May 14, 1940. J. E. KLINE 2,200,506

TOOL FOR MACHINING TAPERED BORES

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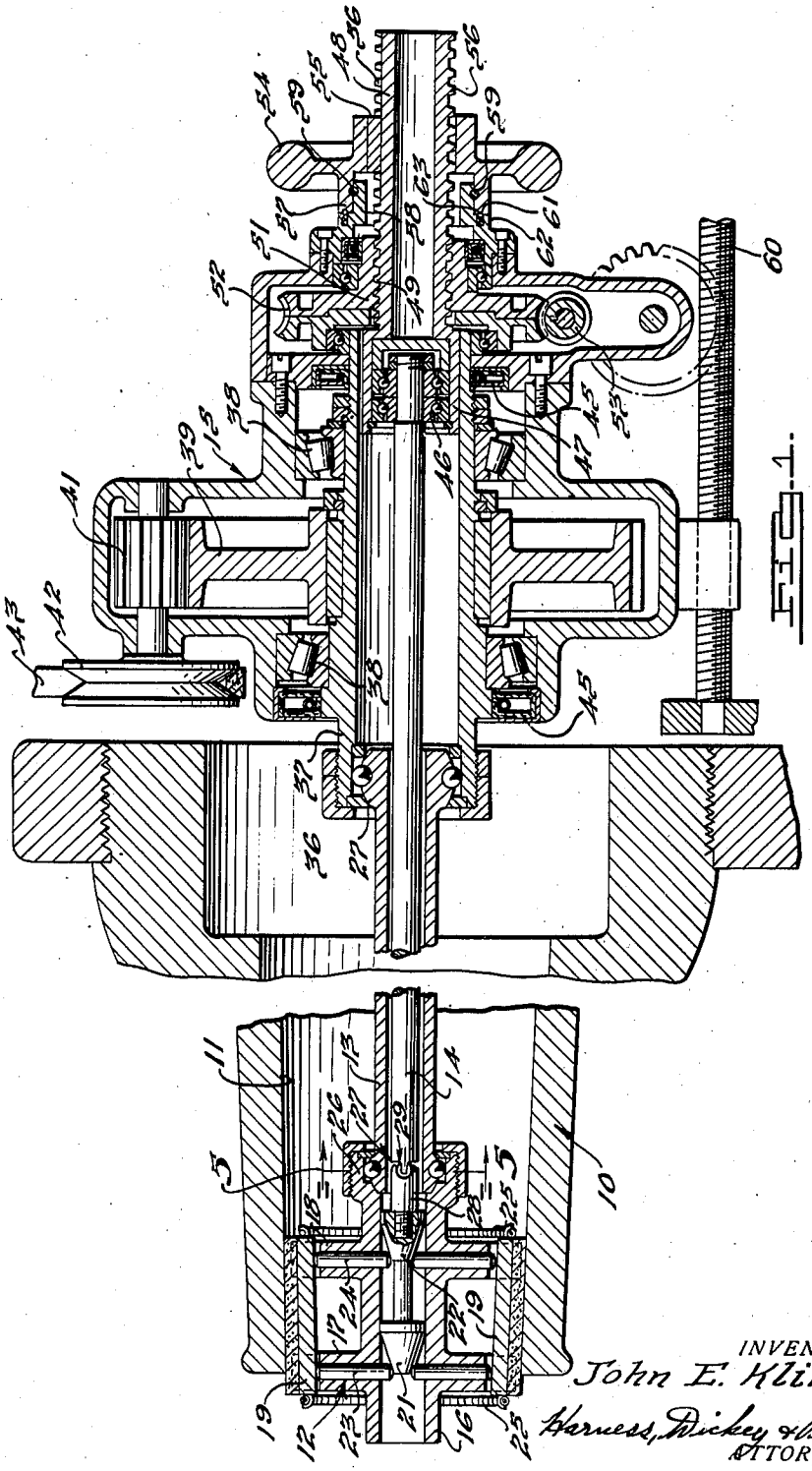


Fig. 1.

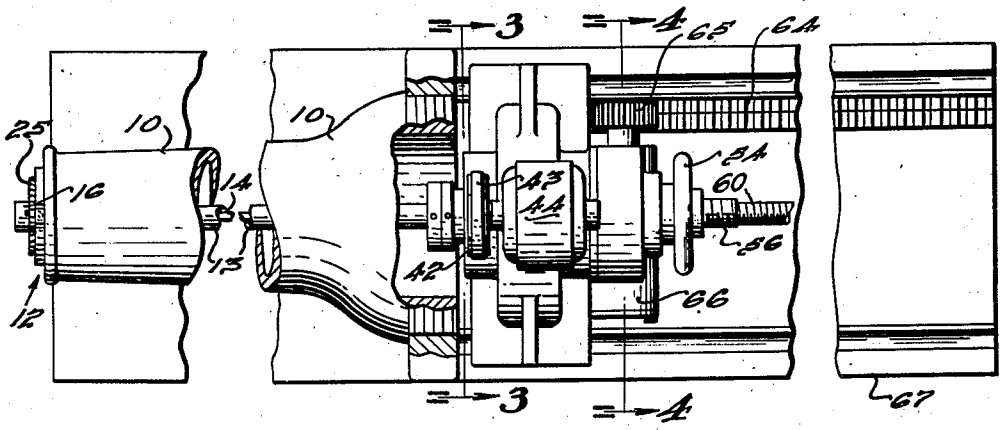
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FIG. 2.



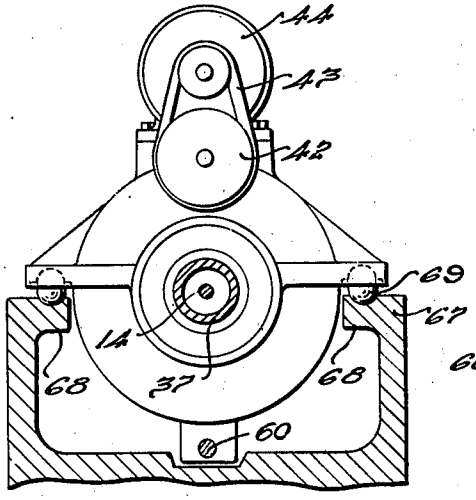




FIG. 3.

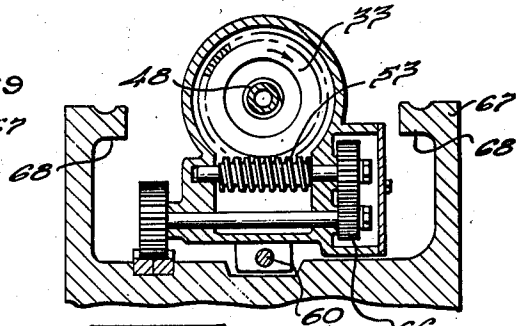



FIG. 4.

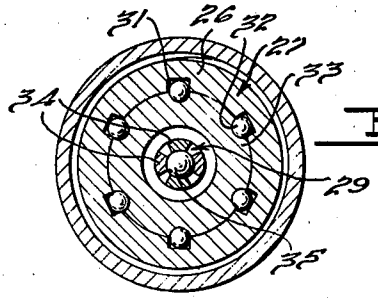



FIG. 5.

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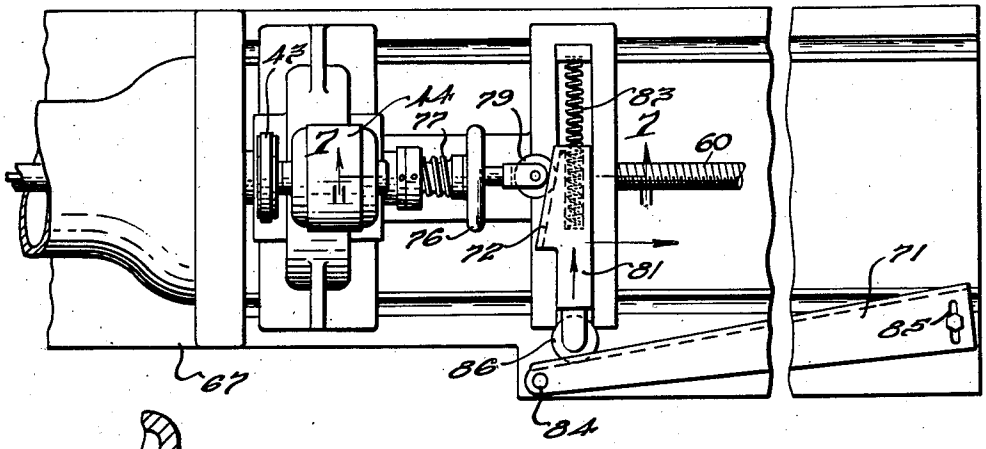
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Fig. 5.



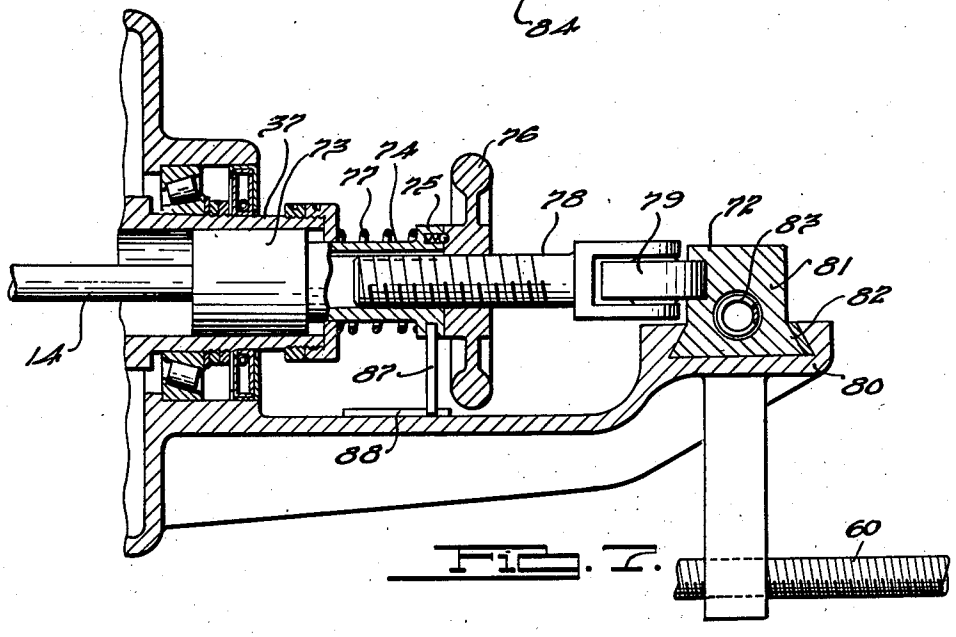




Fig. 7.

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# UNITED STATES PATENT OFFICE

2,200,506

## TOOL FOR MACHINING TAPERED BORES

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Application February 3, 1938, Serial No. 188,531

11 Claims. (Cl. 51—34)

My invention relates to honing tools and methods, and particularly to a honing tool and method for accurately honing a taper on an inner surface of a cylindrical member.

Difficulty has always been experienced in attempting to grind an accurate tapered surface particularly on the interior of an element. Especially is this true if in the taper great accuracy is desired. For example, the taper as provided in the casings of large rifles, howitzers and the like, with which a liner containing the rifling is releasably secured for permitting the liners to be renewed in the field, present a difficult problem in view of the accurate taper to be provided on the inner surface of the casing.

To effect such very accurate honing of tapers in long tubular elements I have invented a unique type of honing tool, that which embodies a plurality of abrading elements disposed substantially on the taper desired and mounted to be radially adjustable on the taper. Means may be provided for driving the tool in rotation, and for expanding and contracting the tool in direct relation to the axial forward and reverse traverse of the tool relative to the tapered element to be machined. Means are also provided on the tool for adjusting the abrading elements radially to compensate for stone wear. Means are further provided for adjusting the angle of taper of the abrading element, and the relationship of expansion and contraction thereof with respect to the axial movement of the honing tool relative to the tapered element to be honed. With my construction, the abrading stones do not follow the angle of the rough taper provided in the bore, but the abrading elements are accurately positioned and actuated relative to the desired taper to be produced on the work element after it is finished.

Accordingly, the main objects of my invention are; to provide a honing tool having an abrading head comprising abrading stones disposed in a tapered position which is maintained as they are expanded and contracted: to provide an abrading head, having stones whose working faces are disposed in an angular relation to its axis and which may be expanded and contracted, with means for affecting the expansion and contraction of the stone in definite accordance with the movement of the head axially; to provide a tapered abrading head with means for driving the head with or without rotation and for expanding and contracting the abrading head an amount proportional to the relative axial movement of the head; to provide a tapered abrading head having means for expanding and contracting the head in accordance with the axial movement thereof with means for adjusting the abrading elements outwardly independent of the axial movement of the head; and in general, to provide a tapered abrading head which is accurately and progressively expanded and contracted in accordance with the taper to be desired, all of which is simple in construction, positive in operation, and economical to manufacture.

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

Figure 1 is a broken sectional view of a honing tool embodying features of my invention positioned in relation to a work piece to be honed;

Fig. 2 is a broken plan view, partly in section, of the structure illustrated in Fig. 1, mounted on the bed of a machine;

Fig. 3 is a sectional view of the structure illustrated in Fig. 2, taken on the line 3—3 thereof;

Fig. 4 is a sectional view of the structure illustrated in Fig. 2, taken on the line 4—4 thereof;

Fig. 5 is an enlarged sectional view of the structure illustrated in Fig. 1, taken on the line 5—5 thereof;

Fig. 6 is a view of the structure, similar to that illustrated in Fig. 2, showing a modified form thereof; and,

Fig. 7 is a section of the view of the structure illustrated in Fig. 6, taken on the line 7—7 thereof.

The work piece 10, illustrated in Fig. 1, is the casing of a rifle of large caliber of conventional form which may be a casting, a forging, a built-up type of casing comprising a plurality of hoops and bands sweated together, or which may be of the wire wound type, or of any other conventional form of rifle casing. The inner surface of the casing is provided with a slight taper which must be machined accurately to receive a liner having on the inside thereof the conventional lands and grooves for producing the rotation of the projectile. The purpose of the tapered relation between the casing and liner is to permit the liner to be easily replaced when the lands and grooves thereof become worn to such a degree as to deleteriously affect the accuracy of the trajectory of the projectile. The diameter of the casing bore decreases from the breech end toward the muzzle, and this taper while slight is sufficient to retain the liner within the casing by a compressive force.

The honing tool for accurately machining the tapered surface 11 of the casing 10 embodies in general a honing head 12, a driving shaft 13, an adjusting shaft 14, and an operating head 15. The abrading head 12 includes a housing 16 having flanges 17 and 18 for receiving radially adjustable abrading elements 19. The housing 16 is hollow for receiving expanding means herein illustrated as comprising a pair of cones 21 and 22, which are axially movable therein for adjust-

ing pins 23 and 24 outwardly when the cones 21 and 22 are advanced axially to the left, as viewed in the figure. It is to be understood that a single cone, or other means known in the art to be suitable, may be employed for effecting the radial movement of the abrading elements. It will be noted that the pins 24 are of slightly greater length than the pins 23 to provide the desired slope to the abrading elements 19 relative to the axis of the head. Suitable means, such as garter springs 25 are secured to the abrading element 19 employed for retracting the elements as the cones 21 and 22 are moved to the right, as viewed in the figure, to reduce the radial position of the pins 23 and 24.

The end 26 of the head 12 forms a universal driving connection 27 with the driving shaft 13. Similarly the end 28 of the cones 21 and 22 form a universal connection 29 with the adjusting rod 14. The connection is illustrated more clearly in Fig. 5 wherein the universal drive connection 27 is formed through a plurality of slots 31 in the end 26 of the honing head 12. Balls 32 are recessed in openings in the rounded end 33 of the driveshaft 13 and project into the slots 31 to permit tilting movement, while at the same time forming a driving connection between the two elements. The end 28 and of the cones 21 and 22, and the end of the driving element 14 are provided with inter-engaging fingers 34 which are bent over a ball 35 to provide a driving connection which also has an axially universal movement.

The opposite end of the drive shaft 13 forms a similar universal drive connection 36 with the driving head 15. Connection is made with a hollow shaft 37, which is supported on suitable bearings 38 and driven by a gear 39 and pinion 41 through a pulley 42 which is driven by a belt 43 from a motor 44. Sealing element 45 may be provided for sealing the ends of the shaft against the escape of a lubricant provided for the bearings. The driving shaft 14 extends rearwardly through the hollow shaft 37 and is secured, through bearings 46, to an axially movable head 47. The head is provided with a threaded shank 48 which is engaged by the threads 49 on the hub 51 of a split worm wheel 52. The worm wheel 52 is driven by a worm 53, the backlash between which has been removed through the adjustment of the split halves of the worm wheel 52.

The hand wheel 54 is keyed to the shank 48 by a key 55 which may slide in a slot 56 disposed in the shank 48. The hand wheel 54 is provided with a hub 57 which is journaled on a hub 58 for rotary movement relative thereto. The hubs are locked together by an annular series of balls 59 which roll in an internal annular recess in hub 57 and an external annular recess in the hub 58. An aperture (not shown) is disposed in the hub 57 through which the balls are introduced into the recesses in the hubs after the hubs are moved into recessed mating relation and a plug is thereafter employed for closing the aperture for retaining the balls within the recess. A plurality of recesses 61 are provided in the face of the hub 57 presented toward a shoulder 62 carrying a plurality of spring pressed balls 63 by which the hand wheel is retained in adjusted position. The spring pressed balls project into the recesses and retain the hand wheel against movement while permitting the hand wheel to be readily turned when sufficient force is applied thereto. By the turning of the hand wheel the threaded element 48 rotates relative to the threaded hub 51 and advances or retracts adjusting rods 14 to thereby advance or retract the cones 21 and 22 and therefore the abrading stones 19.

For producing the expansion and contraction of the head 12 in exact relationship with the retraction and advancement of the honing tool along the axis to the work, I have provided a split rack 64 adjacent to the head 15 in a position to engage a pinion 65 carried by the head. The split rack 64 is adjustable to take up the backlash between the teeth of the rack and those of the pinion. The pinion is to drive through a set of change gears 66 to operate the worm 53 and turn the worm wheel 52 to advance or retract the shank end 48 of the head 47. By selecting the proper gears in the set of the change gears 66, any degree of expansion and contraction of the abrading elements 19 may be had relative to the unit movement of the head 12 axially.

Referring more particularly to Figs. 2, 3, and 4, I have illustrated a bed 67 for supporting the tool for reciprocation thereon, which bed may also provide the support for the work piece as herein illustrated. The head 15 of the tool is mounted on ways 68 on the bed, preferably on rollers 69 to permit the head and tool to be readily moved axially. This movement may occur through hand manipulation or suitable driving means, such as a lead screw 60, may be provided in the bed of the machine for driving the tool in reciprocation.

When operating the tool the work 10 is first mounted on the bed of the machine and the tool is moved into the tapered inner surface which is to be accurately machined. In the present instance the work piece is a rifle casing which is tapered from the rear to the front end so that wedge engagement may occur between the outer tapered wall of the inner liner and the tapered bore of the casing.

The hand wheel 54 is operated to adjust the abrading elements 19 into engagement with the inner surface of the casing even though the tool is rotating through the operation of the pinion 41 and gear 39, and the head 15 is reciprocated substantially axial of the bore. Through the operation of the pinion 65 on the rack 64 through the change gear 66 the adjusting rod 14 is advanced or retracted axially an amount proportional to the movement of the head 15.

The change gears 66 are selected to produce a proper degree of continuous expansion for retaining the surfaces of the abrading stones 19 at all times on the surface of a cone having the taper of the bore to be finished. As the head is moved within the bore its surface is machined accurately on a taper with a high finish. The conical surface thus produced will be extremely accurate irrespective of whether or not the roughing operation on the surface 11 of the casing was accurate since the abrading elements are held centrally of the tool when positively adjusted to follow a taper. The reciprocating movement of the head 12 is continued until the machining operation is completed, which occurs when the true conical surface produced reaches the desired diameter.

Referring to Figs. 6 and 7, I have shown a further form which my invention may assume. In this arrangement, the change gears 66 and rack 64 are eliminated and a pair of cam tracks 71 and 72 substituted therefor. The rear end of

the adjusting shaft 14 is secured to a piston 73 similar to the piston 47, Fig. 1, which is movable within the hollow shaft 37. A rearwardly projecting sleeve 74 is a unit extension of the piston 73, and is provided with an enlarged end 75 against which a threaded hand wheel 76 abuts. The sleeve 74 is retained against rotary movement by a pin 87 which is freely slidable in the slot provided between plates 88 mounted on the bracket 80. A spring 77 urges the sleeve 74, piston 73 and rod 74 rearwardly against the hand wheel 76. The hand wheel 76 is threaded on a bifurcated stud 78 in the end of which a roller 79 is journaled. The roller 79 abuts against the cam track 72 under the bias of the spring 77. Through the operation of the hand wheel 76 the position of the cones 21 and 22 is regulated. The cam 72 is mounted on a carriage 81 which is disposed laterally across the bed 67 having a dovetail connection 82 with a supporting bracket 80. A spring 83 urges the carriage laterally of the bed against the cam track 71. The cam track 71 is preferably pivoted at one end at 84, and is secured in position relative to the bed through a slot and bolt connection 85 which permits the adjustment of the cam 71 to a predetermined angle relative to the axis of the bed. It is to be understood that the cam track 72 may likewise be adjustable so that a greater amount of movement may be obtained from the two cam tracks without having one disposed at too great an angle.

When the operating head 15 is moved to the right, as viewed in Fig. 2, to move the abrading head, assumably 12, from the smaller to the larger end of the work piece, the roller 86 on the end of the carriage 81 operates against the cam track 71. This causes the carriage 81 to move laterally against the tension in the spring 83 to move the cam track 72 therewith. The cam track 72 operating through the rollers 79, moves the stud 78, collar 74, piston 72 and the adjusting rod 14 forwardly against the bias of the spring 77 to effect the expansion of the abrading elements 19 a predetermined amount relative to the degree of withdrawal of the honing head 12 from the front end of the work piece. When the head 15 has been moved to the right an amount sufficient to withdraw a portion of the head 12 from the end of the bore being machined, the movement of the head 15 is reversed. As the head 15 is moved toward the smaller end of the casing, or to the left, the carriage 81 is moved laterally by the spring 83 to maintain the roller 86 in contact with the cam track 71. The spring 77 retains the roller 79 in contact with the cam track 72, thereby moving the adjusting rod 14 and cones 21 and 22 to the right permitting the abrading elments 19 to contract, which contraction maintains the abrading elements 19 on the taper of the bore of the casing. The continued reciprocation of the head 12 and its adjustment relative to the reciprocable movement, maintains the surfaces of the abrading elements in the surface of a cone and accurately machines the surface of the casing on a taper having a desired slope from one end thereof to the other.

For the purpose of illustration the work being operated on had a tapered bore converging toward the front end. In this arrangement the abrading elements were contracted as the head was advanced toward the forward end of the work piece and expanded during the reverse movement of the head. It is to be understood that the taper could diverge toward the front end of the work piece and the abrading elements expand as the head was advanced toward the front end and contract during the reverse movement of the head. This may be accomplished by changing the slope of the cam track 72 to reverse the movement of the adjusting shaft 14 relative to the axial movement of the abrading head 12. By changing the hand of the helix of the thread of the worm gearing 52 and 53 the same result may be obtained relative to the structure illustrated in Figs. 1 to 5 inclusive.

While I have described the support for the tool as being mounted for rotation, it is to be understood that any rotation between the tool and work is relative, and that the work piece itself may be rotated independently of the head or where desirable, both the work piece and the head may be rotated. When the base of the groove between the lands in the liner or rifle barrel are to be machined the rotation is eliminated and turning movement provided to the head on the helix angle of the lands.

While I have described and illustrated but two embodiments of my invention, it will be apparent to those skilled in the art that various changes, omissions, additions and substitutions may be made therein without departing from the spirit and scope of my invention, as set forth in the accompanying claims.

What I claim is:

1. An abrading tool embodying a head, an abrading element in said head disposed at an angle to the axis thereof, means for radially moving said abrading element toward and away from said axis, means for operating said radially moving means, means for driving said head in rotation, means for reciprocating said head along the axis of a tapered work piece, and means exteriorly of said head for actuating said operating means through the movement of said head for synchronizing the radial movement of the abrading element with its relative axial movement to have the surface of the abrading element maintained in the surface of a cone as the axial movement progresses.

2. In a device for machining tapered surfaces on an element, a base for supporting said element, a slide on said base, a tool carried by said slide, an abrading head on said tool having sloping abrading elements therein which are radially movable and disposed in the surface of a cone, means for producing relative rotation between said element and said tool, means for reciprocating said slide and tool, and means carried by said slide for actuating the abrading elements to retain them in the surface of said cone during the movement of the slide which moves the tool relatively along the axis of the work piece.

3. A honing device for accurately machining a tapered surface, including, in combination, a base, means for supporting an element to be machined thereon, an operating head on said base, means for reciprocating said operating head, a honing tool carried by said operating head, abrading elements in said honing tool disposed at an angle to the axis thereof to have the surfaces of the elements fall in the surface of a cone, means for driving said tool in rotation, means in said tool for adjusting said abrading elements radially, and means exteriorly of said head operating said adjusting means for radially moving said abrading elements relative to the position of said operating head to have the abrading elements maintain their position in the surface of

said cone as the tool is moved by the operating head relative to the element being machined.

4. In a honing tool, sloping abrading elements disposed in the surface of the cone, means for radially adjusting the abrading elements relative to the axis of the tool, means for moving the tool along the axis of a work piece to be machined, positive means operating said adjusting means for retaining the surface of the elements in said conical surface to accurately machine a tapered surface on the work piece as the tool is moved along the axis thereof, and means for adjusting said positive means for varying the relation between the radial movement of said elements and the axial movement of said head for changing the slope of the surface of said cone in which the surface of the elements are maintained.

5. In an abrading element for machining a tapered work piece, an abrading tool having the abrading elements thereof disposed in the surface of a cone, means for driving the tool in rotation, means for moving the tool along the axis of the work piece, means for adjusting the abrading elements radially, and additional means exteriorly of said head for operating said adjusting means through the movement of said head for retaining the surfaces of the abrading elements in the said conical surface as the tool is continuously moved along the axis of the work piece.

6. In a honing tool for machining a tapered surface of a work piece, a bed, means for supporting the work piece on said bed, a carriage movable longitudinally of said bed, a honing tool supported by said carriage, abrading elements on said honing tool disposed at an angle to the axis thereof to have the surface of the elements disposed in the surface of a cone, means for moving the abrading elements radially of the tool, axially swivelable driving means connecting the honing tool to the carriage, an axially swivelable adjusting shaft connected to said moving means, adjusting means on said carriage connected to said shaft, means in said carriage for operating said driving means for rotating the honing tool, means on said carriage for actuating the adjusting shaft for operating said moving means for the abrading elements, and means for further operating said adjusting shaft and moving means through the movement of the carriage for maintaining the surface of the abrading elements in the surface of said cone during the longitudinal travel of said tool.

7. In a honing tool for machining a tapered surface of a work piece, a bed, means for supporting the work piece on said bed, a carriage movable longitudinally of said bed, a honing tool supported by said carriage, abrading elements on said honing tool disposed at an angle to the axis thereof to have the surface of the elements disposed in the surface of a cone, means for moving the abrading elements radially of the tool, driving means connecting the honing tool to the carriage, an adjusting shaft connected to said moving means, adjusting means on said carriage connected to said shaft, means in said carriage for operating said driving means for rotating the honing tool, means on said carriage for actuating the adjusting shaft for operating said moving means for the abrading elements, and means for further operating said adjusting shaft and moving means through the movement of the carriage for maintaining the surface of the abrading elements in the surface of said cone during the longitudinal travel of said tool, said last means embodying a rack and pinion for driving through change gears for operating a worm wheel and the adjusting shaft for effecting the movement of the abrading element adjusting means.

8. In a honing tool for machining a tapered surface of a work piece, a bed, means for supporting the work piece on said bed, a carriage movable longitudinally of said bed, a honing tool supported by said carriage, abrading elements on said honing tool disposed at an angle to the axis thereof to have the surface of the elements disposed in the surface of a cone, means for moving the abrading elements radially of the tool, driving means connecting the honing tool to the carriage, an adjusting shaft connected to said moving means, adjusting means on said carriage connected to said shaft, means in said carriage for operating said driving means for rotating the honing tool, means on said carriage for actuating the adjusting shaft for operating said moving means for the abrading elements, and means for further operating said adjusting shaft and moving means through the movement of the carriage for maintaining the surface of the abrading elements in the surface of said cone during longitudinal travel of said tool, said last means embodying a cam carried by said bed, a laterally movable carriage on said bed, a cam on said last carriage for operating the adjusting rod and abrading element adjusting means.

9. In a device for machining the tapered surface of a work piece, a honing tool having radially expandable segmental abrading elements, means within said tool for radially positioning said elements at an angle to the axis of said tool, means for moving the tool along its axis, means exteriorly of said tool for actuating said positioning means, and additional means exteriorly of said tool operating through said first exterior means for increasing or decreasing the radial position of said elements uniformly along their lengths, during said axial movement.

10. In a device for machining the tapered surface of a work piece, including a tool having radially expandable segmental elements adjustable to conform to the angle of the tapered surface desired, a rod extending through said tool for adjusting said elements radially, means for moving said tool and rod axially, and means operating said rod to maintain the radial movement proportionate to said axial movement to maintain the elements on the surface of said taper.

11. In a device for machining the tapered surface of a workpiece, a honing tool having radially expandable abrading elements, means within said tool for radially adjusting said elements, means exteriorly of said tool for operating said adjusting means, and means actuating said exteriorly disposed means to vary said adjusting means additionally to said first adjustment to have the surface of said elements maintained on the surface of the cone of said tapered surface.

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