June 12, 1945. J. E. KLINE 2,378,302

METHOD AND MEANS FOR GENERATING HELICES

Filed Aug. 22, 1942 3 Sheets-Sheet 1

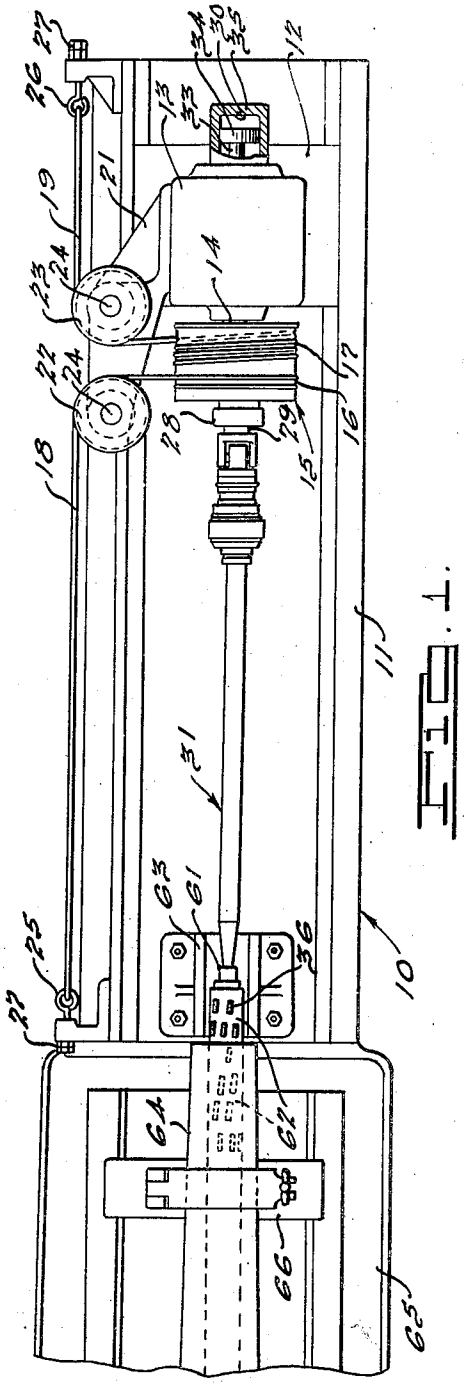


Fig. 1.

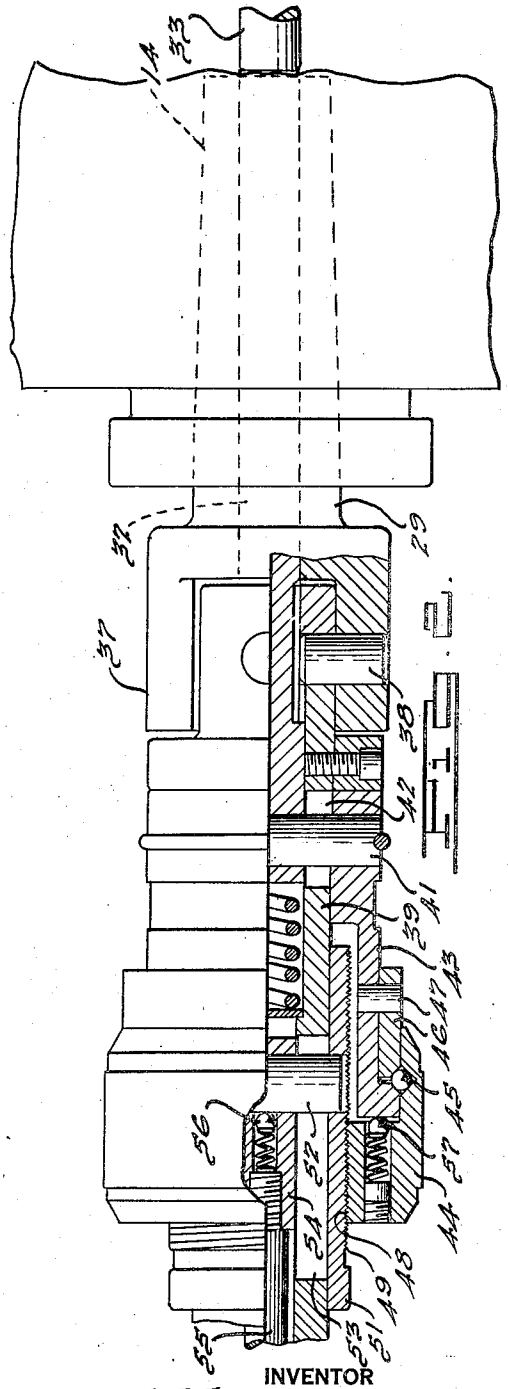


Fig. 2.

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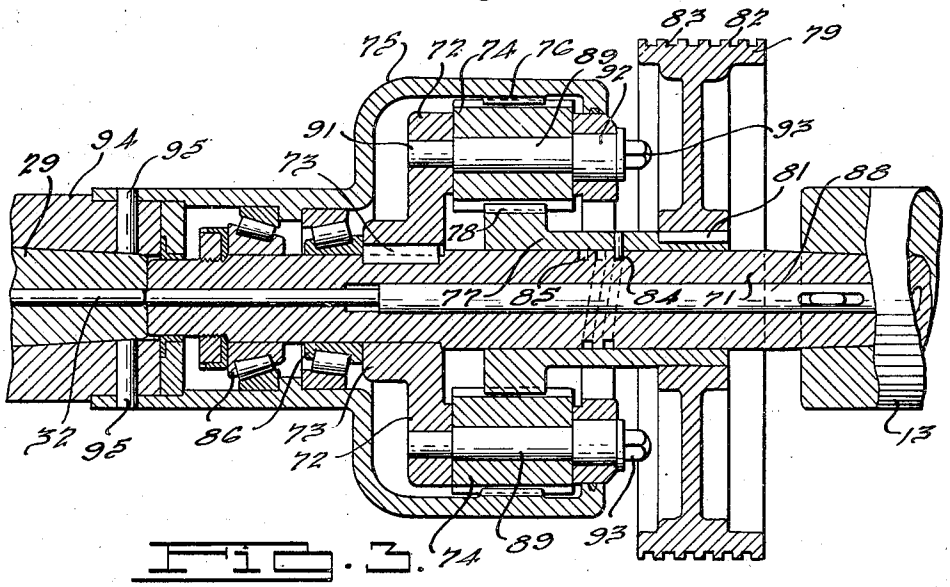


Fig. 3.

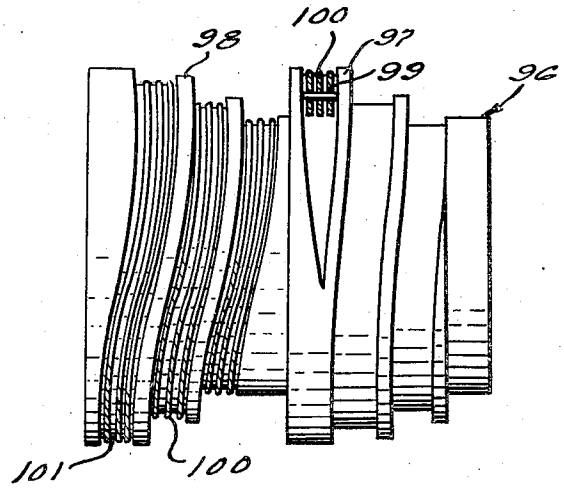


Fig. 4.

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Filed Aug. 22, 1942 3 Sheets-Sheet 3

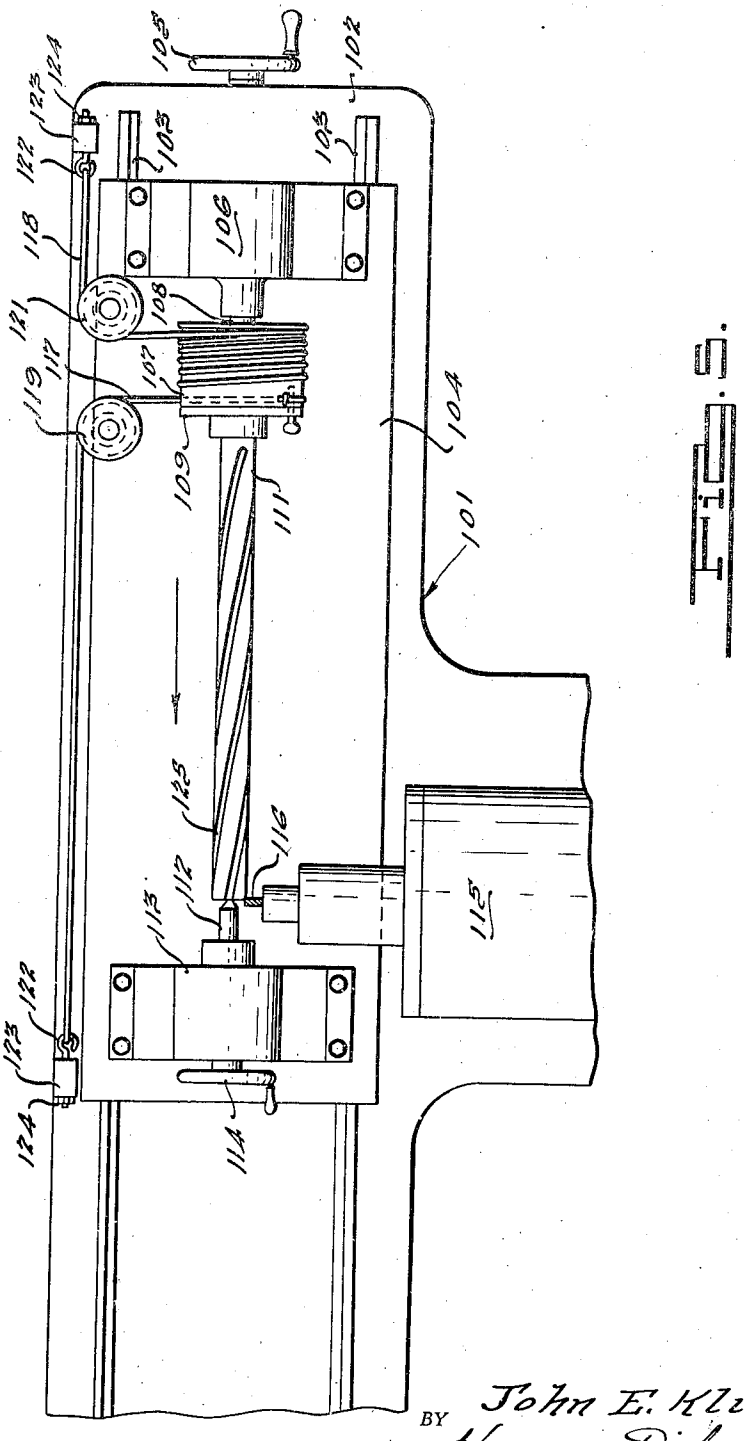


Fig. 5.

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UNITED STATES PATENT OFFICE

2,378,302

METHOD AND MEANS FOR GENERATING HELICES

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Application August 22, 1942, Serial No. 455,712

10 Claims. (Cl. 51—59)

This invention relates to methods and devices for producing helices and particularly to a method and device for rotating an element in predetermined relation to its pitch circle and axial movement.

It has been the practice in the gun construction art to employ single or multiple tools or a series of broaches for cutting the grooves in the wall of the barrel to produce lands of predetermined helical form projecting from the wall thereof. This proved not only to be a lengthy process requiring extreme care and skill, but often resulted in the production of a large number of defective barrels. The tools would pile up cuttings as they advanced through the barrel which prevented the proper functioning of the cutting teeth and the metal would be torn and a rough enlarged groove would be formed in the gun barrel. A lapping operation is then necessary to smooth the walls and base of the grooves between the lands as an endeavor to salvage the workpiece.

One phase of the present invention has for its object the use of a device for rotating a honing tool having one or a plurality of sets of honing stones which are disposed on the angle of the helix on which the grooves are to be machined. As the honing tool is reciprocated within the barrel, the tool is rotated on the pitch circle of the helical lead of the lands and the grooves are quickly honed to required depth by the honing stones.

The present commercial machines may be employed when performing the cutting or honing operations on cylindrical elements such as broaches, lead bars, gun barrels and the like when utilizing the method and device embodying this invention. The device comprises a drum having a pair of cables wound thereabout in opposite directions and which are stationarily anchored at opposite ends of the machine. The cables extend over a pair of adjacent pulleys and are drawn taut to eliminate any backlash between the movements in rotation and reciprocation of the tool. As the tool is advanced, one section of the cable unwinds from one of the drum sheaves while the other section is winding upon the other and the rotation produced to the drum and therefore the tool in this manner is timed with the advancing movement of the table carrying the drum and tool. After the tool is advanced to cutting position, it is relatively reciprocated over the entire length of the workpiece as it is rotated by the winding and unwinding of the cables over the drum.

In producing helical slots or grooves in the internal or external surface of a workpiece, the relative rotation of the tool and workpiece is timed with the relative longitudinal movement therebetween by the cables operating on the drum, the pitch circumference of which is equal to the desired lead of the helices produced on the workpiece. The length of the helical lead of the workpiece and the size of the cable predicate the diameter of the drum over which the cable is wound for rotating the tool or workpiece about its axis. The diameter of the drum is obtained by dividing the required lead by "pi" and subtracting the diameter of cable therefrom. The circumference of the axis of the cable on the drum will thus equal the lead of the helix, which is the length of the workpiece in which the helix makes one complete turn. If the cable is to have more than one wrap around the drum, as may be required in the generation of helices having more than one turn, it is obvious that the cables may require a comparable number of turns around the drum thus describing a slight spiral thereabout. In such instances the root (or base) diameter of the drum is obtained by dividing the lead of the helix to be generated on the workpiece by "pi" times the secant of the angle of spiral the cables describe around the drum and subtracting the diameter of the cable from the quotient thereof; or:

If:

B equals root (or base) diameter of the required drum

L equals lead of helix desired in workpiece

a equals angle of spiral of cable about the drum (with respect to the transverse plane of the latter)

and,

d equals diameter of cable.

Then:

$$B \text{ equals } \frac{L}{\text{"pi" sec } a} \text{ minus } d$$

When the helix is extremely long, it will be apparent that the circumference of the drum must be large and its diameter will reach such a proportion that it will be impractical to use the invention on a standard type of machine. For this reason, a reduction gear unit may be employed in combination with a reduced drum diameter to produce the timed rotation between the rotation and reciprocation.

The smaller drum may then rotate several times faster than the tool or workpiece but the reduction gear unit compensates for this faster

rotation. The root (or base) diameter of the spiral grooves in this smaller drum is obtained by dividing the length of lead to be generated upon the workpiece by the product of the ratio of gear reduction times "pi" times the secant of the angle of the spiral of the cable around the drum and subtracting the diameter of the cable from the quotient thereof; or:

If:

R equals number of teeth in internal gear divided by number of teeth in Sun gear of reducer

Then:

$$B \text{ equals } \frac{L}{\text{"pi" } R \sec a} \text{ minus } d$$

It is also within the purview of this invention to employ a drum having a pair of like sheaves which are of spiral-helical form so as to produce an accelerated lead to the helical groove generated, as is the case in some gun barrels. By changing the spiral-helical form of the sheaves, the rotation of the tool or workpiece may be progressively varied to any desired degree throughout the length of the helix generated upon the work.

Accordingly, other objects of this invention are: to generate a helix by relating the reciprocation of the tool or work to its rotation derived from a base circle whose effective circumference is predicated upon the lead of said helix; to provide a drum which is rotated by a pair of cables which wind and unwind thereover in timed relation to relative axial movement between the work and the tool to create a precise oscillatory movement therebetween; to mount a drum on a reciprocable head for rotating a tool or workpiece through a set of reduction gears thereby reducing the size of the drum to be actuated by a pair of cables wound thereover in opposite directions; to provide a fluid actuated cylinder on the head of the reciprocable carriage for expanding and contracting the stones of the honing tool; to form a drum having two sheave portions which are of spiral-helical form for varying the lead angle of the slots generated by the tool, and, in general, to provide an adapting means to a commercial machine for rotating a tool or workpiece in predetermined relation to its reciprocation while eliminating backlash between them during alternate directions of reciprocation therebetween.

Other objects and features of novelty of this invention will be specifically pointed out or will become apparent when referring, for a better understanding of the invention, to the following description taken in conjunction with the accompanying drawings, wherein:

Figure 1 is a plan view of a honing machine which embodies features of the invention:

Fig. 2 is an enlarged sectional view of a portion of the driving end of the tool provided on the machine illustrated in Fig. 1:

Fig. 3 is a sectional view of a drum and driving portion of a device similar to that illustrated in Fig. 1 showing a further form which this invention may assume:

Fig. 4 is a view of a drum similar to that illustrated in Fig. 1 showing a further form of the invention; and

Fig. 5 is a plan view of structure similar to that illustrated in Fig. 1 showing a further form of the invention.

Referring to Fig. 1, a honing machine 10 is illustrated having a bed 11 on which a table 12 may be reciprocated. The table supports a driving head 13 having a recess in which a shank 14 on one end of a drum 15 is inserted for rigidly supporting the drum. The drum 15 rotates upon the shank 14 and is provided with a pair of sets of helical grooves 16 and 17 of the same hand. The grooves form a pair of sheaves upon which a pair of cables 18 and 19 are secured and are wound in opposite directions. The head 13 has a bracket 21 secured thereto on which a plurality of pulleys 22 and 23 are pivotally supported on pins 24. The cables 18 and 19 extend over the pulleys 22 and 23, respectively, and their ends are secured to adjustable I-bolts 25 and 26 at opposite ends of the bed 11. Nuts 27 on the end of the I-bolts take up the slack in the cables 18 and 19 and retain them taut over the pulleys and about the sheave portions of the drum 15.

The drum is provided with a tool-receiving collet 28 in which the driving end 29 of the tool 31 is secured. The driving end 29 of the tool is hollow and an adjusting rod 32 extends therethrough, as illustrated more clearly in Fig. 2. The end of the adjusting rod abuts against the piston rod 33 which extends through the head 13 and is secured to the piston 34. The piston is enclosed within a cylinder 35 on the right hand end of the head 13 as illustrated in Fig. 1. Fluid is conducted to the cylinder and is employed for moving the piston to the left or right for contracting and expanding, respectively, the abrasive stones 36 carried by the tool 31.

The rod 32 extends through the universal joint 37 on the driving end 29 of the tool which is secured by pins 38 to the end of a driving tube 39. A pin 41 extends through the rod 32, through a slot 42 in the tube 39, and into an outer sleeve 43 which extends thereover. An internally threaded collar 44 is rotatably secured to the end of the sleeve 43 by a plurality of balls 45 which are retained in position by a collar 46 which is secured to the sleeve by pins 47. The threads 48 of the sleeve 44 engage tht threads 49 on a sleeve 51 disposed over the tube 39. A pin 52 extends through a slot 53 in the tube 39 and through a block 54 disposed within the tube.

An adjusting rod 55 is threaded into the end of the block 54 and extends the entire length of the tube 39 to the body of the tool containing the stones 36. A spring-pressed ball 56 secures the pin 52 against axial movement while a spring-pressed ball 57 is employed for retaining the sleeve 44 in adjusted position. By rotating the sleeve 44, the sleeve 51 is extended or retracted so as to extend or retract the adjusting rod 55. When fluid is admitted to the cylinder 35 on the right hand side of the piston 34, the piston 34 is moved to the left, as viewed in Fig. 1, moving the piston rod 33 and the adjusting rod 32 to the left. This movement is transmitted through the pin 41 to the sleeves 44 and 51 and then through the pin 52 to the adjusting rod 55.

The tube 39 is connected by a universal connection 61 to tool body 62 which has a series of apertures therein which are helically disposed with reference to the body axis. Stone holders carrying the stones 36 are disposed within the slots for radial movement. Within the body, tapered members are provided for engaging the stone holders and moving them outwardly when the rod 33 is advanced to the left as viewed in the figure. When the rod is moved in the opposite direction, the pressure on the stones is released and these may retract or be retracted by suitable spring means. The tool follows the construction of that

illustrated and described in the copending application of J. E. Kline and C. S. White Serial No. 456,608, filed August 29, 1942 which was assigned to the assignee of the present invention.

A cradle 63 is employed adjacent to the end of the gun barrel 64 for receiving the end of the honing tool when the tool is withdrawn from the barrel. The extending frame 65 of the base 11 has a plurality of supporting brackets 66 upon which the barrel is clamped in substantially aligned relation with the tool 31. The universal connections at the driving head 37 and the tool body 61 permit the misalignment of the axis of the barrel with that of the tool during the honing operation. This eliminates the necessity of attempting to accurately align the axis of the shank 14 or its path of traverse with that of the barrel.

Referring to Fig. 3, a further form of the invention is illustrated wherein the head 13 supports an arbor 71 on which a spider 72 is secured by keys 73. The spider carries a plurality of gears 74, preferably four or more in number, to form an even number of gears for a purpose which will be explained more fully hereinafter.

A housing 75 carries an internal gear 76, the teeth of which are in mesh with the teeth of the pinion gears 74. A sleeve 77 contains an external gear 78, the teeth of which are also in mesh with the pinions 74. The sleeve has a drum 79 secured thereto by keys 81 and has on its outer face the sheave portions 82 and 83, the leads of the grooves of which are both right or both left hand depending upon the hand of helix to be generated. The sleeve 77 has an internally projecting pin 84 which extends into a helical groove 85, the lead of which is the same as the lead of the grooves in the sheaves so that the drum will advance along the arbor 71 to maintain the cable grooves in tangential alignment with the pulleys in 119 and 121 in all positions of the drum.

A set of radial thrust bearings 86 supports the housing 75 on the arbor 71 while the extending portion 87 of the housing has bearing relation with the sleeve 77. An adjusting rod 88 extends through the arbor 71, with one end abutting against the piston rod 33 in the head 13, the other end of which abuts against the adjusting rod 32 of the tool.

The pinions 74 are mounted on shafts 89, the ends 91 and 92 of which are mounted eccentric to the central body portion so that the axes of alternate pinions 74 may be annularly offset in one direction while other intermediate pinions 74 may be annularly offset in the opposite direction to bear against opposite sides of the teeth of the gears 76 and 78 so as to entirely eliminate any backlash which would otherwise exist therebetween. This adjustment is made by turning the shafts 89 at the heads 93 provided on the ends thereof.

A tool receiving adapter 94 is secured to the end of the housing 75 by pins 95. The driving end 29 of the tool may be secured in the head 94 in the same manner as the driving end was secured to the head 28 of the drum illustrated in Figs. 1 and 2. When a barrel is to have slots honed therein which are of considerable length of lead, one that would require a drum of large diameter if the structure of Fig. 1 were employed, the structure illustrated in Fig. 3 is utilized instead. The smaller drum 79 may make any number of revolutions during one revolution of the tool, depending upon the relation of the sun gear 78 to the internal gear 76 and the number of turns to be made within the length of the barrel. If a three to one relation exists between the rotation of the drum 79 and housing 75, then the nominal diameter of the drum 79 may be one-third that of the diameter of a drum which would be employed if a direct drive were utilized between the drum and the adapter 94. In this manner, the large cumbersome drum, which would otherwise be required, is eliminated.

Backlash will be entirely eliminated from between the cables and drum, by suitably tensioning the former, and also from between the gears by utilizing the sets of gears which may be offset in opposite directions to eliminate any play between the teeth. When the drum is rotated as a result of the advance of table 12, the gear 78 is caused to rotate and drive the pinions 74 on stationary axes and they in turn drive the ring gear 76 which rotates the housing 75 at a speed in predetermined ratio and in the opposite direction to that of the gear 78. This rotates the tool supporting adapter 94 and the tool in predetermined timed relation to the advancement of the table 12 and the tool 31.

Referring to Fig. 4, a drum 96 is illustrated having two sheave portions 97 and 98 which are of spiral helical form and which may be substituted for the drums 15 or 79 above referred to. One or a plurality of cables 100 are wound around each of the sheaves having one end of said cables secured thereto at the major diameter of one sheave and at the minor diameter of the other sheave and the other ends of the cables extending to the rear at the points 99 and 101. A drum of this particular type will progressively change the speed of rotation of the tool relative to its movement in reciprocation so that an accelerating or increasing lead may be provided to the grooves in the barrel of the gun, which is desirable in certain types of gun barrel construction. It is within the purview of this invention to vary the lead of the spiral angle of the sheaves so that the increase of the lead of the slot in the barrel will be variable rather than constant from the breech to the muzzle of the gun. The lands between such slots will produce very little turning of the shell near the breach and will increase to maximum turning at the muzzle. By having both of the sheave portions 97 and 98 exactly alike, whether they are of constant or variable spiral angle, the cables are maintained taut at all times so that no backlash will be present in the tool as it is reciprocated through the barrel.

In Figure 5, a machine 101 is illustrated in which the rotating device is applied to the workpiece, on the surface of which helical grooves are to be machined. The machine embodies a base 102 having ways 103 on which a carriage 104 is reciprocated. The carriage is operated by a lead screw (not shown) attached to a hand wheel 105, which is driven through gears (not shown) in the conventional manner. The carriage 104 has a head stock 106 to which a drum 107 is secured by a stub shaft 108. The drum freely rotates on the shaft and carries an index plate 109, to which a workpiece 111 is secured to rotate as a unit with the drum. The opposite end of the workpiece is supported by a center 112 in a tail stock 113 having a hand wheel 114 which moves the center 112 axially.

The bed of the machine also supports a head 115 which drives a milling cutter 116 in rotation or carries a suitable stationary cutting tool such

as a planer tool. The carriage 104 is advanced by the lead screw on the ways 103. This advances the workpiece 111 past the cutter 116, and during such advancement the drum 120, index plate 109, and workpiece 111 are rotated in timed relation thereto independent of the lead screw which drives the carriage.

The drum 120 is provided with a pair of cables 117 and 118, which extend over pulleys 119 and 121 journalled on the carriage, and have their ends secured by eye-bolts 122 to the bosses 123 which are secured to the base 102. The nuts 124 on the eye-bolts draw the cables 117 and 118 taut over the pulleys and about the drums, as explained hereinabove.

As the carriage 104 advances to the left, as illustrated in the figure, the cable 115 winds off of the drum while the cable 117 winds thereon. This rotates the workpiece 111 clockwise, as viewed from the right hand end of the machine, to produce a right hand spiral slot 125 in its surface.

Upon the reverse movement of the machine, after the advancement of the cutting tool 116 toward the workpiece axis, the slot is deepened on the reverse movement of the carriage 104 without adding width thereto while the tool accurately follows the helical lead. In this manner, depth may be added to the slot in each direction of movement of the carriage. After the slot has been machined to depth, the plate 109 may be rotated to index the workpiece 111 in position to machine the next adjacent slot in the surface thereof.

It is to be understood that the gear reduction element of Figure 3 and the spiral helical sheaves on the drum of Figure 4 may be employed on the machine 101, either alone or in combination, for the purpose hereinabove more fully explained. It will thus be seen that the invention is useful not only in rotating tools in a predetermined manner relative to the workpiece, but also the workpiece in relation to the tool. This rotation may be applied to either the tool or the workpiece when machining the internal or external surfaces of the latter. Either the tool or the workpiece will be rotated in synchronism with its reciprocation to generate a predetermined helical lead to a groove machined in the surface of the workpiece.

While reference was made herein to honing when employing abrading sticks, it is to be understood that the invention is not limited to machining by an abrasive material. Diamond impregnated cutting elements could be employed in place of the abrasive sticks, as well as file-like elements which could be substituted therefor. While heretofore the machining of the grooves in a cylinder wall could be accomplished only on the advancing movement of the tool, the abrasive sticks, diamond cutting elements, file-like members, milling cutters and similar cutting elements will operate to machine the groove just as readily on the return stroke as during the advancing stroke. This is made possible by entirely eliminating all backlash between the relative movement of the tool and workpiece in both directions of reciprocation thereof.

What is claimed is:

1. The combination with an element in the nature of a tool, a drum for rotating said element as it is moved axially, said drum having a pair of like sheaves of spiral helical form for producing a varying speed of rotation of the element relative to its longitudinal movement.

2. The combination with an element in the nature of a tool, a drum for rotating said element, said drum having a pair of like sheaves of spiral helical form, a gear unit disposed between said drum and element, and cables over said sheaves wound thereon in opposite directions.

3. In a honing machine, a reciprocable carriage, a head on said carriage, a drum on said head having a pair of sheaves, a honing tool supported by said drum, a pair of cables secured to said sheaves and wound thereon in opposite directions for rotating said drum as the carriage is moved, a cylinder on said head, a piston in said cylinder having a rod projecting into said head, and an adjusting rod in said tool operable by said piston rod.

4. In a honing machine, a reciprocable carriage, a head on said carriage, a drum carried by said head for rotation relative thereto, a gear unit operated by said drum, a honing tool connected to said gear unit for rotation at a speed different from that of the drum, and cables wound in opposite directions over said drum for producing the drum's rotation when the carriage is moved.

5. In a honing machine, a reciprocable carriage, a head on said carriage, a drum carried by said head for rotation relative thereto, a gear unit operated by said drum, a honing tool connected to said gear unit for rotation at a speed different from that of the drum, cables wound in opposite directions over said drum for producing the drum's rotation when the carriage is moved, a piston and cylinder carried by said head, a rod in said head actuated by said piston, and an adjusting rod in said tool operated by said first rod.

6. In a machine, a reciprocable carriage, a head carried thereby, a drum mounted on said head having a pair of sheaves of spiral helical form, a tool carried by said drum, a pair of cables wound on said sheaves for producing the rotation of said tool at a varying rate as it is advanced by said carriage.

7. In a honing machine, a reciprocable carriage, a head carried thereby, a drum mounted on said head having a pair of sheaves of spiral helical form, a honing tool carried by said drum, a pair of cables wound on said sheaves for producing the rotation of said tool a varying amount as it is advanced by said carriage, a piston and cylinder on said head, a rod in said head operated by said piston, and an adjusting rod within said honing tool operated by said first rod for adjusting the diameter of the honing tool.

8. In a honing machine, a reciprocable carriage having a tool carrying head, a drum supported by said head having a pair of sheaves of spiral helical form, a gear unit driven by said drum, a tool supported and driven by said gear unit, and a pair of cables wound in opposite directions about said sheaves for rotating said tool a varying amount and at a different speed from that of the drum as the tool is advanced by the carriage.

9. In a honing machine, a reciprocable carriage having a tool carrying head, a drum supported by said head having a pair of sheaves of spiral helical form, a gear unit driven by said drum, a tool supported and driven by said gear unit, a pair of cables wound about said sheaves for rotating said tool a varying amount and at a different speed from that of the drum, as the tool is advanced by the carriage, a piston and cylinder carried by said head, a rod in said head

operated by the piston, and an adjusting rod within the honing tool operated by said first rod for adjusting the diameter of the honing tool.

10. The method of cutting helical slots in the inner smooth surface of a gun barrel which includes the steps of; reciprocating a tool having a plurality of cutting elements within the barrel, rotating said tool in timed relation to said reciprocation, radially moving the cutting elements of said tool while the tool is being reciprocated and rotated, and machining the slots in said barrel on both strokes in reciprocation of said tool.

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