

June 1, 1965

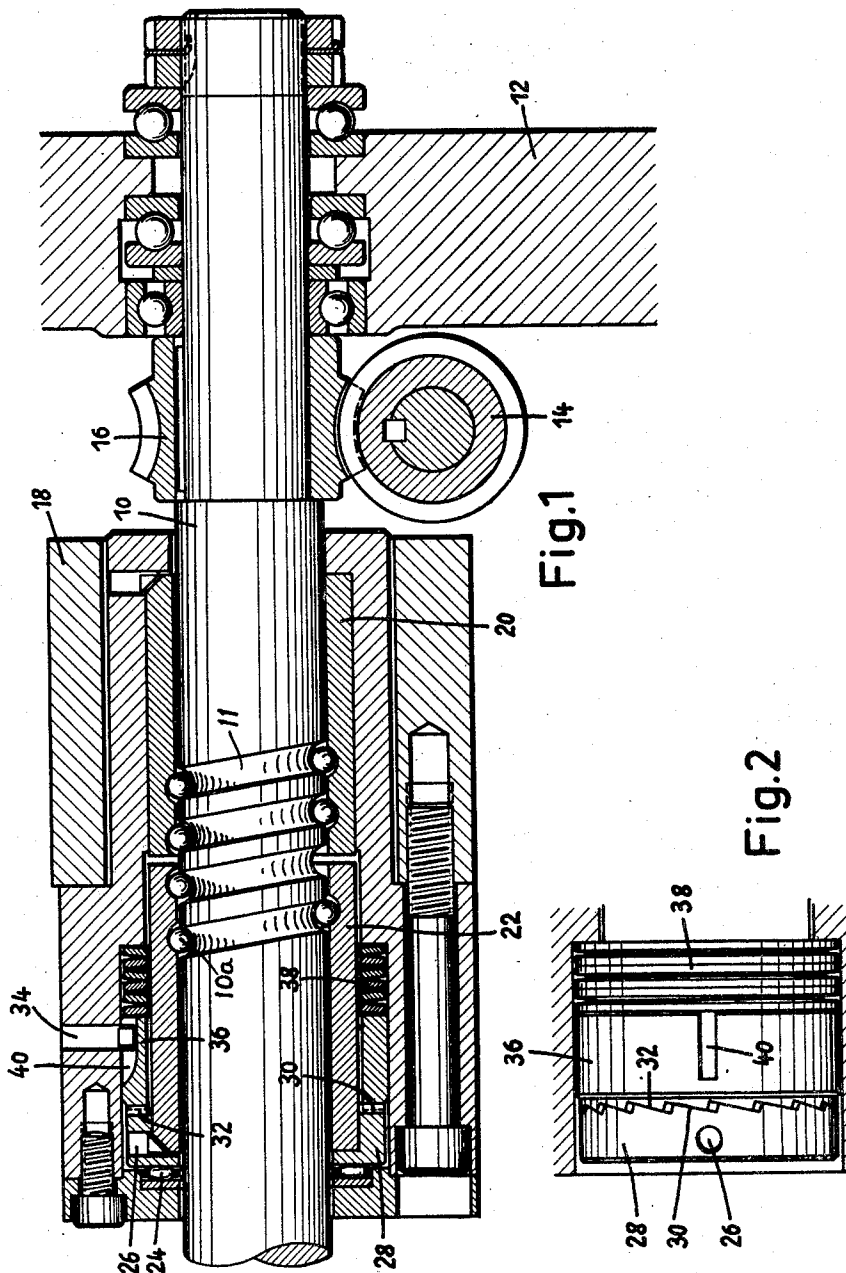
H. LANZENBERGER

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CARRIAGE DRIVE FOR MACHINE TOOLS

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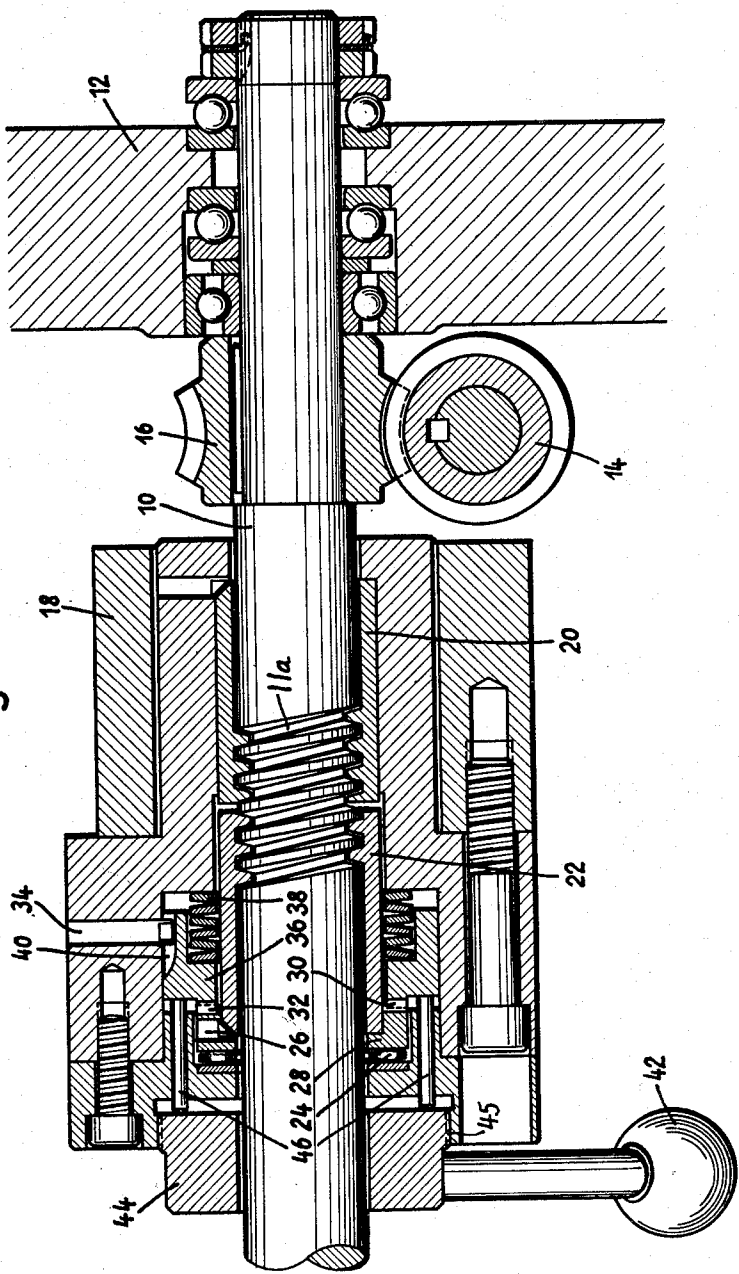
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CARRIAGE DRIVE FOR MACHINE TOOLS

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Fig. 3



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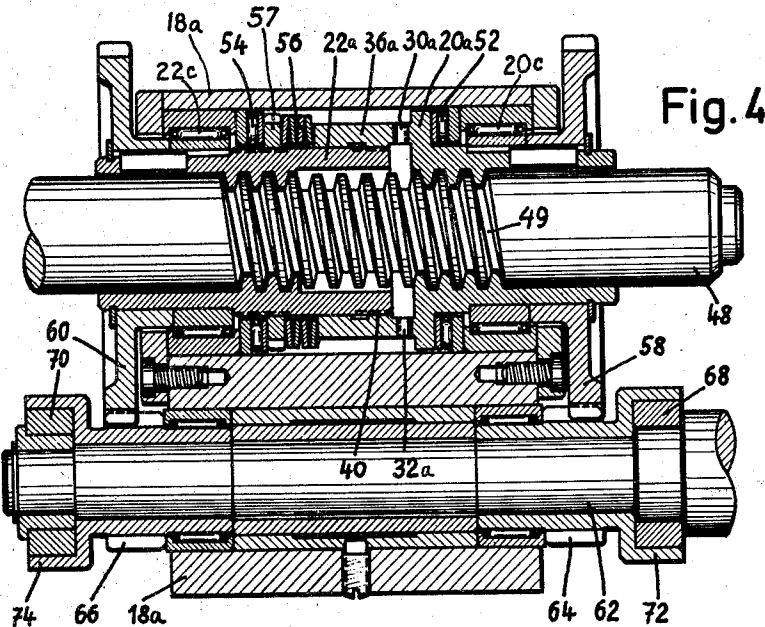


Fig. 4

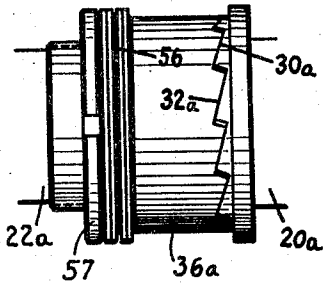


Fig. 5

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CARRIAGE DRIVE FOR MACHINE TOOLS

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D 39,053

20 Claims. (Cl. 74-409)

This invention relates to a carriage drive for machine tools, and particularly to a drive which is free from play or backlash.

Many attempts have been made in the prior art to provide drives which are free from play, but all of the prior attempts have objections or unsatisfactory features of one kind or another.

An object of the present invention is the provision of the generally improved and more satisfactory drive of this kind.

Another object is the provision of a play-free drive which does not subject the lead screw of the drive spindle to excessive spring pressure or other excessive forces, as is done in many prior drives.

A further object is the provision of an improved drive so designed as to have freedom from play or backlash under the influence of relatively light springs, and without causing undesirable severe loading of any parts.

A still further object is the provision of a drive having means for relieving the play-eliminating or backlash-eliminating feature or rendering it inoperative when desired, in a simple and effective manner.

These and other desirable objects may be attained in the manner disclosed as an illustrative embodiment of the invention in the following description and in the accompanying drawings forming a part hereof, in which:

FIG. 1 is a somewhat schematic longitudinal section through a drive in accordance with a first embodiment of the present invention;

FIG. 2 is a view partly in section and partly in elevation, illustrating a fragment of the same;

FIG. 3 is a view similar to FIG. 1, illustrating a second embodiment of the invention;

FIG. 4 is a similar view of a third embodiment; and

FIG. 5 is an elevation of part of the mechanism shown in FIG. 4, with surrounding parts omitted.

Referring first to the embodiment shown in FIGS. 1 and 2, there is a feed spindle 10 mounted rotatably in the support 12, but held against axial movement therein. The feed spindle is driven from any suitable source, either by hand or by a motor, through a worm 14 meshing with a worm wheel 16 fixed to the spindle. As the spindle is turned in one direction or the other, it is intended to produce feeding movement in one direction or the other of any suitable machine tool part, such as a carriage, indicated schematically and in general at 18. The details of the carriage or other driven part 18, and the details of the support 12, are unimportant for purposes of the present invention, since the invention (in this particular embodiment) deals only with the manner in which the rotation of the spindle 10 is transmitted to the member 18 for feeding this member in one direction or the other, without play or backlash when the direction of rotation of the spindle 10 is reversed, or at any other time.

In this embodiment, the spindle 10 is developed as a ball roller spindle having the conventional helical ball race 11 receiving the balls 10a. Two nuts 20 and 22 surround the spindle 10 and have interior helical ball races in which the balls 10a run. The first nut 20 is rigidly connected to the carriage or other member 18 which is to be moved by rotation of the spindle 10, so that any axial

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movement transmitted by the spindle to the nut 20 is thereby transmitted also to the member 18.

The second nut 22 is slightly spaced axially from the first nut 20, and is mounted in a suitable cavity in the member 18 for limited movement therein both rotatably and axially, although it will be apparent as the description proceeds that the nut 22 is always held in axial contact with its thrust bearing, so the nut does not actually move axially in practice. The nut 22 needs no particular radial support in the member 18, since the balls running in the ball races of the spindle and the nut, respectively, will provide a sufficient radial support for this nut. It may be mentioned that only a fragment of the ball races of the spindle and the two nuts have been illustrated, for the sake of simplicity of the drawings, the ball races actually extending throughout such axial length of the spindle and the nuts as may be required. There is, of course, a return channel for the balls, as customary in a ball roller spindle of this kind.

The left end of the second nut 22 is connected by a bolt 26 to a bushing 28. Either directly or through the bushing 28, the left end of the nut bears on a thrust bearing 24 mounted in the carriage or driven member 18, so that any leftward movement of the nut 22 (along the feed spindle 10) is transmitted through the thrust bearing 24 to the carriage 18. Since the first nut 20 is fixed both axially and rotationally in the member 18, it is apparent that the member 18 constitutes, in effect, a cage or abutment means limiting the extent to which the two nuts may move axially away from each other, although the second nut 22 may turn to a limited extent on the thrust bearing 24.

The bushing 28 is provided at its right end with oblique flanks or steps 30 engaging suitable mating flanks or steps 32 of a bushing 36 which surrounds the nut 22 and is axially movable to a limited extent in a cavity in the surrounding member 18, but which is held against rotation therein, by means of the bolt 34 fixed in the member 18 and extending radially inwardly into a longitudinal or axial slot 40 formed in the bushing 36. The bushing 36 is constantly urged in a leftward direction by spring means preferably formed by a series of annular leaf springs 38 which loosely surround the nut 22 and press leftwardly on the right end of the bushing 36 while reacting rightwardly against a shoulder on the carriage or other driven member 18, as shown. It should be noted that the angle of inclination of the oblique flanks 30 and 32 is slightly greater than what is called the self-locking angle, or angle of repose, so that the axial pressure of the bushing 36 in a leftward direction (caused by the springs 38) pressing the flanks 32 against the flanks 30, actually causes a rotary force or torque force on the bushing 28 and, of course, on the nut 22, since the nut is pinned to the bushing 28 to turn therewith. As is well understood in the field of machine tool design, the self locking angle, or angle of repose, varies according to the character of the metal (or of the two metals if they are dissimilar) as well as upon the condition of lubrication between all associated moving parts, so it is desirable to make the angle of the teeth or flanks 30, 32 sufficiently great so that self-locking will not occur even under lubrication conditions which are less than normal or ideal.

This construction provides a relatively simple and inexpensive feed which is completely free from play or backlash, and yet does not impose excessive pressures on the lead screw of the feed spindle. As above explained, the nut 20 does not turn but is rigidly fastened in the driven member 18. The second nut 22 constantly tends to rotate slightly, under the influence of the springs 38 producing axial pressure on the oblique flanks 30, thereby by constantly keeping the nut 22 turned to a position in

which it is tight on the threads or ball races of the feed spindle 10, with the left end of the nut 22 bearing tightly on the thrust bearing 24. Rotation of the feed spindle in one direction (a clockwise direction if viewed from the right-hand end of FIG. 1) will cause rightward pressure on the nut 20, to move the carriage 18 in a rightward direction. Rotation of the feed screw in the opposite direction will immediately, without backlash, cause leftward force on the second nut 22, thereby acting through the thrust bearing 24 to move the carriage 18 in a leftward direction. As the carriage travels back and forth, if it reaches a portion of the lead screw which is more worn than another portion, the spring pressure on the oblique flanks 30, 32 will turn the nut 22 a little farther in a tightening direction, to take up the wear. When the parts travel back to a less worn portion of the lead screw, the nut 22 will be forced to turn slightly in the opposite direction, forcing the bushing 36 slightly rightwardly (relative to the carriage 18) against the action of the springs 38. Thus at all times the second nut 22 will be kept tight on the threads of the lead screw, and a reversal of direction of rotation of the feed spindle 10 will immediately cause reversal of direction of movement of the carriage 18, without any play or backlash. It will be noted also that this is accomplished without transmitting the feeding force through the springs 38, which do not serve to carry the feeding load or pressure, but which serve only to keep the nut 22 tight as above explained.

A second embodiment of the invention is illustrated in FIG. 3. In this second embodiment, the construction is similar in general to the first embodiment, but means are provided for relieving the rotary force or torque on the second nut, whenever, desired. This is helpful because it relieves unnecessary pressure and wear (even though slight) when operating the machine tool under conditions where freedom from play or backlash is not necessary, and also because this arrangement may be helpful in eliminating the extra resistance which is felt (particularly during a hand feeding operation) when the carriage moves from a worn part of the feed spindle to a less worn part.

It does not matter, for purposes of the present invention, what type of lead screw is used on the feed spindle. In the first embodiment, FIG. 1, the lead screw was formed by ball races containing balls. The second embodiment, FIG. 3, illustrates the lead screw as being formed by screw threads 11a of trapezoidal cross section, sometimes called an Acme thread. Except for this difference in threads (which is immaterial, as above mentioned) the parts in the second embodiment contain all the features above described in connection with the first embodiment, and operate in the same way, the corresponding parts being designated by the same reference numerals used in the first embodiment. In addition to this, the second embodiment has the further feature of means for relieving the axial pressure of the bushing 36 against the inclined flanks 30 of the bushing 28, whenever desired. This is accomplished by means of an annular nut 44, loosely surrounding the feed spindle 10 and having external screw threads 45 engaging internal screw threads in an annular cavity at the left end of the carriage 18. By means of a hand lever 42 fixed to the nut 44, this nut 44 can be turned so as to screw it further into or out of the left end of the carriage 18. When screwed in an inward direction, it presses against the left ends of the pins 46 movable axially in suitable bores in the carriage 18, and presses the right ends of these pins against a leftwardly faced shoulder of the bushing 36, thereby displacing the bushing rightwardly against the force of the springs 38, and relieving the pressure of the oblique flanks 32 on the oblique flanks 30. This relieves, of course, the component of force which tends to turn the second nut 22 in a tightening direction against the threads of the spindle. As above indicated, this feature of the invention may be used with a spindle having any type of thread or lead screw. However, this feature of relieving the pressure

tending to rotate the second nut is particularly valuable and useful with a spindle of the sliding thread type as distinguished from the ball roller thread type, since the resistance when moving from a worn part of the spindle to a less worn part is particularly severe with a sliding thread.

A third embodiment of the invention is illustrated in FIGS. 4 and 5. The same general principles are present in this third embodiment, but the construction is somewhat different. In this embodiment, the feed spindle is shown at 48, and is provided with a feeding or lead screw thread 49 of any suitable kind, such as the trapezoidal or Acme thread illustrated, only part of the length of the thread being shown in FIG. 4 in order to simplify the drawing. The thread will, of course, extend through a greater part of the length of the spindle 48, than illustrated. In the first two embodiments the thread was of the non-self-locking type, but in this third embodiment the proportions of the thread are preferably such that it is a self-locking thread. The feeding motion to be performed in this embodiment of the invention is a relative motion between the support 18a and the spindle 48, and the motion is secured in this instance, not by turning the spindle, but by turning the nuts around the spindle. It does not matter whether the support 18a is held stationary and the spindle 48 travels longitudinally or axially through the support, or whether the spindle is held axially stationary and the support 18a moves bodily along it, since it is a matter of a relative feeding motion in either case.

The threads of the spindle carry two nuts 20a and 22a, serving in principle like the nuts 20 and 22 in the previous embodiments. These nuts are mounted within the support 18a, and each nut is held against axial movement in one direction relative to the support 18a. The nut 20a reacts rightwardly against a thrust bearing 52 in the support 18a, and the other nut 22a reacts leftwardly against a thrust bearing 54 in the support, these thrust bearings thus serving to limit the extent to which the two nuts may move axially away from each other.

The left face of the right-hand nut 20a is provided with a circumferentially extending series of inclined or oblique flanks 30a which mate with corresponding inclined or oblique flanks 32a at the right end of the sleeve 36a which surrounds the right end of the left nut 22a and is splined thereto at 40, so that the sleeve 36a can move longitudinally or axially on the nut 22a, to the necessary extent, but cannot turn thereon. Like the corresponding flanks 30 and 32 in the previous embodiments, the inclined flanks 30a and 32a in the present embodiment are inclined at a sufficient angle so that they are not self-locking. As before, the angle should be close to the self-locking angle, but sufficiently greater than the self-locking angle so that there will not be a self-locking action even if the lubrication is poor.

The sleeve 36a is constantly pressed rightwardly, into contact with the flanks 30a, by the nest or series of annular leaf springs 56 which correspond in general to the leaf springs 38 in the first embodiment. These leaf springs surround the nut 22a, just to the left of the sleeve 36a, and press rightwardly on the left end of the sleeve 36a, reacting leftwardly against a collar 57 screwed on the perimeter of the nut 22a, the collar advantageously serving also to retain one side of the thrust bearing 54.

Both nuts 20a and 22a are rotatable within the housing or support 18a, and are respectively supported radially by suitable bearings such as the roller bearings 20c and 22c, respectively. The nut 20a is keyed or otherwise non-rotatably connected to a gear 58, and the other nut 22a is similarly connected to a second gear 60. Through these gears 58 and 60, the nuts are driven, when relative motion of the parts is required, from a drive shaft 62 which is mounted for rotation in the support 18a, on an axis substantially parallel to the spindle 48, and which is driven in any suitable conventional manner, either by hand or by motor. Rotatable on the shaft 62 is a pinion

64 which meshes at all times with the gear 58, and a second pinion 66 which meshes at all times with the gear 60.

The respective pinions 64 and 66 are operatively connected to the shaft 62, to be turned thereby, by suitable conventional means which will cause driving torque to be applied to one pinion when the shaft 62 is turned in one direction and to the other pinion when the shaft is turned in the opposite direction. Such means may take the form of a conventional electromagnetic change-over clutch, or may be in the form of a pair of conventional one-way roller clutches respectively indicated schematically at 68 and 70, the inner drive ring of each one-way clutch being formed as part of or mounted non-rotatably on the drive shaft 62, while the outer ring of each one-way clutch is on a sleeve 72 or 74, respectively, which carries the pinions 64 or 66, respectively. The two one-way clutches 68 and 70 are arranged to transmit torque in opposite directions, so that when the drive shaft 62 is turned in one direction the clutch 68 will drive the sleeve 72 and pinion 64, and when the shaft 62 is turned in the opposite direction, the clutch 70 will drive the sleeve 74 and pinion 66. The directions of the clutches should be such that they will transmit torque to turn the respective gears 58 and 60, as the case may be, in directions which will turn the immediately driven nut (20a and 22a, as the case may be) in a direction to relieve the pressure of its flanks against the flanks of the screw thread 49 on the spindle 48. The other nut (that is, the nut which is not immediately driven through the appropriate roller clutch or one-way clutch) will then be driven from the first nut by torque transmitted through the oblique flanks 30a and 32a, and will cause the required relative movement between the support 18a and the spindle 48, without play or backlash.

Assume, for example, that the spindle 48 is to be fed in a rightward direction relative to the stationary support 18a, or that the support 18a is to be fed in a leftward direction relative to the spindle 48, which amounts to the same thing. To accomplish this, the drive shaft 62 is turned in a counterclockwise direction when viewed from the right side of FIG. 4, and the clutch 68 is the one which should be operative at this time, causing corresponding driving in a counterclockwise direction of the pinion 64, thereby driving the gear 58 in a clockwise direction when viewed from the right end of FIG. 4. This will cause corresponding clockwise rotation of the first nut 20a, and it will be noted from the direction of the screw threads 49 as seen in FIG. 4 that this will tend to relieve the pressure of the flanks of the teeth on the nut 20a from the flanks of the screw threads 49. This clockwise rotation of the first nut 20a will be transmitted through the oblique flanks 30a and 32a to the sleeve 36a, and will cause, in turn, corresponding clockwise rotation of the second nut 22a. The flanks of the teeth of the nut 22a will bear against the flanks of the screw threads 49 on the spindle 48, in a direction to move the spindle 48 axially rightwardly (or to move the support 18a axially leftwardly along the spindle, as the case may be).

Similarly, if relative motion in the opposite direction is desired, the drive shaft 62 is turned in the opposite or clockwise direction when viewed from the right end of FIG. 4, and this time the one-way clutch 70 will be operative to turn the gear 60 in a counterclockwise direction, similarly turning the nut 22a which will thereby relieve its pressure on the threads 49. The rotation of the nut 22a will be transmitted through the sleeve 36a and the oblique flanks 32a and 30a, to the nut 20a, and the action of this nut will press leftwardly on the threads 49, moving the spindle 48 in a leftward direction relative to the support 18a.

As wear on the threads 49 of the spindle occurs through continued use, one nut 20a will turn slightly relative to the other nut 22a, within the support 18a, to keep

the nuts always pressing tightly in opposite directions against the flanks of the threads of the lead screw, so that upon reversal of direction of rotation there will be an immediate reversal of longitudinal movement, without any play or backlash, in a manner similar to the other embodiments earlier described.

With the foregoing specific structural embodiments in mind, it will now be possible more easily to understand and appreciate a discussion of certain general principles, which discussion has accordingly been deferred until after the specific embodiments were described.

Many drives having freedom from play or backlash have heretofore been proposed. The prior drives have the disadvantage, however, that the flanks of the threads of the lead screw are subjected to very high initial loads between the nuts and the threads of the screw, either by elastic clamping or by rigid clamping of the nuts. Thus the threads are subjected to a correspondingly large amount of wear, and require a stronger drive, than drives which do not attempt to eliminate or equalize the play or backlash. In the case of prior nuts which are loaded elastically by means of a spring, the high application of pressure on the flanks of the threads is caused by the fact that the spring pressure rests against the flanks with the full force of the spring, which force must exceed the greatest thrust force which is to be transmitted. The present invention, on the contrary, practically completely excludes the flank pressure resulting from clamping of the two nuts relative to each other. In all embodiments of the present invention there are stops for limiting the axial distance of the two nuts relative to each other, and a spring element which reacts against one of the nuts (or against a member which is axially fixed relative to one of the nuts) displaces an axially movable bushing which, in turn, by means of non-self-locking flanks, turns the second nut to equalize the play. With this arrangement, there is obtained in all cases a complete elimination of play, automatically compensating not only for initial manufacturing variations or tolerances, but also for wear of the flanks of the thread and of the nuts, which occurs after continued use.

In a particularly advantageous form of the invention, the angle of inclination of the oblique flanks of the bushing or sleeve, which tend to turn one of the nuts to take up the play, is made close to the self-locking angle. For the sake of safety, it is advisable to select the angle of inclination not too close to the self-locking angle, since the occurrence of self-locking depends partly on the condition of lubrication of all of the parts which must be moved by the spring upon the occurrence of play. But by selecting the angle relatively close to the self-locking angle, the result is obtained that the component of the spring force which effects a rotation of the second nut is so slight that only a negligibly small pressing pressure is produced on the flanks between the spindle and the nut, thereby making for ease of operation of the drive, as well as reducing wear which will occur upon continued use of the drive.

In designing or determining the required spring force to act on a bushing to produce a turning moment on the second nut, it is desirable to consider what is to be accomplished by the drive. For ordinary milling (with opposing direction of cutter and table movement) freedom from play is not usually required. But for milling where the cutter movement and table movement are in the same or parallel direction, sometimes called downcutting, freedom from play is required. Freedom from play is also desirable in the operation of copying machines or profile milling machines. In this connection it is desirable to make a distinction between the following two cases:

In the case of a drive which is equipped with a non-self-locking threaded spindle, the cutting force of the milling tool (that is, the force by which the tool is pressed against the work) acting in the direction of movement of the support in which the rotatable nut is mounted,

produces a moment of rotation of the rotatable nut, and through the oblique flanks on this nut this moment of rotation is converted into an axial force on the bushing, producing an axial force acting on the spring. Therefore, the stronger the cutting force which is to be applied to the tool, the stronger the spring force must be made, if it is to maintain the drive free from play. It should be borne in mind in this connection that the portion of the cutting force of the cutter which acts on the spring of the play-free mechanism is reduced, in the case of parallel milling or down-cut milling, by the friction of the guiding of the support, since the spindle maintains this cutting force through the action of the spring and allows the support to advance in the direction of the cutting force. In the case of conventional milling, on the other hand, the portion of the cutting force which acts on the spring is increased by the friction of the guiding of the support, since the spindle advances the support in opposition to the cutting force. The latter is unimportant, however, for designing the strength of the spring, since freedom from play is not needed in purely conventional milling. Thus when the spring force is designed to be sufficient for the active or effective portion of the cutting force in the case of parallel milling or down-cut milling, it will in general also be sufficient for carrying out profiling work or copying work without reversing error or backlash, since normally the active portions of the feeding forces in profiling work, even in the conventional milling phase, will be smaller than the corresponding portions of the cutting force in parallel milling or down-cut milling, in view of the slight rigidity of the profiling members.

As distinguished from the above mentioned case of drives equipped with non-self-locking threads on the spindle, consider the case of a drive in which the spindle has a self-locking thread. With a self-locking thread, and with nuts driven through a cross drive (as in the third embodiment above disclosed, for example) no moment of rotation can be produced in a nut from a force acting in the direction of movement of the support, so that no effects can be transmitted to the spring in this way. Therefore, the spring need only be dimensioned or designed sufficiently strong so that the maximum drive torque which is to be transmitted without play can be transmitted through the oblique flanks between the bushing and the nut, without axial displacement of the bushing. This maximum torque, for a play-free parallel milling or down-cut milling device, need at most overcome the table friction, so that in this case the spring can be relatively weak. If the reversing error or backlash is to be excluded also for profiling or copying work, then the spring force is determined from the maximum drive torque needed for profiling work in conventional milling.

Regardless of these principles of spring design, as discussed above, it will be advisable to dimension the spring in such manner that even the largest torque of an additional manual drive is transmitted without play. Thus any play which may suddenly occur without being felt on the hand wheel, does not falsify the size of the adjustment movement.

If the force tending to deform or compress the spring exceeds the force of the spring, then the spring is compressed until the mating flanks of the two nuts rest against the mating flanks of the spindle. The drive will then operate, but with some degree of play or backlash. Hence it is desirable to make the spring strong enough, according to the above explained principles, so that the spring resists the maximum forces likely to be transmitted to it, as above explained, so that the device operates in the intended manner, free from play or backlash.

In the embodiment of the invention which utilizes a self-locking thread on the spindle and two rotatable nuts (as in FIGS. 4 and 5) each nut is directly driven only in a direction which will relieve the pressure of the flanks

of the nut from the flanks of the lead screw on the spindle, being driven in the opposite direction only indirectly through the other nut and the oblique flanks of the sleeve or bushing. With this arrangement, relieving one nut from pressure against the lead screw, one avoids the nuts becoming locked with respect to each other. In order to obtain always the correct direction of rotation, the drive of the nuts may contain an electromagnetic change-over clutch which connects the proper nut to the common drive shaft, depending upon the direction of rotation of the drive shaft, or this can be accomplished by a pair of one-way clutches mounted to become effective in opposite directions of rotation, which is the specific form disclosed in connection with FIG. 4. The tooth backlash of the teeth between the gears 58 and 60, rigidly connected to the respective nuts, and the teeth of the driving pinions 64 and 66, respectively, is taken up or compensated for by the same spring mechanism which compensates for play or backlash of the nuts on the spindle, with a minimum of clamping force. In this type of construction (as in FIGS. 4 and 5) the angle of inclination or pitch angle of the oblique non-self-locking flanks 30a and 32a should be made somewhat greater than the angle of inclination used when the lead screw is not self-locking, because the occurrence or possibility of self-locking in this construction depends, in addition, upon the friction between the respective gears 58, 65 and 60, 66.

It is seen from the foregoing disclosure that the objects and purposes of the invention are well fulfilled. It is to be understood that the foregoing disclosure is given by way of illustrative example only, rather than by way of limitation, and that without departing from the invention, the details may be varied within the scope of the appended claims.

What is claimed is:

1. A play-free drive for machine tools, comprising a support and a threaded spindle movable relative to each other in a direction longitudinally of the spindle and two threaded nuts operatively connected to the support and engaging the threads of the spindle and bearing against the spindle threads in opposite directions, characterized by stop means for limiting axial movement of the nuts relatively to each other, oblique flanks on one of said nuts, a sleeve surrounding and movable axially on one of said nuts, oblique flanks on said sleeve for mating with the oblique flanks on said one of said nuts, and spring means tending to move said sleeve axially in a direction to press its oblique flanks against the oblique flanks on said one of the nuts to tend to turn said nut which has the oblique flanks, in a direction to cause such nut to become tight on the threads of the spindle and to press axially against said stop means, said oblique flanks being at such an angle that they are not self-locking.

2. A construction as defined in claim 1, further characterized by the fact that the oblique flanks on the sleeve are developed as beveled end surfaces on the sleeve.

3. A construction as defined in claim 1, further characterized by the fact that the angle of said oblique flanks is relatively close to but greater than the angle at which the flanks would be self-locking against each other.

4. A construction as defined in claim 1, further characterized by the fact that the two nuts rotate relative to said support while said spindle remains rotationally fixed relative to said support, and that there is means for directly rotating each nut only in a direction to relieve the pressure of its threads against the threads of the spindle, the other nut being driven indirectly through the rotation of the nut which is directly rotated.

5. A construction as defined in claim 1, further characterized by the fact that the two nuts rotate relative to said support while said spindle remains rotationally fixed relative to said support, and that there is a drive

shaft operatively connected to both of said nuts to rotate them, and clutch means operatively interposed between said drive shaft and said nuts and operative to apply rotary force directly to only one of said nuts when said drive shaft is turned in one direction and only to the other of said nuts when said drive shaft is turned in the opposite direction.

6. A construction as defined in claim 5, in which said clutch means comprises two uni-directional roller clutches, one effective to transmit torque in one direction and the other effective to transmit torque in the opposite direction.

7. A construction as defined in claim 1, in which the first nut is rigidly mounted in said support and the second nut is mounted in said support for limited axial and rotary movement therein, and in which said sleeve surrounds and is movable axially on said second nut, further including means holding said sleeve against rotation relative to said support.

8. A construction as defined in claim 7, further including means for nullifying the force of said spring means tending to press the oblique flanks on said sleeve against the oblique flanks on one of said nuts.

9. A construction as defined in claim 8, in which said means for nullifying the force of said spring means comprises an annular screw threaded member and a plurality of pins moved axially by said threaded member and pressing axially against said sleeve to move said sleeve against the force of said spring means.

10. A construction as defined in claim 1, further including means for nullifying the force of said spring means tending to press the oblique flanks on said sleeve against the oblique flanks on one of said nuts.

11. A construction as defined in claim 10, in which said means for nullifying the force of said spring means comprises an annular screw threaded member and a plurality of pins moved axially by said threaded member and pressing axially against said sleeve to move said sleeve against the force of said spring means.

12. A construction as defined in claim 1, in which said two nuts are both mounted for rotation in said support, and in which said sleeve is axially slidable on and non-rotatably fixed to the nut other than the one which has the oblique flanks thereon.

13. A machine tool feed drive free from play, comprising a support and a screw-threaded spindle capable of feeding movement relatively to each other in either direction longitudinally of said spindle, a first nut mounted for rotation in said support and engaging the threads of said spindle, a second nut also mounted for rotation in said support in axially spaced relation to the first nut and also engaging the threads of said spindle, thrust bearings operatively interposed between said nuts and said support to limit the extent to which said nuts may move axially relative to each other, and means tending to turn the two nuts relative to each other in opposite directions effective to tighten the nuts against the respective thrust bearings and against the threads of the spindle.

14. A machine tool feed drive free from play, comprising a support and a screw-threaded spindle capable of feeding movement relatively to each other in either direction longitudinally of said spindle, a first nut mounted for rotation in said support and engaging the threads of said spindle, a second nut also mounted for rotation in said support in axially spaced relation to the first nut and also engaging the threads of said spindle, thrust bearings operatively interposed between said nuts and said support to limit the extent to which said nuts may move axially relative to each other, and means tending to turn the two nuts relative to each other in opposite directions effective to tighten the nuts against the respective thrust bearings and against the threads of the spindle, said means tending to turn the two nuts relative to each other including oblique

jaw teeth on the first nut facing obliquely toward the second nut, a sleeve mounted on the second nut for axial sliding movement thereon and held against rotation relative thereto, said sleeve having oblique jaw teeth mating with the jaw teeth on the first nut, and annular spring means surrounding the second nut and reacting against the second nut and said sleeve to tend to move said sleeve axially toward the first nut.

15. A construction as defined in claim 14, in which the angle of said oblique jaw teeth is greater than the self-locking angle, so that the axial force produced on said sleeve by said spring means will produce a relative turning force on the two nuts.

16. A construction as defined in claim 15, in which the angle of the threads on said spindle is less than the self-locking angle, so that axial force exerted between the nuts and the spindle will not produce rotation of the nuts.

17. A machine tool feed drive free from play, comprising a support and a screw-threaded spindle capable of feeding movement relatively to each other in either direction longitudinally of said spindle, a first nut mounted stationarily in said support and engaging the threads of said spindle, a second nut mounted for limited rotation in said support in axially spaced relation to the first nut and also engaging the threads of said spindle, a thrust bearing operatively interposed between said second nut and said support to limit the extent to which said nuts may move axially relative to each other, and means tending to turn the second nut relative to the support and the first nut in a direction effective to tighten the second nut against said thrust bearing and against the threads of the spindle.

18. A machine tool feed drive free from play, comprising a support and a screw-threaded spindle capable of feeding movement relatively to each other in either direction longitudinally of said spindle, a first nut mounted stationarily in said support and engaging the threads of said spindle, a second nut mounted for limited rotation in said support in axially spaced relation to the first nut and also engaging the threads of said spindle, a thrust bearing operatively interposed between said second nut and said support to limit the extent to which said nuts may move axially away from each other, and means tending to turn the second nut relative to the support and the first nut in a direction effective to tighten the second nut against said thrust bearing and against the threads of the spindle, said means tending to turn the second nut including oblique jaw teeth on the second nut, a sleeve mounted on the second nut for axial sliding movement thereon and held against rotation relative to said support, said sleeve having oblique jaw teeth mating with the jaw teeth on the second nut, and annular spring means surrounding the second nut and reacting against said support and said sleeve to tend to move said sleeve axially toward the oblique jaw teeth on the second nut.

19. A construction as defined in claim 18, in which the angle of said oblique jaw teeth is greater than the self-locking angle, so that the axial force produced on said sleeve by said spring means will produce a torque force tending to turn said second nut relative to said support.

20. A construction as defined in claim 19, in which the angle of the threads on said spindle is greater than the self-locking angle.

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