

IMPROVEMENTS IN AND RELATING TO BALL SCREWS

The invention relates to a ball screw.

5 It is known to provide a ball screw comprising a hollow member formed with an internal thread, a spindle received within the hollow member and formed with an external thread of the same pitch as said internal thread, a series of balls received between the threads in such a manner that the threads define a helical path along which
10 the balls can move to define a bearing between said spindle and said hollow member. Such ball screws require a recirculating mechanism to return the balls from one end of the helical path to the other. In German Offenlegungsschrift 2 451 665 and German Offenlegungsschrift 2 741 333
15 ball screws are disclosed having a ball recirculating guideway provided inside the spindle. However such internal recirculating arrangements are complicated, expensive to produce and cause a reduction in efficiency due to considerable friction losses.

20 With a view to overcoming these disadvantages, the present invention provides a ball screw comprising a hollow member formed with an internal thread, a spindle received within the hollow member and formed with an external thread of the same pitch as the internal thread, a series of balls
25 received between the threads bearingly and drivingly interconnecting the hollow member and the spindle, wherein, for returning the balls to be recirculated during relative rotation of the hollow member and the spindle, a recess is provided in the spindle between the opposite thread flanks
30 of two adjacent threads and a pair of deflectors are provided in the recess for guiding the balls from the opening of one of the adjacent threads into the recess to the opening of the other of the adjacent threads into the recess, the bottom surface of the recess and opposite
35 guide surfaces one on each deflector defining a substantially square-sided, externally open U-shaped guideway

between the two said openings.

In a preferred arrangement grooves are formed in the spindle thread at the respective ends of the guideway, the grooves running into the bottom surface of the recess. Preferably the bottom surface is flat and the guide surfaces on the deflectors are also flat.

In order that the invention may be more fully understood and readily carried into effect an exemplary embodiment thereof will now be described by way of example and with reference to the accompanying drawing wherein:

Figure 1 is a longitudinal section through a ball screw according to the invention,

Figure 2 is a plan view of a deflector for use in the ball screw,

Figure 2a is a view of the deflector in the direction of the arrow IIA in Figure 2,

Figure 3 is a partial cross-section along the section line III-III in Figure 1, and

Figure 4 is a longitudinal section through a short-stroke push/pull cylinder, which is sealed to prevent dirt accumulation, provided with permanent lubrication and which comprises a ball screw substantially as shown in Figure 1 to 3.

Figures 1 and 3 show a hollow internally threaded member in the form of a ball nut 1 formed with an internal thread 13 having thread

flanks 1a, and within which is received a ball spindle 2 having an external thread 12 with thread flanks 2a, the threads 12, 13 being of the same pitch. The threads 12 and 13 define a helical path which receives a series of balls 3 that define a bearing between the ball nut 1 and the spindle 2.

recess having a flat bottom
A ~~flat~~ surface 5 is produced, for example by milling, between the two outer most thread flanks 2a of two most adjacent turns of the spindle 2. The width of the planar surface 5, measured in the axial direction of the spindle 2, is determined by the axial spacing between said outer most thread flanks 2a. The length of the surface 5 measured approximately at right angles to the axial direction of the spindle 2, is determined by the requirement that the spindle 2 should be milled away sufficiently to allow the balls 3, when moving onto the surface 5 from the thread 13 of the ball nut 1 to move out of engagement with the thread flanks 1a on the ball nut 1. This results in the spacing d shown in Figure 3, which could if desired be reduced by redesigning the surface 5 with a slight curvature along the circumference of the spindle.

Thus, the threads 12, 13 define a helical path for the balls 3, which opens at opposite ends onto the surface 5. The surface 5 provides a path, over which the balls can recirculate from one end of the helical path to the other. The recirculatory passage of the balls 3 over the surface 5 is aided by deflectors 14 which present ball guiding surfaces 4. Grooves 6 are provided, running from the ends of the helical path onto the surface 5, in the spindle thread 12, in order to provide for unhindered passage of the balls to and from the helical path and the surface 5. The required angle α (between the guide surfaces 4 and the thread flank 2a), at which the balls 3 are recirculated, can be determined from the design in Figures 1 and 3 if effect of the sloping surfaces 6, is allowed for. In Figure 1 two guide elements, namely substantially flat guide surfaces 4, which are approximately axially spaced apart from and parallel to one another, are indicated by broken lines, the said guide surfaces combining with part of the surface 5, viewed in axial longitudinal section through the spindle 2, to define a generally U-shaped section ball recirculating guideway 18. As can be seen from Figure 1, the ball recirculating

guideway 18 is slightly bent laterally at one end (in the area leading to the threads 12).

Figures 2 and 2a show the thus determined shape of the deflectors 14 which are screwed, by means of countersunk screws (not shown) located in bores 15, on the surface 5 which, for this purpose, is provided with threaded holes 7.

Figure 4 illustrates a short-stroke push/pull cylinder utilising a ball screw substantially as shown in Figures 1 to 3. Instead of only one ball recirculating guideway 18, any desired number of such ball recirculating guideways can be provided on the circumference of the ball spindle 2. The ball spindle 2 is in the form of a hollow spindle. The two hollow shaft ends of the ball spindle 2 are guided in end pieces 8 of the ball nut 1, for example in self-lubricating sintered bronze bearings 9, and sealed by means of suitable seals 10 to prevent grease from escaping and dirt and water from penetrating. Bores 11 enable the grease to be replaced during the reciprocating movement of the ball nut 1.

A square head 16 on the spindle 2, and a connecting piece 17 on the nut 1 enable the arrangement to drive and be driven.

In the event of high rotational speeds and great forces to be transmitted, the material used for the deflectors 14 should consist of the same material as the ball spindle 2 and ball nut 1, that is to say it should have the same hardness and toughness.

In the event of low rotational speeds and small forces, it is possible to use, for the deflectors 14, plastic material which has the advantage of creating noiseless running when the balls pass over the deflectors.

The ball screw according to Figures 1 to 4 converts the rotation of the spindle 2 into a translatory motion of the nut in the direction of the double arrow x. It is obviously possible

in principle to effect kinematic reversal with the illustrated exemplary embodiments.

5 The ball recirculating guideways 18 are advantageously hardened. However, with the known ball screws described in the introduction, the hardening of the ball recirculating guideways presents considerable difficulties. Non-uniform depths of hardness in fact occur because of the complicated design of the known ball recirculating guideways and, because of the accompanying structural stresses, this can
10 result in sub-standard units or to surface damage during operation. In contrast, the described example of ball screw according to the invention, comprising the flat surface 5 and the sloping surfaces 6, creates a simple uniform surface which permits problem-free uniform hardening.

15 In addition, it should be mentioned that for the sake of simplifying the drawing the balls 3 are not shown in Figure 1.



- 6 -

CLAIMS

1. A ball screw comprising a hollow member formed with an internal thread, a spindle received within the hollow member and formed with an external thread of the same pitch as the internal thread, a series of balls received between the threads bearingly and drivingly interconnecting the hollow member and the spindle, wherein, for returning the balls to be recirculated during relative rotation of the hollow member and the spindle, a recess is provided in the spindle between the opposite thread flanks of two adjacent threads and a pair of deflectors are provided in the recess for guiding the balls from the opening of one of the adjacent threads into the recess to the opening of the other of the adjacent threads into the recess, the bottom surface of the recess and opposite guide surfaces one on each deflector defining a substantially square-sided, externally open U-shaped guideway between the two said openings.
2. A ball screw as claimed in claim 1 wherein the bottom surface of the recess is flat.
3. A ball screw as claimed in claim 1 or claim 2 wherein the bottom surface of the recess is provided with a groove at each said opening for unrestricted entry and exit of the balls to the said guideway.
4. A ball screw as claimed in claim 1, claim 2 or claim 3 wherein the said guide surfaces are flat.
5. A ball screw substantially as hereinbefore described with reference to the accompanying drawing.

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