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(54) **AXIAL PISTON MACHINE HAVING A CONICAL PISTON**

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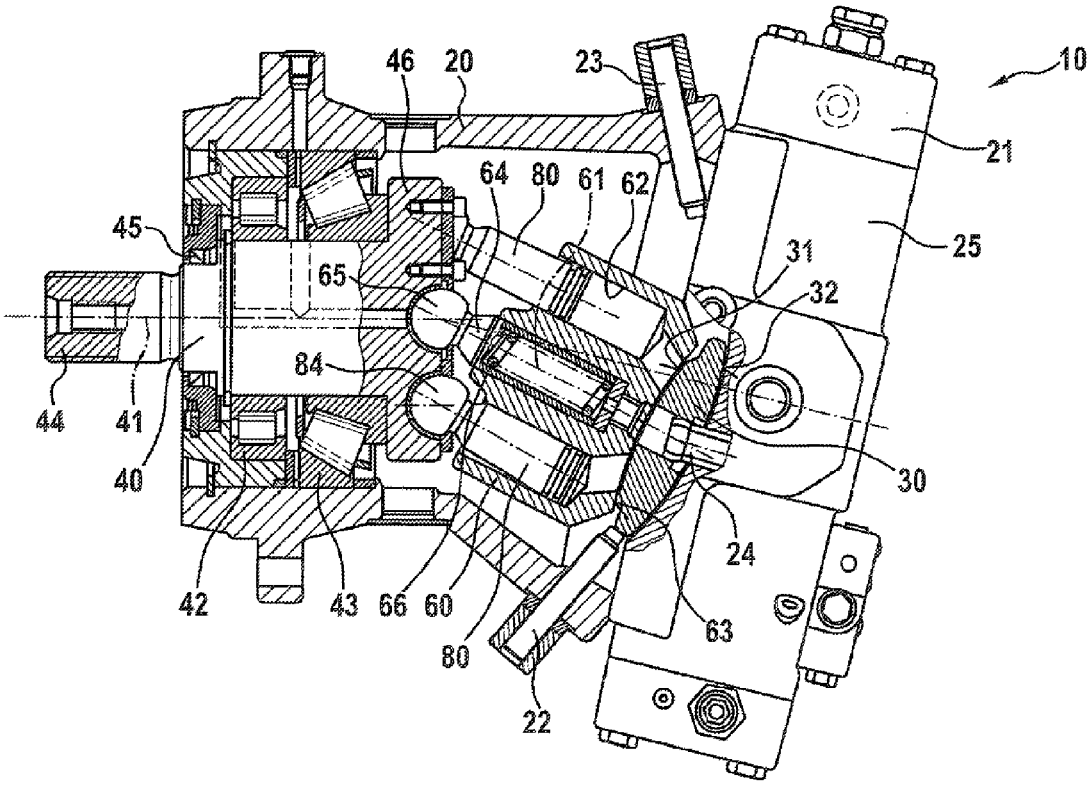
(57) **ABSTRACT**

An axial piston machine includes a housing, a drive shaft, and a cylinder drum. The drive shaft is mounted in the housing so as to be rotatable with respect to a first axis of rotation. The cylinder drum is mounted so as to be rotatable with respect to a second axis of rotation. The cylinder drum has at least one cylinder bore that linearly guides an elongate piston. The piston has a first end connected to the drive shaft by a ball joint and a section in the form of a circular cone which tapers toward the first end. The piston also has a spherical section at the second end that is situated opposite the first end. The cone-shaped section merges without offsets and kinks into the spherical section. The piston has a flat end face at the second end which defines a plane that intersects the spherical section.



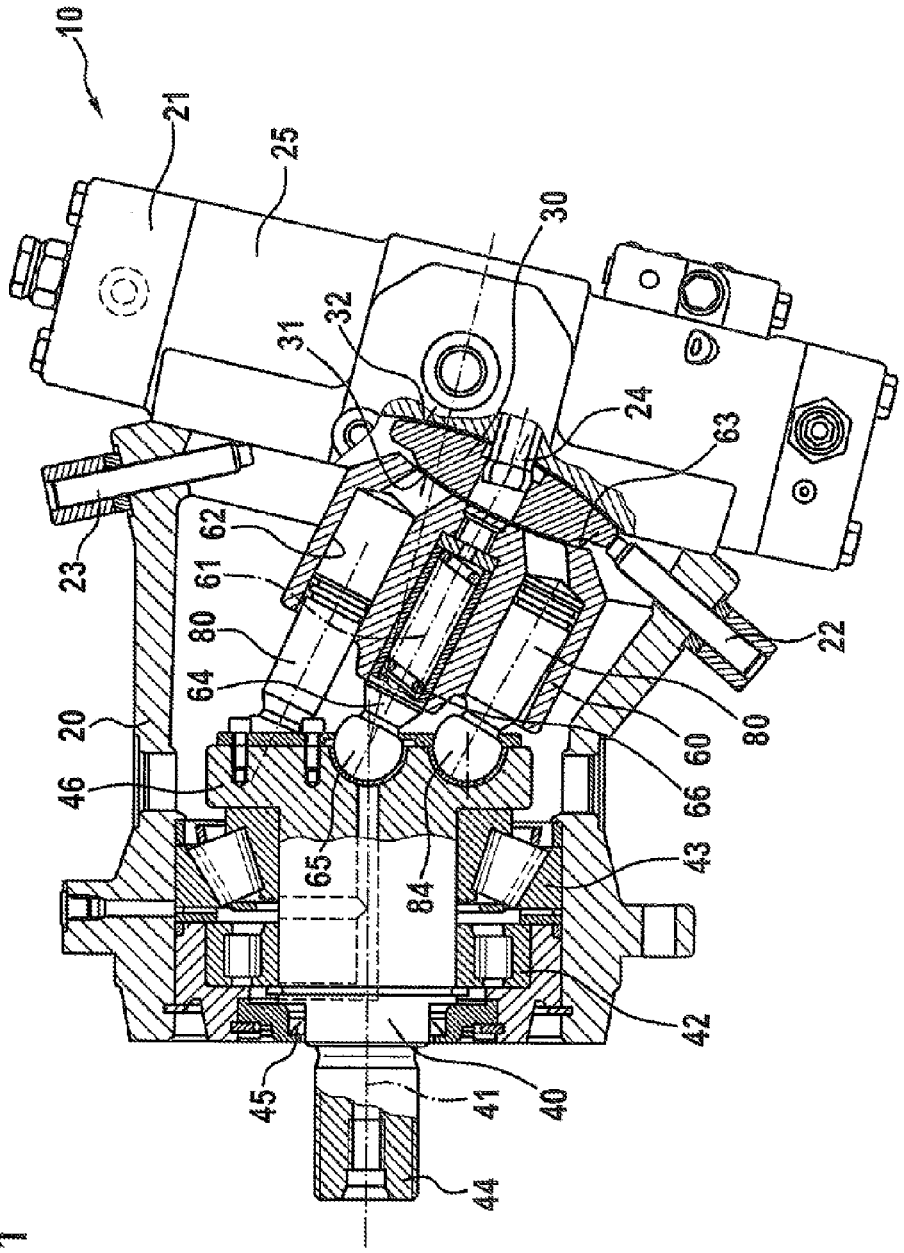

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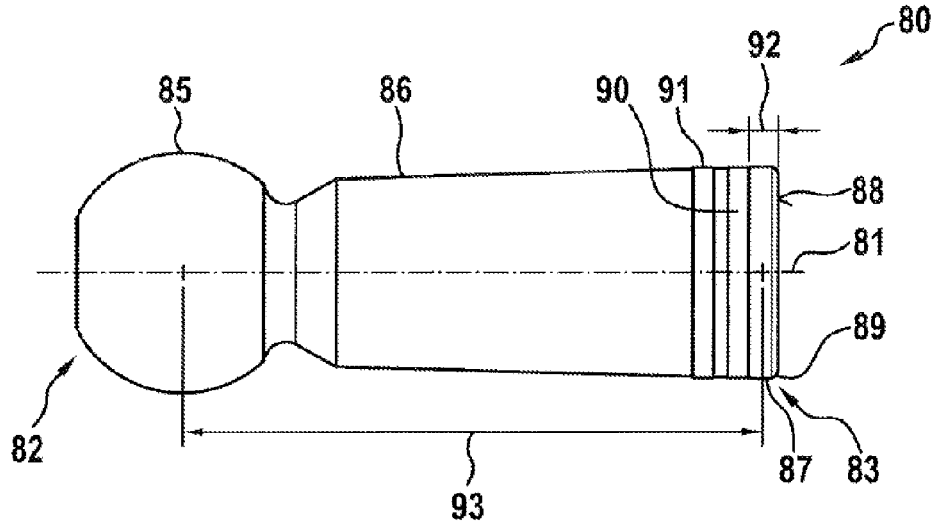
Fig. 1

Fig. 2



AXIAL PISTON MACHINE HAVING A CONICAL PISTON

[0001] This application claims priority under 35 U.S.C. §119 to patent application no. DE 10 2012 222 172.7 filed on Dec. 4, 2012 in Germany, the disclosure of which is incorporated herein by reference in its entirety.

BACKGROUND

[0002] The disclosure relates to an axial piston machine.

[0003] DE 23 58 870 B2 has disclosed an axial piston machine of oblique axis construction which can be operated either as a pump or as a motor. The axial piston machine comprises a housing, a drive shaft and a cylinder drum. The drive shaft is mounted in the housing in such a way as to be rotatable with respect to a first axis of rotation by means of a hydrostatic sliding bearing. The cylinder drum is mounted so as to be rotatable with respect to a second axis of rotation, which intersects the first axis of rotation. The angle of inclination between the first and second axes of rotation can be adjusted by means of an adjusting device, wherein the disclosure under consideration can also be used in the case of axial piston machines in which said angle of inclination is fixed. The cylinder drum has a plurality of circular-cylindrical cylinder bores, which are aligned parallel to the second axis of rotation. A piston is accommodated in each cylinder bore in a manner which allows linear motion, said piston being connected at a first end to the drive shaft by means of a ball joint. Here, the ball joint is arranged away from the first axis of rotation on a flange of the drive shaft. When the drive shaft rotates, the pistons rest against the cylinder bore, giving a rotary drive connection between the drive shaft and the cylinder drum. The pistons have a section in the form of a circular cone which tapers toward the ball joint. This enables the pistons to be tilted relative to the associated cylinder bores, ensuring that they do not jam during the rotation of the drive shaft. At the second end, that situated opposite the first end, the pistons have a spherical section, by means of which they rest in a substantially sealed manner on the cylinder bore, more specifically in each of the tilted positions thereof. This spherical section is also referred to as a piston land. The section in the form of a circular cone merges without offsets and kinks into the spherical section.

[0004] It is the object of the disclosure to minimize abrasion on the cylinder bore caused by the reciprocating motion of the pistons. At the same time, the installation space occupied by the axial piston machine should not be increased.

SUMMARY

[0005] According to the disclosure, this object is achieved by virtue of the fact that the piston has, at the second end, a flat end face, which forms a corner with the spherical section. This means that the distance between the bearing force in the ball joint and the bearing force on the spherical section of the piston for a given piston length is particularly large. At the same time, the length of the piston which projects into the cylinder bore is particularly great. The ratio between the two said lengths determines the magnitude of the supporting forces acting between the piston and the cylinder bore. The increase in said lengths means that said supporting forces are particularly small, thereby reducing wear on the cylinder bore. The end face of the piston is preferably aligned perpendicularly to a center line defined by the conical section.

[0006] Advantageous developments and improvements of the disclosure are given in the dependent claims.

[0007] The corner between the end face and the spherical section of the piston can have a radius or a chamfer. This enables the piston to be inserted easily into the cylinder bore during the assembly of the axial piston machine. At the same time, the radius or chamfer do not hinder the tilting movement of the associated piston.

[0008] The cylinder drum can be composed of cast iron. In the case of a cylinder drum made of cast iron, the wear caused by the piston on the cylinder bore is particularly great, and therefore the minimization according to the disclosure of said wear is particularly advantageous. The use of the following types of materials is preferred: EN-GJS-400-15, EN-GJS-400-18, EN-GJS-500-7 and EN-GJS-600-3

[0009] The cylinder drum can be produced by casting. As a result, the cylinder drum can be produced at a particularly low cost. The cylinder drum is preferably finish-machined in the region of the cylinder bore to ensure that the surface is particularly smooth and the bore diameter is particularly accurate there.

[0010] The cylinder bore can have a surface layer which has a greater hardness than the remainder of the cylinder drum. By means of the high hardness of said surface layer, wear can be further minimized Surface layers of this kind typically have a low thickness of, for example, less than 20 μm. The wear-related abrasion of said surface layer must never be greater than the thickness thereof during the entire operating life of the axial piston machine because the axial piston machine would otherwise suffer excessive wear after a very short time. The minimization according to the disclosure of wear in connection with the surface layer proposed is therefore particularly advantageous.

[0011] The section of the piston which is in the form of a circular cone can be interrupted adjacent to the spherical section by an encircling first groove, in which a separate first sealing ring is accommodated. It is not possible to completely exclude a small gap between the spherical section of the piston and the cylinder bore. It is for this reason that the seal at that point is supposed to be improved by the first sealing ring. This sealing ring can be designed in accordance with DE 10 2009 018 297 A1, for example. For optimum sealing, it is important that the first sealing ring should be arranged very close to the spherical section of the piston. At the same time, the first groove must not project into the spherical section since, otherwise, the contact between the spherical section and the cylinder bore would be disrupted. This would result in increased wear on the cylinder bore. By means of the proposed arrangement of the first sealing ring, the ring is protected by the spherical section from damage due to contaminants in the pressurized fluid.

[0012] The section of the piston which is in the form of a circular cone can be interrupted by an encircling second groove, in which a separate second sealing ring is accommodated, wherein the second sealing ring is arranged on the side of the first sealing ring remote from the spherical section. By means of the second sealing ring, sealing between the cylinder bore and the piston is further improved.

[0013] The width of the spherical section can be between 2 and 8 mm. This width has proven advantageous in tests carried out by the applicant.

[0014] A spherical head of the ball joint can be arranged on the first end of the piston, wherein the distance between the center of the spherical head and the spherical section of the

piston is between 80 mm and 140 mm. This distance has proven advantageous in tests carried out by the applicant. In particular, the overlap between the sealing rings and the cylinder bore for the maintenance of the sealing function in any position of the axial piston machine is assured.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] The disclosure is explained in greater detail below with reference to the attached drawings, in which:

[0016] FIG. **1** shows a longitudinal section through an axial piston machine according to the disclosure; and

[0017] FIG. **2** shows a side view of a piston of the axial piston machine shown in FIG. **1**.

DETAILED DESCRIPTION

[0018] FIG. **1** shows a longitudinal section through an axial piston machine **10** according to the disclosure. The axial piston machine **10** comprises a housing **20**, in which a drive shaft **40** is mounted in such a way as to be rotatable with respect to a first axis **41** of rotation. For this purpose, a first rotation bearing **42** in the form of a cylindrical roller bearing and a second rotation bearing **43** in the form of a taper roller bearing is installed between the drive shaft **40** and the housing **20**. A drive journal **44** of the drive shaft **40** projects from the housing **20** and can have a multi-spline shaft profile. A radial shaft sealing ring **45** is arranged between the drive shaft **40** and the housing **20** in the region of the drive journal **44** to ensure that no pressurized fluid, in particular no hydraulic oil, can escape from the axial piston machine **10** there.

[0019] At the opposite end from the drive journal **44**, the drive shaft **40** has a flange **46**. There, the drive shaft **40** is connected to a plurality of pistons **80**, in each case by means of an associated ball joint **84**. In this case, the ball joints **84** are arranged away from the first axis **41** of rotation.

[0020] A cylinder drum **60**, which has a circular-cylindrical cylinder bore **62** for each piston **80**, is furthermore provided. The end face **63** of the cylinder drum remote from the drive shaft **40** has a concave spherical curvature and rests on a matching first end face **31** on a control disk **30**. This engagement between the cylinder drum **60** and the control disk **30** forms a hydrostatic sliding bearing, by means of which the cylinder drum **60** is mounted so as to be rotatable with respect to a second axis **61** of rotation. The second axis **61** of rotation is defined by a separate bearing part **64**, which engages in the flange **46** of the drive shaft **40** by means of a ball joint **65**. In this case, the ball joint **65** is arranged at the point of intersection of the first and second axes **41**; **61** of rotation. The bearing part **64** engages by means of a circular-cylindrical section in a matching circular-cylindrical bore in the cylinder drum **60**, which are arranged concentrically with respect to the second axis **61** of rotation. A spring **66**, in particular a helical spring, is installed under preload between the bearing part **64** and the cylinder drum **60**, with the result that the cylinder drum **60** is pressed against the control disk **30**.

[0021] The second end face **32** of the control disk **30** is of circular-cylindrical design with respect to the point of intersection of the first and second axes **41**; **61** of rotation and rests against a matching circular-cylindrical surface on the end plate **25** of the housing **20**. The second axis **61** of rotation of the cylinder drum **60** can therefore be pivoted relative to the first axis **41** of rotation. For this purpose, an adjusting device **21** is provided on the housing **20**, being hydraulically actuable for example. The adjusting device **21** has a movable driver **24**, which engages in the control disk **30**, thus enabling it to move the latter with respect to the housing **20**. Here, the path of motion of the control disk **30** is limited by a first and a second end stop **22**; **23**, which are in the form of screw bolts which are screwed into the housing **20**. The greater the angle between the first and second axes **41**; **61** of rotation, the larger is the displacement volume, i.e. the sum of the swept volumes of all the pistons **80**, of the axial piston machine **10**.

[0022] FIG. **2** shows a side view of a piston **80** of the axial piston machine shown in FIG. **1**, wherein all the pistons **80** of the axial piston machine are of identical design. The piston **80** has a section **86** in the form of a circular cone which defines a center line **81** of the piston **80**. The section **86** in the form of a circular cone tapers toward a first end **82** of the piston. Arranged at the first end **82** of the piston **80** is the spherical head **85** of the ball joint by means of which the piston **80** is connected to the drive shaft. The center of the spherical head **85** is arranged on the center line **81**.

[0023] The spherical section **87** of the piston is arranged on the second end **83** of the piston **80**, the end opposite the first end **82**. The sphere diameter of the spherical section **87** corresponds to the bore diameter of the cylinder bore, wherein the center of the sphere is arranged on the center line **81**. The section **86** in the form of a circular cone merges without offsets and kinks into the spherical section **87**. The width **92** of the spherical section **87** is 3 mm, for example. The distance **93** between the spherical section **87** and the center of the spherical head **85** is 99.5 mm, for example. A flat end face **88**, which is aligned perpendicularly to the center line **81**, is furthermore provided on the second end **83** of the piston **80**. With the spherical section **87**, the end face **88** forms a corner, on which a small radius **89** is provided.

[0024] The section **86** in the form of a circular cone on the piston **80** is interrupted by a first and a second groove, which are formed in a rotationally symmetrical manner with respect to the center line **81**. A first sealing ring **90** is accommodated in the first groove, wherein a second sealing ring **91** is accommodated in the second groove. The first and/or second sealing ring **90**; **91** can be designed in accordance with DE 10 2009 018 297 A1, for example, the entire contents of which are incorporated by reference into the present application. The first sealing ring **90** is arranged as close as possible to the spherical section **87**. In the extreme case, that edge of the first groove which is on the right in FIG. **2** forms the boundary between the section **86** in the form of a circular cone and the spherical section **87**. In this case, the cone defined by the conical section **86** merges without offsets and kinks into the spherical section **87**.

LIST OF REFERENCE SIGNS

[0025] **10** axial piston machine
[0026] **20** housing
[0027] **21** adjusting device
[0028] **22** first end stop
[0029] **23** second end stop
[0030] **24** driver
[0031] **25** end plate
[0032] **30** control disk
[0033] **31** first end face of the control disk
[0034] **32** second end face of the control disk
[0035] **40** drive shaft
[0036] **41** first axis of rotation
[0037] **42** first rotation bearing
[0038] **43** second rotation bearing

[0039] **44** drive journal
[0040] **45** radial shaft sealing ring
[0041] **46** flange
[0042] **60** cylinder drum
[0043] **61** second axis of rotation
[0044] **62** cylinder bore
[0045] **63** end face of the cylinder drum
[0046] **64** bearing part
[0047] **65** ball joint of the bearing part
[0048] **66** spring
[0049] **80** piston
[0050] **81** center line
[0051] **82** first end of the piston
[0052] **83** second end of the piston
[0053] **84** ball joint of the piston
[0054] **85** spherical head
[0055] **86** section in the form of a circular cone
[0056] **87** spherical section
[0057] **88** end face
[0058] **89** radius
[0059] **90** first sealing ring
[0060] **91** second sealing ring
[0061] **92** width
[0062] **93** distance

What is claimed is:

1. An axial piston machine, comprising:

a housing;

a drive shaft mounted in the housing in such a way so as to be rotatable with respect to a first axis of rotation;

a cylinder drum mounted so as to be rotatable with respect to a second axis of rotation, the cylinder drum defining at least one circular-cylindrical cylinder bore; and

an elongate piston accommodated in the at least one circular-cylindrical cylinder bore in a manner which allows linear motion, the piston having (i) a first end connected to the drive shaft by a ball joint, (ii) a section in the form of a circular cone which tapers toward the first end, and (iii) a spherical section at a second end situated opposite the first end,

wherein the cone defined by the section in the form of a circular cone merges without offsets and kinks into the spherical section, and

wherein the piston has a flat end face at the second end which forms a corner with the spherical section.

2. The axial piston machine according to claim **1**, wherein the corner between the end face and the spherical section of the piston has a radius or a chamfer.

3. The axial piston machine according to claim **1**, wherein the cylinder drum is composed of cast iron.

4. The axial piston machine according to claim **3**, wherein the cylinder drum is produced by casting.

5. The axial piston machine according to claim **3**, wherein the cylinder bore has a surface layer that has a greater hardness than the remainder of the cylinder drum.

6. The axial piston machine according to claim **1**, wherein the section of the piston in the form of a circular cone is interrupted adjacent to the spherical section by an encircling first groove, and wherein a separate first sealing ring is accommodated in the first groove.

7. The axial piston machine according to claim **6**, wherein the section of the piston in the form of a circular cone is interrupted by an encircling second groove, wherein a separate second sealing ring is accommodated in the second groove, and wherein the second sealing ring is arranged on the side of the first sealing ring remote from the spherical section.

8. The axial piston machine according to claim **1**, wherein a width of the spherical section is between 2 mm and 8 mm.

9. The axial piston machine according to claim **1**, wherein a spherical head of the ball joint is arranged on the first end of the piston, and wherein a distance between the center of the spherical head and the spherical section of the piston is between 80 mm and 140 mm.

10. The axial piston machine according to claim **1**, wherein the axial piston machine is configured as a pump or a motor.

* * * * *