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(54) **Shoe for swash plate type compressor**

(57) A shoe for a swash plate type compressor disposed between a swash plate and a corresponding one of a plurality of pistons, the shoe being characterized by

comprising: a base body (146) formed of an aluminum alloy; and a metal plating film (148) which covers at least a portion of a surface of the base body.

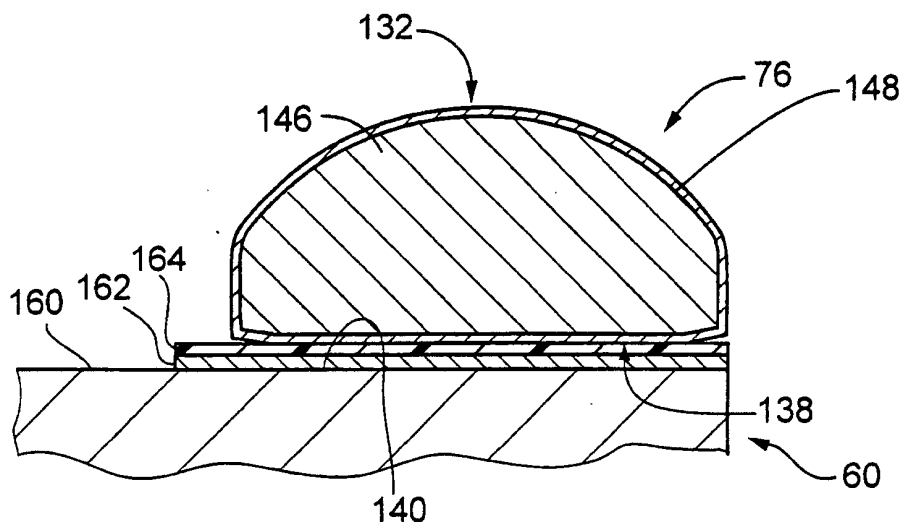


FIG. 2

Description

[0001] This application is based on Japanese Patent Application No. 2001-378450 filed December 12, 2001, the contents of which are incorporated hereinto by reference.

BACKGROUND OF THE INVENTION**Field of the Invention**

[0002] The present invention relates in general to a shoe for a swash plate type compressor, which shoe is disposed between a swash plate and a piston of the swash plate type compressor. More specifically, the present invention is concerned with such a shoe formed of an aluminum alloy, and the swash plate type compressor equipped with the shoe.

Discussion of the Related Art

[0003] A swash plate type compressor is adapted to compress a gas by converting a rotary movement of the swash plate into a reciprocating movement of a plurality of pistons. Between the swash plate which is rotated at a relatively high speed and each piston which is reciprocated at a relatively high speed, a shoe as a sliding member is disposed for permitting a smooth relative movement therebetween. In the swash plate type compressor used in an air conditioning system of an automotive vehicle, which compressor is particularly required to have a reduced weight, it is proposed to use an aluminum alloy for forming the shoe as one component of the compressor.

[0004] The swash plate and the piston which slide on the shoe are often formed of an aluminum alloy. In this case, the seizure is likely to occur due to the sliding contact between the swash plate and the shoe, and between the piston and the shoe, since the swash plate, the piston, and the shoe are formed of similar materials which contain the aluminum as a major component. Where the swash plate or the piston is not formed of the aluminum alloy, e.g., where the swash plate is formed of a ferrous material, the seizure will take place between the swash plate and the shoe since the shoe slides on the swash plate under severe or heavy load conditions. In addition, the shoe formed of the aluminum alloy tends to suffer from damages such as scratches and dents on its surface due to relatively low degrees of strength and hardness of the aluminum alloy. The scratches formed on the surface of the shoe in turn give damages the sliding surfaces of the swash plate and the piston on which the shoe slides, resulting in deterioration of the sliding characteristics of the compressor. Since the shoe slides under heavy load conditions, the durability of the shoe is deteriorated due to the low degrees of strength and hardness of the aluminum alloy.

SUMMARY OF THE INVENTION

[0005] It is therefore an object of the present invention to provide a shoe formed of an aluminum alloy and having good sliding characteristics, and a practically useful swash plate type compressor equipped with the shoe. The objects may be achieved according to any one of the following modes of the present invention in the form of a shoe for a swash plate type compressor and a swash plate type compressor equipped with the shoe. Each of the following modes is numbered like the appended claims and depends from the other mode or modes, where appropriate, to indicate and clarify possible combinations of elements or technical features of the present invention, for easier understanding of the invention. It is to be understood that the present invention is not limited to the technical features or any combinations thereof which will be described for illustrative purpose only. It is to be further understood that a plurality of elements or features included in any one of the following modes of the invention are not necessarily provided all together, and that the invention may be embodied without some of the elements or features described with respect to the same mode.

[0006] (1) A shoe for a swash plate type compressor disposed between a swash plate and a corresponding one of a plurality of pistons, the shoe comprising: a base body formed of an aluminum alloy; and a metal plating film which covers at least a portion of a surface of the base body.

[0007] The shoe for the swash plate type compressor according to the present invention is characterized in that the metal plating film is formed on the surface of its base body made of the aluminum alloy. Owing to the metal plating film, the shoe exhibits good sliding characteristics.

[0008] Various known metal plating films can be employed. Examples of the metal plating film are described below. A preferable composition and a preferable thickness of each metal plating film will be described in the following DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT. A method of forming the metal plating film, i.e., a plating method, is not particularly limited. Namely, the metal plating film may be formed under appropriate conditions according to known methods as employed in the fields for plating other articles while considering that the metal plating film is formed on the surface of the shoe. The metal plating film formed on the surface of the present shoe may be constituted by only one of the plating films described below, or a plurality of those plating films superposed on each other.

[0009] The aluminum alloy used for the base body of the shoe is not particularly limited, but may be selected from among aluminum alloys conventionally used for producing the shoe, and various known aluminum alloys. For example, it is possible to use an Al-Si alloy having a ratio of content of Al to Si which is nearly equal to that at which an eutectic mixture is formed. The Al-Si alloy is, for instance, A4032 according to the Japanese Industrial Standard (JIS) H4100. The Al-Si alloy has a small coefficient of thermal expansion and exhibits a good abrasion resistance, so that the shoe formed of the Al-Si alloy exhibits good sliding characteristics. It is also possible to use an Al-Cu-Mg alloy such as A2017, A2024 according to the JIS H4100, which alloy has a high degree of strength. The shoe formed of the Al-Cu-Mg alloy exhibits high degrees of strength and durability.

[0010] (2) A shoe according to the above mode (1), wherein the metal plating film comprises an electroless plating film which contains at least one of Ni and Co as a major constituent element.

[0011] The nickel-based or cobalt-based electroless plating permits uniform formation of the metal plating film having a relatively high degree of hardness, on the surface of the base body of the shoe, for thereby improving the sliding characteristics of the shoe.

[0012] (3) A shoe according to the above mode (2), wherein the electroless plating film comprises at least one electroless nickel plating film selected from the group consisting of an Ni-P based film, an Ni-B based film, an Ni-P-B based film, an Ni-P-W based film, an Ni-B-W based film, and an Ni-P-B-W based film.

[0013] The electroless nickel plating permits uniform formation of the metal plating film on the surface of the base body of the shoe as described above. In addition, the plating film formed by the electroless nickel plating has a Vickers hardness value higher than Hv 500, and exhibits high degrees of resistances to abrasion and corrosion. Accordingly, the metal plating film formed by the electroless nickel plating on the surface of the base body of the shoe is effective to prevent the shoe from suffering from scratches which cause deformation of the base body formed of the aluminum alloy. Thus, the shoe according to the present mode exhibits excellent sliding characteristics and durability when used for the swash plate type compressor.

[0014] The advantages of the respective plating films described above are as follows. The Ni-P based electroless nickel plating film exhibits good adhesion with respect to the aluminum alloy of the base body of the shoe, and a high degree of corrosion resistance. Further, the Ni-P based film can be formed at a relatively high rate and at a relatively low cost by using a relatively inexpensive plating bath material. The Ni-B based electroless nickel plating film and the Ni-P-B based electroless nickel plating film have a high degree of hardness and exhibit good resistances to abrasion and oxidation at a relatively high temperature. In particular, the Ni-P-B based film has a hardness value of not lower than Hv 650. The Ni-P-W based film, the Ni-B-W based film, and the Ni-P-B-W based film exhibit a significantly high degree of abrasion resistance owing to tungsten (W) included therein. Any suitable one of, or any suitable combination of those plating films may be employed by taking into account the advantages of the respective plating films.

[0015] The electroless nickel plating film may include two or more of the above-described electroless nickel plating films having respective different compositions and superposed on each other. Where a plurality of plating films are described in the following modes, only one of those plating films may be employed, or two or more of those plating films which are superposed on each other may be employed, for providing the metal plating film formed on the surface of the base body of the shoe.

[0016] (4) A shoe according to the above modes (2) or (3), wherein the electroless plating film comprises at least one electroless cobalt plating film selected from the group consisting of a Co-P based film and a Co-P-W based film.

[0017] The electroless cobalt plating film has excellent friction characteristics. Where the base body of the shoe is covered with the electroless cobalt plating film, the shoe exhibits good sliding characteristics.

[0018] (5) A shoe according to any one of the above modes (2)-(4), wherein the electroless plating film comprises at least one electroless nickel-cobalt plating film selected from the group consisting of an Ni-Co based film and an Ni-Co-P based film.

[0019] The electroless nickel-cobalt plating film has excellent friction characteristics. Where the base body of the shoe is covered with the electroless nickel-cobalt plating film, the shoe exhibits good sliding characteristics.

[0020] (6) A shoe according to any one of the above modes (2)-(5), wherein the electroless plating film contains polytetrafluoroethylene (PTFE).

[0021] In the electroless plating film according to this mode, the PTFE is deposited together with the matrix phase of the plating film. Where the electroless plating film includes the PTFE therein, the plating film exhibits good lubrication characteristics, for thereby improving the sliding characteristics of the shoe.

[0022] (7) A shoe according to any one of the above modes (2)-(6), wherein the metal plating film further comprises at least one covering film which is formed on a surface of the electroless plating film and which contains at least one of Sn, TiCN, TiN, CrN, and TiAlN

[0023] The covering film which contains Sn exhibits excellent sliding characteristics where the lubrication by the lubricant oil is insufficient, since the Sn which is a soft metal has a function similar to that of a solid lubricant. The covering film which contains TiCN, TiN, CrN, or TiAlN has a high degree of hardness and exhibits good abrasion resistance. Accordingly, the covering film formed on the surface of the electroless plating film permits the shoe to exhibit

good sliding characteristics. The covering film which contains Sn may be formed by electroplating or chemical plating (e.g., autocatalytic deposition) while the covering film which contains TiCN, TiN, CrN, or TiAlN may be formed by physical vapor deposition (PVD), for instance.

[0024] (8) A shoe according to any one of the above modes (1)-(7), wherein the metal plating film comprises an electroplating film which contains at least one of Ni, Fe, Cr, and Co as a major constituent element.

[0025] The electroplating film containing at least one of Ni, Fe, Cr, and Co as a major constituent element has a high degree of hardness, so that such an electroplating film is suitably employed as a covering film which covers the surface of the shoe formed of the aluminum alloy. Further, the electroplating can be effected at a lower cost than the above-described electroless plating, reducing the cost of manufacture of the shoe.

[0026] (9) A shoe according to the above mode (8), wherein the electroplating film comprises at least one nickel electroplating film selected from the group consisting of an Ni based film, an Ni-P based film, an Ni-W based film, an Ni-Fe based film, an Ni-Mo-W based film.

[0027] The nickel electroplating film is not likely to suffer from defects such as pinholes and cracks, and exhibits a smoothing or leveling effect for smoothing or leveling the surface of the base body, in other words, improving the surface smoothness. Further, the nickel electroplating film has a high degree of hardness. The shoe whose surface is covered with the nickel electroplating film exhibits good sliding characteristics owing to those advantages.

[0028] (10) A shoe according to the above mode (8) or (9), wherein the electroplating film comprises at least one ferrous electroplating film selected from the group consisting of an Fe based film, an Fe-P based film, an Fe-W based film, an Fe-C based film, and an Fe-N based film.

[0029] The ferrous electroplating film can be formed at a relatively low cost, for thereby reducing the cost of manufacture of the shoe.

[0030] (11) A shoe according to any one of the above modes (8)-(10), wherein the electroplating film comprises at least one chromium electroplating film selected from the group consisting of a Cr based film and a Cr-Mo based film.

[0031] The chromium electroplating film has a higher degree of hardness and a lower coefficient of friction than the above-described nickel electroplating film, for instance, so that the shoe covered with the chromium electroplating film exhibits good sliding characteristics.

[0032] (12) A shoe according to any one of the above modes (8)-(11), wherein the electroplating film comprises at least one cobalt electroplating film selected from the group consisting of a Co based film and a Co-W based film.

[0033] The cobalt electroplating film has good friction characteristics, so that the shoe covered with the cobalt electroplating film exhibits good sliding characteristics.

[0034] (13) A shoe according to any one of the above modes (1)-(12), wherein the metal plating film contains at least one of SiC, Si₃N₄, Al₂O₃, and CrC.

[0035] The above-described substances have high melting points and high hardness values. Accordingly, the metal plating film containing at least one of those substances exhibits excellent abrasion resistance, so that the sliding characteristics of the shoe formed of the aluminum alloy can be further improved. These substances are contained in the metal plating film in the form of fine particles, for instance. During formation of the metal plating film, the fine particles of those substances are dispersed in the plating bath, so that those substances are included in the formed metal plating film.

[0036] (14) A shoe according to any one of the above modes (1)-(13), wherein the metal plating film has a hardness value of not smaller than Hv 300.

[0037] The shoe whose base body is formed of the aluminum alloy and covered with the plating film having a Vickers hardness of not lower than Hv 300 exhibits practically sufficient operating performance. For increasing the abrasion resistance and effectively preventing the shoe from being damaged, the metal plating film preferably has the hardness of not lower than Hv 500, more preferably not lower than Hv 600, still more preferably not lower than Hv 700. For preventing excessive abrasion of the member on which the shoe slides and protecting the member from being damaged by fragments of the covering film which may peel off from the base body, the metal plating film preferably has the hardness of not higher than Hv 1500, more preferably not higher than Hv 1100.

[0038] (15) A shoe according to any one of the above modes (1)-(14), wherein the metal plating film covers at least a portion of the base body, which portion is held in sliding contact with the swash plate.

[0039] In the swash plate type compressor, the shoe slides on the swash plate and a corresponding one of the plurality of pistons. Where the shoe is covered with the metal plating film at a portion thereof which is held in sliding contact with the swash plate or the piston, the shoe exhibits good sliding characteristics. In view of the fact that the swash plate is rotated at a relatively high speed, at least a portion of the base body of the shoe, which portion is held in sliding contact with the swash plate, is preferably covered with the metal plating film, as described in this mode of the invention. For assuring high degrees of corrosion resistance of the shoe and configurational stability of the shoe, and easier plating operation, it is preferable to cover the entire surface of the base body of the shoe with the plating film.

[0040] (16) A shoe according to any one of the above modes (1)-(15), wherein the metal plating film constitutes at least a part of an outer surface of the shoe.

[0041] The swash plate type compressor shoe according to the present invention may include another covering film formed on the surface of the metal plating film. For instance, a lubricating film formed of a synthetic resin containing a solid lubricant may be formed on the metal plating film. The lubricating film is effective to improve the sliding characteristics of the shoe. The solid lubricant may be selected from among molybdenum disulfide (MoS_2), boron nitride (BN), tungsten disulfide (WS_2), graphite, and polytetrafluoroethylene (PTFE), for instance, while the synthetic resin may be selected from among polyamide imide, epoxy resin, polyetherketone, and phenol resin, for instance. The lubricating film may be formed such that the synthetic resin in which the solid lubricant is dispersed is coated on the surface of the metal plating film by spraying, for instance, and the resin is hardened for providing the lubricating film. As described in this mode, the metal covering film may not be covered with any other covering film. The shoe without any additional covering film is produced at a relatively low cost, and practically useful.

[0042] While there have been described various modes of the shoe for the swash plate type compressor according to the present invention, the shoe of the invention may have any one of the technical features in the following modes relating to the swash plate type compressor, depending upon the specific application of the shoe.

[0043] (17) A swash plate type compressor comprising: a swash plate; a plurality of pistons; and a plurality of shoes as defined in any one of the above modes (1)-(16), each of the plurality of shoes being disposed between the swash plate and a corresponding one of the plurality of pistons.

[0044] The swash plate type compressor according to this mode of the invention is equipped with the above-described shoe of the present invention. Owing to the good sliding characteristics of the shoe, the present swash plate type compressor exhibits excellent durability while assuring a smooth operation thereof.

[0045] (18) A swash plate type compressor according to the above mode (17), wherein the swash plate is formed of a ferrous material.

[0046] The ferrous material is generally inexpensive, so that the swash plate type compressor having the swash plate formed of the ferrous material is relatively inexpensive. In the swash plate type compressor of a variable capacity type, for instance, the displacement capacity of the compressor is adjusted or changed by changing an angle of the swash plate with respect to a plane perpendicular to the rotation axis of the rotary drive shaft, namely by changing an angle of inclination of the swash plate with respect to the above-indicated plane. (The angle is hereinafter referred to as an "inclination angle" of the swash plate.) While the compressor is operated so as to maintain a predetermined constant displacement capacity, the swash plate is desirably rotated while being kept at a predetermined inclination angle. If the swash plate has a relatively large mass, the inertial force permits the swash plate to be rotated with high stability while being kept at the predetermined inclination angle. Accordingly, the swash plate type compressor equipped with the ferrous swash plate exhibits a high degree of operating stability since the ferrous swash plate having a relatively large mass can be rotated with high stability. In the swash plate type compressor of variable capacity type described above, if the ferrous swash plate is used in combination with the shoe formed of a lightweight aluminum alloy, the swash plate can be rotated with further higher stability. In view of the fact that the configuration of the swash plate is complicated, the ferrous swash plate is preferably formed by casting. In view of this, the swash plate is desirably formed of cast iron. Among various cast irons, it is preferable to use a spheroidal graphite cast iron which exhibits high degrees of strength and durability. In particular, the ductile cast iron FCD 700 according to the JIS G 5502 having a considerably high degree of strength is preferably employed. The material used for the swash plate is not particularly limited. For instance, the swash plate may be formed of an aluminum alloy for reducing its weight.

[0047] If the ferrous swash plate is employed, the swash plate may include, on the sliding surfaces thereof which slide on the shoes, metal sprayed films formed of a material selected from the group consisting of aluminum, copper, an aluminum alloy, and a copper alloy, for improving the sliding characteristics. The swash plate may be subjected to a quenching treatment on the sliding surfaces thereof which slide on the shoes. Where the present shoe having the metal covering film slides on the swash plate according to those arrangements, the present shoe is not likely to suffer from seizure and abrasion, for thereby effectively maintaining good sliding characteristics. Accordingly, the shoe of the present invention is suitably used in combination with the swash plate whose sliding surfaces are covered with the metal sprayed films or subjected to the quenching treatment.

[0048] (19) A swash plate type compressor according to the above mode (17) or (18), wherein the swash plate includes lubricating films formed on sliding surfaces thereof which slide on the plurality of shoes.

[0049] The swash plate and the shoes slide on each other under considerably heavy load conditions since the swash plate is rotated at a relatively high speed. In the swash plate type compressor having the swash plate whose sliding surfaces which slide on the shoes are covered with the lubricating films, the friction between the swash plate and the shoes is reduced, assuring a smooth operation of the compressor.

[0050] The lubricating film formed on each sliding surface of the swash plate may have a structure similar to that of the lubricating film formed on the surface of the metal covering film of the shoe described above. The lubricating film has a relatively low degree of strength, and tends to peel off from the swash plate due to the scratches formed on the shoe during the sliding contact with the shoe. Where the shoe slides on the swash plate at its portion on which the metal covering film is formed, the shoe is not likely to suffer from any scratches at that portion owing to the metal

covering film, so that the lubricating film formed on each sliding surface of the swash plate is prevented from being damaged by the scratches of the shoe. Thus, the present swash plate type compressor maintains good sliding characteristics for a long period of service.

[0051] (20) A swash plate type compressor according to any one of the above modes (17)-(19), further comprising a displacement capacity changing mechanism for changing a displacement capacity of the compressor by changing an inclination angle of the swash plate.

[0052] In the swash plate type compressor of variable capacity type, the displacement capacity of the compressor is generally adjusted by changing the inclination angle of the swash plate with respect to the plane perpendicular to the rotation axis of the rotary drive shaft, for thereby changing the reciprocating stroke of the pistons. In the thus arranged swash plate type compressor of variable capacity type, when the swash plate is inclined with respect to the above-indicated plane, the shoes have an elliptical path on the swash plate. With an increase in the inclination angle of the swash plate, the major axis of an ellipse of the path is increased. Since the swash plate type compressor needs to be compact, the size, i.e., the diameter of the swash plate, is made small to such an extent that the swash plate does not interfere with the pistons when the swash plate is not inclined. In other words, the diameter of the swash plate is determined so as to permit the shoes to engage the swash plate such that the end of the shoe on the radially outer side of the swash plate is flush with the outer circumferential surface of the swash plate, in other words, to prevent the shoe from radially outwardly protruding from the radially outer portion of the swash plate, when the swash plate is not inclined. In the compressor having the thus designed swash plate, when the swash plate is inclined at a relatively large angle, the shoes engaging the pistons which are located near the opposite ends of the major axis of the elliptical path of the shoes, namely, the shoes engaging the pistons located near the compression stroke end and the suction stroke end, respectively, slide on the swash plate such that portions of the shoes radially outwardly protrude from the radially outer portion of the swash plate, depending upon the structure of the compressor. In this case, the area of contact or engagement of the swash plate and the shoes is undesirably reduced, so that a relatively large pressing force of the shoes acts on the swash plate at its small surface area contacting the shoes. The shoes may slide on the swash plate while the shoes are inclined. In this case, the pressing force of the shoes acts on portions of the swash plate in the vicinity of its circumferential edges having an extremely small surface area. Accordingly, the shoes used for the swash plate type compressor of variable capacity type are operated under very severe or heavy load conditions. Since the strength of the lubricating films formed on the sliding surfaces of the swash plate is relatively small, the lubricating films are likely to be worn when the shoes slide on a small surface area of the swash plate as described above. Thus, in the swash plate type compressor wherein the inclination angle of the swash plate is changed, the shoes and the swash plate slide on each other under very severe or heavy load conditions. The present swash plate type compressor equipped with the shoes each having the metal plating film formed on the surface thereof have good sliding characteristics. In other words, the shoe of the present invention is particularly advantageously applicable to the swash plate type compressor of variable capacity type in which the inclination angle of the swash plate is changed to change the displacement capacity of the compressor.

BRIEF DESCRIPTION OF THE DRAWINGS

[0053] The above and optional objects, features, advantages and technical and industrial significance of the present invention will be better understood and appreciated by reading the following detailed description of a presently preferred embodiment of the invention, when considered in connection with the accompanying drawings, in which:

Fig. 1 is a front elevational view in cross section of a swash plate type compressor equipped with shoes constructed according to one embodiment of the present invention;

Fig. 2 is a front elevational view in cross section showing the shoe and a portion of the swash plate which slides on the shoe; and

Fig. 3 schematically shows a test device used for examining the resistance of the shoe to seizure.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0054] Referring to the accompanying drawings, there will be described a presently preferred embodiment of this invention as applied to a swash plate type compressor used for an air conditioning system of an automotive vehicle, and a shoe installed on the swash plate type compressor as one component of the compressor.

[0055] Referring first to Fig. 1, there is shown a compressor of swash plate type. In Fig. 1, reference numeral 10 denotes a cylinder block having a plurality of cylinder bores 12 formed so as to extend in its axial direction such that the cylinder bores 12 are arranged along a circle whose center lies on a centerline of the cylinder block 10. Single-headed pistons generally indicated at 14 (hereinafter simply referred to as "piston 14") are reciprocally received in the respective cylinder bores 12. To one of the axially opposite end faces of the cylinder block 10, (the left end face as

seen in Fig. 1, which will be referred to as "front end face"), there is attached a front housing 16. To the other end face (the right end face as seen in Fig. 1, which will be referred to as "rear end face"), there is attached a rear housing 18 through a valve plate 20. The front housing 16, rear housing 18 and cylinder block 10 cooperate to constitute a housing assembly of the swash plate type compressor. The rear housing 18 and the valve plate 20 cooperate to define a suction chamber 22 and a discharge chamber 24, which are connected to a refrigerating circuit (not shown) through an inlet 26 and an outlet 28, respectively. The valve plate 20 has suction ports 32, suction valves 34, discharge ports 36 and discharge valves 38.

[0056] A rotary drive shaft 50 is disposed in the cylinder block 10 and the front housing 16 such that the axis of rotation of the drive shaft 50 is aligned with the centerline of the cylinder block 10. The drive shaft 50 is supported at its opposite end portions by the front housing 16 and the cylinder block 10, respectively, via respective bearings, such that the drive shaft 50 is rotatable relative to the front housing 16 and the cylinder block 10. The cylinder block 10 has a central bearing hole 56 formed in a central portion thereof, and the bearing is disposed in this central bearing hole 56, for supporting the drive shaft 50 at its rear end portion. The front end portion of the drive shaft 50 is connected, through a clutch mechanism such as an electromagnetic clutch, to an external drive source (not shown) in the form of an engine of an automotive vehicle. In operation of the compressor, the drive shaft 50 is connected through the clutch mechanism to the vehicle engine in operation so that the drive shaft 50 is rotated about its axis.

[0057] The rotary drive shaft 50 carries a swash plate 60 such that the swash plate 60 is axially movable and tiltable relative to the drive shaft 50. The swash plate 60 has a central hole 61 through which the drive shaft 50 extends. The inner dimension of the central hole 61 as measured in a vertical direction of Fig. 1 gradually increases in a direction from the axially intermediate portion toward each of the axially opposite ends, and the transverse cross sectional shape of the central hole 61 at each of the axially opposite ends is elongated. To the drive shaft 50, there is fixed a rotary member 62 as a torque transmitting member, which is held in engagement with the front housing 16 through a thrust bearing 64. The swash plate 60 is rotated with the drive shaft 50 by a hinge mechanism 66 during rotation of the drive shaft 50. The hinge mechanism 66 guides the swash plate 60 for its axial and tilting motions. The hinge mechanism 66 includes a pair of support arms 67 fixed to the rotary member 62, guide pins 69 which are formed on the swash plate 60 and which slidably engage guide holes 68 formed in the support arms 67, the central hole 61 of the swash plate 60, and the outer circumferential surface of the drive shaft 50.

[0058] The piston 14 indicated above includes an engaging portion 70 engaging the radially outer portion of the opposite surfaces of the swash plate 60, and a head portion 72 formed integrally with the engaging portion 70 and slidably fitted in the corresponding cylinder bore 12. The head portion 72 of the piston 14 in the present embodiment is made hollow, for thereby reducing the weight of the piston 14. The head portion 72, cylinder bore 12, and valve plate 20 cooperate with one another to define a pressurizing chamber. The engaging portion 70 engages the radially outer portion of the opposite surfaces of the swash plate 60 through a pair of part-spherical-crown shoes 76. The shoes 76 will be described in greater detail.

[0059] The rotary motion of the swash plate 60 is converted into a reciprocating linear motion of the piston 14 through the shoes 76. A refrigerant gas in the suction chamber 22 is sucked into the pressurizing chamber of the cylinder bore 12 through the suction port 32 and the suction valve 34, when the piston 14 is moved from its upper dead point to its lower dead point, that is, when the piston 14 is in the suction stroke. The refrigerant gas in the pressurizing chamber of the cylinder bore 12 is pressurized by the piston 14 when the piston 14 is moved from its lower dead point to its upper dead point, that is, when the piston 14 is in the compression stroke. The pressurized refrigerant gas in the pressurizing chamber is discharged into the discharge chamber 24 through the discharge port 36 and the discharge valve 38. A reaction force acts on the piston 14 in the axial direction as a result of compression of the refrigerant gas in the pressurizing chamber. This compression reaction force is received by the front housing 16 through the piston 14, swash plate 60, rotary member 62 and thrust bearing 64.

[0060] The cylinder block 10 has an intake passage 80 formed therethrough for communication between the discharge chamber 24 and a crank chamber 86 which is defined between the front housing 16 and the cylinder block 10. The intake passage 80 is connected to a solenoid-operated control valve 90 provided to control the pressure in the crank chamber 86. The solenoid-operated control valve 90 includes a solenoid coil 92. The amount of electric current applied to the solenoid coil 92 is controlled depending upon the air conditioner load by a control device not shown constituted principally by a computer.

[0061] The rotary drive shaft 50 has a bleeding passage 100 formed therethrough. The bleeding passage 100 is open at one of its opposite ends to the central bearing hole 56, and is open at the other end to the crank chamber 86. The central bearing hole 56 communicates at its bottom with the suction chamber 22 through a communication port 104.

[0062] The present swash plate type compressor is of variable capacity type. By controlling the pressure in the crank chamber 86 by utilizing a difference between the pressure in the discharge chamber 24 as a high-pressure source and the pressure in the suction chamber 22 as a low pressure source, a difference between the pressure in the pressurizing chamber of the cylinder bore 12 and the pressure in the crank chamber 86 is regulated to change the angle of inclination of the swash plate 60 with respect to a plane perpendicular to the axis of rotation of the drive shaft 50, for thereby

changing the reciprocating stroke (suction and compression strokes) of the piston 14, whereby the displacement capacity of the compressor can be adjusted. Described in detail, by energization and de-energization of the solenoid coil 92 of the solenoid-operated control valve 90, the crank chamber 86 is selectively connected to and disconnected from the discharge chamber 24, so that the pressure in the crank chamber 86 is controlled. The displacement capacity changing mechanism in the swash plate type compressor of the present embodiment for changing the displacement capacity of the compressor is constituted by the hinge mechanism 66, cylinder bores 12, pistons 14, suction chamber 22, discharge chamber 24, central bearing hole 56, crank chamber 86, bleeding passage 100, communication port 104, control device not shown, etc.

[0063] The cylinder block 10 and each piston 14 are formed of an aluminum alloy. The piston 14 is coated at its outer circumferential surface with a fluoro resin film which prevents a direct contact of the aluminum alloy of the piston 14 with the aluminum alloy of the cylinder block 10 so as to prevent seizure therebetween, and makes it possible to minimize the amount of clearance between the piston 14 and the cylinder bore 12. Other materials may be used for the cylinder block 10, the piston 14, and the coating film.

[0064] The end portion of the engaging portion 70 of the piston 14, which is remote from the head portion 72, has a U-shape in cross section. Described in detail, the engaging portion 70 has a base section 124 which defines the bottom of the U-shape, and a pair of substantially parallel arm sections 120, 122 which extend from the base section 124 in a direction perpendicular to the axis of the piston 14. The two opposed lateral walls of the U-shape of the engaging portion 70 have respective recesses 128 which are opposed to each other. Each of these recesses 128 is defined by a part-spherical inner surface of the lateral wall. The part-spherical inner surfaces of the recesses 128 are located on the same spherical surface.

[0065] As shown in Fig. 2, each of the pair of shoes 76 has a substantially part-spherical crown shape, and includes a generally convex part-spherical surface 132 and a generally flat surface 138. Strictly speaking, the flat surface 138 is a slightly convex curved surface (e.g., a convex part-spherical surface having a considerably large radius of curvature), and includes a tapered portion formed at a radially outer portion thereof. The part-spherical surface 132 has a cylindrical portion formed adjacent to the flat surface 138. The boundary between the convex curved surface and the tapered portion, the boundary between the tapered portion and the cylindrical portion, and the boundary between the cylindrical portion and the part-spherical convex surface, are rounded so as to have respective different small radii of curvature. The pair of shoes 76 slidably engage the part-spherical inner surfaces of the recesses 128 of the piston 14 at their part-spherical surfaces 132 and slidably engage the radially outer portion of the opposite surfaces of the swash plate 60, i.e., the sliding surfaces 140, 142 of the swash plate 60, at their flat surfaces 138. In other words, each shoe 76 slides on the swash plate at its flat surface 138 and slides on the piston 14 at its part-spherical surface 132. The pair of shoes 76 are designed such that their convex part-spherical surfaces 132 are located on the same spherical surface. In other words, each shoe 76 has a part-spherical crown shape whose size is smaller than a hemi-sphere by an amount corresponding to a half of the thickness of the swash plate 60.

[0066] The shoe 76 includes a base body 146 and a metal plating film 148 which covers the surface of the base body 146, more specifically, the entire surface of the base body 146. In Fig. 2, the thickness of the metal plating film 148 is exaggerated for easier understanding.

[0067] The base body 146 is formed of an Al-Si alloy, i.e., A 4032 according to the JIS H 4100, which contains aluminum as a major component, and silicon. Various kinds of aluminum alloy can be used as the material for the base body 146 of the present shoe 76. The shoe may be produced according to the following method, for instance. Initially, there is prepared a bar-shaped member having a predetermined diameter. The bar-shaped member is prepared by extruding a billet which is formed of an aluminum alloy having a predetermined composition and which is obtained by casting. The bar-shaped member is cut into a plurality of pieces each having a predetermined length, by a shearing device or a sawing machine. Each cut piece is subjected to cold forging by using a press including a suitable die assembly, so that the cut piece is formed into a roughly-shaped precursor shoe. The method of producing the present shoe is not limited to cold forging, but may be selected from among known methods such as hot forging, casting, punching by a press, machining, etc., and any suitable combination thereof. Thereafter, the roughly-shaped precursor shoe may be subjected to a suitable heat treatment. In general, a so-called T6 treatment (according to the JIS H 0001) is conducted, wherein the roughly-shaped precursor shoe is subjected to an artificial age hardening treatment after it has been subjected to a solution heat treatment. The shoe which has been subjected to the T6 treatment exhibits significantly high degrees of strength and hardness. The T6 treatment may be replaced with other heat treatment such as a T7 treatment (according to JIS H 0001), wherein the roughly-shaped precursor shoe which has been subjected to the solution heat treatment is subjected to an over-aging treatment which is conducted beyond conditions of the artificial age hardening treatment at which the maximum strength is obtained. After the heat treatment, a grinding operation is effected on the roughly-shaped precursor shoe, so that the roughly-shaped precursor shoe is formed into a predetermined shape corresponding to that of the base body of the shoe. Since the base body 146 of each shoe is formed of the aluminum alloy, the swash plate type compressor equipped with the shoes has a reduced weight.

[0068] The metal plating film 148 formed on the surface of the shoe 76 may be selected from among those described

in the SUMMARY OF THE INVENTION. The advantages of the respective plating films are described above. The method of forming each of the plating films may be suitably selected from among any known method. Where the metal plating film 148 of the shoe 76 is constituted by a single film selected from among those plating films, the composition and thickness of each plating film is determined as described below. The following TABLE 1 indicates respective compositions of various electroless plating films while TABLE 2 indicates respective compositions of various electroplating films. The thickness of each of the electroless plating films and electroplating films is as follows. Namely, the lower limit of the film thickness is 10 μm , for assuring a substantial effect of the plating film, more preferably 20 μm for assuring a higher effect. The upper limit of the film thickness is preferably 150 μm , more preferably 100 μm , for preventing adverse influences due to an excessively large thickness value, and for reducing the cost of manufacture. In the following TABLE 1 and TABLE 2, "LOWER LIMIT 1" indicates a preferable lower limit value indicative of the amount of each element included in each plating film for assuring a substantial effect by addition of that element, or by formation of the plating film, while "LOWER LIMIT 2" indicates a more preferable lower limit value indicative of the amount of each element included in each plating film for assuring a higher effect. "UPPER LIMIT 2" indicates a preferable upper limit value indicative of the amount of each element included in each plating film for preventing adverse influences by addition of that element, or due to an excessively large thickness value of the film, or for reducing the cost of manufacture, while "UPPER LIMIT 1" indicates a more preferable upper limit value indicative of the amount of each element. In the following TABLE 1 and TABLE 2, the element whose amount is indicated by a symbol "-" means a major component of the plating film, and constitutes a substantial part of the balance. In TABLE 1 and TABLE 2, the amount of each element is represented by % by weight per 100 % by weight of the plating film.

TABLE 1

<Electroless plating film>					
		(unit: % by weight)			
PLATING FILMS	ELEMENTS	LOWER LIMIT 1	LOWER LIMIT 2	UPPER LIMIT 1	UPPER LIMIT 2
Ni-P based film	Ni	-	-	-	-
	P	≤ 0.05	≤ 0.5	≥ 10	≥ 15
Ni-B based film	Ni	-	-	-	-
	B	≤ 0.05	≤ 0.1	≥ 5	≥ 10
Ni-P-B based film	Ni	-	-	-	-
	P	≤ 0.05	≤ 0.5	≥ 10	≥ 15
	B	≤ 0.01	≤ 0.05	≥ 0.2	≥ 2
Ni-P-W based film	Ni	-	-	-	-
	P	≤ 0.05	≤ 0.5	≥ 10	≥ 15
	W	≤ 0.05	≤ 1	≥ 35	≥ 40
Ni-B-W based film	Ni	-	-	-	-
	B	≤ 0.01	≤ 0.05	≥ 2	≥ 5
	W	≤ 0.05	≤ 3	≥ 35	≥ 40
Ni-P-B-W based film	Ni	-	-	-	-
	P	≤ 0.05	≤ 0.5	≥ 10	≥ 15
	B	≤ 0.01	≤ 0.01	≥ 0.2	≥ 2
	W	≤ 0.01	≤ 0.01	≥ 0.5	≥ 1
Co-P based film	Co	-	-	-	-
	P	≤ 0.05	≤ 0.5	≥ 10	≥ 15
Co-P-W based film	Co	-	-	-	-
	P	≤ 0.05	≤ 0.5	≥ 10	≥ 15
	W	≤ 0.05	≤ 1	≥ 35	≥ 40

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TABLE 1 (continued)

<Electroless plating film>					
		(unit: % by weight)			
PLATING FILMS	ELEMENTS	LOWER LIMIT 1	LOWER LIMIT 2	UPPER LIMIT 1	UPPER LIMIT 2
Ni-Co based film	Ni	-	-	-	-
	Co	< 0	≤ 10	≥ 90	> 100
Ni-Co-P based film	Ni	-	-	-	-
	Co	≤ 2	≤ 10	≥ 90	≥ 98
	P	≤ 0.05	≤ 0.5	≥ 10	≥ 15

TABLE 2

<Electroplating film>					
		(unit: % by weight)			
PLATING FILM	ELEMENT	LOWER LIMIT 1	LOWER LIMIT 2	UPPER LIMIT 1	UPPER LIMIT 2
Ni based film	Ni	-	-	-	-
N-P based film	Ni	-	-	-	-
	P	≤ 0.1	≤ 0.2	≥ 10	≥ 15
Ni-W based film	Ni	-	-	-	-
	W	≤ 0.05	≤ 1	≥ 40	≥ 50
Ni-Fe based film	Ni	-	-	-	-
	Fe	≤ 1	≤ 2	≥ 30	≥ 40
Ni-Mo-W based film	Ni	-	-	-	-
	Mo	≤ 0.05	≤ 1	≥ 40	≥ 50
	W	≤ 0.05	≤ 1	≥ 40	≥ 50
Fe based film	Fe	-	-	-	-
Fe-P based film	Fe	-	-	-	-
	P	≤ 0.05	≤ 0.1	≥ 5	≥ 10
Fe-W based film	Fe	-	-	-	-
	W	≤ 0.05	≤ 1	≥ 60	≥ 70
Fe-C based film	Fe	-	-	-	-
	C	≤ 0.05	≤ 0.1	≥ 5	≥ 7
Fe-N based film	Fe	-	-	-	-
	N	≤ 0.05	≤ 0.1	≥ 5	≥ 7
Cr based film	Cr	-	-	-	-
Cr-Mo based film	Cr	-	-	-	-
	Mo	≤ 0.05	≤ 1	≥ 40	≥ 50
Co based film	Co	-	-	-	-
Co-W based film	Co	-	-	-	-
	W	≤ 0.05	≤ 1	≥ 40	≥ 50

[0069] As described above, the electroless plating film may contain the PTFE therein. In other words, the PTFE may be deposited together with the matrix phase of the plating film. For obtaining a substantial effect by addition of the PTFE, the PTFE is preferably included in the electroless plating film in an amount of not smaller than 0.5 % by weight, more preferably not smaller than 0.7 % by weight, per 100 % by weight of the electroless plating film, for obtaining a higher effect. The strength of the plating film is undesirably lowered by addition of an excessively large amount of the PTFE. In view of this, it is practically preferable that the PTFE is included in the plating film in an amount of not greater than 12 % by weight, more preferably not greater than 10 % by weight.

[0070] As described above, the electroless plating film may be covered with at least one covering film which contains at least one of Sn, TiCN, TiN, CrN, and TiAlN, so that the electroless plating film and the at least one covering film formed thereon cooperate to constitute the metal plating film 148. In this case, the lower limit value of the thickness of each of the at least one covering film is preferably 0.1 μm for obtaining a substantial effect by provision of the covering film, more preferably 0.5 μm for obtaining a higher effect. The upper limit value of the thickness of each of the at least one covering film is preferably 5 μm , more preferably 4 μm , for preventing adverse influences due to an excessively large thickness value and for reducing the cost of manufacture.

[0071] The metal plating film may include at least one of SiC, Si_3N_4 , Al_2O_3 , and CrC. The lower limit value of the amount of each of those substances included in the metal plating film is preferably 0.5 % by weight for obtaining a substantial effect by addition of the substance, more preferably 1 % by weight for a higher effect, per 100 % by weight of the metal plating film. The upper limit value of the amount of each substance included in the metal plating film is preferably 20 % by weight, more preferably 15 % by weight, per 100 % by weight of the metal plating film, for preventing adverse influences due to addition of an excessively large amount of the substance and for reducing the cost of manufacture.

[0072] There will be next described a structure of the swash plate 60. The swash plate 60 which engages the shoes 76 includes a base body 160 formed of spheroidal graphite cast iron, generally called as ductile cast iron such as FCD 700 according to the JIS G 5502. The swash plate 60 includes sliding surfaces 140, 142 which are to be held in sliding contact with the shoes 76. (In Fig. 2, only one sliding surface 140 is shown.) At each portion of the base body 160 of the swash plate 60 providing each of the sliding surfaces 140, 142, a metal sprayed film in the form of an aluminum sprayed film 162 and a lubricating film 164 are formed in this order. In Fig. 2, the thickness of each of the aluminum sprayed film 162 and the lubricating film 164 is exaggerated for easier understanding. The lubricating film 164 is formed of a synthetic resin in the form of polyamideimide in which MoS_2 and graphite are dispersed. The lubricating film 164 has a thickness of 60 μm , and is effective to reduce the friction between the sliding surfaces of the swash plate 60 and the shoe 76. The aluminum sprayed film 162 has a thickness of 60 μm , and is effective to maintain good sliding characteristics of the shoe 76 while preventing a direct contact of the base body 160 of the swash plate 60 with the shoe 76 even when the lubricating film 164 is removed or separated due to abrasion, for instance.

[0073] The swash plate type compressor according to the present embodiment exhibits good sliding characteristics and assures smooth operation thereof owing to the advantages provided by the shoe 76 and the swash plate 60 described above. Accordingly, the present swash plate type compressor exhibits excellent durability while maintaining good sliding characteristics for a long period of service. The metal plating film 148 formed on the surface of the shoe 76 is particularly effective to improve the sliding characteristics of the compressor.

[0074] While the presently preferred embodiment of this invention has been described above, for illustrative purpose only, it is to be understood that the present invention is not limited to the details of the illustrated embodiment. For example, the principle of the invention is applicable to a swash plate type compressor equipped with double-headed pistons each having head portions on the opposite sides of the engaging portion which engages the swash plate, or a swash plate type compressor of fixed capacity type. It is to be understood that the present invention may be embodied with various changes and improvements such as those described in the SUMMARY OF THE INVENTION, which may occur to those skilled in the art.

<Experiments for confirming the properties of the shoe for the swash plate type compressor>

[0075] There were produced, according to the illustrated embodiment, various swash plate type compressor shoes having respective different metal plating films. The following experiments were conducted on those shoes, for examining the resistance of the shoes to seizure by using a test device, and the sliding characteristics of some of the shoes by effecting a so-called "dry-locking" test (which will be described in greater detail) while the shoes are installed on the swash plate type compressor.

<Shoes used in the Experiments>

[0076] Initially, there were prepared base bodies of the shoe by first forging, in a cold state, an Al-Si alloy corresponding to the above-described A 4032, then conducting a grinding operation after the T6 treatment. On the surfaces

of the thus prepared base bodies, there were formed respective different metal plating films, which were surface-treated by buffing, so that fifteen shoes (#1 through #15) were produced. The shoes #1-#8 include respective different electroless plating films while the shoes #9-#15 include respective different electroplating films. The following Table 3 shows the composition, the thickness, and the hardness of each of the metal plating films formed on the respective shoes. The amount of each element included in each metal plating film is represented by % by weight. The shoe #1 includes an Ni-P based electroless nickel plating film which contains the PTFE. The shoes #3-#7 include an Ni-P-B-W based electroless nickel plating film, and respective different covering films formed of Sn, TiCN, TiN, CrN, and TiAlN, respectively. In each of the shoes #3-#7, the Ni-P-B-W based electroless nickel plating film and the covering film cooperate to provide the metal plating film. Accordingly, the thickness value of the plating film in each of the shoes #3-#7 indicated in TABLE 3 corresponds to a sum of the thickness of the Ni-P-B-W based electroless nickel plating film and the thickness of the covering film, while the hardness value of the plating film in each of the shoes #3-#7 indicated in TABLE 3 shows the hardness of the Ni-P-B-W based electroless nickel plating film. In "REMARKS" in TABLE 3, there are indicated the amount of PTFE included in the plating film of the shoe #1, and the thickness of each of the covering films respectively formed of Sn, TiCN, TiN, CrN, and TiAlN, which covering films are provided on the respective Ni-P-B-W based electroless nickel plating films in the shoes #3-#7.

TABLE 3

No.	Composition of metal plating film	Thickness of the film (μm)	Hardness of the film (Hv)	REMARKS
Electroless plating	#1 Ni-8%P/PTFE	25	350	the amount of PTFE: 8% (23 vol%)
	#2 Ni-0.3%B	25	750	
	#3 Ni-2%P-0.03%B-0.1%W/Sn	26	700	the thickness of Sn: 1 μm
	#4 Ni-2%P-0.03%B-0.1%W/TiCN	27	700	the thickness of TiCN: 2 μm
	#5 Ni-2%P-0.03%B-0.1%W/TiN	27	700	the thickness of TiN: 2 μm
	#6 Ni-2%P-0.03%B-0.1%W/CrN	27	700	the thickness of CrN: 2 μm
	#7 Ni-2%P-0.03%B-0.1%W/TiAlN	27	700	the thickness of TiAlN: 2 μm
	#8 Co-5%P	25	550	
Electroplating	#9 Ni-5%P	25	600	
	#10 Ni-5%P	25	700	
	#11 Ni-30%W	25	600	
	#12 Ni-20%Fe	25	600	
	#13 Fe-1%P	25	550	
	#14 Cr	25	800	
	#15 Co-17%W	25	350	

<Experiment for examining the seizure resistance of the shoes>

[0077] The following test was conducted on each of the shoes #1-#15 produced as described above, for examining its resistance to seizure. In the test, each shoe 76 was pressed against the sliding surface of a suitable swash plate 60 by a pressing jig 190 under a suitable load, as shown in Fig. 3. In this state, the swash plate 60 was rotated. For each shoe 76, there was measured a time from a moment of starting of the sliding contact between the swash plate and the shoe and to a moment at which the seizure took place was measured. (The time is hereinafter referred to as "seizure time"). The swash plate 60 used in the test is similar to that described in the DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT. Namely, the swash plate 60 is formed of the above-described FCD 700, and includes the aluminum sprayed film and the lubricating film formed in this order on each sliding surface thereof. In the test, each shoe was subjected to the load applied by the pressing jig 190 such that the pressing force applied to the shoe from the swash plate was 8.5 N/mm² which corresponds to a quotient obtained by dividing the pressing load applied to the shoe from the pressing jig, by the area of the flat surface of the shoe. Further, the peripheral speed of the swash plate 60 on sliding surface which slides on the shoe was 10.5 m/s. The test was conducted in the absence of the lubricating oil between the swash plate and each shoe, i.e., in a non-lubricating state. The results of the test are indicated in the following TABLE 4 in which the above-indicated seizure time measured for each shoe is shown. As is

apparent from the results in TABLE 4, the shoes #1-#15 showed relatively long seizure times in the non-lubricating state. Accordingly, it is confirmed that all of the shoes #1-#15 exhibit excellent seizure resistance. Thus, the shoes #1-#15 are capable of exhibiting excellent sliding characteristics.

TABLE 4

<Results of the test for examining the seizure resistance of the shoes>	
No.	Seizure time (seconds)
#1	30
#2	60
#3	30
#4	24
#5	24
#6	24
#7	24
#8	30
#9	30
#10	30
#11	60
#12	30
#13	60
#14	36
#15	30

<Experiment for examining the sliding characteristics of the shoes according to dry-locking test>

[0078] On the shoes #1, #2, #8, #11, #13, and #15 as representative examples, a dry-locking test was conducted in the following manner, by installing each shoe on the swash plate type compressor. The swash plate type compressor used in the test is similar to that described in the DESCRIPTION OF PREFERRED EMBODIMENT, and a detailed explanation of which is dispensed with. With each shoe being installed on the compressor, the compressor was operated in the absence of the refrigerant, in other words, in the non-lubricating state (i.e., in a dry state), such that the rotating speed of the swash plate was 1000 rpm. In this state, there was measured, for each shoe, a time from a moment of starting of the compressor to a moment at which the compressor was subjected to a so-called "dry-locking" phenomenon. The dry-locking phenomenon means that the compressor suffers from seizure between the swash plate and the shoe while the swash plate and the shoe slide on each other in the non-lubricating state, so that the swash plate and the shoe are prevented from sliding on each other due to the seizure. In the shoe which received the largest pressing force from the swash plate, this pressing force was about 6.8N/mm² which corresponds to a quotient obtained by dividing the load applied to the shoe from the swash plate, by the area of the flat surface of the shoe. The results of the test are shown in the following TABLE 5 in which the above-indicated time for each shoe is shown.

TABLE 5

<Results of the dry-locking test>	
No.	Time from a moment of starting of compressor to a moment at which compressor was subjected to dry-locking (seconds)
#1	42
#2	50
#8	50
#11	39

TABLE 5 (continued)

<Results of the dry-locking test>	
No.	Time from a moment of starting of compressor to a moment at which compressor was subjected to dry-locking (seconds)
#13	35
#15	32

[0079] As is apparent from the results indicated in the above TABLE 5, the above-indicated time was more than 20 seconds in all cases when the compressor was equipped with the selected shoes, i.e., #1, #2, #8, #11, #13, and #15. In the swash plate type compressor, the shoes are lubricated by the lubricating oil which is mixed or contained in the refrigerant. While the compressor is not operated, the refrigerant is liquefied, and stored in the compressor. In this case, the shoes are placed in the substantially non-lubricating state. Since it takes about 20 seconds for the refrigerant to circulate in the compressor after the starting of the operation of the compressor, the shoes are kept in the non-lubricating state during the time period of about 20 seconds. As is apparent from the results indicated in TABLE 5, the compressor did not suffer from the dry-locking phenomenon during the time period (i.e., during the non-lubricating state) in all cases when the compressor was equipped with the above-indicated selected shoes. Accordingly, each of the shoes exhibits excellent sliding characteristics without suffering any trouble during its practical use.

[0080] A shoe for a swash plate type compressor disposed between a swash plate and a corresponding one of a plurality of pistons, the shoe being characterized by comprising: a base body (146) formed of an aluminum alloy; and a metal plating film (148) which covers at least a portion of a surface of the base body.

Claims

1. A shoe for a swash plate type compressor disposed between a swash plate and a corresponding one of a plurality of pistons, said shoe being **characterized by** comprising:

a base body (146) formed of an aluminum alloy; and
a metal plating film (148) which covers at least a portion of a surface of said base body.

2. A shoe according to claim 1, wherein said metal plating film comprises an electroless plating film which contains at least one of Ni and Co as a major constituent element.

3. A shoe according to claim 2, wherein said electroless plating film comprises at least one electroless nickel plating film selected from the group consisting of an Ni-P based film, an Ni-B based film, an Ni-P-B based film, an Ni-P-W based film, an Ni-B-W based film, and an Ni-P-B-W based film.

4. A shoe according to claim 2 or 3, wherein said electroless plating film comprises at least one electroless cobalt plating film selected from the group consisting of a Co-P based film and a Co-P-W based film.

5. A shoe according to any one of claims 2-4, wherein said electroless plating film comprises at least one electroless nickel-cobalt plating film selected from the group consisting of an Ni-Co based film and an Ni-Co-P based film.

6. A shoe according to any one of claims 2-5, wherein said electroless plating film contains polytetrafluoroethylene (PTFE).

7. A shoe according to any one of claims 2-6, wherein said metal plating film further comprises at least one covering film which is formed on a surface of said electroless plating film and which contains at least one of Sn, TiCN, TiN, CrN, and TiAlN.

8. A shoe according to any one of claims 1-7, wherein said metal plating film comprises an electroplating film which contains at least one of Ni, Fe, Cr, and Co as a major constituent element.

9. A shoe according to claim 8, wherein said electroplating film comprises at least one nickel electroplating film selected from the group consisting of an Ni based film, an Ni-P based film, an Ni-W based film, an Ni-Fe based film,

an Ni-Mo-W based film.

10. A shoe according to claim 8 or 9, wherein said electroplating film comprises at least one ferrous electroplating film selected from the group consisting of an Fe based film, an Fe-P based film, an Fe-W based film, an Fe-C based film, and an Fe-N based film.

11. A shoe according to any one of claims 8-10, wherein said electroplating film comprises at least one chromium electroplating film selected from the group consisting of a Cr based film and a Cr-Mo based film.

12. A shoe according to any one of claims 8-11, wherein said electroplating film comprises at least one cobalt electroplating film selected from the group consisting of a Co based film and a Co-W based film.

13. A shoe according to any one of claims 1-12, wherein said metal plating film contains at least one of SiC, Si₃N₄, Al₂O₃, and CrC.

14. A shoe according to any one of claims 1-13, wherein said metal plating film has a hardness value of not smaller than Hv 300.

15. A shoe according to any one of claims 1-14, wherein said metal plating film covers at least a portion of said base body, which portion is held in sliding contact with said swash plate.

16. A shoe according to any one of claims 1-15, wherein said metal plating film constitutes at least a part of an outer surface of said shoe.

17. A swash plate type compressor comprising:

a swash plate (60);

a plurality of pistons (14); and

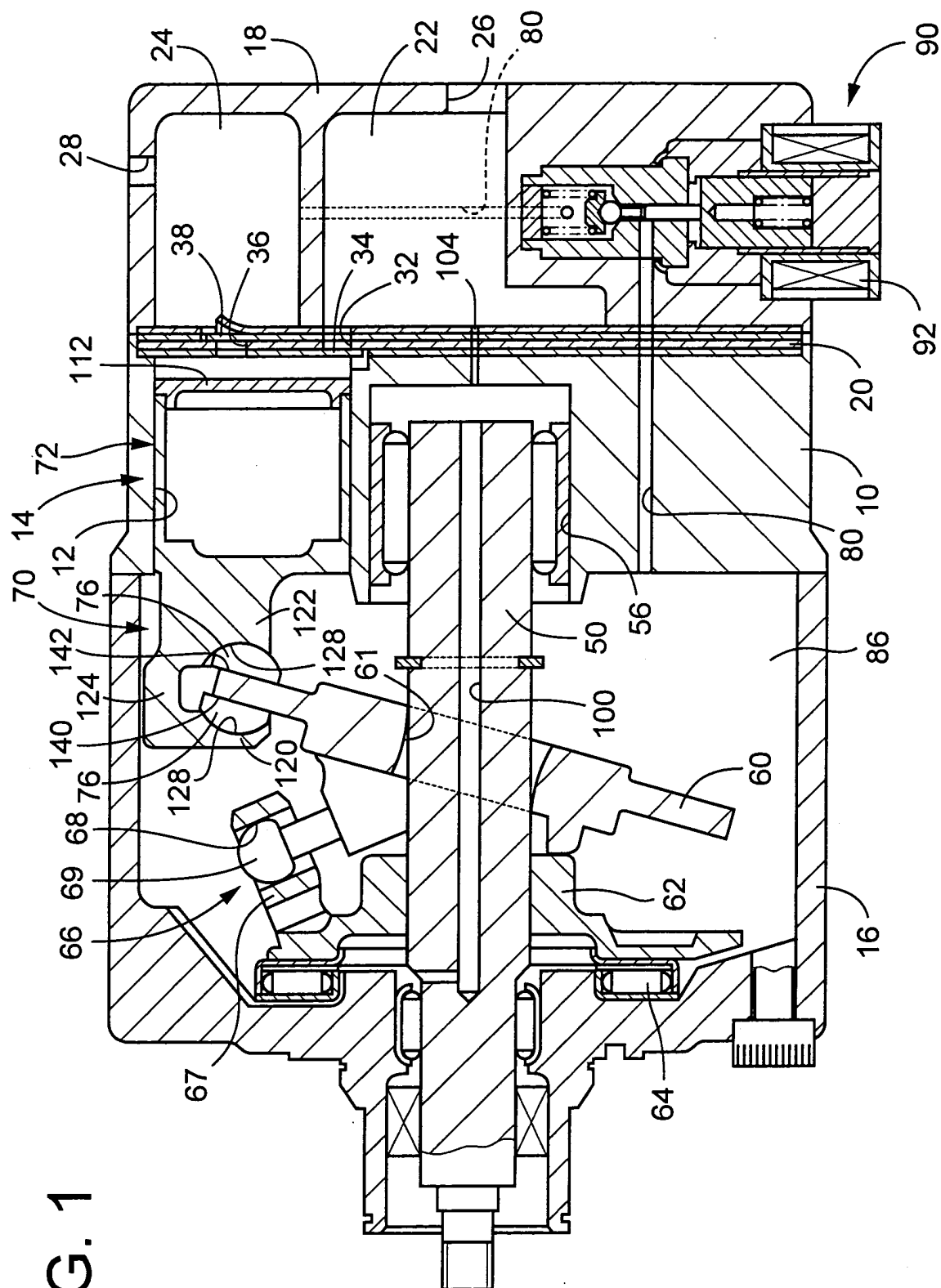
a plurality of shoes (76) as defined in any one of claims 1-16, each of said plurality of shoes being disposed between said swash plate and a corresponding one of said plurality of pistons.

18. A swash plate type compressor according to claim 17, wherein said swash plate is formed of a ferrous material.

19. A swash plate type compressor according to claim 17 or 18, wherein said swash plate includes lubricating films (164) formed on sliding surfaces (140, 142) thereof which slide on said plurality of shoes.

20. A swash plate type compressor according to any one of claims 17-19, further comprising a displacement capacity changing mechanism (12, 14, 22, 24, 56, 66, 86, 100, 104) for changing a displacement capacity of said compressor by changing an inclination angle of said swash plate.

FIG. 1



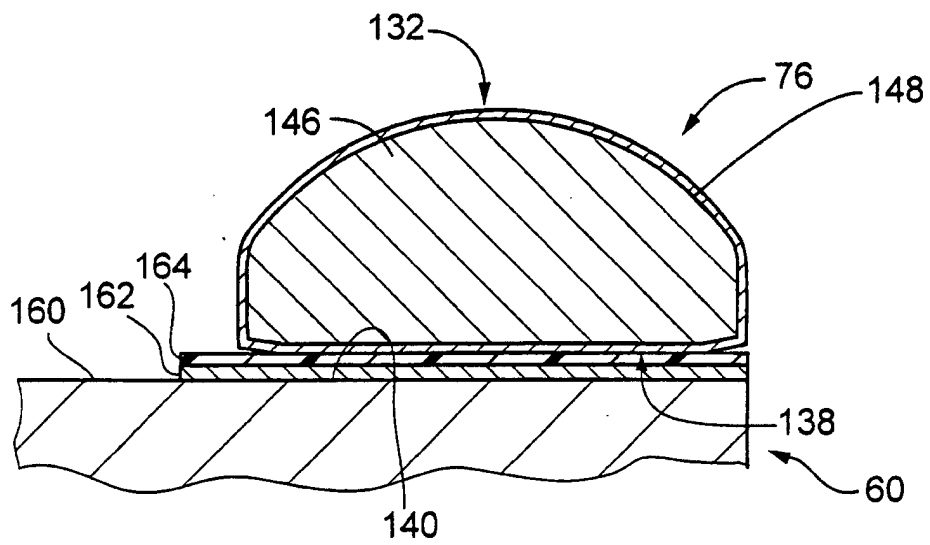


FIG. 2

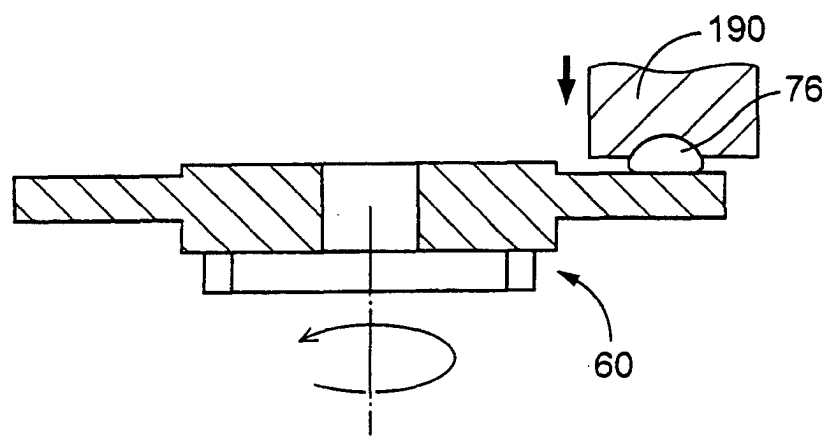


FIG. 3