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(54) **Swash or wobble plate compressors**

Taumelscheibenverdichter

Compresseur à plateau en biais

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(56) References cited:
EP-A- 0 748 936 US-A- 4 762 468
US-A- 5 638 736

• **PATENT ABSTRACTS OF JAPAN vol. 017, no. 306
(M-1428), 11 June 1993 (1993-06-11) -& JP 05
026156 A (TOYOTA AUTOM LOOM WORKS LTD),
2 February 1993 (1993-02-02)**

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Description

[0001] The present invention relates to a swash or wobble plate compressor, in particular a compressor for a vehicle air-conditioning system, and to piston for use in such a compressor.

[0002] As illustrated diagrammatically in Fig. 1, a conventional swash or wobble plate compressor comprises a piston 1 with a piston head 2 at one end which reciprocates in a cylinder bore 3. The end 4 of the piston 1 opposite the piston head 2 extends out of the cylinder bore 3 and is provided with a recess 5 in which is mounted a part-spherical bearing 6 that is centrally disposed with respect to the longitudinal axis 7 of the piston 1. A swash or wobble plate arrangement 8, which is rotatably driven by a drive shaft (not shown) of the compressor, is connected to the bearing 6 so that drive forces are transmitted from the arrangement 8 via the bearing 6 to the piston 1. As the swash or wobble plate arrangement 8 is inclined with respect to the longitudinal axis 9 of the drive shaft, the forces transmitted to the piston 1 are not exclusively axial forces but comprise a substantial radial component F_Q , which is dependent on the angle of inclination of the plate arrangement 8. The radial component F_Q results in forces of reaction F_A and F_B , which cause contact to occur between the piston 1 and the cylinder bore 3 that leads to wear in bore 3 and consequent compression and wear of the piston 1.

[0003] JP05 026 156 is considered as the closest prior art, and discusses a compressor which is very similar to that claimed. This document does not disclose, however, an offset in the bearing for a single headed piston in order to reduce excessive wear.

[0004] The object of the present invention is to provide a swash or wobble plate compressor in which the effects of wear caused by lateral forces are substantially mitigated.

[0005] According to a first aspect of the present invention there is provided a compressor comprising at least one piston moveable in a cylinder, a drive shaft, a swash or wobble plate arrangement rotatably mounted between the piston and the drive shaft, an at least part-spherical bearing attached to the piston against which the swash or wobble plate arrangement acts to reciprocate the piston in the cylinder.

[0006] The piston defines a recess at one end in which the bearing is located.

[0007] The centre of the bearing is located at a position offset with respect to a longitudinal plane in which both the longitudinal axis of the piston and a longitudinal axis of a drive shaft for the piston lie.

[0008] The centre of the bearing is located at a position offset radially outwardly with respect to the longitudinal axis of the piston. Preferably, the centre of the bearing is located at a position offset in the direction of rotation of the drive shaft.

[0009] Preferably also, the centre of the bearing is located at a position offset at a position located between

240° and 360° in the direction of rotation of the drive shaft. Advantageously, the centre of the bearing is located at a position offset at a position located between 270° and 360° in the direction of rotation of the drive shaft.

[0010] Preferably also, the bearing comprises part-spherical pockets located on opposite sides of the recess.

[0011] Alternatively, the bearing comprises a ball attached to one end of the piston against which the swash or wobble plate arrangement acts to reciprocate the piston.

[0012] According to a second aspect of the present invention there is provided a piston for use in a swash or wobble plate compressor comprising a piston head at one end and attached at its other end to an at least part-spherical bearing against which a swash or wobble plate arrangement of a compressor can act to reciprocate the piston in a cylinder.

[0013] The piston defines a recess at one end in which the bearing is located.

[0014] The centre of the bearing is located at a position offset radially with respect to the longitudinal axis the piston and in a selected direction of rotation of the swash or wobble plate arrangement in a compressor with respect to the piston.

[0015] The present invention will now be described by way of example with reference to the accompanying drawings, in which:

Fig. 1 is a diagrammatic, part longitudinal cross-sectional view of a piston and piston guide means forming part of a conventional driving mechanism of a swash or wobble plate compressor;

Fig. 2a is a diagram showing the forces acting on a piston in a conventional swash or wobble plate compressor;

Fig. 2b is a diagram showing the forces acting on a piston in a swash or wobble plate compressor according to the present invention;

Fig. 3 is a diagram showing a piston and piston guide means forming part of a first embodiment of swash or wobble plate compressor according to the invention;

Fig. 4 is a diagram similar to Fig. 3 but of a second embodiment of compressor;

Figs. 5a is a diagram showing the location of lateral forces acting around the circumference of a conventional piston during its operation and the length of its stroke;

Fig. 5b is a diagram showing graphically the lateral forces projected onto the contact length of the piston during its stroke; and

Fig. 5c is a diagram showing graphically the lateral forces acting on the piston during its stroke.

[0016] In all the drawings, the same components or components with the same function have been given the same reference numeral.

[0017] As described above with reference to Fig. 1, in a swash or wobble plate compressor forces are transmitted to the piston 1 that are not exclusively axial forces but comprise a substantial radial component F_Q dependent on the angle of inclination of the swash plate arrangement 8. These radial or lateral forces cause wear to occur in the cylinder bore 3 and on the piston 1.

[0018] With reference to Figs. 2a and 2b, it will be demonstrated that if the centre of a bearing arrangement such as the centre of a shoe pocket of a piston of a compressor is arranged off-axis, an opposite moment is introduced into the piston which offsets the aforesaid forces F_A and F_B . Wear between the piston and the cylinder is thereby reduced.

[0019] Figs. 2a and 2b are diagrams of a cross-section through piston 1 with a bearing 6 and swash or wobble plate arrangement 8. The radial force F_Q is shown that is dependent on the angle of inclination of the arrangement 8 and this is resolved into the lateral forces of reaction F_A and F_B .

[0020] It can be seen that in the conventional arrangement shown in Fig. 2a, the lateral force F_{Aa} can be determined as follows:-

$$F_{Aa} * a = F_Q * (a + b)$$

$$\therefore F_{Aa} = F_Q * \frac{(a + b)}{a}$$

[0021] However, in the arrangement according to the invention shown in Fig. 2b, the lateral force F_{Ab} differs by virtue of the offsetting of the centre of the bearing 6 from the longitudinal axis 7 of the piston 1 by the distance e . In this case the lateral force F_{Ab} is determined as follows:-

$$F_{Ab} * a = F_Q * (a + b) - F_T * e$$

$$\therefore F_{Ab} = F_Q * \frac{(a + b)}{a} - F_T * \frac{e}{a}$$

Where

F_G is the gas force of the compressor
 F_T is the resultant of the gas force
 F_Q is the radial force
 F_A and F_B are the resultant forces of the radial force
 e is the distance of the off-axis shift of the centre of the bearing
 a is the length of the piston between the

points of application of the resultant forces

F_A and F_B

b

is the distance between the points of application of the forces F_B and F_Q

[0022] The ratio of F_{Aa} to F_{Ab} is therefore as follows:-

$$\frac{F_{Aa}}{F_{Ab}} = \frac{F_Q * \frac{(a + b)}{a}}{F_Q * \frac{(a + b)}{a} - \frac{F_T * e}{a}}$$

[0023] Hence

$$F_{Ab} = F_{Aa} \left[1 - \frac{F_T * e}{F_Q * (a + b)} \right]$$

[0024] It can thus be seen that, all other forces being equal, the lateral force F_{Ab} must be less than the lateral force F_{Aa} . It should be appreciated that for the purposes of these calculations it has been assumed that the force F_B does not generate a moment, the pivot point being taken at the point of intersection of the central pivot axis and the point of application of F_B . All other forces were determined accordingly.

[0025] F_B will increase in the embodiment according to the invention shown in Fig. 2b because a moment $F_T * e$ is introduced. F_B will therefore increase by the reaction moment. However, the increase in this resultant force can be tolerated because the most damaging wear caused by lateral forces occurs at the end of the piston opposite the piston head 2 and at the corresponding end of the bore 3. Very little, if any, wear is ever found at the piston head 2 and the closed end of the bore 3. Hence, it is not expected that a slight increase in the force F_B will cause significant increased wear.

[0026] It will be appreciated that offsetting of the centre of the bearing 6 from the longitudinal axis 7 of the piston 1 by the distance e does not reduce the forces acting on the piston 1 overall but the advantage is that their points of application are shifted to locations where they are, in part, internally compensated for within the piston body and, where any transmitted to the cylinder bore 3, it is at locations less damaging to operation of the compressor as a whole than would otherwise be the case. These locations are in areas which are subjected to less stress and are distributed in a better way. The effects of wear caused by lateral forces are therefore substantially reduced.

[0027] The offsetting of the centre of the bearing 6 radially outwardly from the longitudinal axis 7 of the piston 1 can be carried out in any swash or wobble plate com-

pressor.

[0028] In a first exemplary embodiment as shown in Fig. 3, a wobble plate arrangement 8 comprises a double-slide arrangement in which the bearing 6 comprises a pair of part-spherical sliding shoes 10 between which a swash or wobble plate 8 is located. The shoes 10 are mounted between two pressure-bearing shoe pockets 11 defined respectively on opposite sides of the recess 5, each of the pockets 11 defining a part-spherical bearing surface. The centres 12 of the pocket surfaces are located at a position offset radially outwardly with respect to the longitudinal axis 7 of the piston 1.

[0029] In a second exemplary embodiment as shown in Fig. 4, at the end of the piston 1 opposite the piston head 2 is a bearing 6 comprising a ball 13 with a spherical working surface around which is located a washer 14 and retainer 15 connected via a bearing 16 to the swash or wobble plate arrangement 8. The arrangement 8 also comprises a pressure-bearing shoe 17 which bears against the part-spherical end surface portion of the ball 13 to transmit force to the piston 1. As before, it can be seen that the centre 18 of the surface portion of the ball 13 is located at a position offset radially outwardly with respect to the longitudinal axis 7 of the piston 1.

[0030] In addition to the centres 12 and 18 of the part-spherical surfaces of the bearings 6 for the piston against which the swash or wobble plate arrangements 8 bear being offset radially with respect to the longitudinal axis 7 of the piston 1, it is also advantageous if the centres 12 and 18 are offset with respect to a longitudinal plane in which both the longitudinal axis 7 of the piston 1 and the longitudinal axis 9 of the drive shaft for the piston 1 lie.

[0031] Figs. 5a, 5b and 5c show the circumferential lateral forces running around a conventional piston and the length of its path of contact during the piston stroke. These determine the amount of wear caused by the lateral forces and hence can be used to determine the preferred position for the location of the centres 12 and 18 of the bearings 6.

[0032] With reference to Fig. 5a, at top dead centre OT the length of the piston contact area is maximal, whereas at the lower dead centre UT it is minimal. Now, if the circumferential lateral force is projected onto the contact length, as shown in Fig. 5b, it is clear that for a lengthened support area of the piston, or a correspondingly lengthened cylinder face, the following priority sequence results: D, A, B, C. That is, in position C the imposed load is least and between positions A and C the imposed load rises to its maximum at position D. Preferably, therefore, the location of the centre 12 or 18 of the bearings 6 should be offset to counter the higher levels of the force in the direction of rotation at an offset position located between 240° and 360° in the direction of rotation of the drive shaft, such as at the positions 19 and 20 marked with an 'x'. Position 19, which lies at 360° is simply a translation of the point of contact radially with respect to the longitudinal axis 7 of the piston. Advantageously, however, a position 20 is selected which lies is between

270° and 360° in the direction of rotation of the drive shaft and which is offset with respect to a longitudinal plane in which both the longitudinal axis 7 of the piston 1 and a longitudinal axis 9 of a drive shaft for the piston 1 lie.

[0033] It will be appreciated that Fig. 5a does not indicate the direction in which the swash or wobble plate arrangement 8 is turning. Depending on its direction of rotation, in Figs. 5b and 5c there will be a mirror-image reflection of the paths about the x or horizontal axis.

[0034] It will also be appreciated that during the manufacture of a piston in accordance with the present invention that in order for the position 20 for the centre of the bearing 6 to be selected at an offset position located between 240° and 360°, the direction of rotation of the swash or wobble plate arrangement 8 within the compressor with respect to the piston 1 will have had to have been decided.

Claims

1. A compressor comprising at least one piston (1) moveable in a cylinder (3), a drive shaft, a swash or wobble plate arrangement (8) rotatably mounted between the piston (1) and the drive shaft, an at least part-spherical bearing (6) attached to the piston (1) against which the swash or wobble plate arrangement (8) acts to reciprocate the piston (1) in the cylinder (3), wherein the piston (1) defines a recess (5) at one end in which the bearing (6) is located; and wherein further the centre (12, 18) of the bearing (6) is located at a position (20) offset radially outwardly with respect to a longitudinal plane in which both the longitudinal axis (7) of the piston (1) and a longitudinal axis (9) of a drive shaft for the piston (1) lie.
2. A compressor as claimed in Claim 1, wherein the centre (12, 18) of the bearing (6) is located at a position (20) offset in the direction of rotation of the drive shaft.
3. A compressor as claimed in either of Claims 1 or 2, wherein the centre (12, 18) of the bearing (6) is located at a position (20) offset at a position located between 240° and 360° in the direction of rotation of the drive shaft.
4. A compressor as claimed in either of Claims 1 or 2, wherein the centre (12, 18) of the bearing (6) is located at a position (20) offset at a position located between 270° and 360° in the direction of rotation of the drive shaft.
5. A compressor as claimed in any of Claims 1 to 4, wherein the bearing (6) comprises part-spherical pockets (11) located on opposite sides of the recess

- (5).
6. A compressor as claimed in any of Claims 1 to 4, wherein the bearing (6) comprises a ball (13) attached to one end of the piston (1) against which the swash or wobble plate arrangement (8) acts to reciprocate the piston (1).
7. A piston (1) for use in a swash or wobble plate compressor comprising a piston head (2) at one end, and attached at its other end to an at least part-spherical bearing (6) against which a swash or wobble plate arrangement (8) of a compressor can act to reciprocate the piston (1) in a cylinder (3), wherein the piston (1) defines a recess (5) at one end in which the bearing (6) is located, and wherein further the centre (12, 18) of the bearing (6) is located at a position (21) offset radially outwardly with respect to the longitudinal axis (7) of the piston, and in a selected direction of rotation of the swash or wobble plate arrangement (8) in a compressor with respect to the piston (1).
8. A piston as claimed in Claim 7, wherein the centre (12, 18) of the bearing (6) is located at a position (21) between 240° and 360° in the selected direction of rotation for the piston (1).

Patentansprüche

1. Kompressor, welcher zumindest einen Kolben (1), welcher in einem Zylinder (3) bewegbar ist, eine Antriebswelle, eine Schräg- oder Taumelscheiben-Anordnung (8), welche zwischen dem Kolben (1) und der Antriebswelle drehbar befestigt ist, ein zumindest teilweise kugelförmiges Lager (6), welches an dem Kolben (1) befestigt ist, gegen welches die Schräg- oder Taumelscheiben-Anordnung (8) zu einer Wechselwirkung des Kolbens (1) in dem Zylinder (3) wirkt, enthält, wobei der Kolben (1) eine Aussparung (5) an einem Ende bestimmt, an welchem sich das Lager (6) befindet, und wobei sich ferner das Zentrum (12, 18) von dem Lager (6) an einer Position (20) befindet, welche mit Bezug auf eine Längsebene, in welche sowohl die Längsachse (7) von dem Kolben (1) als auch eine Längsachse (9) von einer Antriebswelle für den Kolben (1) liegen, nach außen radial versetzt ist.
2. Kompressor nach Anspruch 1, bei welchem sich das Zentrum (12, 18) von dem Lager (6) an einer Position (20) befindet, welche in Richtung der Umdrehung von der Antriebswelle versetzt ist.
3. Kompressor nach einem der Ansprüche 1 oder 2, bei welchem sich das Zentrum (12, 18) von dem La-

ger (6) an einer Position (20) befindet, welche an einer Position versetzt ist, welche zwischen 240° und 360° in Richtung der Umdrehung von der Antriebswelle positioniert ist.

4. Kompressor nach einem der Ansprüche 1 oder 2, bei welchem sich das Zentrum (12, 18) von dem Lager (6) an einer Position (20) befindet, welche an einer Position versetzt ist, welche zwischen 270° und 360° in Richtung der Umdrehung von der Antriebswelle positioniert ist.
5. Kompressor nach einem der Ansprüche 1 bis 4, bei welchem das Lager (6) zumindest teilweise kugelförmige Taschen (11) enthält, welche an gegenüberliegenden Seiten von der Aussparung (5) positioniert sind.
6. Kompressor nach einem der Ansprüche 1 bis 4, bei welchem das Lager (6) einen Ball (13) enthält, welcher an einem Ende von dem Kolben (1) befestigt ist, gegen welchen die Schräg- oder Taumelscheiben-Anordnung (8) zu einer Wechselwirkung des Kolbens (1) wirkt.
7. Kolben (1) zur Verwendung in einem Schräg- oder Taumelscheiben-Kompressor, welcher einen Kolbenkopf (2) an einem Ende enthält, und wobei er an seinem weiteren Ende an einem zumindest teilweise kugelförmigen Lager (6) befestigt ist, gegen welches eine Schräg- oder Taumelscheiben-Anordnung (8) von einem Kompressor zu einer Wechselwirkung des Kolbens (1) in einem Zylinder (3) wirken kann, wobei der Kolben (1) eine Aussparung (5) an einem Ende bestimmt, an welchem sich das Lager (6) befindet, und wobei ferner das Zentrum (12, 18) von dem Lager (6) an einer Position (21) positioniert ist, welche mit Bezug auf die Längsachse (7) von dem Kolben und in einer ausgewählten Richtung der Umdrehung von der Schräg- oder Taumelscheiben-Anordnung (8) in einem Kompressor mit Bezug auf den Kolben (1) nach außen radial versetzt ist.
8. Kolben nach Anspruch 7, bei welchem das Zentrum (12, 18) von dem Lager (6) an einer Position (21) zwischen 240° und 360° in der ausgewählten Richtung der Umdrehung des Kolbens (1) positioniert ist.

Revendications

1. Compresseur comportant au moins un piston (1) mobile dans un cylindre (3), un arbre d'entraînement, un agencement de plateau oscillant ou de disque en nutation (8) monté de manière rotative entre le piston (1) et l'arbre d'entraînement, et au moins un palier partiellement sphérique (6) fixé sur le piston (1), con-

- tre lequel l'agencement de plateau oscillant ou de disque en nutation (8) agit pour déplacer le piston (1) dans le cylindre (3) en va-et-vient, dans lequel le piston (1) définit un évidement (5) à une première extrémité, dans lequel le palier (6) est situé, et dans lequel en outre le centre (12, 18) du palier (6) est positionné dans une position (20) décalée radialement vers l'extérieur par rapport à un plan longitudinal dans lequel l'axe longitudinal (7) du piston (1) et un axe longitudinal (9) d'un arbre d'entraînement pour le piston (1) se trouvent. 5 10
2. Compresseur selon la revendication 1, dans lequel le centre (12, 18) du palier (6) est positionné dans une position (20) décalée dans la direction de rotation de l'arbre d'entraînement. 15
3. Compresseur selon la revendication 1 ou 2, dans lequel le centre (12, 18) du palier (6) est positionné dans une position (20) décalée au niveau d'une position positionnée entre 240° et 360° dans la direction de rotation de l'arbre d'entraînement. 20
4. Compresseur selon la revendication 1 ou 2, dans lequel le centre (12, 18) du palier (6) est positionné dans une position (20) décalée au niveau d'une position située entre 260° et 360° dans la direction de rotation de l'arbre d'entraînement. 25 30
5. Compresseur selon l'une quelconque des revendications 1 à 4, dans lequel le palier (6) comprend des poches partiellement sphériques (11) situées sur des côtés opposés de l'évidement (5). 35
6. Compresseur selon l'une quelconque des revendications 1 à 4, dans lequel le palier (6) comprend une bille (13) fixée sur une première extrémité du piston (1), contre laquelle l'agencement de plateau oscillant ou de disque en nutation (8) agit pour déplacer le piston (1) en va-et-vient. 40
7. Piston (1) destiné à être utilisé dans un compresseur à plateau oscillant ou disque en nutation, comprenant une tête de piston (2) à une première extrémité, et fixé à son autre extrémité à au moins un palier partiellement sphérique (6) contre lequel un agencement de plateau oscillant ou de disque en nutation (8) d'un compresseur peut agir pour déplacer le piston (1) dans un cylindre (3) en va-et-vient, dans lequel le piston (1) définit un évidement (5) à une première extrémité, dans lequel le palier (6) est positionné, et 45 50
8. Piston selon la revendication 7, dans lequel le centre (12, 18) du palier (6) est positionné dans une position (21) entre 240° et 360° dans la direction de rotation sélectionnée pour le piston (1). 55
- de disque en nutation (8) dans un compresseur par rapport au piston (1).

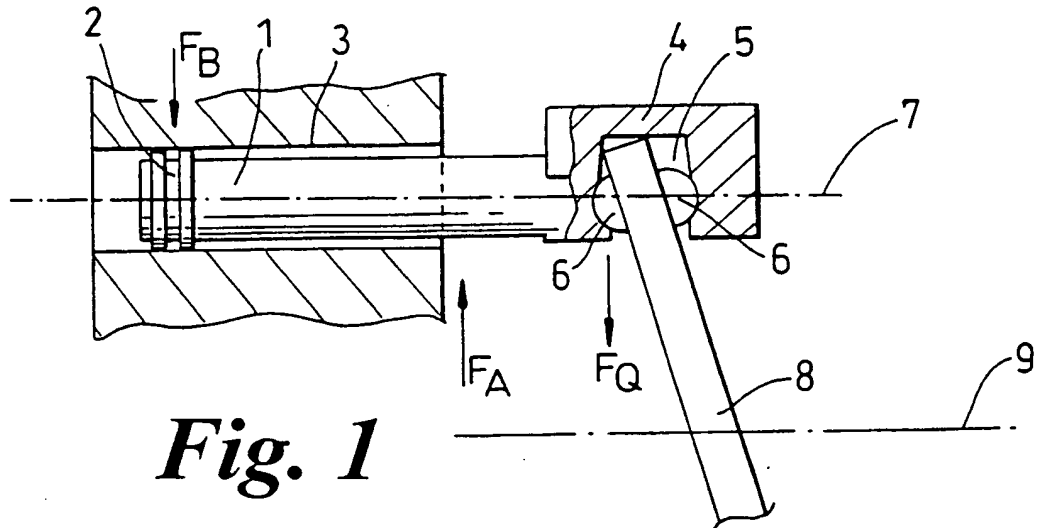


Fig. 1

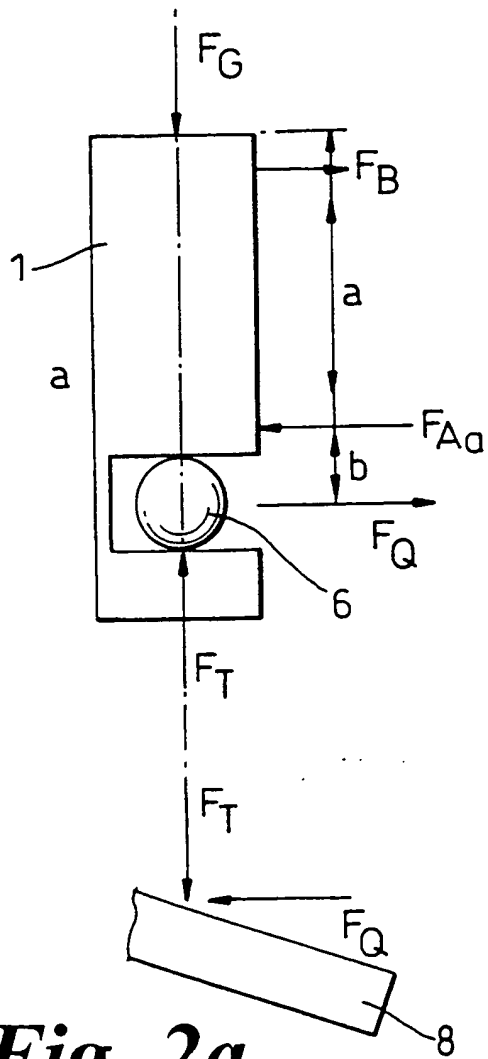


Fig. 2a

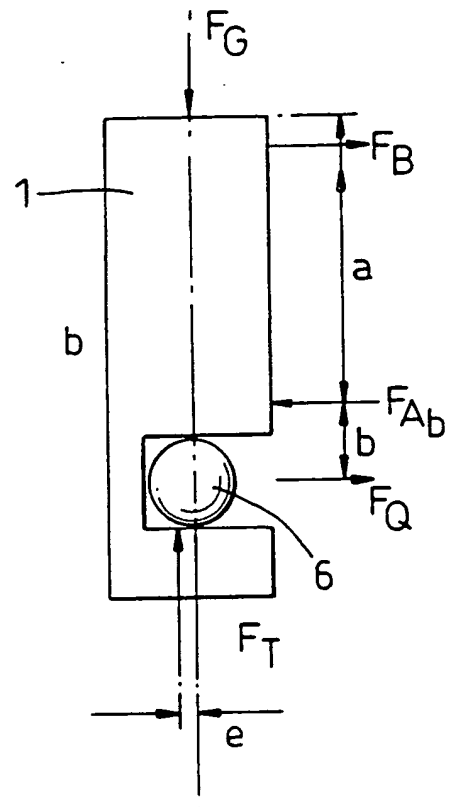


Fig. 2b

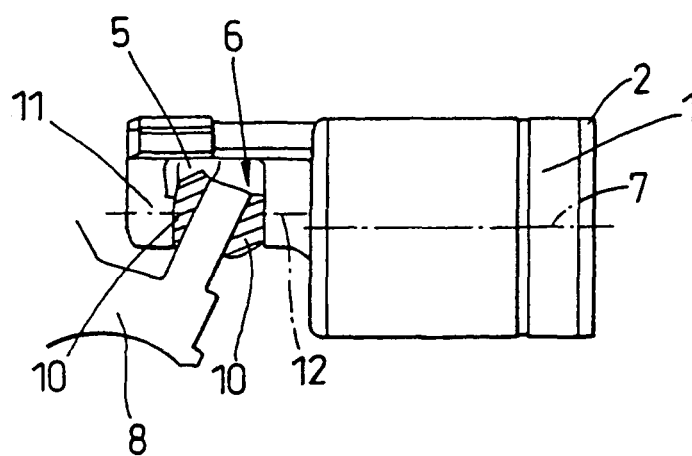


Fig. 3

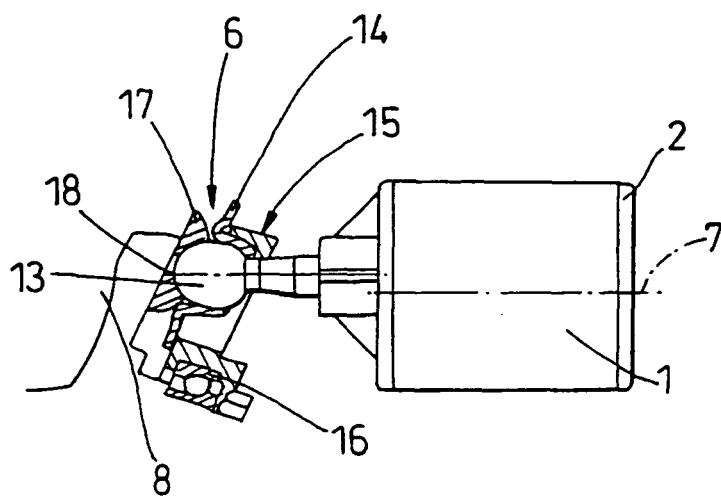
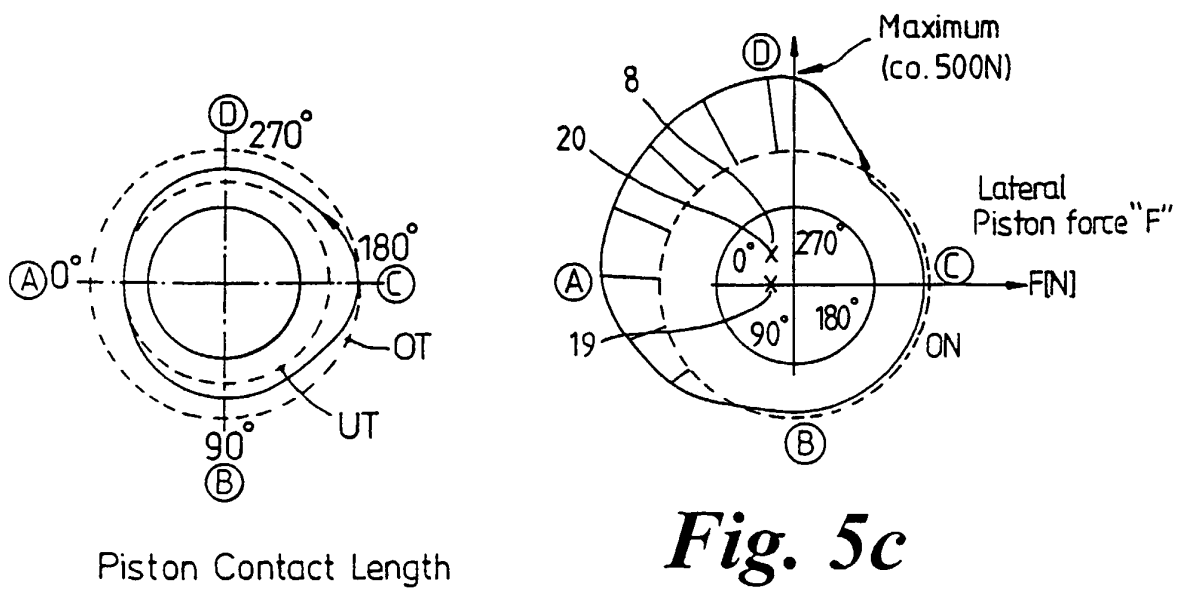
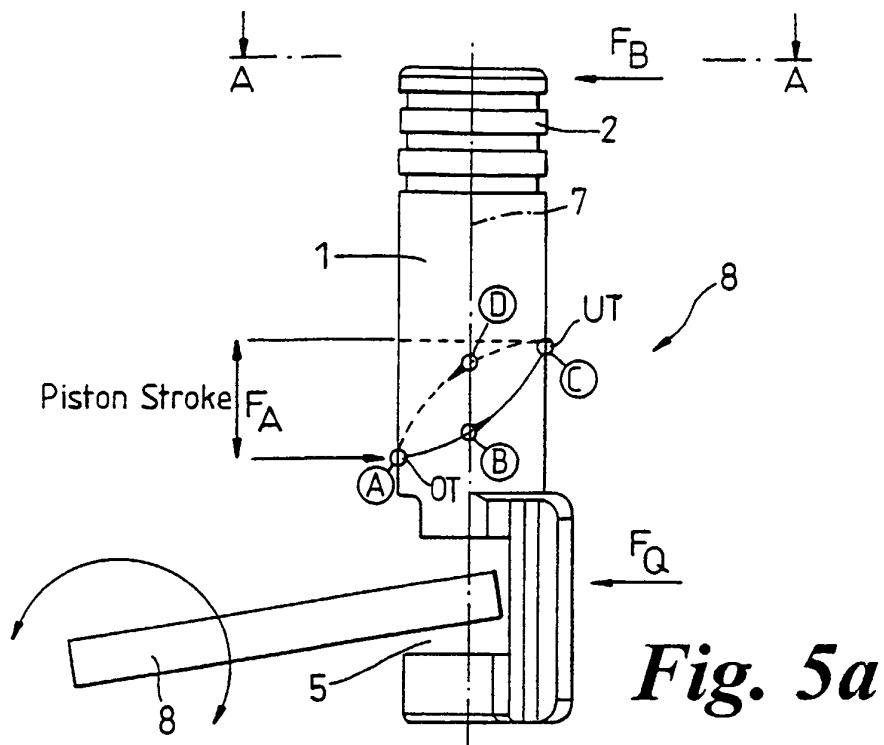


Fig. 4



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 05026156 B [0003]