United States Patent [19]

Toth

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[54] **METHOD AND CONSTRUCTION FOR INCREASING THE SERVICE LIFE OF ROLLING SCREW MECHANISM WITH DOUBLE-NUT PRESTRESS**

[75] Inventor: **Ivan Toth,** Budapest, Hungary

[73] Assignee: **Csepeli Szerszamgepgyar,** Budapest, Hungary

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July 13, 1972 Hungary 10986

[52] **U.S. Cl.** **74/459,** 74/441

[51] **Int. Cl.** **F16h 55/04,** F16h 55/18

[58] **Field of Search** ..... 74/459, 424.8 A, 441 X

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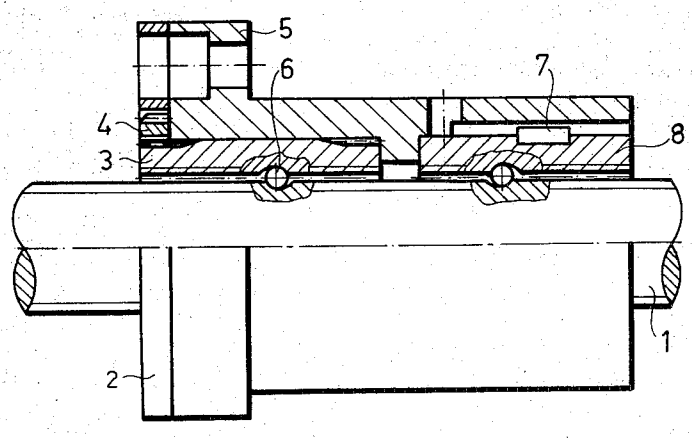
Primary Examiner—Leonard H. Gerin

Attorney, Agent, or Firm—Karl F. Ross; Herbert Dubno

[57] **ABSTRACT**

The invention aims at the considerable increase of the service life of rolling screw mechanisms. Theoretically it renders possible even a 100 per cent increase, which — taking into account the exceptionally high price of such mechanisms — provides for a considerable economic advantage.

8 Claims, 14 Drawing Figures



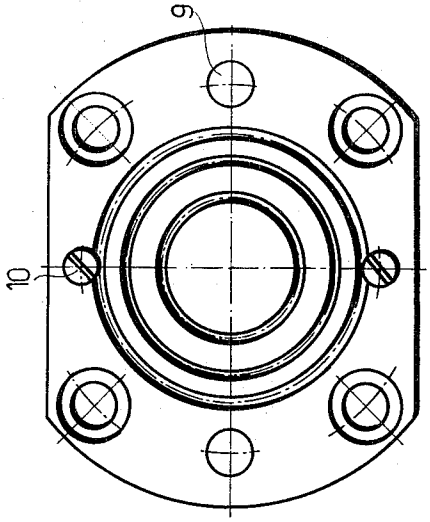


Fig. 2

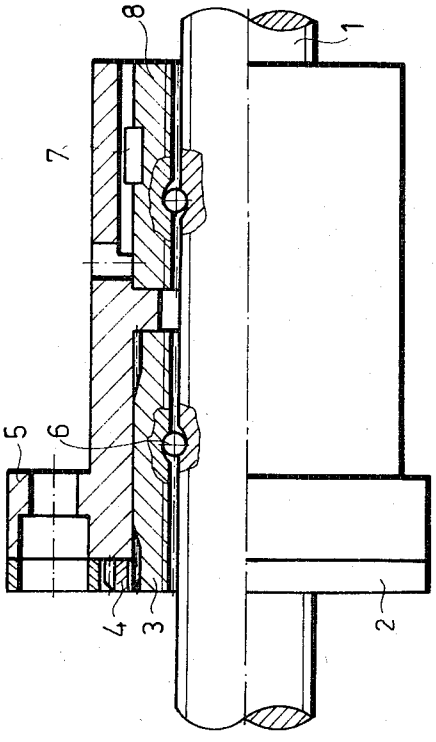


Fig. 1

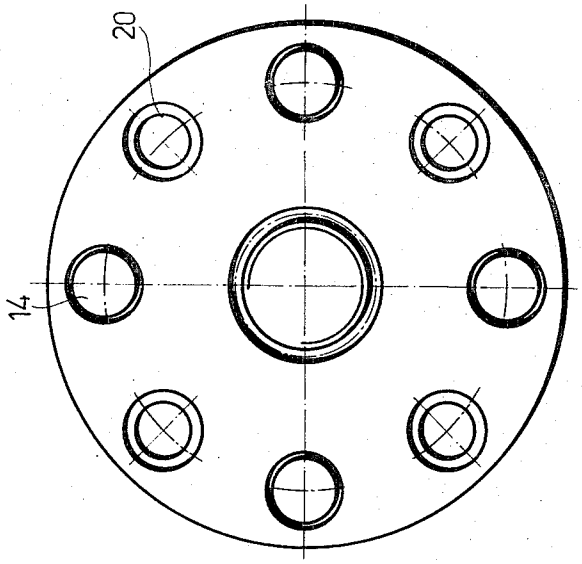


Fig.4

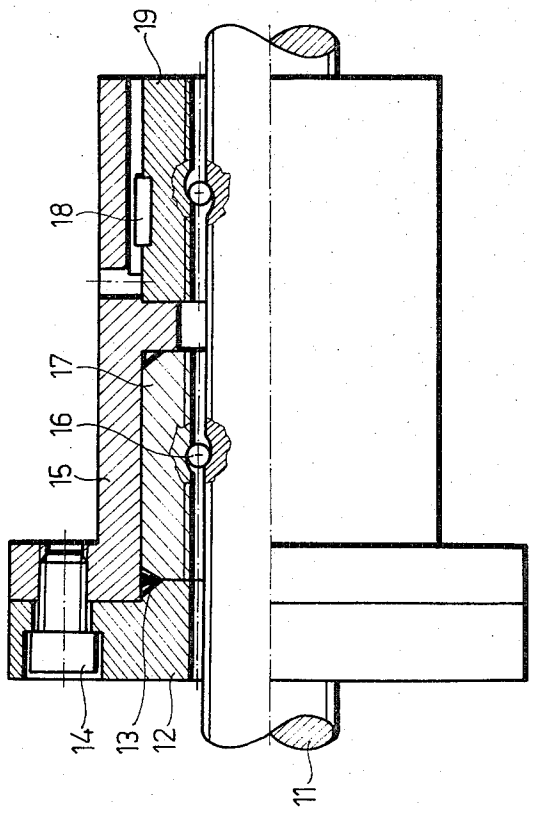


Fig.3

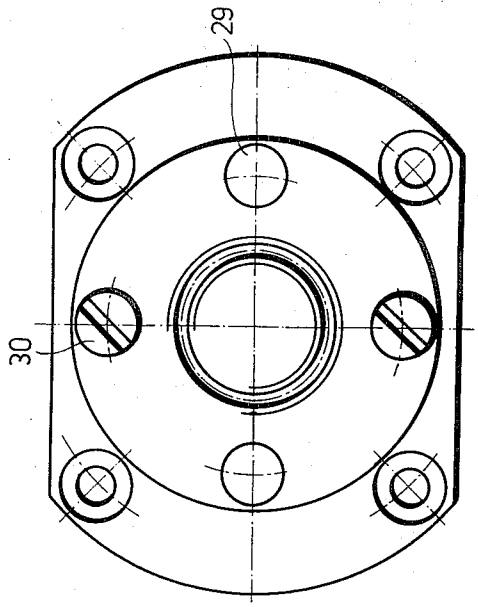


Fig.6

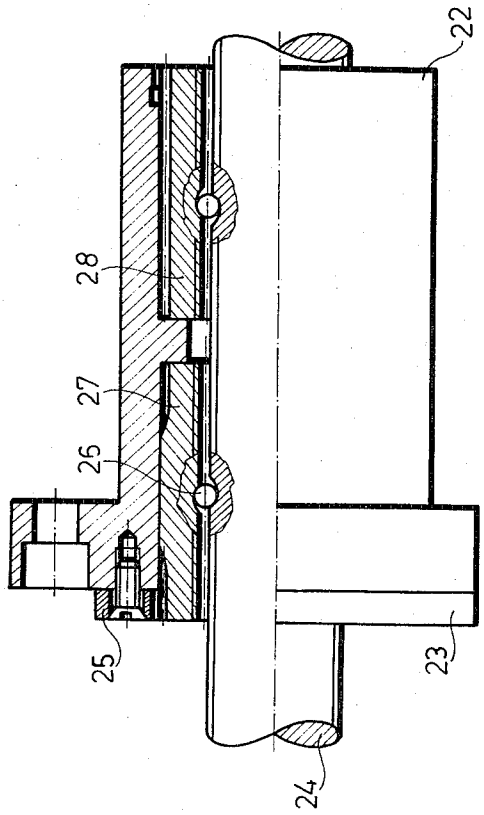


Fig.5

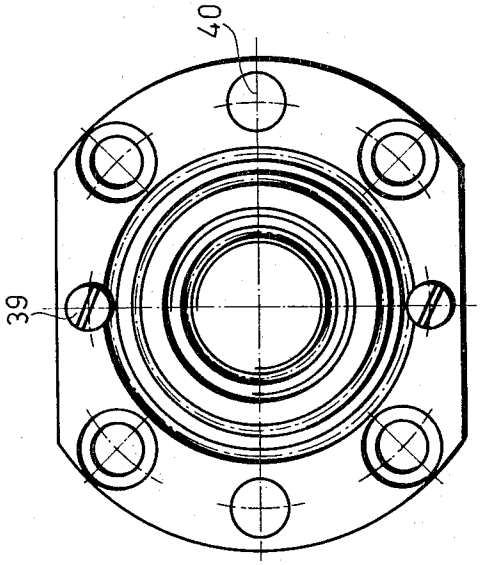


Fig. 8

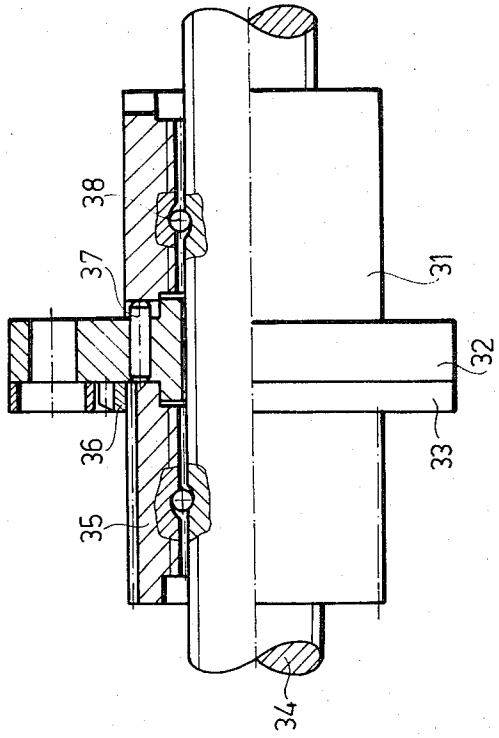


Fig. 7

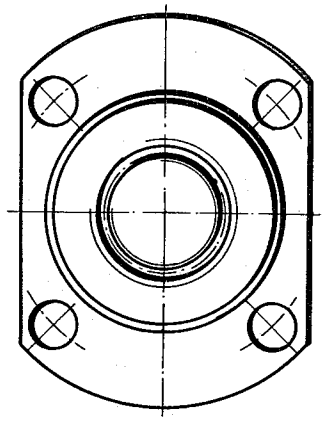


Fig.10

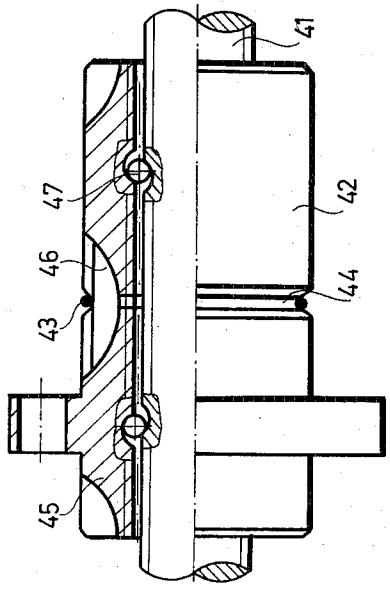


Fig.9

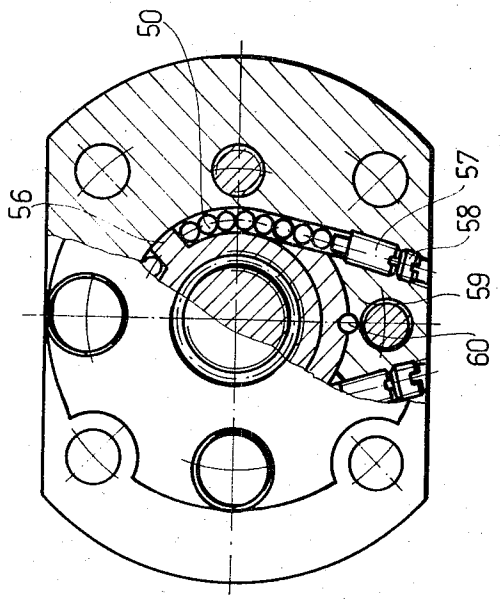


Fig. 12

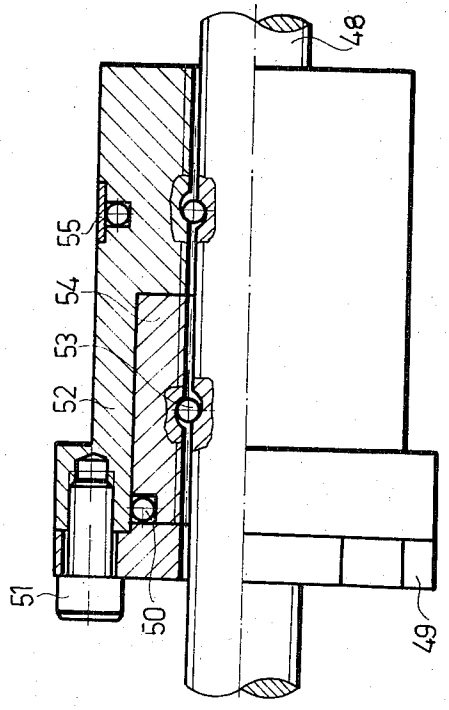


Fig. 11

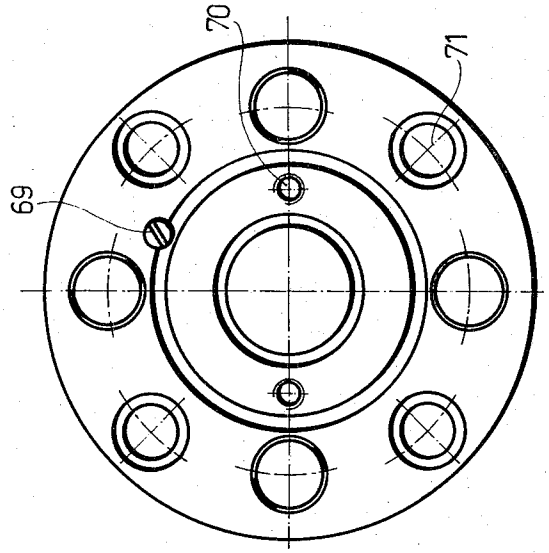


Fig. 14

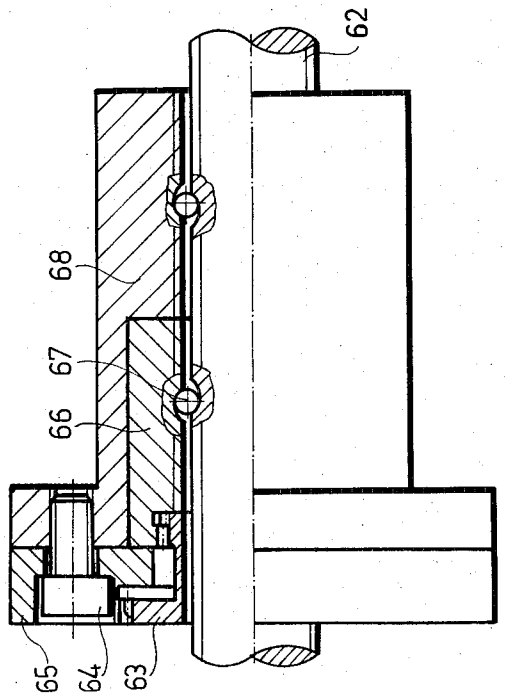


Fig. 13

METHOD AND CONSTRUCTION FOR INCREASING THE SERVICE LIFE OF ROLLING SCREW MECHANISM WITH DOUBLE-NUT PRESTRESS

The invention relates to a technique providing for the doubling of the service life of rolling screw mechanisms with double-nut prestress, as well as to a rolling screw construction of improved service life.

Rolling screw mechanisms serve for the transformation of rotary movement to linear movement or of linear movement to rotary movement and one of their main field of application is the machine-tool industry.

In rolling screw mechanisms, rolling bodies are arranged in the channel formed by the threaded notches of the spindle and of the nut so that the transmission of the movement — contrary to the traditional sliding screw mechanisms — is carried out without sliding friction. The profiles (thread profiles) of the threaded notches of the spindle and the nut depend essentially on the shape of the rolling bodies. Cylindrical rollers, barrel-shaped rollers and, more often balls are used as rolling bodies; in this latter special case the rolling screw mechanism is also called a ball spindle mechanism. It should be emphasized that the object of the invention is not limited only to ball spindle mechanisms but includes generally the rolling screw mechanisms with double-nut prestress.

In some cases, e.g., with machine-tools, an important requirement for the rolling screw mechanisms is a perfect freedom from clearance, as is ensured in most of the known devices by using two rolling nuts by means of which the mechanism can be rendered free from clearance; moreover, it can be prestressed. Characteristic of to any of these double-nut devices is the fact that only one side of the thread profile of the nuts is loaded, whereas the other side of the thread profile, being finished with the same carefulness for technological reasons as the former one, doe not participate in the operation of the mechanism. This means practically that with the devices known up to now only one side of the thread profile constitutes a running surface for the balls. At the same time, it is also obvious that in case of a normal operation, the failure of the rolling screw mechanisms occurs due to the fatigue of the running surfaces. It is true, on the other hand, that the number of operating threads of the rolling nuts generally does not exceed four, whereas the number of operating threads of the spindle is much higher; this means that the running surface the nuts is subjected to many times greater fatique stress than the running surface of the spindle, in accordance with the number of operating threads of the nuts. Consequently, the service life of rollingg screw mechanisms is generally determined by the service life of the running surfaces of the rolling nuts.

It is well known that the rolling screw mechanisms are of high cost. Thus, it is obvious that with respect to the economy, the possibility of a considerable increase of service life of rolling screw mechanisms would be highly advantageous.

The aim of the invention is the doubling of the service life of rolling screw mechanisms.

The method of the invention for doubling the service life of rolling screw mechanisms of double-nut prestress, is based on the fact that upon expiration of the

expected service life of the race courses on the side loaded according to the original adjustment of the thread profile of the rolling nuts, the rolling screw mechanism is readjusted or changed over in such a manner that the side unloaded according to the original adjustment of the thread profile of rolling nut shall be in contact with the load-bearing rolling bodies.

The rolling screw mechanism for carrying out the above method, comprises a rolling spindle, rolling bodies of adequate number, two rolling units and a coupling unit are arranged, this latter being provided with turn-off preventing surface elements engaging with the turn-off preventing surface elements developed on the rolling nuts. The invention provides that at both ends of at least one rolling nut turn-off preventing surface elements are provided for, rendering possible the disassembly of the rolling screw mechanism at the expiration of the expected service life and then the turning-over by **180°** of both rolling nuts about a respective axis normal to its centerline and remounting then in their original places, or without the said turning-over, the rolling nuts being interchanged. According to the invention a rolling screw mechanism comprises a rolling spindle, rolling bodies of adequate number, a main nut in the bore of which a counternut is provided, as well as a coupling unit are arranged, this latter being provided with turn-off preventing surface elements engaging with the turn-off preventing surface elements developed on the rolling nuts. That at the end towards the counternut of the main nut a cover is fastened enclosing the counternut in the bore of the main nut, and of stressing of the counternut against the main nut, turning the former either to the right or to the left.

The invention also includes a ball screw mechanism which comprises a rolling spindle, two rolling nuts, rolling bodies of adequate number and a coupling unit. Between the two rolling nuts a disc is arranged, on both sides of which outer centering surfaces are formed for the nuts to which centering bores made at the ends of the nuts fit, whereas both nuts are connected to the disc encased thereby, thus impeding the turning-off of the nuts.

Nowadays several variants of rolling screw mechanisms are known among them being those in which the used rolling bodies (cylindrical rollers, taper rollers, barrel-shaped rollers, etc.) rotate around the radial or nearly radial axles fastened to the nut or spindle. There are others in which the rolling bodies (rollers of various shapes, balls) move within a closed outline between the threaded notches of the spindle and the nut, carrying out a planetary motion with respect to the spindle. There are also those in which the rolling bodies are returned from the last thread of the nut into the first thread of the nut and there are mechanisms without return. Systems are known where the return is carried out in the notch developed on the outer mantle of the nut, in the axial bore of the nut, in a pipe fitting to the threads of the nut or between the nut and the spindle in path broken through the threads of the nut, etc. others, There are also arrangements in which threaded planetary rollers are used as rolling bodies, being supported in bearing in a common case, etc.

The present description and the enclosed drawings disclose only a special variant of the rolling screw mechanisms in which balls are used as rolling bodies, these solutions being called ball spindle mechanisms or, for short ball spindles. It should be, however, empha-

sized that the invention relates to most of the different variants of rolling screw mechanisms, including those mentioned in the previous paragraph, provided of course that the freedom from clearance and the prestress are ensured by two nuts. Correspondingly, in the description and in the claims the general terminology of the rolling screw mechanisms is used (thus the ball is called a rolling body, the ball spindle is termed rolling spindle, etc.) It may be mentioned that the invention may actually applied with the traditional (sliding) screw mechanisms (e.g. with milling machines where for the cut-down milling screw mechanism rendered free from clearance by two nuts is used).

The invention will be described in greater detail with reference to the accompanying drawing in which:

FIG. **1** is a longitudinal section of a first embodiment,

FIG. **2** shows an end view of the first embodiment,

FIG. **3** is a longitudinal section of a second embodiment,

FIG. **4** shows an end view of the second embodiment,

FIG. **5** is a longitudinal section of a third embodiment,

FIG. **6** shows an end view of the third embodiment,

FIG. **7** is a longitudinal section of a fourth embodiment,

FIG. **8** shows an end view of the fourth embodiment,

FIG. **9** is a longitudinal section of a fifth embodiment,

FIG. **10** is an end view of the fifth embodiment,

FIG. **11** is a longitudinal section of a sixth embodiment,

FIG. **12** is an end view of the sixth embodiment,

FIG. **13** is a longitudinal section of the seventh embodiment, and

FIG. **14** is an end view of the seventh embodiment.

In FIGS. **1** and **2**, a solution based on a rotax patent is shown, in which the rolling nuts **3** and **8** are connected to the rolling spindle **1** via rolling bodies **6**; the rolling nuts are arranged in the sleeve **5**. On the nut **8** the locking slot developed on the outer mantle constitutes the turn-off preventing surface element connected to the sleeve **5** by means of the catch **7**. The turn-off preventing surface elements on the nut **3** consist of the toothing made at both ends. It is to be seen in the drawing that the toothing at the outer end of the nut **3** engages with the internally toothed part of the internally-externally toothed ring **4** whereas the externally toothed part of the internally-externally toothed ring **4** engages with the internally toothed ring **2**. the internally toothed ring **2** is connected to the sleeve **5** by means of the dowel pin **9** and of the screw **10**. At the same time, the screws **10** prevent the externally-internally toothed ring **4** from falling out. The toothing of the internal and external teeth rims of the ring **4** differ by one or a few tooth rendering possible the fine adjustment of the relative angular position of the nuts **3** and **8**. In the given case, the coupling unit consists of the locking slot of the nut **8**, of the catch **7**, of the locking slot of the sleeve **5**, of the sleeve **5** itself, of the rings **2** and **4** and finally of the toothed end of the nut **3**. It is thus obvious that the coupling unit — considering its function — serves for the adjustment and fixation of the prestress. It often occurs that multiple-function parts are built in the coupling unit; such a multiple-function part is e.g. the sleeve **5** which — in addition to the adjustment and fixation of the angular position of the two nuts — serves for the engagement of the nut unit to an outer unit and for the prevention of the balls in case of outer ball return from falling out of the return slot. From the point of view of the invention it is essential that both ends of the rolling nut **3** are provided with turn-off preventing surface elements, in the present case, e.g., both ends of the nut are toothed. Thereby it is rendered possible that, the expected service life of the pathes on the side loaded at the original adjustment (not shown in the drawing) of the thread profile of the rolling nuts **3** and **8** being expired, the mechanism is disassembled and rolling nuts **3** and **8** are each turned over by 180° around a respective axis normal to their centerline and then remounted to their original place, finally the nut **3** is stressed to the nut **8**. As a result of this operation the leftside thread profile shown as unloaded in the drawing of the rolling nut **3** gets in contact with the load-bearing rolling bodies **6** and forms a new running path of excellent condition. The same is true for the rolling nut **8**, too.

In FIGS. **3** and **4** a solution based similarly on a ROTAX patent is to be seen in which the rolling spindle **11** is connected to the rolling nuts **17** and **19** through the rolling bodies **16** and the said rolling nuts **17** and **19** are located in a common sleeve **15**. The angular displacement of the nut **19** relative to the sleeve **15** is impeded by the catch **18**. Both ends of the rolling nut **17** are provided with toothing (here, the toothing taken in the strictest sense of the word is not needed, a knurling is sufficient) and a similar toothing is to be found at the rim of the pressure ring **12**. The pressure ring **12** is fastened to the sleeve **15** by means of screws **14** and dowel pins **21**. Between the toothing of the nut **17** and the ring **12** the deformation ring **13** is pressed in by the pressing force of the screws **14**. The deformation ring **13** is made of a plastic but suitably solid material (e.g. of copper which becomes solid just due to the deformation) and in the one side thereof the teeth of the ring **12**, in the other side the teeth of the nut **17** are pressed in. At both ends of the nut **17** bores are also made for peg wrench (not shown in the drawing) and by means of the bores the nut **17** can be stressed to the nut **19**. Then, the relative angular position of the two ball nuts can be fixed by means of the deformation ring **13**, pressure ring **12** and screws **14**. Both ends of the rolling nut **17** being toothed, the nuts can be turned over as described above after the expiration of the expected service life and the profile sides unloaded according to the original adjustment form a new excellent path. The fastening of the nut unit to an outer unit, e.g., to the slide of a machine-tool can be carried out by means of the bores **20**.

FIGS. **5** and **6** show a solution similarly based on a ROTAX patent in which the rolling spindle **24**, the rolling nuts **27**, and **28**, the sleeve **22** and the rolling bodies **26** are arranged as described above. Both ends of the nuts **27** and **28** are toothed, engaging with the internally toothed parts on the right side of the sleeve **22** and on the toothed ring **23**. The ring **23** is fastened to the sleeve **22** by means of dowel pins **29** and screw **30**. The adjustment of the prestress is exactly the same as with the ROTAX solution but the fact that both ends of both nuts are toothed renders possible the turning

over of the nuts in a manner described in connection with FIGS. 1 and 2 so that the profile sides unloaded in the original adjustment form a new path.

In the ball spindle mechanism shown in FIGS. 7 and 8 the rolling spindle 34, the rolling nuts 31 and 35 as well as the rolling bodies 38 are arranged as described above. The nuts 31 and 35 encase the disc 32 to which the nut 31 is turn-free connected by the pin 37. To the side of the disc opposite to the pin 37 the internally toothed ring 33 is fastened by screws 39 and dowel pins 40. The rolling nut 35 towards the ring 33 is toothed in the entire length of its outer mantle. Between the nut 35 and the toothed ring 33 the connection is ensured by the internally and externally toothed ring 36. For the pin 37 slot is formed at both ends of the nut 31. The fact that both ends of both rolling nuts are provided with turn-off preventing surface elements renders possible the doubling of the service life, applying the technique described in connection with FIGS. 1 and 2. This construction can be considered a new and advantageous solution even if the possibility of doubling the service life is left out of consideration. No such solution called by us disc-type ball spindle mechanism is known and mentioned in the technical literature. Thus the ball spindle mechanism according to FIGS. 7 and 8, that is one in which only one end of the nut 35 is toothed whereas only at one end of the nut 34 notch and adjusting bores constituting the turnoff preventing surface element are provided for, is independently patentable.

In FIGS. 9 and 10 a so-called main nut solution is to be seen. Such main nut solutions are characterized in that one of the rolling nuts, the main nut, is provided with suitable surface elements bored rim or bottom for the purpose of being fastened to an outer unit, whereas the rolling nut, the counternut, is stressed to the main nut. As it is to be seen in FIG. 9, the rolling spindle 41 is connected to the main nut 45 and to the counternut 42 through the rolling bodies 47 and between the two nuts a spacing piece 44 is located determining the amount of the prestress. The relative angular position of the two rolling nuts is ensured by the key 46 which is protected against falling out by the spring ring 43. As is shown in FIGS. 9 and 10, both ends of both rolling nuts are provided with locking slots, which enables that the expected service life of the mechanism being expired, the mechanism can be disassembled, both rolling nuts are turned over by 180° around respective axis each normal to their centerline and then remounted in their original places, or without the said turning over, the rolling nuts are each remounted in the place of the other one, whereby new excellent path is developed in the threaded notches of the rolling nuts.

FIGS. 11 and 12 indicate similarly a main nut solution in which the rolling spindle 48 is connected to the main nut 52 and to the counternut 54 through the rolling bodies 53. Here the counternut is entirely arranged in the bore of the main nut 52. The cover 49 fastened by screws 51 to the main nut 52 encloses the counternut 54 in the boring of the main nut 52 and does not press the counternut 54 in axial direction to the shoulder at the end of the boring of the main nut 52, that is the counternut 54 is shorter by a few hundreth or tenth of millimeter than the available place. At the outer end of the counternut 54 on the mantle there is a protruding part 56 sandwiched from two sides by the balls 50 or rollers. The other ends of the ball rows consisting of the balls 50 run into the adjusting screws 57 which are secured by the screw 58 against loosening. The arranged position of the balls 50 is ensured by the deflecting insert 59 the position of which is determined by the dowel pin 60. The ball return channel of the main nut 54 is covered by the plate 55. The prestress is adjusted by the suitable turning of the screws 57. The service life of profile sides loaded in the original adjustment being expired, the prestressing shall be carried out in the opposite direction, that is if in the original adjustment the counternut 52 was stressed to the main nut 54, then, in order to double the service life the counternut 52 shall be stressed to the cover 49 by means of screws 57. A special advantage of this solution consists also in that the proceeding for doubling the service life can be carried out without the disassembly of the mechanism.

In FIGS. 13 and 14 a main nut solution is again to be seen, in which the rolling spindle 62 is connected to the main nut 68 and counternut 66 via the rolling bodies 67. Here too, the counternut 66 is completely countersunk in the boring of the main nut 68. The cover 65 fastened to the main nut 68 by screws 64 closes the counternut 66 in the boring of the main nut 68, but the counternut 66 is somewhat shorter than the available place. The relative angular position of the two nuts is ensured by the toothed ring 63 which engages the toothing on the nut 66, on the one hand, and with the toothing on the cover 65, on the other. The tooth number of the toothing on the nut 66 preferably differs by one or by a few teeth from that on the cover 65. The toothed ring 63 is secured against falling out by the screw 69. The disassembly is promoted by the threaded borings 70. The borings 71 serve for the fastening to an outer unit. The technique for doubling the service life is carried out as with the previous solution, i.e., by that the prestressing is carried out in the opposite direction.

In the course of the introduction of the constructions no mention was made of the return method of rolling bodies since whatever suitable return method known from the technical literature can be applied. It must be, however, mentioned that, e.g., with the solutions shown in FIGS. 7 to 14 a so-called internal return should be expediently used where the balls are returned in the paths of the inserts built into the nuts touching the thread web of the spindle, which, however, does not mean that the use of the so-called external return would be excluded. FIG. 11 indicates just such an external return. Otherwise, the various methods of ball return are described fully detailed in the article "Ball Screw Mechanisms" by Levit (Stanki i Instrument, 1963, No. 4).

The introduced examplified embodiments described the use of various coupling units. The turn-off preventing surface elements operating in the coupling units may be different, e.g., as in the shown case catch, pin or toothing, but in addition to this, every functionally suitable solution may be considered turn-off preventing surface element, even the use of metal cement included.

The basic advantage of the proceeding and construction according to the invention consists in that the utilization of both sides of the threaded notches developed in the rolling nuts renders possible the theoretical doubling of the service life of rolling screw mechanisms.

The numerous examplified embodiments so to say demonstrating the wide-ranging adaptability of the in-

ventive idea, shown in FIGS. 1 to 14, indicate rolling screw mechanisms considerably differing in several respects and they have some partial advantages relative to each other. Thus e.g. the solution shown in FIGS. 1 and 2 provides for the easy adjustability, the solution introduced in FIGS. 3 and 4 for the increased rigidity and accurate adjustment, whereas the solution according to FIGS. 7, 8, 9, 10 for the low volumetric capacity and the solutions according to FIGS. 11, 12, 13 and 14 for the simple practicability of the proceeding for doubling the service life.

All the described solutions, however, correspond to each other in that they render possible the expedient realization of the proceeding according to the main claim 1 and correspond to the stipulations of the co-ordinate main claims 2 and 3 relating to the construction. The co-ordinate main claim 4 intends to protect the basic variant of the solution shown in FIGS. 7 and 8 that is the solution being in itself unsuitable for the doubling of the service life, since the nuts 35 and 31 are provided with turn-off preventing surface elements only at one end. Such disc-type ball spindle mechanism is not known until now in the technical literature and the advantage of this solution manifests itself in the exceptionally low volumetric capacity. In our opinion, the unity of the invention is proved by that the basic variant outlined in claim 4 can be transformed subsequently in a very simple manner by the subsequent development of turn-off preventing surface elements at the outer ends of the nuts to such a solution rendering possible the carrying out of the proceeding according to claim 1.

What we claim is:

1. A method of operating a roller-spindle mechanism comprising an externally threaded spindle, a pair of nuts mounted on said spindle and each formed with a helical thread having oppositely facing flanks, and a multiplicity of roller elements received between the threads of said nuts and said spindle, said method comprising the steps of:

relatively rotating said nuts to stress the roller elements against the flanks of the nut thread of one nut facing in one direction and the flank of the other nut thread facing in the opposite direction;

driving said mechanism until the stressed flanks of said nut threads are worn; and

displacing one of said nuts to cause said roller elements to be stressed against the previously unstressed flank of each nut thread for further driving of the mechanism for a doubling of the essential life of said nut threads.

2. A method of operating a roller-spindle mechanism comprising an externally threaded spindle, a pair of nuts mounted on said spindle and each formed with a helical thread having oppositely facing flanks, and a multiplicity of roller elements received between the threads of said nuts and said spindle, said method comprising the steps of:

relatively rotating said nuts to stress the roller elements against the flanks of the nut thread of one nut facing in one direction and the flank of the other nut thread facing in the opposite direction;

driving said mechanism until the stressed flanks of said nut threads are worn; and

removing at least one of said nuts and rotating same through 180° about an axis perpendicular to its thread axis and reinserting the removed nut so that its flanks face in directions opposite to their original facing directions, and relatively rotating said nut to stress the roller elements of the previously moved nut against the previously unstressed flank of the nut thread thereof.

3. A method of operating a roller-spindle mechanism comprising an externally threaded spindle, a pair of nuts mounted on said spindle and each formed with a helical thread having oppositely facing flanks, and a multiplicity of roller elements received between the threads of said nuts and said spindle, said method comprising the steps of:

relatively rotating said nuts to stress the roller elements against the flanks of the nut thread of one nut facing in one direction and the flank of the other nut thread facing in the opposite direction;

driving said mechanism until the stressed flanks of said nut threads are worn; and

thereafter interchanging said nuts and relatively rotating same to stress said roller elements against the previously unstressed flank of each nut thread for further operation of said mechanism, thereby doubling the effective life of each nut.

4. A roller spindle mechanism comprising:

a spindle having an external thread;

a pair of nuts surrounding said thread in axially offset relation and having internal threads with oppositely facing flanks;

a multiplicity of roller elements received between the threads of each nut and the thread of said spindle, one of said nuts being provided with identical formations at least at opposite ends thereof in symmetrical relationship about a median plane through said one nut perpendicular to the axis thereof; and

locking means engageable with said formations for retaining said nuts in relatively rotated positions whereby said roller elements are stressed against one flank of each nut thread in one orientation of said one of said nuts by engagement with said formations at one end thereof, and said roller elements are stressed against the other flank of each nut thread upon reorientation of said one of said nuts to engage said locking means with said formations at the other end of said one of said nuts.

5. The mechanism defined in claim 4 wherein said formations are provided in opposite end faces of said one of said nuts.

6. The mechanism defined in claim 5 wherein said locking means includes a pin receivable in one of said formations.

7. The mechanism defined in claim 5 wherein said locking means includes a disk adapted to abut said end faces and provided with formations cooperating with those of said one of said nuts.

8. The mechanism defined in claim 4 wherein said formations are gear toothings along the periphery of said one of said nuts and said locking means includes an eternally toothed gear.

* * * * *