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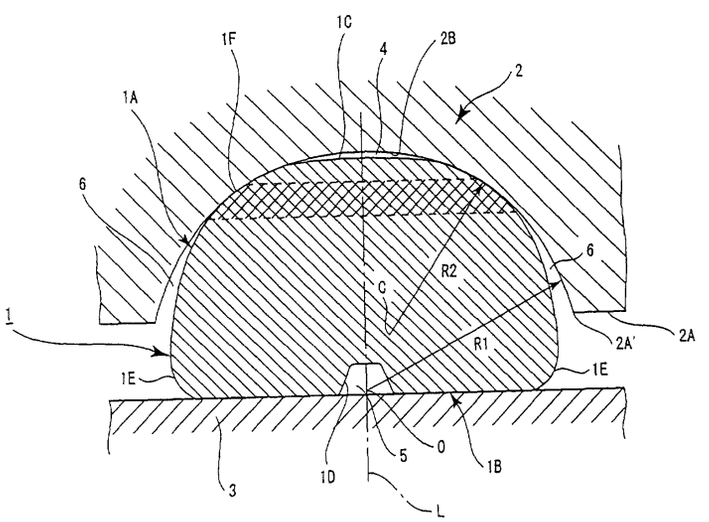
(54) HEMISPHERICAL SHOE

(57) A semi-spherical shoe 1 has a convex semi-spherical surface 1A which is disposed in sliding contact with a semi-spherical recess 2A formed in a piston 2. The convex semi-spherical surface 1A is defined by a convex surface of a revolving body which is formed when an arc of a circle having a radius of R2 and having a center C offset from the axis L of the semi-spherical shoe in an direction orthogonal thereto is rotated about the axis L as a center of rotation. A lead-in 1G which is arcuate in section is formed toward the top of the convex semi-spherical surface 1A and maintains a clearance 7 with respect to the semi-spherical recess 2A. A lubricant oil which is stored in a space 4 is smoothly supplied onto a sliding surface 1F through the clearance 7. The invention provides a semi-spherical shoe 1 having a good sliding response and an increased length of useful life.

Fig. 1



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Description

FIELD OF THE INVENTION

[0001] The invention relates to a semi-spherical shoe, and in particular, to a semi-spherical shoe which is preferred to be interposed between a piston and a swash plate of a swash plate compressor, for example.

BACKGROUND

[0002] A semi-spherical shoe having a semi-spherical convex surface which is fitted into a semi-spherical recess formed in a piston and an end face which is disposed in sliding contact with a flat surface of a swash plate is known in the art.

[0003] A semi-spherical shoe in which the convex semi-spherical surface has a diameter R2 which is chosen by a given amount less than the diameter R1 of the semi-spherical recess formed in the piston is also known in the art (see, for example, Japanese Utility Model Publication No. 5, 259/1995).

[0004] The disclosed semi-spherical shoe includes a semi-spherical recess and a convex semi-spherical surface having sizes chosen in the manner mentioned above, and this allows a clearance to be maintained between an inlet region of the semi-spherical recess in the piston and an opposing convex semi-spherical surface of the shoe. This allows a lubricant oil to be introduced into the clearance through the inlet of the semi-spherical recess, and allows the lubricant oil to be supplied into sliding portions of the convex semi-spherical surface and the semi-spherical recess as the shoe rocks in accordance with the angle of the swash plate.

[0005] In the disclosed semi-spherical shoe, a top region of the convex semi-spherical surface is notched to define a flat surface, thus forming a space, which is arcuate in section, between the flat surface and the opposing top of the semi-spherical recess. It is intended that the space serves as a reservoir of lubricant oil, thus allowing the latter to be supplied into the sliding portions of the convex semi-spherical surface and the semi-spherical recess.

[0006] In the disclosed semi-spherical shoe, however, the flat surface on the top of the convex semi-spherical surface has its edge formed at an acute angle, thus greatly reducing the clearance left between the edge of the flat surface and the semi-spherical recess. This results in a disadvantage that the lubricant oil stored in the space formed between the flat surface on the convex semi-spherical surface and the top of the semi-spherical recess of the semi-spherical shoe is less susceptible to be conveyed into the sliding portions of the convex semi-spherical surface and the semi-spherical recess.

[0007] Additionally, another disadvantage accrues after the semi-spherical shoe in the piston and the convex semi-spherical surface of the shoe adapt themselves to each other in that the extent of the sliding portions thereof of increase to a degree, and a central area of the sliding portions can not be lubricated satisfactorily when the shoe undergoes a rocking motion of a reduced magnitude or when the angle of the swash plate is small.

DISCLOSURE OF THE INVENTION

[0008] In view of the forgoing, the invention relates to a spherical shoe including a convex semi-spherical surface which is fitted into a semi-spherical recess formed in a first movable member so as to be in sliding contact therewith, and an end face disposed for sliding contact with a flat surface on a second movable member. In accordance with the invention, the convex semi-spherical surface which is disposed in sliding contact with the semi-spherical recess formed in the first movable member is defined by a convex surface of a revolving body which is formed by rotating an arc of a circle having a center which is disposed at a given distance from an axis in a direction orthogonal thereto about the axis.

[0009] With this arrangement, the top region of the convex semi-spherical surface of the semi-spherical shoe has an edge which is arcuate in section, maintaining a clearance between the edge of the top region and the opposing recess which is wedge-shaped in section. This allows a lubricant oil, which is stored in a space formed between the top region of the convex semi-spherical surface of the semi-spherical shoe and the top of the semi-spherical recess in the first movable member, to be supplied onto the sliding portions of the convex semi-spherical surface and the semi-spherical recess through the wedge-shaped clearance in a facilitated manner. This enables a semi-spherical shoe having a good sliding response and a long life to be provided.

[0010] In addition, the width of an area of abutment between the semi-spherical recess in the first movable member and the convex semi-spherical surface of the semi-spherical shoe can be reduced as compared with the prior art, allowing the lubricant oil to be effectively supplied to a central area of the sliding portions if the semi-spherical shoe undergoes a rocking motion of a reduced magnitude or when the angle of inclination of the second movable member is small.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011]

Fig. 1 is a cross section of one embodiment of the present invention; and
Fig. 2 is an enlarged view of part shown in Fig. 1.

BEST MODES OF CARRYING OUT THE INVENTION

[0012] The present invention will now be described with reference to an embodiment shown in the drawings. Referring to Fig. 1, a swash plate compressor comprises a semi-spherical shoe 1, a piston 2 which is driven for

reciprocating motion in the vertical direction as viewed in Fig. 1, and a flat swash plate 3 which is driven for rotation by a rotary shaft. The piston 2 has an end face 2A, in which a semi-spherical recess 2B is formed. In this embodiment, the semi-spherical recess 2B is formed with a common curvature, represented by a radius R1, over the entire area.

[0013] The semi-spherical shoe 1 includes a convex semi-spherical surface 1A in the form of a semi-sphere, and a smoothened end face 1B. A top portion, as viewed in Fig. 1, of the convex semi-spherical surface 1A is formed as a non-contact region 1C which is prevented from contacting the semi-spherical recess 2B. The end face 1B is formed centrally, or in a region around the axis thereof, with a substantially conical opening 1D.

[0014] The convex semi-spherical surface 1A of the semi-spherical shoe 1 is fitted into the semi-spherical recess 2B in the piston 2 while the end face 1B is disposed in abutment against the swash plate 3. When the semi-spherical shoe 1 is interposed between the semi-spherical recess 2B and the swash plate 3, a region of the convex semi-spherical surface 1A which is located toward a boundary 1E between the semi-spherical surface 1A and the end face 1B and adjacent thereto is exposed externally of an edge 2' (inlet) of the semi-spherical recess 2B in a space between the end face 2A of the piston 2 and the swash plate 3.

[0015] A space 4 is formed between the non-contact region 1C and the opposing semi-spherical recess 2B in the piston 2, and a space 5 is formed by the opening 1D and the swash plate 3. These spaces 4 and 5 serve as temporary reservoirs of lubricant oil, containing a supply of lubricant oil therein.

[0016] A clearance 6 which is wedge-shaped in section is defined between a region of the semi-recess 2B which is located adjacent to an edge 2A' (inlet) and the opposing convex semi-spherical surface 1A. Accordingly, in the present embodiment, a region of the convex semi-spherical 1A which is located nearer the non-contact region 1C or the space 4 than the clearance 6 defines a sliding surface 1F with respect to the semi-spherical recess 2B (shown hatched in Fig. 1).

[0017] When the swash plate 3 is driven for rotation, the piston 2 is driven through the semi-spherical shoe 1 for reciprocating motion. This takes place by a sliding movement between the end face 1B of the semi-spherical shoe 1 and the swash plate 3 and a sliding motion of the sliding surface 1F of the convex semi-spherical surface 1A relative to the semi-spherical recess 2B. During the process, the lubricant oil is introduced into the clearance 6 from the side represented by the edge 2' to be fed into the sliding portions of the sliding surface 1F of the convex semi-spherical surface 1A and the semi-spherical recess 2B. In addition, the lubricant oil which is stored in the top space 4 permeates into the sliding portions of the sliding surface 1F of the convex semi-spherical surface 1A and the semi-spherical recess 2B, thus cooling the sliding portions. Finally, the lubricant oil stored in the space 5 permeates into the sliding portions of the end face 1B and the swash plate 3, again cooling these portions.

[0018] As an alternative, an opening which is similar to the opening 1D formed in the end face 1D may be formed centrally in the non-contact region 1C or in the top of the convex semi-spherical surface 1A.

[0019] In the present embodiment, an arrangement to promote a supply of lubricant oil stored in the space 4 to the sliding surface 1F of the convex semi-spherical surface 1A is made by forming the convex semi-spherical surface 1A of the semi-spherical shoe 1 in a manner to be described below.

[0020] Specifically, in the present embodiment, the convex semi-spherical surface 1A is defined by a convex surface of a revolving body which results when an arc of a circle having a radius R2 and having a center C which is located at a given distance offset from an axis L of the semi-spherical shoe 1 in a direction orthogonal thereto is rotated about the axis L. The no-contact region 1C is formed by a top portion of the revolving body. The no-contact region 1C is shown to be gently arcuate in section, but the non-contact region 1C may be delineated by a flat surface which extends orthogonal to the axis L.

[0021] In the present embodiment, the radius R2 of the arc of a circle is chosen to be less than the radius R1 of the semi-spherical recess 2B. Specifically, a difference R1-R2 is chosen to be greater than 150 μm. In addition, in the present embodiment, a distance by which the center C is offset from the axis in an orthogonal direction is chosen to be in a range from 20 to 500 μm.

[0022] What results is shown to an enlarged scale in Fig. 2 where it will be noted that a lead-in 1G which is arcuate in section is formed in a boundary region between the non-contact region 1C and the sliding surface 1F. When the lead-in 1G is formed, a clearance 7 which is wedge-shaped in section and which becomes narrower toward the sliding surface 1F is maintained between the lead-in 1G and the semi-spherical recess 2B.

[0023] In the present embodiment, an arrangement is made such that a distance by which the sliding surface 1F is spaced from the axis L is less than a distance by which the outer peripheral edge of the end face 1B which is in sliding contact with the swash plate 3 is spaced from the axis L. In other words, the sliding surface 1F is disposed so that it is located nearer the axis L than the outer peripheral surface of the end face 1B , thus facilitating a rocking motion of the semi-spherical shoe 1.

[0024] An extent of sliding motion as the sliding surface 1F slides with respect to the semi-spherical recess 2B is chosen such that when referenced to the axis of the semi-spherical recess 2B of the piston 2 and centered about the center O of the radius R1 of the semi-spherical recess 2B, the sliding surface 1F slides within an extent of 60° from the axis of the semi-spherical recess 2B of the piston 2, more preferably, within an extent

from 5° to 60° and most preferably in an extent from 20° to 40° from the axis of the semi-spherical recess 2B.

[0025] When the convex semi-spherical surface 1A of the semi-spherical shoe 1 is formed in the manner mentioned above to define the lead-in 1G toward the space 4, the lubricant oil which is stored in the space 4 can be smoothly introduced onto the sliding surface 1F through the clearance 7, thus allowing the sliding surface 1F to be cooled in a favorable manner. Accordingly, the semi-spherical shoe 1 of the present embodiment has a good cooling effect of the sliding surface 1F by the lubricant oil and also has a good sliding response, both contributing to increasing the useful life thereof as compared with the prior art.

[0026] In addition, with the present embodiment, the width of an area of abutment between the convex semi-spherical surface 1A of the semi-spherical shoe 1 and the semi-spherical recess 2B of the piston 2 can be reduced as compared with the prior art, allowing the lubricant oil to be effectively supplied to the center area of the sliding portions of the sliding surface 1Fof the semi-spherical shoe 1 and the semi-spherical recess 2B when the amplitude of rocking motion of the semi-spherical shoe 1 is small or when a angle of inclination of the swash plate 3 is small.

[0027] In the above description of the embodiment, regions of the convex semi-spherical surface 1A other than the non-contact region 1C are constructed by a convex surface which is described in relation to the arc of the radius R2, but at least the region of the sliding surface 1F may be constructed by a convex surface which is described in relation to the arc of the radius R2.

INDUSTRIAL AVAILABILITY

[0028] As described, according to the present invention, there can be provided a semi-spherical shoe which has a good sliding response and an increased length of useful life.

Claims

1. A semi-spherical shoe including a convex semi-spherical surface fitted into a semi-spherical recess formed in a first movable member for sliding movement thereto, and an end face disposed in sliding contact with a flat surface on a second movable member;

   characterized in that the convex semi-spherical surface which is in sliding contact with the semi-spherical recess in the first movable member is defined by a convex surface of a revolving body which is formed when an arc of an circle offset by a given distance from axis in a direction orthogonal thereto is rotated about the axis as a center of rotation.

2. A semi-spherical shoe according to Claim 1 in which when the radius of the semi-spherical recess in the first movable member is denoted by R1 and the radius of the arc by R2, a difference R1-R2 is chosen to be greater than 150 μm.

3. A semi-spherical shoe according to Claim 1 or 2 in which the distance by which the center of the arc is offset from the axis in the orthogonal direction is chosen in a range from 20 to 500 μm.

Fig. 1

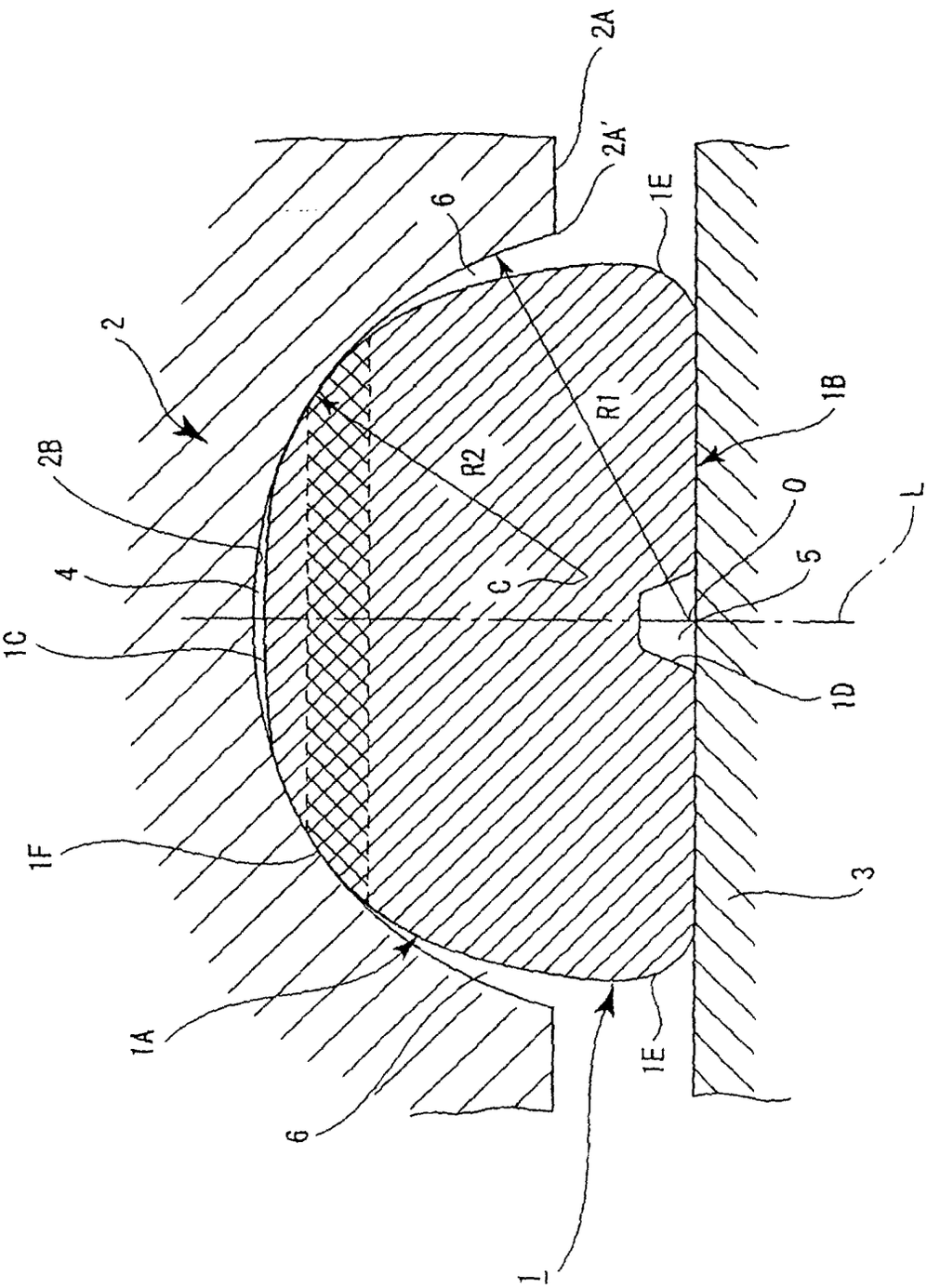
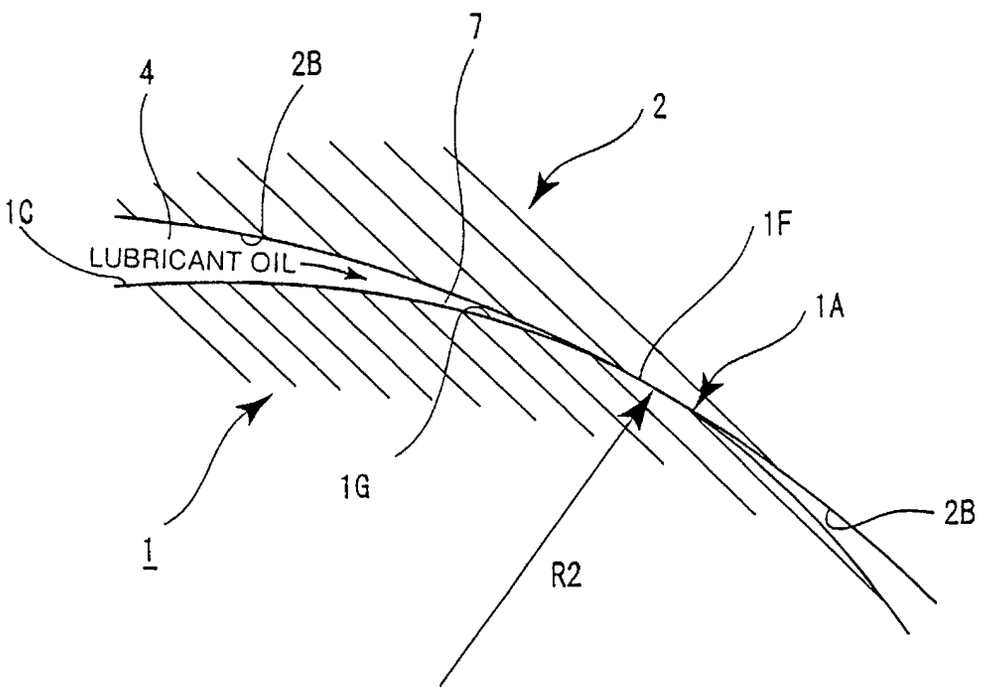


Fig.2



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP01/01114

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[7] F04B27/08

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[7] F04B27/08

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Toroku Jitsuyo Shinan Koho 1994-2001
Kokai Jitsuyo Shinan Koho 1971-2001 Jitsuyo Shinan Toroku Koho 1996-2001

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 A	JP, 11-50960, A (NTN corporation), 23 February, 1999 (23.02.99), Full text & DE, 19830228, A & FR, 2767359, A	1 2,3
A	JP, 11-50958, A (NTN corporation), 23 February, 1999 (23.02.99), Full text & DE, 19830228, A & FR, 2767359, A	1-3
A	JP, 11-159457, A (Sanden Corp.), 15 June, 1999 (15.06.99), Full text & EP, 919719, A	1-3

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* Special categories of cited documents:
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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
26 April, 2001 (26.04.01)	15 May, 2001 (15.05.01)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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