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(71) Applicant: **Zexel Valeo Climate Control Corporation**
Saitama 360-0193 (JP)

(72) Inventor: **Schwarzkopf, Otfried,**
c/o Zexel Valeo Compressor
71634 Ludwigsburg (DE)

(74) Representative: **Popp, Eugen, Dr. et al**
MEISSNER, BOLTE & PARTNER
Postfach 86 06 24
81633 München (DE)

(54) **A piston for a swash plate compressor**

(57) A piston (1) for use in a swash plate compressor for a vehicle air conditioning system comprises a piston head (3) at one end and defines a recess (6) at its other end. A pressure-bearing shoe (8) is connected to the piston (1) on the piston head-side of the recess (6) in a fixed, non-rotational manner. Preferably, the shoe (8) is connected to the piston (1) by means of mating formations (9a, 9b) formed respectively on or in the shoe (8) and on or in the piston (1).

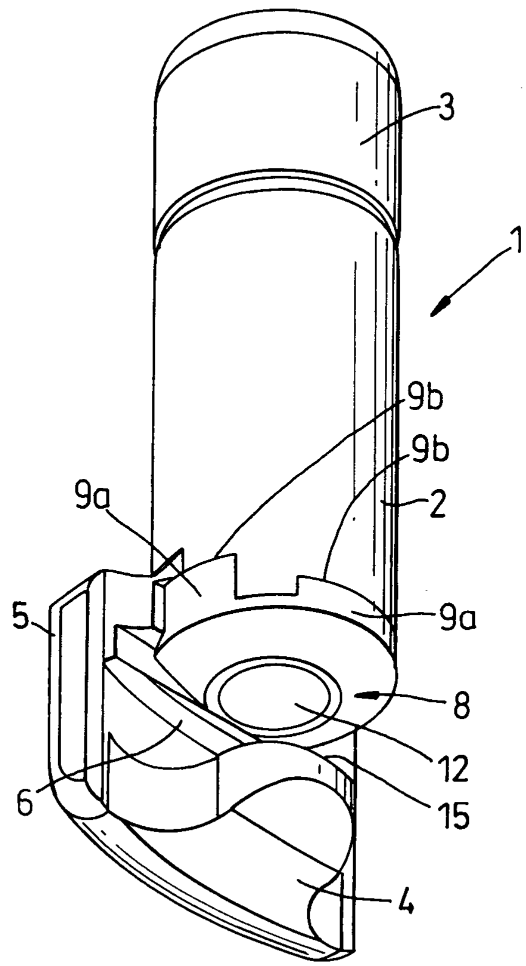

Fig. 1

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Description

[0001] The present invention relates to a piston for use in a swash plate compressor, in particular a CO_2 compressor, for a vehicle air-conditioning system and to a compressor incorporating such a piston.

[0002] US 5,387,091 describes a variable capacity type swash plate compressor for an air-conditioning system in a vehicle having a drive shaft and at least one piston movable in a cylinder. A swinging swash plate of the compressor is provided on each side with an annular rail over which is fitted a semi-spherical inner sliding shoe. The inner sliding shoes engage semi-spherical outer shoes machined on inner surfaces of a swash plate receiving groove at the neck of a piston of the compressor. This arrangement allows a separation between the rotational movement that takes place between the swash plate and the inner sliding shoes, and the translational movement of the outer shoes and the piston.

[0003] In US 5,826,490 is also described a swash plate compressor but here a wobble plate arrangement is used between the piston and the drive shaft. The wobble plate arrangement comprises a swash plate on which a wobble plate is rotatably mounted and between the wobble plate and the piston is arranged a bearing which allows movements of the wobble plate relative to the piston in a circumferential direction. The wobble plate is able to rotate freely both with respect to the swash plate and with respect to the piston. The bearing comprises a slider shoe arrangement in which a pair of part-spherical sliding shoes are swivel mounted between two complementarily formed outer shoes located in a recess of the piston, the wobble plate being received between two opposed smooth sliding surfaces of the sliding shoes respectively. The two outer shoes are provided by bearing shells which are fixed in the piston.

[0004] The use of bearing shells to form the outer shoes attached to the piston in this compressor provides several advantages, as follows.

- It enables the piston to be hollowed out from its bottom end so that its bulk is greatly reduced, enabling the compressor to be optimally designed. As the pistons are made of steel rather than aluminum, which would be unsuitable for this design of compressor, weight reduction becomes an important design consideration.

- The shells have a simple shape and are relatively easy to produce by machining.

- If a regulating screw is provided for adjustment of the position of the piston-side bearing shell, the axial clearance or play of the shells can be adjusted. Hence, as the shells wear owing to the action of the sliding shoes, the end play of the shells can be adjusted.

- The fact that the position of the shells can be adjusted permits adjustment to take place to compensate for less than precise manufacturing tolerances.

More generally, because wear takes place in the bearing arrangement, the bearing shells have to be appropriately designed by a suitable choice of materials and optionally by a subsequent thermal treatment or coating.

It should be appreciated that pressure is applied to the piston-side bearing shell mainly during piston movement on the compression stroke when the piston rises from the bottom to the top of the cylinder. In contrast, pressure is applied to the regulating-side bearing shell mainly during the intake stroke, when the piston descends from the top of the cylinder to the bottom. The characteristic of the gas forces acting on the piston is such that during the compression stroke, when the crank angle of the piston is between 180° to 360°, the force acting on the piston-side bearing shell is significantly greater than that applied to the regulating-side bearing shell during the intake stroke, when the crank angle of the piston is approximately in the range 50° to 200°. In addition to the gas forces, other forces caused by overshooting losses, and inertial losses will also act on the bearing shells to produce wear.

A critical factor in the design of bearing arrangements for swash plate compressors is the so-called *pv* value, which is the product of the applied surface pressure and the velocity. As the wobble plate of a compressor of the type disclosed in US 5,826,490 performs only small rotational movements, the product of the surface pressure and the velocity is small and the bearing shells can be made with small dimensions, mainly taking into account only the surface pressure. Essentially, therefore, the size of the sliding shoes determines the size of the complementarily formed bearing shells.

However, the arrangement described in US 5,826,490 has several drawbacks, in particular with regard to the nature and design of the bearing shells. These drawbacks have been primarily brought about by the desire to mass produce the compressor, which involves changing from steel to aluminum pistons. These drawbacks include the following.

- The bearing shells may, and in fact do, rotate in their seating in the piston. This causes wear in the seating, which is especially pronounced when the piston is made of aluminum.

- Rotation of the bearing shells in their seatings causes friction so that the mechanical losses of the driving mechanism are increased.

- If aluminum is used as the piston material, then bearing shells of the type described will create an unacceptably high surface pressure on the piston-side seating of the shells.

- The aforementioned drawback is increased in severity if the piston is made hollow as described in US 5,826,490 as here only an annular rim of the piston is available as the seating surface for the piston-side bearing shell.

- The use of a regulating screw to adjust the position of the piston-side bearing shell increases the length of the piston required and thus results in a increased overall length for the driving mechanism, and hence the compressor as a whole.

- An increased overall length of the driving mechanism of the compressor, in particular an increased length of the swash plate and wobble plate, leads to a greater variability of the centre of gravity of the compressor when it is tilted, as happens for the purposes of power control, and thus causes imbalance and noise, especially at higher speeds.

- Whilst the use of a piston-side bearing shell is useful because it can be manufactured with a view to minimizing wear resistance by a suitable choice of materials and the use of hardening techniques and wear-resistant coatings, the use of a regulating-side bearing shell is not as useful. This is because the surface pressures occurring on this side of the bearing arrangement are normally significantly smaller than that on the piston-side. In addition, the provision of a regulating-side bearing shell increases the length of the piston and therefore of the driving arrangement of the compressor.

- If regulating screws are employed in compressors comprising a larger number of pistons, for example those with seven pistons, the quantity of assembly work required to mass produce the compressor becomes excessive. However, without the use of regulating screws and the associated drilling through the bottom of the piston necessitated thereby, insertion of the bearing shells into the piston is very difficult and, in the embodiment illustrated in US 5,826,490, is practically impossible.

[0005] The object of the present invention is to provide a piston for use in a compressor as described above which overcomes or substantially mitigates the aforementioned disadvantages.

[0006] According to a first aspect of the present invention there is provided a piston for use in a compressor for a vehicle air conditioning system comprising a piston head at one end and defining a recess at its other end, and comprising a pressure-bearing shoe which is connected to the piston on the piston head-side of the recess, characterised in that the pressure-bearing shoe is connected to the piston in a fixed, non-rotational manner.

[0007] Preferably, the pressure-bearing shoe is fitted axially to an end of the piston adjacent the recess.

[0008] Preferably also, the pressure-bearing shoe is connected to the piston by means of mating formations formed respectively on or in the shoe and on or in the piston. Advantageously, the mating formations are arranged around the circumference of the piston in such a way that lateral forces acting on the piston cannot push the shoe out of position with respect to the piston.

[0009] Preferably also, the mating formations are formed by machining of the piston from one end in a direction parallel with the longitudinal axis of the piston.

[0010] Preferably also, the mating formations comprise one or a series of projections formed on the shoe which locate into respectively into complementarily shaped rebates defined by the piston or *vice versa*.

[0011] Advantageously, the projections and the rebates have a rectangular section. Preferably also, the rectangular section rebates define three adjoining sides which take up any lateral forces acting on the pressure-bearing shoe.

[0012] In an alternative embodiment, the pressure-bearing shoe is preferably connected to the piston by means of pins.

[0013] In another alternative embodiment, the pressure-bearing shoe is connected to the piston by being clamped or adhered thereto. Advantageously in this embodiment, the pressure-bearing shoe is also connected to the piston by means of mating formations which are formed by a deformation of the shoe circumferentially around the piston thereby clamping the shoe to the piston.

[0014] In all of the aforementioned embodiments, preferably the pressure-bearing shoe is made primarily of steel whereas the piston is made primarily of aluminum.

[0015] In a further alternative embodiment, the pressure-bearing shoe is integrally formed with the piston. Here, the pressure-bearing shoe is preferably formed from a coating applied to the piston. Advantageously, the pressure-bearing shoe is formed by a ceramic coating which has been applied by thermal spraying to the piston and which has been subsequently machined to define the shoe.

[0016] Advantageously, the pressure-bearing shoe defines a part-spherical pressure-bearing surface through which in use translational forces may be transmitted to the shoe from a slider shoe in contact therewith. Preferably, the part-spherical pressure-bearing surface is formed by machining of the pressure-bearing shoe.

[0017] The pressure-bearing shoe preferably transmits the translational forces to the bottom of the piston via a contact surface at the bottom of the piston, the part-spherical pressure-bearing surface having a surface area which is substantially smaller than the surface area of the contact surface.

[0018] Preferably also, the piston comprises a cylindrical body with the piston head at one end and a foot portion at its other end, and a bridge links the foot portion to the cylindrical body, the recess being defined between the foot portion and the cylindrical body.

[0019] Preferably also, the foot portion is provided with a part-spherical bearing surface so that in use translational forces may be transmitted directly to the surface from a slider shoe in contact therewith.

[0020] Preferably also, the width of the foot portion is substantially smaller than the diameter of the cylindrical body.

[0021] According to a second aspect of the present invention there is provided a compressor for a vehicle air conditioning system comprising a piston according to the first aspect of the invention.

[0022] According to a third aspect of the present invention there is provided a compressor for a vehicle air conditioning system comprising at least one piston moveable in a cylinder, a drive shaft, a wobble plate arrangement comprising a swash plate on which a wobble plate is rotatable mounted located between the piston and the drive shaft, a bearing mounted in the piston into which the wobble plate extends, and a pressure-bearing shoe on the piston-side of the wobble plate, characterised in that the pressure-bearing shoe is connected to the piston in a fixed, non-rotational manner.

[0023] It will be appreciated that in the various aspects of the present invention the piston comprising the pressure-bearing shoe is such at it can be manufactured and assembled relatively simply and provides a safeguard against any relative rotation between the pressure-bearing shoe and the piston. The connection between the pressure-bearing shoe and the piston is such that the pressure-bearing shoe can transmit the surface pressure of adjacent sliding shoes to the piston without any unacceptably high surface pressure causing damage to the piston, especially if the piston is made of aluminum. The need for a separate pressure-bearing shoe to be connected to the piston on the regulating-side of the recess of the piston can also be eliminated, which enables the overall piston length and therefore that of the driving mechanism of the compressor to be considerably reduced.

[0024] The present invention will now be described by way of example with reference to the accompanying drawings, in which:-

Fig. 1 is a perspective side view of a piston for use in a compressor according to the present invention;

Fig. 2 is a view similar to that of Fig. 1 but showing the piston and an associated pressure-bearing shoe in a disassembled state;

Fig. 3 is a diagrammatic longitudinal cross-section through a driving mechanism of a compressor according to the invention and incorporating a piston similar to that shown in Figs. 1 and 2;

Fig. 4 is a perspective side view of a second embodiment of piston for use in a compressor according to the present invention with a scrap view of a portion thereof shown to an enlarged scale;

Figs. 5 is a schematic end view showing the profile of a calibrating tool for use in the manufacture of a piston according to the present invention;

Fig. 6 is a longitudinal sectional view of a third embodiment of piston according to the present invention and showing the position of the calibrating tool in relation thereto when in use.

[0025] The piston 1 shown in Figs. 1 and 2 comprises a cylindrical body 2 with a head portion 3 at one end and a foot portion 4 at its other end. A bridge 5 links the foot portion 4 to the cylindrical body 2 so that a recess 6 is defined between the foot portion 4 and the cylindrical body 2. The recess 6 is intended to accommodate a bearing 7 for a wobble plate arrangement of the compressor as shown in Fig. 3.

[0026] A pressure-bearing shoe 8 is mounted at the bottom of the cylindrical body 2 on the piston-head side of the recess 6. The shoe 8 is mounted axially on to the bottom of the cylindrical body 2 and connects thereto by means of mating formations 9a, 9b formed respectively on and in the shoe 8 and the bottom of the cylindrical body 2. In particular, the mating formations comprise one or a series of projections 9a formed on the shoe 8 which locate respectively into complementarily shaped rebates 9b defined in the bottom of the body 2, or *vice versa.* This arrangement prevents any relative rotation between the shoe 8 and the piston body 2. In addition, the mating formations 9a, 9b centre the shoe 8 on the body 2.

[0027] Preferably, the projections 9a and the rebates 9b have a rectangular section but they may have different profiles provided that they mate with one another. It is however important that they are arranged around the circumference of the piston 1 in such a way that the shoe 8 interlocks with the body 2 and lateral forces acting on the piston 1 cannot push the shoe 8 out of its interlocked position with the cylindrical body 2. In this regard, rectangular section rebates 9b enable any lateral forces acting on the shoe 8 to be taken up by the three adjoining sides 10a, 10b and 10c of the rebates 9b.

[0028] In addition, rectangular section projections 9a and rebates 9b enable the rebates 9b to be machined from the underside of the foot portion 4 of the piston 1 and preferably the foot portion 4 is configured so as to permit machining of the rebates 9b in a direction parallel with the longitudinal axis 11 of the piston 1.

[0029] As the shoe is pressure-bearing, it is preferably made from a material which is harder than that of the piston and, as is described below, it is possible for there to be a significant difference in the hardness of the materials used for each. In a preferred embodiment the shoe 8 is made from steel whereas the piston 2 is made of aluminum. The shoe 8 comprises a part-spherical bearing surface 12 through which translational forces are transmitted to the shoe 8 from slider shoes 13 in contact therewith as shown in Fig. 3. The pressure-bearing shoe 8 then transmits these forces to the bottom of the piston 1 via a contact surface 14 at the bottom of the cylindrical body 2 of the piston 1. As the shoe 8 is made from steel, which may have been be subjected to a hardening process, the surface area of the bearing surface 12 can be made significantly smaller than the area of the contact surface 14, which can be made large enough to enable the piston 1 to be made from aluminum or an aluminum material. In particular, the surface area of the bearing surface 12 can be made between two and three times smaller than the surface area of the contact surface 14.

[0030] The *pv* value is also relevant here as in the compressor of the invention, as described in more detail below with reference to Fig. 3, the wobble plate performs only small rotational movements so that the product of the surface pressure and the velocity is small and the slider shoes 8 can be made with small dimensions, mainly taking into account only the surface pressure. The size of the sliding shoes 13 therefore determines the size of the complementarily formed bearing surfaces 12 of the shoes 8. Preferably, the diameters of the part-spherical surfaces 12 and the part spherical surfaces of the slider shoes 13 are in the range 8 mm to 12 mm inclusive.

[0031] The shoe 8 may be made by appropriately machining a component, in which case it may not need any hardening, especially in the region of the bearing surface 12, as the machining process itself will strength the surface of the shoe. Alternatively, the shoe may be made by stamping or punching from a blank.

[0032] The foot portion 4 of the piston 1 must also be dimensioned so that it is capable of withstanding the forces which it must carry without deformation or cracking. In this regard, it is preferable to increase the thickness of the foot portion 4 rather than its width relative to its longitudinal length because the geometrical moment of inertia is essentially determined by the height of the foot portion 4. The width of the foot portion 4 is therefore preferably substantially smaller than the diameter of the cylindrical body 2, which also facilitates the machining of the rebates 9b in a direction parallel with the longitudinal axis 11 of the piston 1.

[0033] The foot portion 4 is provided with a part-spherical bearing surface 15 so that translation forces are transmitted directly to it, without any interposed pressure-bearing shoe equivalent to the shoe 8. Such an arrangement is possible because whereas the load on the piston head-side of the recess 6 on the compression stroke is relatively high, necessitating the use of the pressure-bearing shoe 8, the load on the regulating-side of the recess 6 on the intake stroke is lower and a pressure-bearing shoe is not a requirement.

[0034] The piston 1 as described above has thus been designed to withstand the translation forces transmitted to it in a differentiated way.

[0035] Fig. 3 shows a driving mechanism, without any casing, of a compressor incorporating a piston as described above. The same parts of the piston as have already been described have been given the same reference numerals in the following description.

[0036] The compressor comprises a CO_2 compressor for a vehicle air-conditioning system wherein the ratio of the piston diameter, that is the diameter of the cylindrical body 2, to piston stroke is preferably approximately 1.

[0037] The compressor comprises a drive shaft 16 and at least one piston 1 movable in a cylinder (not shown). A wobble plate arrangement 17 comprising a swash plate 18 on which a wobble plate 19 is rotatably mounted is arranged between the piston 1 and the drive shaft 15. The wobble plate 19 is able to rotate freely both with respect to the swash plate 18 and with respect to the piston 1. The wobble plate 19 extends into the bearing 7 which is located in the recess 6 of the piston 1 and which allows movements of the wobble plate 19 relative to the piston 1 in a circumferential direction. The bearing comprises a slider shoe arrangement in which a pair of part-spherical sliding shoes 13 (as mentioned above) are swivel mounted between the pressure-bearing shoe 8 connected to the bottom of the cylindrical body 2 of the piston on the piston-head side of the recess 6 and the part-spherical bearing surface 14 provided on the foot portion 4 of the piston 1.

[0038] As only one pressure-bearing shoe 8 is required, it can be seen in Fig. 3 that the invention leads to a considerable reduction in the length of the driving mechanism for the compressor and therefore of the compressor as a whole.

[0039] In a modification, the pressure-bearing shoe 8 is not connected to the piston 1 by the use of mating formations 9a, 9b formed respectively on and in the shoe 8 and bottom of the cylindrical body 2 but is pinned to the cylindrical body 2 of the piston. The mating formations 9a, 9b are therefore not required. Two pins, for example, would be sufficient to safeguard the shoe 8 against rotation relative to the piston 1. Preferably, bores for the pins are provided in such a position in the cylindrical body 2 of the piston 1 that they can be made by machining laterally past the piston foot in a direction parallel with the longitudinal axis 11 of the piston 1.

[0040] In further embodiments, the pressure-bearing shoe 8 is attached to the cylindrical body 2 of the piston 1 by being clamped or adhered thereto. The shoe 8 itself may also be formed by pressing or stamping.

[0041] In Fig. 4 is shown an embodiment wherein the pressure-bearing shoe 8 is clamped to the cylindrical body of the piston 1 by deformation. In this embodiment the shoe 8 is mounted axially at the bottom of the cylindrical body 2 on the piston-head side of the recess 6 and comprises a cup which is located over the end of the cylindrical body 2. The shoe 8 is connected to the body 2 by means of mating formations 20 formed by pressing an annular groove 21 into the exterior of the shoe 8 circumferentially around the cylindrical body 2, which groove 21 deforms the underlying body 2 of the piston 1 to form the two mating formations 20 thus clamping the shoe 8 to the body 2. However, immediately prior to the clamping procedure, the piston 1 is calibrated to ensure that the shoe 8, once clamped in position, will be located correctly. This calibration is accomplished using a calibration tool which is inserted into the recess 6 and then turned to ensure that the part-spherical bearing surfaces 12 and 15 are correctly aligned.

[0042] As shown in Fig. 5, a calibrating tool 22 has a profile which defines two part-spherical surfaces 23 and 24 of diameter *d.* These surfaces 23 and 24 are arranged so that they exactly match the diameter, alignment and separation of the two part-spherical bearing surfaces 12 and 15, which also have a diameter *d.* However, the tool 22 has a reduced width *b* which corresponds to the width of the recess 6 (see Fig. 6) so that it can be inserted into the recess 6. Upon insertion, the surfaces 23 and 24 are out of alignment with the surfaces 12 and 14 but when the tool 22 is turned axially through 90°, the surfaces 23 and 24 lie adjacent the surfaces 12 and 15 respectively. This enables the position of the shoe 8 and thereby the surface 12 which it defines to be correctly adjusted prior to the attachment of the shoe 8 to the cylindrical body 2.

[0043] In a third embodiment as shown in Fig. 6, the shoe 8 is connected to the cylindrical body 2 of the piston 1 by caulking. As in the previous embodiment, here the shoe 8 also comprises a cup which is located over the end of the cylindrical body 2. A calibrating tool 22 as previously described and with dimensions *b* and *d* is used to ensure the correct position of the shoe 8 relative to the body 2 of the piston 1. The shoe 8 is then fixed in this position by caulking or other adhesive means.

[0044] It will be appreciated that preferably, as in the embodiments described above the shoe is mounted on the body 2 of the piston after separate final machining of the part-spherical surfaces 12 and 15. However, it is possible to attach the shoe 8 to the body 2 of the piston by the means previously described before final machining of the surfaces 12 and 15 has taken place, although this is considerably more difficult to accomplish. In this case, the machine tools used would also have to have dimensions *b* and *d* in order that they can be inserted into the recess 6 to machine the surfaces 12 and 15. In any event, for quiet operation of the mechanism, the surfaces 12 and 15 must be machined with a high precision.

[0045] In a further embodiment, the pressure-bearing shoe 8 is provided by a coating applied to the piston 1. A coating process must be chosen which provides a thickly coated layer on the exterior of the cylindrical body 2 of the piston 1 in order to enable the part-spherical bearing surface 12 through which translational forces are transmitted to the shoe 8 to be machined from the coated layer. Hence, the coating should have a thickness at least in the order of millimetres of thickness. A ceramic coating applied by thermal spraying fulfils these requirements.

Claims

1. A piston for use in a compressor for a vehicle air conditioning system, comprising a piston head (3) at one end and defining a recess (6) at its other end, and a pressure-bearing shoe (8) which is connected to the piston (1) on the piston head-side of the recess (6),
   characterised in that
   the pressure-bearing shoe is connected to the piston (1) in a fixed, non-rotational manner.

2. A piston as claimed in Claim 1,
   characterised in that
   the pressure-bearing shoe (8) is fitted axially to an end of the piston (1) adjacent the recess (6).

3. A piston as claimed in Claim 1 or Claim 2,
   characterised in that
   the pressure-bearing shoe (8) is connected to the piston (1) by means of mating formations (9a, 9b, 20) formed respectively on or in the shoe (8) and on or in the piston (1).

4. A piston as claimed in Claim 3,
   characterised in that
   the mating formations (9a, 9b) are arranged around the circumference of the piston (1) in such a way that lateral forces acting on the piston (1) cannot push the shoe (8) out of position with respect to the piston (1).

5. A piston as claimed in Claim 4,
   characterised in that
   the mating formations (9a, 9b) on the piston (1) are formed by machining of the piston (1) from one end in a direction parallel with the longitudinal axis (11) of the piston (1).

6. A piston as claimed in Claim 4 or Claim 5,
   characterised in that
   the mating formations (9a, 9b) comprise one or a series of projections (9a) formed on the shoe (8) which locate into respectively into complementarily shaped rebates (9b) defined by the piston (1) or *vice versa.*

7. A piston as claimed in Claim 6,

characterised in that
the projections (9a) and the rebates (9b) have a rectangular section.

8. A piston as claimed in Claim 7,
characterised in that
the rectangular section rebates (9b) define three adjoining sides (10a, 10b, 10c) which take up any lateral forces acting on the pressure-bearing shoe (8).

9. A piston as claimed in Claim 3,
characterised in that
the mating formations (20) are formed by a deformation of the shoe (8) circumferentially around the piston (1) thereby clamping the shoe (8) to the piston (1).

10. A piston as claimed in Claim 1 or Claim 2,
characterised in that
the pressure-bearing shoe (8) is connected to the piston (1) by means of pins.

11. A piston as claimed in Claim 1 or Claim 2,
characterised in that
the pressure-bearing shoe (8) is connected to the piston (1) by being clamped or adhered thereto.

12. A piston as claimed in any of Claims 1 to 11,
characterised in that
the pressure-bearing shoe (8) is made primarily of steel whereas the piston (1) is made primarily of aluminum.

13. A piston as claimed in Claim 2 or Claim 3,
characterised in that
the pressure-bearing shoe (8) is integrally formed with the piston (1).

14. A piston as claimed in Claim 13,
characterised in that
the pressure-bearing shoe (8) is formed from a coating applied to the piston (1).

15. A piston as claimed in Claim 14,
characterised in that
the pressure-bearing shoe (8) is formed by a ceramic coating which has been applied by thermal spraying to the piston and which has been subsequently machined to define the shoe (8).

16. A piston as claimed in any of Claims 1 to 15,
characterised in that
the pressure-bearing shoe (8) defines a part-spherical pressure-bearing surface (12) through which in use translational forces may be transmitted to the shoe (8) from a slider shoe (13) in contact therewith.

17. A piston as claimed in Claim 16,
characterised in that
the part-spherical pressure-bearing surface (12) is formed by machining of the pressure-bearing shoe (8).

18. A piston as claimed in Claim 16 or Claim 17,
characterised in that
the pressure-bearing shoe (8) transmits the translational forces to the bottom of the piston (1) via a contact surface (14) at the bottom of the piston (1), the part-spherical pressure-bearing surface (12) having a surface area which is substantially smaller than the surface area of the contact surface (14).

19. A piston as claimed in any one of Claims 1 to 18, comprising a cylindrical body (2) with the piston head (3)at one end and a foot portion (4) at its other end,
characterised in that
a bridge (5) links the foot portion (4) to the cylindrical body (2) and the recess (6) is defined between the foot portion (4) and the cylindrical body (2).

20. A piston as claimed in Claim 19,
characterised in that
the foot portion (4) is provided with a part-spherical bearing surface (15) so that in use translational forces may be transmitted directly to the surface (15) from a slider shoe (13) in contact therewith.

21. A piston as claimed in Claim 20,
characterised in that
the part-spherical pressure-bearing surfaces (12, 15) and the associated slider shoes (13) have diameters in the range 8 mm to 12 mm inclusive.

22. A piston as claimed in any one of Claims 19 to 21,
characterised in that
the width of the foot portion (4) is substantially smaller than the diameter of the cylindrical body (2).

23. A compressor for a vehicle air conditioning system,
characterised in that
it comprises a piston as claimed in any one of Claims 1 to 22.

24. A compressor for a vehicle air conditioning system comprising at least one piston (1) moveable in a cylinder, a drive shaft (16), a wobble plate arrangement (17) comprising a swash plate (18) on which a wobble plate (19) is rotatable mounted located between the piston (1) and the drive shaft (16), a bearing (7) mounted in the piston (1) into which the wobble plate (19) extends, and a pressure-bearing shoe (8) on the piston-side of the wobble plate (19),
characterised in that
the pressure-bearing shoe (8) is connected to the

piston (1) in a fixed, non-rotational manner.

25. A compressor as claimed in Claim 23 or Claim 24, **characterised in that** the ratio of the piston diameter to piston stroke is approximately 1.

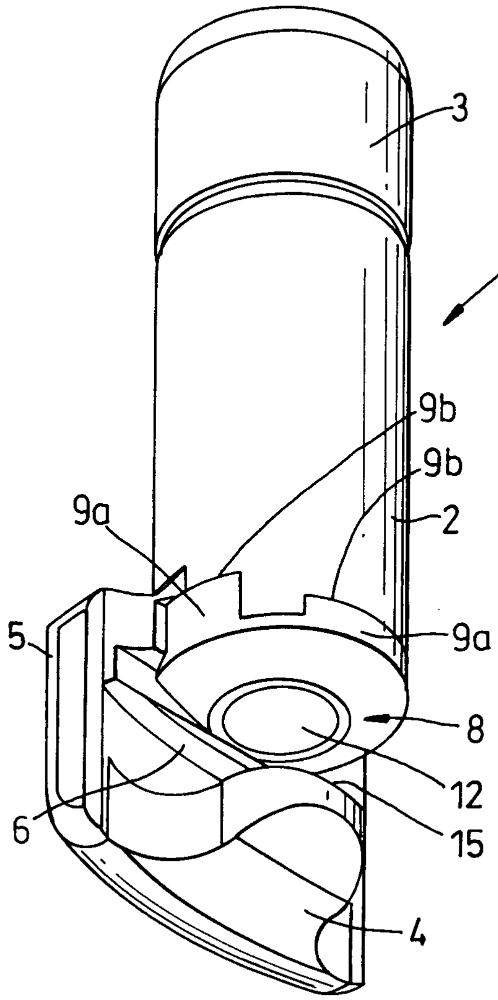

Fig. 1

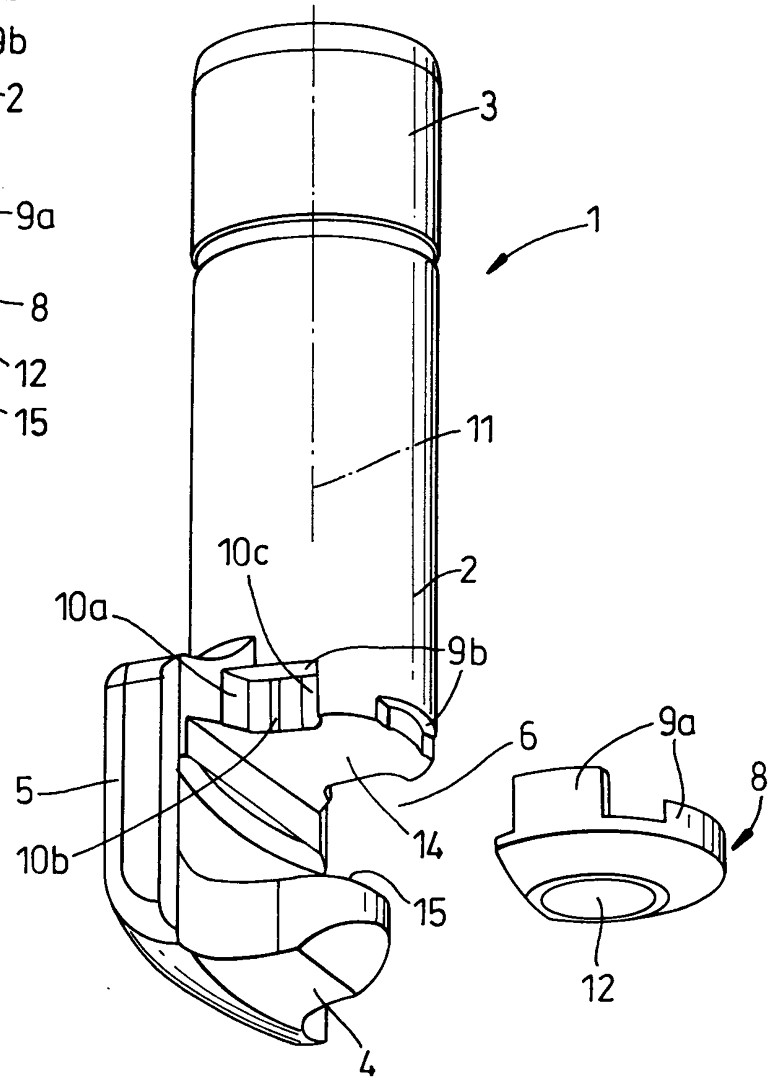

Fig. 2

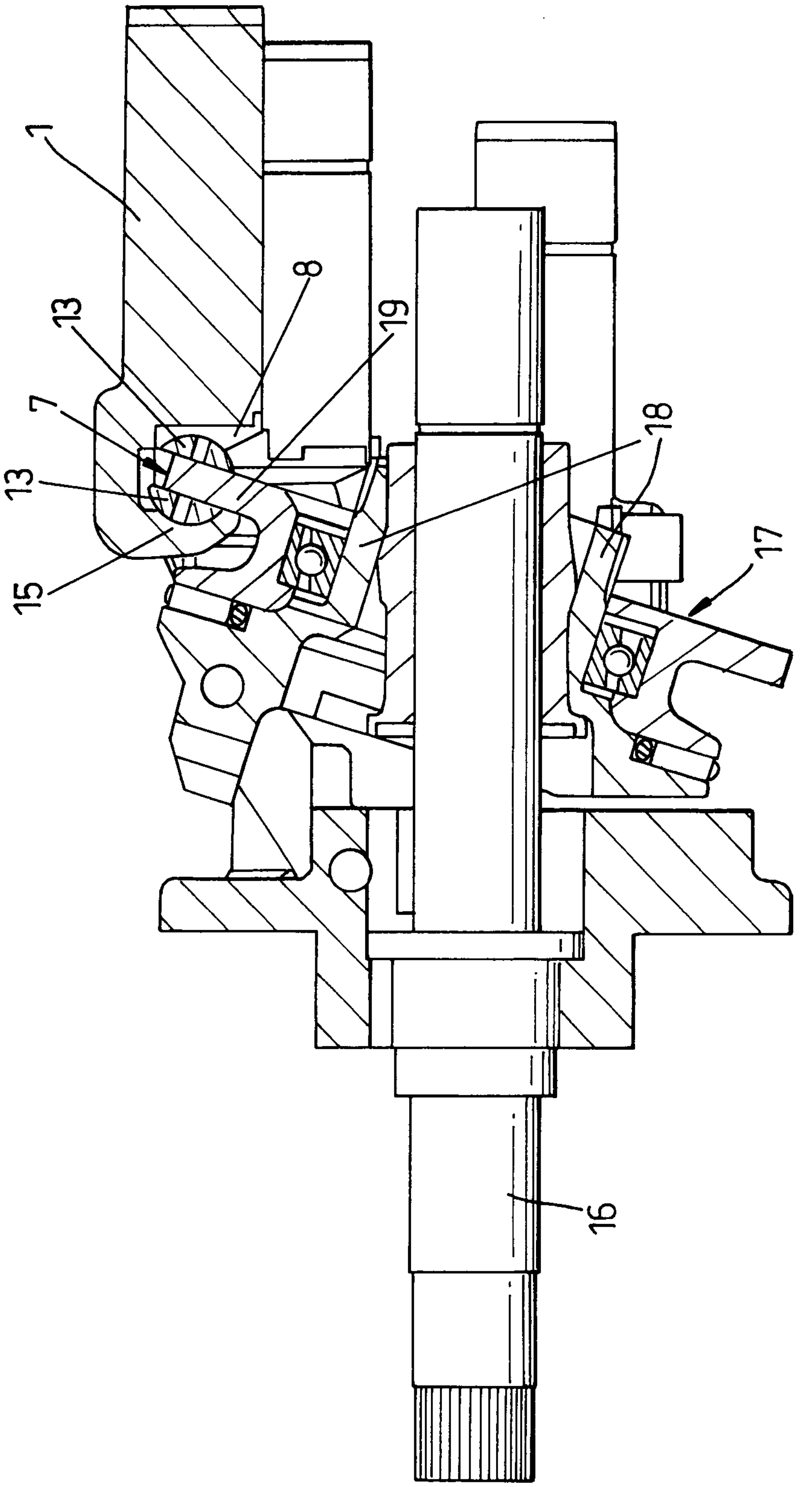

Fig. 3

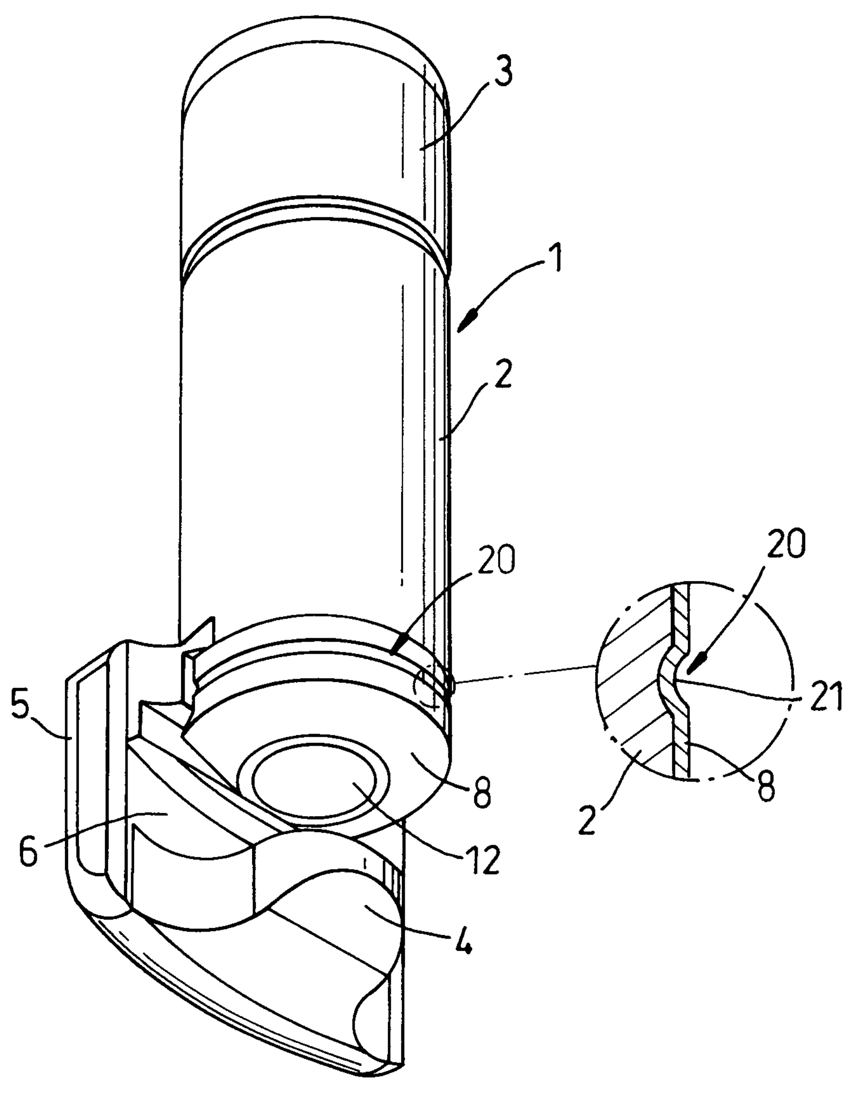

Fig. 4

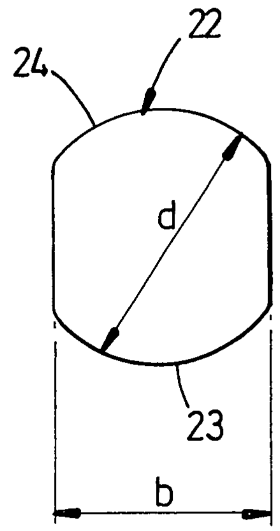

Fig. 5

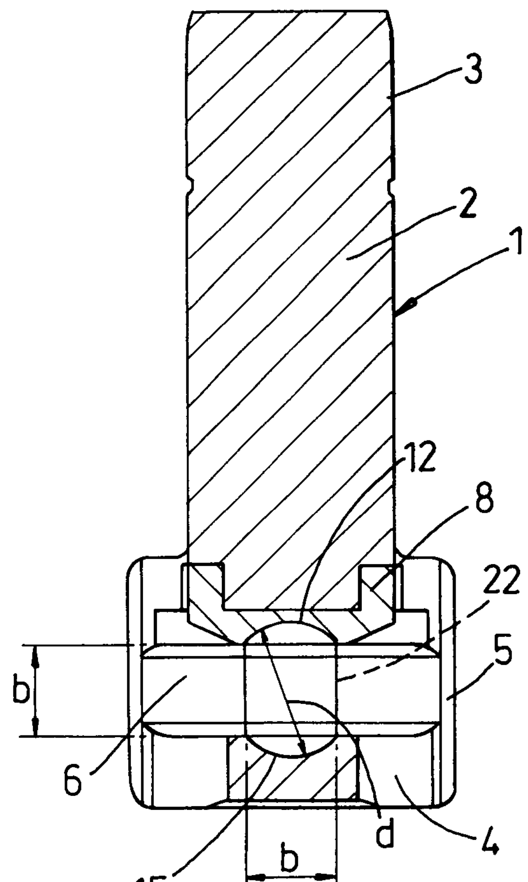

Fig. 6

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 01 10 9047

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	PATENT ABSTRACTS OF JAPAN vol. 017, no. 544 (M-1489), 30 September 1993 (1993-09-30) -& JP 05 149246 A (SANDEN CORP), 15 June 1993 (1993-06-15) * abstract; figures 1-6 * ---	1-3,11, 16,19-25	F04B27/08
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	29 August 2001	Ingelbrecht, P

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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