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(54) AXIAL PISTON HYDRAULIC ROTATING MACHINE

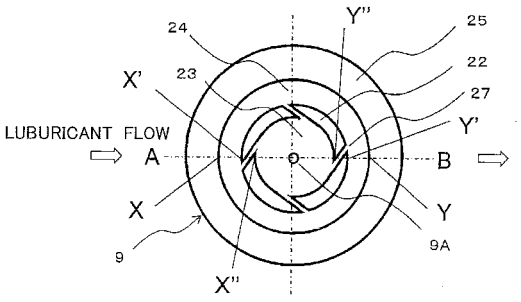
(57) PROBLEM TO BE SOLVED:

To provide an axial piston hydraulic rotating machine having high stability of a piston shoe.

SOLUTION:

A circular internal static pressure pocket 23 communicated with a filler opening 9A, an inner peripheral land portion 22 formed on the outer periphery of the internal static pressure pocket 23, an external static pressure pocket 24 formed on the outer periphery of the inner peripheral land portion 22, and an outer peripheral land portion 25 formed on the outer periphery of the external static pressure pocket 24 are formed on the sliding surface in contact a piston shoe 9 with the swash palate 10. The inner peripheral land portion 22 is annularly formed around the filler opening 9A. Oil passing grooves 27 through which the internal static pressure pocket 23 communicates with the external static pressure pocket 24 are formed in parts of the inner peripheral land portion 22 on straight lines, passing through the center of the filler opening 9A. The oil passing grooves 27 are inclined with respect to the straight line A-B passing through the center of the filler opening 9A. An inner wall surface and an outer wall surface of the inner peripheral land portion 22 are disposed on the straight lines that connect the center of the filler opening 9A to the center of the oil passing groove 27.

FIG.1



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Description

TECHNICAL FIELD

[0001] The present invention relates to an axial piston hydraulic rotating machine used for a hydraulic pump and a hydraulic motor of a construction machine, and more particularly, to a structure of a piston shoe that is attached to a piston end and pressed against a swash plate.

BACKGROUND ART

[0002] A sliding surface between a piston shoe attached to a piston end of an axial piston hydraulic rotating machine and a swash plate serves as a hydrostatic bearing provided with a static pressure pocket at the center and a filler opening communicated therewith. The aforementioned structure allows a fluid pressure of a lubricant supplied from the filler opening to the piston shoe to be balanced with the pressing force applied from the piston so that an oil film with appropriate thickness is formed between the piston shoe and the swash plate. The piston shoe is allowed to be smoothly slidable without being in contact with the swash plate. However, especially in a hydraulic rotating machine of variable capacity swash plate type, change in a tilt angle of the swash plate may change both horizontal and vertical components of the pressing force from the piston, which will bring the piston shoe into contact with the swash plate. This is likely to cause abrasion in the piston shoe.

[0003] As shown in Fig. 5, the structure which solves the aforementioned problem has been proposed by providing an annular inner peripheral land portion 22 within a region of forming a static pressure pocket of a piston shoe 9, dividing the circular region of forming the static pressure pocket into an internal static pressure pocket 23 inside the inner peripheral land portion 22 and an external static pressure pocket 24 outside the inner peripheral land portion 22, and forming an outer peripheral land portion 25 as an outer periphery of the external static pressure pocket 24 (see Patent Literature 1). The aforementioned structure allows a pressure receiving area of the piston shoe 9 to be larger than the area of the structure without the inner peripheral land portion 22. This makes it possible to improve abrasion proof property of the piston shoe 9. The inner peripheral land portion 22 is annularly formed around a filler opening 9A, and partially provided with an oil passing groove 27 which communicates the internal static pressure pocket 23 with the external static pressure pocket 24 so that both ends at the internal static pressure pocket 23 and the external static pressure pocket 24 are disposed on a straight line which passes through the center of the filler opening 9A.

CITATION LIST

PATENT LITERATURE

[0004]

Patent Literature 1: Japanese Patent Application Laid-Open No. 11-50950

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0005] The piston shoe 9 disclosed in Patent Literature 1 is formed such that the oil passing groove 27 is formed so as to have both ends at the internal static pressure pocket 23 and the external static pressure pocket 24 disposed on the straight line A-B that passes through the center of the filler opening 9A. If the piston shoe 9 slides with respect to a swash plate 10 in the state where the oil passing groove 27 is directed in accordance with the sliding direction of the piston shoe 9 with respect to the swash plate, the lubricant flows in an arrowed direction. Referring to Fig. 6, the lubricant flows into wide static pressure pockets 23, 24 after passing through a very small clearance between the swash plate 10 and the piston shoe 9. So the pressure at an inner peripheral portion X of the outer peripheral land portion 25 does not become so high at an inflow side A of the lubricant adhered to the swash plate 10. On the contrary, at an outflow side B of the lubricant, where the oil film is formed while being interposed between the piston shoe 9 and the swash plate 10, the lubricant flows outside through the very small clearance between the swash plate 10 and the piston shoe 9 from the wider static pressure pockets 23, 24. This may raise the pressure at an inner peripheral portion Y of the outer peripheral land portion 25 to a considerably high value.

[0006] The axial piston hydraulic rotating machine disclosed in Patent Literature 1 causes imbalance between the pressure distributions in the static pressure pockets 23, 24, which makes the oil film between the piston shoe 9 and the swash plate 10 at one side of the piston shoe 9 considerably thin. This may bring the piston shoe 9 into contact with the swash plate 10, thus causing the risk of eccentric wear.

[0007] The present invention has been made in consideration of the aforementioned circumstances, and an object of the present invention is to provide a hydraulic rotating machine with high reliability which is capable of keeping the pressure distribution within the static pressure pocket equalized as well as preventing the eccentric wear of the piston shoe.

SOLUTION TO PROBLEM

[0008] In order to achieve the object, the present invention provides an axial piston hydraulic rotating ma-

chine which includes a rotary shaft, a rotor attached to the rotary shaft, a piston slidably provided in a cylinder hole formed in the rotor, a piston shoe swingably attached to the piston, and a swash plate with which the piston shoe is slidably in contact. A sliding surface of the piston shoe with respect to the swash plate has an inner peripheral land portion, an external static pressure pocket, and an outer peripheral land portion formed in this sequence concentrically with respect to a filler opening communicated with the cylinder hole via an oil passing hole formed in the piston and an internal static pressure pocket communicated with the filler opening on an outer periphery thereof, and an oil passing groove through which the internal static pressure pocket communicates with the external static pressure pocket is formed in a part of the inner peripheral land portion on a straight line that passes through a center of the filler opening. An inner wall surface and an outer wall surface of the outer peripheral land portion, and an inner wall surface and an outer wall surface of the other land portion except the outer peripheral land portion are disposed on a straight line that connects the center of the filler opening to the center of the oil passing groove.

[0009] For the aforementioned structure, the inner and outer wall surfaces of the outer peripheral land portion, and the inner and outer wall surfaces of the other land portion except the outer peripheral land portion are disposed on a straight line which connects centers of the filler opening and the oil passing groove. Even if the piston shoe slides with respect to the swash plate in the state where the direction of the straight line which connects the centers of the filler opening and the oil passing groove is consistent with the sliding direction of the piston shoe with respect to the swash plate, the pressure distribution is equalized at the inflow and outflow sides of the lubricant that forms the oil film interposed between the piston shoe and the swash plate. This may suppress the eccentric wear in the piston shoe, thus enhancing durability of the axial piston hydraulic rotating machine.

[0010] In the structure according to the present invention, a direction of forming the oil passing groove is inclined with respect to the straight line that connects the center of the filler opening to the center of the oil passing groove, and the inner wall surface and outer wall surface of the inner peripheral land portion are disposed on the straight line that connects the center of the filler opening to the center of the oil passing groove.

[0011] In the aforementioned structure, the inner and outer wall surfaces of the inner peripheral land portion are disposed on the straight line which connects the centers of the filler opening and the oil passing groove. This makes it possible to equalize the pressure distribution at the inflow and outflow sides of the lubricant that forms the oil film interposed between the piston shoe and the swash plate when the piston shoe slides with respect to the swash plate.

[0012] In the structure according to the present invention, a shielding land portion that is larger than an interval between the oil passing grooves is formed in at least one of the internal static pressure pocket and the external static pressure pocket opposite an open end of the oil passing groove.

[0013] In the aforementioned structure, a shielding land that is larger than an interval between the oil passing grooves is formed opposite an open end of the oil passing groove in at least one of the internal and external static pressure pockets. This makes it possible to equalize the pressure distribution at the inflow and outflow sides of the lubricant that forms the oil film interposed between the piston shoe and the swash plate when the piston shoe slides with respect to the swash plate.

ADVANTAGEOUS EFFECTS OF INVENTION

[0014] According to the present invention, the inner and outer wall surfaces of the outer peripheral land portion, and the inner and outer wall surfaces of the other land portion except the outer peripheral land portion are disposed on the straight line that connects the centers of the filler opening and the oil passing groove. Even if the piston shoe slides with respect to the swash plate in the state where the sliding direction of the piston shoe with respect to the swash plate is consistent with the direction of the straight line that connects the centers of the filler opening and the oil passing groove, the pressure distribution may be equalized at the inflow and outflow sides of the lubricant that forms the oil film interposed between the piston shoe and the swash plate. This makes it possible to prevent the eccentric wear of the piston shoe as well as enhance durability of the axial piston hydraulic rotating machine.

BRIEF DESCRIPTION OF DRAWINGS

[0015]

Fig. 1 is a view showing a structure of a sliding surface of a piston shoe according to a first embodiment.

Fig. 2 shows a positional relationship between the piston shoe and the swash plate with respect to a cross-section of the piston shoe according to the first embodiment taken along straight line A-B of Fig. 1, and a graph representing a pressure change between the piston shoe and the swash plate.

Fig. 3 is a sectional view of an axial piston hydraulic rotating machine according to an embodiment.

Fig. 4 illustrates a structure of a sliding surface of a piston shoe according to a second embodiment.

Fig. 5 illustrates a structure of a sliding surface of a piston shoe as related art.

Fig. 6 shows a positional relationship between the piston shoe and a swash plate with respect to a cross-section of the piston shoe as related art taken along straight line A-B of Fig. 5, and a graph representing a pressure change between the piston shoe and the swash plate.

Fig. 7 is a graph showing a change in rotating speed with respect to time from activation of the axial piston hydraulic rotating machine according to the embodiment in comparison with the related art.

DESCRIPTION OF EMBODIMENTS

[0016] A structure of an axial piston hydraulic rotating machine according to an embodiment will be described referring to Fig. 3. As shown in Fig. 3, the axial piston hydraulic rotating machine 1 according to the embodiment is configured to have a rotary shaft 4 integrally linked with a rotor 5, and rotatably stored in a casing formed of a front casing 2 and a rear casing 3. A plurality of cylinder holes 6 are formed in the rotor 5 in a circumferential direction. A piston 8 is provided in each of the cylinder holes 6. An end portion of the piston 8 is swingably connected to a piston shoe 9 via a spherical bearing. One surface of the piston shoe 9 is slidably in contact with a surface of a swash plate 10 tiltably held at the front casing 2. The swash plate 10 is configured to have the tilt angle changeable by a not shown servo piston. The stroke of the piston 8 is changed by adjusting the tilt angle of the swash plate 10. A valve plate 7 with which the rotor 5 is slidably in contact is fixed to the rear casing 3. The valve plate 7 is provided with a suction port and a discharge port which are not shown. The piston 8 has an oil passing hole 8A communicated with the suction port or the discharge port of the valve plate 7 via the cylinder hole 6, and the piston shoe 9 has a filler opening 9A at the center, which is communicated with the oil passing hole 8A formed in the piston 8.

[0017] If the rotary shaft 4 is driven and rotated by a not shown motor, the hydraulic fluid supplied from the suction port is compressed by the piston 8, and discharged from the discharge port so that the axial piston hydraulic rotating machine according to the embodiment functions as a hydraulic pump. When supplying pressurized oil from the suction port into the cylinder hole 6, the piston 8 is driven under the pressure of the pressurized oil, and the rotary shaft 4 and the rotor 5 are driven and rotated accompanied therewith so that the axial piston hydraulic rotating machine functions as a hydraulic motor.

[0018] Referring to Fig. 1, the piston shoe 9 has a circular internal static pressure pocket 23 communicated with the filler opening 9A, an inner peripheral land portion 22 formed on the outer periphery of the internal static pressure pocket 23, an external static pressure pocket 24 formed on the outer periphery of the inner peripheral land portion 22, and an outer peripheral land portion 25 formed on the outer periphery of the external static pressure pocket 24 on the sliding surface in contact with the swash palate 10.

[0019] The inner peripheral land portion 22 is annularly formed around the filler opening 9A. Two oil passing grooves 27 through which the internal static pressure pocket 23 communicates with the external static pressure pocket 24 are formed in parts of the inner peripheral land portion 22 on straight lines, passing through the center of the filler opening 9A. The oil passing grooves 27 are inclined with respect to the straight line A-B passing through the center of the filler opening 9A. An inner wall surface and an outer wall surface of the inner peripheral land portion 22 are disposed on the straight lines that connect the center of the filler opening 9A to the center of the oil passing groove 27.

[0020] The axial piston hydraulic rotating machine according to the embodiment is configured to form the oil passing groove 27 that is directed to incline with respect to the straight line A-B passing through the center of the filler opening 9A, and to dispose the inner wall surface and outer wall surface of the inner peripheral land portion 22 on the straight line that connects the center of the filler opening 9A to the center of the oil passing groove 27. The structure allows the pressure distribution to be equalized at the inflow side A and the outflow side B of the lubricant that forms the oil film interposed between the piston shoe 9 and the swash plate 10 even if the straight line A-B that passes through the center of the filler opening 9A is consistent with the sliding direction of the piston shoe 9 with respect to the swash plate 10.

[0021] Referring to Fig. 2, as the filler opening 9A communicated with the cylinder hole 6 is opened in the center of the sliding surface of the piston shoe 9, each pressure of the filler opening 9A, the internal static pressure pocket 23, the external static pressure pocket 24 which are communicated with the filler opening 9A, and the oil passing grooves 27 becomes substantially the same as the pressure inside the cylinder hole 6. The pressure at the inner periphery of the outer peripheral land portion 25 becomes the same as that in the cylinder hole 6: however, the pressure is decreased toward the outer peripheral side. The pressure at the outer periphery becomes the same as that of the hydraulic fluid which is accumulated inside the casing 1. The pressure distributions on the section taken along straight line A-B shown in Fig. 1 are indicated by dashed straight lines in Fig. 2 when there is no relative motion between the piston shoe 9 and the swash plate 10. Solid straight line in Fig. 2 shows the pressure distribution at the same positions when there is the relative motion of the swash plate 10 with respect to the piston shoe 9 in the arrowed direction as shown in Fig. 1. Owing to the relative motion, the pressure drops at an inlet (X) of the external static pressure pocket 24 and an inlet (X") of the internal static pressure pocket 23 at upstream side of the pad center of the hydraulic fluid flow, and the pressure rises at an outlet (Y) of the external static pressure pocket 24 and an outlet (Y") of the internal static pressure pocket 23 at downstream side. The former pressure drop is caused by rapid enlargement of the flow passage, and the latter pressure rise is caused by rapid shrinkage of the flow passage. In the case where the inner and outer wall surfaces of the inner peripheral land portion 22 are designed to be oriented to an arbitrary direction that passes through the center of the filler opening 9A as the em-

bodiment, the flow passage is rapidly enlarged at a time point (X) of the inflow into the external static pressure pocket 24. However, the shrinkage (X') of the flow passage is caused by the inner peripheral land portion 22 immediately so as to suppress the pressure drop to be kept low. As for the downstream side, shrinkage occurs in the flow passage to raise the pressure at the outlet (Y) of the external static pressure pocket 24. However, the pressure rise may be suppressed to be kept low because of enlargement of the flow passage at the inlet (Y') of the external static pressure pocket 24 just before the outlet. The pressure distribution shown in Fig. 2 indicates the case where there is the relative motion of the swash plate 10 in the arrowed direction. In this embodiment, the inner peripheral land portion 22 is provided to cover the direction that passes through the center of the filler opening 9A. This makes it possible to provide similar effects regardless of the direction of the relative motion. The pressure distribution on the sliding surface is brought into substantially equalized entirely on the sliding surface. This makes it possible to stabilize the posture of the piston shoe 9, prevent the eccentric wear, and reduce the risk of damage. Then highly reliable hydraulic rotating machine with high efficiency may be realized.

[0022] Figs. 4(a), 4(b) and 4(c) show another embodiments of the present invention. Referring to Fig. 4(a), a shielding land portion 28 that is larger than a groove interval of the oil passing groove 27 is formed in the external static pressure pocket 24 opposite the oil passing groove 27. Referring to Fig. 4(b), the shielding land portion 28 that is larger than the groove interval of the oil passing groove 27 is formed in the internal static pressure pocket 23 opposite the oil passing groove 27. Referring to Fig. 4(c), the shielding land portions 28 each larger than the groove interval of the oil passing groove 27 are formed both in the external static pressure pocket 24 opposite the oil passing groove 27 and the internal static pressure pocket 23 opposite the oil passing groove 27. These embodiments are capable of providing the similar effects to those from the structure shown in Fig. 1.

[0023] The shielding land portion 28 may be formed only in the internal static pressure pocket 23, or may be formed in both the internal static pressure pocket 23 and the external static pressure pocket 24.

[0024] Application of the axial piston hydraulic rotating machine according to the present invention to the motor and the pump of the construction machine may allow the construction machine to have a quick response because of small friction inside the hydraulic rotating machine. For example, when applying the related art to the drive motor, the change in the rotating speed with respect to time from activation is expressed by a curve 31 as shown in Fig. 7. Meanwhile, the change in the rotating speed resulting from application of the present invention may be expressed by a curve 32. As the drawings clearly show, the rotating speed of the axial piston hydraulic rotating machine at a time T_1 elapsing from activation becomes N_1 for the related art, and N_2 for the present invention. The present invention is capable of providing the response quicker than related art.

REFERENCE SIGNS LIST

[0025]

1	Axial piston hydraulic rotating machine
2	Front casing
3	Rear casing
4	Rotary shaft
5	Rotor
6	Cylinder hole
8	Piston
8A	Oil passing hole
9	Piston shoe
9A	Filler opening
10	Swash plate
22	Inner peripheral land portion
23	Internal static pressure pocket
24	External static pressure pocket
25	Outer peripheral land portion
27	Oil passing groove
28	Shielding land portion

Claims

1. An axial piston hydraulic rotating machine comprising: a rotary shaft; a rotor attached to the rotary shaft; a piston slidably provided in a cylinder hole formed in the rotor; a piston shoe swingably attached to the piston; and a swash plate with which the piston shoe is slidably in contact,
wherein: a sliding surface of the piston shoe with respect to the swash plate has an inner peripheral land portion, an external static pressure pocket, and an outer peripheral land portion formed in this sequence concentrically with respect to a filler opening communicated with the cylinder hole via an oil passing hole formed in the piston and an internal static pressure pocket communicated with the filler opening on an outer periphery thereof, and an oil passing groove through which the internal static pressure pocket communicates with the external static pressure pocket is formed in a part of the inner peripheral land portion on a straight line that passes through a center of the filler opening; and
an inner wall surface and an outer wall surface of the outer peripheral land portion, and an inner wall surface and an outer wall surface of the other land portion except the outer peripheral land portion are disposed on a straight line that connects the center of the filler opening to the center of the oil passing groove.

2. The axial piston hydraulic rotating machine according to claim 1, wherein a direction of forming the oil

passing groove is inclined with respect to the straight line that connects the center of the filler opening to the center of the oil passing groove, and the inner wall surface and outer wall surface of the inner peripheral land portion are disposed on the straight line that connects the center of the filler opening to the center of the oil passing groove.

3. The axial piston hydraulic rotating machine according to claim 1, wherein a shielding land portion that is larger than an interval between the oil passing grooves is formed in at least one of the internal static pressure pocket and the external static pressure pocket opposite an open end of the oil passing groove.

FIG.1

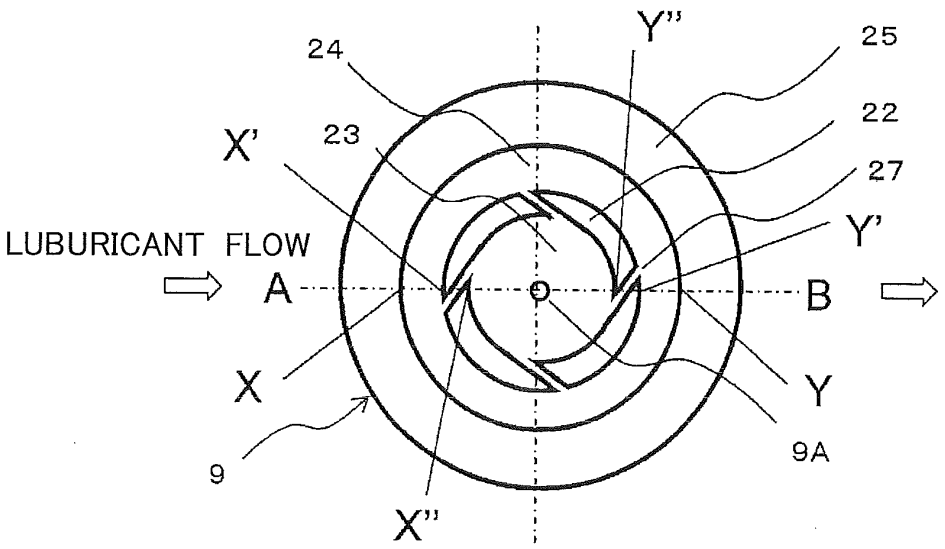

Y''
24
25
22
X'
23
27
Y'
LUBURICANT FLOW
A
O
B
X
Y
9
9A
X''

FIG.2

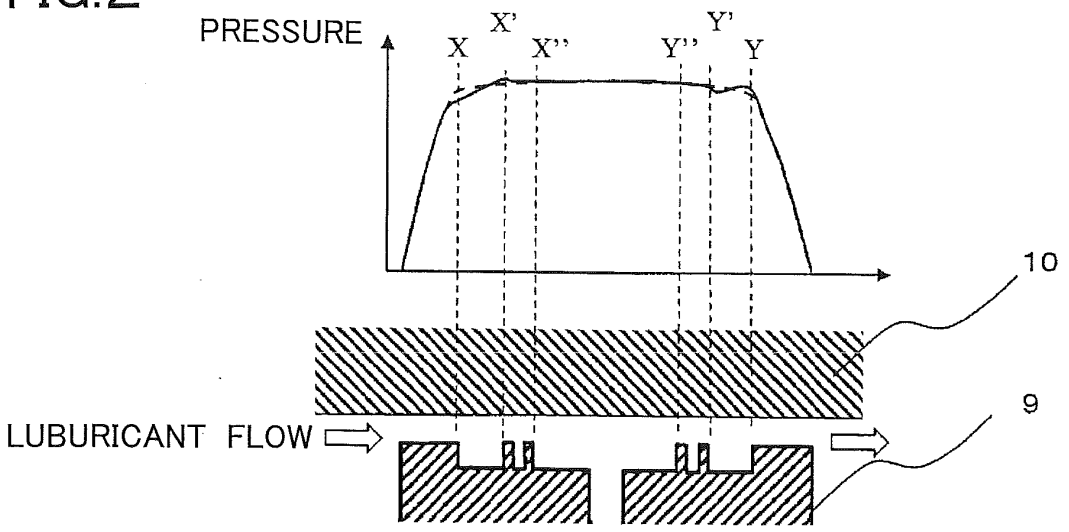

PRESSURE
X'
Y'
X
X''
Y''
Y
10
9
LUBURICANT FLOW

FIG.3

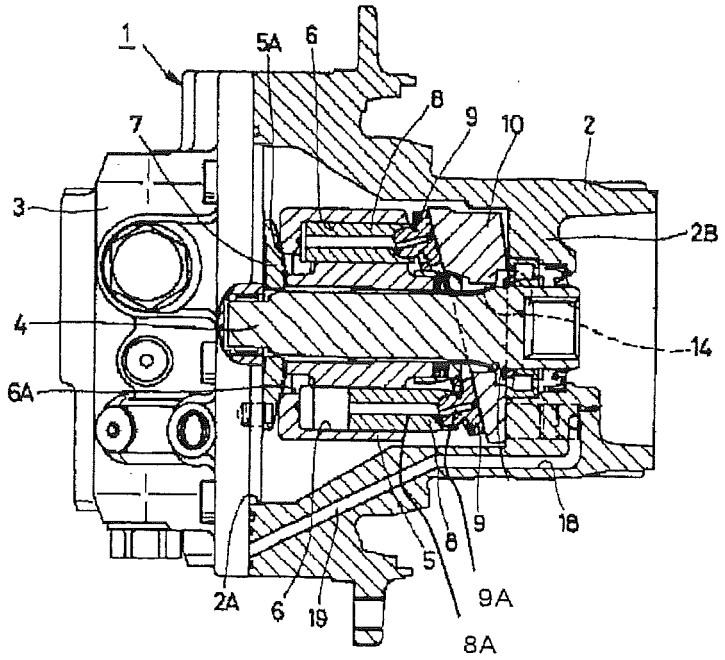


FIG.4

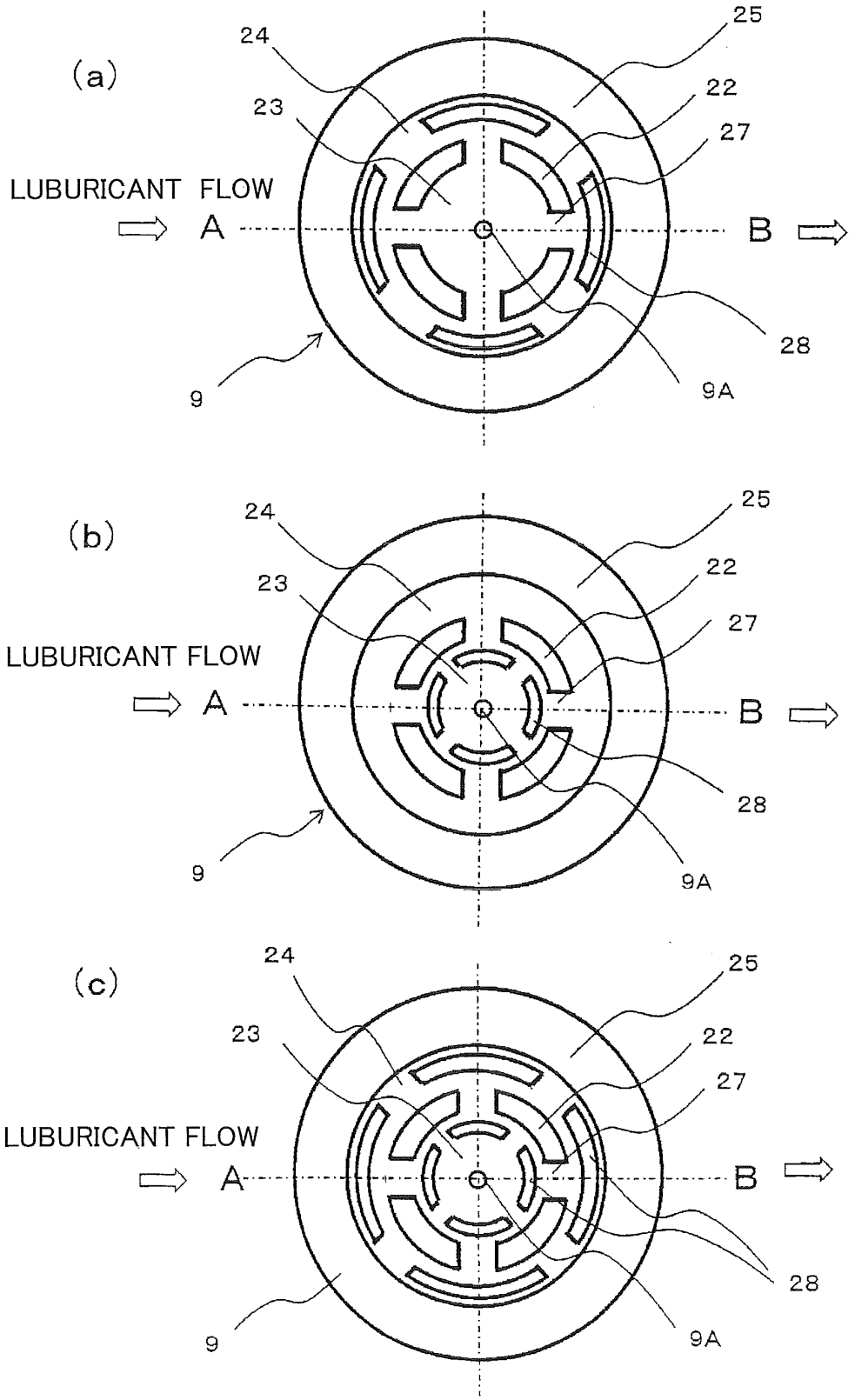
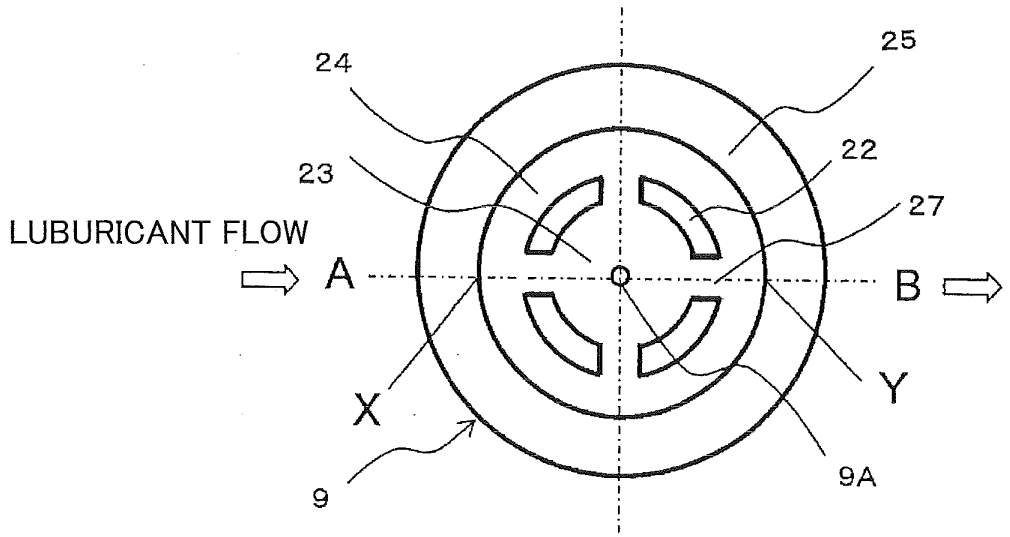

(a)
24
25
23
22
27
LUBURICANT FLOW
A
B
28
9
9A
(b)
24
25
23
22
27
LUBURICANT FLOW
A
B
28
9
9A
(c)
24
25
23
22
27
LUBURICANT FLOW
A
B
28
9
9A

FIG.5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23
22
27
LUBURICANT FLOW
A
O
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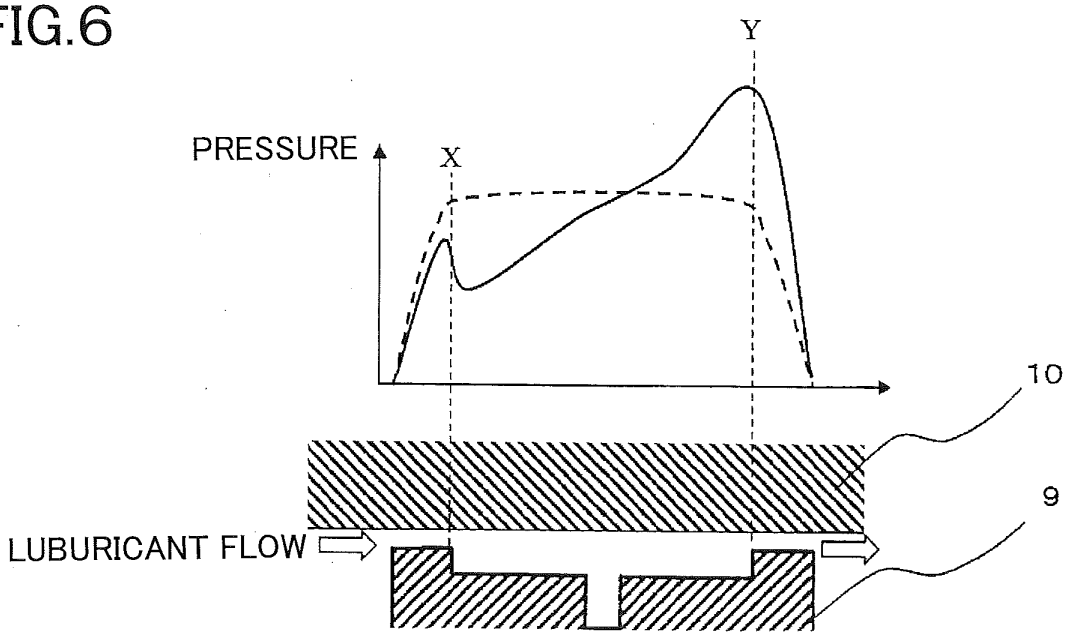
X
Y
9
9A

FIG.6


Y
PRESSURE
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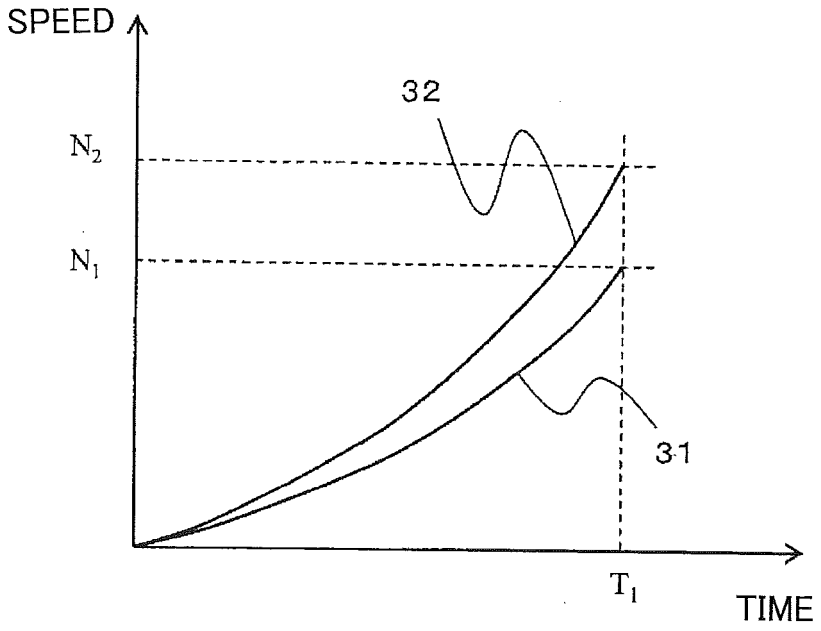
10
9
LUBURICANT FLOW

FIG.7



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2010/068736

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)
F04B1/00-1/30, F03C1/00-1/40

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	1996-2011
Kokai Jitsuyo Shinan Koho	1971-2011	Toroku Jitsuyo Shinan Koho	1994-2011

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.
X	GB 983310 A (Hans THOMA), 15 February 1965 (15.02.1965), page 1, lines 8 to 22; page 2, lines 57 to 89; page 3, lines 4 to 11; page 3, lines 34 to 38; fig. 1, 8 (Family: none)	1-2
X	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 77263/1988(Laid-open No. 1476/1990) (Komatsu Ltd.), 08 January 1990 (08.01.1990), page 2, line 2 to page 4, line 6; fig. 3 to 5 (Family: none)	1,3

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"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 January, 2011 (06.01.11)	18 January, 2011 (18.01.11)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2010/068736

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 84840/1971(Laid-open No. 42103/1973) (Hitachi, Ltd.), 30 May 1973 (30.05.1973), page 2, line 18 to page 3, line 5; page 5, lines 8 to 17; fig. 1 to 3 (Family: none)	1,3
A	JP 11-50950 A (Kayaba Industry Co., Ltd.), 23 February 1999 (23.02.1999), paragraphs [0004] to [0005], [0009], [0040], [0049] to [0051]; fig. 1, 4, 15 to 16 & US 6092457 A & EP 896151 A2 & DE 69815766 T2	1

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

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 11050950 A **[0004]**