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(71) Applicant: **KYB Corporation**
Tokyo 105-6111 (JP)

(72) Inventor: **ISHIKAWA, Ryunosuke**
Tokyo 105-6111 (JP)

(74) Representative: **TBK**
Bavariaring 4-6
80336 München (DE)

(54) **HYDRAULIC ROTARY MACHINE**

(57) A piston pump/motor 100 includes a cylinder block 2 rotated with the shaft 1; a piston 6 slidably inserted into the cylinder 2b that is formed on the cylinder block 2; a shoe 20 rotatably connected to a tip end portion of the piston 6, the shoe 20 being in sliding contact with the tip end portion; and a swash plate 8 with which the shoe 20 is in sliding contact. The shoe 20 has a piston slide portion 30 in sliding contact with the piston 6 and a swash-plate slide portion 31 in sliding contact with the swash plate 8; a shoe body portion 21 on which the piston slide portion 30 and the swash-plate slide portion 31 are mounted; and a first lock portion 40 and a second lock portion 50 provided across the shoe body portion 21, and the piston slide portion 30 and the swash-plate slide portion 31, respectively, the first lock portion 40 and the second lock portion 50 regulating relative rotation between the shoe body portion 21, and the piston slide portion 30 and the swash-plate slide portion 31.

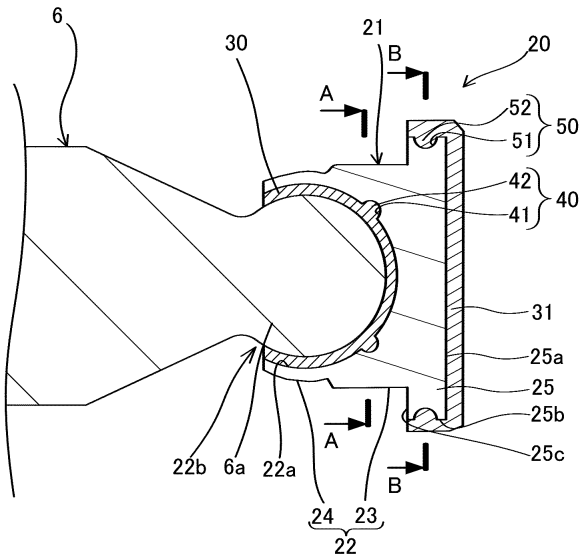

FIG. 2

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Description

TECHNICAL FIELD

[0001] The present invention relates to a hydraulic rotary machine.

BACKGROUND ART

[0002] JP2005-220787A discloses an axial piston pump/motor including a slipper sliding on a swash plate, a cylinder block having a plurality of cylinder bores, and a plurality of pistons reciprocating in the cylinder bores. In the axial piston pump/motor disclosed in JP2005-220787A, a piston is connected to one end of a connecting rod through a resin layer, while a slipper is connected to the other end through the resin layer.

SUMMARY OF INVENTION

[0003] In the axial piston pump/motor disclosed in JP2005-220787A, removal of the resin layer from the slipper is prevented by providing an annular groove in the slipper and by filling the resin layer in the annular groove.

[0004] Here, a slide portion (resin layer) made of resin mounted on a portion in sliding contact with a shoe (slipper) is generally formed by mold-forming a resin on a shoe body portion and then, by cutting the molded resin. In forming the slide portion as above, when the resin is machined by a large machining force, there is a concern that the slide portion and the shoe body portion make relative rotation.

[0005] Moreover, in an operation of the hydraulic rotary machine, there is a concern that the slide portion and the shoe body portion make relative rotation by sliding resistance acting on the slide portion.

[0006] As described above, in the machining of the slide portion or in the operation of the hydraulic rotary machine, if the slide portion and the shoe body portion make relative rotation, the resin filled in the annular groove is worn, and there is a concern that the removal from the shoe body portion cannot be sufficiently prevented.

[0007] The present invention has an object to improve durability of the shoe in the hydraulic rotary machine.

[0008] According to one aspect of the present invention, a hydraulic rotary machine includes a cylinder block to which a shaft is connected, the cylinder block being configured to be rotated with the shaft; a plurality of cylinders formed on the cylinder block, the plurality of cylinders being disposed at a predetermined interval in a circumferential direction of the shaft; a piston slidably inserted into the cylinder, the piston defining a volume chamber inside the cylinder; a shoe rotatably connected to a tip end portion of the piston, the shoe being in sliding contact with the tip end portion; and a swash plate with which the shoe is in sliding contact. The shoe has a slide portion made of resin provided on at least either one of a portion in sliding contact with the piston and a portion in sliding contact with the swash plate; a shoe body portion on which the slide portion is mounted; and a lock portion provided across the shoe body portion and the slide portion, the lock portion regulating relative rotation between the shoe body portion and the slide portion. The lock portion has a dent portion formed on either one of the shoe body portion and the slide portion; and a projecting portion formed on the other of the shoe body portion and the slide portion, the projecting portion being locked by the dent portion.

BRIEF DESCRIPTION OF DRAWINGS

[0009]

Fig. 1 is a sectional view of a hydraulic rotary machine according to an embodiment of the present invention;
Fig. 2 is an enlarged sectional view of a shoe of the hydraulic rotary machine according to the embodiment of the present invention;
Fig. 3 is a sectional view along A-A line in Fig. 2;
Fig. 4 is a sectional view along B-B line in Fig. 2;
Fig. 5 is a sectional view illustrating a procedure of a manufacturing method of the shoe and illustrates a state where a swash-plate slide portion is provided on a core member;
Fig. 6 is a sectional view illustrating a procedure of the manufacturing method of the shoe and illustrates a state where a resin is filled in a recess portion of the core member; and
Fig. 7 is a sectional view illustrating a procedure of the manufacturing method of the shoe and illustrates a state where a reduced-diameter portion is formed in the shoe.

DESCRIPTION OF EMBODIMENTS

[0010] An embodiment of the present invention will be described below by referring to the attached drawings.

[0011] First, by referring to Figs. 1 to 4, a hydraulic rotary machine according to the embodiment of the present invention will be described.

[0012] In this embodiment, a case where the hydraulic rotary machine is a water-pressure rotary machine 100 using water as an operating liquid will be described. The water-pressure rotary machine 100 functions as a piston pump capable of supplying water as the operating fluid when a shaft 1 is rotated by power from an outside and a piston 6 is reciprocated and also functions as a piston motor capable of outputting a rotary driving force when the piston 6 is reciprocated by a fluid pressure of the water supplied from the outside and the shaft 1 is rotated. The water-pressure rotary machine 100 may function only as a piston pump or may function only as a piston motor.

[0013] In the description below, the case where the

water-pressure rotary machine 100 is used as a piston pump is exemplified, and the water-pressure rotary machine 100 is called a "piston pump 100".

[0014] The piston pump 100 includes the shaft 1 rotated by a power source, a cylinder block 2 connected to the shaft 1 and rotated with the shaft 1, and a case 3 accommodating the cylinder block 2. The case 3 includes a case body 3a whose both ends are open, a front cover 4 sealing one of opening ends of the case body 3a and through which the shaft 1 is inserted, and an end cover 5 sealing the other opening end of the case body 3a and accommodating an end portion of the shaft 1.

[0015] To one end portion 1a of the shaft 1 protruding to the outside through an insertion hole 43a of the front cover 4, the power source is connected. The end portion 1a of the shaft 1 is rotatably supported by the insertion hole 4a of the front cover 4 through a first bush 16. The other end portion 1b of the shaft 1 is accommodated in an accommodating recess portion 5a provided on the end cover 5 and is rotatably supported through a second bush 17.

[0016] The cylinder block 2 has a through hole 2a through which the shaft 1 penetrates and is spline-coupled with the shaft 1 through the through hole 2a. As a result, the cylinder block 2 is rotated with rotation of the shaft 1. The cylinder block 2 is rotatably supported by the case 3 through a slide bearing 15.

[0017] On the cylinder bock 2, a plurality of cylinders 2b each having an opening portion on one end surface is formed in parallel with the shaft 1. The plurality of cylinders 2b is formed at a predetermined interval in a circumferential direction of the cylinder block 2. Into the cylinder 2b, the columnar piston 6 dividing a volume chamber 7 is inserted capable of reciprocating. A tip end side of the piston 6 protrudes from the opening portion of the cylinder 2b, and a spherical surface seat 6a is formed on the tip end portion.

[0018] The piston pump 100 further includes a shoe 20 rotatably connected to the spherical surface seat 6a of the piston 6 and in sliding contact with the spherical surface seat 6a, a swash plate 8 with which the shoe 20 is in sliding contact with rotation of the cylinder block 2, and a valve plate 9 interposed between the cylinder block 2 and the end cover 5.

[0019] The shoe 20 has a slide portion made of a resin and a shoe body portion 21 made of metal. The shoe body portion 21 has, as illustrated in Fig. 2, a receiving portion 22 for receiving the spherical surface seat 6a of each of the pistons 6 and a disc-shaped flat plate portion 25 having an outer diameter larger than the receiving portion 22.

[0020] The receiving portion 22 has a body portion 23 formed having a cylindrical shape and a reduced-diameter portion 24 whose diameter is reduced from the body portion 23. The reduced-diameter portion 24 is formed by drawing (caulking) one end portion of the body portion 23 from an outer side in a radial direction. The other end portion of the body portion 23 is connected to the flat plate portion 25.

[0021] In the receiving portion 22, a recess portion 22a having an opening portion 22b on an end surface is formed across the body portion 23 and the reduced-diameter portion 24. In the recess portion 22a, an inner peripheral surface is formed having a spherical surface shape, and a piston slide portion 30 as a slide portion is provided on an inner side of the recess portion 22a.

[0022] The piston slide portion 30 is formed by mold-forming a resin in the recess portion 22a of the receiving portion 22. The receiving portion 22 receives the spherical surface seat 6a of the piston 6 through the piston slide portion 30 and is in sliding contact with an outer surface of the spherical surface seat 6a. As a result, the shoe 20 is capable of angular displacement with respect to the spherical surface seat 6a.

[0023] Moreover, the recess portion 22a is formed so that an opening diameter of the opening portion 22b is smaller than an outer diameter of the spherical surface seat 6a with formation of the reduced-diameter portion 24 by reducing the diameter of one end portion of the body portion 23 in a state where the spherical surface seat 6a of the piston 6 is inserted inside. As a result, removal of the spherical surface seat 6a from the recess portion 22a is regulated.

[0024] The flat plate portion 25 is formed having a disc shape having a circular flat surface 25a and an outer peripheral surface 25b having a cylindrical surface shape and is faced with the swash plate 8 (see Fig. 1). On the flat plate portion 25, a swash-plate slide portion 31 as a slide portion is provided so as to cover the flat surface 25a and the outer peripheral surface 25b. The swash-plate slide portion 31 is formed by mold-forming the resin on the flat plate portion 25. The flat plate portion 25 is in sliding contact with the swash plate 8 through the swash-plate slide portion 31.

[0025] As described above, the slide portion is provided on a portion where the shoe 20 is in sliding contact with another member. That is, the shoe 20 has the piston slide portion 30 provided on the inner side of the recess portion 22a of the receiving portion 22 which is the portion where the shoe 20 is in sliding contact with the spherical surface seat 6a of the piston 6 and in sliding contact with the spherical surface seat 6a of the piston 6, and the swash-plate slide portion 31 provided on the flat plate portion 25 of the shoe body portion 21 which is a portion where the shoe 20 is in sliding contact with the swash plate 8 and in sliding contact with the swash plate 8, as the slide portion.

[0026] The shoe 20 further has a first lock portion 40 provided across the receiving portion 22 and the piston slide portion 30 and a second lock portion 50 provided across the flat plate portion 25 and the swash-plate slide portion 31.

[0027] The first lock portion 40 has a first dent portion 41 formed on an inner surface of the body portion 23 of the receiving portion 22 and a first projecting portion 42 provided on the piston slide portion 30 and locked by the

first dent portion 41. That is, the first lock portion 40 is provided across the body portion 23 of the receiving portion 22 and the piston slide portion 30. The first lock portion 40 is provided, as illustrated in Fig. 3, at four spots at an equal interval in the circumferential direction across the receiving portion 22 and the piston slide portion 30.

[0028] The first dent portion 41 does not have a right-angled corner part but is formed only by a curved surface as illustrated in Figs. 2 and 3.

[0029] The first projecting portion 42 is formed integrally with the piston slide portion 30 by mold-forming. By filling a part of the mold resin in the first dent portion 41 formed in the body portion 23 of the receiving portion 22, the first projecting portion 42 locked by the first dent portion 41 is formed on the piston slide portion 30. As a result, relative rotation between the shoe body portion 21 and the piston slide portion 30 is regulated.

[0030] The second lock portion 50 has, as illustrated in Fig. 2, a second dent portion 51 formed on the outer peripheral surface 25b of the flat plate portion 25 and a second projecting portion 52 formed on the swash-plate slide portion 31 and locked by the second dent portion 51. The second lock portion 50 is, as illustrated in Fig. 4, provided at four spots at an equal interval in the circumferential direction across the flat plate portion 25 and the swash-plate slide portion 31.

[0031] As illustrated in Figs. 2 and 4, the second dent portion 51 does not have a right-angled corner part but is formed only by a curved surface similarly to the first dent portion 41.

[0032] The second projecting portion 52 is formed integrally with the swash-plate slide portion 31 by mold-forming. By filling a part of the mold resin in the second dent portion 51 formed in the outer peripheral surface 25b of the flat plate portion 25, the second projecting portion 52 locked by the second dent portion 51 is formed on the swash-plate slide portion 31. As a result, relative rotation between the shoe body portion 21 and the swash-plate slide portion 31 is regulated, and removal of the swash-plate slide portion 31 from the flat plate portion 25 is prevented.

[0033] Moreover, by forming the second dent portion 51 on the flat surface 25a faced with the swash plate 8, thermal deformation when the molded resin is cooled becomes uneven, and there is a concern that surface accuracy of a sliding surface of the swash-plate slide portion 31 lowers. On the other hand, in the piston pump 100, since the second dent portion 51 is not formed on the flat surface 25a but is formed on the outer peripheral surface 25b, there is no concern that the surface accuracy of the sliding surface lowers.

[0034] As illustrated in Fig. 1, the swash plate 8 is fixed to an inner wall of the front cover 4 and has a sliding contact surface 8a inclined from a direction perpendicular to an axis of the shaft 1. The swash-plate slide portion 31 provided on the flat plate portion 25 of the shoe 20 is in surface contact with the sliding contact surface 8a.

[0035] The valve plate 9 is a disc member with which a base end surface of the cylinder block 2 is in sliding contact and is fixed to the end cover 5. In the valve plate 9, a suction port 9a connecting a suction passage 10 formed in the end cover 5 and the volume chamber 7 and an ejection port 9b connecting an ejection passage 11 formed in the end cover 5 and the volume chamber 7 are formed.

[0036] Subsequently, by referring to Figs. 5 to 7, a manufacturing method of the shoe 20 and a connecting method of the piston 6 and the shoe 20 to each other will be described.

[0037] In the manufacture of the shoe 20, first, as illustrated in Fig. 5, a core member 120 having the flat plate portion 25 and the body portion 23 is formed, and the swash-plate slide portion 31 is formed on the core member 120. At this stage, the reduced-diameter portion 24 is not formed on the end portion of the body portion 23.

[0038] Specifically, in forming of the swash-plate slide portion 31, the resin is mold-formed on the flat plate portion 25. In mold-forming of the swash-plate slide portion 31, a part of the mold resin is filled in the second dent portion 51, and the second lock portion 50 is formed at the same time. Since the second dent portion 51 of the second lock portion 50 does not have a right-angled corner part, the mold resin is filled in the second dent portion 51 easily, and the second projecting portion 52 can be formed easily. Moreover, since the second dent portion 51 does not have a right-angled corner part, a right-angled corner part is not formed on the second projecting portion 52, either. Thus, stress concentration on the corner part is prevented, and durability of the second dent portion 51 and the second projecting portion 52 is improved.

[0039] After the resin is mold-formed on the flat plate portion 25, finishing (cutting or the like) is applied to the mold-formed resin. As a result, the swash-plate slide portion 31 having a smooth sliding contact surface in sliding contact with the swash plate 8 is formed. When the finishing is applied to the molded resin, relative rotation between the mold resin and the core member 120 is regulated by the second lock portion 50. As described above, since the relative rotation between the mold resin and the core member 120 caused by the machining force of finishing is regulated by the second lock portion 50, wear of the swash-plate slide portion 31 in manufacture of the shoe 20 is prevented.

[0040] Subsequently, the piston slide portion 30 is formed on the inner side of the recess portion 22a of the receiving portion 22.

[0041] In forming of the piston slide portion 30, as illustrated in Fig. 6, the resin is filled in the entire recess portion 22a. When the resin is filled in the entire recess portion 22a, a part of the mold resin is filled in the first dent portion 41, and the first lock portion 40 is formed. Since the first dent portion 41 does not have a right-angled corner part similarly to the second dent portion 51, the first projecting portion 42 can be formed easily, and durability of the first dent portion 41 and the first projecting

portion 42 can be improved.

[0042] After the resin is mold-formed on the recess portion 22a, the filled mold resin is cut/machined so as to form a sliding contact surface having a spherical surface shape in sliding contact with the spherical surface seat 6a of the piston 6. At this time, the relative rotation between the mold resin and the core member 120 in the recess portion 22a is regulated by the first lock portion 40. As described above, since the relative rotation between the mold resin and the core member 120 caused by the machining force for machining the sliding contact surface is regulated by the first lock portion 40, wear of the piston slide portion 30 in the manufacture of the shoe 20 is prevented.

[0043] Subsequently, as illustrated in Fig. 7, the spherical surface seat 6a of the piston 6 is inserted into the recess portion 22a, and the end portion (left end portion in the figure) in the body portion 23 on the opening portion 22b side is drawn with the piston slide portion 30 from the outer side in the radial direction, and its diameter is reduced (see an arrow in Fig. 7). As a result, the opening diameter of the opening portion 22b of the recess portion 22a is formed smaller than the outer diameter of the spherical surface seat 6a of the piston 6, whereby removal of the spherical surface seat 6a from the recess portion 22a is regulated.

[0044] As described above, the receiving portion 22 having the reduced-diameter portion 24 and the body portion 23 is formed, and the shoe 20 as illustrated in Fig. 2 is manufactured, and the shoe 20 and the piston 6 are connected to each other.

[0045] Here, in a case where the first lock portion 40 is provided between the reduced-diameter portion 24 and the piston slide portion 30, when the reduced-diameter portion 24 is formed, the first projecting portion 42 has its diameter reduced together with a part of the body portion 23 and is deformed. When the first projecting portion 42 is deformed as above, a crack or the like occurs, and there is a concern that durability of the first projecting portion 42 lowers. On the other hand, in the piston pump 100, since the first lock portion 40 is provided across the piston slide portion 30 and the body portion 23 of the receiving portion 22, it is not deformed when the reduced-diameter portion 24 is formed. Thus, lowering of the durability of the first projecting portion 42 can be prevented.

[0046] Subsequently, an action of the piston pump 100 will be described.

[0047] When the shaft 1 is rotated/driven by power from the outside, and the cylinder block 2 is rotated, the flat plate portion 25 of each shoe 20 slides with respect to the swash plate 8 through the swash-plate slide portion 31, and each piston 6 reciprocates in the cylinder 2b with a stroke amount according to an inclination angle of the swash plate 8. By means of reciprocating of each piston 6, the volume of each volume chamber 7 is increased/decreased.

[0048] Into the volume chamber 7 expanding by rotation of the cylinder block 2, water is led through the suction passage 10 of the end cover 5 and the suction port 9a of the valve plate 9. The water suctioned into the volume chamber 7 has its pressure increased by contraction of the volume chamber 7 by rotation of the cylinder block 2 and is ejected through the ejection port 9b of the valve plate 9 and the ejection passage 11 of the end cover 5. As described above, in the piston pump 100, suction and ejection of the water is continuously performed with rotation of the cylinder block 2.

[0049] As described above, in the operation of the piston pump 100, the shoe 20 is rotated around the shaft 1 while in sliding contact with the swash plate 8 through the swash-plate slide portion 31. In the operation of the piston pump 100 as above, too, since the second lock portion 50 is provided, the relative rotation between the swash-plate slide portion 31 and the flat plate portion 25 caused by the sliding resistance with the swash plate 8 is regulated. Thus, in the operation of the piston pump 100, wear of the swash-plate slide portion 31 caused by the relative rotation between the swash-plate slide portion 31 and the shoe body portion 21 is also prevented.

[0050] Moreover, in the operation of the piston pump 100, since the piston 6 is reciprocated in the cylinder 2b by rotation of the shoe 20 around the shaft 1 while sliding on the swash plate 8, sliding resistance occurs also between the spherical surface seat 6a of the piston 6 and the piston slide portion 30 of the shoe 20. On the other hand, since the first lock portion 40 is provided, the relative rotation between the piston slide portion 30 and the receiving portion 22 caused by the sliding resistance with the spherical surface seat 6a of the piston 6 is also regulated. Thus, in the operation of the piston pump 100, wear of the piston slide portion 30 caused by the relative rotation between the piston slide portion 30 and the shoe body portion 21 is also prevented.

[0051] According to the aforementioned embodiment, the following effect is exerted.

[0052] In the piston pump 100, the relative rotation between the piston slide portion 30 and the receiving portion 22 of the shoe body portion 21 in the forming of the piston slide portion 30 and in the operation of the piston pump 100 is regulated by the first lock portion 40. Thus, the relative rotation of the piston slide portion 30 with respect to the shoe body portion 21 and the wear thereof are prevented. Therefore, removal of the piston slide portion 30 from the shoe body portion 21 is sufficiently prevented, and durability of the shoe 20 can be improved.

[0053] Moreover, in the piston pump 100, the relative rotation between the swash-plate slide portion 31 and the flat plate portion 25 of the shoe body portion 21 in the forming of the swash-plate slide portion 31 and in the operation of the piston pump 100 is regulated by the second lock portion 50. Thus, the relative rotation of the swash-plate slide portion 31 with respect to the shoe body portion 21 and the wear thereof are prevented. Therefore, removal of swash-plate slide portion 31 from the shoe body portion 21 is sufficiently prevented, and durability of the shoe 20 can be further improved.

[0054] Moreover, the first dent portion 41 of the first lock portion 40 and the second dent portion 51 of the second lock portion 50 are formed on the receiving portion 22 and the flat plate portion 25 of the shoe body portion 21, respectively. As a result, by filling the resin in the first dent portion 41 and the second dent portion 51, the first projecting portion 42 and the second projecting portion 52 are formed. Thus, as compared with the case where the first projecting portion 42 and the second projecting portion 52 are formed by machining the shoe body portion 21, the first lock portion 40 and the second lock portion 50 can be formed easily.

[0055] Moreover, the first dent portion 41 of the first lock portion 40 and the second dent portion 51 of the second lock portion 50 are formed only by curved surfaces, respectively. Since the first dent portion 41 and the second dent portion 51 do not have corner parts at a right angle, the resin can be filled easily, and the first projecting portion 42 and the second projecting portion 52 can be formed easily. Thus, productivity can be improved. Moreover, since the first dent portion 41 and the second dent portion 51 do not have corner parts at a right angle, stress concentration on the corner part is prevented, whereby durability of the first lock portion 40 and the second lock portion 50 can be improved. Moreover, since resin can be filled easily, air bubbles are prevented from remaining in the resin, whereby durability of the first lock portion 40 and the second lock portion 50 can be further improved.

[0056] Subsequently, a variation of this embodiment will be described.

[0057] In the aforementioned embodiment, the piston pump/motor 100 using water as the operating liquid has been described. Instead of this, the operating liquid may be an operating oil or other substances.

[0058] Moreover, in the aforementioned embodiment, the fixed-volume piston pump/motor in which an inclination angle of the swash plate 8 is fixed has been described. Instead of this, the piston pump/motor 100 may be a variable volume piston pump/motor in which an inclination angle of the swash plate 8 can be changed.

[0059] Moreover, in the aforementioned embodiment, the shoe 20 has the piston slide portion 30 and the swash-plate slide portion 31 as slide portions. However, the shoe 20 is not limited to those having both the piston slide portion 30 and the swash-plate slide portion 31 but may be those having only either one of them.

[0060] Moreover, in the aforementioned embodiment, the first dent portion 41 and the second dent portion 51 are formed only by curved surfaces. Instead of this, the first dent portion 41 and the second dent portion 51 may be formed having an arbitrary shape as long as it is a shape not having a right-angled corner part such as a chamfered (taper chamfering, R-chamfering or the like) shape, for example. In this case, too, the resin can be filled in the first dent portion 41 and the second dent portion 51 easily, and stress concentration can be prevented. Moreover, it is preferable that the first dent portion 41 and the second dent portion 51 do not have a right-angled corner part, but they may have a shape having a right-angled corner part if there is no concern of damage caused by stress concentration on the first lock portion 40 and the second lock portion 50 or when the resin can be filled sufficiently.

[0061] Moreover, in the aforementioned embodiment, the second lock portion 50 has the second dent portion 51 formed on the outer peripheral surface 25b of the flat plate portion 25. Instead of this, the second lock portion 50 may have notch-shaped dent opened in the outer peripheral surface 25b of the flat plate portion 25 and a flange surface 25c (see Fig. 2) on a side opposite to the flat surface 25a in the flat plate portion 25. In this case, the second projecting portion 52 of the second lock portion 50 is formed having a shape corresponding to the shape of the dent and is locked by the dent. By constituting the second lock portion 50 as above, air bubbles cannot enter the resin easily.

[0062] Moreover, in the aforementioned embodiment, the first dent portion 41 and the second dent portion 51 are provided on the shoe body 21, and the first projecting portion 42 and the second projecting portion 52 are provided on the piston slide portion 30 and the swash-plate slide portion 31, respectively. Instead of this, the first dent portion 41 and the second dent portion 51 may be provided on the piston slide portion 30 and the swash-plate slide portion 31, respectively, and the first projecting portion 42 and the second projecting portion 52 may be provided on the shoe body 21.

[0063] Constitutions, actions, and effects of the embodiment of the present invention will be described altogether.

[0064] The piston pump/motor 100 includes the cylinder block 2 to which the shaft 1 is connected and rotated with the shaft 1, the plurality of cylinders 2b formed on the cylinder block 2 and disposed at a predetermined interval in the circumferential direction of the shaft 1, the piston 6 slidably inserted into the cylinder 2b and defining the volume chamber 7 inside the cylinder 2b, the shoe 20 rotatably connected to the tip end portion of the piston 6 and in sliding contact with the tip end portion, and the swash plate 8 with which the shoe 20 is in sliding contact. The shoe 20 has the slide portion (the piston slide portion 30, the swash-plate slide portion 31) made of resin provided on at least either one of the portion in sliding contact with the piston 6 and the portion in sliding contact with the swash plate 8, the shoe body portion 21 on which the slide portion (the piston slide portion 30, the swash-plate slide portion 31) is mounted, and the lock portion (the first lock portion 40, the second lock portion 50) provided across the shoe body portion 21 and the slide portion (the piston slide portion 30, the swash-plate slide portion 31) and regulating the relative rotation between the shoe body portion 21 and the slide portion (the piston slide portion 30, the swash-plate slide portion 31). The lock portion (the first lock portion 40, the second lock portion 50) has the dent portion (the first dent portion 41, the

second dent portion 51) formed on either one of the shoe body portion 21 and the slide portion (the piston slide portion 30, the swash-plate slide portion 31) and the projecting portion (the first projecting portion 42, the second projecting portion 52) formed on the other of the shoe body portion 21 and the slide portion and locked by the dent portion (the first dent portion 41, the second dent portion 51).

[0065] In this constitution, since the projecting portion (the first projecting portion 42, the second projecting portion 52) are locked by the dent portion (the first dent portion 41, the second dent portion 51), the relative rotation between the shoe body portion 21 and the mold resin in machining of the slide portion (the piston slide portion 30, the swash-plate slide portion 31) is regulated. Moreover, in the operation of the piston pump/motor 100, too, the relative rotation between the shoe body portion 21 and the slide portion (the piston slide portion 30, the swash-plate slide portion 31) caused by the sliding resistance is regulated by the lock portion (the first lock portion 40, the second lock portion 50). As described above, since the relative rotation between the shoe body portion 21 and the slide portion (the piston slide portion 30, the swash-plate slide portion 31) is regulated by the lock portion (the first lock portion 40, the second lock portion 50), the wear of the slide portion (the piston slide portion 30, the swash-plate slide portion 31) in machining and the wear of the slide portion (the piston slide portion 30, the swash-plate slide portion 31) in the operation of the piston pump/motor 100 are both prevented. Therefore, the durability of the shoe 20 in the piston pump/motor 100 is improved.

[0066] Moreover, in the piston pump/motor 100, the piston 6 has the spherical surface seat 6a formed on the tip end portion, the shoe body portion 21 has the receiving portion 22 receiving the spherical surface seat 6a of the piston 6, the receiving portion 22 has the body portion 23 and the reduced-diameter portion 24 whose diameter is reduced from the body portion 23 and regulating removal of the spherical surface seat 6a from the receiving portion 22, the shoe 20 has the piston slide portion 30 as the slide portion provided on the inner periphery of the receiving portion 22 and in sliding contact with the spherical surface seat 6a of the piston 6, and the first lock portion 40 is provided across the body portion 23 of the receiving portion 22 and the piston slide portion 30.

[0067] In this constitution, the piston slide portion 30 is provided on the inner periphery of the receiving portion 22 with which the shoe 20 and the piston 6 are in sliding contact. The first lock portion 40 is provided across the piston slide portion 30 and the body portion 23 of the receiving portion 22 and regulates the relative rotation between the piston slide portion 30 and the shoe body portion 21. As described above, since the first lock portion 40 is provided on the body portion 23 instead of the reduced-diameter portion 24, when the reduced-diameter portion 24 is to be formed by reducing the diameter of a part of the body portion 23, the first lock portion 40 is not deformed. Thus, lowering of durability of the first lock portion 40 can be prevented.

[0068] Moreover, in the piston pump/motor 100, the shoe body portion 21 has the flat plate portion 25 formed having a disc shape and faced with the swash plate 8, the shoe 20 has the swash-plate slide portion 31 as the slide portion provided on the flat plate portion 25 so as to cover the outer peripheral surface 25b of the flat plate portion 25 and in sliding contact with the swash plate 8, and the second lock portion 50 is provided across the outer peripheral surface 25b of the flat plate portion 25 and the swash-plate slide portion 31.

[0069] In this constitution, the swash-plate slide portion 31 is provided on the flat plate portion 25 with which the shoe 20 and the swash plate 8 are in sliding contact. The second lock portion 50 is provided across the swash-plate slide portion 31 and the outer peripheral surface 25b of the flat plate portion 25. Thus, the relative rotation between the swash-plate slide portion 31 and the shoe 20 body is regulated by the second lock portion 50, and removal of the swash-plate slide portion 31 from the shoe 20 body is prevented.

[0070] Moreover, in the piston pump/motor 100, the projecting portion (the first projecting portion 42, the second projecting portion 52) is provided on the slide portion (the piston slide portion 30, the swash-plate slide portion 31), and the dent portion (the first dent portion 41, the second dent portion 51) is provided on the shoe body portion 21.

[0071] In this constitution, by filling the resin in the dent portion (the first dent portion 41, the second dent portion 51), the projecting portion (the first projecting portion 42, the second projecting portion 52) can be formed. Therefore, the projecting portion (the first projecting portion 42, the second projecting portion 52) can be formed more easily than the case where the projecting portion (the first projecting portion 42, the second projecting portion 52) is provided by machining the shoe body portion 21.

[0072] Moreover, in the piston pump/motor 100, the dent portion (the first dent portion 41, the second dent portion 51) is formed by a curved surface.

[0073] According to this constitution, since a right-angled corner part is not formed on the dent portion (the first dent portion 41, the second dent portion 51), the resin can be filled in the dent portion (the first dent portion 41, the second dent portion 51) easily, and stress concentration on the corner part is prevented, whereby durability of the dent portion (the first dent portion 41, the second dent portion 51) and the projecting portion (the first projecting portion 42, the second projecting portion 52) can be improved.

[0074] The embodiments of the present invention described above are merely illustration of some application examples of the present invention and not of the nature to limit the technical scope of the present invention to the specific constructions of the above embodiments.

[0075] The present application claims a priority based on Japanese Patent Application No. 2015-183222 filed

with the Japan Patent Office on September 16, 2015, all the contents of which are hereby incorporated by reference.

Claims

1. A hydraulic rotary machine comprising:

a cylinder block to which a shaft is connected, the cylinder block being configured to be rotated with the shaft;
a plurality of cylinders formed on the cylinder block, the plurality of cylinders being disposed at a predetermined interval in a circumferential direction of the shaft;
a piston slidably inserted into the cylinder, the piston defining a volume chamber inside the cylinder;
a shoe rotatably connected to a tip end portion of the piston, the shoe being in sliding contact with the tip end portion; and
a swash plate with which the shoe is in sliding contact, wherein
the shoe has
a slide portion made of resin provided on at least either one of a portion in sliding contact with the piston and a portion in sliding contact with the swash plate;
a shoe body portion on which the slide portion is mounted; and
a lock portion provided across the shoe body portion and the slide portion, the lock portion regulating relative rotation between the shoe body portion and the slide portion, and

the lock portion has
a dent portion formed on either one of the shoe body portion and the slide portion; and
a projecting portion formed on the other of the shoe body portion and the slide portion, the projecting portion being locked by the dent portion.

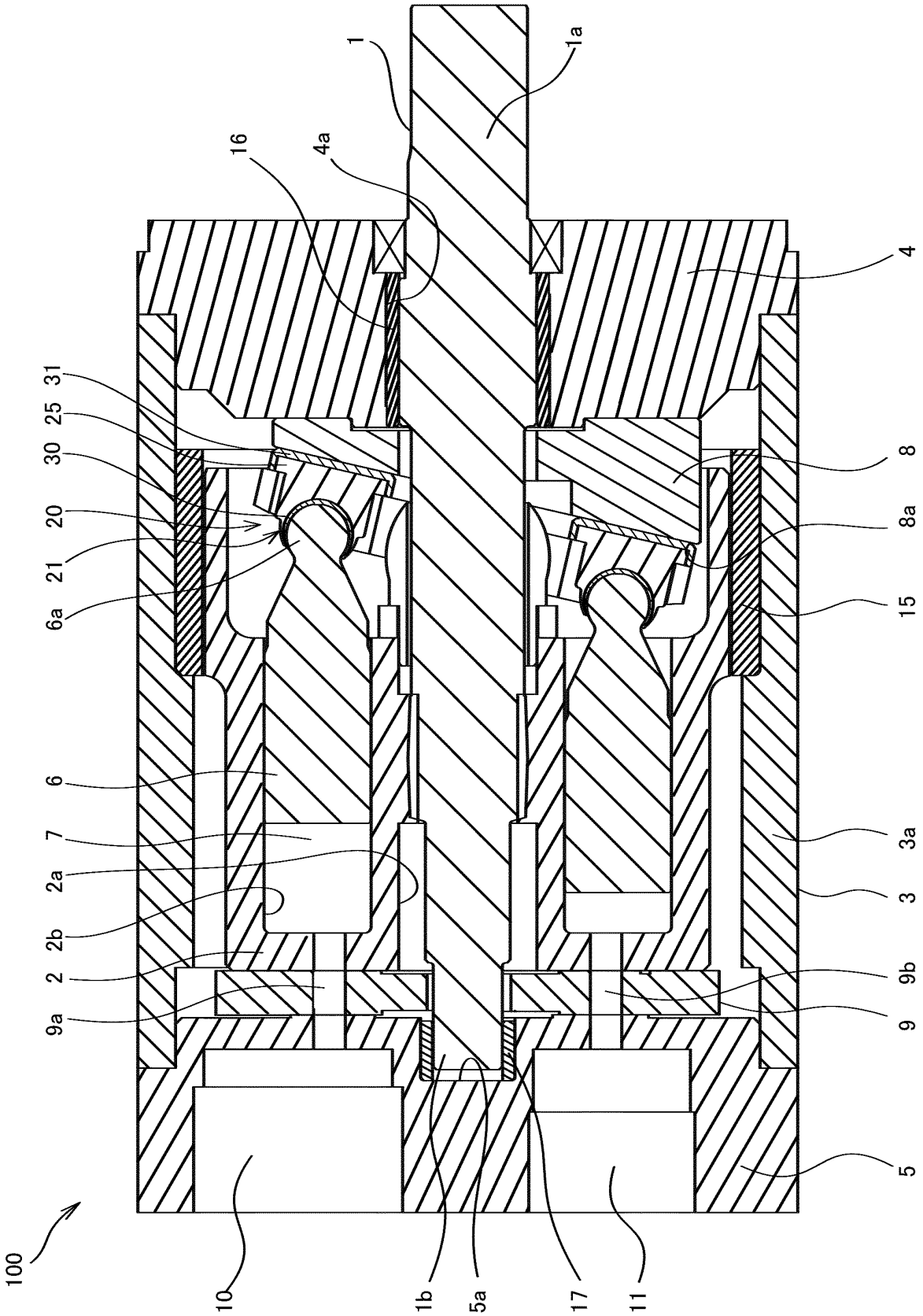
2. The hydraulic rotary machine according to claim 1, wherein
the piston has a spherical surface seat formed on the tip end portion,
the shoe body portion has a receiving portion receiving the spherical surface seat of the piston,

the receiving portion has
a body portion; and
a reduced-diameter portion whose diameter is reduced from the body portion, the reduced-diameter portion regulating removal of the spherical surface seat from the receiving portion,
the shoe has a piston slide portion as the slide portion provided on an inner periphery of the receiving portion, the piston slide portion being in sliding contact with the spherical surface seat of the piston, and
the lock portion is provided across the body portion of the receiving portion and the piston slide portion.

3. The hydraulic rotary machine according to claim 1, wherein
the shoe body portion has a flat plate portion formed having a disc shape and faced with the swash plate,
the shoe has a swash-plate slide portion as the slide portion provided on the flat plate portion so as to cover an outer peripheral surface of the flat plate portion, the swash-plate slide portion being in sliding contact with the swash plate, and
the lock portion is provided across the outer peripheral surface of the flat plate portion and the swash-plate slide portion.

4. The hydraulic rotary machine according to claim 1, wherein
the dent portion is provided on the shoe body portion, and
the projecting portion is provided on the slide portion.

5. The hydraulic rotary machine according to claim 1, wherein
the dent portion is formed by a curved surface.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16
4a
4
31
25
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6a
8
8a
15
6
7
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2b
2
9a
3a
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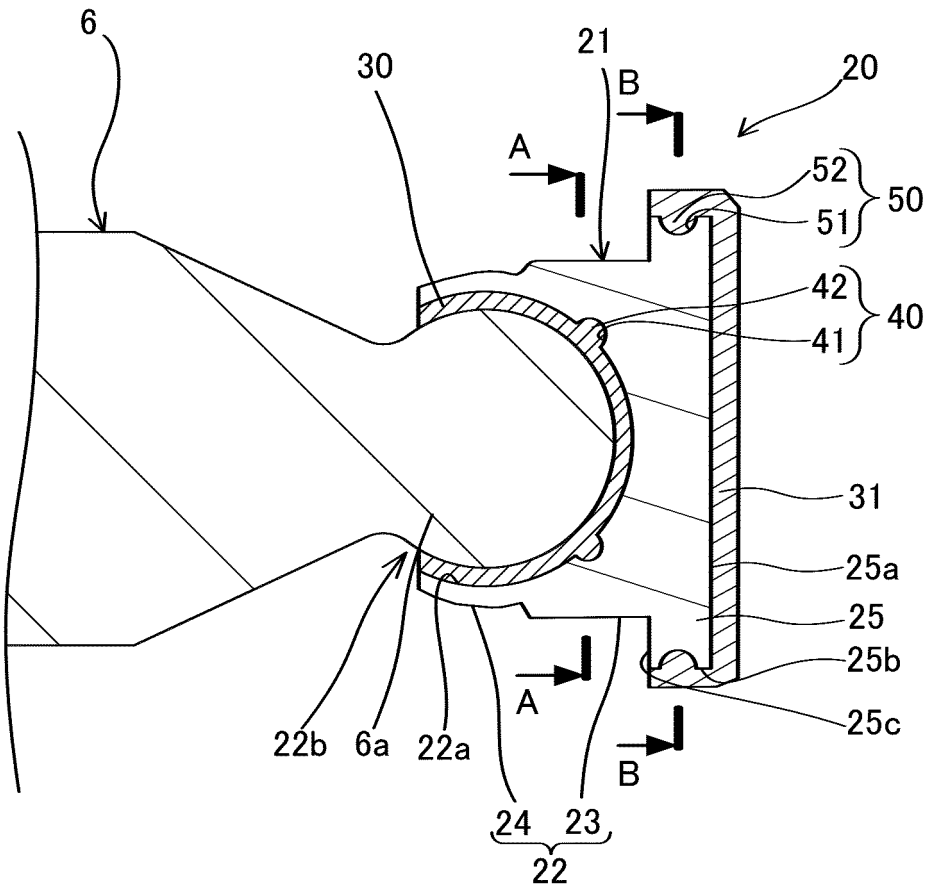
9b
9
5
100
10
1b
5a
17
11

FIG. 1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52
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25b
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22b
6a
22a
24
23
22

FIG. 2

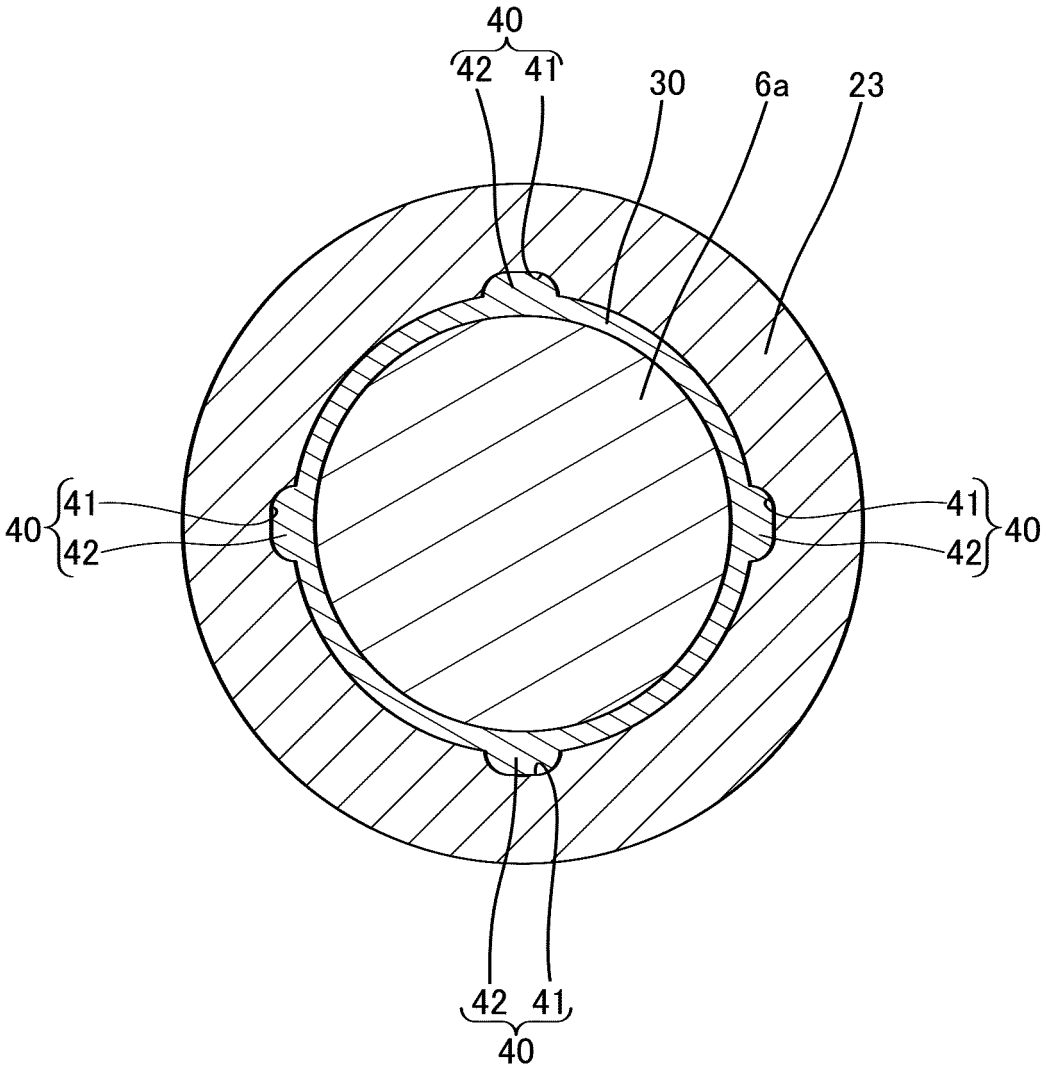

FIG. 3

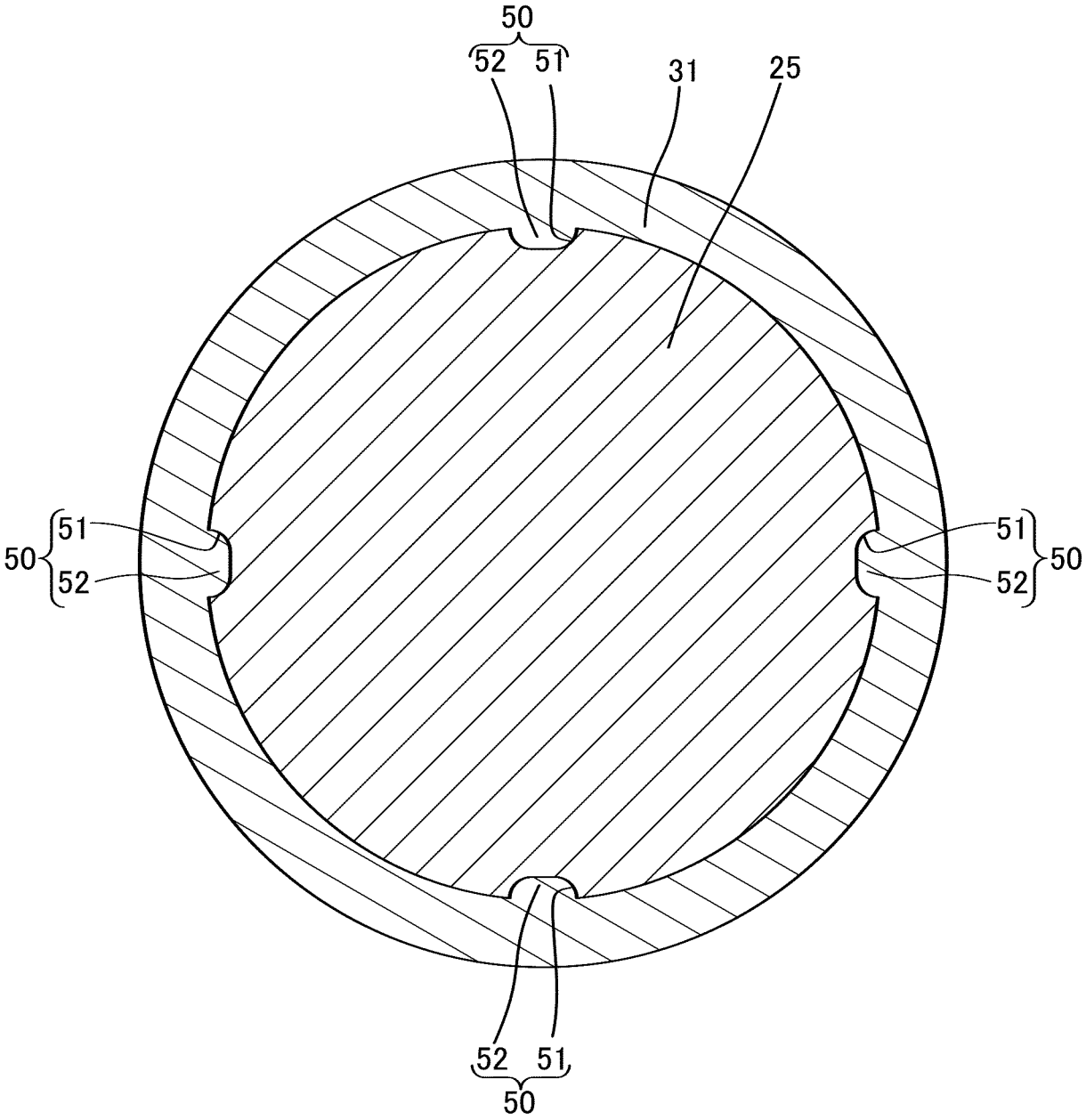

FIG. 4

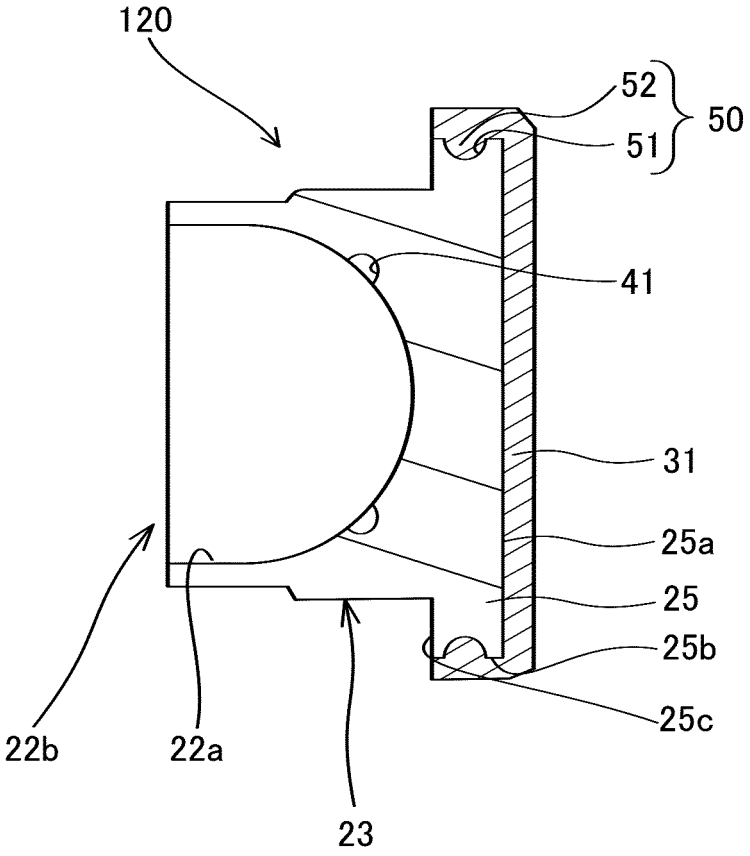

FIG. 5

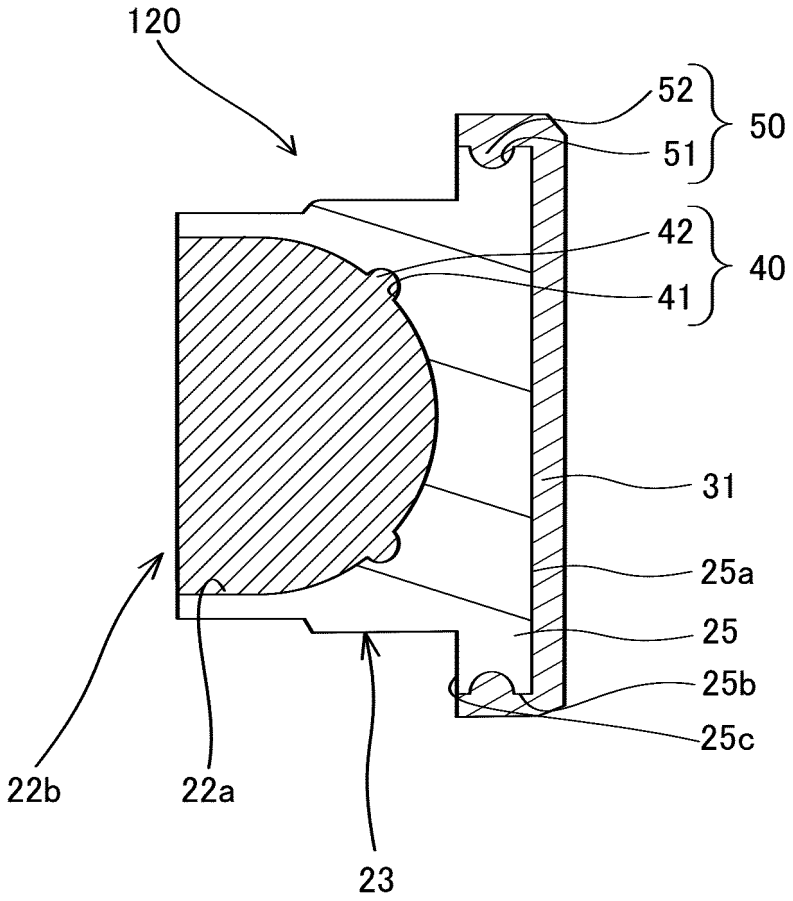

FIG. 6

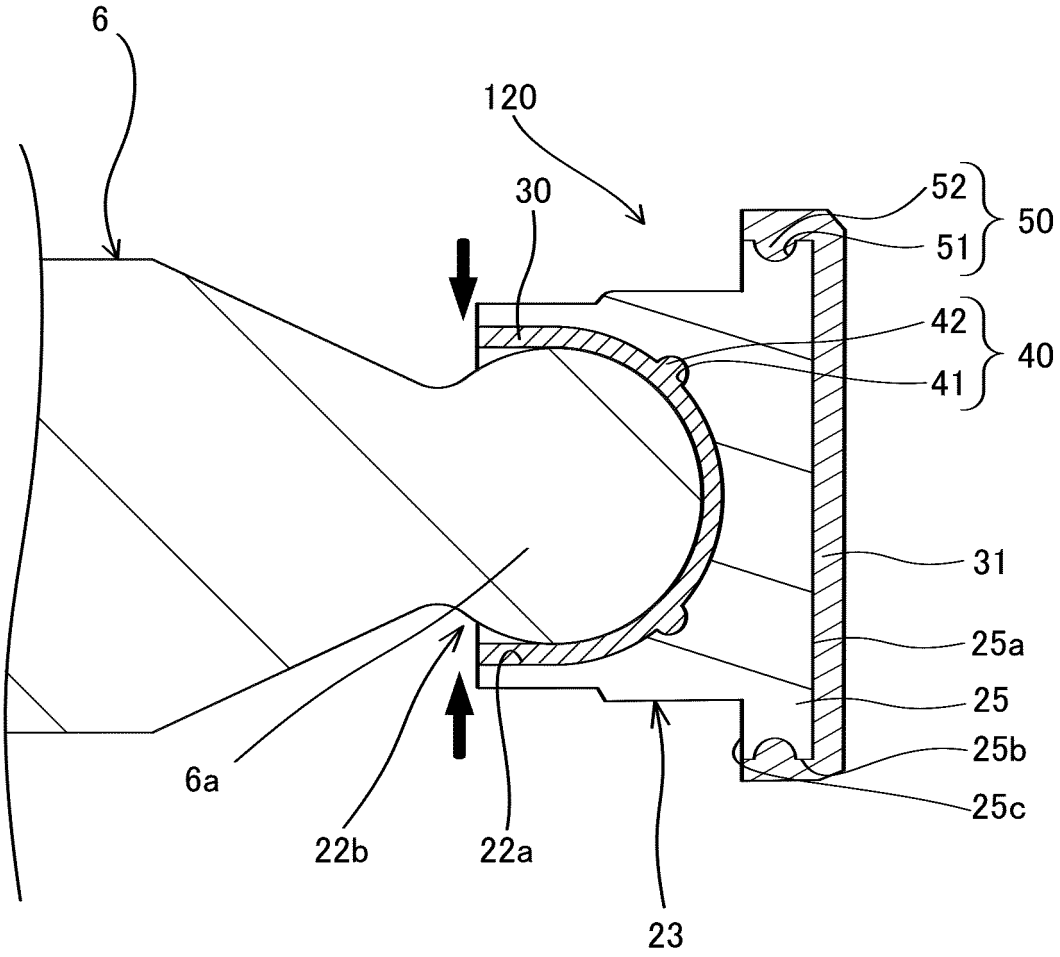

FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/077190

A. CLASSIFICATION OF SUBJECT MATTER
F04B1/22(2006.01)i, *F03C1/253*(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)
F04B1/22, F03C1/253

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 1996-2016
Kokai Jitsuyo Shinan Koho 1971-2016 Toroku Jitsuyo Shinan Koho 1994-2016

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	US 5762477 A (JEPSEN, Hardy Peter), 09 June 1998 (09.06.1998), column 3, line 61 to column 6, line 6; fig. 1 & WO 1996/002754 A1 description, page 7, line 30 to page 12, line 23; fig. 1	1-5
Y	JP 2728978 B2 (Danfoss A/S), 18 March 1998 (18.03.1998), column 7, line 6 to column 8, line 41; fig. 1 to 3 & WO 1994/016224 A1 description, page 6, line 23 to page 9, line 13; fig. 1 to 3	1-5

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

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"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
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
06 December 2016 (06.12.16)	20 December 2016 (20.12.16)
Name and mailing address of the ISA/ Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/077190

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 2012-218707 A (NHK Spring Co., Ltd.), 12 November 2012 (12.11.2012), paragraphs [0043] to [0047]; fig. 10(A) to (D) (Family: none)	3
Y	JP 2001-9160 A (Aruze Corp.), 16 January 2001 (16.01.2001), paragraphs [0010] to [0020]; fig. 1(a) to 2(b) (Family: none)	3
Y	JP 2009-121635 A (Mitsubishi Fuso Truck and Bus Corp.), 04 June 2009 (04.06.2009), paragraphs [0024] to [0040]; fig. 2(a), (b), (c) (Family: none)	3

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 2005220787 A **[0002] [0003]**
- JP 2015183222 A **[0075]**