(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 074 736 A2

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
07.02.2001 Bulletin 2001/06

(51) Int. Cl.[7]: **F04B 27/08**, F04B 39/00

(21) Application number: **00114020.1**

(22) Date of filing: **04.07.2000**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **06.08.1999 JP 22382999**

(71) Applicant:
Kabushiki Kaisha Toyoda Jidoshokki Seisakusho
Aichi-ken 448-8671 (JP)

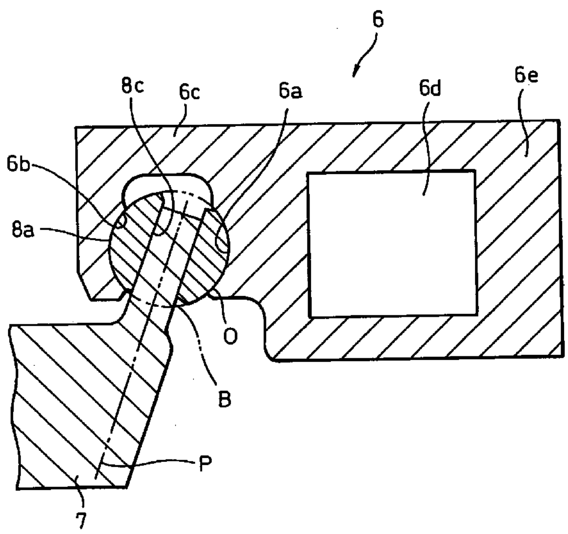
(72) Inventors:
- **Sugiura, Manabu**
  Kariya-shi, Aichi-ken 448-8671 (JP)
- **Iwama, Kazuaki**
  Kariya-shi, Aichi-ken 448-8671 (JP)

(74) Representative:
Hoeger, Stellrecht & Partner
Uhlandstrasse 14 c
70182 Stuttgart (DE)

(54) **Piston of a swash plate compressor**

(57) A single-head swash-plate refrigerant compressor of fixed displacement type is disclosed, in which the neck portion of each piston is not easily deformed, by the force of inertia W exerted on the neck portion of the piston, in a bending direction, and therefore superior durability is exhibited. The paired spherical seat surfaces 6a, 6b of the piston 6 form a single spherical shape.

Fig. 2



EP 1 074 736 A2

Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a single-head swash-plate refrigerant compressor of a fixed displacement type.

2. Description of the Related Art

[0002] A refrigeration circuit used in an air-conditioning system for an automotive vehicle has a compressor built therein to compress the refrigerant gas. The compressor may be a fixed displacement type or a variable displacement type compressor. More particularly, a fixed displacement refrigerant compressor may be a single-head swash plate type, or a double-head swash plate type etc. This is also the case with a variable displacement refrigerant compressor.

[0003] Among these compressors, the single-head swash-plate compressor of a fixed displacement type comprises a housing internally defined into and forming at least a cylinder bore, a crank chamber, a suction chamber and a discharge chamber. A single-head piston is reciprocally movably arranged in each cylinder bore. Also, the drive shaft supported rotatably in the housing is adapted to be driven by an external drive source such as an engine, and a swash plate is synchronously and rotatably supported at a fixed inclination angle on the drive shaft. The swash plate is provided with shoes for driving each piston. The piston has a pair of spherical seat surfaces which has concave portions at a neck portion thereof in a longitudinally opposing manner, and each shoe comprises a spherical surface slidably accommodated in the corresponding spherical seat surface and an end surface facing the spherical surface in sliding contact with the swash plate.

[0004] In the single-head swash-plate refrigerant compressor of a fixed displacement type, when the drive shaft is driven by an external drive source, the swash plate is synchronously rotated at a fixed inclination angle so that the piston is reciprocated in the cylinder bore via the shoes. As a result, since the cylinder bore forms a compression chamber between it and the piston head, when the compression chamber is in a suction stroke, a low-pressure refrigerant gas is drawn into the compression chamber from a suction chamber connected with the evaporator of the refrigeration circuit. When the compression chamber is in compression stroke, on the other hand, a high-pressure refrigerant gas is discharged to the discharge chamber from the compression chamber. The discharge chamber is connected to the condenser of the refrigeration circuit and the refrigeration circuit is used in an air-conditioning system for an automotive vehicle. The single-head swash-plate refrigerant compressor of a fixed displacement type secures the slidability in a space such as between the spherical seat surface of the piston and the spherical surface of the shoe with a mist of lubricant contained in the refrigerant gas.

[0005] In the conventional single-head swash-plate refrigerant compressor of fixed displacement type, however, the paired spherical seat surfaces of the piston are each actually hemispherical and independent of each other, and are not formed in a single spherical shape. For this reason, the neck portion of the piston forming the spherical seat surfaces is easily deformed, and problems such as a failure of the reciprocation of the piston may occur and lead a reduced durability.

[0006] A double-head swash-plate refrigerant compressor, whether it is a fixed displacement type or variable displacement type, has a double-head piston with a head at both ends of the piston. The piston is reciprocated in a cylinder bore faced with each of both heads thereof. The force of inertia W exerted in a longitudinal direction on each piston is given as

$$W = M \bullet S/2 \bullet \sin^2 \omega t = M \bullet S/2 \bullet \sin^2 (2\pi \bullet N/60)$$

where M is the mass of the piston, S is the stroke of the piston, and ω (rad) is the angular velocity of the drive shaft per unit time t (second), and N (rpm) is the rotational speed of the drive shaft. This force of inertia W is exerted in the direction of bending the neck portion of the piston. However as the head formed on the both sides of the neck portion of this piston is supported by the cylinder bore, the neck portion is not deformed by bending. Even though each spherical seat surface of the piston is not formed in a single spherical shape, the piston reciprocation can be adequately attained so that the durability is not deteriorated.

[0007] A single-head swash-plate refrigerant compressor, on the other hand, regardless of whether it is fixed displacement type or variable displacement type, comprises a single-head piston having a head only on one end thereof. In such a piston, a single head is reciprocated in the cylinder bore. Also, in this compressor, the aforementioned force of inertia W is exerted on the neck portion of each piston in the direction of bending. In view of the fact that one side of the neck portion of the single-head piston is a free end, this force of inertia W is more likely to cause a bending deformation. Thus, in such a compressor, the force of inertia W increases with an increase in the rotational speed N and may cause the piston neck portion to be deformed in resulting in a deteriorated durability. Also, the bending deformation of the neck portion increases the gap between the spherical seat surfaces and the resulting increase in the clearance between the spherical seat surface and the shoe may generate noise.

[0008] Especially in the single-head swash-plate refrigerant compressor of fixed displacement type, the inclination angle of the swash plate is constant, unlike the compressor of variable displacement type in which the inclination angle of the swash plate is changeable and the stroke S of the piston described above is constant so that the force of inertia W acting on each piston is always large. As a result, a large force of inertia W always acts on the neck portion of each piston, which is liable to bend.

[0009] Unless the paired spherical seat surfaces of the piston form a single spherical shape, the neck portion of the piston is undesirably lengthened in axial direction, and is more liable to be bent by the force of inertia W.

[0010] Also, a lengthened neck portion of the piston increases the mass M of the piston, which in turn increases the force of inertia W, with the same result that the neck portion of the piston is more liable to be bent. Further, an increased piston mass increases the weight of the compressor.

SUMMARY OF THE INVENTION

[0011] The present invention has been developed in view of the aforementioned situation, and the object thereof is to provide a single-head swash-plate refrigerant compressor of fixed displacement type in which the neck portion of the piston is highly durable and not easily bent by the force of inertia W exerted in the bending direction on the neck portion of the piston.

[0012] According to this invention, there is provided a single-head swash-plate refrigerant compressor of fixed displacement type comprising a housing including at least one cylinder bore, a crank chamber, a suction chamber and a discharge chamber defined and formed therein, a single-head piston accommodated reciprocally movably in each said cylinder bore, a drive shaft supported rotatably in the housing and driven by an external drive source, and a swash plate synchronously and rotatably supported at a fixed inclination angle to the drive shaft for driving said piston via a pair of shoes arranged on the front and rear portions of the swash plate, wherein said piston has a pair of spherical seat surfaces which has concave portions at a neck portion thereof in a longitudinally opposing manner and each of said shoes has a spherical surface accommodated slidably in each of said spherical seat surfaces and an end surface facing said spherical surface in sliding contact with said swash plate, and wherein the paired spherical seat surfaces of the piston described above form a single spherical shape.

[0013] The compressor according to the invention is of single-head swash plate type, and therefore the force of inertia W described above acts on the neck portion of the piston in the bending direction. Especially, in the compressor according to the invention which is of fixed displacement type, the neck portion of the piston is easily bent by the force of inertia W. Nevertheless, the piston of the compressor according to the invention has paired spherical seat surfaces which form a single spherical shape. As a result, the neck portion of the piston is axially shortened and is more difficult to be bent by the force of inertia. Also, the piston having a pair of spherical seat surfaces forming a single spherical shape is shortened in axial length as a whole due to the axial shortening of the neck portion, leading to a smaller mass. This in turn results in a smaller force of inertia, so that the neck portion of the piston is more difficult to bend.

[0014] In this way, the single-head swash-plate refrigerant compressor of fixed displacement type according to the invention can exhibit a superior durability.

[0015] The piston of the compressor according to the invention preferably has a portion which is cut off except for the head. Then, the piston mass is reduced thereby to reduce the force of inertia and the neck portion of the piston becomes more difficult to bend. Also, a smaller mass of the piston can reduce the weight of the compressor for an improved fuel consumption rate. The portion cut off for this purpose may constitute a hollow portion, for example, formed in the piston. Such a hollow portion may be either totally hermetic or may communicate with the exterior through a through hole etc.

[0016] The present invention may be more fully understood from the description of preferred embodiments of the invention set forth below, together with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] In the drawing:

Fig. 1 is a longitudinal sectional view of the general configuration of a compressor according to an embodiment.
Fig. 2 is an enlarged sectional view of the key parts of the compressor according to an embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0018] The embodiments embodying a single-head swash-plate refrigerant compressor of fixed displacement type of the present invention will be explained below with reference to the accompanying drawings.

[0019] This compressor, as shown in Fig. 1, comprises a front housing 2 coupled to the forward end of a cylinder block 1, and a crank chamber 2a formed in the cylinder block 1 and the front housing 2. A suction valve 13, a valve plate 4, a discharge valve 14 and a rear housing 3 via a retainer not shown, are coupled to the rear end of the cylinder block 1. A suction chamber 3a is formed in the central area of the rear housing 3, and an annular discharge chamber 3b is formed in the outer peripheral area of the rear housing 3.

[0020] The suction chamber 3a is connected to an evaporator EV of an external refrigeration circuit by piping, and the evaporator EV is connected to a condenser

CO through an expansion valve V by piping. Further, the condenser CO is connected to the discharge chamber 3b by piping.

[0021] A drive shaft 5 is rotatably supported in the front housing 2 and the cylinder block 1 via bearing units 2b, 1b. The cylinder block 1 is provided with five cylinder bores 1a in parallel to the axial line of the drive shaft 5, and a single-head piston 6 is reciprocally movably accommodated in each cylinder bore 1a. A swash plate 7 is rotatably attached to the drive shaft 5 via a bearing unit 2c between the front housing 2 and the drive shaft 5 in the crank chamber 2a of the front housing 2. Each piston 6 is connected to the swash plate 7 via a pair of shoes 8.

[0022] The piston 6, as shown in Fig. 2 has a pair of spherical seat surfaces 6a, 6b concavely arranged on the drive shaft 5 side of the neck 6c thereof so as to oppose each other in a longitudinal direction.

[0023] The characteristic feature of the invention is that the spherical seat surfaces 6a, 6b are in a single spherical shape B with a center point O. The point O is located in the central plane P of the swash plate 7. Also, the piston 6 is formed with an internal hollow portion 6d as a cut-off portion. The piston 6 has a head 6e for compression within the cylinder bore 1a, and the hollow portion 6d is formed in the portion other than the head 6e.

[0024] The shoe 8 includes a spherical surface 8a accommodated slidably in each of the spherical seat surfaces 6a, 6b of the piston 6 and an end surface 8c facing the spherical surface 8a in sliding contact with the swash plate 7.

[0025] As shown in Fig. 1, the valve plate 4 is formed with a suction port 4a and a discharge port 4b for establishing communication from the cylinder bore 1a to the suction chamber 3a and the discharge chamber 3b, respectively. The suction port 4a is opened/closed by the suction valve 13 corresponding to the reciprocation of the piston 6. In similar manner, the discharge port 4b is opened/closed by the discharge valve 14 corresponding to the reciprocation of the piston 6.

[0026] The compressor configured as described above is built into the air-conditioning system of a vehicle together with the evaporator EV, the expansion valve V and the condenser CO of the external refrigeration circuit. With this compressor, once the drive shaft 5 is driven by an engine not shown, the swash plate 7 is synchronously rotated at a fixed inclination angle, so that each piston 6 reciprocates within the cylinder bore 1a via the shoes 8. As a result, a compression chamber is formed between the cylinder bore 1a and the head 6e of the piston 6. When the compression chamber is in suction stroke, therefore, a low-pressure refrigerant gas is drawn into the compression chamber from the suction chamber 3a connected to the evaporator EV of the refrigeration circuit. When the compression chamber is in compression stroke, on the other hand, a high-pressure refrigerant gas is discharged into the discharge chamber 3b from the compression chamber. In the meantime, the slidability is secured in a space such as between the spherical seat surface 6a of the piston 6 and the spherical surface 8a of the shoe 8 in the compressor by the mist-like lubricant contained in the refrigerant gas.

[0027] Also in this compressor which is of a single-head swash plate type, the force of inertia W described above is exerted in such a direction as to bend the neck portion 6c of the piston 6. Especially, since the compressor is of fixed displacement type, the neck portion 6c of the piston 6 is easily bent by the force of inertia W. In view of the fact that the pair of the spherical seat surfaces 6a, 6b of the piston 6 each form a single spherical shape, however, the neck portion 6c of the piston 6 of this compressor is shorter in the axial direction and therefore is less easier to bend by the force of inertia W.

[0028] Further, the piston of this compressor has a hermetically sealed hollow portion 6d as a cut-off portion so that the mass of the piston 6 is smaller and so is the force of inertia W described above. Thus, the neck 6c of the piston is more difficult to bend.

[0029] In this way, this compressor can exhibit a superior durability. Also, the small mass of the piston 6 can realize a reduced weight of the compressor for an improved fuel consumption rate of the vehicle. Further, the piston and the shoe, as common parts can be shared with the variable displacement compressor in which the inclination angle of the swash plate is changeable since the paired spherical seat surfaces of the piston are required to form a single spherical shape in order to maintain a fixed clearance between the piston and the shoe even when the inclination angle of the swash plate is changed.

[0030] While the invention has been described by reference to specific embodiments chosen for the purpose 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 single-head swash-plate refrigerant compressor of fixed displacement type comprising:

    a housing including at least one cylinder bore, a crank chamber, a suction chamber and a discharge chamber defined and formed therein;
    at least one single-head piston accommodated reciprocally movably in said cylinder bore;
    a drive shaft driven by an external drive source and supported rotatably in said housing; and
    a swash plate supported synchronously rotatably at a fixed inclination angle to said drive shaft for driving said piston via a pair of shoes arranged on the front and rear portions of said swash plate;

wherein said piston includes a pair of spherical seat surfaces which has concave portions at a neck portion thereof in a longitudinally opposing manner;

wherein each of said shoes includes a spherical surface accommodated slidably in the each of said spherical seat surfaces and an end surface facing said spherical surface in sliding contact with said swash plate; and

wherein said paired spherical seat surfaces of said piston form a single spherical shape.

2. A single-head swash-plate refrigerant compressor of fixed displacement type according to claim 1,

wherein said piston has a cut-off portion except for the head thereof.

3. A single-head swash-plate refrigerant compressor of fixed displacement type according to claim 2,

wherein said cut-off portion is a hollow portion formed in said piston.

Fig. 1

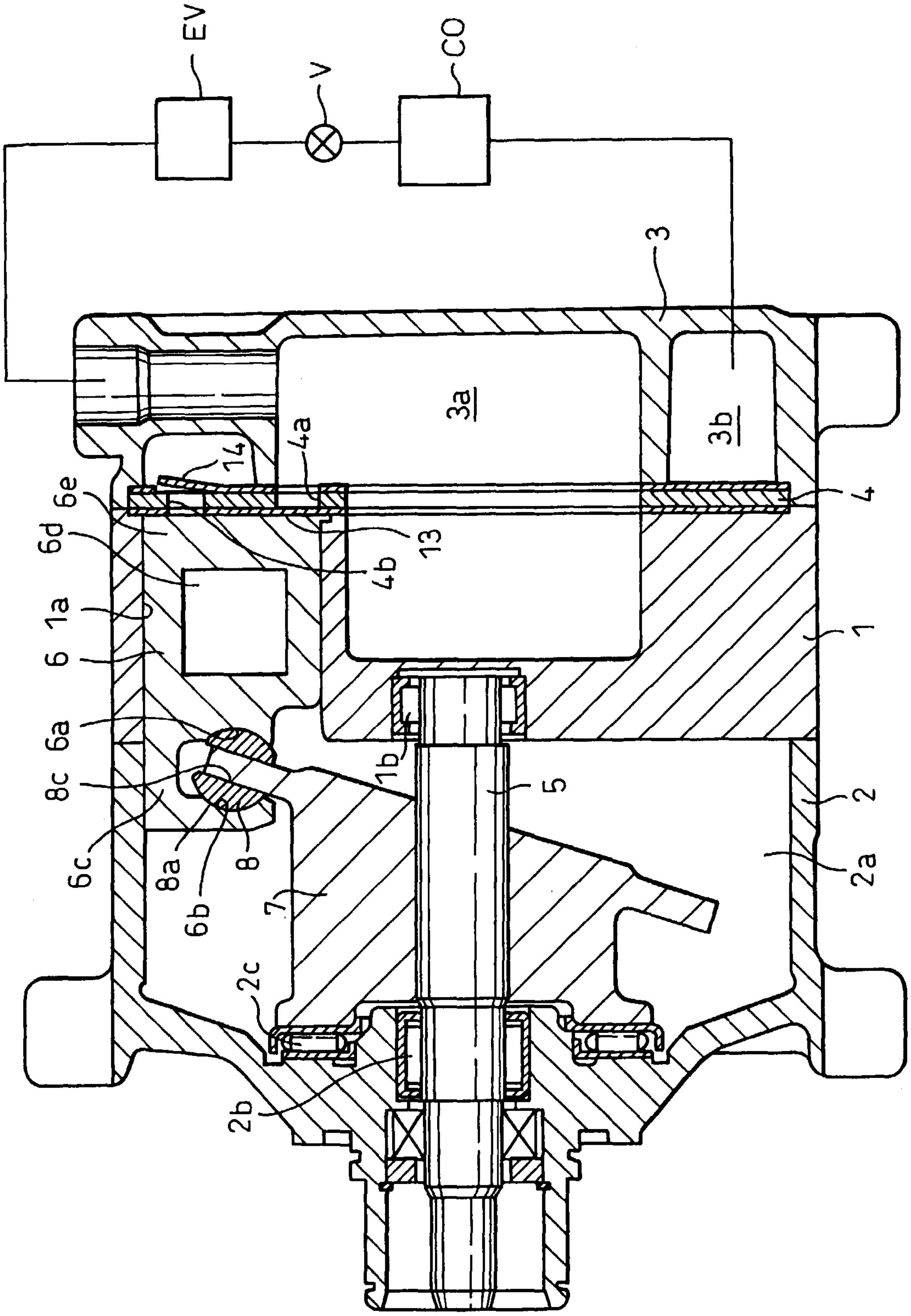


Fig.2