D2 between the second central axes C2 ($D1 = D2$). Thus, the second contact points P2 formed due to the displacement of the side plate 5 (6) to the low-pressure chamber-side VL in the orthogonal direction V are located on the low-pressure chamber-side VL in the orthogonal direction V, with respect to the first central axes C1 (second central axes C2). Straight lines respectively passing through the second contact points P2 and the second central axes C2 corresponding to the second contact points P2 are defined as first straight lines L1. The second contact points P2 are located such that the first straight lines L1 and the second straight line L2 are orthogonal to each other.

[0024] Next, a displacement state of the gears 7, 8 when the gear pump 1 is in the driving state will be described. FIG. 5B is a schematic sectional view of the gear pump 1 in the driving state, illustrating the displacement state of the gears 7, 8 as viewed in the axial direction of the support shafts 15, 16. When the gear pump 1 is in the driving state where the gears 7, 8 rotate, the gears 7, 8 are displaced to the low pressure-side mainly under the differential pressure between the low-pressure chamber 31 and the high-pressure chamber 41. As viewed in the axial direction of the support shafts 15, 16, addendum circles 70, 80 of the gears 7, 8 form first contact points P1 at which the addendum circles 70, 80 are in contact with the inner peripheral surface 2a that defines the housing hole 2 (the inner peripheral surfaces 21a, 22a that define the cylindrical hole sections 21, 22). Each first contact point P1 is a contact point at which the addendum circle 70 (80) is in contact with the inner peripheral surface 2a via a thin film of the working fluid.

[0025] The positions of the first contact points P1 are

adjusted as follows. As illustrated in FIG. 2 and FIG. 4, a relief groove 23 and a relief groove 24 are provided in each of gear-side side surfaces 5a, 6a of the side plates 5, 6. The relief groove 23 extends from the meshing position MP between the gears 7, 8 toward the low-pressure chamber 31, and the relief groove 24 extends from the meshing position MP between the gears 7, 8 toward the high-pressure chamber 41. The relief grooves 23, 24 are separated from each other such that the relief grooves 23, 24 are not communicated with each other.

[0026] The relief grooves 23, 24 have the function of suppressing a confined pressure that is generated when the working fluid is confined in a closed region K defined by the gear-side side surfaces 5a, 6a of the side plates 5, 6 and the meshed teeth of the gears 7, 8 at the meshing position MP. Specifically, although not illustrated in the drawings, in accordance with the rotation of the gears 7, 8, the communication state is switched from a state where the closed region K is communicated with the high-pressure chamber 41 via the relief groove 24 to a state where the closed region K is communicated with the low-pressure chamber 31 via the relief groove 23. The confined pressure to be generated in the closed region K can be adjusted through setting of the positions and shapes of the relief grooves 23, 24.

[0027] As illustrated in FIG. 2 and FIG. 5B, the confined pressure generated in the closed region K applies, to the gears 7, 8, pressing forces E having force components acting in directions in which a center C3 of the gear 7 and a center C3 of the gear 8 move away from each other. FIG. 6 is a sectional view taken along line VI-VI in FIG. 1. As illustrated in FIG. 6, a seal groove 26 generally in the shape of a figure of three is provided in a side surface 5b that is on the opposite side of the side plate 5 from the gear-side side surface 5a. The seal member 50 is housed in the seal groove 26. The seal member 50 is generally in the shape of a figure of three. The seal member 50 has a pair of end portions. The end portions of the seal member 50 respectively have seal surfaces 51, 52 configured to come into elastic contact with the inner peripheral surfaces that define the cylindrical hole sections 21, 22 of the housing hole 2 of the housing 3.

[0028] A space between the side plate 5 and the cover plate 11 is partitioned into a low-pressure chamber-side region LA that is in communication with the low-pressure chamber 31 and a high-pressure chamber-side region HA that is in communication with the high-pressure chamber 41 such that the seal member 50 serves as a boundary between the low-pressure chamber-side region LA and the high-pressure chamber-side region HA. The high-pressure chamber-side region HA extends toward the low-pressure chamber 31 beyond the fourth straight line L4 (which substantially coincides with the second straight line L2) passing through the centers C3 of the gears 7, 8 (which substantially coincides with the second central axes C2), as viewed in the axial direction of the support shafts 15, 16. The high-pressure chamber-side region HA is wider than the low-pressure chamber-

side region LA.

[0029] Through the setting of the designs of the components (the housing 3, the side plates 5, 6, the gears 7, 8, and the seal members 50), it is possible to adjust the pressure distribution in the circumferential direction of the cylindrical hole sections 21, 22 based on the differential pressure between the low-pressure chamber 31 and the high-pressure chamber 41. As illustrated in FIG. 5B, the directions of the pressing forces F applied to the gears 7, 8 due to the differential pressure can be adjusted by adjusting the pressure distribution based on the differential pressure. The pressing forces F due to the differential pressure in the present embodiment have force components acting in directions in which the gears 7, 8 approach each other. Thus, the directions of resultant forces G of the pressing forces E applied to the gears 7, 8 due to the confined pressure and the pressing forces E applied to the gears 7, 8 due to the differential pressure between the high-pressure chamber 41 and the low-pressure chamber 31 are adjusted such that the direction of the resultant forces G are directions toward the low-pressure chamber-side VL in the orthogonal direction V.

[0030] Thus, as viewed in the axial direction of the support shafts 15, 16, the first contact points P1 formed by the gears 7, 8 are located such that the third straight lines L3 passing through the first contact points P1 and the centers C3 (which generally coincide with the second central axes C2) of the gears 7, 8 corresponding to the first contact points P1 are orthogonal to the second straight line L2 (which generally coincides with the fourth straight line L4) passing through the second central axes C2. As described above, the positions of the second contact points P2 with respect to the inner peripheral surface 2a that defines the housing hole 2 of the housing 3 are adjusted by adjusting the first distance D1 between the first central axes C1 and the second distance D2 between the second central axes C2, and the positions of the first contact points P1 with respect to the inner peripheral surface 2a that defines the housing hole 2 are adjusted by adjusting the directions of the resultant forces G of the pressing forces due to the pressures (the confined pressure, the differential pressure) applied to the gears 7, 8.

[0031] Consequently, as illustrated in FIG. 7 that is a schematic view of the gear pump 1, the first contact points P1 are covered with the side plate 5, with the positions of the second contact points P2 coinciding with the positions of the first contact points P1, as viewed in the axial direction of the support shafts 15, 16 (the direction orthogonal to the sheet on which FIG. 7 is drawn). Thus, it is possible to suppress the working fluid from leaking from the high pressure-side to the low pressure-side while bypassing the first contact points P1, at an axial end portion of each of the gears 7, 8. Thus, it is possible to deliver stable pump performance.

[0032] The side plates 5, 6 are displaced toward the low pressure-side under the differential pressure. The displacement causes the outer peripheral surfaces of the disc portions 18, 19 of each of the side plates 5, 6 to form

contact points (second contact points P2) with respect to the inner peripheral surfaces that define the cylindrical hole sections 21, 22 of the housing hole 2. The first distance D1 that is a distance between the central axes (first central axes C1) of the cylindrical hole sections 21, 22 of the housing hole 2 is equal to the second distance D2 that is a distance between the central axes (second central axes C2) of the disc portions 18, 19 of each side plate 5, 6 ($D1 = D2$). Thus, the straight lines (first straight lines L1) connecting the second contact points P2 to the central axes (first central axes C1) of the disc portions 18, 19 corresponding to the second contact points P2 are orthogonal to the straight line (second straight line) connecting the central axes (second central axes C2) of the cylindrical hole sections 21, 22 of the housing hole 2. That is, the second contact points P2 are formed on the inner peripheral surface 2a at positions closest to the low-pressure chamber 31 in the direction (orthogonal direction V) orthogonal to the second straight line L2.

[0033] Consequently, even when the positions of the second contact points P2 vary in the circumferential direction of the cylindrical hole section 21, 22 due to variations in the actual dimensions of the housing 3 and the side plates 5, 6 with respect to the dimensional tolerances thereof, the variations in the positions of the second contact points P2 in the direction (orthogonal direction V) orthogonal to the second straight line L2 can be kept small. Thus, the displacement of the side plates 5, 6 that are displaced under the differential pressure and the displacement of the gears 7, 8 supported by the side plates 5, 6 can be kept substantially constant. As a result, it is possible to suppress variations in the performance.

[0034] Geometric analysis was performed on Example 1 in which a condition 1 ($D1 = D2$) was satisfied and on Example 2 in which a condition 2 (the side plates 5, 6 cover the first contact points P1) was satisfied but the condition 1 was not satisfied. FIG. 8 is a schematic view illustrating a comparison in a variation state of the position of the second contact point P2 between Example 1 and Example 2. As illustrated in FIG. 8, in Example 1, ΔYa is a distance (variation amount) between a position P2a and a position P2b in the orthogonal direction when the position of the second contact point P2 varies within a circumferential length ΔX in the circumferential direction of the cylindrical hole section 21 (22) between the position P2a and the position P2b due to variations in the actual dimensions of the components with respect to the dimensional tolerances thereof.

[0035] In the gear pump in Example 2 in which the condition 2 that the first distance D1 is equal to the second distance D2 ($D1 = D2$) is not satisfied, ΔYc is a distance (variation amount) between a position P2c and a position P2d in the orthogonal direction V when the position of the second contact point P2 varies within the circumferential length ΔX in the circumferential direction of the cylindrical hole section 21 (22) between the position P2c and the position P2d. The variation amount ΔYa in the orthogonal direction V in Example 1 is considerably

smaller than the variation amount ΔY_c in the orthogonal direction V in Example 2 ($\Delta Y_a < \Delta Y_c$). Thus, even when the positions of the second contact points P2 vary in the circumferential direction of the cylindrical hole sections 21, 22 due to variations in the actual dimensions of the components with respect to the dimensional tolerances thereof, the variation in the position of each second contact point P2 in the orthogonal direction V in Example 1 is considerably smaller than that in Example 2. Thus, in Example 1, variations in the performance are considered to be further reliably suppressed.

[0036] The invention is not limited to the above-described embodiment. Although not illustrated in the drawings, only the positions of the first contact points P1 may be adjusted by adjusting the directions of the resultant forces G such that the axial ends of the first contact points P1 of the gears 7, 8 are covered with the side plate 5, 6 having the second contact points P2 at any positions, such as positions offset, in the circumferential direction of the cylindrical hole sections 21, 22, from the positions of the second contact points P2 with which the first straight lines are orthogonal to the second straight line, for example, as illustrated in FIG. 5A.

[0037] Only the positions of the second contact points P2 may be adjusted by adjusting the second distance D2 with respect to the first distance D1, so that the axial ends of the first contact points P1 of the gears 7, 8 are covered with the side plates 5, 6.

Claims

1. A gear pump comprising:

a housing having a housing hole;
a pair of side plates disposed in the housing hole so as to face each other such that a gear chamber is defined between the side plates, each of the side plates having a pair of support holes;
and

a pair of gears disposed in the gear chamber so as to be meshed with each other, the gears being rotatably supported by the side plates via support shafts inserted into the support holes,
wherein

when the gear pump is viewed in an axial direction of each of the support shafts during rotation of the gears, a low-pressure chamber and a high-pressure chamber that is higher in pressure than the low-pressure chamber are defined inside the gear chamber, with a meshing position interposed between the low-pressure chamber and the high-pressure chamber, the meshing position being a position at which the gears are meshed with each other,

an addendum circle of each of the gears that are displaced under a differential pressure between the low-pressure chamber and the high-pres-

sure chamber forms a first contact point with respect to an inner peripheral surface that defines the housing hole in which the gears are housed, and

the first contact point is covered with the side plates that are displaced under the differential pressure.

2. The gear pump according to claim 1, wherein the housing hole includes a pair of cylindrical hole sections in which the gears are respectively housed, each of the side plates includes a pair of disc portions respectively fitted in the cylindrical hole sections, and a first distance and a second distance are equal to each other, the first distance being a distance between central axes of the cylindrical hole sections of the housing hole, and the second distance being a distance between central axes of the disc portions of each of the side plates.

FIG.1

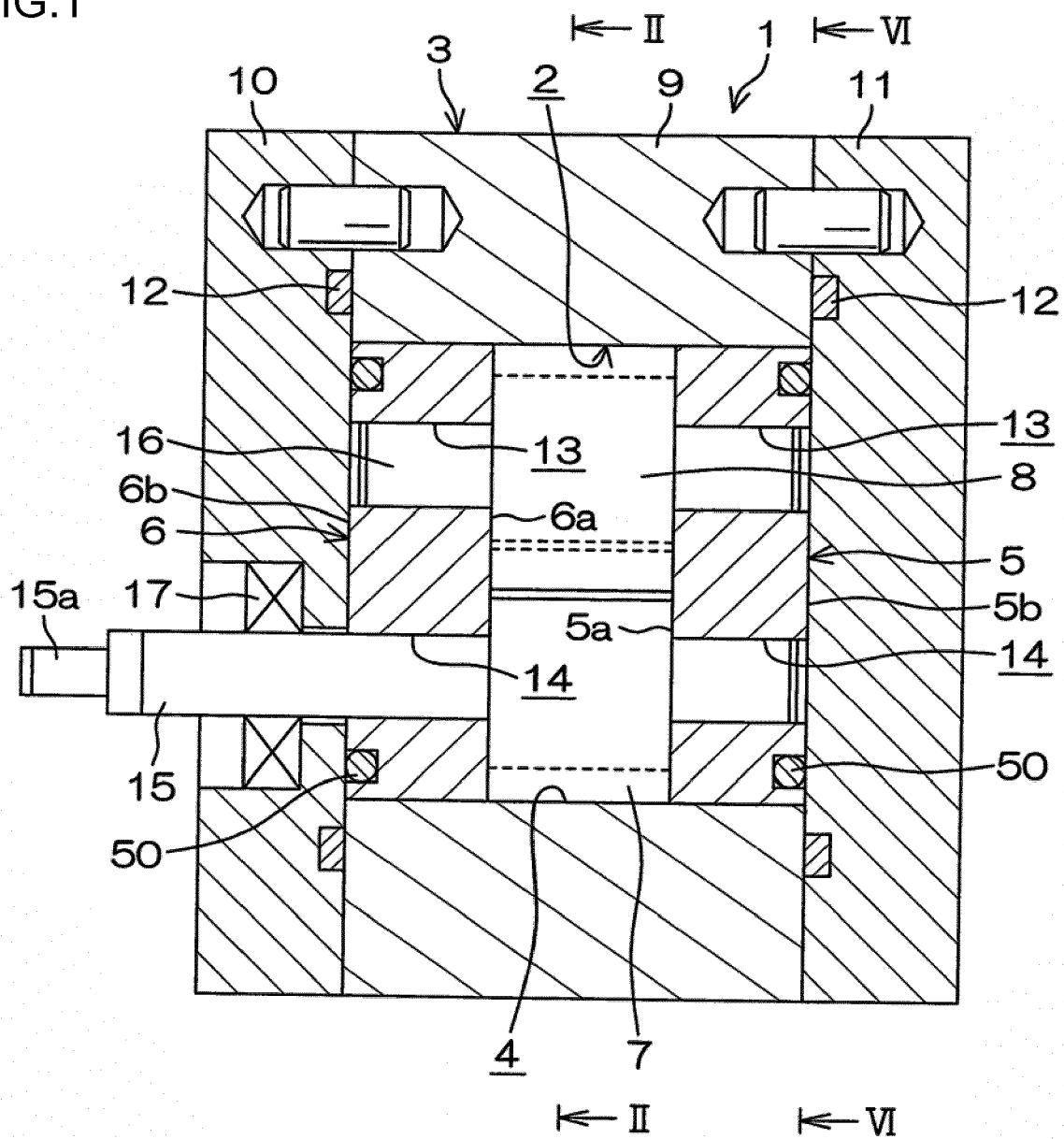


FIG.2

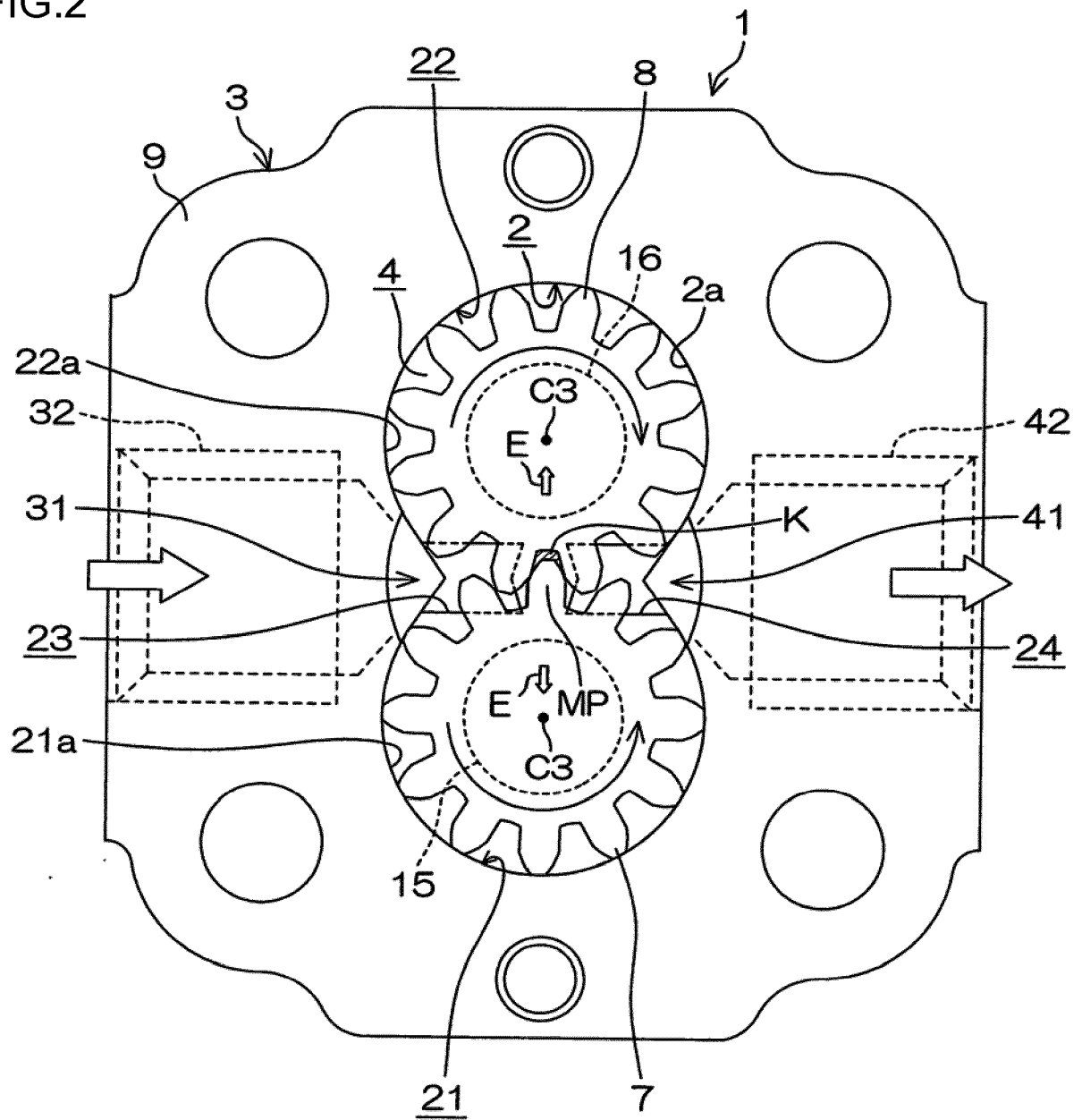


FIG.3

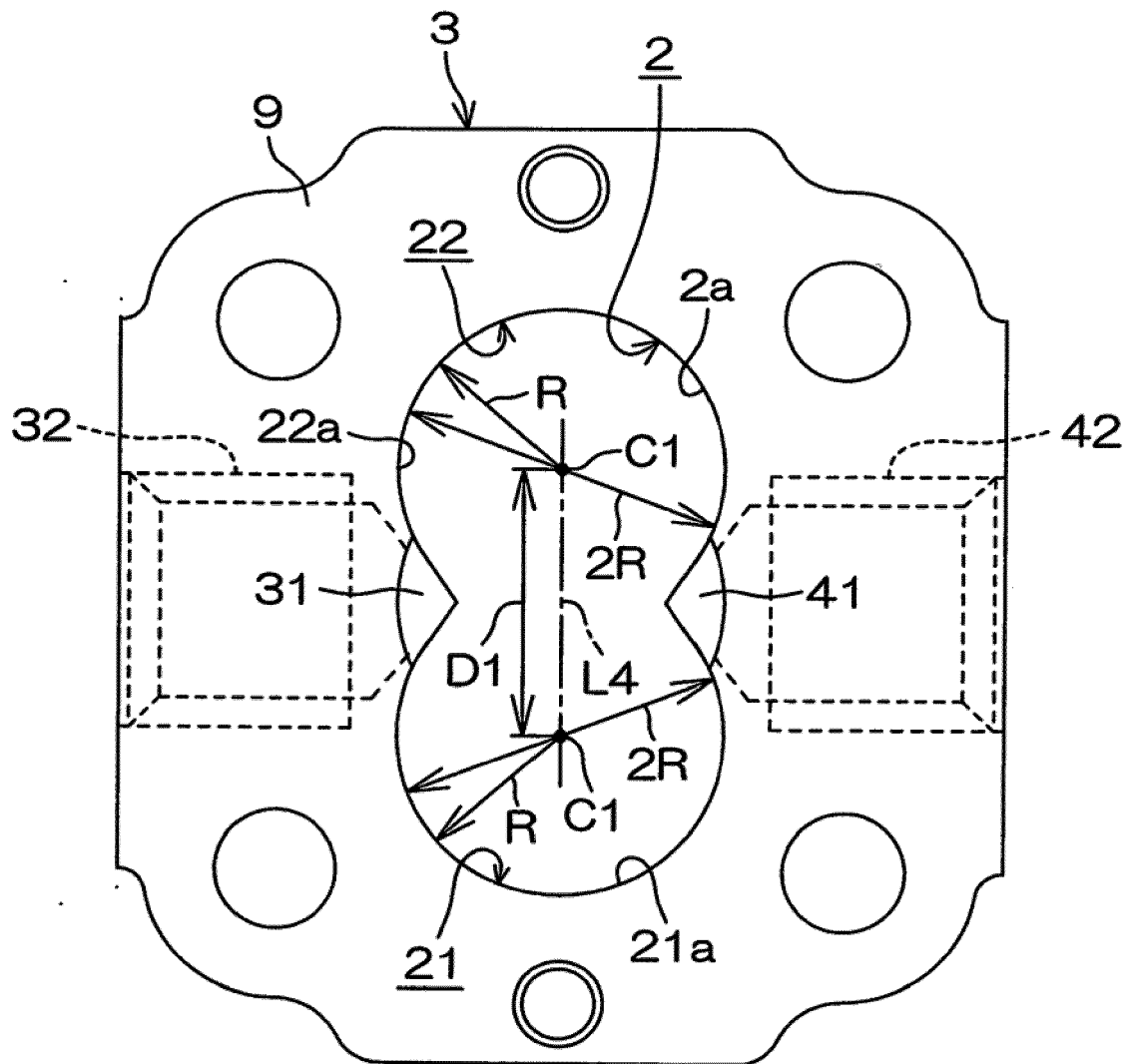


FIG.4

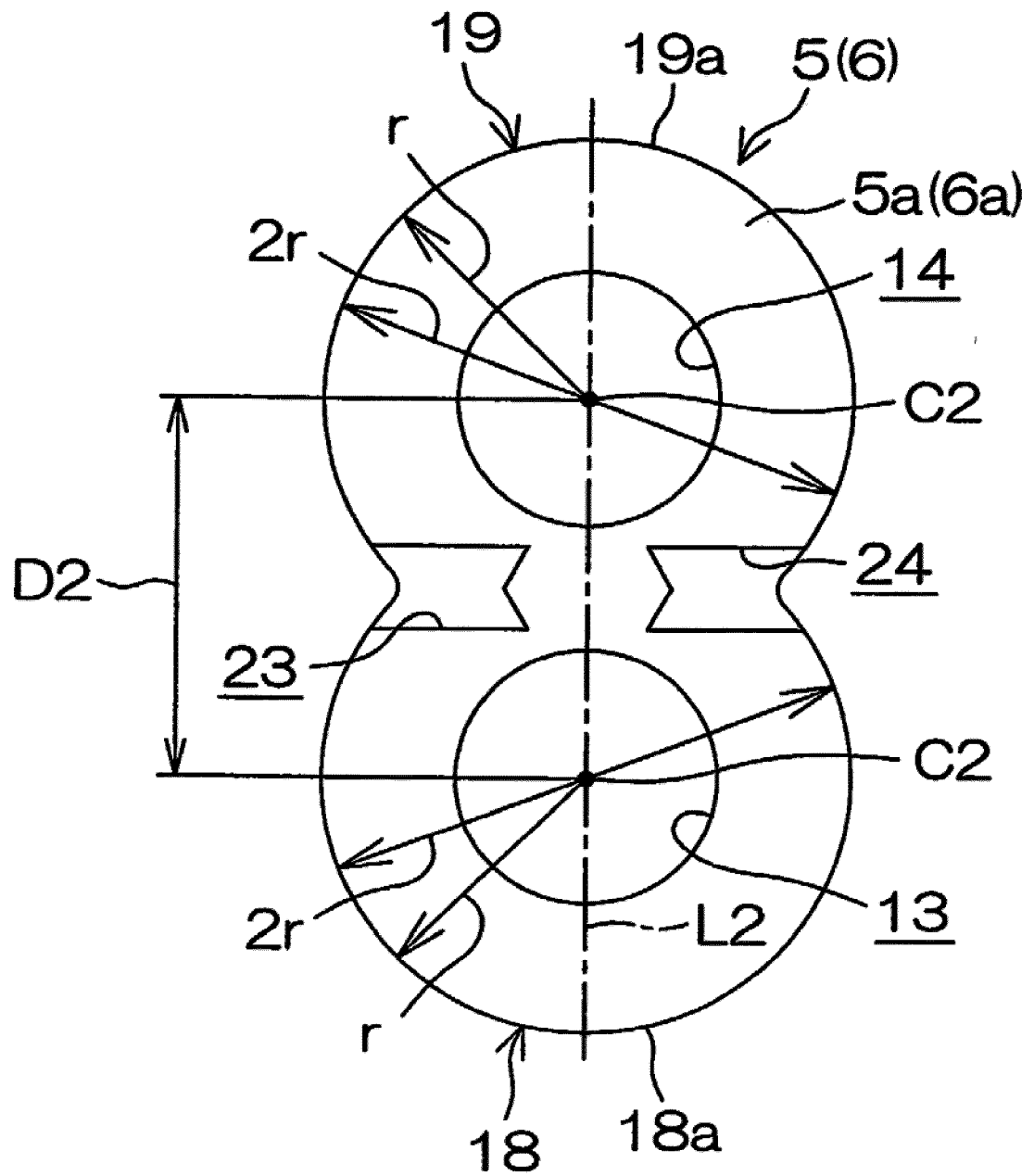


FIG.5A

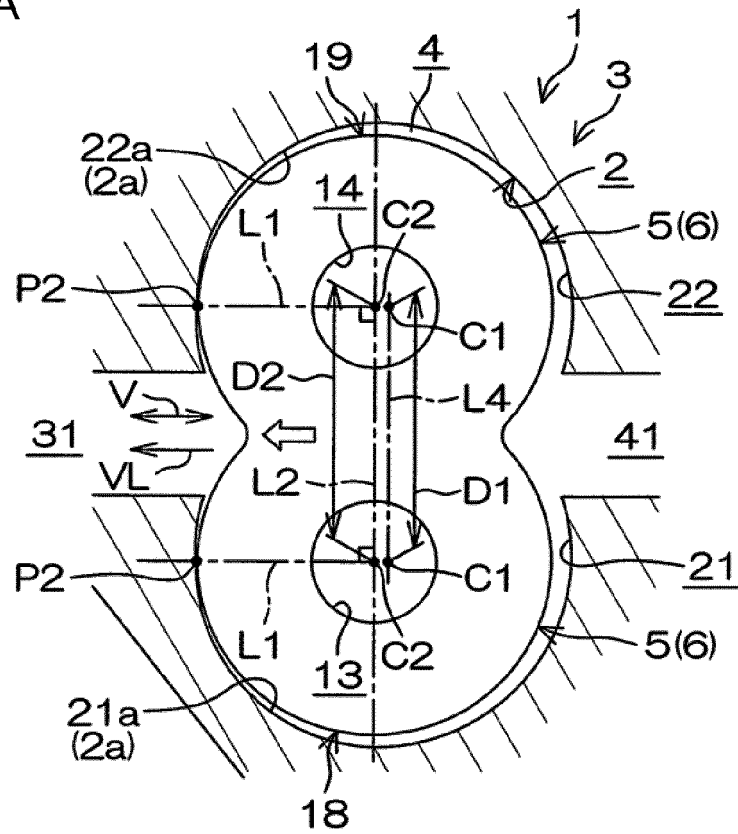


FIG.5B

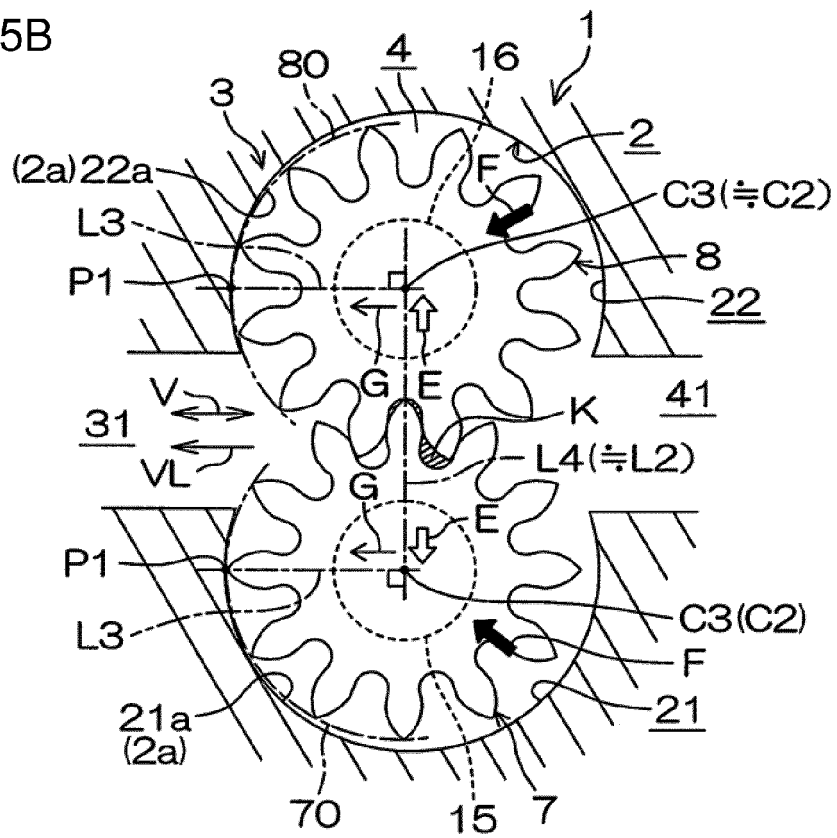


FIG.6

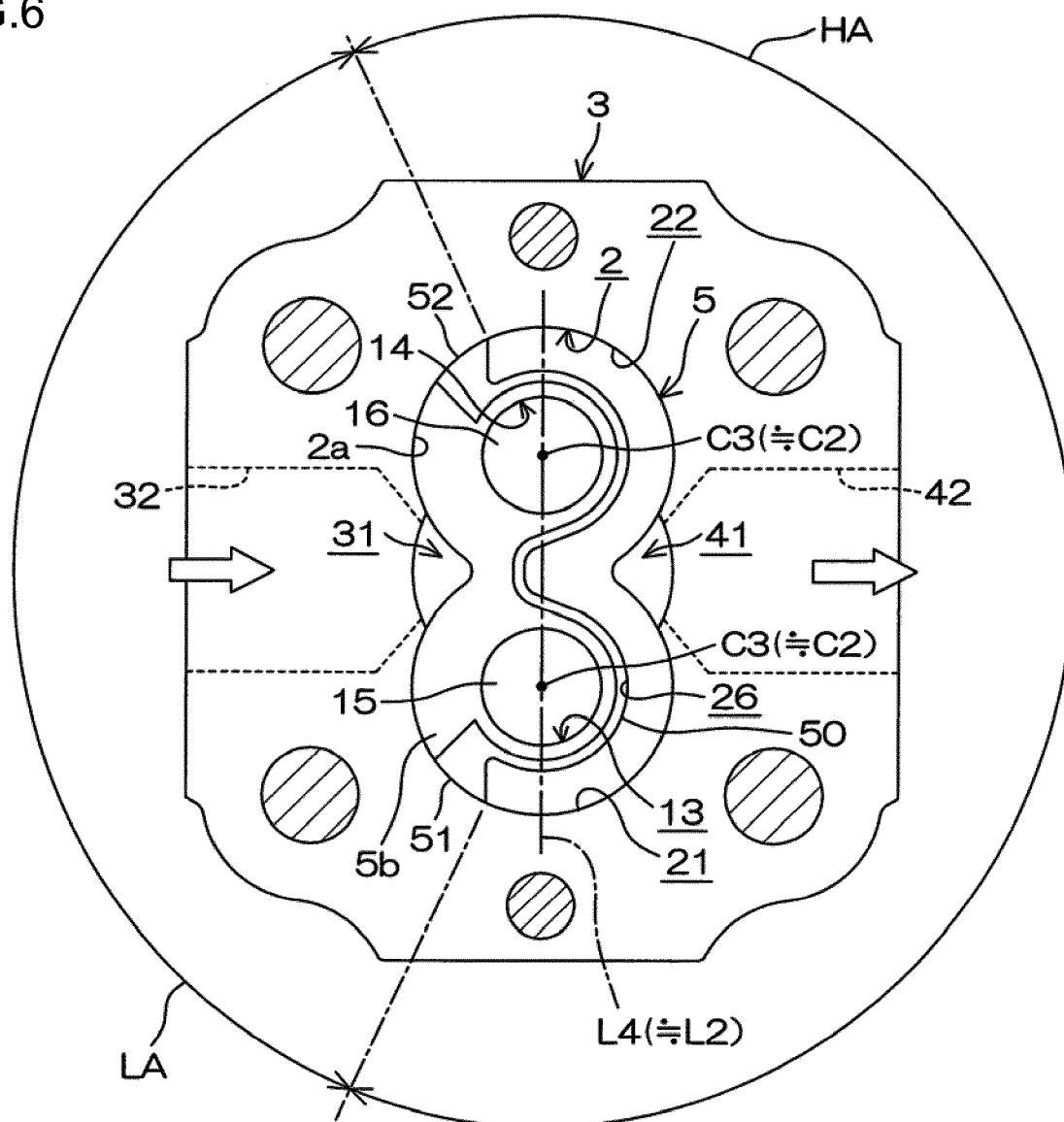


FIG.7

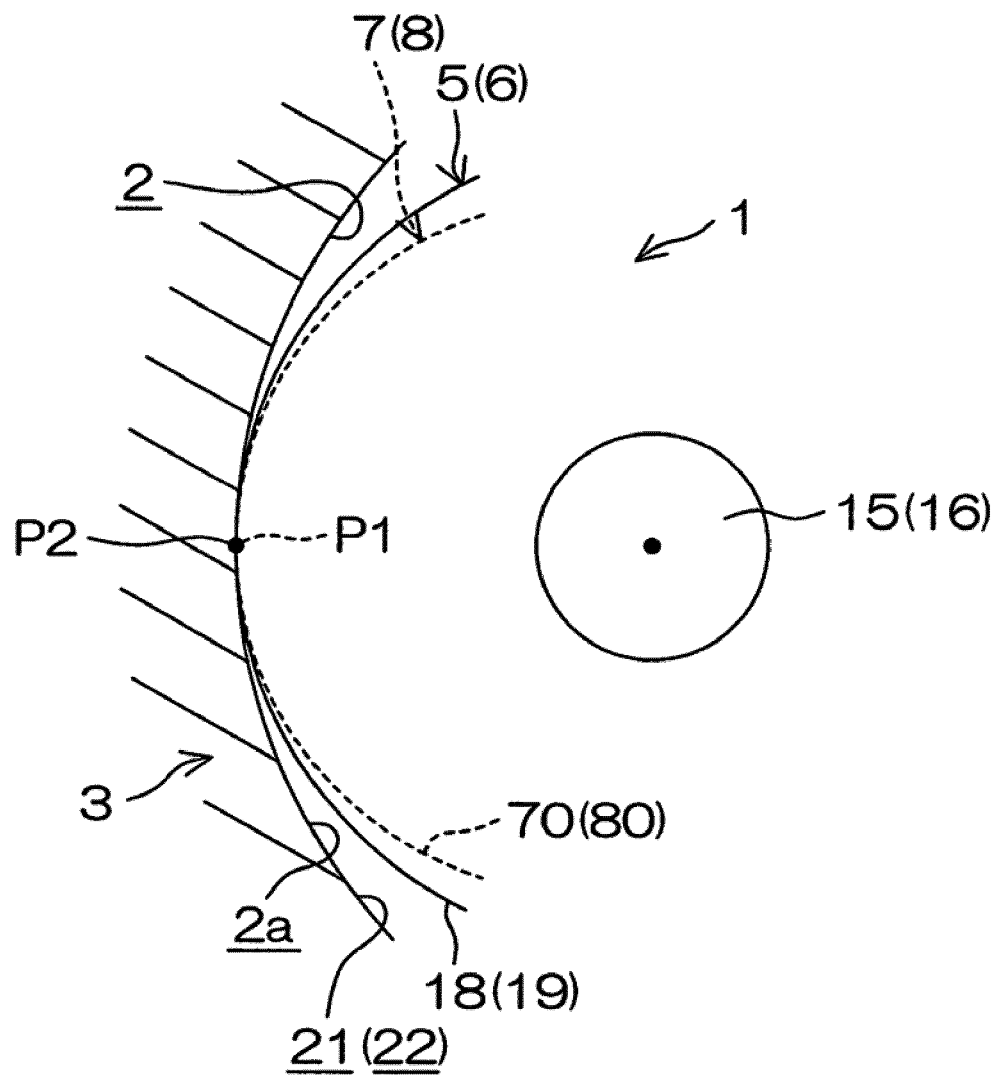


FIG.8

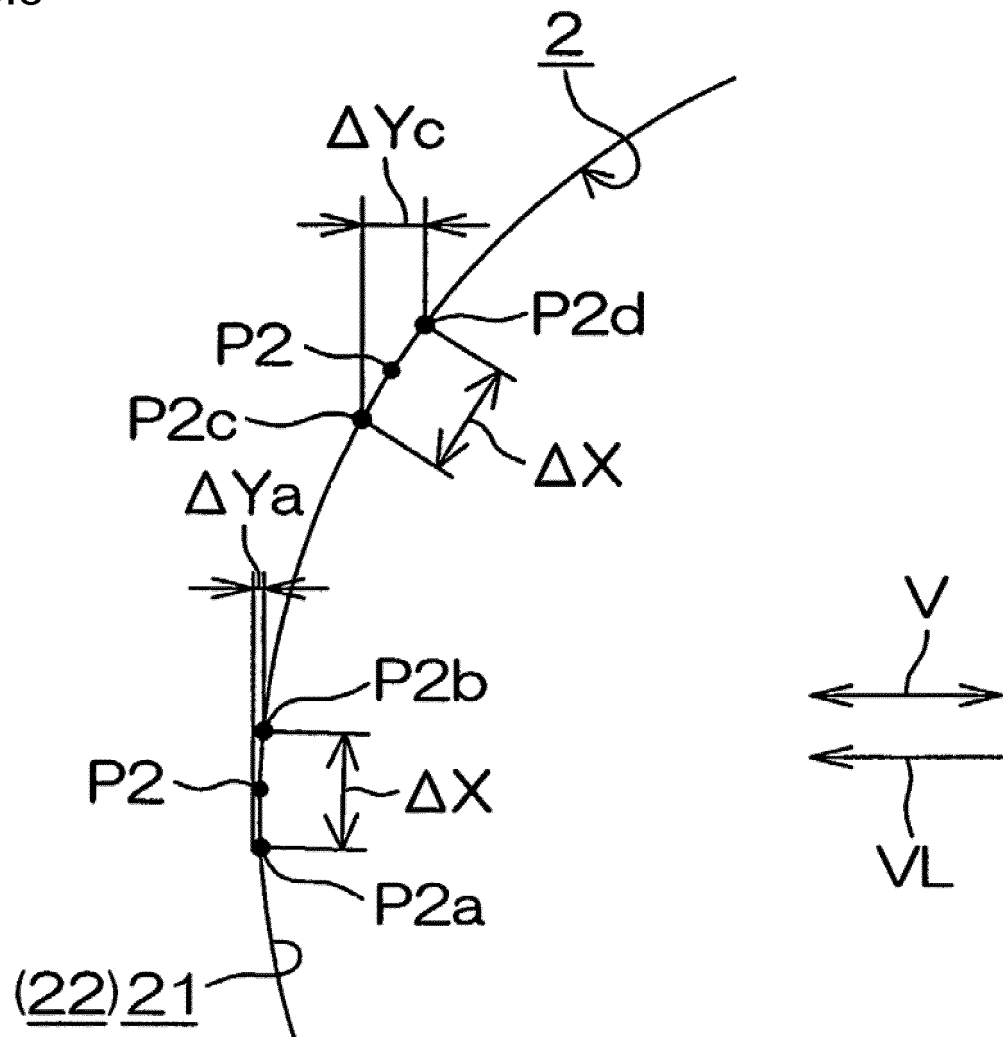
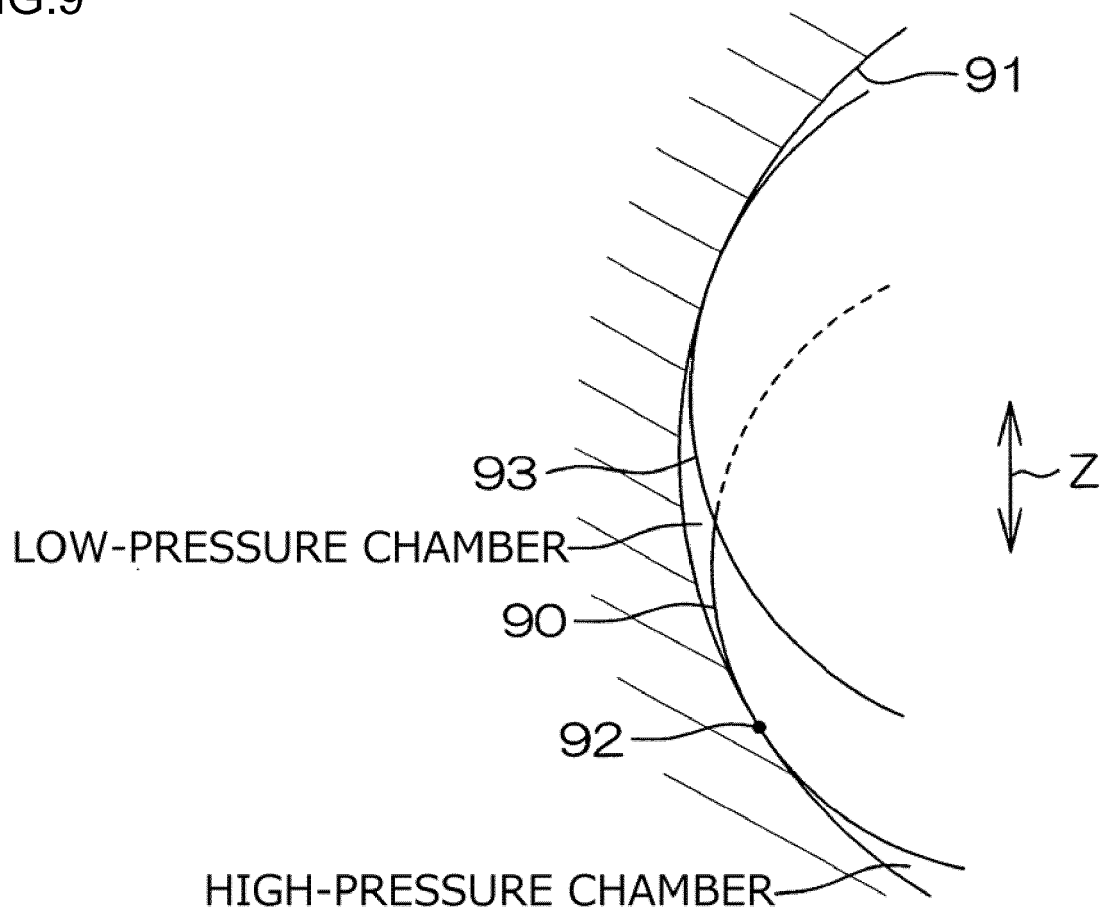


FIG.9





EUROPEAN SEARCH REPORT

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			F04C
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 13 September 2017	Examiner Bocage, Stéphane
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5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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