

Jan. 17, 1950

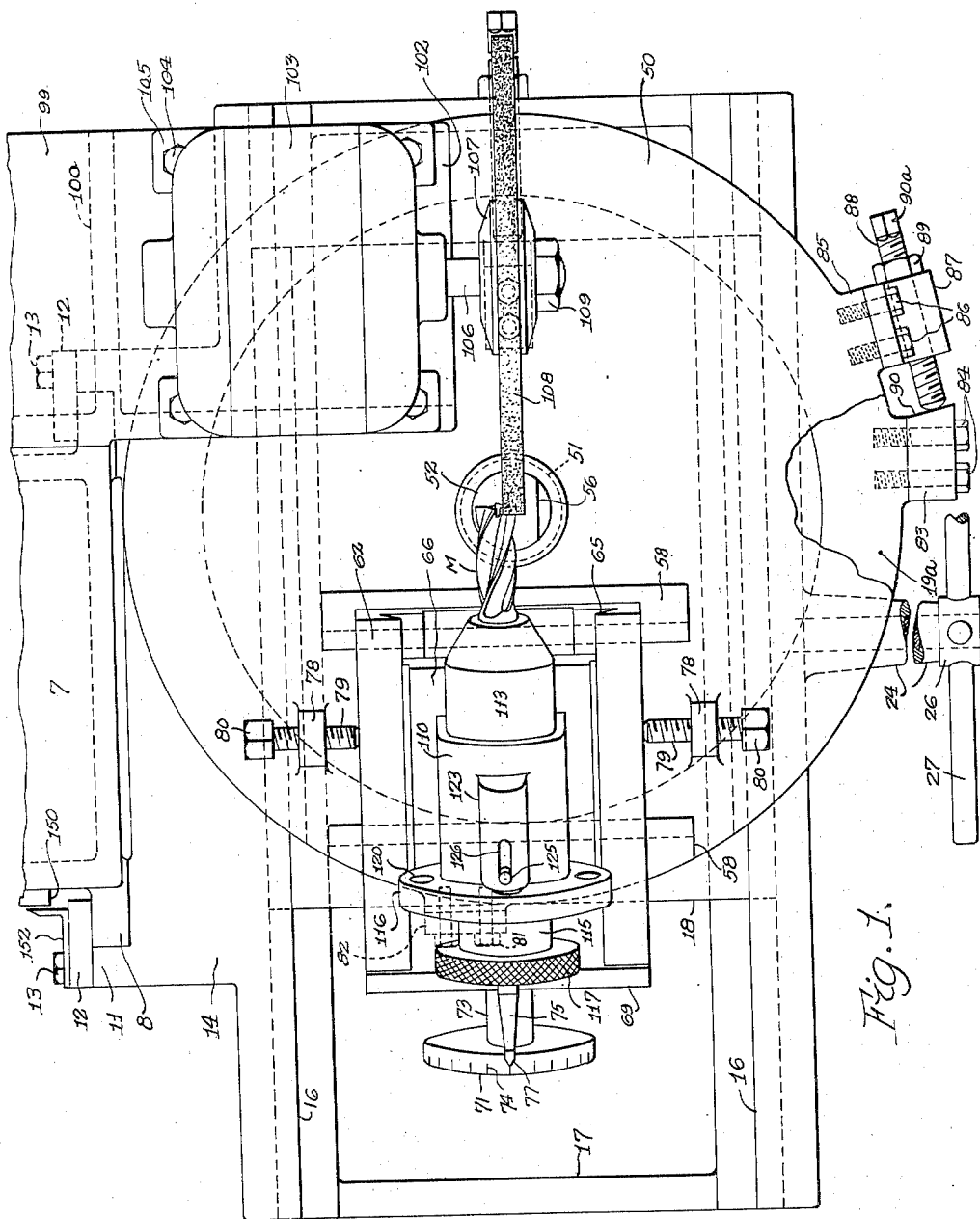
W. MELIN

2,494,825

ROTARY CUTTING TOOL GRINDING MACHINE

Filed March 10, 1945

4 Sheets-Sheet 1



Inventor

William Melin
Barth & Bugbee

Barth & Bugbee

Attorneys

Jan. 17, 1950

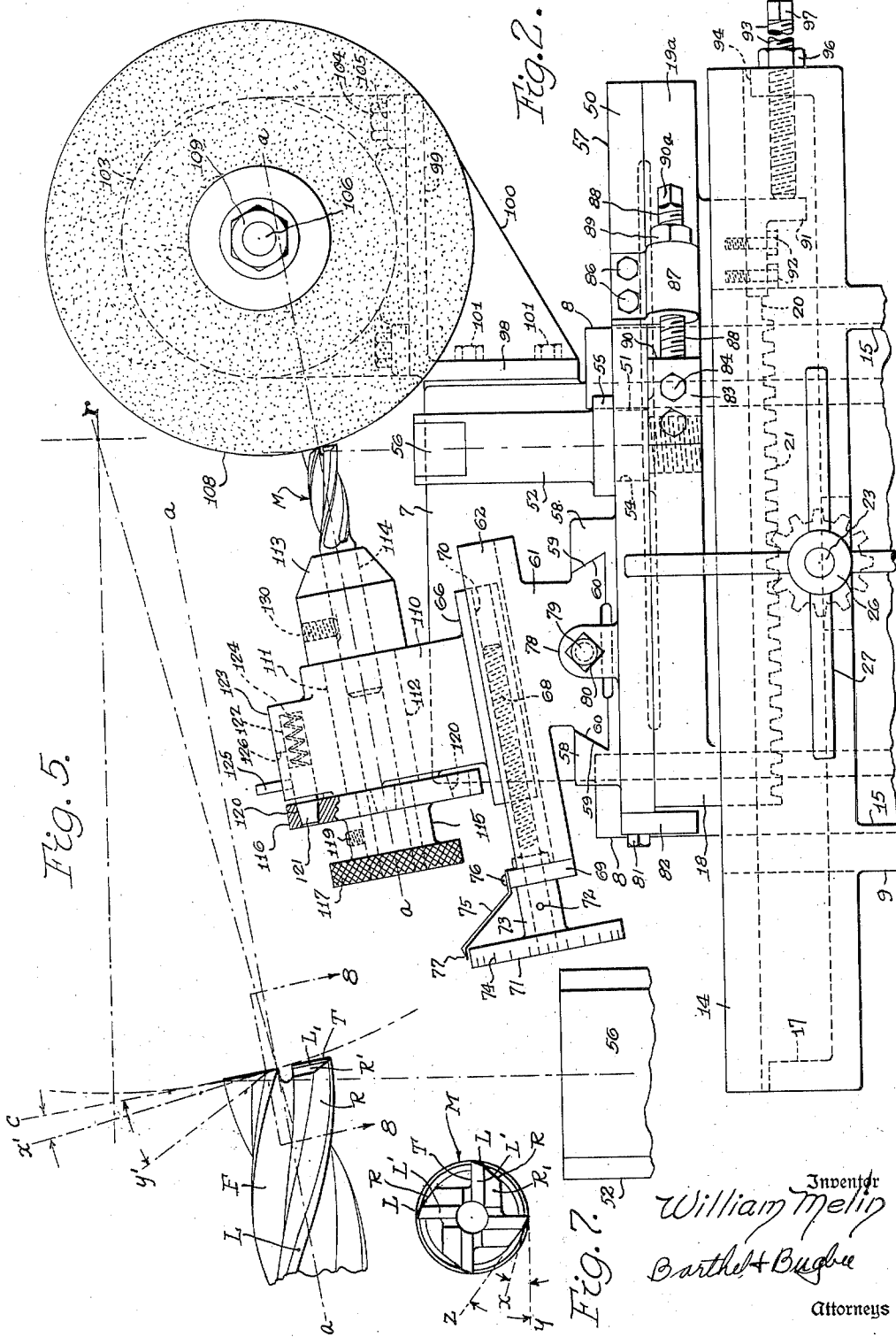
W. MELIN

2,494,825

ROTARY CUTTING TOOL GRINDING MACHINE

Filed March 10, 1945

4 Sheets-Sheet 2



Jan. 17, 1950

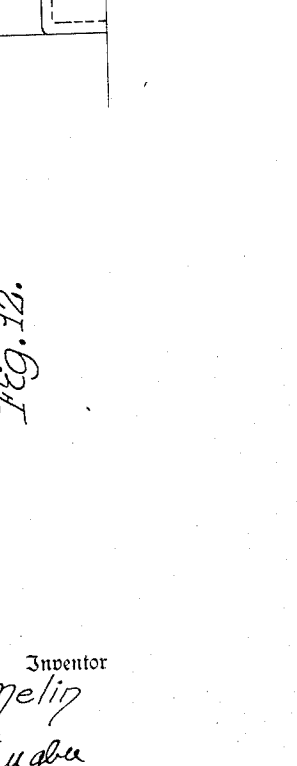
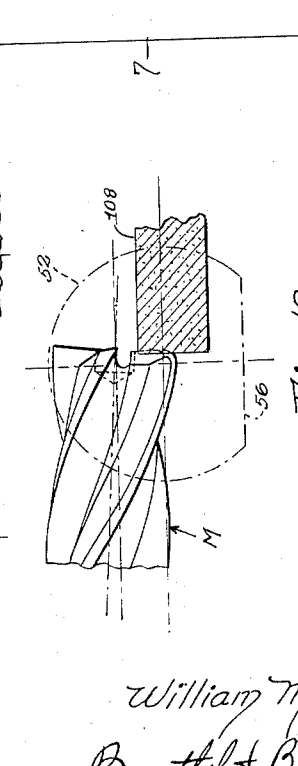
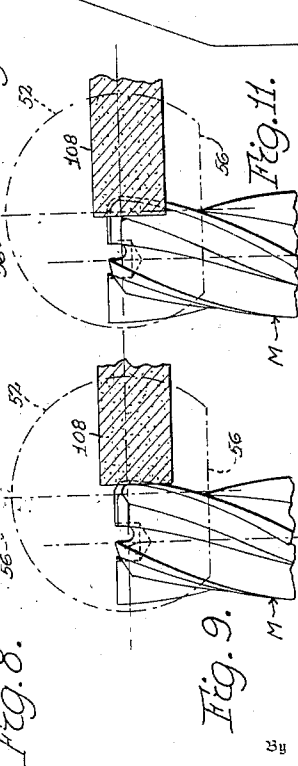
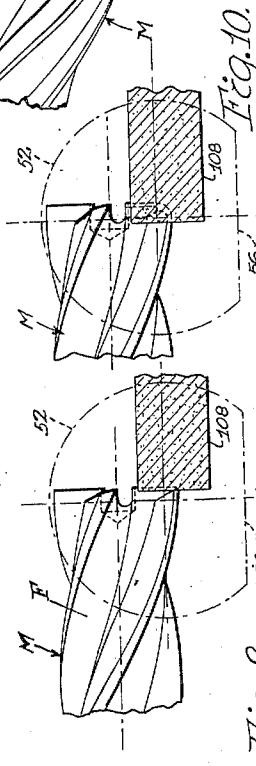
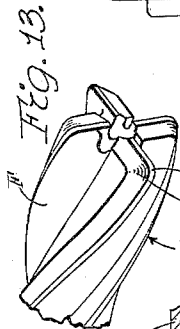
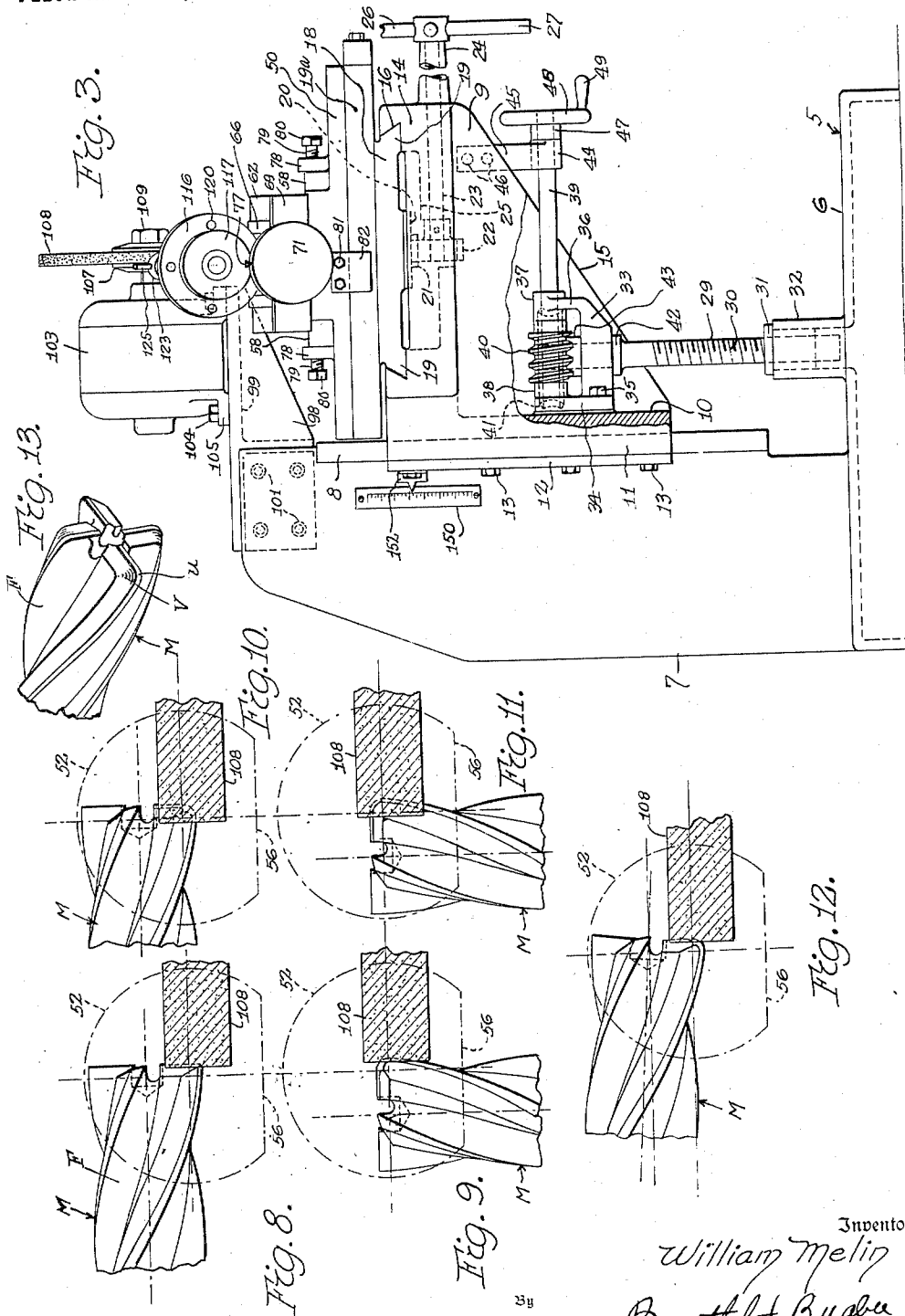
W. MELIN

2,494,825

ROTARY CUTTING TOOL GRINDING MACHINE

Filed March 10, 1945

4 Sheets-Sheet 3



Inventor
William Melin
Barthel & Bugba
Attorneys

Jan. 17, 1950

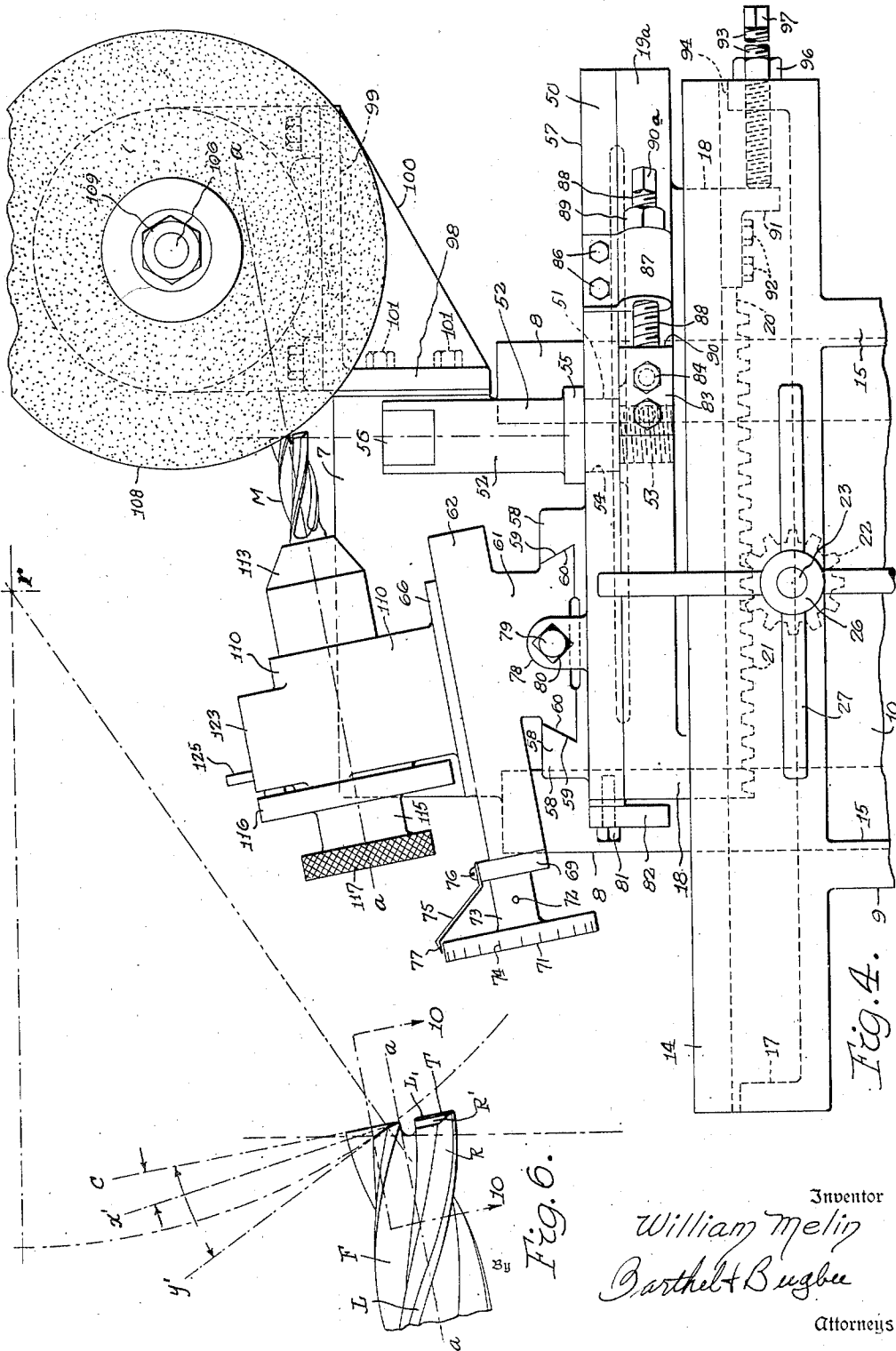
W. MELIN

2,494,825

ROTARY CUTTING TOOL GRINDING MACHINE

Filed March 10, 1945

4 Sheets-Sheet 4



UNITED STATES PATENT OFFICE

2,494,825

ROTARY CUTTING TOOL
GRINDING MACHINE

William Melin, Grand Rapids, Mich.

Application March 10, 1945, Serial No. 582,030

1 Claim. (Cl. 51—96)

1

The present invention relates to improved grinding and finishing machines and more particularly to a machine for grinding and finishing the cutting lips of fluted tools such as end mills, twist drills and the like.

The primary object of the invention is to provide a grinding machine in which a cutting tool may be presented to the grinding wheel in such a manner as to permit manipulation of the tool so as to round the corners thereof and form a cutting tool such as an end mill or the like, which, when used, to cut or remove metal will leave a fillet of the meeting edges of the walls of the cut or recess with well rounded corners.

Another object of the invention is to provide a grinding and finishing machine which may be set to grind the various relief surfaces of the cutting lips of the tool so that a large number of such tools may be ground and finished within a minimum amount of time and with a high degree of accuracy.

Another object of the invention is to provide a grinding and finishing machine of the above-mentioned character in which the cutting tool being ground and finished may be rotated about a vertical axis to round the corners of the cutting lips of said tool and which may be rotated about a horizontal axis to present the various cutting lips of said tool in position for grinding and finishing the relief surfaces of said cutting tool lips.

Another object of the invention is to provide a grinding and finishing machine as set forth in the preceding objects in which the tool may be adjusted and presented to the grinding wheel so that the required roundness and radius of curvature may be given to the corners of the cutting lips by adjusting the position of the cutting tool relative to the grinding wheel.

Another object of the invention is to provide a grinding and finishing machine for end mills and other fluted cutting tools in which the cutting lips of the cutting tool may be presented at different angles to the peripheral surface of the grinding wheel to thereby grind and finish the relief edge of the cutting lips as well as the land thereof.

Other objects and advantages will become apparent during the course of the following description of the accompanying drawings, wherein:

Figure 1 is a top plan view of the grinding and finishing machine showing the various details of construction and the manner in which the end of the mill or cutting tool is presented to the peripheral surface of the grinding wheel;

Figure 2 is a front elevational view of the upper portion of the machine showing the manner in

2

which the end mill is presented to the grinding wheel and the various adjustments for manipulating the end mill to produce the various surfaces on the cutting lips thereof;

5 Figure 3 is an end elevational view of the grinding and finishing machine showing the manner in which the several adjustments of the work holder may be facilitated to move the end mill toward and away from the grinding wheel;

10 Figure 4 is a view similar to Figure 2 showing the end mill adjusted to permit the grinding of the relief surface of the cutting lips;

Figure 5 is a diagrammatic view illustrating the manner in which the end mill or cutting tool is angled with respect to the grinding wheel for grinding and finishing the land of the cutting lip prior to the grinding and finishing of the relief surface thereof;

Figure 6 is a diagrammatic view similar to Figure 5 showing the manner in which the work support is lowered and fed toward the grinding wheel to facilitate the grinding and polishing of the relief surface without necessitating the removal of the end mill or cutting tool from the machine;

Figure 7 is an end elevational view of an end mill showing the angular relationship between the land of the cutting lip and the relief surface thereof;

Figure 8 is a fragmentary diagonal cross sectional view taken on the oblique line 8—8 of Figure 5 looking in the direction of the arrows and illustrating the relative position between the end mill or cutting tool and the peripheral surface of the grinding wheel;

Figure 9 is an oblique cross sectional view similar to Figure 8 showing the end mill or cutting tool rotated about an arc of 90 degrees to produce the desired radius of curvature between the cutting lip and land;

Figure 10 is a diagonal cross sectional view taken on the oblique line 10—10 in Figure 6 looking in the direction of the arrows to illustrate the manner in which the end mill or cutting tool is presented to the peripheral surface of the grinding wheel to grind and finish the relief surface of the land or cutting lip;

Figure 11 is a diagonal cross sectional view similar to Figure 10 but showing the end mill or cutting tool rotated about an arc of 90 degrees to show the manner in which the relief surfaces of the cutting lips and lands of the end mill or cutting tool are blended when the lands and cutting lips are rounded at the corners thereof;

Figure 12 is a diagrammatic view similar to

Figures 8 to 11 inclusive illustrating the end mill or cutting tool slightly angled laterally of the radial face of the grinding wheel to facilitate the grinding and polishing of end mills with a cup-shaped end contour; and

Figure 13 is a fragmentary perspective view of an end mill illustrating the manner in which the lands and cutting lips have been rounded at their corners so that when the end mill is used in the formation of a groove or slot a fillet will be left in the groove at the corners thereof.

In the drawing, wherein for the purpose of illustrating the invention like reference characters will be employed to designate like parts throughout, attention is directed to Figure 3 wherein there is shown a machine base generally represented by the reference character 5 and said base is formed of a casting to provide a flat top wall 6. Formed integral with the base 5 at the rear thereof is a vertical support 7 which is likewise constructed of a hollow casting and formed on the sides of the vertical standard 7 is a guide rib 8 to provide supporting means for a vertically movable knee 9. The vertically movable knee 9 is of angular construction and includes a rear wall member 10 adapted to ride on the guides 8 and said knee is provided with an extension 11 at each side thereof adapted to overlap the guide ribs 8. Slide plates 12 are bolted to the extensions 11 as at 13 to overhang the guide ribs 8 and permit slidable movement of the vertically adjustable knee 9 thereon. The horizontal bed portion 14 of the vertically adjustable knee 9 is reinforced and supported from the rear wall 10 by means of triangular integrated web portions 15 at each side thereof. The top surface of the base 14 is dove-tailed as at 16 to provide undercut slide ways and said top wall is constructed with a central longitudinal opening 17 to reduce the weight of the machine and facilitate the easy construction thereof. If desired, the vertically adjustable knee 9 may be formed from a casting or may be built up of plates fabricated and welded together in any desired fashion.

Slidably mounted on the vertically adjustable knee 9 is a slide or carriage 18 having slide ribs 19 for reception in the dove-tailed slot 16 to permit longitudinal movement of the slide. Said slide is provided intermediate its ends with an enlarged disc-like portion 19a and has on its bottom surface a depending rack 20 having rack teeth 21 adapted to be engaged by a pinion 22 mounted on the inner end of the shaft 23 which is journaled in a bearing extension 24 formed integral with the adjustable knee base or bed 14 as shown in Figure 3. The inner end of the rotary shaft 23 extends through a tubular bearing portion 25 integrated with the horizontal bed 14 and terminating adjacent the center thereof. Mounted on the outer end of the rotary shaft 23 is the hub 26 of a hand wheel 27 to permit rotation of the shaft and feed of the slide 18 along the ways 16.

The vertically adjustable knee 9 may be raised and lowered by means of an adjusting screw 29 having its threaded portion 30 extending into a nut 31 anchored in the tubular boss 32 formed integral with the top wall 6 of the base 5. The upper end of the adjusting screw shaft 29 is rotatably mounted in a bracket 33 (Figure 3) having its base portion 34 fastened to the rear wall 10 of the vertically adjustable knee 9 by means of bolts or the like as at 35. The bracket 33 is provided with an extension arm 36 having a tubular bearing portion 37 in axial alignment with a tubular bearing portion 38 formed on the base 34. Ro-

tatably mounted in the tubular bearing portions 37 and 38 is a control shaft 39 having keyed thereto a worm 40 which resides between the tubular bearing portions 37 and 38 and is adapted to mesh with a worm wheel 41 on the upper end of the screw-threaded adjusting shaft 29. Endwise movement of the screw-threaded adjusting shaft 29 with respect to the bracket 33 is prevented by means of an enlarged annular portion 42 formed integral therewith and disposed on one side of the bracket and a retaining collar 43 on the other side of the bracket and beneath the worm wheel 41. The outer end of the control shaft 39 is supported in a tubular bearing 44 formed integral with a depending bracket 45 connected to one of the webs 15 of the vertically adjustable knee 9 by means of machine screws or the like as at 46. Secured to the extreme free end of the control shaft 39 is the hub 47 of a handwheel 48 and said hand wheel may be rotated to facilitate the vertical adjustment of the knee 9 by the crank handle 49. It will thus be seen that the vertically adjustable knee 9 will be raised and lowered by manipulating the hand crank 49 and the slide 18 moved in a horizontal direction by the hand wheel 27. Rotatably mounted on the slide 18 is a rotary worktable or turntable 50 and said rotary worktable is provided with a central opening 51 for receiving a vertical pivot post 52. The lower end of the vertical pivot post 52 is threaded as at 53 for being received in a correspondingly threaded opening in the slide 18. The bearing portion 54 of the post 52 is machined with a well-rounded surface to fit the opening 51 and prevent loose play therebetween. An annular enlarged portion 55 is formed on the bearing post 52 and extends over the edge of the opening 51 so as to retain the rotary table 50 in position, with respect to the base 18. The upper end of the post 52 is flattened as at 56 to provide a reference point or base from which measurements may be made when setting the work in a manner which will be hereinafter more fully described.

Formed on the top wall or surface 57 of the rotary work table 50 is a pair of slide guides 58 undercut as at 59 to provide opposed ways and for receiving the dove-tailed portion 60 of a slide 61. Formed integral with the slide 61 is a platform 62 and said platform is angled as indicated in Figures 2 and 4 to present the work pieces to the grinding wheel at the proper angle. The platform 62 is likewise undercut as at 65 to provide dove-tailed ways which are directed transversely to the ways or slide guides 58 for receiving a slide 66 having its edges bevelled and dove-tailed for reception in said undercut slot 65. Thus the slide 61 moves tangentially and the slide 66 chordally with respect to the rotary work table or turntable 50. An adjusting screw 68 (Figure 2) is rotatably mounted in an end plate 69 affixed to the platform 62 and said screw shaft extends into a threaded opening 70 formed in the slide 66 and is provided with a hand wheel 71 to facilitate rotation thereof. The hand wheel is secured to the shaft by means of a set screw 72 extending through the hub thereof as at 73 and engaging the threaded shaft at the inner end thereof. The hand wheel 71 is graduated as at 74 to register with a pointer 75 secured to the end plate 64 by means of a screw or the like 76 so that the point of the pointer as at 77 will register with the graduations 74 and indicate the degree of sliding movement imparted to the slide 66. Lateral move-

5

ment of the platform 62 and slide 61 is limited by means of a pair of oppositely disposed stop members 78 having adjusting screws 79 with their free ends projecting inwardly to engage the slide 61 and the adjusting screws may be provided with polygonal-shaped heads 80 to receive a wrench or other adjusting tool and thereby adjust the slide 61 on the guides 53. If desired, a screw-threaded adjusting rod similar to the rod 58 may be provided for adjusting the slide 61 laterally in substantially the same manner as the screw adjustment for the slide 66.

Extending downwardly from the peripheral surface of the rotary table 50 and secured thereto by means of a machine screw 81 is a stop 82 adapted to engage a stop 83 fastened to the circular portion of the slide 18 by means of bolts or the like as at 84. The rotary work table 50 is provided with an extension 85 at the periphery thereof to which is fastened by machine screws or bolts 86 a screw-threaded bracket 87 for an adjusting screw 88. A nut 89 is threaded on the adjusting screw 88 to lock the same in an adjusted position so that the opposite end of the adjusting screw 88 will engage an opposed surface 90 on the stop 83. It will thus be seen that the rotary work table 50 may be rotated about an arc of 90 degrees or more depending on the adjustment of the screw-threaded adjusting member 88 so as to swing the superstructure about a similar arc during the grinding and finishing of the work pieces such as cutting tools and end mills in order to round the corners thereof. The adjusting screw 88 is provided with a polygonal-shaped end 90a to receive an adjusting wrench or key so as to permit the adjustment of the screw-threaded stop 88 and permit the rotation of the table 50 about an arc greater than 90 degrees.

The slide 18 is round to conform to the rotary work table 50 and is provided with a depending bracket 91 fastened in place by machine screws or the like as at 92 to engage an adjustable screw-threaded stop 93 (Figures 2 and 4) which is threaded in a threaded boss 94 formed integral with the platform 14 of the vertically adjustable knee 9 so that the bracket 91 will engage the stop and limit the longitudinal movement of the round slide 18. A lock nut 96 is threaded on the adjusting rod 93 to retain the same in an adjusted position and the free end of the adjusting screw is polygonally-shaped as at 97 to receive an adjusting wrench or key.

Mounted on the upper end of the vertical support 7 and at one side thereof is a bracket 98 having a platform portion 99 interconnected by means of a reinforcing web 100. Machine screws or the like as at 101 are passed through apertures in one of the flanges of the bracket 98 to securely bolt the same in place to the side of the vertical support 7. The platform 99 is provided with a forwardly extending portion 102 upon which is mounted an electric motor 103 and said motor is held in place by means of machine screws or the like 104 extending through the base lugs 105 with their free ends threaded in openings formed in the platform extension 102. The armature shaft 106 of the motor is adapted to receive the hub 107 of a grinding wheel 108 and said armature shaft is threaded for receiving a retaining nut 109 to thereby lock the hub 107 of the grinding wheel and said grinding wheel on the armature shaft 106. It is to be noted that the motor 103 and grinding wheel 106 are projected forwardly

6

a sufficient distance so that the peripheral surface of the grinding wheel will extend a slight distance beyond and tangent to the axis of the rotary table 50 so that work carried by the rotary work table may be swung about said axis and the desired radius of curvature produced thereon.

Mounted on the slide 66 is a circular housing 110 (Figure 2) integrated with said slide and provided with a bore 111 for receiving a chuck spindle or shaft 112. The chuck spindle is provided with a chuck 113 having a bore 114 for receiving the shank of an end mill M. The opposite end of the tubular chuck shaft 112 is provided with a hub 115 having formed integral therewith a disc-like index head 116 and a knurled handle portion 117. A set screw 119 extends through the hub 115 for securing the hub to the chuck shaft 112. The disc-like index head 116 is provided with a series of circumferentially and equidistantly spaced apertures 120 for receiving the ends of a locking detent 121 slidably mounted in a bore 122 in an extension 123 of the housing 110. A coil spring 124 is mounted in the bore 122 so that one end will engage the rear wall thereof and the opposite end engages the detent 121 to project the same into the openings 120. A finger piece 125 is attached to the detent 121 and projects through a slot 126 in the top wall of the housing 123 to permit the manual retraction of said detent and the adjustment of the index head and the end mill M with respect to the grinding wheel 108 so as to present another cutting lip thereof to the peripheral surface of said wheel. The chuck 113 is provided with a set screw 130 to engage the shank of the end mill M and securely hold the same in position.

Mounted on the vertical standard 7 at the side thereof is a graduated plate 150 (Figure 3) for cooperation with a pointer 152 on the vertically adjustable knee 9. The plate may be graduated with suitable indicia such as graduations to indicate linear distances.

The present grinding machine is particularly adapted for grinding and finishing rotary cutting tools such as fluted end mills having two or more cutting lips as shown in Figures 5 to 13 inclusive. Generally, end mills of the type shown in the drawing include a series of spiral flutes F having lands L and relief surfaces R to facilitate the easy passage of metal chips during the cutting operation. The end of the mill is provided with cutting lips T having lands L' clearly illustrated in Figure 7 and as in the case of the lands L, the lands L' are similarly ground to provide relief surfaces R'. The various surfaces are usually produced on a fluted blank by grinding said surfaces to the required dimensions and, as shown in Figure 7, the end mill is ground with longitudinal lands L to provide an angular surface indicated by the dot and dash lines x and y where the dot-dash line y represents a line tangent to the periphery of the end mill and the line x the angle of the land surface L. The relief surface R is ground on an angle denoted by the line Z and it is to be noted that the angle between the dot-dash lines x and y is substantially equal to the angle between the dot-dash lines x, z. The cutting lips T of the end mill are similarly ground with their land and relief surfaces angled as indicated in Figures 5 and 6, and as shown in Figure 5, one of the lands L' is presented to the periphery of the grinding wheel 108 on an angle such that the axis of the end mill is coincident with the dot-dash line a—a offset slightly from

the radial dot-dash line $r-r$. The land L' of the cutting lip is presented to the peripheral surface of the grinding wheel at a point of contact coincident with a dot-dash line C perpendicular to the offset radial dot-dash line $a-a$ offset slightly from the radial dot-dash line $r-r$. The land L' of the cutting lip is presented to the peripheral surface of the grinding wheel at a point of contact coincident with a dot-dash line C perpendicular to the offset radial dot-dash line $a-a$ so that lands L' of the cutting lips will coincide with a dot-dash line x' tangent to the grinding wheel 108. The relief surfaces R are ground on an angle with respect to the perpendicular dot-dash line C as denoted by the dot-dash line $7'$. It is thus seen that the included angle between the land L' on the dot-dash line x' and the dot-dash line C (Figure 5) is smaller than the included angle between the land L on the dot-dash line x and the tangent line y (Figure 7). In rounding the corners of the lands L and L' as well as the relief surfaces R and R' at the meeting point thereof, the difference of angularity above described is compensated for by mounting the end mill or cutting tool in the chuck 113 at an angle of approximately 10 degrees so that when said chuck and end mill are turned about an angle of 90 degrees the longitudinal land and relief surfaces and cutting lips will be blended. By so rounding the corners of the meeting edges of the longitudinal lands of the cutting lips and the lands, an end mill of unusual form and utility is provided which may be employed for difficult work where it is necessary to round the corners of work having meeting walls so as to shape a fillet thereat.

Mode of operation of the grinding machine

In the operation of the machine, it will first be assumed that a cutting tool such as an end mill has been inserted in the chuck 113 and the same secured in position by tightening the set screw 130 with the index head 116 properly positioned so that the detent 121 is received in one of the apertures 120 and the cutting lip of the end mill substantially horizontal and extending transversely of the peripheral surface of the grinding wheel.

When the end mill has been properly positioned as above set forth, the adjusting screws 79 on each side of the slide 62 are manipulated to adjust the slide and end mill in a lateral direction so that the corner of the end mill will be moved inwardly a slight distance beyond the vertical axis of the pivot post 52 dependent on the radius of curvature desired. In effecting the above adjustment, a gauge is applied to the flat face 56 of the pivot post 52 so as to measure the distance of said lateral movement required to produce the desired radius of curvature at the corners of the end mill cutting lips.

After the end mill M has been positioned in offset relation to the vertical axis of the pivot post 52, the slide 66 is manipulated by the graduated hand wheel 71 to move the tip of the end mill beyond the vertical axis of the pivot post 52 a distance equal to the distance of lateral movement which, as mentioned above, corresponds with the radius of curvature desired. When the end mill has this been properly aligned, the vertically adjustable knee 9 is adjusted upwardly or downwardly by operating the hand wheel 48 to cause said knee to move a predetermined distance measured along the scale 150 on the vertical standard 7. At different ele-

variations of the adjustable knee the angle of tangency will vary and for this reason it is necessary that the elevation of the vertically adjustable knee be predetermined to produce the required lip angle as well as the relief surface angle.

With the end mill in position as shown in Figure 5 the vertically adjustable knee 9 has been elevated to a predetermined position and the stop 93 has been set to abut the slide 18 and limit horizontal movement of the end mill with respect to the grinding wheel 108 for operation upon the cutting lip lands L' .

The rotary table 59 may now be turned about an arc of 90 degrees from the position shown in Figure 8 to that shown in Figure 9 so as to round off the corner of the cutting lip land L' presented to the wheel. The stop block 83 prevents rotary movement of the table 50 beyond the limits of the 90° spaced stop plate 82 and the stop screw 88 so that the radius of curvature of the corners of the lands L and L' will blend with one another as at 153.

When the longitudinal lands L and L' and cutting lips have thus been rounded by being ground and finished at the corners thereof, the vertically adjustable knee 9 is lowered to a new elevation by manipulating the hand wheel 48. The slide 18 is then advanced to a predetermined position by adjusting the stop screw 93 to thereby position the end of the mill so that the relief surface thereof will be presented to the grinding wheel 108 as shown in Figure 6. The above adjustments are made while the end mill is presented to the grinding wheel 108 as shown best in Figure 10 whereby the rotation of the rotary work table about an arc of 90 degrees to a position as shown in Figure 11 will cause the longitudinal relief surfaces R and relief surfaces of the cutting lips R' to be ground and finished at the corners thereof in substantially the same manner as pointed out in connection with the lands L and L' and thereby blend and round the relief surfaces at the corners as at V , Figure 13.

In certain types of end mills in which the lands are inclined and the end of the mill dished as shown in Figure 12, the adjusting screw 88 may be adjusted to permit the rotary work table to swing about an arc slightly greater than 90 degrees so that the end mill will be presented to the grinding wheel at a slight compound angle and thereby facilitate the grinding and finishing of the cutting lip lands L' as well as rounding the corners thereof by the same grinding operation. Similarly, the relief surfaces of the cutting lips R' will be finished and rounded at the corners thereof by positioning the adjustable knee 9 at a new elevation and resetting the limit stop screw 93 as pointed out in connection with the adjustment shown in Figures 6, 10 and 11.

The motor may be controlled by a suitable switch (not shown) to facilitate the starting and stopping of the grinding wheel between adjustments. It is understood that the motor and grinding wheel are set in motion at the beginning of each grinding operation incident to the grinding and finishing of the various cutting lip lands and relief surfaces thereof.

It is to be understood that the form of the invention herewith shown and described is to be taken as a preferred embodiment of the same and that various changes may be made in the shape, size and arrangement of parts without departing from the spirit of the invention or the scope of the subjoined claims.

What I claim is:

A machine for grinding and rounding the ends of workpieces consisting of fluted rotary tools with cutting lips, comprising a frame, a rotary abrasive wheel mounted on said frame, an adjustable support movably mounted on said frame, mechanism for adjustably moving said support and said abrasive wheel relatively to one another in both horizontal and vertical paths, a vertical pivot member mounted on said support with its axis aligned substantially tangentially to the periphery of said wheel, a turntable rotatably mounted on said support around said pivot member, a tangentially movable slide mounted on said turntable eccentrically of said pivot member, a chordally movable slide mounted on said tangentially movable slide, and a workpiece holder mounted on said chordally movable slide in proximity to said abrasive wheel, said chordally movable slide being reciprocable in a plane which is inclined relatively to the plane of reciprocation of said tangentially movable slide.

WILLIAM MELIN.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
439,154	Holz	Oct. 28, 1890
1,156,292	Johnson et al.	Oct. 12, 1915
1,306,400	Barr	June 10, 1919
1,326,423	Rennie	Dec. 30, 1919
1,377,884	Heryngfel	May 10, 1921
1,662,078	Severson	Mar. 13, 1928
1,662,079	Severson	Mar. 13, 1928
1,783,540	Hogg et al.	Dec. 2, 1930
2,362,873	Wessman	Nov. 14, 1944

FOREIGN PATENTS

Number	Country	Date
111,395	Great Britain	Nov. 29, 1917
174,728	Great Britain	Feb. 1, 1922
361,659	Germany	Oct. 17, 1922
516,740	Germany	Jan. 30, 1931