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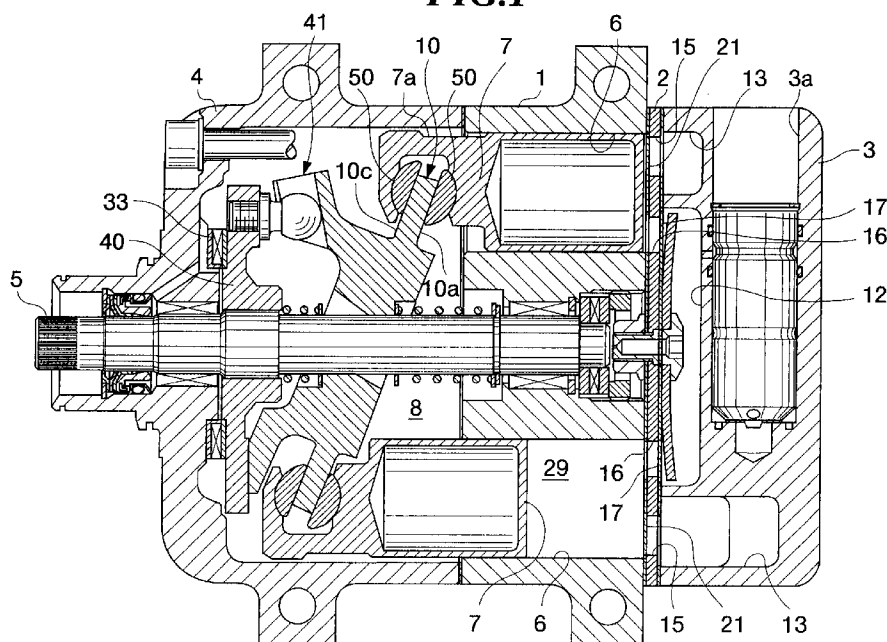
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Britter & Co.
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Baldock Hertfordshire SG7 5NT (GB)**(54) **Swash plate compressor**

(57) A swash plate (10) of a swash plate compressor has opposite sliding surfaces (10a, 10c) and is rotatable as a drive shaft (5) rotates. Each of a plurality of pistons (7) is connected to the swash plate (10) via a pair of shoes (50) arranged to perform relative rotation on respective opposite sliding surfaces (10a, 10c) of the swash plate (10) with respect thereto, and is reciprocable within a corresponding one of a plurality of cylinder bores (6) formed through a cylinder block (1), as the

swash plate (10) rotates. Each of the opposite sliding surfaces (10a, 10c) of the swash plate (10) is coated with a surface-treatment coating having a thickness which is set in a manner such that when the swash plate (10) has been assembled with each piston (7) via the pair of shoes (50), pressure is applied from the pair of shoes (50) on the sliding surfaces (10a, 10c) of the swash plate (10), and when initial abrasion of the surface-treatment coating has been completed, the base material of the swash plate (10) is not exposed.

FIG.1**EP 0 854 286 A2**

Description

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to a swash plate compressor in which each piston is assembled with a swash plate via shoes.

Description of the Prior Art

In general, a swash plate compressor includes a drive shaft, a swash plate rotating as the drive shaft rotates, and a plurality of pistons each of which is connected to the swash plate via a pair of shoes performing relative rotation on sliding surfaces of the swash plate, respectively, with respect to the swash plate, and reciprocates within a cylinder bore as the swash plate rotates.

Torque of an engine installed on an automotive vehicle is transmitted to the drive shaft to rotate the same. Torque of the drive shaft is transmitted to the swash plate to cause rotation of the swash plate.

As the swash plate rotates, each pair of shoes perform relative rotation on the sliding surfaces of the swash plate, whereby torque transmitted from the swash plate is converted into reciprocating motion of the piston. As the piston reciprocates within the cylinder bore, the volume of a compression chamber within the cylinder bore changes, whereby suction, compression and delivery of refrigerant gas are carried out sequentially.

According to the conventional swash plate compressor, when pistons are assembled with a swash plate, it is required to select a seemingly suitable pair of shoes out of various types of shoes different in thickness, actually assemble the selected pair of shoes with the piston and the swash plate, and then measure an actual gap (shoe gap) between each sliding surface of the swash plate and a corresponding one of the shoes. The adjustment work of setting the shoe gap to a proper value is carried out repeating the above assembly procedure until the measured shoe gap becomes equal to the proper value.

However, the adjustment of shoe gaps is really troublesome to carry out, so that it takes a lot of time to obtain proper or suitable shoe gaps. The need to adjust shoe gaps is one of the factors which make the assembly of swash plate compressors an effort-demanding and time-consuming work.

SUMMARY OF THE INVENTION

It is an object of the invention to provide a swash plate compressor which can be assembled more easily without the need to adjust shoe gaps thereof.

To attain the above object, the present invention provides a swash plate compressor including a drive

shaft, a swash plate having a base material and opposite sliding surfaces and rotating as the drive shaft rotates, a cylinder block formed therethrough with a plurality of cylinder bores, and a plurality of pistons each of which is connected to the swash plate via a pair of shoes performing relative rotation on the opposite sliding surfaces of the swash plate, respectively, with respect to the swash plate, and reciprocates within a corresponding one of the cylinder bores as the swash plate rotates.

The swash plate compressor according to the invention is characterized in that the opposite sliding surfaces of the swash plate are each coated with a surface-treatment coating having a thickness which is set in a manner such that when the swash plate is assembled with the each of the pistons via the pair of shoes, pressure is applied from the pair of shoes on the sliding surface of the swash plate, and when initial abrasion of the surface-treatment coating is completed, the base material of the swash plate is not exposed.

According to the swash plate compressor of the invention, proper shoe gaps between the sliding surfaces of the swash plate and the shoes can be obtained after initial abrasion of the surface-treatment coatings covering the sliding surfaces of the swash plate, so that it is possible to dispense with the adjustment work for setting each shoe gap to a suitable value, which contributes to reduction of time required for assemblage of the compressor.

Preferably, the thickness of the surface-treatment coating is set to such a value that a shoe gap between each shoe of the pair of shoes and a corresponding one of the opposite sliding surfaces of the swash plate assumes a minus value when the swash plate is assembled with the each of the pistons via the pair of shoes, and becomes equal to zero when the initial abrasion of the surface-treatment coating is completed.

More preferably, the surface-treatment coating is formed of a solid lubricant.

Further preferably, the solid lubricant is molybdenum disulfide.

The above and other objects, features and advantages of the present invention will become more apparent from the following detailed description taken in conjunction with accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a longitudinal cross-sectional view showing the whole arrangement of a swash plate compressor according to an embodiment of the invention; and

FIG. 2 is a graph showing the relationship between depth of wear of a surface-treatment coating covering a sliding surface of a swash plate and a total time period over which the compressor has been in operation.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The invention will now be described in detail with reference to the drawings showing a preferred embodiment thereof.

Referring first to FIG. 1, there is shown the whole arrangement of a variable capacity swash plate compressor according to an embodiment of the invention.

The variable capacity swash plate compressor has a cylinder block 1 having one end thereof secured to a rear head 3 via a valve plate 2 and the other end thereof secured to a front head 4. The cylinder block 1 has a plurality of cylinder bores 6 formed therethrough at predetermined circumferential intervals about a drive shaft 5. Each cylinder bore 6 has a piston 7 slidably received therein.

Within the front head 4, there is formed a crankcase 8. The crankcase 8 has a swash plate 10 received therein. The swash plate 10 is slidably and tiltably fitted on the drive shaft 5.

The swash plate 10 is connected to the piston 7 via a pair of hemispherical shoes 50. The shoes 50 are held at one end 7a of the piston 7 such that they can perform relative rotation on front-side and rear-side sliding surfaces 10c, 10a of the swash plate 10, respectively, with respect to the swash plate 10.

Within the rear head 3, there are formed a discharge chamber 12 and a suction chamber 13 surrounding the discharge chamber 12. Further, the rear head 3 has a suction port 3a communicating between a refrigerant outlet port, not shown, of an evaporator, not shown.

The drive shaft 5 has a thrust flange 40 rigidly fitted on a front-side portion thereof for transmitting torque of the drive shaft 5 to the swash plate 10. The thrust flange 40 is rotatably supported on an inner wall of the front head 4 by a thrust bearing 33. The thrust flange 40 and the swash plate 10 are connected with each other via a linkage 41. The swash plate 10 can tilt with respect to a plane perpendicular to the drive shaft 5.

The sliding surfaces 10a, 10c of the swash plate 10 are each coated with a surface-treatment coating formed of a soft material such as molybdenum disulfide (MoS_2). The surface-treatment coating has a thickness which is set such that when the swash plate 10 is assembled with the pistons via the pair of shoes 50, pressure is applied from the pair of shoes on the sliding surfaces 10a, 10c of the swash plate, or assemblage of the swash plate 10 with the piston 7 is effected in a slightly press-fitted manner, (i.e. such that each of the shoe gaps between the pair of shoes 50 and the sliding surfaces 10a, 10c of the swash plate 10 assumes a minus value), and a base material of the swash plate 10 is not exposed when initial abrasion of the surface-treatment coating is terminated.

More specifically, each of the surface-treatment coatings covering the sliding surfaces 10a, 10c is reduced in thickness by $5\mu\text{m}$ due to initial abrasion there-

of, so that to prevent the base material of the swash plate 10 from being exposed, it is required that the surface-treatment coatings each have a thickness of at least $6\mu\text{m}$, and that shoe gaps (clearances between the shoes 50 and the sliding surfaces 10a, 10c of the swash plate 10) each assume a minus value such that the swash plate 10 is assembled with the piston 7 in a slightly press-fitted manner.

FIG. 2 shows the relationship between depth of wear of the surface-treatment coating covering the sliding surface of the swash plate and a total time period over which the compressor has been in operation.

As described above, the sliding surfaces 10a, 10c of the swash plate 10 are each coated with a surface-treatment coating having a thickness of at least $6\mu\text{m}$ such that each of the shoe gaps can be set to a minus value, so that the shoe gaps are not proper ones before the compressor is initially put into operation.

The depth of wear of the surface-treatment coating continues to increase sharply after the start of initial operation of the compressor until approximately 100 to 150 hours have elapsed. Then, the depth of wear gently increases until approximately 300 hours have elapsed since the start of the initial operation of the compressor, but thereafter, the depth of wear hardly increases. That is, the surface-treatment coating is reduced in thickness by abrasion by approximately $5\mu\text{m}$ in 300 hours after the compressor was initially put into operation, and then the abrasion substantially ceases. Thereafter, there is no sharp increase of the shoe gap between each of the shoes 50 and the sliding surface 10a(10c) of the swash plate 10.

Accordingly, if the sliding surfaces 10a, 10c of the swash plate 10 are each coated with a surface-treatment coating having a thickness of e.g. $6\mu\text{m}$, and shoe gaps are each set to a value of e.g. $-10\mu\text{m}$ before the start of the initial operation of the compressor, the surface-treatment coatings are each reduced in thickness by abrasion by approximately $5\mu\text{m}$ in approximately 300 hours after the start of the initial operation of the compressor, whereby the shoe gaps are each decreased to approximately $0\mu\text{m}$ (the compressor can be operated with the shoe gaps equal to or larger than $-15\mu\text{m}$). The shoe gaps are held at $0\mu\text{m}$ after 300 hours have elapsed since the start of the initial operation of the compressor.

Next, the operation of the variable capacity swash plate compressor constructed as above will be described.

Torque of an engine, not shown, installed on an automotive vehicle, not shown, is transmitted to the drive shaft 5 to rotate the same. Torque of the drive shaft 5 is transmitted to the swash plate 10 via the thrust flange 40 and the linkage 41 to cause rotation of the swash plate 10.

The rotation of the swash plate 10 causes relative rotation of the shoes 50, 50 on the sliding surfaces 10a, 10c of the swash plate 10 with respect to the swash plate 10, whereby the torque transmitted from the swash plate

10 is converted into reciprocating motion of the piston 7. As the piston 7 reciprocates within the cylinder bore 6, the volume of a compression chamber 29 within the cylinder bore 6 changes. As a result, suction, compression and delivery of refrigerant gas are sequentially carried out in the compression chamber 29, whereby high-pressure refrigerant gas is delivered from the compression chamber 29 in an amount corresponding to an inclination of the swash plate 10. During the suction stroke, the suction valve 21 opens to draw low-pressure refrigerant gas from the suction chamber 13 into the compression chamber 29 within the cylinder bore 6. During the discharge stroke, the discharge valve 17 opens to deliver high-pressure refrigerant gas from the compression chamber 29 to the discharge chamber 12.

According to the above embodiment, the surface-treatment coatings covering the sliding surfaces 10a, 10c of the swash plate 10 are abraded as the swash plate compressor continues to be in operation, and when the abrasion ceases, proper or suitable shoe gaps are obtained. Therefore, when the swash plate compressor is assembled, a shoe gap-adjusting step can be dispensed with, which contributes to reduction of time required for assemblage of the compressor. That is, it is not required to repeatedly carry out the adjustment work of setting a shoe gap by selecting a seemingly suitable pair of shoes out of various types of shoes different in thickness, actually assembling the selected pair with a piston and a swash plate, and then measuring actual shoe gaps between the shoes and the sliding surfaces of the swash plate.

Although in the above embodiment, description is made of a case in which the invention is applied to a variable capacity swash plate compressor, this is not limitative, but the invention may be applied to a fixed capacity swash plate compressor.

It is further understood by those skilled in the art that the foregoing is the preferred embodiment of the invention, and that various changes and modification may be made without departing from the spirit and scope thereof.

Claims

1. A swash plate compressor comprising a drive shaft (5), a swash plate (10) having a base material and opposite sliding surfaces (10a, 10c) and rotatable as the drive shaft (5) rotates, a cylinder block (1) formed therethrough with a plurality of cylinder bores (6), and a plurality of pistons (7) each of which is connected to the swash plate (10) via a pair of shoes (50) arranged to perform relative rotation on respective opposite sliding surfaces (10a, 10c) of the swash plate (10) with respect to the swash plate (10), and is reciprocable within a corresponding one of the cylinder bores (6) as the swash plate (10) rotates,

characterised in that the opposite sliding surfaces (10a, 10c) of the swash plate (10) are each coated with a surface-treatment coating having a thickness which is set in a manner such that when the swash plate (10) has been assembled with each of the pistons (7) via the pair of shoes (50), pressure is applied from the pair of shoes (50) on the sliding surfaces (10a, 10c) of the swash plate (10), and when initial abrasion of the surface-treatment coating has been completed, the base material of the swash plate (10) is not exposed.

2. A swash plate compressor according to claim 1, wherein the thickness of the surface-treatment coating is set to such a value that a shoe gap between each shoe (50) of the pairs of shoes (50) and a corresponding one of the opposite sliding surfaces (10a, 10c) of the swash plate (10) assumes a minus value when the swash plate (10) has been assembled with each piston (7) via the pair of shoes (50), and becomes equal to zero when initial abrasion of the surface-treatment coating has been completed.
3. A swash plate compressor according to claim 1 or 2, wherein the surface-treatment coating is formed of a solid lubricant.
4. A swash plate compressor according to claim 3, wherein the solid lubricant is molybdenum disulphide.

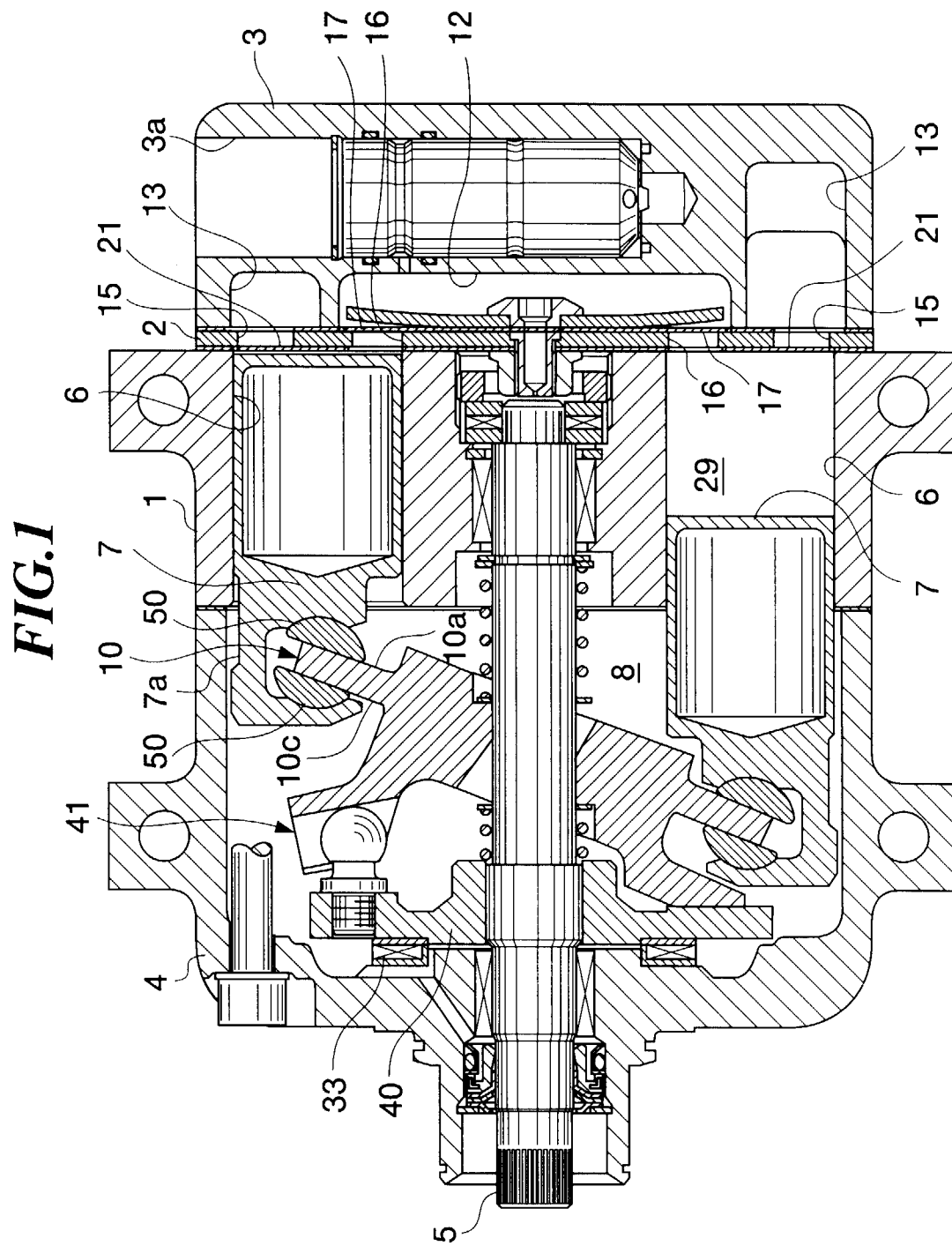


FIG.2