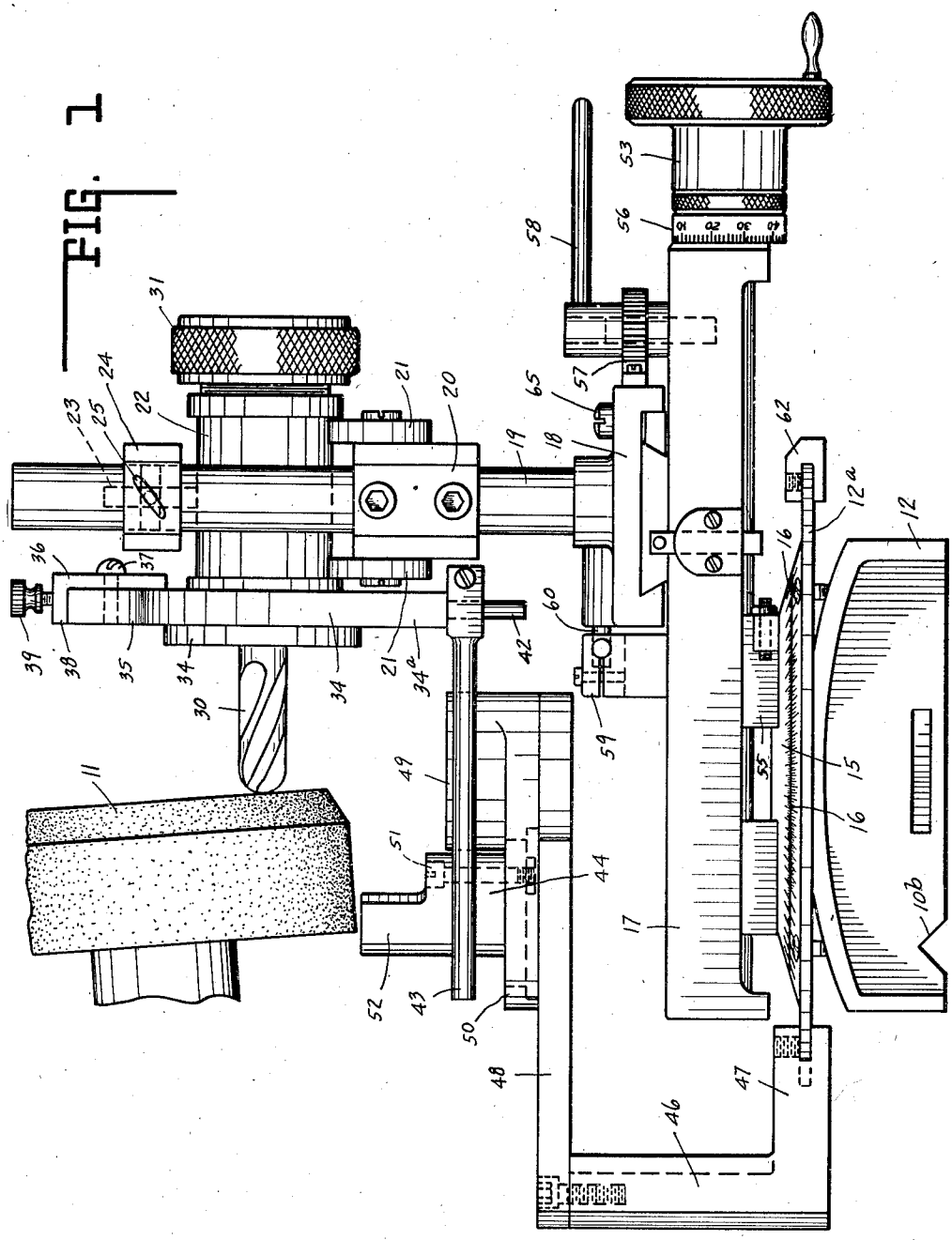
May 27, 1947. I. SNEVA 2,421,358

RADIUS FORMER FOR END MILL

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FIG. 1



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BY

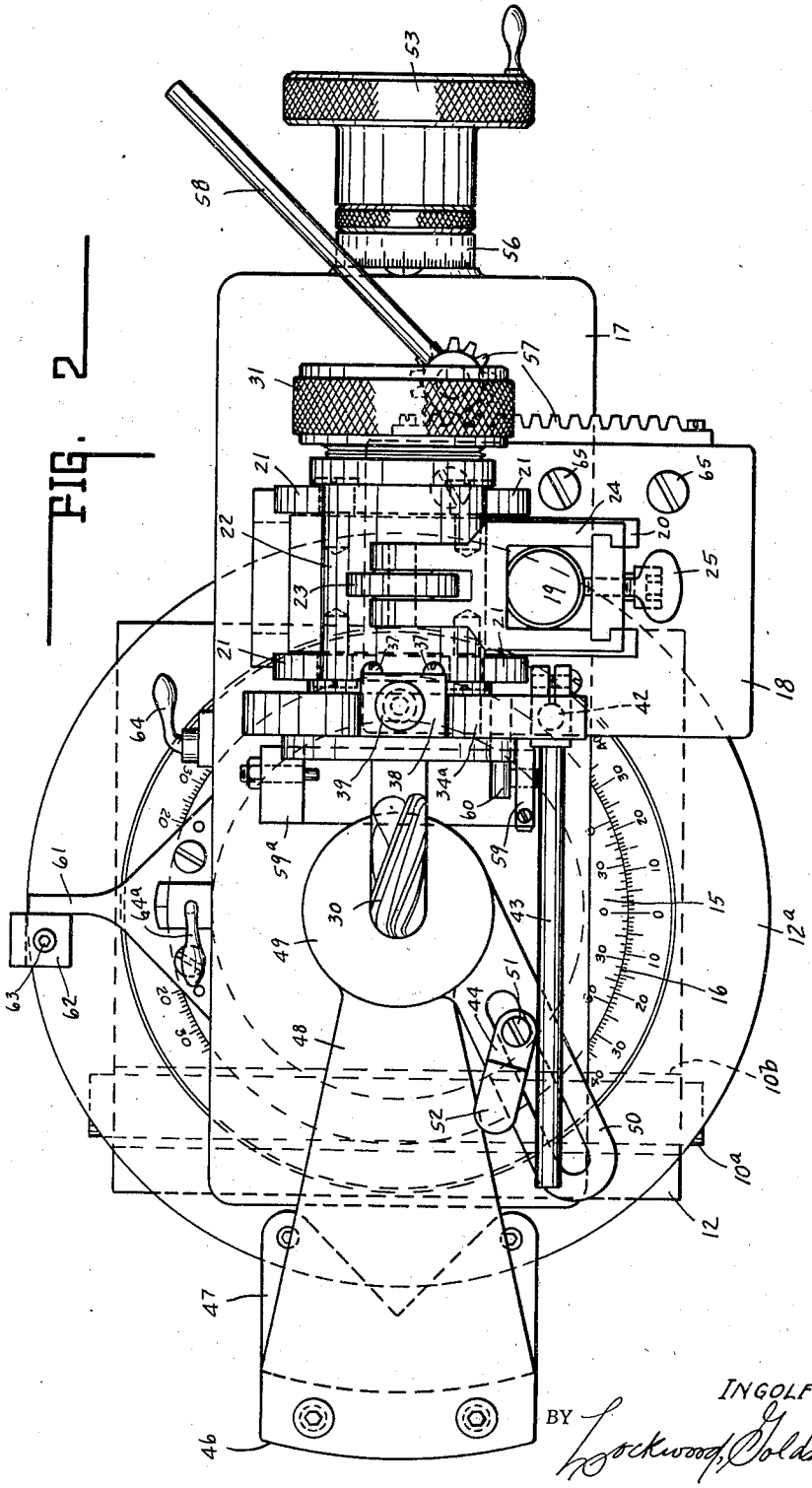
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RADIUS FORMER FOR END MILL

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FIG. 2



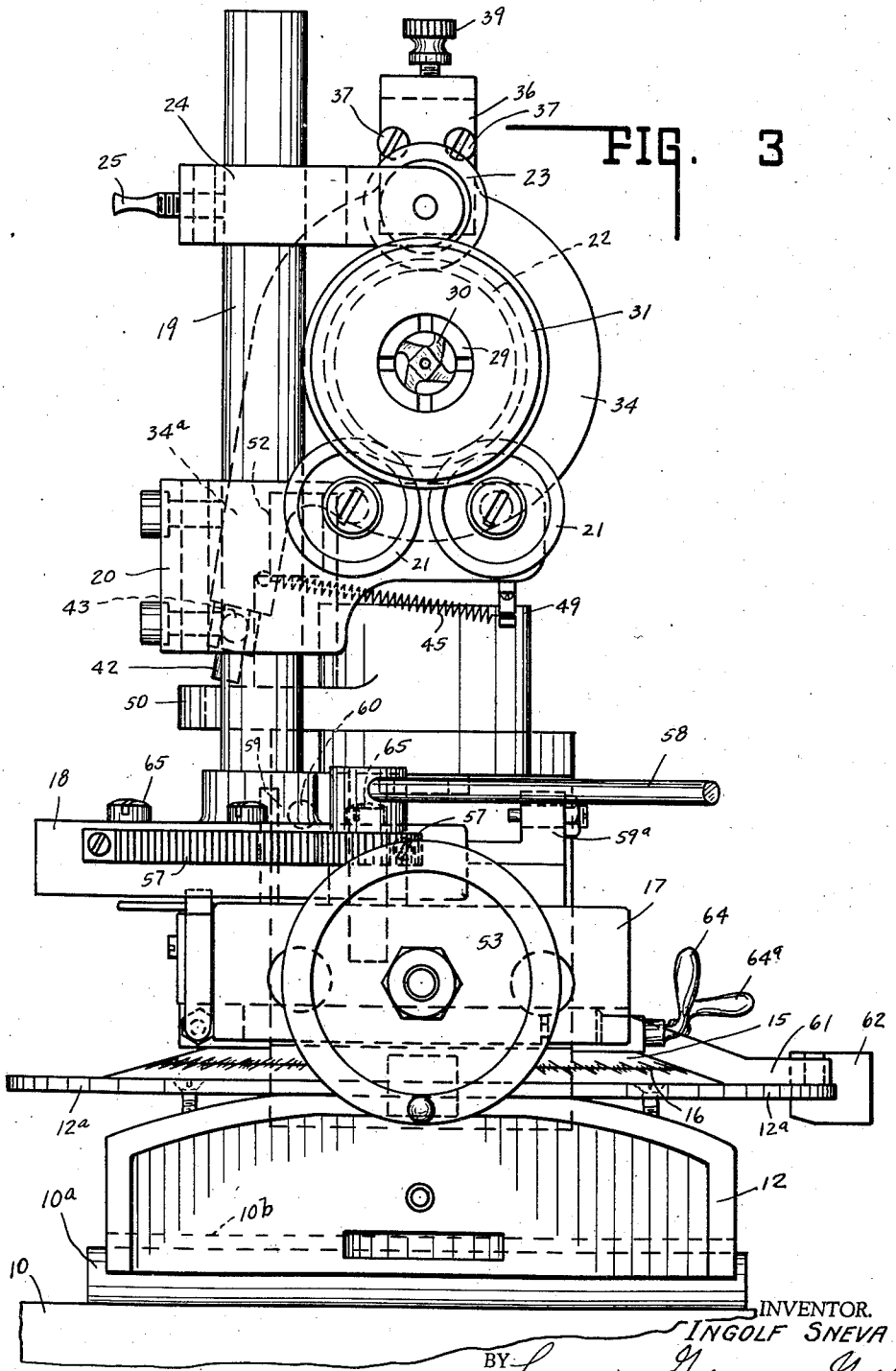
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FIG. 3



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FIG. 4

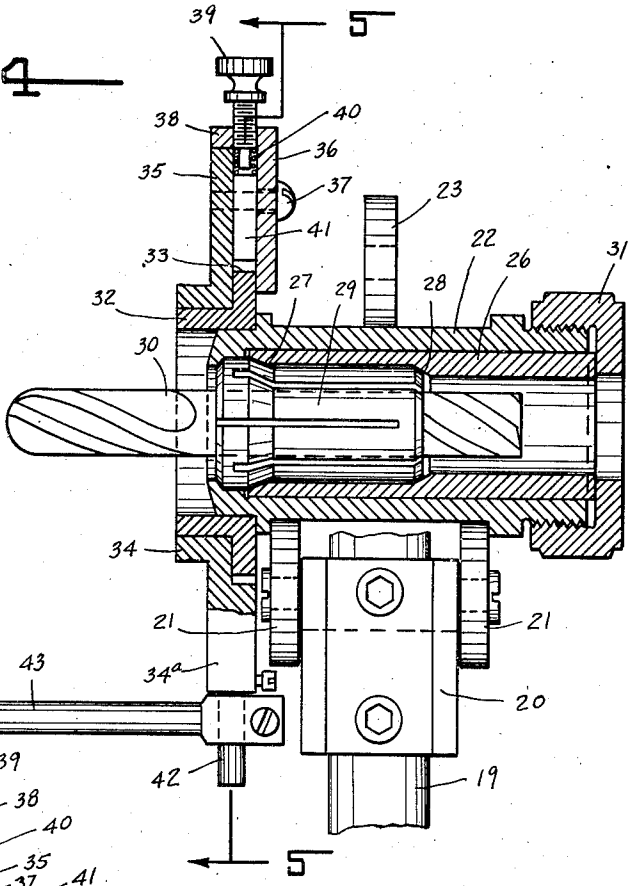


FIG. 6

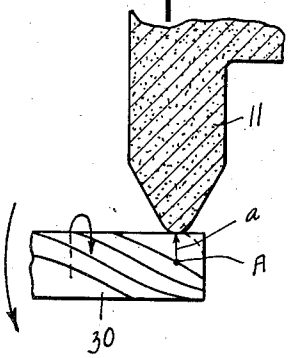


FIG. 5

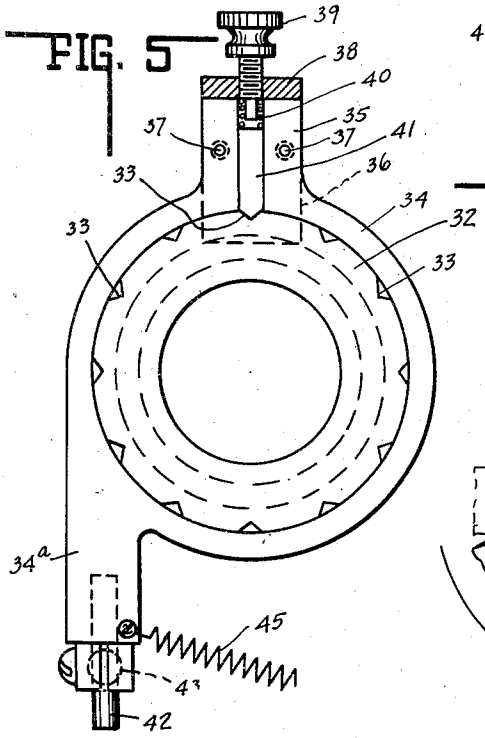


FIG. 7

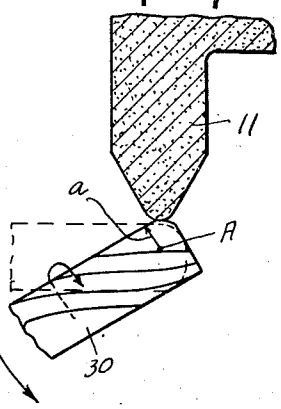
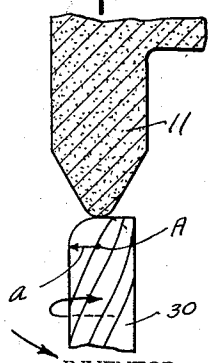


FIG. 8



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Patented May 27, 1947

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UNITED STATES PATENT OFFICE

2,421,358

RADIUS FORMER FOR END MILLS

Ingolf Sneva, Bedford, Ind., assignor to W. F. Meyers Company, Bedford, Ind., a corporation

Application June 16, 1944, Serial No. 540,649

8 Claims. (Cl. 51—225)

1

This invention relates to an apparatus for grinding the spiral fluted end of an end mill or cutting tool to a prescribed radius of curvature, including grinding the relief back of the spiral end cutting edge, reference being had to my application Serial No. 513,896, filed December 11, 1943, entitled "Radius-angle tool former."

It is usually required of an end mill that the spiral fluted cutting ends be of a prescribed radius within very close tolerances, as may be required by the work being cut. However, there is considerable difficulty in grinding the spiral fluted cutting edges of an end mill to an exact prescribed radius. This is largely due to the fact that the fluted cutting end of the mill spirals inwardly which makes it practically impossible to measure. Thus the practice has generally been to grind the end of the mill to produce the proximate radius with frequent checking thereof by a recessed or bored templet.

Also, it is desirable to relieve that portion of the spiral fluted cutting end immediately behind the cutting edge to provide clearance and escape of the metal being cut into the groove between the flutes. This relief has usually been hand ground to a mere proximate radius conforming to the ground radius of the end cutting end.

It is the purpose of this invention to provide an attachment for the radius-angle tool former disclosed in the above application for letters patent, such as will enable an operator to conveniently set the device to accurately grind the prescribed radius with means to rotate the end mill or tool to follow the spiral lead of the cutting edge as it is being ground and according to the angle of pitch.

Another feature of the invention resides in structure for supporting the mill or tool for rotation while being ground for permitting its contact with the grinding wheel to follow the spiral curvature of the flutes providing the cutting edge.

Still a further feature of the invention resides in the indexing of the tool supporting member for locating it in grinding position for each of the spiral flutes according to the number and spacing thereof, and additionally rotatably indexing the tool for similarly grinding the relieved or clearance portion immediately following the cutting edge to the same prescribed radius of curvature.

The full nature of the invention will be understood from the accompanying drawings and the following description and claims:

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Fig. 1 is a side elevation of the tool former with the end radius grinding attachment mounted thereon. Fig. 2 is a plan view thereof. Fig. 3 is an end elevation. Fig. 4 is a central vertical section through the tool supporting and rotating collet. Fig. 5 is a section taken on the line 5—5 of Fig. 4 with the collet removed. Fig. 6 is an enlarged diagrammatical illustration showing one position of the tool and grinding wheel at the beginning of the operation. Fig. 7 is the same as Fig. 6, showing intermediate relative positions of the tool and grinding wheel. Fig. 8 is the same as Fig. 6, showing the final relative position of the tool with respect to the grinding wheel.

In the drawings there is illustrated a radius former for end mills attached to a tool former as disclosed in my said application for Letters Patent Serial No. 513,896. The former is adapted to be secured to an adjustable bed plate 10 on a grinding table in adjustable relation to the usual motor driven cupped grinding wheel 11. The former includes a base 12 having an annular base plate 12a adapted to be securely clamped to the bed plate 10 by any suitable means. Said base plate is provided with a turntable 15, both the base plate and turntable carrying an annular vernier scale, as indicated at 16. Mounted upon the turntable there is an elongated slide 17 slidable diametrically thereon. Carried on said slide 17 there is a transverse slide 18 slidable transversely of the elongated slide. Thus, the slides 17 and 18 provide a compound slide support, the latter carrying a vertical and upwardly extending post 19.

Slidably mounted for vertical adjustment upon the post 19 there is a supporting block 20 carrying two pairs of supporting rollers 21 which are freely rotatable thereon. Cradled upon said rollers for free rotation therewith there is provided a cylindrical collet housing 22 rotatably clamped on said rollers by a top bearing roller 23. Said top bearing roller is freely and rotatably carried near the upper end of the post 19 by a carriage block 24. Said block 24, with its bearing roller, is readily removable from engagement with the collet housing on the rollers 21 by a thumb screw 25.

The collet housing 22, which is clamped between the rollers 21 and 23 but free to rotate therebetween, is provided with an inner sleeve 26 (Fig. 4) having spaced and offset cam shoulders 27, 28 for camming or wedging engagement with corresponding shoulders on the oppositely split collet 29. Said collet is provided with the usual longitudinal splits directed inwardly from op-

posite ends alternately in which the end mill or cutting tool 30 is bodily clamped throughout a substantial length thereof through the wedging action of the sleeve 26, upon tightening the threaded end flange 31.

Surrounding the tool 30 and secured to the end of the collet housing 22 from which the tool extends (Fig. 4), there is an indexing collar 32 having a radially extending flange provided with a series of notches 33 in the peripheral edge thereof (Fig. 5). Rotative movement of the collar 32 correspondingly rotates the housing 22, the collet and the tool 30. Surrounding the collar and free therefrom for relative rotation, there is provided an oscillating ring 34 which closely embraces the collar 32. Extending upwardly from the upper portion of said ring there is an extension 35 to which a plate 36 is secured by the screws 37 so as to be removable therefrom. Said plate has a head portion 38 carrying a set screw 39 adapted to be adjustably screwed through the head 38 to engage a compression spring 40 bearing upon a plunger 41 slidably mounted to engage the notches 33 spaced about the collar 32 under spring tension. Manual turning of the housing 22 and collar 32 indexes the tool from one position to another determined by the relative positions of the notches, upon forcible application sufficient to compress the spring 40, the application being applied by hand to the knurled end flange 31. Thus, as shown in Fig. 5, there are twelve such notches which permit indexing of the tool to twelve different positions.

As illustrated in Figs. 6, 7 and 8, the tool 30 is oscillated relative to the grinding wheel 11 about a radial center indicated at A for grinding the end of the tool to the prescribed radius *a*. However, the grinding action must follow the spiral flutes during the processing. It is also necessary to index the tool in accordance with the number of flutes and their relative spacing. This is accomplished in the manner above described by indexing the tool through rotation of the collar 32 from engagement by the pin 41 in one notch 33 to engagement in a succeeding notch. As herein shown, the twelve notches provide for indexing a tool having up to six flutes. Wherein there may be six flutes, every other notch locates the tool for grinding a flute and every immediate notch locates the tool for grinding the relieved or clearance portion of the flute following the cutting edge. Wherein the tool, as illustrated herein, has four flutes, the indexing thereof will bring a flute into grinding position by rotating the collar for engagement by the plunger with every fourth notch, engagement with the next succeeding notch bringing the clearance portion of the flute into position for grinding.

In order that the grinding operation will follow the contour of the spiral flutes as the tool is oscillated about its center of oscillation A, the following camming mechanism is provided. The lower portion of the oscillating ring 34 is provided with an extension indicated at 34*a* having a pin 42 to which a laterally extending cam follower rod 43 is adjustably connected. Extending upwardly into the path of said rod there is an adjustable cam block 44. The rod 43 is held in engagement with the cam block under spring tension by the spring 45 having one end connected to the extension 34*a* and the other end connected to a lug on the supporting block 20. As the cam block is oscillated back and forth in the following described manner, it imparts an oscillatory movement through the rod 43, ring 34, plunger 41, and collet 29 to the end mill or tool 30. Thus, the tool 30 is caused to rotate about its axial center according to the setting of the cam block.

For supporting the cam block there is a detachable bracket 46 having lower bifurcated jaw members 47 adapted to be mounted over and secured to the stationary base table 12*a*. Said bracket is provided with an inwardly extending arm 48 which lies over the axial center of the turntable 15. Pivoted upon said arm there is secured in rotative adjustment a head 49 having a tangentially extending slotted arm 50. The cam block 44 is mounted on the arm 50 to be locked by a set screw 51 adjustable longitudinally of the slot in the arm 50, and about which the cam block may be rotatably adjusted. For convenience of adjustment, the cam block is provided with an upwardly extending portion 52.

The bracket 46 is secured to the base plate 12*a* with the rotative mounting of the head 49 lying in the axial center of the turntable. Thus, the slotted arm 50 carried by the head may be swung to varying positions about the axial center of the turntable and the cam block may be adjusted thereon to varying rotative positions about the set screw 51 and shifted longitudinally of the arm 50. By setting of the arm 50 and cam block 44 relative to the cam follower arm 43, oscillatory movement of the turntable will cause the tool to rotate about its axial center as it is swung about the radial center A during the grinding operation. Thus, contact of the spiral flute with the grinding wheel is continuously controlled and maintained by the setting of the arm 50 and cam block 44 to follow the spiral lead of the flute.

For centering and setting the tool, the elongated slide 17 is adjusted longitudinally and diametrically of the turntable by a hand wheel 53 mounted on a screw shaft extending through the screw blocks 55. A vernier scale 56 is provided for indicating the extent of revolution of the shaft and relative position of the slide and turntable. The transverse slide 18 is slidably mounted upon suitable guideways carried by the elongated slide 17 and is adjustably positioned by the rack and pinion 57 actuated by the hand lever 58. The elongated slide 17 carries a pair of spaced setting blocks 59 and 59*a* provided with set screws therein and adapted to receive a prescribed gauge block. The transverse slide 18 carries a laterally extending pin 60 positioned to abut against one of said set screws for initially centering the tool. A gauge block may then be interposed for centering the tool to a prescribed radial center A as may be determined. Through manipulation of said slides, the determined center A of the radius to be ground is brought into alignment with the axial center of the turntable.

The turntable carries a radially extending stop arm 61 engageable with the stop block 62 adjustably positioned by the set screw 63 about the periphery of the base plate 12*a*. The elongated slide 17 is provided with a locking lever 64 for locking it in adjusted position, the turntable carrying a similar locking lever 64*a* for locking it against rotation relative to the base. Also, the transverse slide 18 may be locked in adjusted position by the locking screws 65.

For forming a predetermined radius on the end mill, it is rigidly clamped within the collet, and the bracket 46 carrying the cam block is mounted upon the base table and adjusted thereon so that the center of the head 49 is in the axial center of the turntable. The slide 18 is

moved to the left (Fig. 3) to engage a previously adjusted set screw in the block 59 to position the axial center of the tool and collet in intersecting relation with the axial center of the turntable. Thereupon the setting for any desired radius may be made by moving the slide 18 to the right, measuring with a micrometer half the diameter of the tool less the prescribed radius and interposing a gauge block so determined between the screw of block 59 and the pin 60 on the slide. In this manner the center A of the radius to be ground lies in the axial center of the turntable.

The grinding table 10 is adjusted until the grinding wheel 11 touches the side of the end mill, as in Fig. 6, whereupon the grinding table is moved longitudinally so that the end mill is retracted to clear the wheel. The turntable is then rotated 90 degrees and the grinding table again moved longitudinally toward the wheel until the nose of the tool is positioned to engage the wheel by movement of slide 17. At this position the reading on the vernier scale 56 is noted. The slide 17 is then retracted so that the corner of the tool clears the wheel when the turntable is oscillated about its 90 degree arc. With this setting the turntable is oscillated back and forth with the tool in grinding engagement with the wheel which is then being rotated for grinding action thereon. As the grinding action eats into the end corner of the tool (Fig. 7) it is fed into the grinding wheel by advancing the slide 17 through manipulation of the hand wheel 53. Each oscillation through the 90 degree arc limited by the stops 61 and 62, causes the tool to be rotated about its axial center through the action of the spring 45 and cam block 44 engaging the rod 43 to move the rod upwardly and thereby rotate the collet holder on the rollers 21. This action of the cam block when properly adjusted causes the grinding contact between the tool and the wheel to automatically follow the spiral curvature of the flute being ground.

It may be noted that the base 12 is supported and clamped to the grinding table 10 at a slight angle which is controlled by the diameter of the bar 10*a* lying in the V-groove 10*b* provided in the bottom of the base. This has the effect of providing the desired clearance angle between the tool and grinding wheel as shown in Fig. 1, and to develop the cutting edge of the flute.

As the grinding progresses, the slide 17 is advanced until the original reading on the vernier scale 56 is reached, it being noted that the slide after being set at the original reading was backed off so that the corner of the tool cleared the wheel. At this point the operation upon one of the flutes has been completed. As indicated in Fig. 8, the tool is ground as to one of its spiral flutes from a square nose as in Fig. 6, to the prescribed radius *a* about the center of curvature A.

Having completed the grinding of one flute, it is then desirable to grind the following relief or secondary clearance angle to the same radius. For this purpose the indexing collar 38 is manually rotated by the threaded end flange 31 to bring the plunger into locking engagement with the following notch 33. The grinding operation above described is then repeated to grind the flute slightly behind the cutting edge previously ground to provide clearance. Following the grinding of the cutting edge and clearance of one flute, the indexing collar is then adjusted to a succeeding notch 33 to bring the next flute into position for the grinding operation. This is repeated until each of the flutes followed by their respective clearances, have been ground to precisely the prescribed radius, such grinding following the spiral inwardly directed curvature thereof.

As above mentioned, the prescribed radius *a* to which the tool is to be ground, is obtained by measuring the radius of the end mill, deducting therefrom the desired radius, providing a gauge block corresponding to this difference and placing it between the pin 60 and the set screw of the block 39. Since the center of the collet and tool lies in the axial center of the turntable when pin 60 engages the set screw of block 59, such gauge block will thereby set the center A in line with the axial center of the turntable so that oscillation thereof will swing the tool back and forth about said center A. A micrometer may be used for such setting in place of a gauge block, if desired.

For setting of the cam block 44 to cause the tool to be turned in accordance with the spiral curvature of the flute, a surface gauge is employed. By slowly oscillating the turntable and holding the pointer of the surface gauge against one of the flutes to be ground, the cam 44 may be adjusted so that at each position of the turntable the surface gauge will be in line with the flute. When the adjustment is completed so that the flute will follow the pointer of the surface gauge during the 90 degree movement of the turntable, the cam is secured in such position. Having thus been set, the action becomes automatic in respect to all flutes and their relieved clearance throughout the repeated oscillation required to grind them to the prescribed radius. From the foregoing, it will be noted that the adjustable cam 44 acts to automatically turn the tool to compensate for the lead in of the spiral flutes, thereby providing cam controlled rotary movement of the end mill to follow the particular lead of its spiral flutes in accordance with the setting of the cam.

The invention claimed is:

1. Apparatus for forming a prescribed end radius on a spirally fluted cutting tool, including a base member, an oscillating turntable pivotally mounted thereon, a compound slide carried by said turntable, a rotary support for securing said tool mounted on said slide, whereby said tool is simultaneously oscillated through movement of said turntable and fed through movement of said slide into flute grinding contact with a rotating grinding wheel, a cam adjustably mounted on said base member, and a cam follower secured to said rotary support engageable with and movable by said cam upon oscillatory movement thereof for causing controlled rotative movement of said tool about its axial center according to the spiral curvature of said flute.

2. Apparatus for forming a prescribed end radius on a spirally fluted cutting tool, including a base member, an oscillating turntable pivotally mounted thereon, a compound slide carried by said turntable, a rotary support for securing said tool mounted on said slide, whereby said tool is simultaneously oscillated through movement of said slide into flute grinding contact with a rotating grinding wheel, a bracket removably secured to said base member and extending over said turntable, an adjustable cam carried by said bracket, a spring controlled cam follower engageable with said cam, and means for connecting said cam follower to said rotary support, whereby oscillatory movement of said support and tool by said turntable will effect a controlled rotative

movement of said tool about its axial center, the relation of said cam to said follower being such as to cause said rotative movement to follow the spiral curvature of said flute and maintain contact thereof with said wheel during the oscillatory grinding action.

3. Apparatus for forming a prescribed end radius on a spirally fluted cutting tool, including an oscillating turntable having a rotary support upon which said tool is secured, whereby said tool may be oscillated with its flute in grinding contact with a rotating grinding wheel, a fixedly supported cam, and a cam follower carried by said rotary support, a spring operatively connected with said cam follower to maintain it in contact with said cam under spring tension, said cam being adjustable relative to said rotary support and turntable for causing controlled rotative movement of said tool to compensate for the spiral curvature of its flute during its oscillatory movement relative to said grinding wheel.

4. Apparatus for forming a prescribed end radius on a spirally fluted cutting tool, including a base member, an oscillating turntable pivotally mounted thereon, a compound slide carried by said turntable, an upstanding post mounted on said slide, a series of rollers adjustably mounted on said post, a support for securing said tool rotatably mounted between said rollers, means for adjusting said slide upon said turntable for centering said tool relative thereto for grinding engagement with a rotating grinding wheel, whereby oscillation of said turntable will cause the grinding of the end of said tool to a prescribed radius, a cam follower secured to said tool support, and a cam secured to said base member adjustable for engagement by said cam follower for causing controlled rotative movement of said tool about its axial center as said turntable is oscillated, said cam being so adjusted as to thereby maintain said flute in effective grinding engagement with said wheel during said oscillatory movement for grinding it to the prescribed radius.

5. Apparatus for grinding a cutting tool having a plurality of equally spaced spirally formed flutes, including a support movable relative to a rotating grinding wheel, a collet for supporting said tool, a cylindrical holder for said collet adapted to compress it into tool clamping position, a series of rollers for rotatably supporting said cylindrical holder, said rollers being mounted upon said movable support, a peripherally notched flange secured about said holder, a ring surrounding said flange, and a spring pressed plunger slidable in said ring for engagement and disengagement with said notches for locating said holder in different predetermined spaced rotative positions, said notches being spaced about said flange in predetermined relation to the flutes on said tool for locating the respective flutes for grinding.

6. Apparatus for forming a prescribed end radius on a spirally fluted cutting tool, including a base member, an oscillatory turntable pivotally mounted thereon, a compound slide carried by said turntable, a rotary support for securing said tool mounted on said slide, whereby said tool is simultaneously oscillated through movement of said turntable and fed through movement of said slide into flute grinding contact with a rotating grinding wheel, a cam adjustably mounted on said base member, a cam follower secured to said rotary support engageable with and movable by said cam upon oscillatory movement thereof for causing controlled rotative movement of said tool about its axial center according to the spiral curvature of said flute, and an indexing mechanism interposed between said rotary support and tool operable to positively locate said tool in successive positions to present thereto for individually grinding each of its respective flutes.

7. Apparatus for forming a prescribed end radius on a cutting tool having a plurality of spaced spirally extending flutes, including an oscillating turntable having a rotary support on which said tool is secured, whereby said tool may be oscillated with its flutes in grinding contact with a rotating grinding wheel, a cam carried by said apparatus and adjustable thereon, cam follower mechanism carried by said rotary support operable by said cam to cause relative movement of said tool about its axial center according to the spiral curvature of said flutes upon oscillation of said turntable, and an indexing mechanism interposed between said rotary support and tool operable to locate said tool in successive positions relative to said support and grinding wheel for presenting thereto and individually grinding each of its respective flutes.

8. Apparatus for forming a prescribed end radius on a cutting tool having a plurality of spaced spirally directed flutes, including an oscillating turntable having a rotary support upon which said tool is secured, whereby said tool may be oscillated with its flutes in grinding contact with a rotating grinding wheel, a cam carried by said apparatus, a cam follower connected with said rotary support engageable with and movable by said cam upon oscillatory movement thereof for causing controlled rotative movement of said tool about its axial center according to the spiral curvature of said flutes, a series of spaced peripherally positioned notches extending about said rotary support, a driving ring mounted about said notches connected with said cam follower, and a spring pressed plunger mounted in said ring engageable with said notches under spring tension for indexing said tool to different positions relative thereto to positively locate it in successive positions to present each of the respective flutes to said grinding wheel.

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