

(19)



(11)

EP 2 042 731 A2

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:

01.04.2009 Bulletin 2009/14

(51) Int Cl.:

F04B 27/10 ^(2006.01)(21) Application number: **08164894.1**(22) Date of filing: **23.09.2008**

(84) Designated Contracting States:

**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR
HR HU IE IS IT LI LT LU LV MC MT NL NO PL PT
RO SE SI SK TR**

Designated Extension States:

AL BA MK RS(30) Priority: **27.09.2007 JP 2007250639****05.11.2007 JP 2007287250**(71) Applicant: **Kabushiki Kaisha Toyota Jidoshokki****Kariya-shi,****Aichi 448-8671 (JP)**

(72) Inventors:

- **Kubo, Hiroshi**

Kariya-shi Aichi 448-8671 (JP)

- **Kawaguchi, Masahiro**

Kariya-shi, Aichi 448-8671 (JP)

- **Ota, Masaki**

Kariya-shi, Aichi 448-8671 (JP)

- **Matsubara, Ryo**

Kariya-shi, Aichi 448-8671 (JP)

- **Yamashita, Hideharu**

Kariya-shi, Aichi 448-8671 (JP)

- **Kayukawa, Hiroaki**

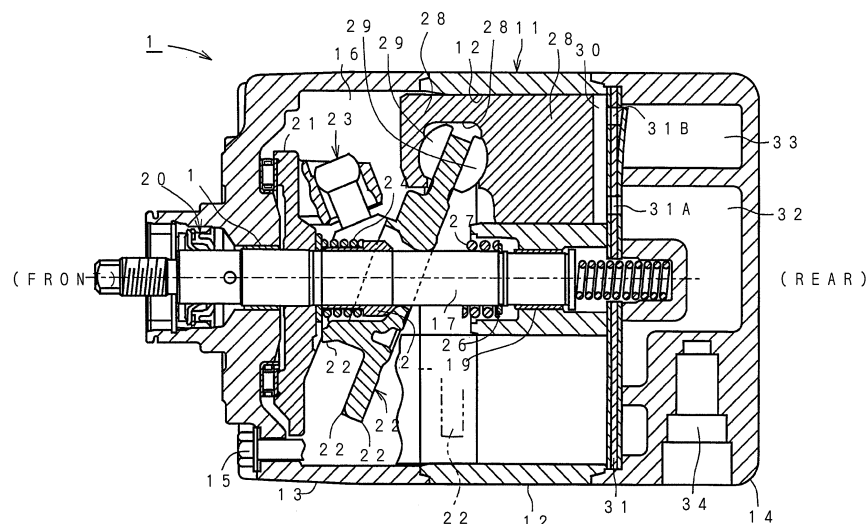
Kariya-shi, Aichi 448-8671 (JP)

- **Makino, Yasunori**

Kariya-shi, Aichi 448-8671 (JP)(74) Representative: **TBK-Patent****Bavariaring 4-6****80336 München (DE)**(54) **Swash plate type compressor**

(57) A swash plate type compressor has a cylinder block, a drive shaft, a piston, a pair of first and second shoes and a swash plate. The swash plate has a first surface on the far side of the swash plate from the cylinder bore in slide contact with the first shoe and a second surface on the same side of the swash plate as the cylinder bore in slide contact with the second shoe. The

swash plate has first and second edges formed between the first and second surfaces and an outer peripheral surface of the swash plate, respectively. The swash plate has a curved surface formed on the first edge at and adjacent to the bottom dead center of the swash plate whose radius of curvature is larger than that of the surface of the second edge.

FIG. 1

Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a swash plate type compressor used for a vehicle air conditioner, and the like.

[0002] Japanese Patent Application Publication No. 2001-317453 discloses a swash plate type compressor in which a shoe is interposed between a swash plate connected to a drive shaft driven to rotate and a reciprocable piston. In the swash plate type compressor, the swash plate has a smooth convex curved surface formed on an axial end faces of the swash plate on which the shoes slide with an extremely large radius of curvature. A wedge-shaped clearance is provided between the convex curved surface of the swash plate and the plane surface of the shoe. Lubricating oil is supplied through such clearance to sliding surfaces of the swash plate and the shoes, thus improving the sliding characteristics between the swash plate and the shoes, and reducing abrasion occurring during sliding.

[0003] Japanese Patent Application Publication No. 2001-317453 discloses a typical swash plate type variable displacement compressor wherein the inclination angle of the swash plate relative to the drive shaft is varied to control the displacement of the compressor. When the compressor is required to be operated at the maximum displacement, the inclination angle of the swash plate is increased, and the reciprocating stroke length of the piston is increased, accordingly. As a result, reciprocating inertia force of the shoe disposed on the front side of the swash plate or on the far side of the swash plate from the cylinder bore is increased. This reciprocating inertia force acting on the shoe becomes maximum when the shoe contacts with the swash plate at the bottom dead center of the swash plate. Fig. 10 schematically illustrates a state wherein the swash plate 50 is positioned at the maximum inclination angle thereof, and the swash plate 50 is in contact at the bottom dead center thereof with the shoe 51A. As shown in Fig. 10, the reciprocating inertia force *F* acting on the shoe 51A in arrow direction (or leftward in Fig. 10) causes a slight clearance *H* to be formed between the plane surface 51C of the shoe 51A and the sliding surface 50A of the swash plate 50. The plane surface 51C of the shoe 51A is in edge contact with the edge 50B of the swash plate 50 at and adjacent to the bottom dead center thereof. In this state, the edge 50B of the swash plate 50 also receives a reaction force against suction force acting so as to urge the shoe 51A against the swash plate 50, as well as a normal force acting so as to urge the swash plate 50 against the shoe 51A. Thus, a load applied to the edge 50B becomes maximum. Then, the contact pressure applied to the plane surface 51C of the shoe 51A that is in contact with the edge 50B becomes also maximum. As a result, the plane surface 51C of the shoe 51A or the edge 50B of the swash plate 50 is abraded, thereby producing abrasion powder.

Abrasion powder mixed in refrigerant gas deteriorates the performance of the compressor. Japanese Patent Application Publication No. 2001-317453 refers to a swash plate having a smooth convex curved surface on axial end faces thereof with an extremely large radius of curvature. However, no reference is made by Publication to an edge between the convex curved surface and the outer peripheral surface of the swash plate at and adjacent to the bottom dead center thereof. It is noted that the slight clearance *H* between the plane surface 51C of the first shoe 51A and the sliding surface 50A of the swash plate 50 is shown exaggerated in Fig. 10 for the sake of understanding the problem underlying the present invention.

[0004] To solve the above problem, it may be contemplated that the swash plate is made with an increased outer diameter, so that the edge of the swash plate at and adjacent to the bottom dead center thereof may be out of contact with the shoe. However, if the outer diameter of the swash plate is increased, it is necessary to design the swash plate in consideration of harmful interference of the swash plate with a piston when the swash plate is positioned at the minimum inclination angle thereof. As a result, the compressor is made larger in size.

[0005] The present invention, which has been made in light of the above problems, is directed to a swash plate type compressor which may restrict the abrasion of an edge of the swash plate or a plane surface of a shoe that are located on the far side of the swash plate from the cylinder bore.

SUMMARY OF THE INVENTION

[0006] In accordance with an aspect of the present invention, a swash plate type compressor has a cylinder block, a drive shaft, a piston, a pair of first and second shoes and a swash plate. The cylinder block has a plurality of cylinder bores. The drive shaft is supported by the cylinder block. The piston is accommodated in the cylinder bore. The first and second shoes are accommodated in the piston. The swash plate is connected to the drive shaft so as to be rotated integrally with the drive shaft. The swash plate is connected to the piston through the first and second shoes. The swash plate rotates around the drive shaft, and moves between the top dead center and the bottom dead center of the swash plate thereby to reciprocate the piston. The swash plate has a first surface on the far side of the swash plate from the cylinder bore in slide contact with the first shoe and a second surface on the same side of the swash plate as the cylinder bore in slide contact with the second shoe. The swash plate has a first edge formed between the first surface and an outer peripheral surface of the swash plate and a second edge formed between the second surface and the outer peripheral surface of the swash plate. The swash plate has a curved surface formed on the first edge at and adjacent to the bottom dead center of the swash plate whose radius of curvature is larger

than a radius of curvature of the surface of the second edge.

[0007] A swash plate type compressor has a cylinder block, a drive shaft, a piston, a pair of a first shoe and a second shoe and a swash plate. The cylinder block has a plurality of cylinder bores. The drive shaft is supported by the cylinder block. The piston is accommodated in the cylinder bore. The first and second shoes are accommodated in the piston. The swash plate is connected to the drive shaft so as to be rotated integrally with the drive shaft. The swash plate is connected to the piston through the first and second shoes. The swash plate rotates around the drive shaft, and moves between the top dead center and the bottom dead center of the swash plate thereby to reciprocate the piston. The swash plate has a first surface on the far side of the swash plate from the cylinder bore in slide contact with the first shoe and a second surface on the same side of the swash plate as the cylinder bore in slide contact with the second shoe. The swash plate has a first edge formed between the first surface and an outer peripheral surface of the swash plate and a second edge formed between the second surface and the outer peripheral surface of the swash plate, having a flat chamfered surface formed on the first edge at and adjacent to the bottom dead center of the swash plate. The swash plate has a coating layer formed on the first surface and the first edge whose thickness on the first edge at and adjacent to the bottom dead center of the swash plate is larger than the thickness on the first surface.

[0008] Other aspects and advantages of the invention will become apparent from the following description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The features of the present invention that are believed to be novel are set forth with particularity in the appended claims. The invention together with objects and advantages thereof, may best be understood by reference to the following description of the presently preferred embodiments together with the accompanying drawings in which:

Fig. 1 is a longitudinal cross-sectional view showing a swash plate type compressor of a first preferred embodiment of the present invention;

Fig. 2 is a fragmentary enlarged cross-sectional view showing the swash plate of Fig. 1 in the bottom dead center thereof and in contact with a shoe;

Fig. 3 is a schematic view showing the swash plate of Fig. 1 as viewed from the front of the compressor;

Fig. 4 is a cross-sectional view taken along the line I-I of FIG. 3;

Fig. 5A is a schematic view showing the swash plate in the bottom dead center thereof and in contact with the shoe according to the first preferred embodiment;

Fig 5B is a schematic view showing the swash plate in an intermediate position thereof between the top and bottom dead centers thereof and in contact with the shoe according to the first preferred embodiment;

Fig. 5C is a schematic view showing the swash plate in the top dead center thereof and in contact with the shoe according to the first preferred embodiment;

Fig. 6 is a cross-sectional view similar to Fig. 4, but showing a swash plate according to a second preferred embodiment;

Fig. 7 is a fragmentary enlarged cross-sectional view showing the swash plate in the bottom dead center thereof and in contact with the shoe according to a third preferred embodiment;

Fig. 8 is a cross-sectional view similar to Fig. 4, but showing a swash plate according to the third preferred embodiment;

Fig. 9A is a schematic view showing the swash plate in the bottom dead center thereof and in contact with the shoe according to the third preferred embodiment;

Fig. 9B is a schematic view showing the swash plate in an intermediate position between the top and bottom dead centers thereof and in contact with the shoe according to the third preferred embodiment;

Fig. 9C is a schematic view showing the swash plate in the top dead center thereof and in contact with the shoe according to the third preferred embodiment; and

Fig. 10 is a fragmentary enlarged cross-sectional view showing the background art.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0010] The following will describe a variable displacement type compressor having a single-headed piston (hereinafter referred to merely as "compressor") according to the first preferred embodiment of the present invention with reference to Figs. 1 through 4, and 5A through 5C. Referring to Fig. 1, a compressor 10 has a housing 11 forming the outer shell of the compressor 10. The housing 11 includes a cylinder block 12, a front housing 13, and a rear housing 14. The cylinder block 12 has a plurality of cylinder bores 12A formed therein. The front housing 13 is joined to the front end of the cylinder block

12. The rear housing 14 is joined to the rear end of the cylinder block 12. In Fig. 1, the left side of the drawing corresponds to the front side of the compressor 10, and the right side of the drawing corresponds to the rear side of the compressor 10. The front housing 13, the cylinder block 12 and the rear housing 14 are fastened together in the longitudinal direction of the compressor 10 by a plurality of bolts 15 inserted through the front housing 13, the cylinder block 12 and the rear housing 14, thus forming the housing 11.

[0011] The front housing 13 has a crank chamber 16 formed therein whose rear end is closed by the cylinder block 12, and through which a drive shaft 17 extends. The drive shaft 17 is rotatably supported by the cylinder block 12 and the front housing 13 through radial bearings 18, 19. A shaft seal mechanism 20 is provided on the drive shaft 17 in front of the radial bearing 18 supporting the front part of the drive shaft 17. The shaft seal mechanism 20 is disposed in slide contact with the circumferential surface of the drive shaft 17. The drive shaft 17 is connected at the front end thereof to an external drive source (not shown) through a power transmission mechanism (not shown).

[0012] A lug plate 21 is secured to the drive shaft 17 in the crank chamber 16 for integral rotation therewith. A swash plate 22 forming a part of the displacement changing mechanism of the compressor is provided on the drive shaft 17 behind the lug plate 21. The swash plate 22 is supported by the drive shaft 17 so as to be slidable in the axial direction of the drive shaft 17 and inclinable relative to the axis of the drive shaft 17. A hinge mechanism 23 is interposed between the swash plate 22 and the lug plate 21, through which the swash plate 22 and the lug plate 21 are connected. Thus, the swash plate 22 is synchronously rotatable with the lug plate 21 and inclinable relative to the drive shaft 17.

[0013] A coil spring 24 is disposed on the drive shaft 17 between the lug plate 21 and the swash plate 22. A sleeve 25 is slidably disposed on the drive shaft 17 and urged rearward by the coil spring 24. The swash plate 22 is urged by the coil spring 24 through the sleeve 25 rearward or in the direction that decreases the inclination angle of the swash plate 22. The inclination angle of the swash plate 22 means an angle made by a plane perpendicular to the axis of the drive shaft 17 and the surface of the swash plate 22.

[0014] The swash plate 22 has a stop 22A projecting from the front end thereof. The stop 22A is contactable with the lug plate 21, thereby regulating the maximum inclination angle of the swash plate 22. The drive shaft 17 has a snap ring 26 fitted thereon behind the swash plate 22, and a coil spring 27 disposed thereon in front of the snap ring 26. The swash plate 22 is contactable with the front part of the coil spring 27, thereby regulating the minimum inclination angle of the swash plate 22. Referring to Fig. 1, the swash plate 22 indicated by the solid line is positioned at the maximum inclination angle thereof, and the swash plate 22 indicated by the chain double-

dashed line is positioned at the minimum inclination angle thereof.

[0015] Each cylinder bore 12A (five cylinder bores in this preferred embodiment) of the cylinder block 12 has a single-headed piston 28 accommodated therein for reciprocation. The piston 28 has a neck 28A having a recess 28B formed therein. A pair of hemispherical first and second shoes 29A, 29B are received in the recess 28B, and the swash plate 22 is held at the outer peripheral portion by and between the first and second shoes 29A, 29B. The first shoe 29A has a spherical surface 29E and a plane surface 29C, and the second shoe 29B has a spherical surface 29F and a plane surface 29D. The first shoe 29A is located on the front side of the swash plate 22 or on the far side of the swash plate 22 from the cylinder bore 12A, and the second shoe 29B is located on the rear side of the swash plate 22 or the same side of the swash plate 22 as the cylinder bore 12A. The first and second shoes 29A, 29B are engaged at the spherical surfaces thereof with the surface of the recess 28B of the piston 28, and in slide contact at the flat surfaces thereof with the flat surfaces of the swash plate 22. As the drive shaft 17 is rotated, the swash plate 22 is rotated integrally with the drive shaft 17, making a wobbling motion in the axial direction of the drive shaft 17, thereby causing the piston 28 to reciprocate through the first and second shoes 29A, 29B forward and backward.

[0016] As shown in Fig. 1, the front end of the rear housing 14 is joined to the rear end of the cylinder block 12 through a valve plate assembly 31. The rear housing 14 has a suction chamber 32 formed at the radially inner region thereof, and a discharge chamber 33 formed at a radially outer region thereof. The suction chamber 32 and the discharge chamber 33 communicate with compression chambers 30 in the cylinder bores 12A through suction ports 31A and discharge ports 31B, respectively. When the piston 28 moves toward the bottom dead center from the top dead center thereof, refrigerant gas is drawn into the compression chamber 30 in the cylinder bore 12A through the suction port 31A. Refrigerant gas thus drawn into the compression chamber 30 is compressed to a predetermined pressure by the movement of the piston 28 from the bottom dead center to the top dead center thereof, and discharged into the discharge chamber 33 through the discharge port 31B.

[0017] A displacement control valve 34 is disposed in the rear housing 14 for changing the inclination angle of the swash plate 22, thereby adjusting the stroke of the piston 28 or the displacement of the compressor 10. The displacement control valve 34 is arranged in a supply passage (not shown) which connects the discharge chamber 33 to the crank chamber 16. High-pressure refrigerant gas is introduced from the discharge chamber 33 into the crank chamber 16 by adjusting the opening of the displacement control valve 34. Refrigerant gas flows out from the crank chamber 16 into the suction chamber 32 through a bleed passage (not shown) connecting the crank chamber 16 to the suction chamber 32.

Therefore, the pressure of the crank chamber 16 is determined depending on the relation between the amount of the refrigerant gas introduced into the crank chamber 16 and the amount of the refrigerant gas flowing out of the crank chamber 16. The pressure difference between the crank chamber 16 and the compression chamber 30 through the piston 28 is varied, thereby changing the inclination angle of the swash plate 22.

[0018] Fig. 2 is an enlarged view showing a state wherein the swash plate 22 is in contact with the first and second shoes 29A, 29B when the swash plate 22 is driven to rotate at the maximum inclination angle or positioned at the bottom dead center thereof. The positions of the top dead center and the bottom dead center of the swash plate 22 indicates the positions of the swash plate 22 in slide contact with the first and second shoes 29A, 29B when the piston 28 is positioned at the top dead center or the bottom dead center of the piston 28. The swash plate 22 has a first surface 22B on the front side of the swash plate 22 or on the far side of the swash plate 22 from the cylinder bore 12A, and a second surface 22C on the rear side of the swash plate 22 or on the same side of the swash plate 22 as the cylinder bore 12A. The first shoe 29A is located on the front side of the swash plate 22 or on the far side of the swash plate 22 from the cylinder bore 12A, and the second shoe 29B is located on the rear side of the swash plate 22 or the same side of the swash plate 22 as the cylinder bore 12A. The first shoe 29A is disposed so that the spherical surface 29E is engaged with the front-side surface of the recess 28B of the piston 28 on the far side of the swash plate 22 from the cylinder bore 12A, and the plane surface 29C is in slide contact with the first surface 22B of the swash plate 22 on the far side of the swash plate 22 from the cylinder bore 12A. The second shoe 29B is disposed so that the spherical surface 29F is engaged with the rear-side surface of the recess 28B of the piston 28 on the same side of the swash plate 22 as the cylinder bore 12A, and the plane surface 29D is in slide contact with the second surface 22C of the swash plate 22 on the same side of the swash plate 22 as the cylinder bore 12A. The shoes 29A, 29B are made of an aluminum-based material.

[0019] A first edge 22E is formed between the first surface 22B and an outer peripheral surface 22D of the swash plate 22 on the far side of the swash plate 22 from the cylinder bore 12A. A second edge 22F is formed between the second surface 22C and the outer peripheral surface 22D of the swash plate 22 on the same side of the swash plate 22 as the cylinder bore 12A. The first edge 22E at and adjacent to the bottom dead center of the swash plate 22 has a curved surface R whose radius of curvature is larger than that of the second edge 22F.

[0020] The swash plate 22 shown in Fig. 2 is positioned at the maximum inclination angle thereof, where the stroke length of the reciprocating piston 28 becomes maximum, and the reciprocating inertia force F1 acting on the first shoe 29A becomes also maximum. Because of the reciprocating inertia force F1 acting in arrow direc-

tion (or leftward in Fig. 2), a slight clearance G is formed between the plane surface 29C of the first shoe 29A and the first surface 22B of the swash plate 22 on which the plane surface 29C of the first shoe 29A slides. Therefore, the plane surface 29C of the first shoe 29A is in edge contact with the first edge 22E of the swash plate 22. It is noted that the slight clearance G in Fig. 2 formed between the plane surface 29C of the first shoe 29A and the first surface 22B of the swash plate 22 on which the plane surface 29C of the first shoe 29A slides is shown exaggerated for the sake of explanation.

[0021] As shown in Fig. 3, the bottom dead center Q of the swash plate 22 is located at a position that is substantially symmetrical to that of the top dead center P of the swash plate 22 with respect to a horizontal center line M passing through the axial center O. The first edge 22E at and adjacent to the bottom dead center Q of the swash plate 22 has a curved surface R. A range for forming the curved surface R is indicated by double-headed arrow in Fig. 3. The first edge 22E of the swash plate 22 except the part thereof at and adjacent to the bottom dead center Q and the entire second edge 22F of the swash plate 22 are chamfered with a radius of curvature smaller than that of the curved surface R. Referring to Fig. 3, one of the pistons 28 is engaged with the swash plate 22 at the top dead center P, but no piston is engaged with the swash plate 22 at the bottom dead center Q. In accordance with the rotation of the swash plate 22 around the drive shaft and the movement between the top dead center P and the bottom dead center Q, each piston 28 reciprocates in the corresponding cylinder bore 12A between the top dead center and the bottom dead center thereof.

[0022] Referring to Fig. 4, a ferrous metal is used for the base material of the swash plate 22 and the surface of the base material is hardened. The first edge 22E formed between the outer peripheral surface 22D and the first surface 22B in slide contact with the plane surface 29C of the first shoe 29A at and adjacent to the bottom dead center Q has the curved surface R whose radius of curvature is half as large as the thickness T of the swash plate 22. Meanwhile, the second edge 22F formed between the outer peripheral surface 22D and the second surface 22C in slide contact with the plane surface 29D of the second shoe 29B has a curved surface S which is formed by ordinary chamfering and has a radius of curvature smaller than that of the curved surface R. As mentioned earlier, the first edge 22E of the swash plate 22 except the part thereof at and adjacent to the bottom dead center Q has a curved surface S which are chamfered in the same manner as the entire second edge 22F of the swash plate 22.

[0023] The hardened surface of the base material has coating layers 35A, 35B formed thereon for improving the characteristics of sliding in contact with the plane surfaces 29C, 29D of the first and second shoes 29A, 29B. The coating layers 35A, 35B are formed by applying a coating having molybdenum disulfide (MoS_2) which is

dispersed in resin binder. As shown in Fig. 4, the coating layer 35A is formed in such a manner that the coating layer 35A is thickened at the curved surface R. More particularly, the coating layer 35A on the flat first surface 22B has a predetermined uniform thickness, while the coating layer 35A at the curved surface R of the first edge 22E is formed thicker toward the outer peripheral surface of the swash plate 22, and the surface of the coating layer 35A is formed flat. In other words, the coating layer 35A at the curved surface of the first edge 22E is thicker than the coating layer 35A on the first surface 22B. The coating layer 35B on the second surface 22C of the swash plate 22 is made of the same material as the coating layer 35A. The coating layer 35B is formed slightly thicker at the curved surface S of the second edge 22F than the coating layer 35B on the second surface 22C. The surface of the coating layer 35B is formed flat. Though not shown in the drawing, the first edge 22E except the curved surface R has the same coating layer 35A as the coating layer 35B on the second edge 22F.

[0024] The following will describe the operation of the compressor 10 of the first preferred embodiment. In accordance with the rotation of the drive shaft 17, the swash plate 22 is rotated while making a wobbling motion. Accordingly, the piston 28 connected to the swash plate 22 reciprocates in the cylinder bore 12A in the longitudinal direction of the compressor 10. Thus, the compressor 10 performs suction, compression and discharge of refrigerant gas. The inclination angle of the swash plate 22 is adjusted by the displacement control valve 34 which controls the pressure difference between the crank chamber 16 and the compression chamber 30 through the piston 28. The following will describe the state wherein the swash plate 22 rotates at the maximum inclination angle or at the maximum displacement thereof.

[0025] Fig. 5A shows the swash plate 22 in the bottom dead center Q and a state wherein the swash plate 22 is in contact with the first and second shoes 29A, 29B engaged with the piston 28. In this state, the piston 28 is positioned at the bottom dead center thereof, which means that suction of refrigerant gas is completed, and the piston 28 is just about to move for compression of the refrigerant gas. In Fig. 5A, arrow F1 shows a reciprocating inertia force acting on the first shoe 29A, arrow F2 shows a force being applied from the spherical recess of the piston 28 to the first shoe 29A, and arrow F3 shows a normal force acting from the swash plate 22 on the first shoe 29A. The forces act in directions indicated by arrows F1, F2, F3 in Fig. 5A. When the swash plate 22 is positioned at the maximum inclination angle thereof, the stroke length of the piston 28 becomes maximum, and the reciprocating inertia force F1 acting on the first shoe 29A becomes maximum, accordingly.

[0026] The force F2 applied to the first shoe 29A from the piston 28 corresponds to the reaction force against the suction force acting rearward or in the direction opposite to the reciprocating inertia force F1. The force F2 is smaller than the reciprocating inertia force F1. Thus,

the reciprocating inertia force F1 is greater than the force F2, with the result that a slight clearance G is formed between the plane surface 29C of the first shoe 29A and the first surface 22B of the swash plate 22. Therefore, the plane surface 29C of the first shoe 29A is in edge contact with the first edge 22E at and adjacent to the bottom dead center Q of the swash plate 22. The first edge 22E of the swash plate 22 receives the normal force F3 acting so as to urge the swash plate 22 against the first shoe 29A, as well as the force F2 acting from the piston 28 so as to urge the first shoe 29A against the swash plate 22. In this state, the load acting on the first edge 22E becomes maximum.

[0027] The first edge 22E is formed with the curved surface R at and adjacent to the bottom dead center of the swash plate 22 whose radius of curvature is half as large as the thickness T of the swash plate 22, and larger than that of the second edge 22F. The first edge 22E with the curved surface R is formed with the coating layer 35A of thick resin containing therein molybdenum disulfide (MoS_2). The plane surface 29C of the first shoe 29A is in contact with the first edge 22E formed by the coating layer 35A. Thus, when the coating layer 35A is in contact repeatedly with the plane surface 29C of the first shoe 29A made of an aluminum-based material, the abrasion of the plane surface 29C is restricted, but the coating layer 35A is gradually abraded. Since the first edge 22E with the curved surface R is formed by the coating layer 35A of thick resin, however, the coating layer 35A can extend the endurance time until the coating layer 35A is abraded to expose the surface of the base material of the swash plate 22.

[0028] If the coating layer 35A is abraded to expose the surface of the base material of the swash plate 22, the curved surface R directly contacts with the plane surface 29C of the first shoe 29A. That is because the surface of the base material of the first edge 22E has the curved surface R whose radius of curvature is half as large as the thickness T of the swash plate 22. According to Hertzian contact stress of tribology, the contact pressure between a plane surface and a cylindrical surface is decreased with an increase of the radius of curvature of the cylindrical surface. Thus, the contact pressure acting on the plane surface 29C of the first shoe 29A may be reduced. Therefore, the abrasion of the plane surface 29C of the first shoe 29A due to contact with the first edge 22E of the swash plate 22 may be reduced, thereby further improving the durability of the plane surface 29C.

[0029] Fig 5B shows the swash plate 22 in an intermediate position thereof between the top dead center P and the bottom dead center Q of the swash plate 22 and in contact with the first and second shoes 29A, 29B. In this state, the piston 28 is positioned at an intermediate position between the top dead center and the bottom dead center thereof. Thus, either compression or suction of refrigerant gas is being performed, and the surfaces 22B, 22C of the swash plate 22 are in slide and surface contact with the plane surfaces 29C, 29D of the shoes 29A, 29B,

respectively.

[0030] Fig. 5C shows the swash plate 22 in the top dead center P and in contact with the first and second shoes 29A, 29B engaged with the piston 28. In this state, the piston 28 is positioned at the top dead center thereof, discharge of compressed refrigerant gas is completed, and the piston 28 is just about to move for suction of refrigerant gas. In Fig. 5C, arrow F1 shows a reciprocating inertia force acting on the second shoe 29B, arrow F2 shows a force acting on the second shoe 29B from the spherical recess of the piston 28, and arrow F3 shows a normal force acting on the second shoe 29B from the swash plate 22. The forces act in directions indicated by arrows F1, F2, F3 in Fig. 5C, respectively. The swash plate 22 in Fig. 5C is located at the maximum inclined angle thereof, and the reciprocation stroke length of the piston 28 becomes also maximum. Accordingly, the reciprocating inertia force F1 applied to the second shoe 29B becomes maximum.

[0031] The force F2 applied from the piston 28 to the second shoe 29B corresponds to the reaction force against the compression force directed toward the front side of the compressor 10 or in the direction opposite to the direction of the reciprocating inertia force F1. The force F2 is greater than the reciprocating inertia force F1. Therefore, the force F2 applied from the piston 28 is greater than the force applied to the second shoe 29B. The plane surface 29D of the second shoe 29B is urged against the second surface 22C of the swash plate 22 in slide and surface contact with the second surface 22C of the swash plate 22. Thus, the second edge 22F is hardly in edge contact with the plane surface 29D of the second shoe 29B.

[0032] According to the compressor 10 of the present invention, the following advantageous effects are obtained.

(1) The first edge 22E at and adjacent to the bottom dead center Q of the swash plate 22 is formed with the curved surface R having a radius of curvature that is larger than that of the second edge 22F, so that the curved surface R of the first edge 22E is in direct contact with the plane surface 29C of the first shoe 29A. According to Hertzian contact stress of tribology, the contact pressure between a plane surface and a cylindrical surface is decreased with an increase of the radius of curvature of the cylindrical surface. Thus, the contact pressure acting on the plane surface 29C of the first shoe 29A may be reduced. Therefore, the abrasion of the plane surface 29C of the first shoe 29A due to contact with the first edge 22E of the swash plate 22 may be reduced.

(2) The coating layer 35A is formed on the first surface 22B and the first edge 22E of the swash plate 22 in such a manner that the coating layer 35A on the first edge 22E is thicker than the coating layer 35A on the first surface 22B. Thus, the coating layer

35A may extend the endurance time until the coating layer 35A is abraded to expose the surface of the base material of the first edge 22E.

(3) The first edge 22E at and adjacent to the bottom dead center Q of the swash plate 22 is formed with the curved surface R whose radius of curvature is half as large as the thickness T of the swash plate 22, and larger than that of the second edge 22F. Thus, in comparison with a structure wherein the curved surface R whose radius of curvature is half as large as the thickness T of the swash plate 22 is formed along the entire first edge 22E, the manufacturing cost may be reduced. In comparison with forming a curved surface R whose radius of curvature is relatively minute, the curved surface R is easier to form, and hence less susceptible to errors in the machining such curved surfaces.

(4) The compressor 10 is a variable displacement compressor which is operable to vary the displacement thereof by adjusting the inclination angle of the swash plate 22 relative to the drive shaft 17. In a fixed displacement swash plate type compressor, since the inclination angle of the swash plate is constant, the outer diameter of the swash plate may be increased, so that the edge of the swash plate may be out of contact with the shoe. In the case of a variable displacement swash plate type compressor, however, it is required to consider the interference between the swash plate and a piston at the minimum inclination angle of the swash plate. It is difficult to keep the edge of the swash plate from being out of contact with the shoe during large-displacement operation of the compressor and, therefore, the abrasion of the swash plate at and adjacent to the bottom dead center thereof tends to occur. According to the above-described first preferred embodiment, the first edge 22E of the swash plate 22 at and adjacent to the bottom dead center Q that is subjected to the maximum load is formed with the curved surface R whose radius of curvature is half as large as the thickness T of the swash plate 22. The coating layer 35A containing therein molybdenum disulfide (MoS_2) is formed on the curved surface R. Therefore, the variable displacement compressor of the first preferred embodiment offers more remarkable effects against abrasion of the shoe in comparison with the fixed displacement compressor.

[0033] The following will describe a swash plate type compressor according to a second preferred embodiment of the present invention with reference to Fig. 6. The second preferred embodiment differs from the first preferred embodiment in that hardened surface of the base material of the swash plate 22 of the first preferred embodiment is modified. The rest of the structure of the compressor of the second preferred embodiment is sub-

stantially the same as that of the first preferred embodiment. For the sake of convenience of explanation, therefore, like or same parts or elements will be referred to by the same reference numeral as those which have been used in the first embodiment, and the description thereof will be omitted.

[0034] As shown in Fig. 6, ferrous metal is used for the base material of the swash plate 22 of the second preferred embodiment. No treatment such as hardening is applied to the front-side surface of the base material of the swash plate 22 on the far side of the swash plate 22 from the cylinder bore 12A. Meanwhile, a rear-side surface of the base material of the swash plate 22 on the same side of the swash plate 22 as the cylinder bore 12A is treated by spraying. During operation of the compressor 10, a load due to reaction force against suction force is mainly applied to a first surface 40B of a swash plate 40 on the far side of the swash plate 40 from the cylinder bore 12A. Meanwhile, a load due to reaction force against compression force is mainly applied to the second surface 40C of the swash plate 40 on the same side of the swash plate 40 as the cylinder bore 12A. The reaction force against the compression force is much greater than that against the suction force. Thus, the surface of the base material subjected to a relatively small load is exposed, while the surface of the base material subjected to a relatively large load is treated by spraying for improving the sliding characteristics of the surface.

[0035] A first edge 40E is formed between an outer peripheral surface 40D and the first surface 40B in slide contact with the plane surface 29C of the first shoe 29A. The first edge 40E is formed with the curved surface R at and adjacent to the bottom dead center Q whose radius of curvature is half as large as the thickness T of the swash plate 40. A second edge 40F is formed between the outer peripheral surface 40D and the second surface 40C in slide contact with the plane surface 29D of the second shoe 29B. The second edge 40F is formed with the curved surface S which is formed by ordinary chambering and whose radius of curvature is smaller than that of the curved surface R. The part of the first edge 40E other than that at and adjacent to the bottom dead center Q is formed with the curved surface S which is made by chamfering in the same manner as the second edge 40F.

[0036] Coating layers 41A, 41B are formed on the first and second surfaces 40B, 40C by applying a coating having molybdenum disulfide (MoS_2) dispersed in resin binder for improving the sliding characteristics against the plane surfaces 29C, 29D of the shoes 29A, 29B. As shown in Fig. 6, the coating layer 41A is formed in the following manner. The coating layer 41A is thickened at the curved surface R. More particularly, the flat first surface 40B has a predetermined uniform thickness, while the coating layer 41A at the curved surface R of the first edge 40E is formed thicker toward the outer peripheral surface of the swash plate 40. Therefore, the surface of the coating layer 41A is flat. The coating layer 41B is formed on the second surface 40C by the same material

as the coating layer 41A. The coating layer 41B is formed in such a manner that the thickness at the curved surface S of the second edge 40F is slightly larger than the rest of the coating layer 41B. Thus, the surface of the coating layer 41B is flat. Though not shown in the drawing, the first edge 40E except the curved surface R is formed in the same manner as the second edge 40F.

[0037] The structure of the swash plate 40 according to the second preferred embodiment is substantially the same as the swash plate 22 according to the first preferred embodiment. Accordingly, operation of the second preferred embodiment is also substantially the same as the first preferred embodiment and, therefore, the description of operation of the swash plate 40 will be omitted. According to the second preferred embodiment, advantageous effects same as (1) through (4) of the first preferred embodiment may be obtained. In addition, the base material of the swash plate 40 requiring surface treatment only on one surface thereof is less costly.

[0038] The following will describe a swash plate type compressor according to a third preferred embodiment of the present invention with reference to Figs. 7 through 8, and 9A through 9C. The compressor 10 of the third preferred embodiment differs from that of the first preferred embodiment in that chamfered shape of the curved surface R of the first edge of the swash plate 22 of the first embodiment is modified. The rest of the structure of the compressor 10 according to the third preferred embodiment is substantially the same as that of the first preferred embodiment. For the sake of convenience of explanation, therefore, like or same parts or elements will be referred to by the same reference numeral as those which have been used in the first preferred embodiment, and the description thereof will be omitted.

[0039] A swash plate 45 in Fig. 7 has a first surface 45B, a second surface 45C, a first edge 45E and a second edge 45F. The first edge 45E is formed between an outer peripheral surface 45D of the swash plate 45 and the first surface 45B on the far side of the swash plate 45 from the cylinder bore 12A. The second edge 45F is formed between the outer peripheral surface 45D and the second surface 45C on the same side as the cylinder bore 12A. The first edge 45E at and adjacent to the bottom dead center of the swash plate 45 is formed by a flat chamfered surface X, on which a coating layer 46A is formed. As shown in Fig. 7, as in the case of the first preferred embodiment, the reciprocating inertia force F11 becomes maximum when the swash plate 45 is at the maximum inclination angle or at the bottom dead center thereof. At this time, the plane surface 29C of the first shoe 29A is in edge contact with the first edge 45E of the swash plate 45. The range of the swash plate 45 where a flat chamfered surface X is formed is the same as that of the swash plate 22 where the chamfer curved surface R is formed in the first preferred embodiment.

[0040] As shown in Fig. 8, as in the case of the first preferred embodiment, ferrous metal is used for the base material of the swash plate 45 of the third preferred em-

bodiment, and the surfaces of the base material of the swash plate 45 are hardened. The first edge 45E at and adjacent to the bottom dead center of the swash plate 45 has the chamfered surface X formed between the outer peripheral surface 45D and the first surface 45B in slide contact with the plane surface 29C of the first shoe 29A. In Fig. 8, the angle of chamfer of the chamfered surface X with respect to the first surface 45B is represented by angle α , and the chamfer dimensions of the chamfered surface X are represented by dimension β and dimension γ . The size of the chamfered surface X is set such that the angle α is 45 degrees, the dimension β is equal to the dimension γ , and the dimensions β , γ are smaller than half the thickness T of the swash plate 45. In the third preferred embodiment, the dimensions β , γ are slightly smaller than half the thickness T of the swash plate 45. The second edge 45F formed between the outer peripheral surface 45D and the second surface 45C in slide contact with the plane surface 29D of the second shoe 29B has the curved surface S formed by chamfering in the same manner as in the first preferred embodiment. The first edge 45E except the part thereof at and adjacent to the bottom dead center Q is formed by the curved surface S which is formed by chamfering in the same manner as the second edge 45F.

[0041] The hardened surfaces of the base material have the coating layer 46A and a coating layer 46B formed thereon for improving the characteristics of sliding in contact with the plane surfaces 29C, 29D of the shoes 29A, 29B. The coating layers 46A, 46B are formed by a copper (Cu) coating. As shown in Fig. 8, the coating layer 46A is formed in such a manner that the coating layer 46A is thickened at the chamfered surface X. More particularly, the coating layer 46A on the flat first surface 45B has a predetermined uniform thickness, while the thickness of the coating layer 46A at the chamfered surface X of the first edge 45E is formed thicker toward the outer peripheral surface of the swash plate 45. Therefore, the surface of the coating layer 46A is flat. In other words, the coating layer 46A on the chamfered surface X of the first edge 45E is formed thicker than the coating layer 46A on the first surface 45B. The coating layer 46B is formed on the second surface 45C by the same material as the layer 46A in such a manner that the thickness of the coating layer 46B on the curved surface S of the second edge 45F is slightly larger than the rest of the coating layer 46B. Thus, the surface of the coating layer 46B is flat. Though not shown in the drawing, the first edge 45E except the chamfered surface X has the same layer as the coating layer 46B on the second edge 45F.

[0042] The following will describe the operation of the compressor according to the third preferred embodiment with reference to Figs. 9A through 9C. Fig. 9A shows the swash plate 45 at the bottom dead center Q and in contact with the shoes 29A, 29B engaged with the piston 28. In this state, the piston 28 is positioned at the bottom dead center thereof, suction of refrigerant gas is completed, and the piston 28 is just about to move for compression

of refrigerant gas. In Fig. 9A, arrow F11 shows a reciprocating inertia force acting on the first shoe 29A, arrow F21 shows a force being applied from the spherical recess of the piston 28 to the first shoe 29A, and arrow F31 shows a normal force being applied from the swash plate 45 to the first shoe 29A. The forces act in directions indicated by arrows F11, F21, F31 shown in Fig. 9A, respectively. The plane surface 29C is in edge contact with the first edge 45E at and adjacent to the bottom dead center Q of the swash plate 45, and the load acting on the first edge 45E then becomes maximum for the same reason as stated with reference to the first preferred embodiment.

[0043] The first edge 45E at and adjacent to the bottom dead center Q is formed with the chamfered surface X, on which the coating layer 46A made of copper (Cu) is formed thick. Thus, the plane surface 29C of the first shoe 29A is in contact with the first edge 45E having the coating layer 46A. The coating layer 46A which is made of a copper (Cu) coating has a remarkably high sliding characteristics. The coating layer 46A subjected to repeated contact with the plane surface 29C of the first shoe 29A which is made of an aluminum-based material will hardly damage the plane surface 29C. Thus, the abrasion of the plane surface 29C is reduced considerably. Though the coating layer 46A is gradually abraded due to contact with the plane surface 29C, because the layer 46A is formed thick on the chamfered surface X, the coating layer 46A can extend the endurance time until the coating layer 46A is abraded to expose the base material of the swash plate 45.

[0044] Fig. 9B shows the swash plate 45 at an intermediate position between the top dead center P and the bottom dead center Q and in contact with the first and second shoes 29A, 29B. In this state, the piston 28 is located at the intermediate position between the top dead center and the bottom dead center thereof during either compression or suction of refrigerant gas, and the first and second surfaces 45B, 45C of the swash plate 45 are in slide and surface contact with the plane surfaces 29C, 29D of the first and second shoes 29A, 29B.

[0045] Fig. 9C shows the swash plate 45 at the top dead center P and in contact with the first and second shoes 29A, 29B engaged with the piston 28. In this state, the piston 28 is located at the top dead center thereof, discharge of compressed refrigerant gas is completed, and the piston 28 is just about to move for suctioning of refrigerant gas. In Fig. 9, arrow F11 shows a reciprocating inertia force being applied to the second shoe 29B, arrow F21 shows a force being applied from the spherical recess of the piston 28 to the second shoe 29B, and arrow F31 shows a normal force being applied from the swash plate 45 to the second shoe 29B. The forces act in directions indicated by arrows F11, F21, F31 shown in Fig. 9C. The plane surface 29D of the second shoe 29B is urged against the second surface 45C and in slide and surface contact with the second surface 45C for the same reason as described with reference to the first preferred

embodiment. Therefore, the second edge 45F is hardly in edge contact with the plane surface 29D of the second shoe 29B.

[0046] According to the compressor of the third preferred embodiment, the following advantageous effects are obtained.

[0047] (5) The first edge 45E at and adjacent to the bottom dead center Q of the swash plate 45 is formed with the chamfered surface X, on which the coating layer 46A made of copper (Cu) is formed. The coating layer 46A on the chamfered surface X is formed thicker than the coating layer 46A on the first surface 45B. The plane surface 29C of the first shoe 29A is in contact with the first edge 45E coated by the coating layer 46A. The coating layer 46A which is made of a copper (Cu) has a remarkably high sliding characteristics. The coating layer 46A subjected to repeated contacts with the plane surface 29C of the first shoe 29A which is made of an aluminum-based material will hardly damage the plane surface 29C. Thus, the abrasion of the plane surface 29C is reduced considerably. Though the coating layer 46A is gradually abraded due to contact with the plane surface 29C, because the coating layer 46A is formed thick on the chamfered surface X, the coating layer 46A can extend the endurance time until the coating layer 46A is abraded to expose the surface of base material of the swash plate 45.

[0048] (6) The first edge 45E at and adjacent to the bottom dead center Q of the swash plate 45 is formed with the chamfered surface X that is formed in the following manner. The chamfer angle α is 45 degrees. The chamfer dimension β is equal to the chamfer dimension γ . The chamfer dimensions β , γ are smaller than half the thickness T of the swash plate 45. The coating layer 46A is formed thick on the chamfered surface X. Thus, in comparison with a structure in which the chamfered surface X and a coating layer are formed along the entire first edge, the present embodiment is advantageous in terms of the ease and cost of manufacturing. The chamfered surface X which can be formed more easily than the curved surface R is advantageous in machining the surface.

[0049] (7) The compressor 10 is a variable displacement type compressor in which the inclination angle of the swash plate 45 with respect to the drive shaft 17 is varied thereby to adjust the compressor displacement. In the case of a fixed displacement swash plate type compressor wherein the inclination angle of the swash plate remains unchanged, the outer diameter of the swash plate may be increased, so that the edge of the swash plate may be out of contact with the shoe. In the case of a variable displacement swash plate type compressor, however, it is required to consider the interference between the swash plate and a piston at the minimum inclination angle of the swash plate. Thus, it is difficult to keep the edge of the swash plate from being out of contact with the shoe during large-displacement operation of the compressor and, therefore, the abrasion of the swash

plate at and adjacent to the bottom dead center thereof tends to occur. The first edge 45E at and adjacent to the bottom dead center Q of the swash plate 45 on which the maximum load acts is formed with the chamfered surface X, on which the coating layer 46A made of copper (Cu) is formed. Thus, remarkably advantageous effects in terms of reduction of the abrasion of the shoe are obtained in the variable displacement compressor in comparison with the fixed displacement compressor.

[0050] The present invention is not limited to the first through third preferred embodiments, but it may be variously modified within the scope of the invention. For example, the above embodiments may be modified as follows.

[0051] In the first and second preferred embodiments, the radius of curvature of the curved surface R on the first edge as half as the thickness T of the swash plate. The radius of curvature of the curved surface R may be of any value as far as it is larger than that of the curved surface S of the second edge. For example, if the curved surface S is chamfered with a radius of curvature that is equal to or less than 0.5 mm, the curved surface R may have a radius of curvature that is equal to or greater than 0.5 mm. Depending on the method of manufacturing of the swash plate, no chamfer may be formed at the edge. In such a case, the radius of curvature of the curved surface S is infinitely close to zero, and the present invention covers such structure. The radius of curvature of the curved surface R is preferably in the range from 0.5 mm to half the thickness T. If the radius of curvature of the curved surface R is equal to or less than 0.5 mm, the effect to reduce the contact pressure between the curved surface R and plane surface of the shoe in edge contact with each other will be decreased considerably. Meanwhile, if the radius of curvature of the curved surface R is equal to or greater than half the thickness T, the area of the curved surface R in slide contact with the shoe also becomes too small.

[0052] In the third preferred embodiment, the chamfered surface X formed on the first edge 45E is set such that the chamfer angle α is 45 degrees, the chamfer dimension β is equal to the chamfer dimension γ , and the chamfer dimension γ is half as large as the thickness T of the swash plate 45. Alternatively, the chamfer angle α may be other than 45 degrees, and the chamfer dimensions β , γ need not to be equal to each other. The size of the chamfered surface X is preferably set so that the chamfer dimension β is equal to or larger than 0.5 mm, and the chamfer dimension γ is smaller than half the thickness T when the chamfer angle α is 45 degrees. If the chamfer dimension β is equal to or less than 0.5 mm, sufficient thickness of a coating layer may not be able to be coated on the chamfered surface X. If the chamfer dimension γ is equal to or greater than half the thickness T, the area of the chamfered surface X in slide contact with the shoe becomes too small when the coating layer at the edge is abraded.

[0053] In the above preferred embodiments, the size

of the chamfered surface X formed on the first edge has been explained in terms of the chamfer angle α and the chamfer dimensions β , γ . Alternatively, at least one of the edges between the chamfered surface X and the first surface of the swash plate and between the chamfered surface X and the peripheral surface of the swash plate may be formed by a curved surface.

[0054] In the first and second preferred embodiments, the coating layer on the surface of the swash plate on which the shoe slides is formed by applying a coating having molybdenum disulfide (MoS_2) dispersed in resin binder. In the third preferred embodiment, the coating layer on the surface of the swash plate on which the shoe slides is made of copper (Cu). Alternatively, copper (Cu) may be used instead of molybdenum disulfide (MoS_2) in the first and second preferred embodiments, and molybdenum disulfide (MoS_2) may be used instead of copper (Cu) in the third embodiment. As solid lubricant, tungsten disulfide, graphite, boron nitride, antimony oxide, lead oxide, indium and stannum may be used instead of molybdenum disulfide (MoS_2) and copper (Cu). The coating layer may be formed by metal plating.

[0055] In the first and second preferred embodiments, coating layers are provided on the surfaces (first surfaces 22B, 40B, second surfaces 22C, 40C, first edges 22E, 40E, and second edges 22F, 40F) of the swash plate on which the shoe slides. Alternatively, the coating layer may be formed only on the second surface of the swash plate on the rear side of the compressor which is subjected to relatively high load from a piston, or no coating layer may be formed on the both surfaces of the swash plate. In such a case, the surface of the base material of the shoe is in direct contact with the surface of the base material of the first edge of the swash plate. However, the first edge of the swash plate at and adjacent to the bottom dead center Q is formed by the curved surface R, so that the contact pressure between the swash plate and the shoe is reduced, and abrasion of the swash plate due to slide contact with the shoe is reduced.

[0056] In the third preferred embodiment, the coating layers are provided on the surfaces (first surface 45B, second surface 45C, first edge 45E and second edge 45F) of the swash plate on which the shoe slides. Alternatively, the coating layer of a material with excellent sliding characteristics such as copper (Cu) may be provided only on the first surface of the swash plate at and adjacent to the bottom dead center thereof where the abrasion of the swash plate tends to occur.

[0057] The first and second preferred embodiments have been described with reference to a single-headed piston swash plate type variable displacement compressor. Alternatively, the swash plate type compressor may be replaced by a fixed displacement compressor, or the single-headed piston type compressor may be replaced by a double-headed piston type compressor. In the case of the double-headed piston type compressor, edges of the swash plate are formed in the flowing manner. As seen from a cylinder bore located on one side of the

swash plate, an edge at and adjacent to the bottom dead center of the swash plate on the far side of the swash plate from the cylinder bore may have a curved surface whose radius of curvature is larger than that of an edge on the same side of the swash plate as the cylinder bore.

[0058] In the third preferred embodiment, the swash plate type compressor is a single-headed piston type variable displacement compressor. Alternatively, the compressor may be a fixed displacement compressor, or double-headed piston type compressor. In the case of the double-headed piston type compressor, edges of the swash plate are formed in the following manner. As seen from a cylinder bore located on one side of the swash plate, an edge of the swash plate at and adjacent to the bottom dead center of the swash plate on the far side of the swash plate from the cylinder bore is formed to be a chamfered surface. A coating layer is provided on the chamfered surface with a thickness larger than that of the coating layer formed on the surface of the swash plate on the far side of the swash plate from the cylinder bore.

[0059] In the first through third preferred embodiments, the base material of the swash plate is made of a ferrous metal, and the base material of the shoe is made of an aluminum-based metal. Alternatively, the base material of the swash plate may be made of an aluminum-based metal, and the base material of the shoe may be made of a ferrous metal. If the base materials of both swash plate and shoe are made of a ferrous metal, the coating layer formed on the edge of the swash plate is abraded to expose, so that the surface of the base material of the swash plate may be in direct contact with the surface of base material of the shoe. In this structure, both of the swash plate and the shoe are abraded.

[0060] Therefore, the present examples and embodiments are to be considered as illustrative and not restrictive, and the invention is not to be limited to the details given herein but may be modified within the scope of the appended claims.

[0061] A swash plate type compressor has a cylinder block, a drive shaft, a piston, a pair of first and second shoes and a swash plate. The swash plate has a first surface on the far side of the swash plate from the cylinder bore in slide contact with the first shoe and a second surface on the same side of the swash plate as the cylinder bore in slide contact with the second shoe. The swash plate has first and second edges formed between the first and second surfaces and an outer peripheral surface of the swash plate, respectively. The swash plate has a curved surface formed on the first edge at and adjacent to the bottom dead center of the swash plate whose radius of curvature is larger than that of the surface of the second edge.

Claims

1. A swash plate type compressor (10) comprising:

a cylinder block (12) having a plurality of cylinder bores (12A);
 a drive shaft (17) supported by the cylinder block (12);
 a piston (28) accommodated in the cylinder bore (12A);
 a pair of a first shoe (29A) and a second shoe (29B) accommodated in the piston (28); and
 a swash plate (22, 40) connected to the drive shaft (17) so as to be rotated integrally with the drive shaft (17), connected to the piston (28) through the first shoe (29A) and the second shoe (29B), rotating integrally with the drive shaft (17) and moving between the top dead center and the bottom dead center of the swash plate (22, 40) thereby to reciprocate the piston (28),
 the swash plate having:

a first surface (22B, 40B) on the far side of the swash plate (22, 40) from the cylinder bore (12A) in slide contact with the first shoe (29A);

a second surface (22C, 40C) on the same side of the swash plate (22, 40) as the cylinder bore (12A) in slide contact with the second shoe (29B);

a first edge (22E, 40E) formed between the first surface (22B, 40B) and an outer peripheral surface (22D, 40D) of the swash plate (22, 40); and

a second edge (22F, 40F) formed between the second surface (22C, 40C) and the outer peripheral surface (22D, 40D) of the swash plate (22, 40),

characterized in that the swash plate (22, 40) has a curved surface formed on the first edge (22E, 40E) at and adjacent to the bottom dead center of the swash plate (22, 40) whose radius of curvature is larger than a radius of curvature of the surface of the second edge (22F, 40F).

2. The swash plate type compressor (10) according to claim 1,

characterized in that a coating layer (35A, 41A) is formed on the first surface (22B, 40B) and the first edge (22E, 40E), and **in that** the coating layer (35A, 41A) on the first edge (22E, 40E) at and adjacent to the bottom dead center of the swash plate (22, 40) is formed thicker than the coating layer (35A, 41A) on the first surface (22B, 40B).

3. The swash plate type compressor (10) according to claims 1 or 2,

characterized in that the coating layer (35A, 41A) is made of resin.

4. The swash plate type compressor (10) according to

any one of claims 1 through 3, **characterized in that** the value of radius of curvature of the first edge (22E, 40E) at and adjacent to the bottom dead center of the swash plate (22, 40) is smaller than half the thickness of the swash plate (22, 40).

5. A swash plate type compressor (10) comprising:

a cylinder block (12) having a plurality of cylinder bores (12A);
 a drive shaft (17) supported by the cylinder block (12);
 a piston (28) accommodated in the cylinder bore (12A);

a pair of a first shoe (29A) and a second shoe (29B) accommodated in the piston (28); and
 a swash plate (22, 40) connected to the drive shaft (17) so as to be rotated integrally with the drive shaft (17), connected to the piston (28) through the first shoe (29A) and the second shoe (29B), rotating integrally with the drive shaft (17) and moving between the top dead center and the bottom dead center of the swash plate (22, 40) thereby to reciprocate the piston (28),
 the swash plate (22, 40) having:

a first surface (22B, 40B) on the far side of the swash plate (22, 40) from the cylinder bore (12A) in slide contact with the first shoe (29A);

a second surface (22C, 40C) on the same side of the swash plate (22, 40) as the cylinder bore (12A) in slide contact with the second shoe (29B);

a first edge (22E, 40E) formed between the first surface (22B, 40B) and an outer peripheral surface (22D, 40D) of the swash plate (22, 40); and

a second edge (22F, 40F) formed between the second surface (22C, 40C) and the outer peripheral surface (22D, 40D) of the swash plate (22, 40),

characterized in that the swash plate (45) has a flat chamfered surface and a coating layer (46A), and **in that**

the flat chamfered surface is formed on the first edge (22E, 40E) at and adjacent to the bottom dead center of the swash plate (22, 40); and **in that**

the coating layer (46A) is formed on the first edge (45E) and the first surface (45B) whose thickness on the first edge (45E) at and adjacent to the bottom dead center of the swash plate (22, 40) is larger than the thickness on the first surface (22B, 40B).

6. The swash plate type compressor (10) according to claim 5,

characterized in that the coating layer (46A) is made of resin.

7. The swash plate type compressor (10) according to claims 5 or 6,
characterized in that the compressor (10) is a variable displacement compressor which is operable to vary the displacement of the compressor by adjusting the inclination angle of the swash plate (45) relative to the drive shaft (17).

5

10

15

20

25

30

35

40

45

50

55

FIG. 1

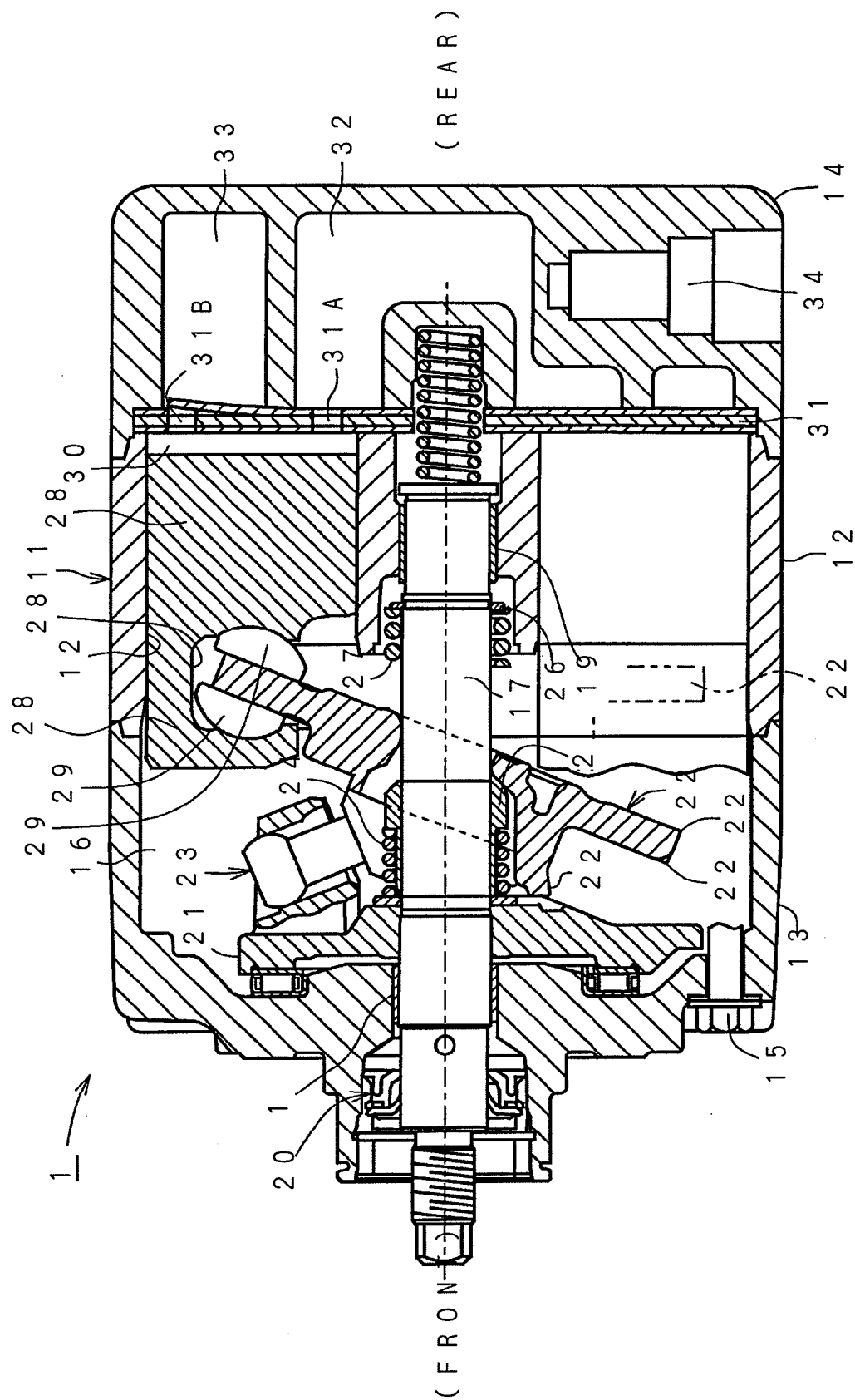


FIG. 2

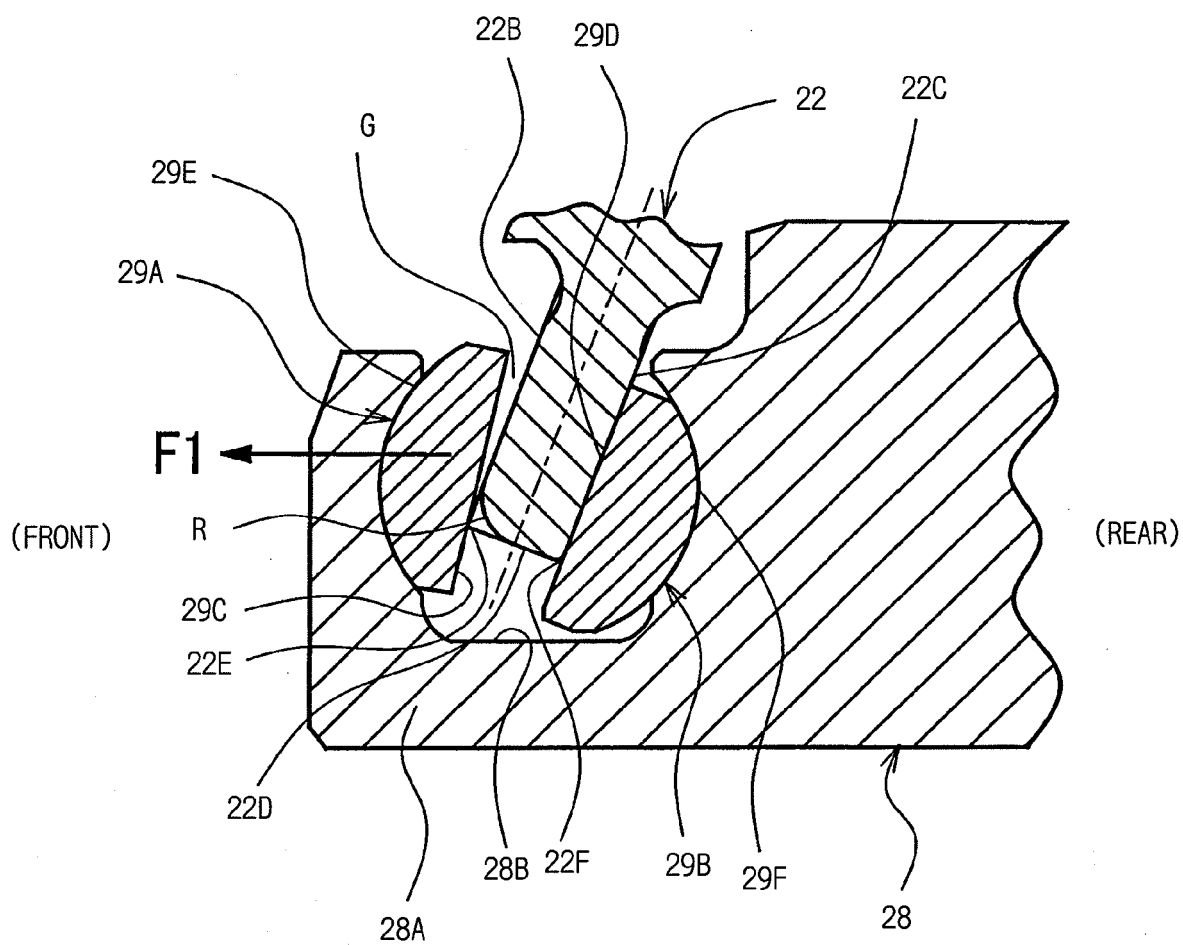


FIG. 3

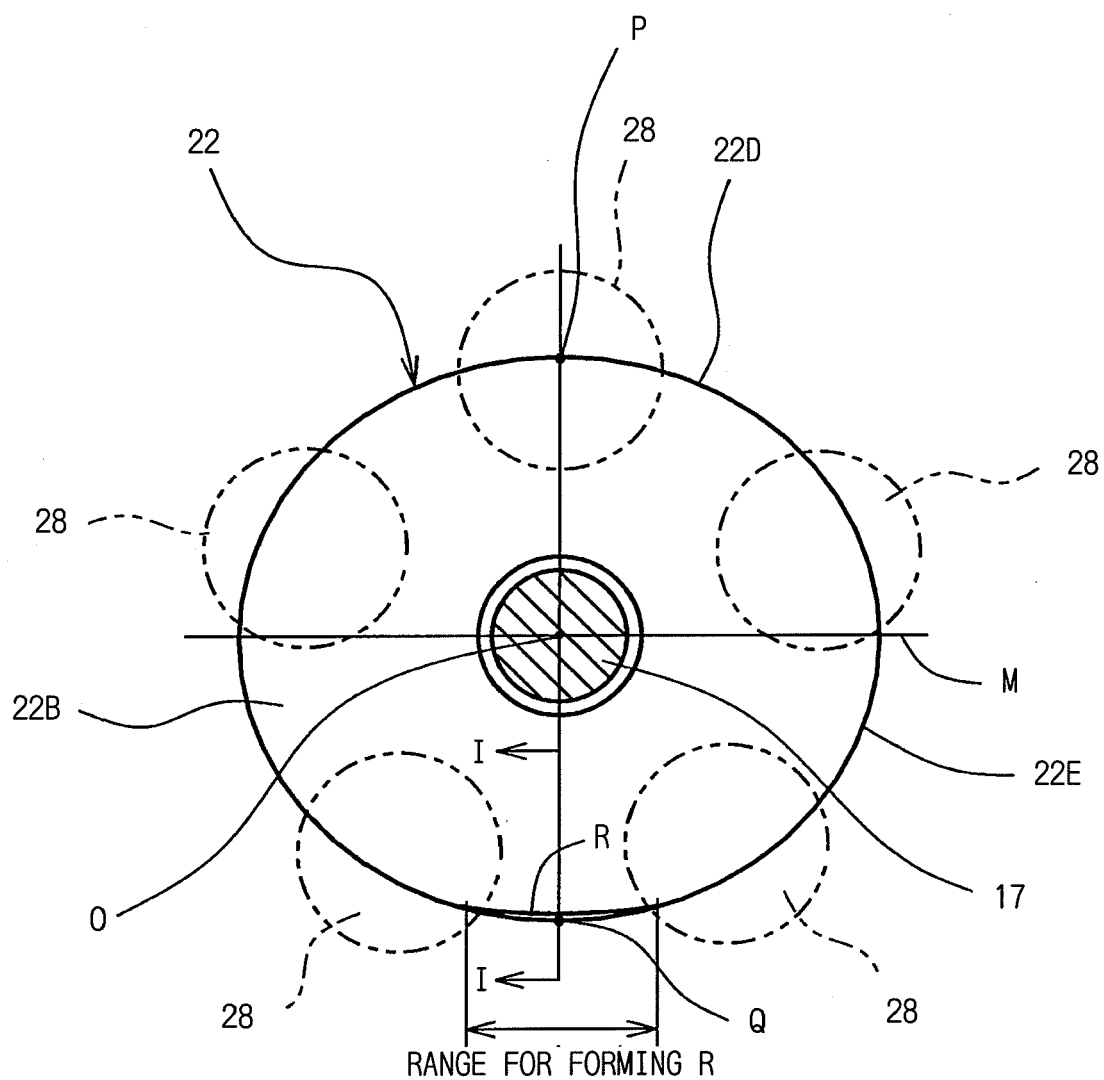


FIG. 4

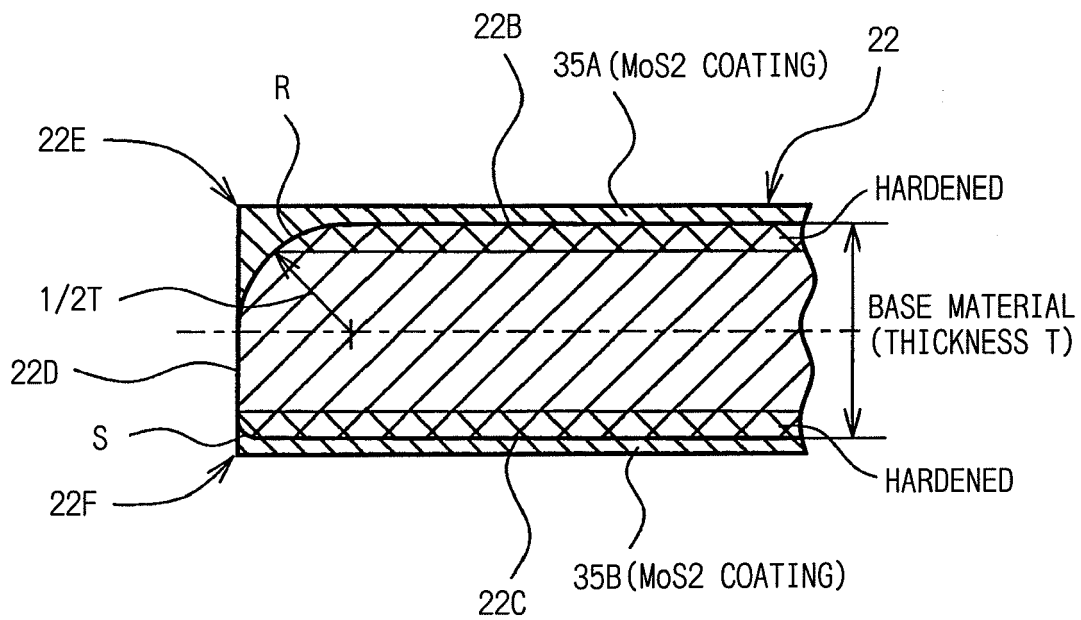


FIG. 5A

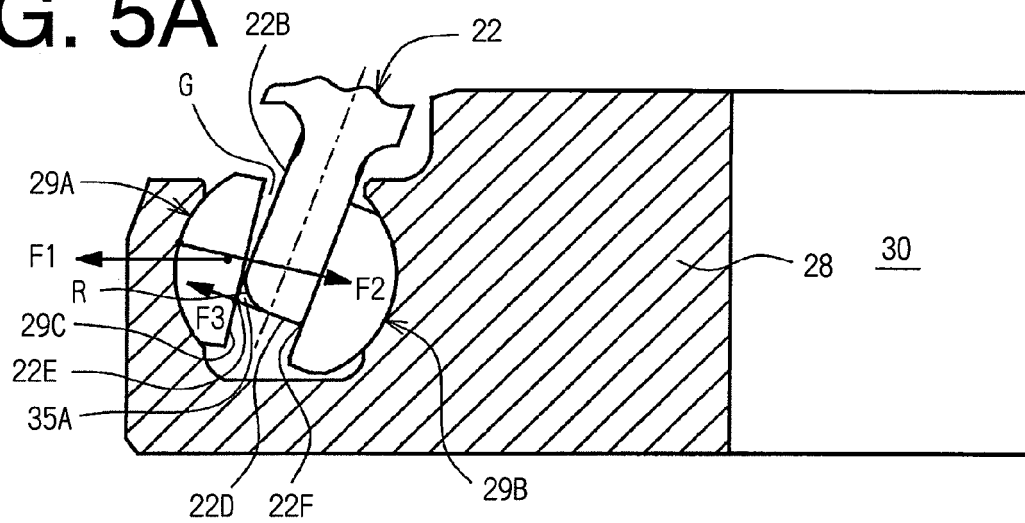


FIG. 5B

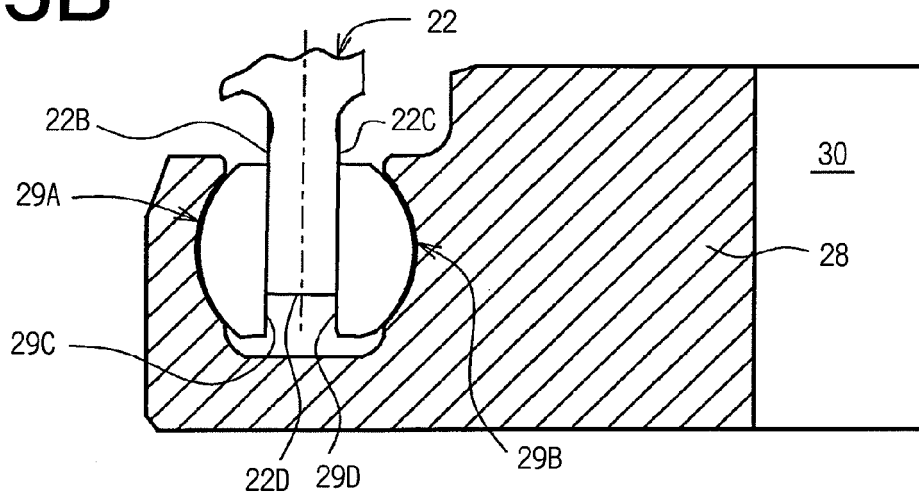


FIG. 5C

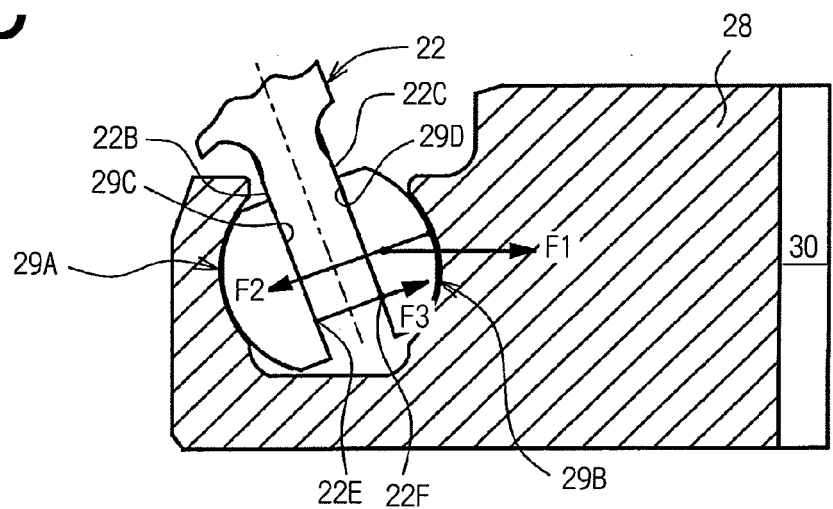


FIG. 6

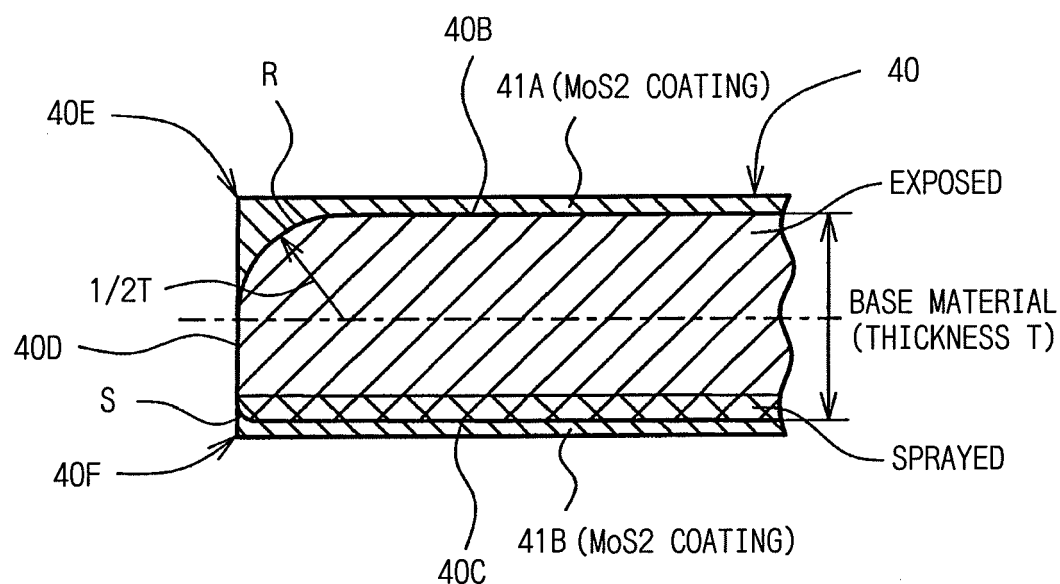


FIG. 7

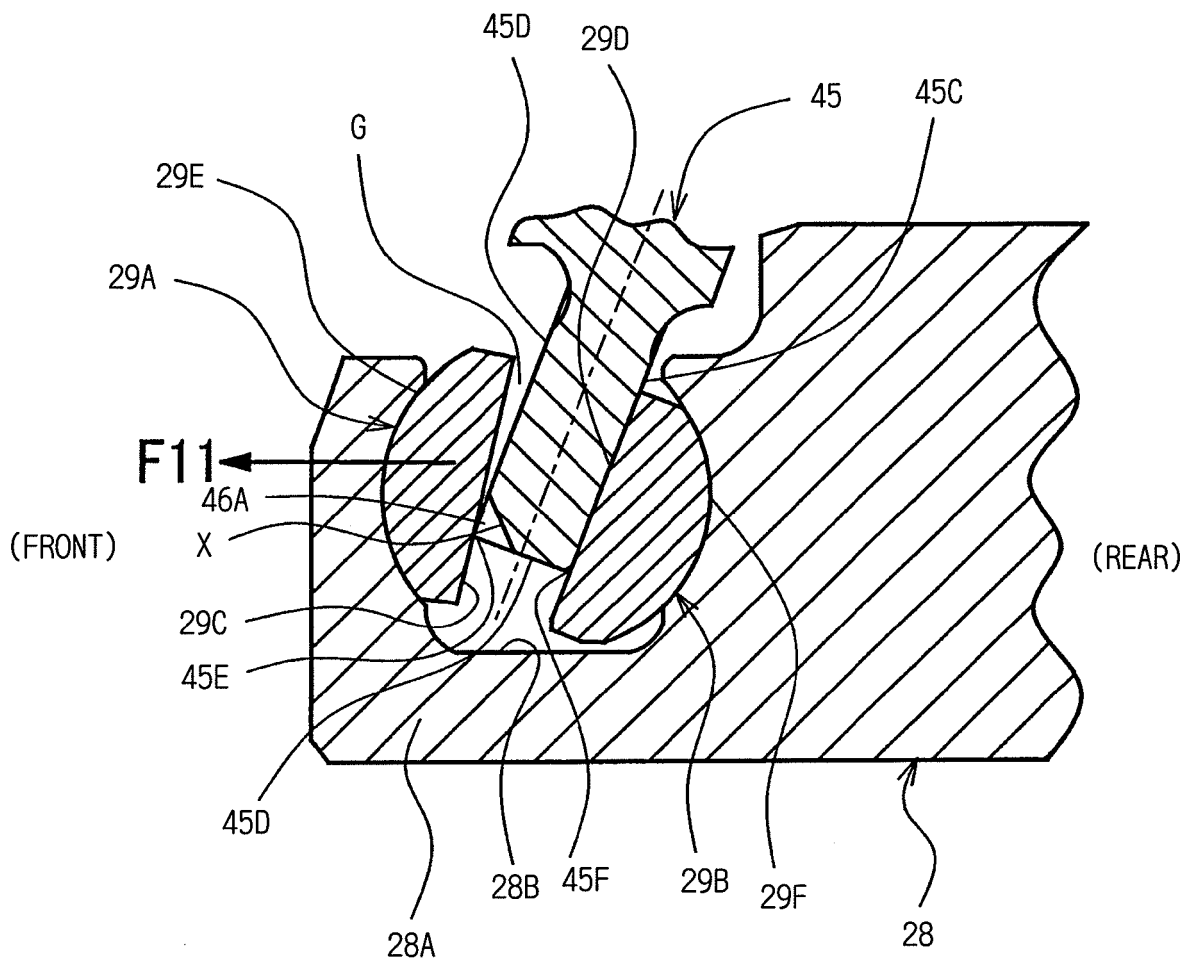


FIG. 8

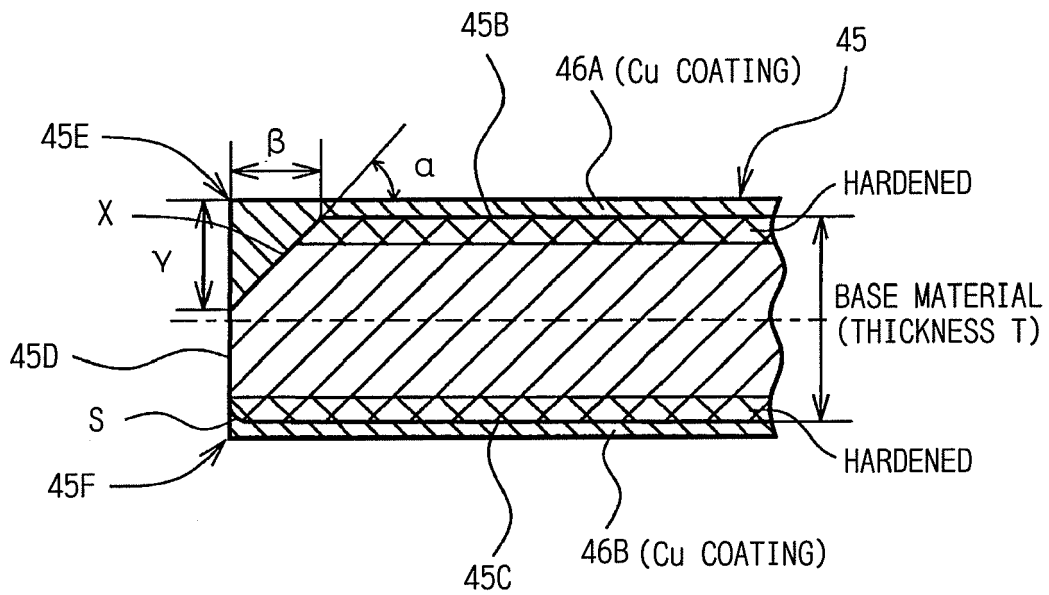


FIG. 9A

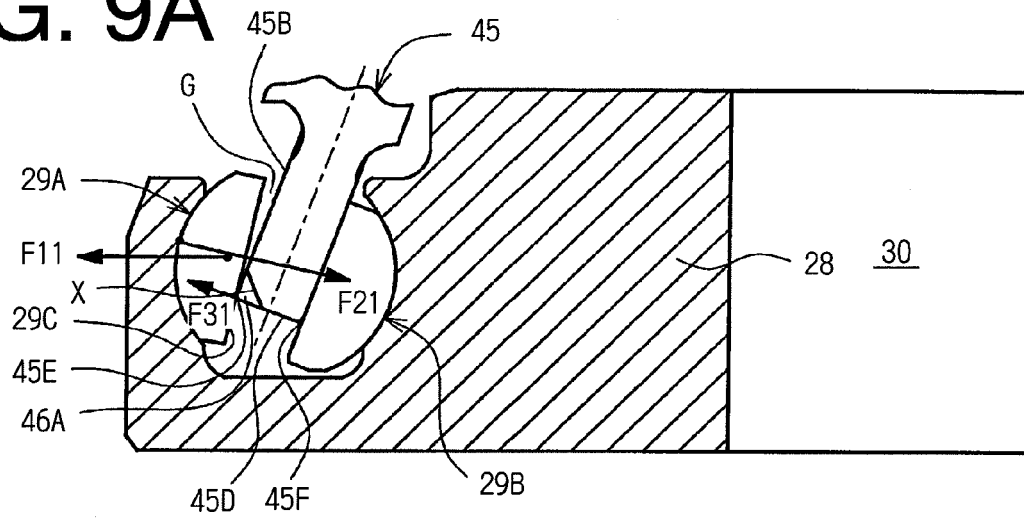


FIG. 9B

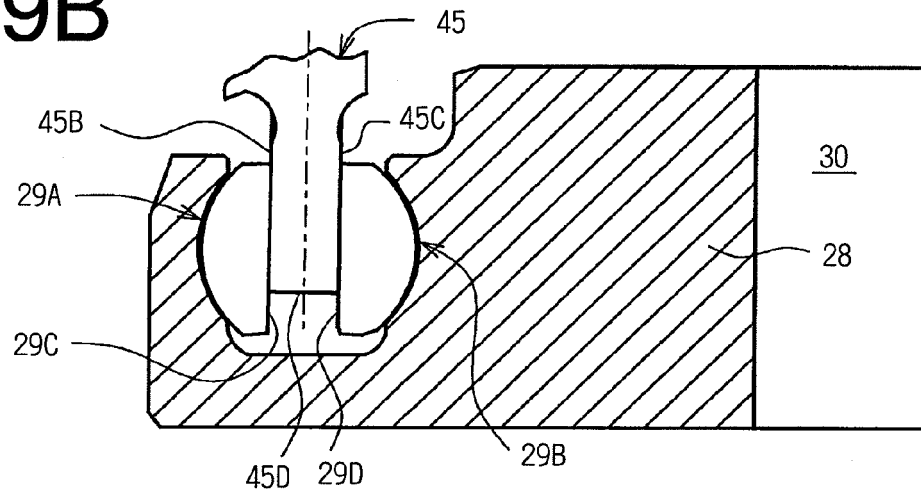


FIG. 9C

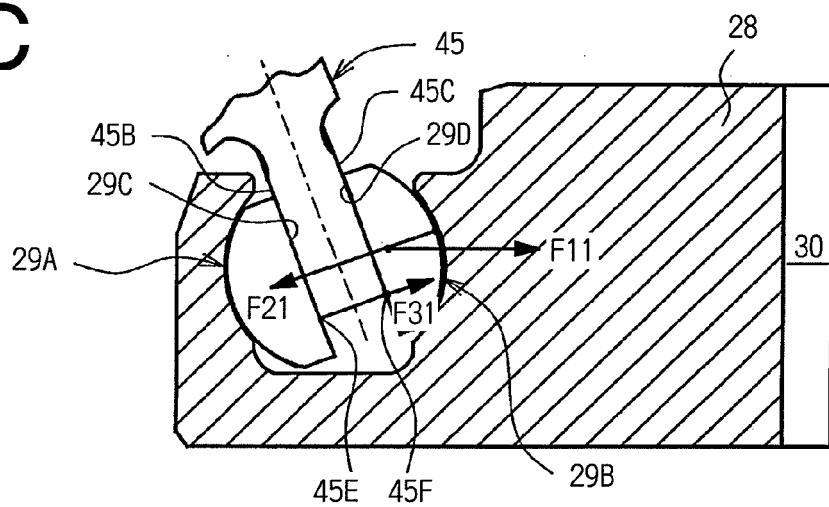
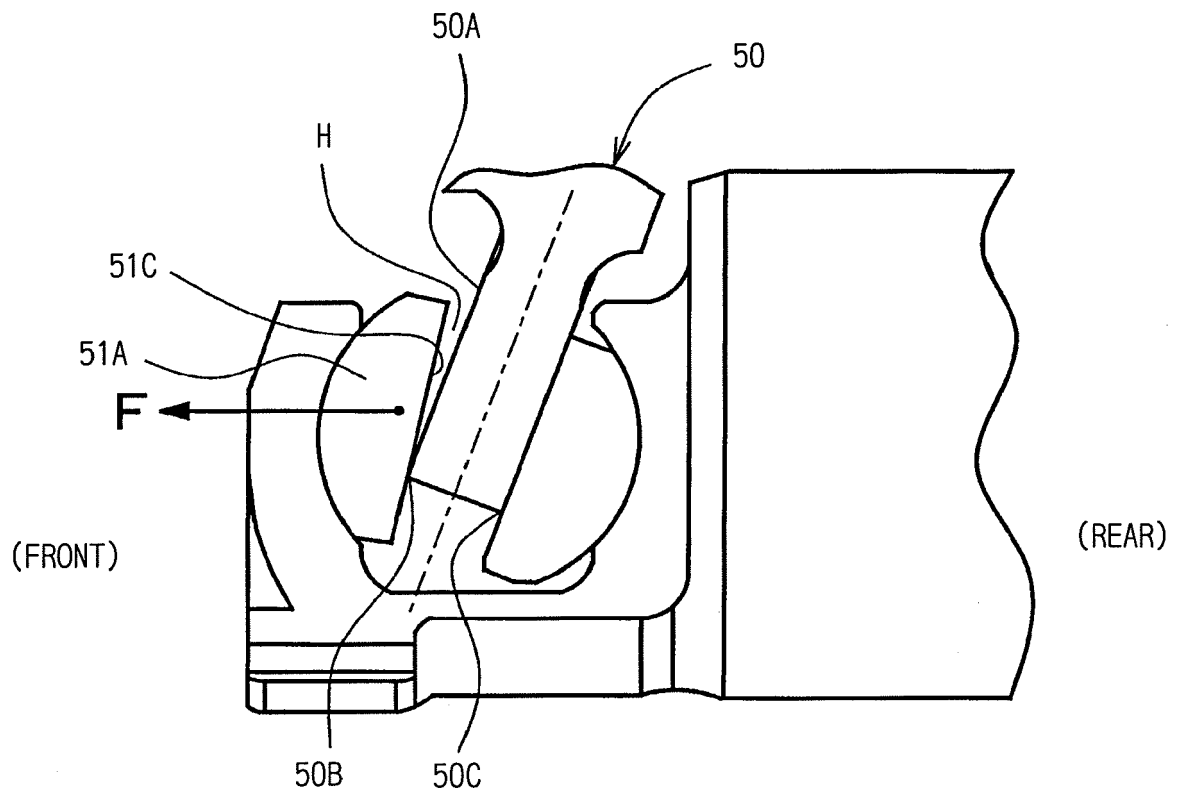


FIG. 10
(Background Art)



REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2001317453 A [0002] [0003] [0003]