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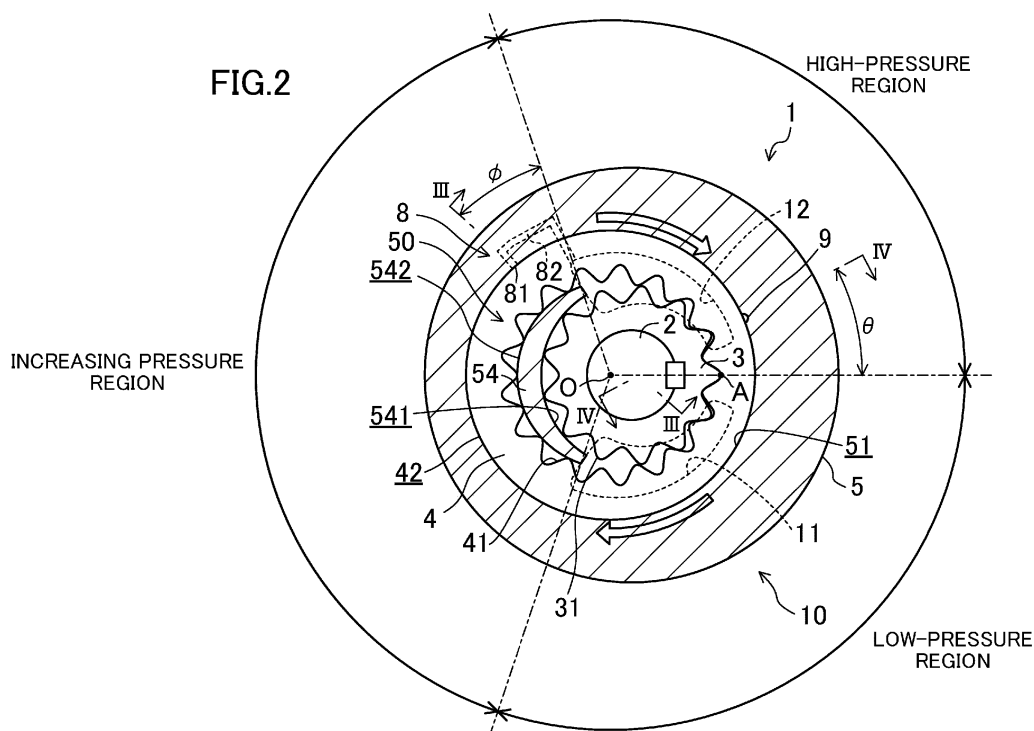
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(54) **INTERNAL GEAR PUMP**

(57) An internal gear pump (1) includes: a pinion gear (3); a ring gear (4); a housing (5) including a crescent (54) and a slide surface (51) on which an outer circumferential surface (41) of the ring gear slides; a high-pressure oil supply (8) having an introduction port (81) open to the slide surface to supply high-pressure hydraulic oil;

and a recess (9) in the slide surface so as to increase the distance between the outer circumferential surface of the ring gear and the slide surface. The introduction port is located in the increasing pressure region, whereas the recess is located in the high-pressure region.



Description

CITATION LIST

TECHNICAL FIELD

PATENT DOCUMENTS

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

5 **[0006]**

BACKGROUND ART

Patent Document 1: Japanese Unexamined Utility Model Application Publication No. S61-179385
 Patent Document 2: Japanese Unexamined Patent Publication No. H07-151066
 Patent Document 3: Japanese Unexamined Utility Model Application Publication No. S62-158181

[0002] Patent Document 1 discloses an internal gear pump including a driving gear with external teeth and a driven gear with internal teeth. The internal gear pump according to Patent Document 1 also includes a pocket in a circumferential surface of a pump housing on a side opposite to a meshing point between the driving and driven gears. The pocket communicates with a discharge port of the internal gear pump. In an operation of the internal gear pump, part of high-pressure hydraulic oil discharged from the discharge port is introduced through the pocket into the gap between the driven gear and the housing.

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SUMMARY OF THE INVENTION

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TECHNICAL PROBLEM

[0003] A crescent-shaped space is formed between the driven gear and the drive gear. The crescent-shaped space is sealed by the abutting teeth of the driving and driven gears. The high-pressure hydraulic oil discharged from the pocket pushes the driven gear so as to press the tooth tips of the driven gear onto the tooth tips of the driving gear. This configuration reduces leakage of the hydraulic oil inside the crescent space from the gaps between the tooth tips of the driving and driven gears.

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[0007] As described in Patent Documents 1 and 2, the internal gear pump supplies the high-pressure hydraulic oil to the gap between the outer circumferential surface of the ring gear and the inner circumferential surface of the housing. In a low-speed operation, the internal gear pump reduces leakage of the hydraulic oil from the gaps between the external teeth of the pinion gear and the internal teeth of the ring gear in an increasing pressure region in which the internal and external teeth are apart from each other. In addition, the internal gear pump with the configuration described above has a smaller gap between the outer circumferential surface of the ring gear and the inner circumferential surface of the housing in a high-pressure region. This configuration reduces the leakage of the hydraulic oil from the high-pressure region to a low-pressure region in which a suction port is open.

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[0004] Patent Document 2 also describes an internal gear pump that reduces leakage of hydraulic oil in a housing. The internal gear pump according to Patent Document 2 has an oil groove in the inner circumferential surface of the housing. The oil groove communicates with a discharge port and extends in the circumferential direction to a position corresponding to the crescent space. In an operation of the internal gear pump, high-pressure hydraulic oil introduced through the oil groove into the housing pushes an outer rotor. This configuration reduces leakage of the hydraulic oil from the gaps between the internal teeth of the outer rotor and the external teeth of an inner rotor.

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[0008] However, the present inventor found that an increasing amount of hydraulic oil inside the housing leaked in a high-speed operation of the internal gear pump with the configuration described above.

[0009] The present disclosure reduces leakage of hydraulic oil inside a housing of an internal gear pump.

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SOLUTION TO THE PROBLEM

[0005] An internal gear pump described in Patent Document 3 includes two pressure balance grooves in the inner circumferential surface of a housing. The two pressure balance grooves are spaced apart from each other in the circumferential direction in a high-pressure region in which a discharge port is open. Each of the two pressure balance grooves is connected to the discharge port. In an operation of the internal gear pump, high-pressure hydraulic oil is supplied through each of the two pressure balance grooves into the gap between the outer circumferential surface of a ring gear and the inner circumferential surface of the housing. This configuration allows the ring gear in a floating state to rotate with respect to the housing and thus reduces the seizure of the ring gear.

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[0010] Assume that the ring gear is pushed and moved from the outer periphery of the increasing pressure region to the rotation center of the ring gear by the high-pressure hydraulic oil supplied to the gap between the outer circumferential surface of the ring gear and the inner circumferential surface of the housing. This reduces the gap between the outer circumferential surface of the ring gear and the inner circumferential surface of the housing in the high-pressure region as described above. In an operation of the internal gear pump, what is called a "wedge effect" occurs at the gap between the outer circumferential surface of the ring gear and the inner circumferential surface of the housing in accordance with the rotation of the ring gear. Note that the "wedge effect" is the following phenomenon. In accordance with the rotation of the ring gear, the hydraulic oil is drawn to the

small gap between the outer circumferential surface of the ring gear and the inner circumferential surface of the housing, which increases the pressure of an oil film formed between the outer circumferential surface of the ring gear and the inner circumferential surface of the housing.

[0011] In a low-speed operation of the internal gear pump, since the "wedge effect" is low, the gap between the outer circumferential surface of the ring gear and the inner circumferential surface of the housing is small in the high-pressure region, which reduces the leakage of the hydraulic oil.

[0012] The present inventor found that, in a high-speed operation of the internal gear pump, the wedge effect increases at the gap between the outer circumferential surface of the ring gear and the inner circumferential surface of the housing to push and move the ring gear from the outer periphery of the high-pressure region to the rotation center of the ring gear. Once the ring gear is pushed and moved from the outer periphery of the high-pressure region to the rotation center of the ring gear due to the wedge effect, the gap increases between the outer circumferential surface of the ring gear and the inner circumferential surface of the housing in the high-pressure region. This increases the leakage of the hydraulic oil from the gap between the outer circumferential surface of the ring gear and the inner circumferential surface of the housing. In the increasing pressure region as well, an increasing amount of hydraulic oil leaks out of the gaps between the external teeth of the pinion gear and the internal teeth of the ring gear.

[0013] From the finding described above, the present inventor decided to partially increase the distance between the outer circumferential surface of the ring gear and the inner circumferential surface of the housing to reduce the wedge effect. The present inventor confirmed that the recess in a specific position in the inner circumferential surface of the housing reduced the leakage of the hydraulic oil inside the housing of the internal gear pump operating at a high speed, and completed the technique disclosed herein.

[0014] Specifically, an internal gear pump according to the present disclosure includes: a pinion gear having external teeth; a ring gear having, on an inner circumferential surface thereof, internal teeth that mesh with the external teeth; a crescent in a position in which the pinion gear and the ring gear are disengaged from each other, the external teeth and the internal teeth abutting on the crescent; a housing having a slide surface on which an outer circumferential surface of the ring gear slides and rotatably housing the pinion gear and the ring gear; a high-pressure oil supply that has an introduction port open to the slide surface and is configured to supply high-pressure hydraulic oil through the introduction port to a gap between the outer circumferential surface of the ring gear and the slide surface; and a recess in the slide surface so as to increase a distance between the outer circumferential surface of the ring gear and the slide surface.

face.

[0015] A space inside the housing is divided into three regions of: a low-pressure region in which a suction port is open, a high-pressure region in which a discharge port is open, and an increasing pressure region including the crescent. The introduction port is located in the increasing pressure region, whereas the recess is located in the high-pressure region.

[0016] According to this configuration, the pinion gear and the ring gear rotate from the low-pressure region through the increasing pressure region to the high-pressure region.

[0017] In an operation of the internal gear pump, high-pressure hydraulic oil is introduced from the introduction port in the increasing pressure region into the gap between the outer circumferential surface of the ring gear and the slide surface of the housing. The high-pressure hydraulic oil pushes and moves the ring gear from the outer periphery of the increasing pressure region toward the rotation center of the ring gear and presses the internal teeth of the ring gear onto the crescent. In the increasing pressure region, less hydraulic oil leaks out of the gaps between the internal teeth of the ring gear and the crescent. In the high-pressure region, less hydraulic oil leaks out of the gap between the outer circumferential surface of the ring gear and the slide surface of the housing.

[0018] Since the ring gear is pushed from the outer periphery of the increasing pressure region toward the rotation center of the ring gear, the wedge effect occurs at the gap between the outer circumferential surface of the ring gear and the slide surface of the housing in the high-pressure region. In the high-pressure region, the slide surface has a recess. The recess partially increases the distance between the outer circumferential surface of the ring gear and the slide surface of the housing. The recess reduces the wedge effect.

[0019] Since the wedge effect decreases, the ring gear is not pushed and moved from the outer periphery of the high-pressure region toward the rotation center of the ring gear in a high-speed operation of the internal gear pump. As a result, in the high-pressure region, less hydraulic oil leaks out through the gap between the outer circumferential surface of the ring gear and the slide surface of the housing. In the increasing pressure region, less hydraulic oil leaks out of the gaps between the internal teeth of the ring gear and the crescent.

[0020] In a low-speed operation of the internal gear pump, the wedge effect does not increase. In the high-pressure region, less hydraulic oil thus leaks out through the gap between the outer circumferential surface of the ring gear and the slide surface of the housing. In the increasing pressure region, less hydraulic oil leaks out of the gaps between the internal teeth of the ring gear and the crescent.

[0021] The hydraulic oil introduced through the introduction port into the gap between the outer circumferential surface of the ring gear and the slide surface of the

housing also functions as lubricating oil between the ring gear and the housing. This reduces the seizure between the ring gear and the housing.

[0022] As described above, the heat generated inside the housing is reduced by reducing the leakage of the hydraulic oil inside the housing. This also reduces the seizure between the ring gear and the housing.

[0023] The recess may be in a shape of a groove.

[0024] The recess in the shape of the groove effectively reduces the wedge effect. The groove-shaped recess is easily formed in the slide surface of the housing.

[0025] The recess may not be connected to the discharge port.

[0026] As described above, the recess functions to reduce the wedge effect by increasing the distance between the outer circumferential surface of the ring gear and the slide surface of the housing. The recess does not necessarily function to introduce high-pressure hydraulic fluid into the housing.

[0027] Assume that high-pressure hydraulic oil is introduced through the recess into the housing. The ring gear is then pushed from the outer periphery of the high-pressure region toward the rotation center of the ring gear by the high-pressure hydraulic oil introduced from the recess. This may also promote, in the high-pressure region, the leakage of the hydraulic oil through the gap between the outer circumferential surface of the ring gear and the slide surface of the housing. This may also promote, in the increasing pressure region, the leakage of the hydraulic oil from the gaps between the internal teeth of the ring gear and the crescent.

[0028] The introduction of the high-pressure hydraulic oil from the introduction port in the increasing pressure region is combined with the reduction in the wedge effect using the recess in the high-pressure region. This combination reduces both the leakage of the hydraulic oil inside the housing and the seizure of the ring gear.

[0029] The high-pressure oil supply may include: an oil passage connecting the discharge port and the introduction port together; and a choke in the oil passage to reduce pressure of the hydraulic oil.

[0030] If the hydraulic oil introduced through the introduction port into the housing has a too high pressure, the tooth tips of the ring gear are strongly pressed onto the crescent. The wear of the teeth of the ring gear easily progresses. The pressure of the hydraulic oil introduced into the housing may be adjusted by a choke provided in the oil passage.

[0031] The adjustment of the pressure of the hydraulic oil introduced into the housing is combined with the reduction in the wedge effect using the recess. This combination reduces the leakage of the hydraulic oil inside the housing and provides reliable lubricity between the ring gear and the housing in a well-balanced manner.

[0032] A lubricating coating may be applied on the outer circumferential surface of the ring gear.

[0033] Accordingly, the seizure between the ring gear and the housing decreases. Processed at a relatively low

processing accuracy with no lubricating coating applied on the outer circumferential surface of a ring gear, typical internal gear pumps need to have the following configuration. As described in Patent Document 3, the hydraulic oil needs to be introduced through the two balance grooves into the housing to reduce the seizure between the ring gear and the housing.

[0034] By contrast, the present internal gear pump can be processed at a higher processing accuracy with the lubricating coating applied on the outer circumferential surface of the ring gear. This configuration reduces the seizure between the ring gear and the housing without introducing the hydraulic oil through two balance grooves into the housing.

ADVANTAGE OF THE INVENTION

[0035] The internal gear pump described above reduces leakage of hydraulic oil inside the housing.

BRIEF DESCRIPTION OF THE DRAWINGS

[0036]

FIG. 1 is a cross-sectional view of an internal gear pump.

FIG. 2 is an end view taken along line II-II in FIG. 1. FIG. 3 is a cross-sectional view taken along line III-III in FIG. 2 and a view on arrow A.

FIG. 4 is a cross-sectional view taken along line IV-IV in FIG. 2 and a view on arrow B.

FIG. 5 is an enlarged cross-sectional view of meshing between a pinion gear and a ring gear in an operation of the internal gear pump.

FIG. 6 is a cross-sectional view showing a configuration of a high-pressure oil supply different from that in FIG. 3 and a view on arrow C.

DESCRIPTION OF EMBODIMENT

[0037] Now, an embodiment of an internal gear pump 1 will be described with reference to the drawings. The following description is an example of the internal gear pump 1.

(Overall Configuration of Internal Gear Pump)

[0038] FIG. 1 is a cross-sectional view of the internal gear pump 1. FIG. 2 is an end view taken along line II-II in FIG. 1. The internal gear pump 1 includes a shaft 2, a pinion gear 3, a ring gear 4, a gear housing 5, a front cover 6, and a rear cover 7. In FIG. 2, the end surfaces of the shaft 2, the pinion gear 3, and the ring gear 4 are not hatched for easier understanding.

[0039] The shaft 2 extends in left-and-right direction in the drawing plane of FIG. 1. The shaft 2 is connected to a prime mover (not shown). The prime mover is an electric motor, for example.

[0040] The pinion gear 3 is fixed to the shaft 2. The pinion gear 3 and the shaft 2 are coaxial. The pinion gear 3 rotates together with the shaft 2. The pinion gear 3 has external teeth 31.

[0041] The ring gear 4 meshes with the pinion gear 3. The ring gear 4 is eccentric with respect to the shaft 2. The ring gear 4 has, on its inner circumferential surface, internal teeth 41. In the right region of the drawing plane of FIG. 2, some of the external teeth 31 of the pinion gear 3 mesh with some of the internal teeth 41 of the ring gear 4. Although not shown in the drawings, a lubricating coating is applied on the outer circumferential surface 42 of the ring gear 4. The lubricating coating may be made of a material containing an inorganic material and a fluorine-based resin, for example.

[0042] The gear housing 5 houses the pinion gear 3 and the ring gear 4. The gear housing 5 has a through-hole 53. The shaft 2 is located in the through-hole 53.

[0043] The pinion gear 3 and the ring gear 4 are rotatably housed in the gear housing 5. The gear housing 5 has a slide surface 51 on which the outer circumferential surface 42 of the ring gear 4 slides. The outer circumferential surface 42 of the ring gear 4 has a circular transverse section. The slide surface 51 of the gear housing 5 also has a circular transverse section. The slide surface 51 is eccentric with respect to the shaft 2.

[0044] The gear housing 5 has a side surface 52 perpendicular to the slide surface 51. The slide surface 51 and the side surface 52 define a space 50 that houses the pinion gear 3 and the ring gear 4. The space 50 is open to the left of the drawing plane of FIG. 1. Each of a first side surface (i.e., the right side surface in FIG. 1) 32 of the pinion gear 3 and a first side surface (i.e., the right side surface in FIG. 1) 43 of the ring gear 4 slides on the side surface 52 of the gear housing 5.

[0045] The front cover 6 is adjacent to the gear housing 5. The front cover 6 is in contact with the gear housing 5 and has a side surface 61 that closes the space 50. Each of a second side surface (i.e., the left side surface in FIG. 1) 33 of the pinion gear 3 and a second side surface (i.e., the left side surface in FIG. 1) 44 of the ring gear 4 slide on the side surface 61 of the front cover 6. The front cover 6 has a bearing member support hole 62 through which the shaft 2 passes. The shaft 2 is supported by the front cover 6 via a bearing 63 and bearing members 64 and 64.

[0046] The rear cover 7 is located opposite to the front cover 6 with the gear housing 5 interposed therebetween. The front cover 6, the gear housing 5, and the rear cover 7 are fixed to each other to be integral. The front cover 6, the gear housing 5, and the rear cover 7 define a housing 10 of the internal gear pump 1.

[0047] Each of the front cover 6 and the gear housing 5 has a suction port 11 through which hydraulic oil is sucked into the space 50, in other words, into the housing 10. As shown in FIG. 1, the inlet of the suction port 11 is open to the outer circumferential surface of the front cover 6. The outlets of the suction port 11 are open to the side surface 61 of the front cover 6 and the side surface 52

of the gear housing 5. As shown in FIG. 2, the outlet of the suction port 11 extends in the circumferential direction in which the shaft 2 rotates.

[0048] Each of the front cover 6, the gear housing 5, and the rear cover 7 has a discharge port 12 through which hydraulic oil is discharged from the inside of the housing 10. As shown in FIG. 1, the outlet of the discharge port 12 is open to the outer circumferential surface of the rear cover 7. The orientations of the inlet of the suction port 11 and the outlet of the discharge port 12 may be the same as illustrated in FIG. 1, or may be different from each other although not shown.

[0049] The inlets of the discharge port 12 are open to the side surface 61 of the front cover 6 and the side surface 52 of the gear housing 5. As shown in FIG. 2, the inlet of the discharge port 12 extends in the circumferential direction in which the shaft 2 rotates on the side opposite to the suction port 11 with the shaft 2 interposed therebetween.

[0050] The gear housing 5 includes a crescent 54. The crescent 54 is placed in a position where the pinion gear 3 and the ring gear 4, which have been meshed with each other, are disengaged from each other. The crescent 54 separates a high-pressure region and a low-pressure region, which will be described later.

[0051] The crescent 54 extends in the circumferential direction over a predetermined angular range in the rotational direction of the shaft 2. More specifically, the crescent 54 has two arc surfaces, namely, a first arc surface 541 and a second arc surface 542, each of which stand on the side surface 52 of the gear housing 5 (see also FIG. 3). As shown in FIG. 2, the crescent 54 is in the shape of a crescent as viewed along the axis of the shaft 2. The tooth tips of the external teeth 31 of the pinion gear 3 abut on the first arc surface 541 of the crescent 54. The tooth tips of the internal teeth 41 of the ring gear 4 abut on the second arc surface 542 of the crescent 54.

[0052] Here, the inside of the housing 10 is divided into three regions, namely, low-, increasing, and high-pressure regions in the circumferential direction about the rotation center O of the ring gear 4. The suction port 11 is open in the low-pressure region. The crescent 54 is located in the increasing pressure region. The discharge port 12 is open in the high-pressure region.

[0053] Now, an operation of the internal gear pump 1 will be briefly described. Once the prime mover rotates the shaft 2 in the direction indicated by a white arrow in FIG. 2, the pinion gear 3 and the ring gear 4 rotate from the low-pressure region through the increasing pressure region to the high-pressure region.

[0054] In the low-pressure region inside the housing 10, with an increasing distance between the external teeth 31 of the pinion gear 3 and the internal teeth 41 of the ring gear 4, which have been meshed with each other, the hydraulic oil is sucked from the suction port 11 into the gaps between the external and internal teeth 31 and 41. In accordance with the rotation of the pinion gear 3 and the ring gear 4, the sucked hydraulic oil is carried

from the low-pressure region through the increasing pressure region to the high-pressure region.

[0055] In the high-pressure region inside the housing 10, the external teeth 31 of the pinion gear 3 and the internal teeth 41 of the ring gear 4, which have been apart from each other, gradually come closer to each other to mesh with each other. Accordingly, the hydraulic oil is discharged from the gaps between the external and internal teeth 31 and 41 through the discharge port 12.

(Configuration for Reducing Leakage of Hydraulic Oil inside Housing)

[0056] The internal gear pump 1 includes a high-pressure oil supply 8 that supplies high-pressure hydraulic oil to the gap between the outer circumferential surface 42 of the ring gear 4 and the slide surface 51 of the gear housing 5. FIG. 3 illustrates a configuration of the high-pressure oil supply 8. FIG. 3 corresponds to the cross section taken along line III-III in FIG. 2.

[0057] The high-pressure oil supply 8 pushes and moves the ring gear 4 from the outer periphery of the increasing pressure region toward the rotation center O of the ring gear 4 using the high-pressure hydraulic oil to reduce the leakage of the hydraulic oil inside the housing 10. The high-pressure oil supply 8 includes an introduction port 81 open to the slide surface 51, an oil passage 82 connecting the discharge port 12 and the introduction port 81 together, and a choke 83 in the oil passage 82.

[0058] As shown in FIG. 2, the introduction port 81 is located in the increasing pressure region. More specifically, the introduction port 81 is opposed to the crescent 54 in a radial direction. As will be described later, the introduction port 81 introduces part of the high-pressure hydraulic oil discharged from the discharge port 12 into the housing 10. Not to allow the high-pressure hydraulic oil introduced into the housing 10 to flow into the low-pressure region, the introduction port 81 is located from an intermediate position to a position closer to the high-pressure region in the increasing pressure region in one preferred embodiment. The introduction port 81 is located in the position closer to the high-pressure region and away from a line connecting the end point of the second arc surface 542 of the crescent 54 and the rotation center O at an angle ϕ of 10 to 40° in the circumferential direction in one more preferred embodiment. In order to effectively press the tooth tips of the ring gear 4 onto the crescent 54 using the high-pressure hydraulic oil introduced from the introduction port 81, the introduction port 81 faces the crescent 54 in one preferred embodiment.

[0059] As illustrated in FIG. 3, the introduction port 81 is located at the center or a substantial center of the slide surface 51 in the axial direction of the shaft 2. The opening of the introduction port 81 is in a circular shape in the configuration example of FIG. 3. Note that the opening of the introduction port 81 is not limited to a specific shape.

[0060] In the configuration example of FIG. 3, the oil

passage 82 is located inside the gear housing 5. The oil passage 82 connects the discharge port 12 open to the side surface 52 of the gear housing 5 to the introduction port 81. As virtually indicated by a chain line in FIG. 3, an oil passage may be provided in the front cover 6 and the gear housing 5 so as to connect the discharge port 12 in the front cover 6 to the introduction port 81. Alternatively, the oil passage may connect the discharge port 12 in the gear housing 5 to the introduction port 81, and the discharge port 12 in the front cover 6 to the introduction port 81.

[0061] The choke 83 reduces the cross-sectional area of the oil passage 82. The choke 83 may be an orifice or a choke. The pressure of the hydraulic oil flowing inside the oil passage 82 from the discharge port 12 toward the introduction port 81 is reduced by the choke 83. The pressure of the hydraulic oil introduced into the gear housing 5 through the introduction port 81 is lower than the pressure of the hydraulic oil discharged from the discharge port 12. The pressure of the hydraulic oil introduced into the gear housing 5 can be adjusted by changing the structure of the choke 83.

[0062] As described above, in an operation of the internal gear pump 1, part of the hydraulic oil discharged from the discharge port 12 is introduced through the oil passage 82 and the introduction port 81 to the gap between the outer circumferential surface of the ring gear 4 and the slide surface 51 of the gear housing 5. The high-pressure hydraulic oil pushes and moves the ring gear 4 from the outer periphery of the increasing pressure region toward the rotation center O. Accordingly, the tooth tips of the ring gear 4 are pressed onto the crescent 54, which reduces the leakage of the hydraulic oil through the gaps between the tooth tips of the ring gear 4 and the crescent 54 in the increasing pressure region. The leakage of the hydraulic oil through the gap between the outer circumferential surface of the ring gear 4 and the slide surface 51 of the gear housing 5 is also reduced in the high-pressure region. A reduction in the leakage inside the housing 10 improves the efficiency of the internal gear pump 1.

[0063] Here, the choke 83 arranged in the oil passage 82 reduces the pressure of the hydraulic oil introduced into the housing 10, which reduces the strong press of the tooth tips of the ring gear 4 onto the crescent 54. Accordingly, the wear of the tooth tips of the ring gear 4 is also reduced.

[0064] The hydraulic oil introduced into the gap between the outer circumferential surface 42 of the ring gear 4 and the slide surface 51 of the gear housing 5 also functions as lubricating oil between the outer circumferential surface 42 of the ring gear 4 and the slide surface 51 of the gear housing 5. Accordingly, the seizure between the ring gear 4 and the gear housing 5 is reduced. As described above, since the leakage inside the housing 10 is reduced, less heat is generated inside the housing 10. This also reduces the seizure between the ring gear 4 and the gear housing 5.

[0065] Further, the internal gear pump 1 has a recess 9. FIG. 4 illustrates a configuration of the recess 9. FIG. 4 corresponds to a cross section taken along line IV-IV in FIG. 2.

[0066] The recess 9 is located in the slide surface 51 of the gear housing 5. As enlarged in FIG. 5, the recess 9 is recessed radially outward from the slide surface 51. In FIG. 5, the size of the gap between the outer circumferential surface 42 of the ring gear 4 and the slide surface 51 of the gear housing 5 is exaggerated for easier understanding. The recess 9 partially increases the distance between the outer circumferential surface 42 of the ring gear 4 and the slide surface 51 of the gear housing 5 (see L in FIG. 5).

[0067] In the configuration example of FIG. 4, the recess 9 is in the shape of a groove extending along the axis of the shaft 2. The recess 9 may have a depth of about 1 to several millimeters, for example.

[0068] The shape of the recess 9 is not limited to the groove. As will be described later, the recess 9 only needs to function to reduce the wedge effect caused between the outer circumferential surface 42 of the ring gear 4 and the slide surface 51 of the gear housing 5. The recess 9 only needs to partially increase the distance between the outer circumferential surface 42 of the ring gear 4 and the slide surface 51 of the gear housing 5. Although not shown, the recess 9 may include, for example, a plurality of holes recessed from the slide surface 51. The recess 9 may be obtained by aligning a plurality of short grooves along the axis of the shaft 2. The recess 9 in the shape of a groove as shown in FIG. 4 is advantageous in being easily processed.

[0069] Only one recess 9 may be provided as shown in FIG. 4. Although not shown, a plurality of recesses 9 may be provided along the circumference of the slide surface 51.

[0070] As shown in FIG. 2, the recess 9 is located in the high-pressure region. As described above, the ring gear 4 is pushed and moved from the outer periphery of the increasing pressure region toward the rotation center O using the high-pressure hydraulic oil introduced from the introduction port 81 of the high-pressure oil supply 8. Since the gap between the outer circumferential surface 42 of the ring gear 4 and the slide surface 51 of the gear housing 5 decreases in the high-pressure region, a wedge effect occurs (see the arrow in FIG. 5). In the high-pressure region causing the wedge effect, the recess 9 is located near the position where the wedge effect largely occurs in one preferred embodiment. More specifically, as shown in FIG. 2, the recess 9 may be located in a position away from the meshing point A between the pinion gear 3 and the ring gear 4 in the circumferential direction at an angle θ of 10 to 40°. At a too large angle θ (i.e., a too large distance of the recess 9 from the meshing point A between the pinion gear 3 and the ring gear 4), the point causing a large wedge effect is apart and thus the function of reducing the wedge effect, which will be described later, works less. On the other hand, a too small

angle θ (i. e., a too small distance of the recess 9 from the meshing point A between the pinion gear 3 and the ring gear 4) may promote the leakage of the hydraulic oil through the gap between the outer circumferential surface 42 of the ring gear 4 and the slide surface 51 of the gear housing 5.

[0071] Since both of the pinion gear 3 and the ring gear 4 rotate together, the meshing point A between the gears 3 and 4 moves in the circumferential direction within a certain range. Here, the center point of the movable range is defined as the meshing point A (see FIG. 2).

[0072] Unlike the high-pressure oil supply 8, the recess 9 does not function to introduce the high-pressure hydraulic oil into the gear housing 5. The recess 9 is not connected to the discharge port 12.

[0073] The recess 9 provided in the slide surface 51 in the high-pressure region partially increases the distance between the outer circumferential surface 42 of the ring gear 4 and the slide surface 51 of the gear housing 5 and thus reduces the wedge effect. Since the wedge effect decreases, the ring gear 4 is not pushed and moved from the outer periphery of the high-pressure region toward the rotation center O at a high rotation speed of the internal gear pump 1. As a result, in the high-pressure region, less hydraulic oil leaks out through the gap between the outer circumferential surface 42 of the ring gear 4 and the slide surface 51 of the gear housing 5. At the same time, in the increasing pressure region, less hydraulic oil leaks out of the gaps between the internal teeth 41 of the ring gear 4 and the crescent 54. In a low-speed operation of the internal gear pump 1, the wedge effect is originally low. Accordingly, in the high-pressure region, less hydraulic oil leaks out through the gap between the outer circumferential surface 42 of the ring gear 4 and the slide surface 51 of the gear housing 5. At the same time, in the increasing pressure region, less hydraulic oil leaks out of the gaps between the internal teeth 41 of the ring gear 4 and the crescent 54.

[0074] As described above, the recess 9 is not connected to the discharge port 12 and does not function to introduce the high-pressure hydraulic oil. Assume that high-pressure hydraulic oil is introduced through the recess 9 into the housing 10. The ring gear 4 is then pushed from the outer periphery of the high-pressure region toward the rotation center O by the high-pressure hydraulic oil. This may promote, in the high-pressure region, the leakage of the hydraulic oil through the gap between the outer circumferential surface 42 of the ring gear 4 and the slide surface 51 of the gear housing 5. This may also promote, in the increasing pressure region, the leakage of the hydraulic oil from the gaps between the internal teeth 41 of the ring gear 4 and the crescent 54. The recess 9 not connected to the discharge port 12 reduces the leakage of the hydraulic oil inside the housing 10 of the internal gear pump 1.

[0075] Typical internal gear pumps are processed at a relatively low processing accuracy and no lubricating coating is applied on the outer circumferential surface of

a ring gear. This leads to employing the configuration in which High-pressure hydraulic oil is introduced from a plurality of introduction ports in a slide surface into a housing to reduce the seizure between the ring gear and the housing.

[0076] By contrast, the internal gear pump 1 according to the present disclosure can be processed at a relatively high processing accuracy and lubricating coating is applied on the outer circumferential surface 24 of the ring gear 4. The internal gear pump 1 reduces the seizure between the ring gear 4 and the gear housing 5 without employing the configuration of introducing the hydraulic oil through a plurality of introduction ports into the housing.

[0077] In this point of view, this internal gear pump 1 includes the introduction port 81 of the high-pressure oil supply 8 in the increasing pressure region to introduce the high-pressure hydraulic oil into the housing 10. On the other hand, the recess 9 into which no high-pressure hydraulic oil is introduced is provided in the high-pressure region. A combination of the high-pressure oil supply 8 and the recess 9 reduces the leakage of the hydraulic oil inside the housing 10, while reducing the seizure between the ring gear 4 and the gear housing 5. This internal gear pump 1 is highly reliable and highly efficient.

[0078] A lubricating coating may be applied on the slide surface 51 of the gear housing 5, or on both the outer circumferential surface 42 of the ring gear 4 and the slide surface 51 of the gear housing 5.

[0079] FIG. 6 shows a variation of the high-pressure oil supply. The high-pressure oil supply 80 shown in FIG. 6 includes an introduction port 810, an oil passage 820, and a choke 830. The introduction port 810 is different in shape from the introduction port 81 shown in FIG. 3, namely, in the shape of a groove. The introduction port 810 is open to the slide surface 51 and extends along the axis of the shaft 2. The introduction port 810 is also open to the surface of the gear housing 5 that abuts on the side surface 61 of the front cover 6.

[0080] In the configuration example of FIG. 6, the oil passage 820 is located in the front cover 6. Like the oil passage 82 described above, the oil passage 820 connects the discharge port 12 and the introduction port 810 together. In the configuration example of FIG. 6, the oil passage 820 extends along the axis of the shaft 2. The oil passage 820 is open to the side surface 61 of the front cover 6 and is connected to the opening of the introduction port 810. The choke 830 is located in an intermediate point of the oil passage 820.

[0081] Like the high-pressure oil supply 8 described above, the high-pressure oil supply 80 with this configuration also introduces high-pressure hydraulic oil into the housing 10 in the increasing pressure region. Accordingly, less hydraulic oil leaks out of the gaps between the tooth tips of the ring gear 4 and the crescent 54, and out of the gap between the outer circumferential surface 42 of the ring gear 4 and the slide surface 51 of the gear housing 5.

[0082] As indicated by a chain line in FIG. 6, the oil passage may be a recessed groove recessed from the surface of the front cover 6 in contact with the gear housing 5 and extends in the radial direction. Although not shown, the oil passage and the choke may be located in the gear housing 5.

[0083] The recess 9 is not connected to the discharge port 12. However, the recess 9 may be connected to the discharge port 12. However, in this case, the ring gear 4 is not pushed and moved from the outer periphery of the increasing pressure region toward the rotation center O by the hydraulic oil introduced through the recess 9 into the gap between the outer circumferential surface 42 of the ring gear 4 and the slide surface 51 of the gear housing 5 in one preferred embodiment.

[0084] Although the internal gear pump 1 illustrated here is of a fixed type where the crescent 54 is immovable, a movable crescent may be included. The technique disclosed herein is also applicable to an internal gear pump without any crescent. In the internal gear pump without any crescent, the combination of the high-pressure oil supply 8 and the recess 9 described above reduces the leakage of the hydraulic oil from the gaps between the tooth tips of the ring gear 4 and the pinion gear 3, and from the gap between the outer circumferential surface 42 of the ring gear 4 and the slide surface 51 of the gear housing 5, while reducing the seizure between the ring gear 4 and the gear housing 5.

[0085] Internal gear pumps of the type where a suction port or a discharge port is open to a slide surface originally have no wedge effect. Even if the technique disclosed herein is applied to this type of internal gear pumps, the advantage cannot be expected.

DESCRIPTION OF REFERENCE CHARACTERS

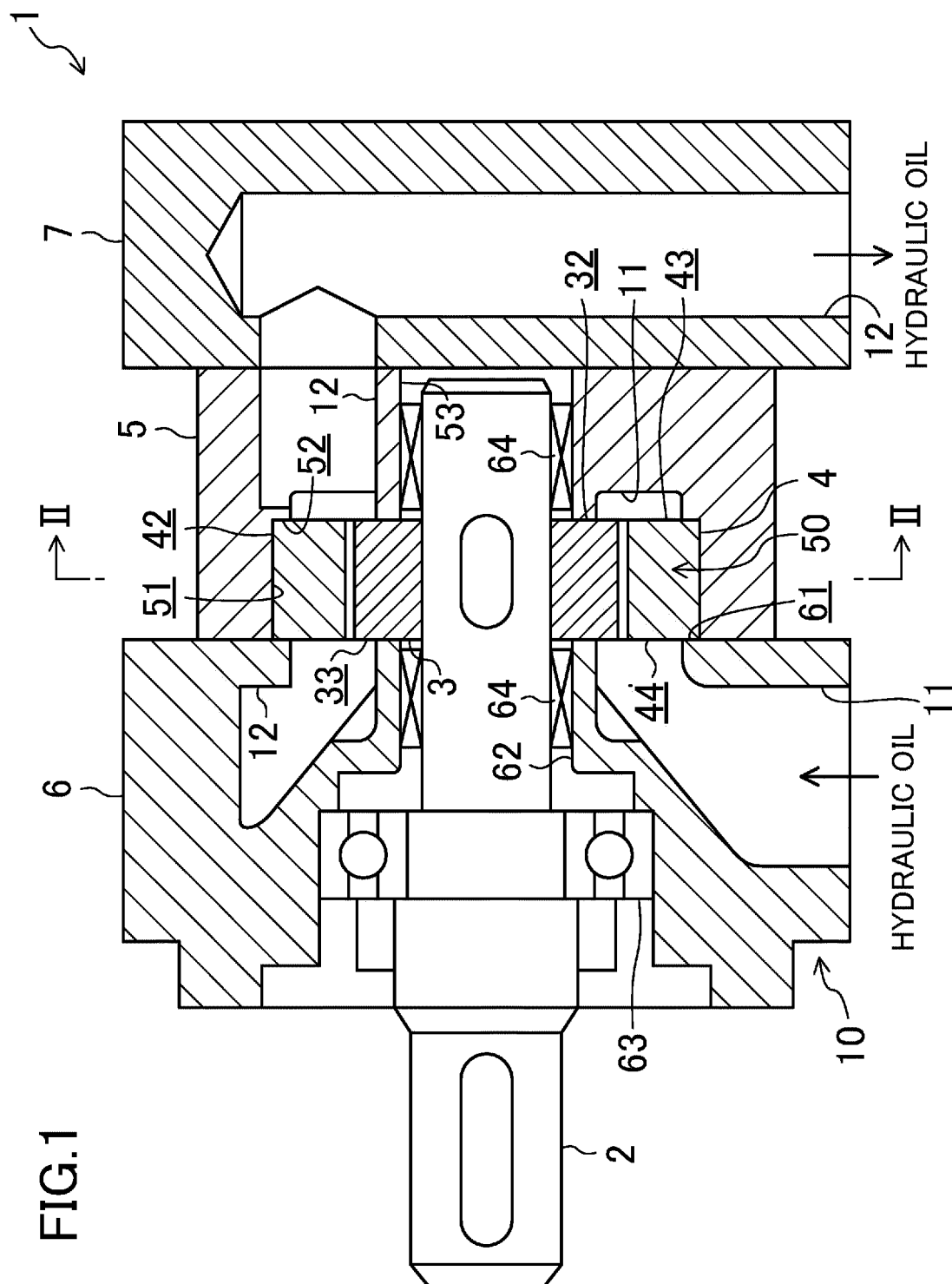
[0086]

1	Internal Gear Pump
10	Housing
3	Pinion Gear
31	External Teeth
4	Ring Gear
41	Internal Teeth
42	Outer Circumferential Surface
5	Gear Housing
51	Slide Surface
54	Crescent
6	Front Cover
7	Rear Cover
8	High-Pressure Oil Supply
80	High-Pressure Oil Supply
81	Introduction Port
810	Introduction Port
82	Oil Passage
820	Oil Passage
83	Choke
830	Choke

9 Recess

Claims

1. An internal gear pump comprising:
 - a pinion gear having external teeth;
 - a ring gear having, on an inner circumferential surface thereof, internal teeth that mesh with the external teeth;
 - a crescent in a position in which the pinion gear and the ring gear are disengaged from each other, the external teeth and the internal teeth abutting on the crescent;
 - a housing having a slide surface on which an outer circumferential surface of the ring gear slides and rotatably housing the pinion gear and the ring gear;
 - a high-pressure oil supply that has an introduction port open to the slide surface and is configured to supply high-pressure hydraulic oil through the introduction port to a gap between the outer circumferential surface of the ring gear and the slide surface; and
 - a recess in the slide surface so as to increase a distance between the outer circumferential surface of the ring gear and the slide surface, wherein
 - a space inside the housing is divided into three regions of: a low-pressure region in which a suction port is open, a high-pressure region in which a discharge port is open, and an increasing pressure region including the crescent,
 - the introduction port is located in the increasing pressure region, and
 - the recess is located in the high-pressure region.
2. The internal gear pump of claim 1, wherein the recess is in a shape of a groove.
3. The internal gear pump of claim 1 or 2, wherein the recess is not connected to the discharge port.
4. The internal gear pump of any one of claims 1 to 3, wherein the high-pressure oil supply includes:
 - an oil passage connecting the discharge port and the introduction port together; and
 - a choke in the oil passage to reduce pressure of the hydraulic oil.
5. The internal gear pump of any one of claims 1 to 4, wherein
 - a lubricating coating is applied on the outer circumferential surface of the ring gear.



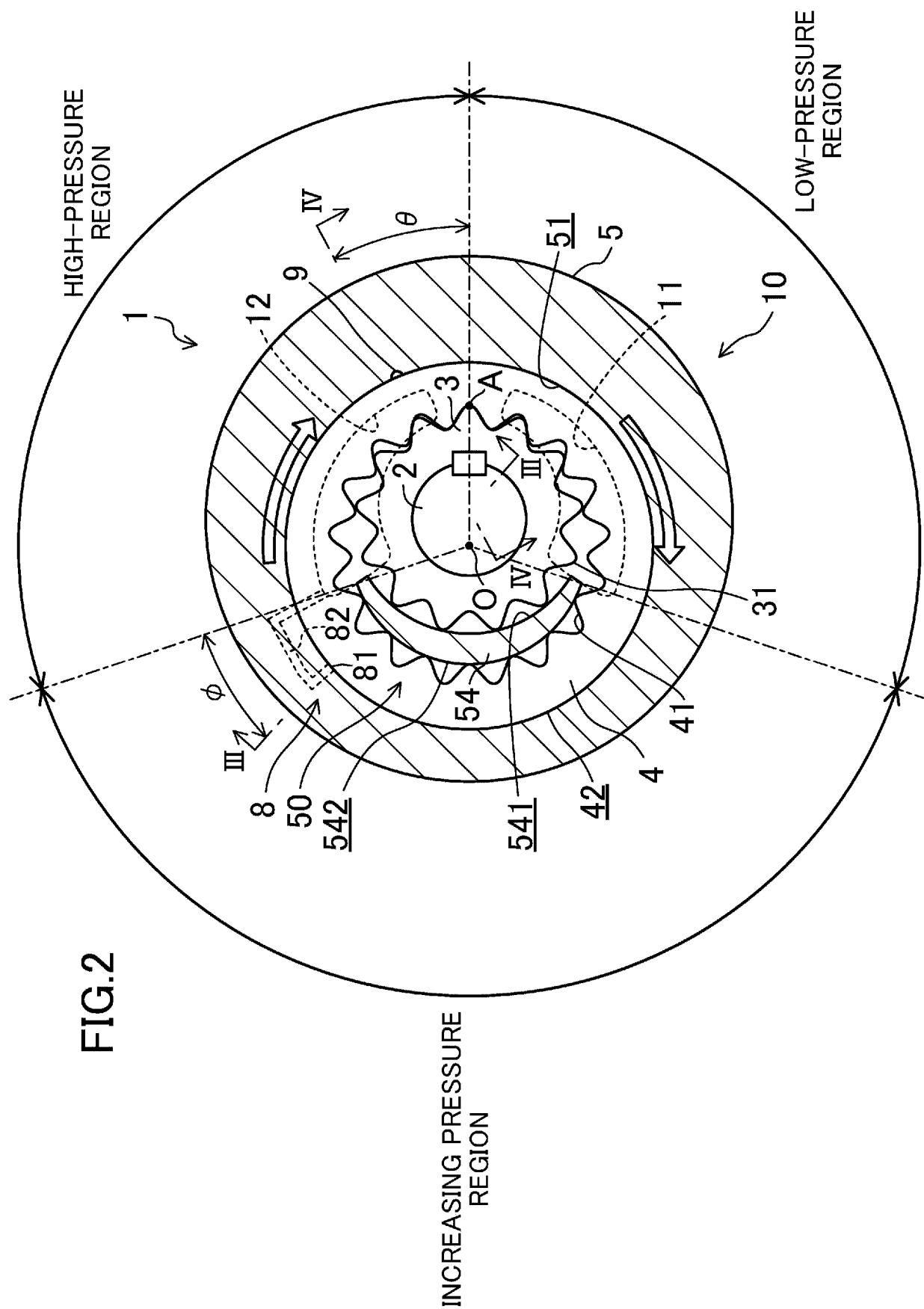


FIG.3

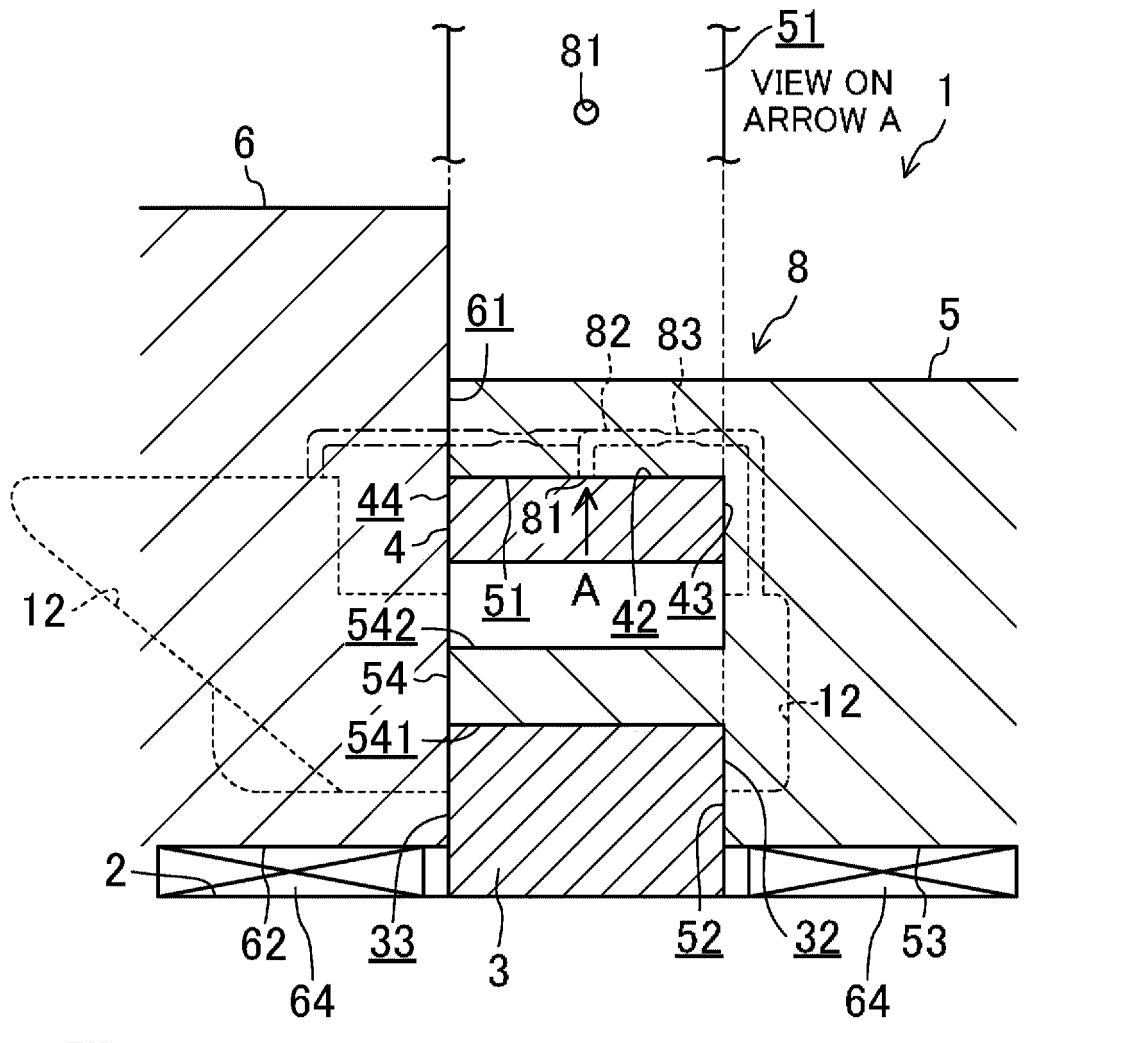


FIG.4

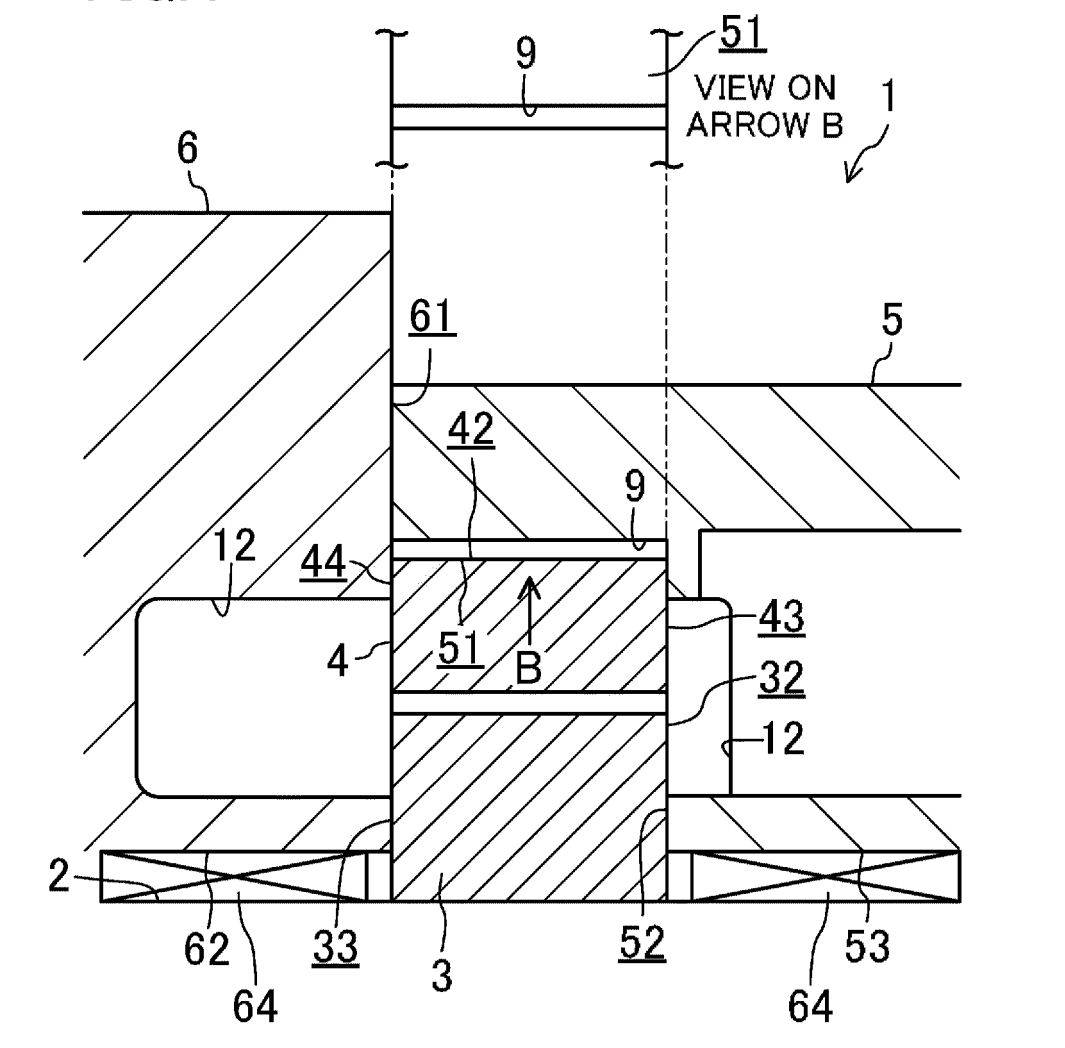


FIG.5

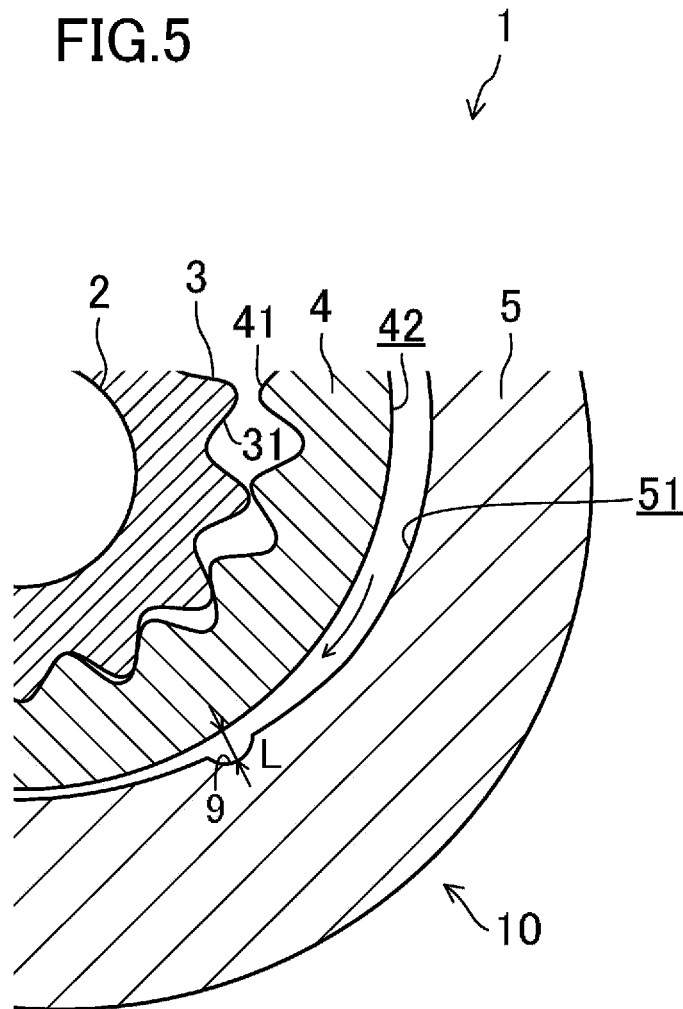
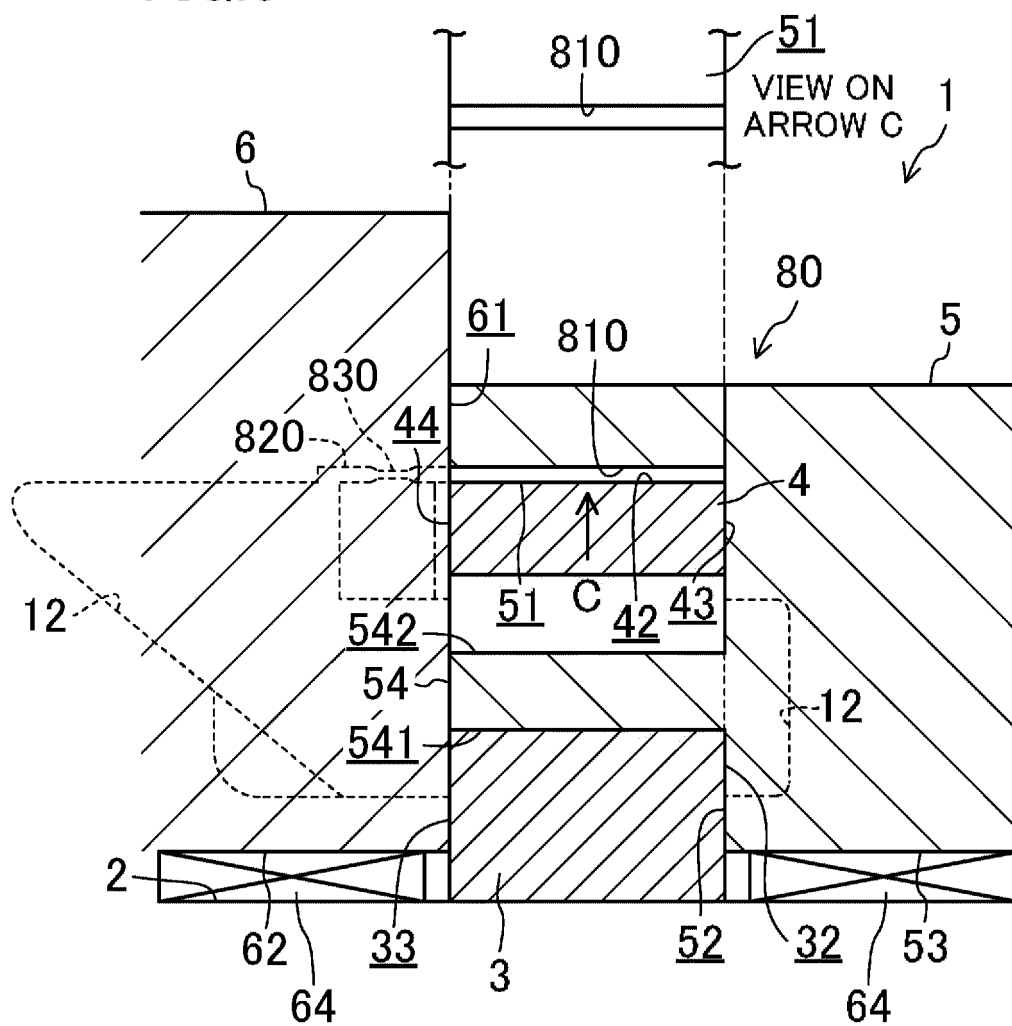


FIG.6



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2018/043438

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. F04C2/10 (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)

Int.Cl. F04C2/10

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

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2019
Registered utility model specifications of Japan	1996-2019
Published registered utility model applications of Japan	1994-2019

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 A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 063656/1985 (Laid-open No. 179385/1986) (TOYODA MACHINE WORKS LTD.) 08 November 1986, specification, page 5, lines 2-16, fig. 1, 2 (Family: none)	1-2, 5 3-4
Y A	JP 07-151066 A (AISIN SEIKI CO., LTD.) 13 June 1995, paragraph [0017], fig. 1-3 & US 5501585 A, column 3, lines 16-23, fig. 1-3	1-2, 5 3-4



Further documents are listed in the continuation of Box C.



See patent family annex.

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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
01.02.2019Date of mailing of the international search report
12.02.2019Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2018/043438

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2014-148907 A (TOYOTA INDUSTRIES CORPORATION) 21 August 2014, paragraphs [0019]-[0022], fig. 1 (Family: none)	1-5
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 055591/1985 (Laid-open No. 171885/1986) (TOYODA MACHINE WORKS LTD.) 25 October 1986, specification, page 5, lines 1-17, fig. 1, 2 (Family: none)	1-5

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP S61179385 B [0006]
- JP H07151066 B [0006]
- JP S62158181 B [0006]