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(54) **Torque-transmitting and axially displaceable mounting**

(57) A torque-transmitting and axially displaceable mounting comprises a ball box (14) inserted in a bush receiving bore (12) of a casing (10) and having ball rings (16, 18) guided in raceways. Each ball ring has a load bearing ring portion which bears radially inwardly on a shaft (20) and radially outwardly on an outer thrust face. At least one ball ring has a torque transmitting ball ring portion (38) engaging a shaft side in a track groove (46) in a shaft and on a thrust face side in a track groove (48) in a running plate (50) incorporated in the ball box. The running plate is urged radially inwardly by a radial clamping device (60) disposed within a clamping bore (56). The clamping device has a contact face (66) which bears on the running plate and which intersects (at 68) a resultant plane (A or B) parallel with the axis of the mounting resulting from the torque transmission forces transmitted by the torque transmitting ball ring portion.

FIG.1

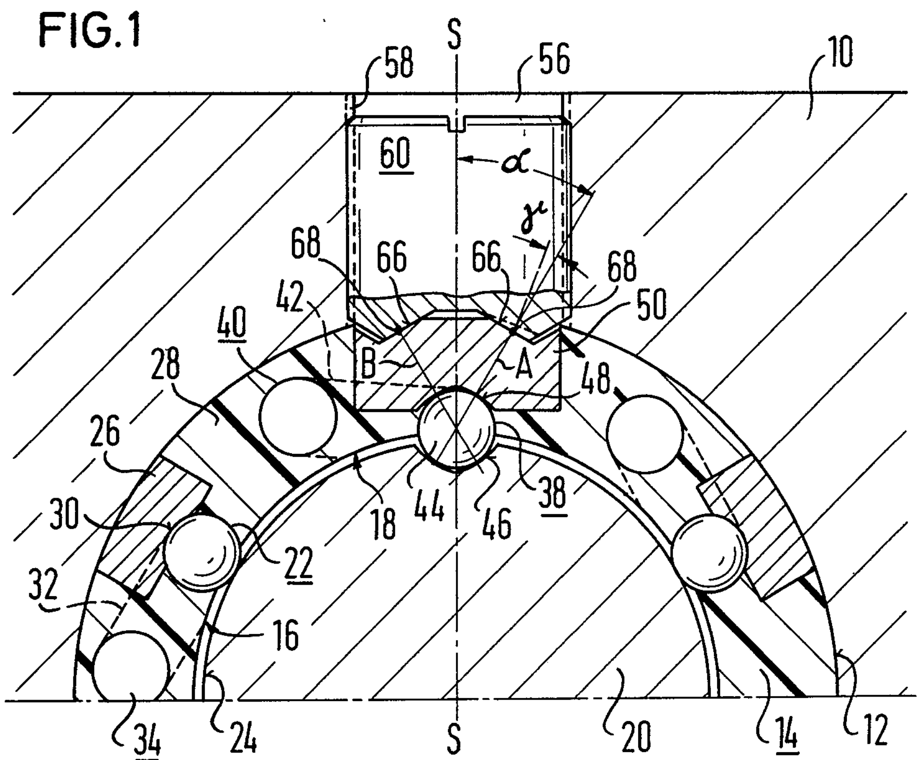

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FIG. 1

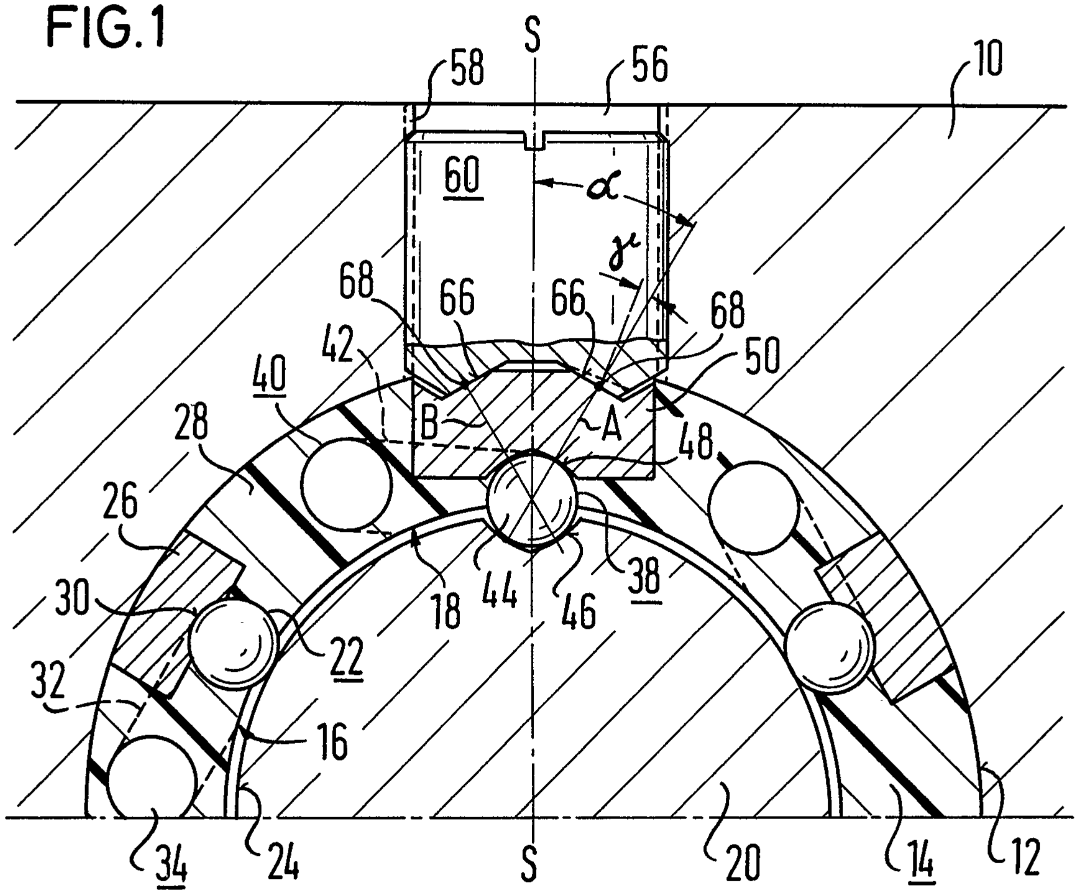


FIG. 2

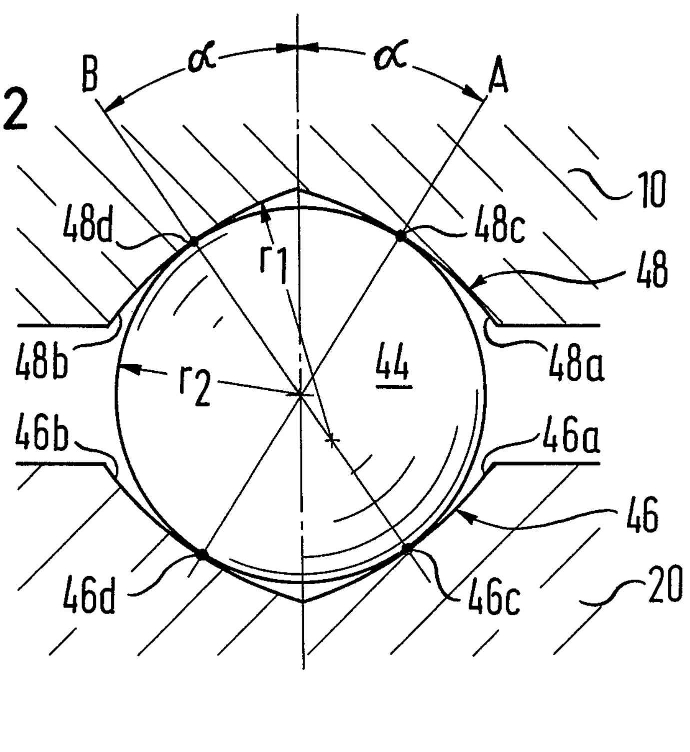


FIG. 3

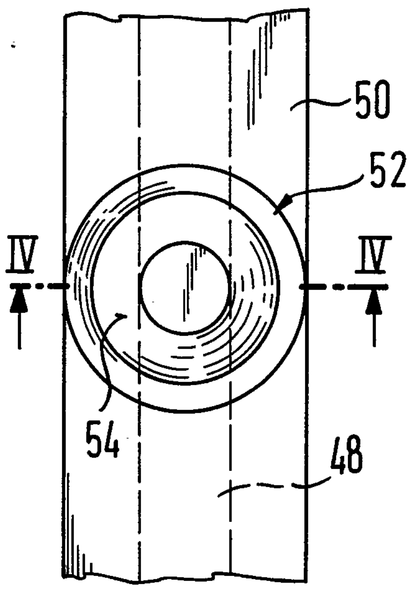


FIG. 4

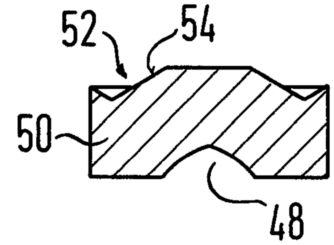


FIG. 5

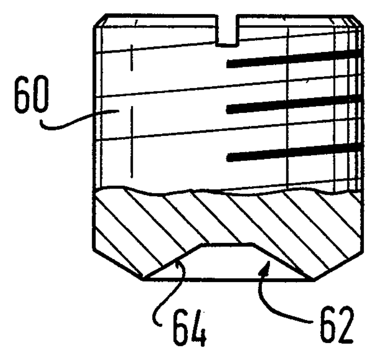
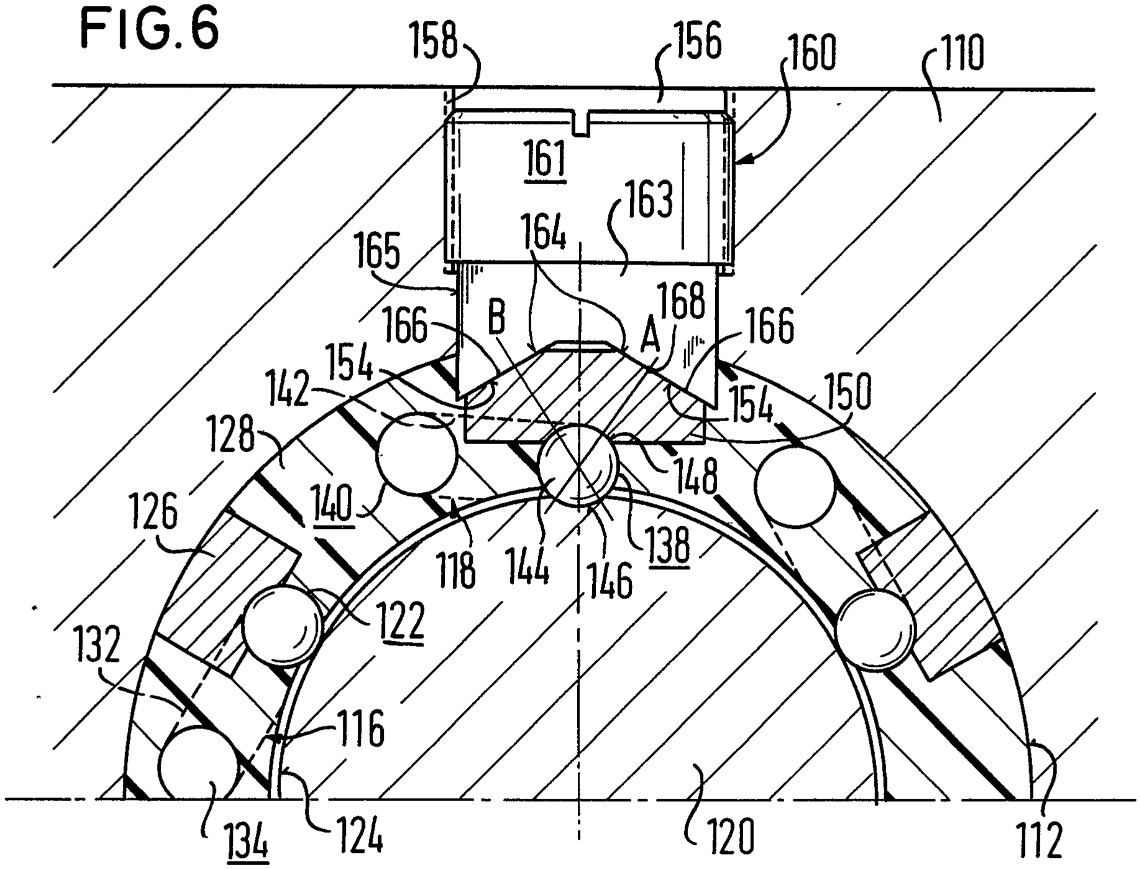


FIG. 6



SPECIFICATION

Torque transmitting and axially displaceable mounting

This invention relates to torque transmitting and axially displaceable mountings.

A torque transmitting and axially displaceable mounting is disclosed in a catalogue published by Messrs. Thomson Industries Incorporated in the year 1975 entitled "Thomson Ball-Groove Shaft and Super Ball Bushing". This mounting comprises a ball box inserted into a bush receiving bore in a casing and having ball rings guided in ball raceways, each ball ring having a load-transmitting ball ring portion which bears radially inwardly on a shaft and radially outwardly on an outer thrust face, at least one ball ring having a torque transmitting ball ring portion engaging in torque transmitting on a shaft side in a track groove in the shaft and on a thrust face side in a track groove of a running plate incorporated into the ball box. The running plate is urged radially inwardly by at least one radial clamping device within a clamping bore which is directed radially of the bush receiving bore.

In a known mounting, the clamping device, which is a threaded bolt screwed into the clamping bore, has a radially inner central frustoconical extension which is of smaller diameter than the diameter of the bolt, which engages loosely into a conical groove on the outside of the running plate. It has been found that with this mounting, it is not entirely out of the question for the running plate to tip about an axis parallel with the axis of the bushing, in the region of application between clamping bolt and running plate, particularly when considerable torque has to be transmitted and if the bushing is made from some resilient material, for example plastics material, so that the running plate is able to move relative to the plastics structure of the bushing. This means that under a torque loading, there is an angular resilience which has a negative effect on guidance accuracy.

The present invention seeks to provide a mounting of this type which is simple, which does not use excessively high quality of material and precision manufacturing for the ball box and the running plates, and which ensures torque rigidity and improved guidance accuracy.

According to the present invention there is provided a torque transmitting and axially displaceable mounting comprising a ball box inserted into a bushing receiving bore of a casing and having ball rings guided in ball raceways, each ball ring having a load bearing ball ring portion which bears radially inwardly on a shaft and radially outwardly on an outer thrust face, at least one ball ring having a torque transmitting ball ring portion engaging in a torque transmitting manner on a shaft side in a track groove in the shaft and on a thrust face side in a track groove in a running plate incorporated in the ball box, the running plate being urged radially inwardly by at least one radial clamping device disposed within a clamping bore directed radially relative to the bush receiving bore, the radial clamping device having a contact face which bears on the running plate and which intersects a resultant plane parallel with the axis of the mounting resulting from the torque transmission forces transmitted by the torque transmitting ball ring portion.

It has been found that it can also theoretically be proved that tipping of the running plate is no longer possible even when considerable torque is being transmitted and therefore the torque rigidity of the mounting and thus the guidance accuracy are substantially improved.

The resultant plane may intersect the contact face at an angle which diverges from 90° by the friction angle or less.

Thus the contact fact may be symmetrical in respect of a plane of symmetry which contains the axis of the mounting and which passes through the centres of the balls of the torque transmitting ball ring portion, two resultant planes for both directions of torque transmission lying symmetrically relative to said plane of symmetry. The location of the resultant plane may be influenced by the form of cross-section in the track grooves in the shaft and in the running plate.

In one embodiment of the present invention a bearing portion of the running plate comprises a convex conical or frustoconical face axially parallel with the axis of the clamping bore, the clamping device having a substantially complementary concave conical or frustoconical face. Thus the concave conical or frustoconical face of said clamping device may be formed on a radially inner end of a threaded bolt screwed into the clamping bore. The clamping device thus may be a threaded bolt which directly engages the running plate.

It goes without saying that a plurality of clamping bores disposed one beside another in the axial direction of the ball box may be associated with one and the same running plate.

According to another embodiment of the present invention there is provided a bearing portion of the running plate which comprises a plurality of convex prism faces parallel with the axis of the mounting, the clamping device having, on a thrust-piece guided in the clamping bore, a concave sequence of prism faces parallel with the axis of the mounting. In the case of this embodiment direct bearing of a rotating part of the clamping device on the running plate is no longer possible, in contrast to the previously discussed embodiment of the present invention, so that the use of a thrust-piece between the running plate and the rotating part of the clamping device becomes necessary.

The thrust-piece may be cylindrical and may be accommodated substantially without clearance in a corresponding radially inner portion of the clamping bore, a threaded bolt, disposed in an internal screwthread of the radially outer portion of the clamping bore, pressing against a radially outer face of the thrust-piece.

The thrust-piece need not be centred in the clamping bore in an angular direction but will itself become centred by application against the running plate. It must be stressed that in both embodiments of the present invention illustrated in the drawings, for establishment of a torque support between the shaft and the casing, no machining of the inner face of the bush receiving bore of the casing is required, because all parts of the torque supporting system, insofar as they are not located inside the bush receiving bore, are accommodated inside the clamping bore.

Preferably the ball box has a cage accommodating the running plate and defining the ball raceways and consisting of relatively resilient material, the running plate being made from a relatively hard material. The cage may be made of synthetic material. The running plate may be made of steel. Thus despite the resiliency of the cage, there is a clearance-free transmission of torque from the shaft to the casing.

The track grooves in the shaft and/or running plate may be ogival in cross-section with a partial arc radius exceeding the ball radius so that the contact points of the balls with the raceways and thus the location of the resultant planes are clearly established.

The resultant planes enclose, for example, an angle of 20° to 50° with the plane of symmetry.

The invention is illustrated, merely by way of example, in the accompanying drawings, in which:—

Figure 1 is a cross-section through one embodiment of a torque-transmitting and axially displaceable mounting according to the present invention;

Figure 2 shows in greater detail part of the mounting of Figure 1 illustrating engagement of a ball with a track groove in a shaft and a track groove in a casing;

Figure 3 is a plan view of the radially outer side of a running plate of the mounting of Figure 1;

Figure 4 is a section of the running plate of Figure 3 taken on the line IV-IV;

Figure 5 illustrates, partly in section, a radially inner end of a threaded bolt of a radial clamping device of the mounting of Figure 1; and

Figure 6 is a cross-section through another embodiment of a torque-transmitting axially displaceable mounting according to the present invention.

A torque-transmitting and axially displaceable mounting according to the present invention and shown in Figure 1 has a casing 10 with a bush receiving bore 12 into which a ball bush or box 14 is inserted. The ball box has a plurality of ball raceways into which ball rings 16, 18 are inserted. The ball ring 16 serves only to accommodate radial loads between a shaft 20 and the casing 10 by means of a radial load transmitting ball ring portion 22. This ball ring portion 22 lies on a cylindrical peripheral face 24 of the shaft 20 and on a steel running plate 26 which is inserted into a ball box cage 28 made from synthetic plastics material. The case 28 has a groove 30 for guidance of the ball ring portion 22. In the cage 28, the ball raceway is shown by broken lines and is indicated by reference numeral 32. The ball ring 16 has a non-bearing return portion 34.

The ball ring 18, in addition to accommodating radial forces, also transmits torque between the shaft 20 and the casing 10. This ball ring 18 comprises a torque-transmitting ball ring portion 38 and a return portion 40. A ball race is indicated by the reference numeral 42. The balls, which in Figure 1 lie in the plane of intersection, are designed by reference numeral 44. The balls 44 run in an axially parallel track groove 46 on the shaft 20 and in an axially parallel track groove 48 in a steel running plate 50. The steel running plate 50 differs from the steel running plate 26 as will be described in greater detail hereinafter.

As can be seen from Figures 1, 3 and 4 on the back of the steel running plate 50 there is a portion 52 including a convex frustoconical bearing face 54. Provided in the casing 10 and bored radially of the bush receiving bore 12 is a clamping bore 56 having an internal screwthread 58. Screwed into the screwthread 58 is a threaded bolt 60. At its radially inner end, as can be seen particularly well in Figure 5, this threaded bolt has a bearing portion 62 having a concave frustoconical bearing face 64 which, in its conicity, is complementary to the bearing face 54, of the running plate 50. The bearing face 54 and the bearing face 64 of the running plate 50 and the threaded bolt 60 respectively together produce a contact surface 66.

In order to explain the transmission of torque between the shaft 20 and the casing 10, reference is now made to Figure 2 where the transmission conditions are shown in greater detail. It can be seen that the track groove 46 of the shaft 20 and the track groove 48 of the casing 10 are of ogival construction, the radius r_1 of partial arcs 46*a*, 46*b*, 48*a*, 48*b* being greater than the radius r_2 of the ball 44.

The points of contact of the ball 44 with the partial arcs 46*a*, 46*b*, 48*a*, 48*b* of the respective track grooves 46, 48 are designated 46*c*, 46*d*, 48*c*, 48*d*. These points of contact simultaneously represent, as seen in Figure 2, the raceways on which the balls 44 roll in the track grooves 46, 48 as they revolve. As a result of this point or spot contact between the balls 44 and the track grooves 46, 48, the direction of the torque supporting forces is established, transmitting torque from the shaft 20 to the casing 10 or vice versa. This direction is designated by lines A and B in Figure 2. The lines A and B in Figure 2 also represent resultant planes in which, considered over the entire length of the mounting, torque supporting forces are transmitted between the shaft 20 and the casing 10. The term "resultant planes" could however be used if the balls 44 did not — as illustrated in Figure 2 — have spot cantact with the partial arcs 46*a*, 48*a* but were to bear on them over a greater length: in this case, for each ball, it would be necessary to define a resultant torque transmission force and the sum of these resultant forces would, in turn, determine the resultant planes.

The resultant planes are shown in Figure 1. It can be seen that the resultant planes intersect the bearing face 54 substantially at right angles in the region of the contact surface 66. This means that the torque supporting forces transmitted in the resultant planes can produce neither a displacement nor a tipping of the running plate 50 with respect to the threaded bolt 60 which serves as a clamping device. To reduce or present any possibility of displacement, it is essential that the running plate 50 bears in self-locking fashion on the threaded bolt 60 at a location 68. A self-locking application results in any event if the resultant plane indicated by line A is at right angles to the contact surface 66 and also if the angle of inclination of either or both of the resultant planes to the contact surface 66, as indicated by broken lines in Figure 1, deviates by less than an angle γ which is defined as a friction angle and is determined by the friction coefficient between the bearing races 54, 56, namely,

$\gamma = \arctan \mu$

where, μ is the coefficient of friction.

Figure 1 shows a plane of symmetry S-S which contains the axis of the threaded bolt 60 and the central point of the ball 44. In relation to this plane of symmetry, the resultant planes are inclined at an angle α which is between 20° and 50° and preferably between 30° and 45°.

The embodiment of the present invention illustrated in Figure 6 differs from that shown in Figure 1 only by a different design of the clamping device and of the abutment between the clamping device and the running plate. Similar parts are provided with the same reference numerals, in each case increased by 100.

In this embodiment, a clamping device 160 comprises a screw threaded bolt 161 which is screwed into an internal screwthread 158. Bearing on the radially inner plane face of the threaded bolt 161 is a thrust-piece 163 on which prism faces 164 are formed. The prism faces 164 bear on prism faces 154 of the running plate 150. The prism faces of the running plate can extend over the length of the ball box. The prism faces 164 of the thrust-pieces 163 are limited to the dimensions of the cylindrical thrust-piece 163. The thrust-piece 163 is accommodated substantially without clearance in a radially inner portion 165 of the bore 156.

With regard to the tipping and slip-free torque supporting force transmission, statements made in connection with the embodiment of Figure 1 also apply to this embodiment. The embodiment shown in Figure 6 is somewhat more complicated in that it has a two-part clamping device consisting of the threaded bolt 161 and the thrust-piece 163 and requires a stepped bore. The embodiment ought, however, to be particularly advantageous where a plurality of clamping devices 160 are disposed one beside another in the longitudinal direction of the bushing, because they can then act on the same prism faces 154 of the running plate 150.

CLAIMS

1. A torque transmitting and axially displaceable mounting comprises a ball box inserted into a bushing receiving bore of a casing and having ball rings guided in ball race ways, each ball ring having a load bearing ball ring portion which bears radially inwardly on a shaft and radially outwardly on an outer thrust face, at least one ball ring having a torque transmitting ball ring portion engaging in a torque transmitting manner on a shaft side in a track groove in the shaft and on a thrust face side in a track groove in a running plate incorporated in the ball box, the running plate being urged radially inwardly by at least one radial clamping device disposed within a clamping bore directed radially relative to the bush receiving bore, the radial clamping device having a contact face which bears on the running plate and which intersects a resultant plane parallel with the axis of the mounting resulting from the torque transmission forces transmitted by the torque transmitting ball ring portion.

2. A mounting as claimed in claim 1 in which the resulting plane intersects the contact face at an angle which diverges from 90° by the friction angle or less.

3. A mounting as claimed in claim 1 or 2 in which the contact face is symmetrical in respect of a plane of symmetry which contains the axis of the mounting and which passes through the centres of the balls of the torque transmitting ball ring portion, two resultant planes for both directions of torque transmission lying symmetrically relative to said plane of symmetry.

4. A mounting as claimed in any preceding claim in which the bearing portion of the running plate comprises a convex conical or frustoconical face axially parallel with the axis of the clamping bore, the clamping device having a substantially complementary concave conical or frustoconical face.

5. A mounting as claimed in claim 4 in which the concave conical or frustoconical face of said clamping device is formed on a radially inner end of a threaded bolt screwed into the clamping bore.

6. A mounting as claimed in any of claims 1 to 3 in which the bearing portion of the running plate comprises a plurality of convex prism faces parallel with the axis of the mounting, the clamping device having, on a thrust-piece guided in the clamping bore, a concave sequence of prism faces parallel with the axis of the mounting.

7. A mounting as claimed in claim 6 in which the thrust-piece is cylindrical and is accommodated substantially without clearance in a corresponding radially inner portion of the clamping bore, a threaded bolt, disposed in an internal screwthread of the radially outer portion of the clamping bore, pressing against a radially outer face of the thrust-piece.

8. A mounting as claimed in any preceding claim in which the ball box has a cage accommodating the running plate and defining the ball raceways and consisting of relatively resilient material, the running plate being made from a relatively hard material.

9. A mounting as claimed in claim 8 in which the cage is made of synthetic plastics material.

10. A mounting as claimed in claim 8 or 9 in which the running plate is made of steel.

11. A mounting as claimed in any preceding claim in which the track grooves in the shaft and/or the running plate are ogival in cross-section with a partial arc radius exceeding the ball radius so that the contact points of the balls with the raceways and thus the location of the resultant planes are clearly established.

12. A mounting as claimed in claim 11 in which the resultant planes enclose an angle of 20° to 50° with the plane of symmetry.

13. A torque transmitting and axially displaceable mounting substantially as herein described with reference to and as shown in the accompanying drawings.

14. Torque transmitting and axially displaceable

mounting of a shaft in a casting, comprising a ball box inserted into a bush receiving bore of the casing and having, guided in ball raceways, ball rings of which in each case a load bearing ball ring portion bears radially inwardly on the shaft and radially outwardly on an outer thrust face, the load bearing portion of at least one ball ring engaging on the shaft side in a track groove in the shaft and on the thrust face side in a track groove in a running plate incorporated into the ball box, the engagement being made in a torque transmitting fashion, and in which this running plate can be pressed radially inwardly by at least one radial clamping device within a clamping bore directed radially of the bush receiving bore, characterised in that the radial clamping device has bearing on the running plate a contact face which intersects at an angle guaranteeing a self-locking effect a resultant plane parallel with the axis of the bushing resulting from the torque transmission forces transmitted by the torque transmitting ball ring portion.

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