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

(11) **EP 4 575 225 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
25.06.2025 Bulletin 2025/26

(21) Application number: **23218579.3**

(22) Date of filing: **20.12.2023**

(51) International Patent Classification (IPC):
F04B 1/126 *(2020.01)* ***F04B 27/08*** *(2006.01)*

(52) Cooperative Patent Classification (CPC):
F04B 1/126; F04B 27/0882; F04B 27/0886

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
KH MA MD TN

(71) Applicant: **Danfoss A/S**
6430 Nordborg (DK)

(72) Inventors:
- **Svendsen, Morten**
  6430 Nordborg (DK)
- **Iversen, Frank Holm**
  6430 Nordborg (DK)
- **Nielsen, Rasmus**
  6430 Nordborg (DK)

(74) Representative: **Keil & Schaafhausen**
Patentanwälte PartGmbB
Bockenheimer Landstraße 25
60325 Frankfurt am Main (DE)

(54) BALL SUPPORT ARRANGMENT FOR AXIAL PISTON MACHINES

(57) The present invention relates to a ball support arrangement for a piston shoe arrangement (1) , wherein the piston shoe arrangement (1) is configured to be provided in an axial piston machine, wherein the piston shoe arrangement (1) comprises a piston body (2) having a ball shaped end (3) and a piston shoe (4), wherein the ball shaped end (3) is provided in the piston shoe (4), wherein the ball support arrangement is arranged between the piston shoe (4) and the balls shaped end (3).

The objective of the present invention is to provide a ball support arrangement, which is easy to replace and low on maintenance.

This objective is solved by a ball support arrangement, which is separate and replaceable, wherein at least a ball portion (5) of the ball support arrangement is configured to accommodate at least part of the ball shaped end (3),

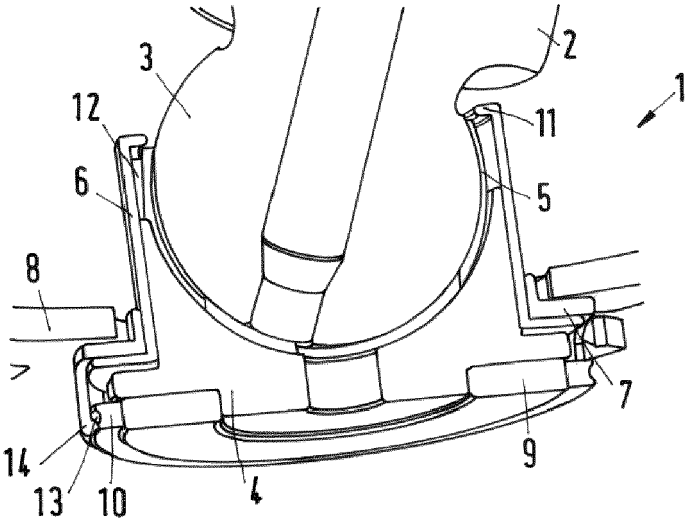

Fig.1

EP 4 575 225 A1

Description

[0001] The present invention relates to a ball support arrangement for a piston shoe arrangement , wherein the piston shoe arrangement is configured to be provided in an axial piston machine, wherein the piston shoe arrangement comprises a piston body having a ball shaped end and a piston shoe, wherein the ball support arrangement is arranged between the piston shoe and the ball shaped end.

[0002] Furthermore, the present invention relates to a piston shoe arrangement configured to be provided in an axial piston machine, wherein the piston shoe arrangement comprises a piston body having a ball shaped end and a piston shoe, wherein the ball shaped end is provided in the piston shoe, wherein a ball support arrangement is provided between the piston shoe and the ball shaped end.

[0003] Further, the present invention relates to an axial piston machine.

[0004] An axial piston machine is for example a hydraulic (variable displacement) pump or motor. The axial piston machine comprises pistons, which reciprocate within respective cylinders, wherein the cylinders are provided in a drum. The drum rotates relatively to a swash plate or vice versa, wherein the swash plate and the drum are arranged at an angle to each other.

[0005] The pistons are in contact with the swash plate via piston shoes. To do so, the piston comprises a ball shaped end, which is accommodated within a respective cup-shaped recess of the piston shoe, wherein a ball support arrangement is provided between the ball shaped end and the piston shoe. The ball support arrangement also provides lubrication and damping. Usually, this ball support arrangement is a synthetic material layer, which is molded onto the piston shoe.

[0006] The piston shoe comprises a sliding element through which the piston shoe is in contact to the swash plate.. In order to provide a low-wear interaction between the swash plate and the piston shoe, the sliding element is formed of ceramics, plastics, fiber reinforced plastics, non-ferrous metals or alike. The sliding element is connected to the piston shoe via a press-fit or similar connecting methods. Usually, the swash plate is made of steel and the piston shoe is made of fiber-reinforced plastic. For a more durable solution, ceramic is used against ceramic.

[0007] During operation of the axial piston machine, moving components, in particular the ball support arrangement, wear out. As soon as the ball support arrangement is worn out, it needs to be replaced. However, in the current design, the ball support arrangement is permanently molded onto the piston shoe, which locks the piston in place., That means the piston needs to be renewed as well. This requires a removal of the worn-out piston having a worn out ball support arrangement and an installation of a new piston having a new ball support arrangement. The replacement of the piston requires a high personal workload and maintenance effort. Furthermore, replacing the piston is cost intensive. It also means that still functional parts of the assembly are not reused as the whole assembly is exchanged.

[0008] Therefore, the objective of the present invention is to provide a ball support arrangement which requires a low maintenance effort and is cost effective.

[0009] This objective is solved by a ball support as described in the outset, wherein the ball support arrangement is separate and replaceable, wherein at least a ball holding portion of the ball support arrangement is configured to accommodate at least a part of the ball shaped end. The term "separate" means in the present application that the ball support arrangement is toolless mountable and dismountable to the piston shoe arrangement. There is no fastening means, adhesive or any other bonding means involved. By separating the ball support arrangement from the piston shoe, the ball support arrangement can be replaced by itself, without replacing the piston shoe as well. Thus, the piston does not need to be replaced, which results in a low maintenance effort. Further, solely the ball support arrangement can be replaced in a cost-effective manner and requires a low personal workload. Furthermore, the separation allows material pairings, which have a good friction characteristic, without being limited to certain materials which allow a molding connection. Furthermore, worn elements, e.g. ball support arrangements, can be replaced individually, resulting in less waste. Further, tolerances can be taken into account by using a separate ball support arrangements having respective dimensions. Moreover, wear compensation can be incorporated.

[0010] In one embodiment, the ball support arrangement is formed of at least one material of a group of materials comprising plastics, ceramics, metal and fibers, wherein plastics is preferably PEEK and the fibers are preferably carbon fiber and/or fiberglass. Furthermore, for example plastics material can comprise a filler, e.g. a ceramic powder. By using different materials for the piston, the piston shoe and/or the ball support arrangement, the lubrication and damping characteristics can be easily adapted to match a predetermined fluid transferred through the axial piston machine. For example, plastics, in particular thermoplastic materials, can be manufactured easily and cost effective by means of injection molding processes.

[0011] In one embodiment the ball support arrangement comprises a mounting arrangement configured to releasable mount the ball support arrangement to the ball shaped end and/or to the piston shoe. Using such a mounting arrangement allows that the ball support arrangement can be easily mounted and removed from the ball shaped end and/or from the piston shoe without requiring further fastening elements such as bolts, pins or alike, which results in a low maintenance and installation effort. For example, the mounting arrangement comprises protrusions, which are configured to interact with recesses of the piston shoe, and/or the mounting ar-

rangement comprises a recess, which is configured to interact with a protrusion of the piston shoe. This allows a positioning having a high repeat accuracy.

[0012] In one embodiment at least the ball holding portion is configured to be retained to the piston shoe by a retainer cup. The retainer cup provides additional stability to the ball support arrangement, in particular if the ball support arrangement is formed of a soft material, such as plastics.

[0013] In one embodiment the ball support arrangement, preferably at least the ball holding portion, is configured to be attached via a snap-on connection to the ball shaped end. In the present embodiment, at least the ball holding portion comprises at least one element that returns to its intended state after deformation. During a mounting process, the ball holding portion is deformed to be slipped over the ball shaped end. After the deformation, the ball support element, in particular at least the ball holding portion, returns to its intended shape such that the ball support arrangement is retained to the ball shaped end, e.g. by friction fit and/or press fit. In order to remove the ball support arrangement, at least the ball holding portion is deformed again to slip over the ball shaped end. This is an easy process which can be performed without any tools.

[0014] In one embodiment, the ball holding portion comprises multiple ball holding elements. For example, a first ball holding element is bowl-shaped, while a second ball holding element is annular. The first ball holding element is configured to be close to the swash plate compared to the second ball holding element, in an assembled state. Further, an inner diameter of the second ball holding element can be smaller than a diameter of the ball shaped end. If the first and second ball holding elements are provided on both sides of a diameter of the ball of the ball shaped end, a degree of movement of the ball shaped end in the piston shoe can be adjusted. As a result, the ball support arrangement can be adjusted to desired characteristics and tolerances can be taken into account.

[0015] In one embodiment, the ball support arrangement comprises a retainer portion which is configured to separate a retainer plate from the piston shoe and/or the retainer cup. As described above, the piston shoe interacts with the swash plate, wherein the piston shoe is coupled to the swash plate by the retainer plate, depending on a design of the axial piston machine. In operation, the piston shoe and the swash plate move relatively to each other. The wear affected area is provided on the retainer portion, such that the retainer portion wears out instead of the piston shoe respectively the retainer plate and/or the retainer plate. Furthermore, the ball support arrangement, in particular the retainer portion, can be easily replaced, which is cost-effective and a low workload.

[0016] In one embodiment, the ball holding portion and the retainer portion are formed in one piece or separate from each other. In one piece design, the positioning of the ball holding portion and retainer portion is always correct, which simplifies the assembly.

[0017] In one embodiment, the ball holding portion and the retainer portion are formed separate from each other. The ball holding portion and retainer portion are separated from each other, such that the ball holding portion and retainer portion can be arranged individually which provides good adjustment options.

[0018] In one embodiment, the ball support arrangement comprises an axis, wherein the ball support arrangement is symmetrical about the axis. In the present case, the term "symmetrical" means that at least one of the following symmetries is present: Rotational symmetry about the axis and/or mirror geometry wherein a mirror plane comprises the axis. Symmetrical elements are easy to design and easy to manufacture. Furthermore, the assembly is easy, since there is no limitation regarding an orientation about the axis.

[0019] In one embodiment, the ball holding portion comprises at least one first recess at least partly in a direction parallel to the axis and/or the retainer portion comprises at least one second recess in at least partly a direction perpendicular to the axis. The recess can accommodate for example debris, dust or other particles. This prevents a premature failure of the ball support arrangement. Furthermore, the at least one recess allow a certain flexibility, which can be adjusted by the design of the at least one recess. More recesses lead to a higher flexibility. Here, a compromise must be found between flexibility and stability. This depends on the size, number and shape of the recesses.

[0020] Further, the above objective is solved by a piston shoe arrangement as described in the outset, wherein the ball support arrangement is formed as described above.

[0021] By providing the above described ball support arrangement to the piston shoe arrangement, the piston shoe arrangement can be easily maintained, by replacing solely the ball support arrangement. This is cost effective and easily to do, since neither the piston nor the piston shoe as a whole need to be replaced. Only the worn parts, in particular the ball support arrangement, are replaced.

[0022] In one embodiment, the ball support arrangement comprises a ball holding portion which is releasably connected to the piston shoe in a fixed manner. Thus, there is no relative movement between the piston shoe and the ball support arrangement, which leads to a low wear.

[0023] Further, the above objective is solved by an axial piston machine comprising the above described piston shoe arrangement having the above described ball support arrangement. By being able to replace solely worn-out parts, maintaining the axial piston machine is easy, cost effective and requires low maintenance effort, respectively a low personal workload.

[0024] In the following, preferred embodiments of the invention are described in conjunction with the drawing. Herein shown:

Fig. 1 A first embodiment of a piston shoe arrangement;
Fig. 2 a spring guide of the first embodiment;
Fig. 3 a ball support arrangement of the first embodiment;
Fig. 4 an alternative sliding arrangement of the first embodiment;
Fig. 5 a second embodiment of a piston shoe arrangement;
Fig. 6 a third embodiment of a piston shoe arrangement;
Fig. 7 a ball support arrangement of the third embodiment;
Fig. 8 a fourth embodiment of a piston shoe arrangement;
Fig. 9 a fifth embodiment of a piston shoe arrangement;
Fig. 10 a ball support arrangement of the fifth embodiment;
Fig. 11 a sixth embodiment of a piston shoe arrangement;
Fig. 12 a ball support arrangement of the sixth embodiment;
Fig. 13 a seventh embodiment of a piston shoe arrangement;
Fig. 14 an eighth embodiment of a piston shoe arrangement.

[0025] Identical components/elements are given the same reference numbers throughout the description.

[0026] Fig. 1 shows a cross sectional view of a first embodiment of a piston shoe arrangement 1 having a piston body 2 with a ball shaped end 3, wherein at least a part of the ball shaped end 3 is arranged in a piston shoe 4. Between the piston shoe 4 and the ball shaped end 3 a ball holding portion 5 is provided. The ball holding portion 5 is retained to the piston shoe 4 by a retainer cup 6. A retainer portion 7 of the ball support arrangement is arranged between the retainer cup 6 and a retainer plate 8. The piston shoe 4 interacts via a friction sealing element 9 with a not depicted swash plate. The friction sealing element 9 is slide press fitted onto the piston shoe 4 and is compressed by a compression ring 10. Further, the friction sealing element 9 is formed of a ceramic material. The compression ring 10 comprises an annular groove 13 on its radially outer side. The retainer portion 7 releasably interlocks by a nib 14 with the groove 13. The retainer plate 8 couples the piston shoe arrangement 1 to a not shown swash plate.

[0027] In the first embodiment, the ball support arrangement is formed of the ball holding portion 5 and the retainer portion 7.

[0028] The piston shoe 4, the retainer cup 6, and the ball holding portion 5 share a not depicted axis, wherein the piston shoe 4, the retainer cup 6, and the ball holding portion 5 are at symmetrical about this axis, rotational symmetrical about the axis or mirror symmetric about a plane, wherein the plane comprises the axis.

[0029] The retainer cup 6 comprises an annular projection 11, which interacts with a top region of the ball holding portion 5 to retain the ball holding portion 5 to the piston shoe 4. In the present case, the ball holding portion 5 comprises protrusions 12 which protrude radially outward with regard to the axis and form ribs on the outer surface of the ball holding portion 5. These protrusions 12 interact with the annular projection 11.

[0030] As provided in Fig. 1 and 2, the retainer portion 7 comprises three sections. A first section is annular and provided on an inside diameter of a second section protruding in a direction of the axis, wherein the second section protrudes in a direction radially outward of an axial end of the first section. The third section is provided on the second section at its outer diameter, wherein the third section protrudes in an opposite direction of the first section. The third section is basically a ring being interrupted several times. At the axial end of the third section a nib 13 is provided which allows a coupling to the groove 14 of the compression ring 10. The retainer portion 7 provides a lubrication and dampening between the retainer cup 6 and the retainer plate 7 in axial and radial direction.

[0031] Fig. 3 shows the ball holding portion 5 of the first embodiment. The ball holding portion 5 is formed in a cup shape to accommodate the ball shaped end 3. The ball holding portion 5 comprises several recesses 15 which are arranged at last partly in a direction for the axis, forming several fingers 16 which are connected to each other in an axial direction. The ball holding portion 5 comprises a hole 17, wherein a hole axis is concentrical to the above described axis. The protrusions 12 are arranged on the outside of the ball holding portion 5, respectively the fingers 16.

[0032] Further, the ball holding portion 5 is formed of plastics, in particular or PEEK. The ball holding portion 5 deforms elastically during an installation process to the ball shaped end 3, wherein the fingers 16 are pushed apart to accommodate the ball shaped end 3. As soon as the ball holding portion 5 is in its final position, the ball holding portion 5 returns to its original, respectively intended, shape. The deformation during assembly is a so called snap-on connection. The mounting assembly may comprise the snap-on connection for example.

[0033] Fig. 4 depicts a cross sectional view of an alternative design of the compression ring 10 and the friction sealing element 9 in a cross sectional view. The remaining elements are identical to the one described with regard to Fig. 1. In the embodiment shown in Fig. 4, the compression ring 10 is formed in one piece with the piston shoe 4. For installing the friction sealing element 9, the piston shoe 4 enlarged by heating. After insertion of the friction sealing element 9, the piston shoe 4 is cooled and shrinks in its original state and compresses the friction sealing element. 9. In this embodiment, the retainer portion 7 comprises only the first and second section.

[0034] Fig. 5 shows a second embodiment in a cross

sectional view, wherein a piston shoe arrangement 1 having a piston body 2, a ball shaped end 3 and a piston shoe 4. The piston body 2 its ball shaped end, and the piston shoe 4 are formed of a ceramic material. The piston shoe 4 is compressed by a compression ring 10, to which the retainer cup 6 is mounted. The retainer cup 6 retains the ball holding portion 5 of the ball support arrangement to the piston shoe 4. Furthermore, a retainer portion 7 is provided between the retainer cup 6 and a retainer plate 8. The ball holding portion 5 is formed identically to the one of the first embodiment. The ball shaped end 3, the piston shoe 4, the ball holding portion 5, the retainer cup 7 and the compression ring 10 are symmetrically about the axis being located concentrically to the compression ring 10, respectively an outside circumferential surface of piston shoe 4. In this embodiment, the ball support arrangement is formed of the ball holding portion 5 and the retainer portion 7. The retainer portion 7 is formed similar to the one of the first embodiment, wherein the retainer portion 7 comprises in the second embodiment solely the first and second sections.

[0035] Fig. 6 shows a third embodiment in a cross sectional view, wherein a ball holding portion 5 and a retainer portion 7 are formed in one piece, forming together the ball support arrangement. The piston body 2, the ball shaped end 3 and the piston shoe 4 are formed of a ceramic material. The piston shoe 4 is compressed by a surrounding compression ring 10. The retainer plate 8 is separated by the retainer portion 7 from the compression ring 10, while the retainer portion 7 guides the retainer plate 8 in an axial and radial direction about the axis, wherein the axis is concentrically to the outer circumferential surface of the piston shoe 4.

[0036] Fig. 7 shows the ball support arrangement of the third embodiment. The ball holding portion 5 is similar to the one of the first embodiment, wherein the first and section of the retainer portion 7 of the first embodiment and the ball holding portion 5 are formed in one piece. Thus, the fingers 16 of the ball holding portion 5 are thickened by the size of the first section of the retainer portion. Further, there is no third section and no protrusion 12 provided in this embodiment compared to the first embodiment. The second section, which protrudes in a radial direction of the axis, comprises several notches 17 intercepting the retainer portion in a circumferential direction.

[0037] Fig. 8 shows a fourth embodiment of a piston shoe arrangement 1 having a ball support arrangement. A piston body 2, a ball shaped end 3 and a piston shoe 4 are formed of ceramics, wherein the piston shoe 4 is compressed in a radial direction by a compression ring 10. The ball shaped end 3 is supported by two ball support elements 5a, 5b, wherein the ball support elements 5a,5b form together the ball holding portion 5.

[0038] The first ball support element 5a is cup shaped having a rim provided on its widest opening diameter. The first ball support element 5 interacts with the piston shoe 4 and is arranged between the piston shoe 4 and the ball shaped end 3. The second ball support element 5b is an annular ring and is provided distanced to the first ball support element 5a in a direction of the axis pointing away from the piston shoe 4. The retainer cup 6 retains the second ball support element 5b, wherein the second ball support element 5b is in touching contact with the retainer cup 6 and the ball shaped end 3.

[0039] A retainer portion 7 is provide on the outside of the retainer cup 6. The retainer cup 6 is radially and axially held to the compression ring 10. The retainer portion 7 is annular comprising a U-shape cross-section, wherein the opening of the U-shape points in a radial direction outwardly. In this embodiment, the ball support arrangement is formed of the first and second ball support elements 5a,5b and the retainer portion 7.

[0040] Each of the first and second ball support elements 5a, 5b may comprise at least one recess. This design allows an easy installation, while debris, dirt and/or dust is collected in the respective recess.

[0041] Fig. 9 depicts a fifth embodiment in a cross sectional view, wherein a piston body 2 and its ball shaped end 3 are formed of steel. A piston shoe 4 is formed of a ceramic material and is compressed by a compression ring 10. An annular element 18 protrudes from the compression ring 10 pointing in an axial direction of the axis away from the piston shoe 4. The ball support arrangement is formed of a ball holding portion 5 being integrally formed with the retainer portion 7. The annular element 18 is arranged between the retainer portion 7 and the ball holding portion 5 in particular between a first section and the ball holding portion 5. The retainer portion 7 provides an axial and radial guidance for a retainer plate 8 in respect to the compression ring 10, respectively to the piston shoe 4, and the corresponding axis. The retainer plate 8 is provided on the retainer portion 7, wherein the retainer portion 7 is arranged in an axial direction between the retainer plate 8 and the compression ring 10.

[0042] Fig. 10 shows the ball support arrangement of the fifth embodiment in a cross-sectional view. The retainer portion 7 comprises an L-shape, wherein one leg of the L-shape extends radially (corresponds to the second section as described above with regard to the first embodiment), and the other leg is axially (corresponds to the first section as described above with regard to the first embodiment) arranged with respect to the axis. The radially arranged leg is a continuous ring, wherein the radially arranged leg comprises several recesses 15, which transition into recesses 15 of the ball holding portion 5. The recesses 15 follow the shape of the ball holding portion 5 and project at least partially in the axial direction with regard to the axis.

[0043] Fig. 11 depicts a sixth embodiment in a cross-sectional view. A piston body 2, a ball shaped end 3 and a piston shoe 4 are formed of a metal, preferably steel. The ball support arrangement is formed of the ball holding portion 5 and a retainer portion 7 wherein the retainer portion 7 and the ball holding portion 5 are formed in one

piece. Similarly to the fifth embodiment, the piston shoe 4 comprises an annular element 18 protruding in the axial direction, wherein the annular element 18 is accommodated between the retainer portion 7 and the ball holding portion 5.

[0044] Fig. 12 depicts the ball support arrangement of the sixth embodiment in a cross-sectional view. This ball support arrangement is similar to the one of the fifth embodiment, the axial leg of the retainer portion 7 comprises several recesses 15, which transition into recesses 15 provided in the ball holding portion 5.

[0045] Figs. 13 and 14 depict both piston shoe arrangements similar to the one of the sixth embodiment. Fig. 13 shows a seventh embodiment in a cross-sectional view, wherein a piston shoe 4 is equipped with a friction sealing element 9, wherein the friction sealing element 9 is configured to be in contact with a not depicted swash plate. The friction sealing element 9 is formed of plastics. Furthermore, the friction sealing element 9 comprises a ring shape, wherein the friction sealing element 9 is compressed by the compression ring 10 provided integrally with the piston shoe 4. The ball support arrangement of seventh embodiment is identical to the one of the sixth embodiment.

[0046] Fig. 14 depicts an eighth embodiment in a cross sectional view. A piston shoe 4 is integrally formed with a compression ring 10, wherein the compression ring 10 and a ring projection 20 provided radially inward of the compression ring 10. The compression ring 10 and the ring projection 20 form together an annular groove which accommodates the friction sealing element 9. The ring projection 20 comprises further an O-ring groove, which in conjunction with an O-ring 19 creates a sealed connection to the friction sealing element 9. The ball support arrangement of eighth embodiment is identical to the one of the sixth embodiment.

[0047] Depending on the required characteristics, a not depicted axial piston machine can be equipped with any of the above described ball support arrangements, respectively the piston shoe arrangements 1. The piston shoe arrangement 1 is coupled to a swash plate of the axial piston machine.

[0048] Each of the above described piston bodies 2, ball shaped ends 3, piston shoes 4 and ball holding portions 5, 5a, 5b is symmetrical, in terms of rotational symmetrical or mirror symmetrical, about an axis. The axis is arranged concentrically to an outer circumferential surface of the piston shoe 4.

[0049] Each of the above described piston bodies 2, ball shaped ends 3, piston shoes 4 and ball holding portions 5, 5a, 5b comprises an axial hole. Wherein the hole is a through hole in the ball shaped ends 3, piston shoes 4 and ball holding portions 5, 5, 5b.

[0050] In each embodiment, the piston body 2 and the ball shaped end 3 are formed in one piece. Therefore, the piston body 2 and the ball shaped end 3 are formed of the same material.

[0051] The ball support arrangement, in particular the ball holding portion 5, is formed to provide a friction fit, or a press fitted fit to the piston shoe 4, the retainer cup 6 and or the compression ring 10, which reassembles a mounting arrangement. This allows an easy mounting and disassembly.

[0052] A flexibility of the ball holding portion 5 is increased by the recesses 15, such that its diameter can be extended during a mounting operation to the ball shaped end 3. As soon as the ball holding portion 5 is provided in its position on the ball shaped end 3, the ball holding portion 5 returns to its intended respective original form. This reassembles a preferred version of the above described mounting arrangement in terms of a snap-on connection.

Reference numbers

[0053]

1	piston shoe arrangement
2	piston body
3	ball shaped end
4	piston shoe
5	ball holding portion
5a, 5b	ball support element
6	retainer cup
7	retainer portion
8	retainer plate
9	friction sealing element
10	compression ring
11	annular projection
12	protrusion
13	groove
14	nib
15	recess
16	finger
17	notch
18	annular element
19	O-ring
20	ring projection

Claims

1. A ball support arrangement for a piston shoe arrangement (1), wherein the piston shoe arrangement (1) is configured to be provided in an axial piston machine, wherein the piston shoe arrangement (1) comprises a piston body (2) having a ball shaped end (3) and a piston shoe (4), wherein the ball shaped end (3) is provided in the piston shoe (4), wherein the ball support arrangement is arranged between the piston shoe (4) and the balls shaped end (3), **characterized in that** the ball support arrangement is separate and replaceable, wherein at least a ball holding portion (5) of the ball support arrangement is configured to accommodate at least part of the ball shaped end (3).

2. The ball support arrangement according to claim 1, wherein the ball support arrangement is formed of at least one material of a group of materials comprising plastics, ceramics, metal and fibers, wherein the plastics is preferably PEEK and the fibers are preferably carbon fiber and/or fiberglass.

3. The ball support arrangement according to claim 1 or 2, wherein ball support arrangement comprises a mounting arrangement configured to releasable mount the ball support arrangement to the ball shaped end and/or to the piston shoe.

4. The ball support arrangement according to claim 1 or 2, wherein at least the ball holding portion (5) is configured to be retained to the piston shoe (4) by a retainer cup (6).

5. The ball support arrangement according to any of claims 1 to 4, wherein the ball support arrangement, preferably at least the ball holding portion (5), is configured to be attached via a snap-on connection to the ball shaped end (3).

6. The ball support arrangement according to any of claims 1 to 5, wherein the ball holding portion (5) comprises multiple ball support elements (5a,5b).

7. The ball support arrangement according to any of claims 1 to 6, wherein the ball support arrangement comprises a retainer portion (7), which is configured to separate a retainer plate (8) from the piston shoe (4) and/or the retainer cup (6).

8. The ball support arrangement according to claim 6, wherein the ball holding portion (5) and the retainer portion (7) are formed in one piece or

9. The ball support arrangement according to claim 6, wherein the ball holding portion (5) and the retainer portion (7) are separate from each other.

10. The ball support arrangement according to any of claims 1 to 6, wherein the ball support arrangement comprises an axis wherein the ball support arrangement is symmetrical about the axis.

11. The ball support arrangement according to any of claims 1 to 7, wherein the ball holding portion (5) comprises at least one recess (14) in at least partly a direction parallel to the axis and/or the retainer portion comprises at least one notch (16) at least partly in a direction perpendicular to the axis.

12. A piston shoe arrangement (1) configured to be provided in an axial piston machine, wherein the piston shoe arrangement (1) comprises a piston body (2) having a ball shaped end (3) and a piston shoe (4), wherein the ball shaped end (3) is provided in the piston shoe (4), wherein a ball support arrangement is provided between the piston shoe (4) and the ball shaped end (3), **characterized in that** the ball support arrangement is formed according to any of claims 1 to 10.

13. The piston shoe arrangement (1) according to claim 8, wherein the ball support arrangement (1) comprises a ball holding portion (5), which is releasably connected to the piston shoe (4) in a fixed manner.

14. An axial piston machine comprising a piston shoe arrangement (1) according to claim 11 or 12.

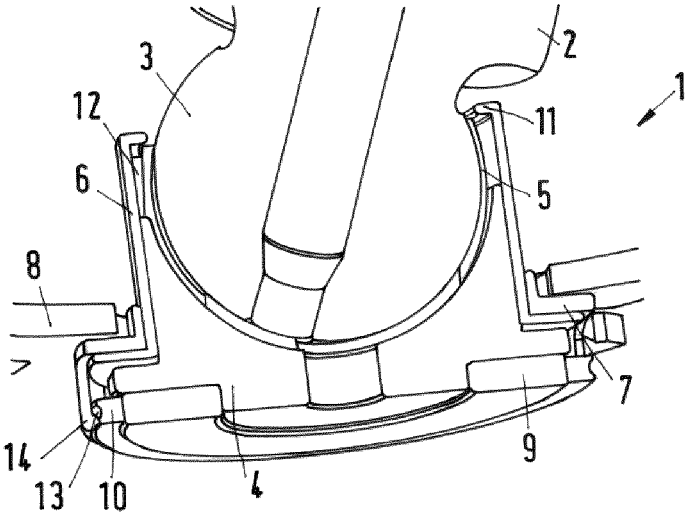

Fig.1

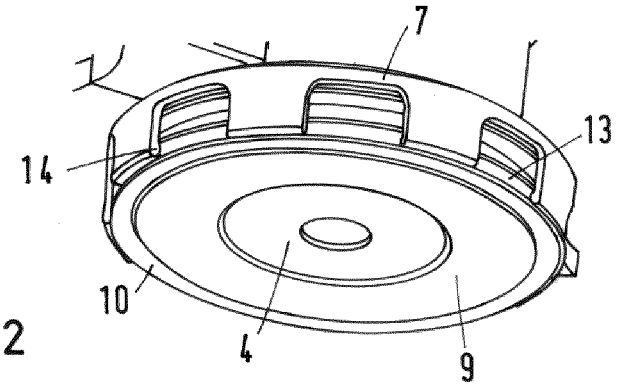

Fig.2

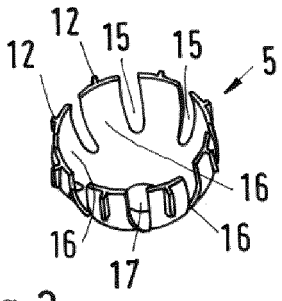

Fig.3

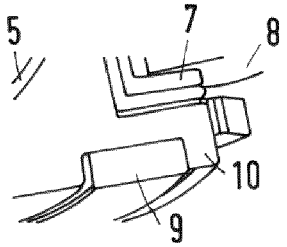

Fig.4

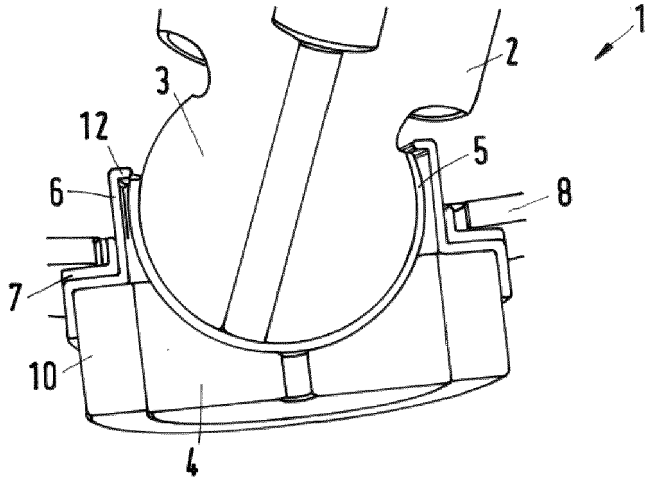

Fig.5

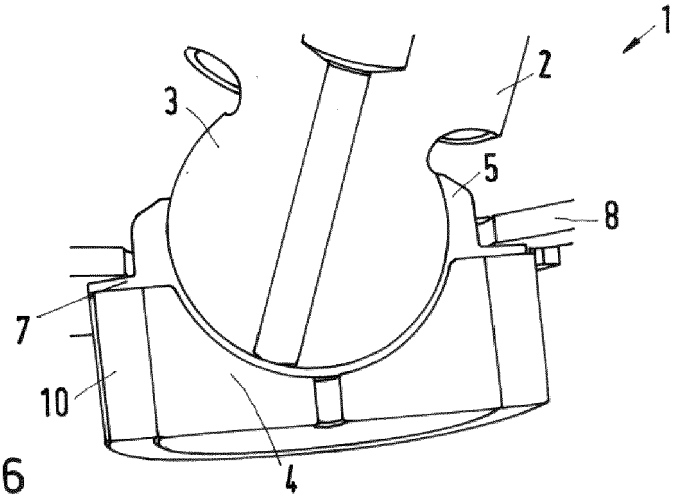

Fig.6

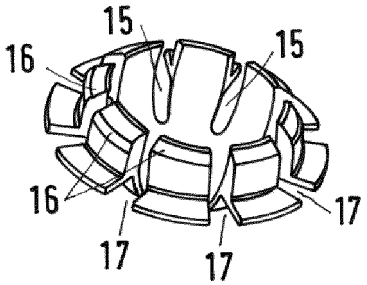

Fig.7

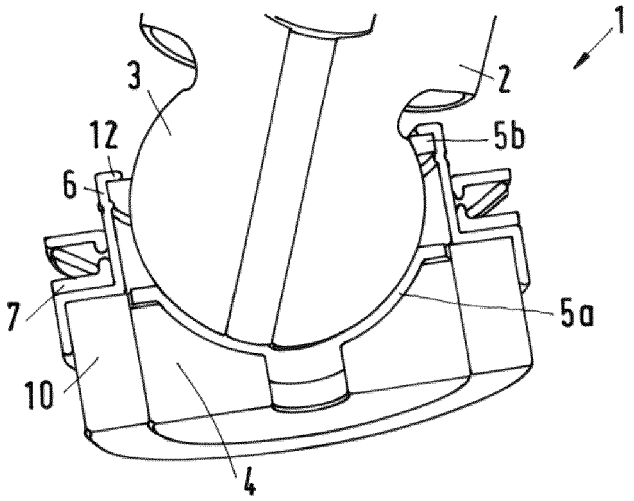

Fig.8

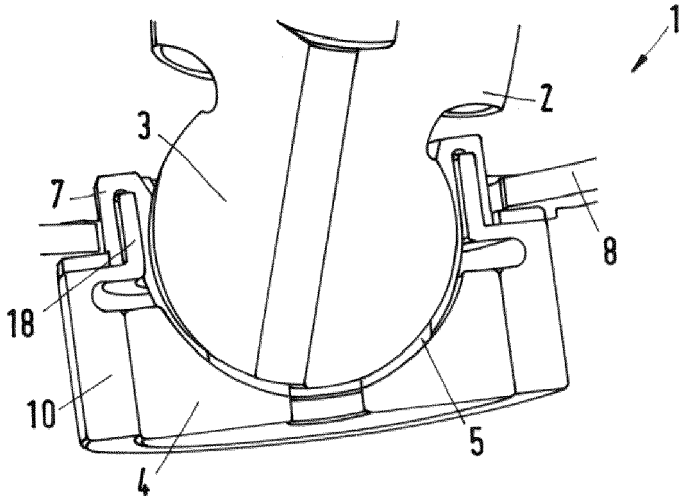

Fig.9

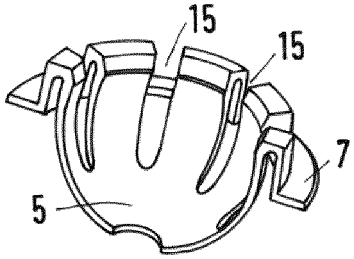

Fig.10

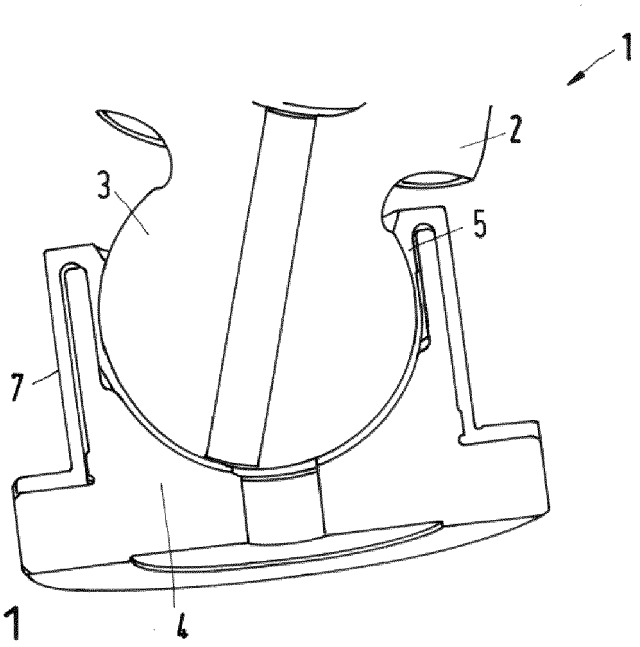

Fig.11

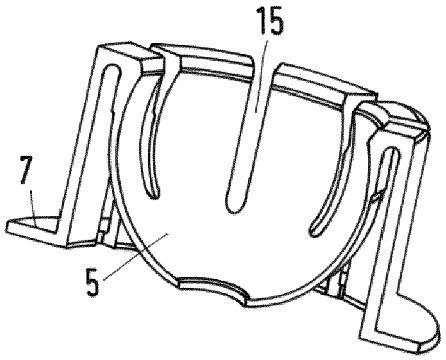

Fig.12

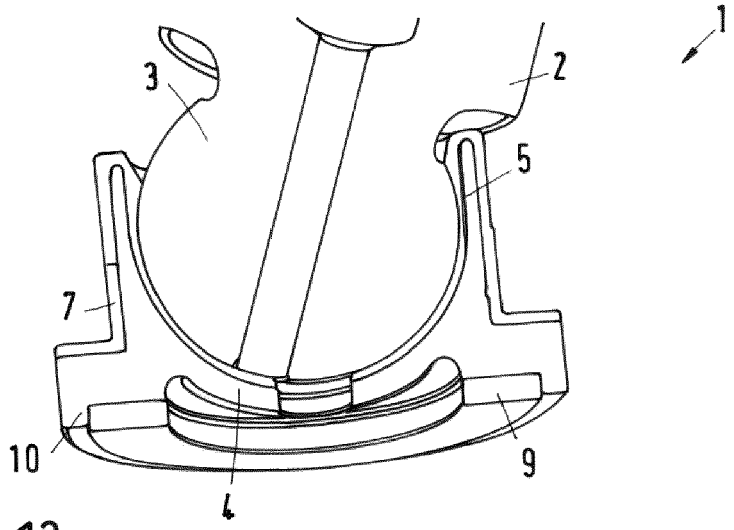

Fig.13

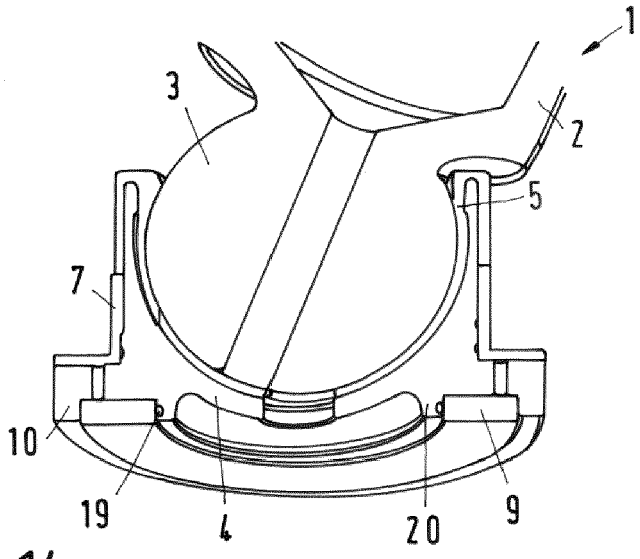

Fig.14

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 23 21 8579

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	JP 4 202832 B2 (EBARA CORP) 24 December 2008 (2008-12-24) * figures 1-7 * * paragraph [0002] - paragraph [0010] * * paragraph [0026] - paragraph [0042] *	1-14	INV. F04B1/126 F04B27/08
A	CA 948 923 A (NAT RES DEV) 11 June 1974 (1974-06-11) * page 8, line 5 - page 9, line 12; figures 10-14 *	1-14	
A	US 4 268 225 A (NAKAYAMA SHOZO ET AL) 19 May 1981 (1981-05-19) * figures 1-10 * * column 3, line 28 - column 7, line 29 *	1-14	
A	CN 116 857 143 A (UNIV HUAQIAO) 10 October 2023 (2023-10-10) * figures 1-2 * * paragraph [0023] - paragraph [0033] *	1-14	
A	US 2008/223207 A1 (OLSEN PALLE [DK] ET AL) 18 September 2008 (2008-09-18) * figures 1-6 * * paragraph [0033] - paragraph [0053] *	1-14	TECHNICAL FIELDS SEARCHED (IPC) F04B
A	GB 1 355 325 A (AISIN SEIKI) 5 June 1974 (1974-06-05) * figures 1-13 * * page 2, line 15 - page 3, line 61 *	1-14	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	28 February 2024	Ricci, Saverio

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 23 21 8579

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

28-02-2024

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 4202832 B2	24-12-2008	JP 4202832 B2	24-12-2008
		JP 2004084660 A	18-03-2004
CA 948923 A	11-06-1974	CA 948923 A	11-06-1974
		FR 2107138 A5	05-05-1972
		IT 939773 B	10-02-1973
US 4268225 A	19-05-1981	JP S5490606 A	18-07-1979
		JP S6137467 B2	23-08-1986
		US 4268225 A	19-05-1981
CN 116857143 A	10-10-2023	NONE	
US 2008223207 A1	18-09-2008	CN 101196182 A	11-06-2008
		DE 102006057364 A1	05-06-2008
		US 2008223207 A1	18-09-2008
GB 1355325 A	05-06-1974	GB 1355325 A	05-06-1974
		US 3866518 A	18-02-1975

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82