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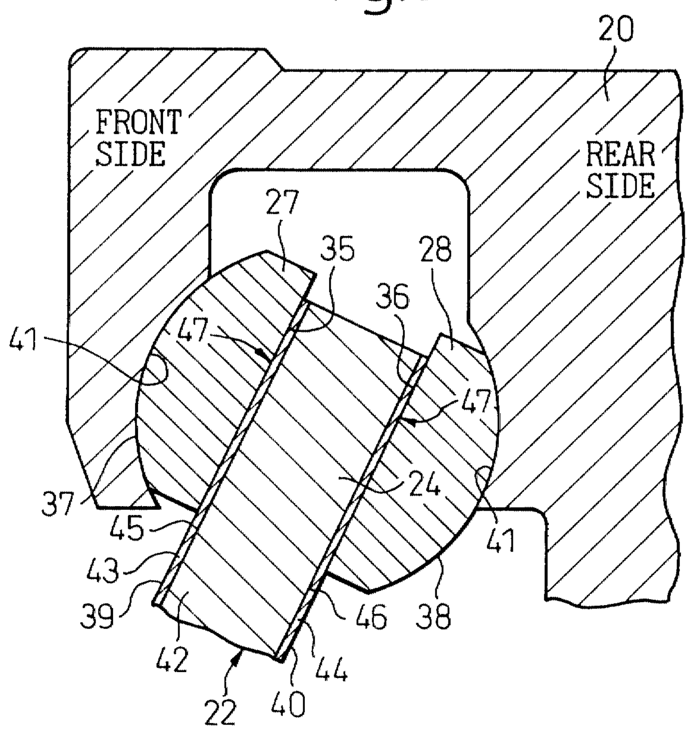
(54) **Swash plate type compressor**

(57) The sliding characteristics of the sliding portions, where components slide on each other, are improved and the work of coating forming thereof is simplified. DLC coatings (43) and (44) are formed on a front surface (39) and a rear surface (40) of a swash plate (22) by a CVD method or a PVD method. Therefore, the sliding characteristics of the sliding portion (47) between the swash plate (22) and shoes (27) and (28) are improved and abrasion or seizure occurs less frequently on the surface of the swash plate (22) and flat surfaces (35) and (36) of the shoes (27) and (28).

Fig.2



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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a swash plate type compressor that sucks and discharges a refrigerant gas by converting the rotational motion of a swash plate into the reciprocating motion of a piston.

2. Description of the Related Art

[0002] In a compressor, such as a swash plate type, for example, lubrication of the sliding portions, where components slide on each other, is ensured by a mist of lubricating oil being carried by the refrigerant gas and supplied to each sliding portion. In a case, however, where the temperature is low and the operation of the compressor is in the initial state, the lubricating oil adhered to the sliding portions is washed away by the refrigerant gas and in effect the sliding portions are prone to become dry. Therefore, a surface treatment is applied to the surface of each sliding portion so that each sliding portion member has excellent sliding characteristics, such as resistance to seizure and abrasion resistance.

[0003] Examples, in which a swash plate in a compressor is surface-treated, of this kind of surface treatment technique have been disclosed in Japanese Unexamined Patent Publication (Kokai) No. 8-199327, Japanese Unexamined Patent Publication (Kokai) No. 11-193780, etc. In the former Publication, a Cu-based or an Al-based material is flame-sprayed onto the surface of the base material of the swash plate to form a flame-sprayed layer and a plating layer, such as a Pb-based, a Sn-based or a Pb-Sn-based plating, or a coating layer made of MoS_2, MoS_2 and graphite mixture, PTFE (polytetrafluoroethylene) or the like is formed on the surface of the flame-sprayed layer. In the latter Publication, an intermediate layer of which the main component is Al, Cu, Sn, a metal phosphate or the like is formed on the surface of the base material of the swash plate and a layer for sliding, which includes a thermosetting resin and a solid lubricant made of at least either one of MoS_2 or graphite, is formed on the surface of the intermediate layer.

[0004] There is, however, a problem in the case where coating forming requires excessive processes when forming a resin layer on the surface of the swash plate because a procedure such as a grinding treatment is necessary. Moreover, in each Publication mentioned above, there is also a problem that plural layers are formed on the surface of the swash plate and a number of working treatments such as preliminary treatment, grinding treatment, calcination treatment, etc., which are carried out when forming coating layers such as a flame-sprayed layer, a resin layer etc., are necessary, therefore, excessive processes for the work of coating forming are required and the cost increases.

SUMMARY OF THE INVENTION

[0005] The present invention has been developed taking the above problems into account and the objective is to provide a swash plate type compressor that is able to improve the sliding characteristics at the sliding portion where components slide on each other, and to facilitate the work during coating forming.

[0006] In order to achieve the above objective, in the first aspect of the present invention, a swash plate type compressor comprises a swash plate assembled so that a rotational motion together with a drive shaft is enabled, at least a pair of shoes connected to the swash plate, and a piston connected to the swash plate via the shoes, wherein an amorphous hard carbon coating is formed on at least one of the sliding portions where components of the compressor slide on each other during the operation thereof.

[0007] According to the present invention, the sliding characteristics, such as abrasion resistance, resistance to seizure, etc., of the components that are in sliding contact when the compressor is in operation, are improved because of the amorphous hard carbon coating formed on at least one of the sliding portions, and the reliability of each component thereof, and the compressor itself as a result, is also improved. Moreover, when an amorphous hard carbon coating is formed on the components, a required coating thickness and a required surface roughness that need no working treatment such as grinding treatment, etc., can be obtained, and the work of coating forming is simplified because an amorphous hard carbon coating has excellent forming accuracy (working accuracy) in coating thickness, surface roughness, etc.

[0008] In the second aspect of the present invention, the amorphous hard carbon coating is formed on at least one of the sliding portions where the swash plate, the shoes, and the piston slide on each other, in addition to that in the first aspect.

[0009] According to the present invention, in addition to the effects in the first aspect of the present invention, abrasion and seizure occurs less frequently at the sliding portions of the swash plate, the shoes, and the piston, and the reliability of the swash plate, shoes, and piston is improved.

[0010] The present invention may be more fully understood from the description of the preferred embodiments of the invention set forth below, together with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] In the drawing:

FIG.1 is a sectional view of a swash plate type compressor of variable displacement type in an embodiment of the present invention.

FIG.2 is an enlarged sectional view near the shoe that illustrates an embodiment of coating forming.

FIG.3 is an enlarged sectional view near the shoe that illustrates another embodiment.

FIG.4 is an enlarged sectional view near the shoe that illustrates still another embodiment.

FIG.5 is an enlarged sectional view near the shoe that illustrates another embodiment.

FIG.6 is an enlarged sectional view near the piston that illustrates further embodiment.

FIG.7 is a sectional view of a double-headed piston and a swash plate in another example.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0012] An embodiment, in which the present invention is embodied in the coating forming method for a swash plate used in a swash plate type compressor of variable displacement type, is described below with reference to FIG.1 through FIG.6.

[0013] As shown in FIG.1, a swash plate type compressor 11 comprises a cylinder block 12, a front housing 13 coupled to the front end of the cylinder block 12, and a rear housing 15 coupled to the rear end of the cylinder block 12 via a valve forming body 14, and these members 11 through 15 are coupled and fixed to each other by plural through-bolts (not shown), constituting a housing assembly H of the compressor.

[0014] In the housing assembly H, a crank chamber 16, a suction chamber 17, and a discharge chamber 18 are defined. Plural cylinder bores (only one is shown) 19 are formed in the cylinder block 12 and a single-headed piston 20 is housed in each cylinder bore 19 so that a reciprocating motion is enabled. The suction chamber 17 and the discharge chamber 18 are selectively communicated with each cylinder bore 19 via various types of flapper valves in the valve forming body 14.

[0015] In the housing assembly H, a drive shaft 21 is penetrated so that a rotational motion is enabled. A swash plate 22 is supported by the drive shaft 21 while being housed in the crank chamber 16. The swash plate 22 has a land portion 23 in the central part and an outer circumferential portion 24 formed with a thickness thinner than that of the land portion 23, which is surrounded by the outer circumferential portion 24. This swash plate 22 is operatively connected to the drive shaft 21 via a hinge mechanism 25 and a lug plate 26 so that the swash plate 22 can synchronously rotate with the drive shaft 21 and tilt with respect to the drive shaft 21 accompanied by a sliding motion in the direction of the axis of the drive shaft 21.

[0016] Because the outer circumferential portion 24 of the swash plate 22 is connected to the end portion of each piston 20 via a pair of shoes 27 and 28, one in front and one at the rear, so that a sliding motion is enabled, every piston 20 is operatively connected to the swash plate. When the swash plate 22 tilting in a required inclination angle rotates together with the drive shaft 21, each piston 20 is forced to reciprocate with a stroke according to the inclination of the swash plate 22, and the cycle, in which refrigerant gas sucked from the suction chamber 17 is compressed and discharged to the discharge chamber 18, is repeated.

[0017] The inclination angle of the swash plate 22 is determined by the interactive balance among various moments such as the moment of the rotational motion based on the centrifugal force when the swash plate rotates, the moment of the spring force based on the biasing action of an inclination reducing spring 29, the moment of the inertia force of the reciprocating motion of the piston 20, the moment of the gas pressure, and so on. The moment of the gas pressure is a moment determined based on the internal pressure of the cylinder bore 19 and the internal pressure of the crank chamber 16, which is the back pressure of the piston 20, and is applied to both directions in which the inclination of the swash plate 22 decreases and increases, according to the crank pressure.

[0018] The swash plate type compressor of variable displacement type 11 comprises a control valve 30 in the rear housing 15, and the control valve 30 is interposed on a pressure supply passage 31 that connects the crank chamber 16 with the discharge chamber 18 communicatively. Also, the crank chamber 16 and the suction chamber 17 are connected communicatively by a pressure releasing passage (a throttle passage) 32. In the swash plate type compressor 11 of variable displacement type, such as this example, the moment of the gas pressure is changed adequately by adjusting the crank pressure by the opening adjustment of the control valve 30. When the crank pressure is set higher, the inclination angle of the swash plate 22 decreases, the stroke of the piston 20 decreases, and the discharge displacement decreases, and on the contrary, when the crank pressure is set lower, the inclination angle of the swash plate 22 increases, the stroke of the piston 20 increases, and the discharge displacement increases.

[0019] Next an embodiment of the swash plate 22, the shoes 27 and 28, and the piston 20, on each of which a coating is formed, is described with reference to FIG.2 through FIG.6.

[0020] As shown in FIG.2, each shoe 27 and 28 has flat surfaces 35 and 36 and spherical surfaces 37 and 38, and the flat surfaces 35 and 36 come into contact with a front surface 39 and a rear surface 40 of the swash plate 22, respectively, and the spherical surfaces come into contact with shoe seats 41 of the piston 20. An iron-based material, an aluminum-based material or the like is used for a substrate (base material) 42 of the swash plate 22. Also, a similar iron-based material (bearing steel, for example) is used for the shoes 27 and 28, of which the mechanical strength thereof, etc. is taken into account.

[0021] Amorphous hard carbon coatings 43 and 44 are formed on both the front surface 39 and the rear surface 40 of the outer circumferential portion 24 of the swash plate 22 ranging over the whole area in the circumferential direction. These amorphous hard carbon coatings 43 and 44 are formed on worked surfaces 45 and 46 of the outer circumferential portion 24 by a CVD method, a PVD method, or the like. Generally, the amorphous hard carbon coatings 43 and 44 are called a synthetic pseudo-diamond thin coating, a diamond-like carbon (DLC), i-carbon, or the like, and hereinafter are referred to as a DLC coating in this example. These DLC coatings 43 and 44 of the swash plate 22 come into contact with the flat surfaces 35 and 36, respectively, of the shoes 27 and 28 and serve as the sliding surfaces with the shoes 27 and 28 of the swash plate 22.

[0022] The DLC coatings 43 and 44 have characteristics similar to diamond in physical properties such as hardness, etc. and also have a specific quality characterized in that the hardness is high and the friction coefficient is low. Since the surface of the swash plate 22 has the DLC coatings 43 and 44, that is, has high sliding characteristics excellent in such as abrasion resistance and resistance to seizure, abrasion and seizure occurs less frequently at the sliding portions 47 between the swash plate 22 and the shoes 27 and 28, and the reliability of the swash plate 22 and the shoes 27 and 28, and the compressor 11 itself as a result, is improved. In addition, since the DLC coatings 43 and 44 have good forming accuracy (working accuracy) in coating thickness, surface roughness, etc., such finishing processes as grinding, etc. to ensure the required coating thickness and surface roughness, are not necessary, resulting in a simplified coating forming work and a lower cost.

[0023] FIG.3 is an example in which a coating is formed only onto the rear surface of the swash plate. In the swash plate type compressor 11, the reaction force, which is produced when the piston 20 is retracted forcedly to suck the refrigerant gas, is applied mainly to the front surface 39 of the swash plate 22 via the shoe 27 on the front side. On the other hand, the reaction force of the compression, which is produced when the piston 20 compresses the refrigerant gas to discharge it, is applied mainly to the rear surface 40 of the swash plate 22 via the shoe 28 on the rear side. Although both forces can be factors that cause abrasion and seizure between the swash plate 22 and the shoes 27 and 28, the reaction force caused by forced retraction of the piston is in effect by far smaller than that caused by compression, therefore, in some cases it may not be necessary to improve the sliding characteristics of the front side of the swash plate 22 so much.

[0024] In the case where the swash plate 22 and the shoes 27 and 28, respectively, are made of different materials, for example, if the swash plate 22 is made of aluminum-based material and the shoes 27 and 28 are made of iron-based material, seizure caused by the so-called "friction phenomenon between the same metal" is unlikely to occur. Therefore, if the fact that the swash plate 22 and the shoes 27 and 28 are made of different materials and the reaction force caused by forced retraction is relatively small is taken into account, there may be the case where the sliding characteristics of the front side of the swash plate 22 need not be improved in particular.

[0025] In this example, therefore, the DLC coating 44 is formed only on the rear surface 40 of the swash plate 22. Saving the coating forming process on the front side, this structure can reduce the excessive processes for coating forming and the manufacturing cost. In addition, since the DLC coating 44 is formed on the rear surface 40 that needs to have the sliding characteristics of high quality, the probability of occurrence of abrasion and seizure does not increase rapidly and the high reliability of the swash plate 22 and the shoes 27 and 28, and the compressor 11 as a result can be ensured.

[0026] FIG.4 shows an example where coatings are formed on both the flat surfaces of a pair of shoes. In this example, the DLC coatings 48 and 49 are formed on the entire area of the flat surfaces 35 and 36 of the shoes 27 and 28. Therefore, the flat surfaces 35 and 36 of the shoes 27 and 28 come into contact with the swash plate 22 on the surfaces of the DLC coatings 48 and 49, respectively, and these DLC coatings 48 and 49 serve as the sliding surfaces between the shoes 27 and 28 and the swash plate 22.

[0027] Also in this example, since the work of coating forming is simplified and the sliding characteristics of the sliding portion 47 between the swash plate 22 and the shoes 27 and 28 is improved, the reliability of the swash plate 22 and the shoes 27 and 28, and even the compressor 11 as a result, is improved. On the other hand, compared to the case where the DLC coatings 43 and 44 are formed on the entire area of the worked surfaces 45 and 46 (refer to FIG.1 or FIG.2) of the swash plate 22, the required area for coating is smaller, resulting in further reduction in cost of materials. In addition, it can be the case where the DLC coating 49 is formed only on the flat surface 36 of the shoe 28 on the rear side to which the reaction force of compression is applied, and no DLC coating 48 is applied on the front side.

[0028] FIG.5 shows an example in which a coating is formed on the entire surface of the shoes. In this example, the DLC coatings 50 and 51 are formed on the entire surface of the shoes 27 and 28. Therefore, on the entire surface of the shoe 27 and 28, the surfaces of the DLC coatings 50 and 51 formed on the spherical surfaces 37 and 38 that slide on the shoe seats 41 serve as the sliding surface between the shoes 27 and 28 and the piston 20, and the surfaces of the DLC coatings 50 and 51 formed on the flat surfaces 35 and 36 that slide with respect to the swash plate 22 serve as the sliding surface between the shoes 27 and 28 and swash plate 22.

[0029] In this example, a surface treatment (Sn-plate treatment, for example) of the shoe seats 41 of the piston 20 can be avoided, and abrasion or seizure occurs less frequently on not only the sliding portion 47 between the swash plate 22 and the shoes 27 and 28, but also the sliding portion 52 between the shoes 27 and 28 and the pistons 20, therefore, the reliability of not only the swash plate 22 and the shoes 27 and 28 but also the pistons 20 is improved. Moreover, it can be the case where the DLC coatings 50 and 51 can be formed only on the spherical surfaces 37 and 38 of the shoes 27 and 28.

[0030] FIG.6 shows an example in which a coating is formed on the piston. In this example, the DLC coating 54 is formed on the entire outer surface of the piston 20. Therefore, on the entire outer surface of the piston 20, the surface of the DLC coating 54 formed on the shoe seats 41 on which the shoes 27 and 28 slide serves as the sliding surface between the piston 20 and the shoes 27 and 28, and the surface of the DLC coating 54 formed on the outer circumferential surface 56 of a piston main body 55, that slides on the cylinder block 12, serves as the sliding surface between the piston 20 and the cylinder block 12.

[0031] Conventionally, in order to give the slidability to the piston 20, a coating layer mainly made of PTFE (polytetrafluoroethylene) has been formed on the outer circumferential surface 56 of the piston 20 and an Sn-plating layer has been formed on the surface of the shoe seats 41. Therefore, conventionally, it used to be necessary to apply such processes as calcination treatment or grinding treatment, when a coating is formed. By utilizing the DLC coating 53 as a coating, however, such working processes can be avoided and further the Sn-plating treatment applied to the shoe seats 41 can also be avoided. Moreover, the sliding characteristics of not only the sliding portion 52 between the shoes 27 and 28 and the piston 20 but also the sliding portion 57 between the piston 20 and the cylinder block 12 are improved and the reliability of the shoes 27 and 28, the piston 20, and the cylinder block 12 is improved. It can also be the case where the DLC coating 54 is formed only on the shoe seats 41 of the piston 20 or only on the outer circumferential surface 56.

[0032] Therefore, the following effects can be obtained in this embodiment.

(1)

Since the DLC coatings 43, 44, 48 through 51, and 54 are formed on each sliding surface of the swash plate 22, the shoes 27 and 28, and the pistons 20, respectively, the sliding characteristics of high quality, excellent in abrasion resistance and resistance to seizure, in each sliding surface 47, 52 and 57 can be ensured. Therefore, abrasion or seizure is made to occur less frequently at the swash plate 20, the shoes 27 and 28, the piston 20, the cylinder block 12, and so on, and the reliability of each component 12, 20, 22, 27, 28, and even the compressor 11 as a result, is improved.

(2)

Since the DLC coatings 43, 44, 48 through 51, and 54 have excellent forming accuracy such as in coating thickness, surface roughness, and so on, it is possible to form a coating with the required thickness and surface roughness by only one surface treatment. Therefore, if the DLC coating is adopted on each sliding surface, a coating can be formed by only one working without need of such special working treatments as grinding, finishing, and so on. Moreover, working treatments such as grinding, etc. can be avoided, resulting in a reduction in cost. A more excellent working environment, such as without noise, can be provided compared to the case where a coating is formed, for example, by the flame spraying method.

(3)

Since a relatively small reaction force caused by forced retraction is applied to the front surface 39 of the swash plate 22, there is almost no problem in the case where the DLC coating is not formed on the front surface 39 if, for example, the swash plate 22 is made of an aluminum-based material. Therefore, in the case where the DLC coating 44 is formed only on the rear surface 40 of the swash plate 22 to which a large reaction force of compression is applied (FIG.3), the DLC coating on the front surface 39 can be saved, and desired abrasion resistance and desired resistance to seizure can be ensured even if the DLC coating is thus avoided.

(4)

In the case where the DLC coatings 50 and 51 are formed on the entire surface of the shoes 27 and 28 (FIG.4), the DLC coatings on the spherical surfaces 37 and 38 serve as the sliding surfaces with the piston 20, and Sn-plating treatment conventionally applied to the shoe seats 41 of the piston 20 can be avoided.

(5)

In the case where the DLC coating 54 is formed on the entire outer surface of the piston 20 (FIG.5), such working treatments as calcination or grinding which are necessary to form a coating mainly made of PTFE conventionally, can be avoided, resulting in the simplified work of coating forming. In this case also Sn-plating treatment applied to the shoe seats 41 can be avoided.

[0033] Embodiments are not restricted to those mentioned above, but the following modifications are available, for example.

[0034] A swash plate type compressor is not restricted to the variable displacement type comprising the piston 20 of single-headed type. As shown in FIG.7, for example, in the swash plate type compressor of fixed displacement type comprising a piston 61 of double-headed type, the DCL coatings 43 and 44 can be formed on both surfaces of a swash plate 62 thereof. In this case also, the sliding characteristics of the swash plate 62 and a shoe 63 are improved and the reliability of components is also improved.

[0035] The location for forming DLC coating can be selected by combining the examples described in the above embodiments adequately and flexibly according to requirement. Examples are shown below.

(1)

Both surfaces of the swash plate 22 shown in FIG.2 and the shoe seats 41 of the piston 20 shown in FIG.6.

The rear surface 40 of the swash plate 22 shown in FIG.3 and the shoe seats 41 of the piston 20 shown in FIG.6.

The flat surfaces 35 and 36 of the shoes 27 and 28 shown in FIG.4 and the shoe seats 41 of the piston 20 shown in FIG.6.

Both surfaces of the swash plate 22 shown in FIG.2 and the spherical surfaces 37 and 38 of the shoes 27 and 28 shown in FIG.5.

The rear surface 40 of the swash plate 22 shown in FIG.3 and the spherical surfaces 37 and 38 of the shoes 27 and 28 shown in FIG.5.

(2)

The locations for forming coating described in above item (1) and the outer circumferential surface 56 of the piston 20 shown in FIG.6.

Both surfaces of the swash plate 22 shown in FIG.2 and the entire outer surface of the piston 20 shown in FIG.6.

The rear surface 40 of the swash plate 22 shown in FIG.3 and the entire outer surface of the piston 20 shown in FIG.6.

The flat surfaces 35 and 36 of the shoes 27 and 28 shown in FIG.4 and the entire outer surface of the piston 20 shown in FIG.6.

The entire surface of the shoes 27 and 28 shown in FIG.5 and the outer circumferential surface 56 of the piston 20 shown in FIG.6.

[0036] In the case of item (1), therefore, the sliding characteristics of the sliding portions 47 and 52 are improved and the compressor 11 with more excellent sliding characteristics can be provided compared to the case where each coating is formed on each sliding portion. In the case of item (2), the sliding characteristics of not only the sliding portions 47 and 52 but also the sliding portion 57 are improved at the same time, and the compressor 11 with further more excellent in sliding characteristics can be provided.

[0037] Forming of the DLC coating is not restricted to the case where the DLC coatings are formed on the sliding portions 47, 52, and 57 between each component, that is to say, the swash plate 22, shoes 27 and 28, and the piston 20. The DLC coating may be formed, for example, on the inner circumferential surface of the hole of the swash plate 22 through which the drive shaft 21 penetrates, the sliding surface between the drive shaft 21 and the swash plate 22, the bearing that supports the drive shaft 21 rotatably, the lip seal that isolates the crank chamber from outside, the hinge mechanism 25, and so on. That is to say, the DLC coating can be formed on any sliding portions that slide on, among comopnents constiting the compressor, while the compressor is in operation.

[0038] Though the DLC coating is formed on only one side of the sliding surface of each sliding portion 47, 52, and 57, the DLC coating may be formed on the both sides of the sliding portions so that the DLC coatings 43, 44, 48, and 49 are formed, for example, on the both surfaces of the swash plate 22 and the flat surfaces 35 and 36 of the shoes. In this case abrasion or seizure of the parts is made to occur even less frequently.

[0039] Though the DLC coatings 43, 44, 48 through 51, and 54 are formed on the entire area of the sliding surface, the DLC coating may be formed only on a part of the sliding surface. That is to say, the DLC coating is not required to be formed on the entire area of the sliding surface if high sliding characteristics are ensured.

[0040] Though the DLC coatings are formed directly on the surface of the substrate (base material) of each component 20, 22, 27, and 28, intermediate layers consisting of a flame-sprayed layer, a plating layer, or the like, may be formed between, for example, the substrate or the DLC coating. In this case, since flame spraying or plating treatments are necessary, the coating forming work requires excessive processes compared to the case where only the DLC coating is formed, but the sliding characteristics are maintained by the intermediate layer even if the DLC coatings are worn out by abrasion or seizure. Therefore, if the double-structure comprising a DLC coating and an intermediate layer is adopted, sliding characteristics of a higher quality can be ensured.

[0041] Though the DLC coating is formed on the entire surface of the front surface 39 and the rear surface 40 of the outer circumferential portion 24 when the DLC coatings 43 and 44 are formed on the swash plate 22, the DLC coating can be formed only on the portion which slides against the shoes 27 and 28.

[0042] Though the DLC coating is formed on the entire outer surface of the piston 20, the coating can be partially formed on the piston 20 so that the DLC coating is formed only on the outer circumferential surface 56 and the shoe seats 41 of the piston 20.

[0043] The technical ideas not shown clearly in claims, which can be grasped from the above-mentioned embodiments and other examples, are described below with their effects.

(1)

The amorphous hard carbon coating is formed on the sliding portions between the swash plate and the shoes, and between the shoes and the piston in the present invention. In this case, the sliding characteristics of each sliding portion can be maintained at the same time and a compressor with excellent sliding characteristics can be provided.

(2)

In the above technical idea (1), the amorphous hard carbon coating is formed on the outer circumferential surface of the piston. In this case, the sliding characteristics of the sliding portions not only between the swash plate and the shoes, and between the shoes and the piston, but also between the piston and the housing can be improved at the same time, and a compressor with more excellent sliding characteristics can be provided.

(3)

In one aspect of the present invention, the amorphous hard carbon coating is formed on the sliding portions between the swash plate and the shoes. In this case, the sliding characteristic between the swash plate and the shoes can be improved and the reliability of the swash plate and the piston is improved.

(4)

In the aspect described in above (3) of the present invention, the amorphous hard carbon coating is formed on the sliding portions between the shoes and the piston. In this case, the sliding characteristic between the shoes and the piston can be improved and the reliability of the shoe and the piston is improved.

(5)

In the aspect described in above (3) of the present invention, the amorphous hard carbon coating is formed on the sliding portion between the piston and the cylinder block that constituents the housing of the compressor. In this case, the sliding characteristic between the piston and the cylinder block can be improved and the reliability of the piston and the cylinder block is improved.

(6)

In the aspect described in above (3) of the present invention, the sliding portions between the swash plate and the shoes and the sliding portions between the shoes and the piston are formed so as to sandwich the swash plate and to provide pairs of sliding portions, respectively, and the amorphous hard carbon coating is formed only on the sliding portions of the side, to which the reaction force of compression applied to the piston during compression is applied, of both the sliding portions that sandwich the swash plate. In this case, though the reaction force of compression is by far larger than the reaction force caused by forced retraction applied to the piston during suction, abrasion or seizure of the components can be efficiently prevented because the amorphous hard carbon coating is formed only on the sliding portions of the side to which such a large force is applied.

(7)

In the present invention, the amorphous hard carbon coating is formed only on one side of the sliding surfaces of the above-mentioned sliding portions. In this case there is almost no problem in sliding characteristics, because the amorphous hard carbon coating is formed on one side of the sliding portions, and therefore, the sliding characteristic of the sliding portions can be improved efficiently. Moreover, since the amorphous hard carbon coating is formed only on the one side of the sliding surfaces, some coating forming work can be avoided compared to the case where coating is formed on the both sides of the sliding surface.

[0044] As described in detail above, according to the present invention, the sliding characteristics of the sliding portion can be improved and the work of coating forming can be simplified by forming an amorphous hard carbon coating on the sliding portion where the components of the compressor slide on each other.

[0045] While the invention has been described by reference to specific embodiments chosen for the purposes of illustration, it should be apparent that numerous modifications could be made thereto by those skilled in the art without departing from the basic concept and scope of the invention.

Claims

1. A swash plate type compressor comprising a swash plate assembled so as to enable a rotational motion together with a drive shaft, at least a pair of shoes connected to the swash plate, and a piston connected to the swash plate via the shoes, wherein

an amorphous hard carbon coating is formed on at least one of the sliding portions where components of the compressor slide on each other during the operation of the compressor.

2. A swash plate type compressor, as set forth in claim 1, wherein the amorphous hard carbon coating is formed on at least one of the sliding portions where the swash plate, the shoes, and the piston slide.

3. A swash plate type compressor, as set forth in claim 1 or 2, wherein the amorphous hard carbon coating is formed on the sliding surfaces of the swash plate against the shoe.

4. A swash plate type compressor, as set forth in claim 1 or 2, wherein the amorphous hard carbon coating is formed on the sliding surfaces of the shoes against the swash plate.

5. A swash plate type compressor, as set forth in any one of claims 1 to 4, wherein the amorphous hard carbon coating is formed on the sliding surfaces of the shoes against the piston.

6. A swash plate type compressor, as set forth in any one of claims 1 to 4, wherein the amorphous hard carbon coating is formed at least on the sliding surface of an outer surface of the piston against the shoes.

7. A swash plate type compressor, as set forth in any one of claims 1 to 6, wherein the amorphous hard carbon coating is formed at least on an outer circumferential surface of the outer surface of the piston.

8. A swash plate type compressor, as set forth in claim 1, wherein the amorphous hard carbon coating is a diamond-like carbon coating.

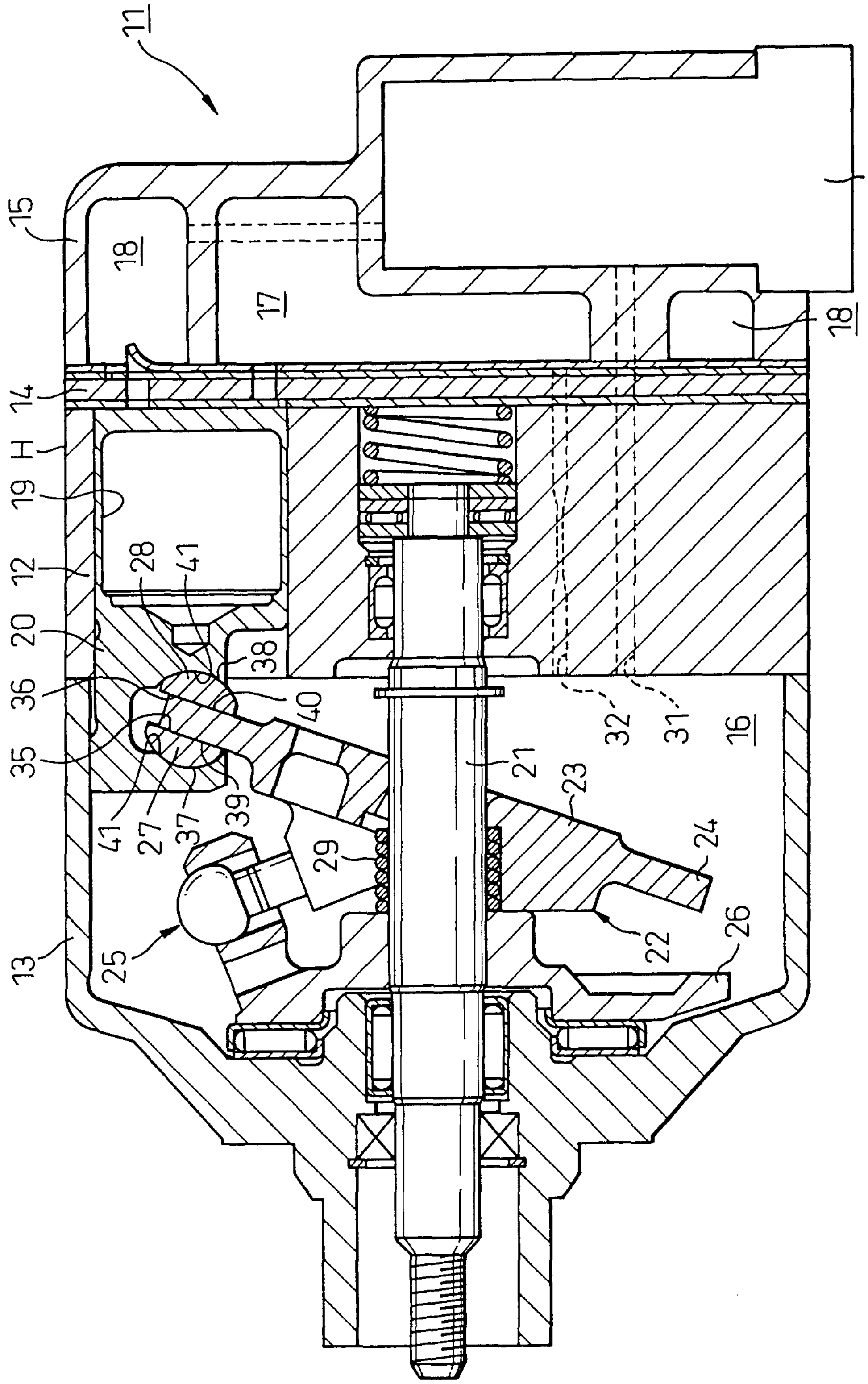
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Fig.1

Fig.2

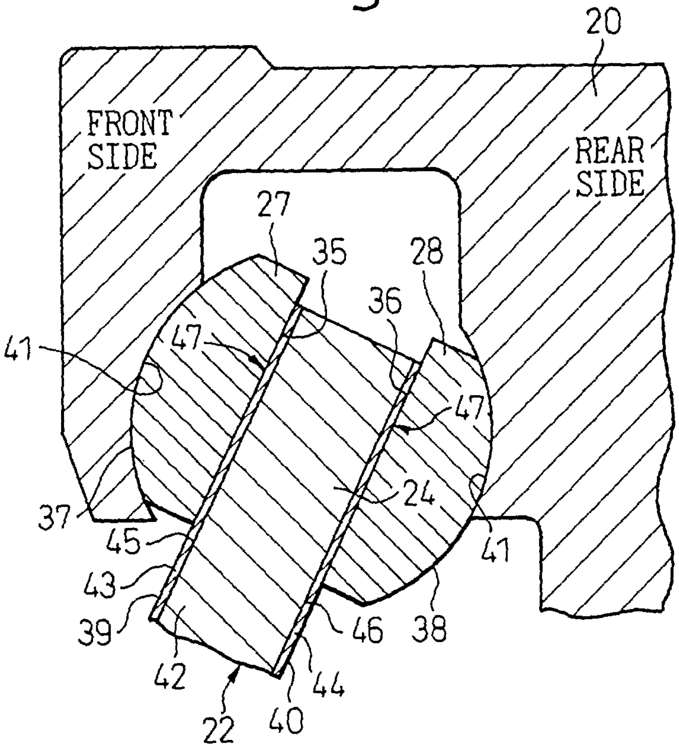
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Fig.3

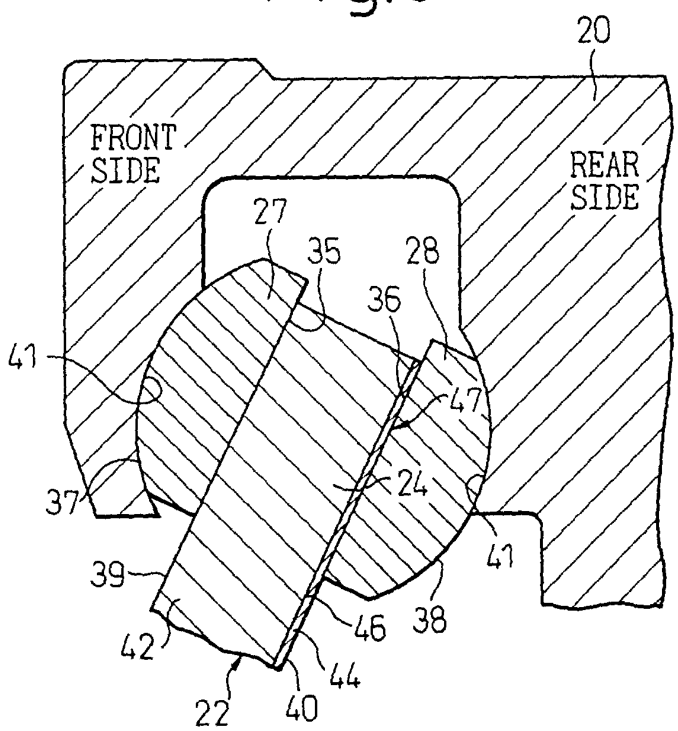
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Fig.4

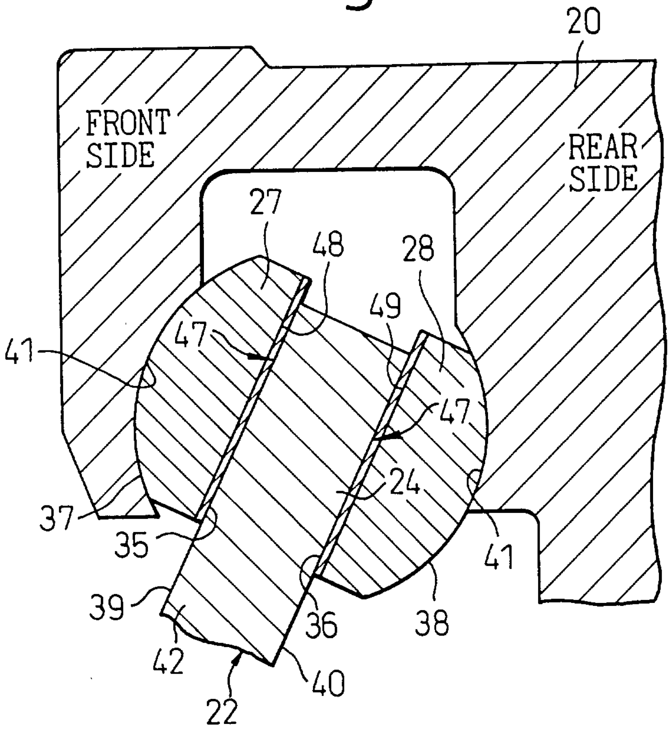
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Fig.5

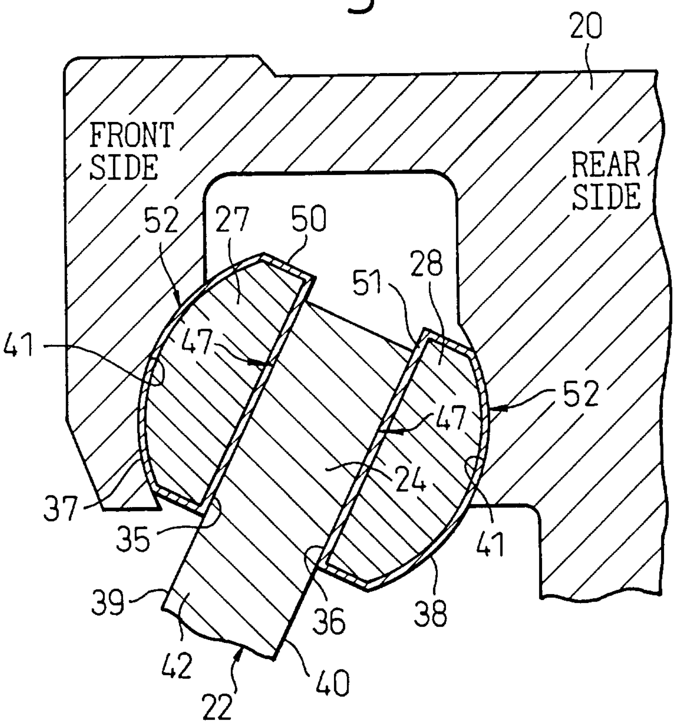
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Fig.6

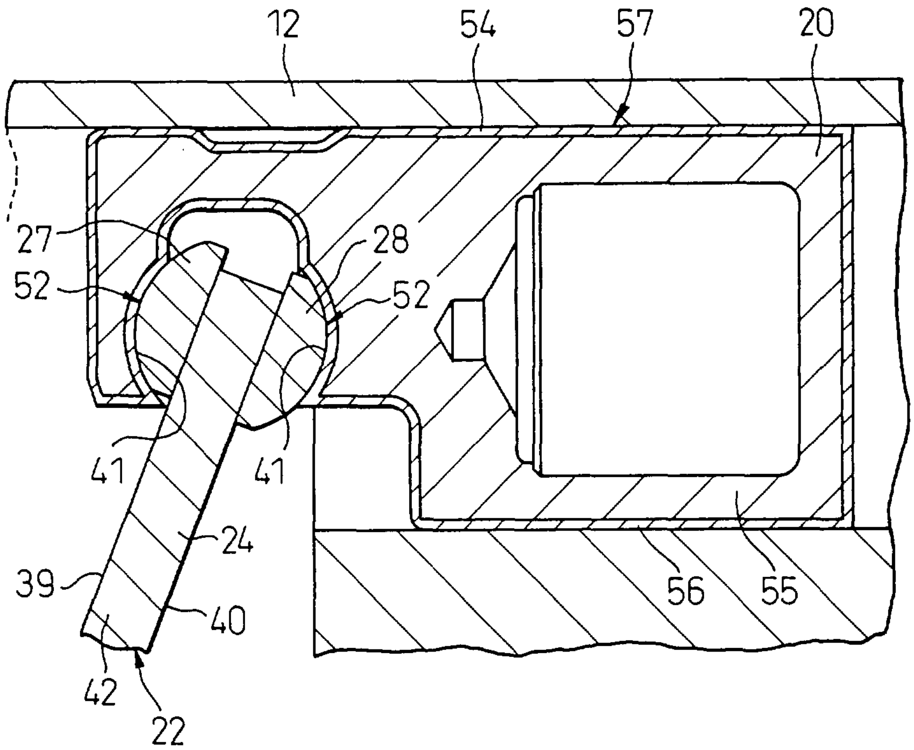

Fig.7