March 2, 1948. I. SNEVA 2,436,873

RADIUS-ANGLE FORMER

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FIG. 1

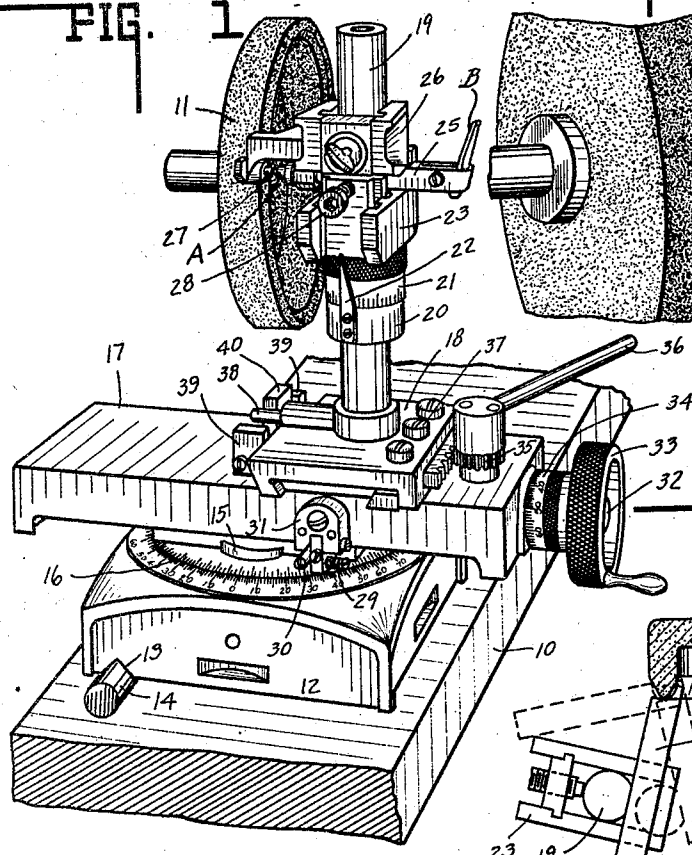


FIG. 2

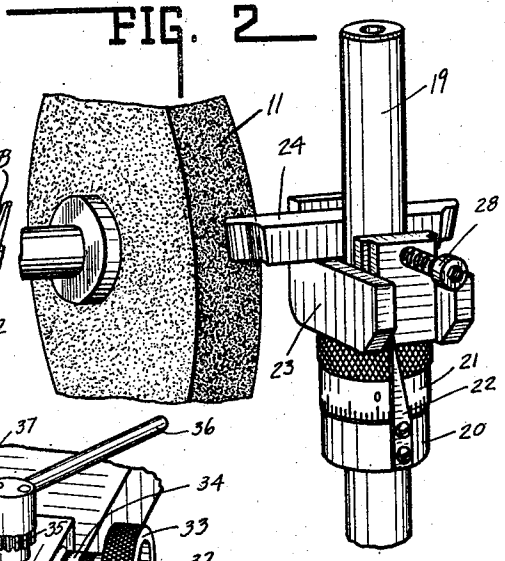


FIG. 3

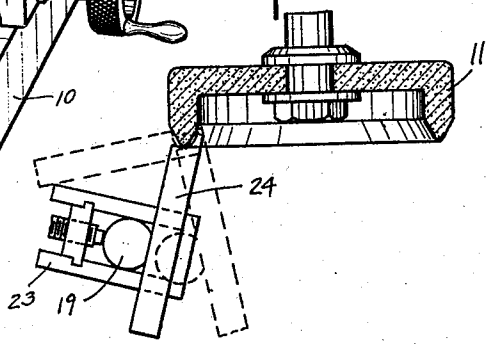


FIG. 4

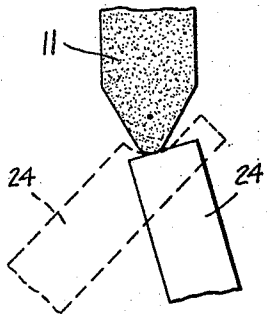


FIG. 5

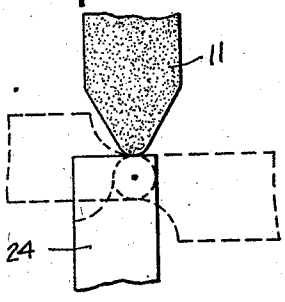
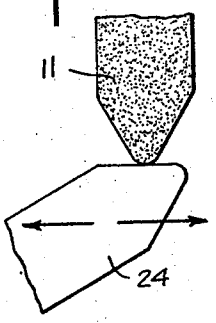


FIG. 6



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FIG. 7

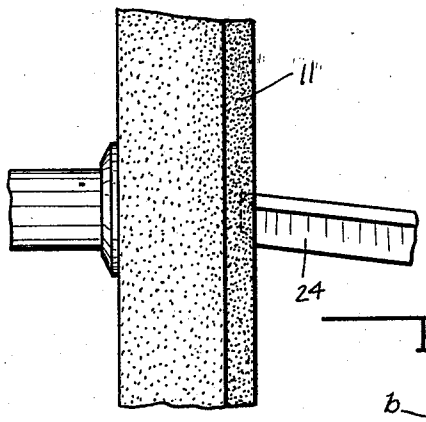


FIG. 8

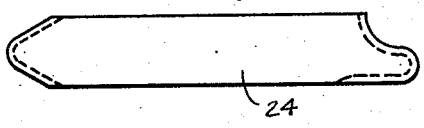


FIG. 10

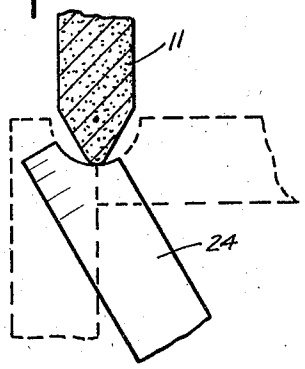


FIG. 12

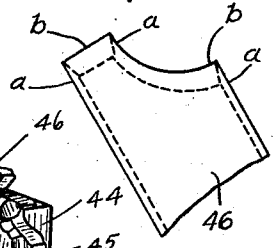


FIG. 9

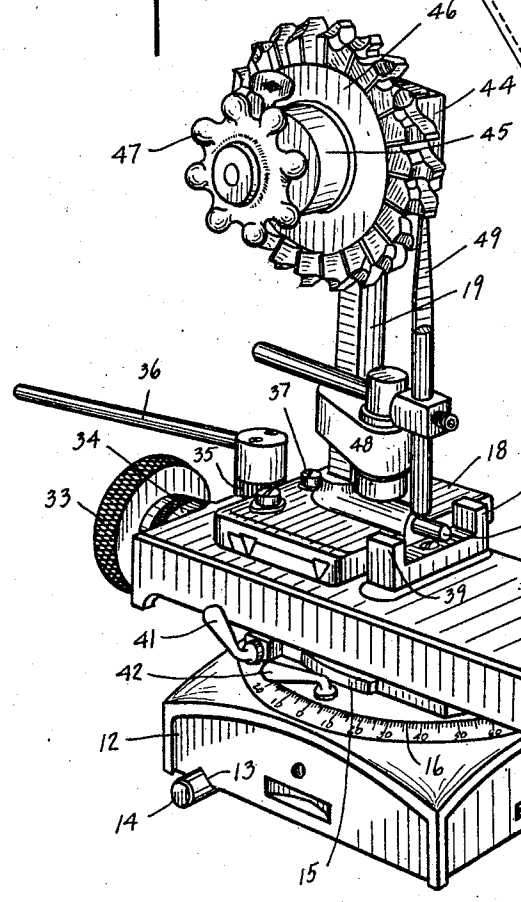
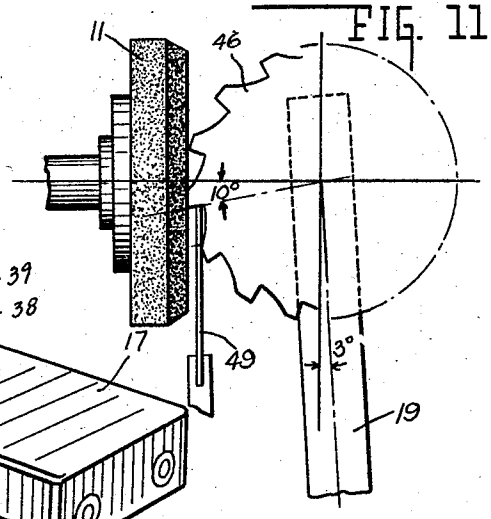


FIG. 11



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Patented Mar. 2, 1948 2,436,873

UNITED STATES PATENT OFFICE

2,436,873

RADIUS-ANGLE FORMER

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Application December 11, 1943, Serial No. 513,896

3 Claims. (Cl. 51—224)

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This invention pertains to an apparatus for dressing grinding wheels, and preferably forming tools by precision grinding on a plain surface wheel, to a prescribed radius of curvature, either concave or convex, or to a prescribed angle, and wherein the apparatus may be adjusted and set to successively grind a wheel or tool to different or compound curvatures and angles merging one into the other.

Heretofore it has been the practice to first form an abrasive grinding wheel about its periphery to the desired curvature or angle into which the tool stock is directly fed, resulting in the tool being ground to the curvature or angle previously formed on the wheel. Several objections to this procedure may be noted. In the first place it requires an additional operation, i. e., the forming of a wheel. Secondly, the radius of curvatures are not precision formed, resulting in the requirement that as the tool is ground the curvatures or angles be constantly checked by templets resulting in delay and possible inaccuracies. More important, however, is the fact that this method of grinding the tool stock leaves scratches or ridges in the ground surface which in turn results in a ridged cutting edge. This causes the tool to wear more rapidly, requiring early regrinding, and results from those abrasive particles on the wheel which may be harder or protruding, to always follow the same path over the ground surface of the tool during the grinding operation.

By means of this invention the above noted objections may be eliminated, whereby tools may be ground to precision by the mere setting thereof, which not only eliminates the preliminary operation of forming the wheel, but requires no checking as to curvature or angle as the tool is ground. Additionally, the back and forth movement of the tool with respect to a plain grinding surface of the wheel eliminates scratching or grooving of the surface and edge, since any outstanding abrasive particle on the wheel will not continuously follow the same path over the ground surface. Thus, once the tool is properly set with respect to the grinding wheel, the grinding operation results in the tool being finally formed with precision to the prescribed curvature or angle without checking by the operator being required. This is particularly of value in

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grinding a series of teeth on a milling cutter to a prescribed curvature, in that all teeth are precision ground to not only the same curvature, but to the same length, wherefore one tooth will not protrude beyond the others as is possible through wear of the formed wheel as heretofore employed.

One feature of the invention lies in the grinding of a tool by manipulation thereof with respect to a wheel having a plain grinding surface or edge, as distinguished from direct application of the tool to a formed grinding wheel. By this invention means is provided for mounting the tool with respect to a plain grinding wheel, preferably cupped, such that the tool may be oscillated in engagement therewith about a fixed center of oscillation to provide the prescribed radius of curvature, and maintain such radius to precision as the grinding progresses and during the oscillation of the tool about its fixed center, and wherein such fixed center may be shifted to grind a different radius of curvature, either concave or convex, and followed if desired by a precision setting to direct the grinding of the tool at an angle tangent to a proceeding or subsequently ground radius of curvature. This permits of a tool being precision ground in virtually one operation, but with different setting, to compound curves and angles merging one with the other.

In grinding tungsten carbide or similar materials, specially formed grinding wheels have been developed, such as "Crystolon," silicon carbide and diamond impregnated wheels. However, "Crystolon" and silicon carbide formed grinding wheels are made soft especially in order to prevent heating and cracking of the tungsten carbide while being ground. Due to the softness of such a wheel, it will break down rapidly and, therefore, not retain its true form and thereby will not be suitable for such accurate form grinding. Furthermore, diamond wheels are too expensive to be formed into various contours and shapes to grind the tools. But with the diamond wheel, shaped as herein disclosed, a carbide tipped tool can be form ground in accordance with this invention about as easily as a high speed steel tool.

A further feature of the invention resides in the mechanism for setting the tool for dressing a grinding wheel relative to a line intersecting the

center of rotation thereof for controlling the radius-angle forming of said wheel. This is accomplished by means of the hereinafter described provision of spaced stop blocks between which a gauge pin associated with a tool support may freely move to different gauged positions for centering the tool relative to the center of rotation for dressing a curve while permitting freedom of movement for dressing an angle tangent to the radius of such curve.

A still further feature of the invention resides in so relating the respective teeth of a milling cutter to the grinding wheel that they will be ground with varying degrees of clearance. Thus, it may be desirable to provide a clearance of three degrees along the side edges of the tooth as compared with a clearance of ten degrees on the forward cutting edge, blending the clearance between the three and ten degree angles about the curved portion. This is accomplished by mounting the former at a prescribed (three degree) angle with respect to the grinder table, at which angle the side edges of the teeth are to be ground for clearance, and then presenting the teeth to the grinding wheel and supporting them at the angle (ten degrees) of clearance at which the cutting edge is to be ground.

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

Fig. 1 is a perspective view of the tool former showing a preliminary mounting of the wheel dressing nibs. Fig. 2 is a perspective view of the former with the tool holder and with the tool applied to a grinding wheel. Fig. 3 is a diagrammatical illustration of the swivel movement of the tool with respect to the grinding wheel. Fig. 4 is an enlarged diagrammatical illustration, showing the grinding of a concave cutting edge. Fig. 5 is the same as Fig. 4, illustrating the grinding of a convex cutting edge. Fig. 6 is the same as Fig. 4, illustrating the grinding of an angle cutting edge. Fig. 7 is an illustrative elevation of the grinding wheel with the tool applied thereto. Fig. 8 is a perspective view of a finished tool. Fig. 9 is a perspective view of the former illustrating the mounting of a milling cutter thereon for grinding its cutting teeth with a convex curve. Fig. 10 is an enlarged illustrative view of the relation of the milling cutter of Fig. 9 of the grinding wheel. Fig. 11 is a schematic illustration of the angular relation of the tool supporting post and the tool with respect to the grinding wheel. Fig. 12 is a portion of the ground tooth of a milling cutter indicating by dotted lines the varying angle of clearance ground thereon in accordance with Fig. 11.

In the drawings there is illustrated a wheel or tool former adapted to be secured to an adjustable bed plate 10 of a grinder table in adjustable relation to the usual motor driven cupped grinding wheel 11. The former includes the base 12 adapted to be securely clamped to the bed plate 10 by any suitable means, said base being provided with a longitudinally-extending V-groove 13 in its bottom surface for receiving a dowel pin 14 for the purpose hereinafter described. Said base is provided with a turntable or swivel support 15, both the base and the swivel support carrying an annular vernier scale, as indicated at 16. Mounted upon the swivel support 15 there is a primary carriage or elongated slide 17 slidable diametrically thereon. Carried on said slide 17 there is a secondary carriage or transverse slide 18 slidable transversely of the elongated slide. Thus the slides 17 and 18 provide a compound slide support, the latter carrying a vertically and upwardly extending post 19.

Slidably mounted upon the post 19 there is a graduated height dial comprising a locking collar 20 and an adjustable collar 21 rotatable in screw threaded association therewith. The locking collar 20 is adapted to be secured in tool-supporting position on said post, and carries a fixed finger 22 extending into indicating position with respect to suitable graduations on the adjustable collar 21. Carried on said post above the graduated height dial and located thereby as to height by the proper adjustment of the adjustable collar 21, there is a tool holder 23 suitable for supporting and clamping either the tool bit 24 to be ground or a diamond nib holder 25, supporting the horizontal diamond nib A at one end, and a vertical diamond nib B at the other end, said diamond nibs being supported thereby when it is desired to dress the wheel 11, as shown in Fig. 1. Also, as shown in Fig. 1, there is superimposed on said shaft above the holder 23 a locator gage 26 carrying an anvil 27. Preferably one side of the post is flattened as indicated in Fig. 3, against which the work, tool bit 24 or nib holder 25 is clamped by the screw 28.

The elongated slide 17 carries on one side thereof an adjustable stop pin 29 adapted to swing in and out of position to engage a contact stop pin 30 mounted on the swivel support 15 and extending outwardly therefrom. In this connection it will be noted that the adjustable stop pin 29 is threaded for adjustment in the depending finger pivotally mounted to swing upwardly on a plate 31 to clear the stop pin 30. The elongated slide 17 also carries longitudinally thereof a rotatable feed screw 32 having threaded engagement with the usual threaded yoke which is carried by the swivel support 15 so that upon rotating said screw by the wheel 33 said slide may be longitudinally adjusted with respect to the swivel support. Said wheel and slide are provided with a graduated dial indicated at 34, to record the extent of movement or indicate the relative position of said slide.

The transverse slide 18 is provided with a rack engageable by the pinion 35 pivotally mounted upon the slide 17 and operable by a handle 36. Through said rack and pinion said transverse slide may be manipulated and locked in adjusted position by a set screw 37. Said transverse slide is provided with an outwardly extending pin 38 movable therewith between a pair of stop blocks 39, a selected gage block 40 being insertable between said pin and one of the stop blocks for positioning the transverse slide 18 with respect to the elongated slide 17.

By way of illustrating the operation, to grind a tool bit it may be assumed that the tool to be ground is as illustrated in Fig. 8, wherein a ¼ inch concave radius is blended into a ⅛ concave radius with 3½ degrees clearance, as indicated by dotted lines. To grind to such clearance, the base 12 is mounted upon the bed plate adjacent the grinding wheel with the V-slot 14 toward the grinding wheel 11 and a prescribed ($\frac{7}{16}$") dowel pin is clamped in the V-groove for tilting the base 12 slightly upwardly toward the wheel. The height dial, comprising the collars 20, 21, is mounted about midway of the post 19 with the upper collar open with respect to the fixed collar 20 to about ½ inch for later closing adjustment. The diamond nib holder 25 is then clamped upon the holder 23 so that the horizontal diamond nib

A is on the diametrical center of the wheel 11. The diamond locator gage 26 is then mounted on the post and the diamond brought into contact with anvil 27. Thereupon the nib holder is clamped securely in position by the clamping screw 28 and the locator gage with its anvil is removed from the post. The height gage in its half inch open position is clamped to the post directly against the holder 23.

The adjustable stop pin 29 is then lowered for engagement with the contact stop pin 30. The wheel 33 is rotated to adjust the elongated slide until pin 29 engages pin 30, whereupon the dial 34 is set at zero. Thereupon the swivel support 15 is adjusted so that the vernier graduations thereon and on the base 12 are set at zero. In this setting the swivel support is locked to the base.

The set screw 37 on the transverse slide 18 is then loosened and a selected gage block 40 is inserted between the pin 38 and one of the stop blocks 39, the handle 36 operating the rack and pinion 35 being employed to slide the pin 38 into contact with the block 40. The grinder bed plate is then advanced to bring the diamond nib A into contact with the grinding edge of the wheel 11 and is then reciprocated to pass the diamond back and forth lightly across the grinding surface of the wheel for dressing it. For the grinding of the concave surface of the tool, the cutting edge of the wheel should be dressed down so that the grinding face will be of less radius than the radius to be ground or in this instance about $\frac{1}{16}$ of an inch with steep angles. With the dial 34 set at zero, the bed plate feed dial should be read and its reading noted, with the diamond nib A in the dressing position with respect to the wheel. The cutting edge of the grinding wheel is thereby centered in respect to the axial center of the swivel support.

Thereupon the nib holder 25 is removed and replaced with the tool bit 24 which preferably has had its surface rough ground to approximately the desired contour. The height dial should then be set by turning the adjustable collar 21 on its supporting collar 20 until its scale reads .3175 of an inch with the holder 23 lowered to rest thereon. Thus, the ½ inch tool bit is properly positioned as to height in respect to the wheel as dressed by the nib.

After the nib holder 25 has been replaced with the tool bit, the elongated slide 17 is retarded until the dial 34 reads at .125 inch, plus .030 inch, or the remaining rough stock on the tool bit 24 has its extreme point in contact with the $\frac{1}{16}$ inch base of the wheel. Thereupon the elongated slide 17 is securely clamped to the swivel support 15. This adjustment positions the top edge of the tool bit 24 at the same relative location as the centered point of the diamond.

The set screw 37 is loosened and a micrometer applied to the outside of a stop block 39 and pin 38 which are adjusted to 1.0685 inches. In forming the ¼ inch concave radius on the left side of the tool bit, the grinder bed plate 10 is advanced .250 inch so that the left side line of the tool bit is on the approximate center of the $\frac{1}{16}$ inch face of the wheel. The bed plate is locked in this position. This adjustment is important as any error will be reflected accordingly in the tool bit.

The cutting operation is then performed by advancing the elongated slide 17 through rotation of the wheel 33, while at the same time manually swivelling the slide about the axial center

of the support 15 to swing the tool repeatedly back and forth past the grinding edge of the wheel. This is continued until the reading on the dial 34 has advanced from zero to .155 inch, or until the stop pin 29 engages pin 30, whereupon the prescribed radius of curvature has been reached and the concave curve has been cut to precisely the prescribed radius.

It then may be desirable, for example, to reset the former to follow with the cutting of a ⅛ inch concex curve merging with the concave, and having a 3½ degree clearance on a ½ inch bit. For this purpose, the set screw 37 is loosened and the transverse slide 18 moved 1.0625 inches. This re-establishes the center of radius for the convex curve. Thereupon the set screw 37 is again tightened. The bed plate 10 of the grinder table is unlocked and shifted .375 inch, whereupon the reading is carefully noted. It is then shifted an additional .030 inch. This adjustment is necessary to provide a clearance angle for the stock on the side of the tool bit requiring several cuts to remove.

The elongated slide 17 is then swung to a 90 degrees' angle and locked in that position by the locking lever 41 so that the right side of the tool bit 24 faces the wheel. A clearance angle is then formed on the side of the tool bit to about ½ inch from the point by moving the transverse slide 18 while advancing the bed plate 10 of the grinder table .030 inch to the original reading of .375 inch, whereupon it is locked in this position. The swivel support 15 of the former is then unlocked by loosening the locking lever 42 and the elongated slide 17 is altered .030 inch by the reading of the dial 34. The tool bit is then ground by swinging the swivel support 15 repeatedly back and forth from 90 degrees on one side to 90 degrees on the other side, or through an arc of 180 degrees about the grinding surface of the wheel. During this operation the hand wheel 33 is gradually rotated to feed the tool bit into the grinding wheel to the extent of .030 on the dial 34, or until stop pin 29 engages the stop 30. Upon reaching this feed-in point, the convex surface will have been ground to the prescribed radius and blended into the concave radius previously formed.

The same procedure may be followed in blending a straight angle surface into one or the other of the curved surfaces by establishing the desired angle through adjustment of the swivel support 15 upon the base 12 with the prescribed reading on the dial 16. Locked in place by locking lever 42, and with the tool thus positioned at the prescribed angle to the wheel, the bed plate 10 may be reciprocated to move the tool back and forth across the face of the grinding wheel, while the elongated slide 17 is fed into the prescribed distance as established by the scale 34 or the stop pins 29, 30.

As illustrated in Fig. 9, a fitting 44 may be applied to the former by mounting on the post 19 to provide a horizontal boss adapted to support a sleeve 45 for carrying a milling cutter 46, locked thereon by the hand wheel 47. On the lower end of the post 19 there is a fitting 48 for supporting the tooth locating spring finger 49 having its upper end positioned to engage the flat side of a cutting tooth. With the milling cutter thus mounted, each tooth may be individually ground to a prescribed radius in the manner above described with respect to a tool bit, by first centering, facing and then swinging the respective teeth about the cutting edge of the grinding wheel. By reason of the precision

adjustments above described, each tooth is ground not only to precisely the same radius of curvature, but to the same depth. Whereas, in grinding such teeth in the usual manner by a formed wheel, the later teeth ground will be longer than the teeth earlier ground by reason of the wear on the wheel. This results in the longer teeth wearing down and dulling due to their taking the cutting load. By means of the operation herein described, all the teeth will be formed to precisely the same radial depth as well as to precisely the same radius of curvature or angle.

It is preferable that the respective teeth of the milling cutter be ground with a lesser relief at the sides than the cutting edge, for example, a three degree clearance at the sides and a ten degree clearance along the cutting edge. It is also desirable that the relief about the curved portion of the cutting edge be correspondingly relieved, starting with the ten degree relief and tapering to a three degree relief, as indicated in Fig. 12. As therein shown, the tooth 46 is ground with a relief of approximately three degree at *a* along the side edges and a ten degree relief indicated at *b* along the cutting edge. This is accomplished by providing a dowel pin 14 of such diameter as to support the base 12 at a three degree angle relative to the grinder table, or such angle as may be desired for relief of the side edges of the teeth. The post 19 then extends at a three degree angle to the vertical. However, to provide clearance on the cutting edge, the locating finger 49 is adjusted on the fitting 48 to arrest a tooth and support it at the prescribed angle to the face of the wheel. For example, as illustrated in Figs. 11 and 12, the finger 49 engages and supports the tooth at a ten degree angle to the axis of rotation of the grinding wheel to cut a ten degree relief along its cutting edge.

The apparatus herein described may also be similarly employed in respect to the grinding or forming of other tools, including die sinking tools, end mills and drills on which spherical points may be desired, and the like, through appropriate attachments similar to those above described and with the corresponding adjustments and manipulations. Also, wherein it may be desired to do so, the diamond nibs, either horizontal nib A or vertical nib B', as illustrated in Fig. 1, may be applied in the usual manner to dress a grinding wheel to the desired forming curve or angle.

In thus dressing a grinding wheel, and wherein it may be desired to form the curve at a predetermined radius with the same or different angles tangent thereto, the gauge block 40 is positioned between the gauge pin 38 and one of the stops 39 to thereby set the dressing tool with respect to a line intersecting the center of rotation of the swivel support 15 and extending longitudinally of the elongated slide 17. With the diamond set back or forward relative to the axial center to the prescribed radius, slide 17 may thereupon be swiveled as it is fed forwardly to dress the wheel to the prescribed radius of curvature. This swivel action is carried on within angular limits gauged by the scale 16 in respect to the angle tangent to be ground. Upon swinging to one extreme position, the handle 36 may be operated to move the transverse slide carrying the gauge pin 38 from engagement with the block 40 to traverse the intervening space toward the opposed stop 39, from right to left and back again, viewing Fig. 1 toward the wheel. Having traversed said space, the angle tangent to the radius will have been ground, the gauge pin 38 being brought back to its position against and set by the gauge block 40. The tool is thereby re-set on center to swivel in the opposite direction to take another radius forming cut, whereupon the gauge block 40 may be placed on the other side of pin 38 and the handle 36 manipulated in the opposite direction to grind the opposed tangent to radius surface on the wheel.

By means of this arrangement, and the selection of different sized gauge blocks 40, the dressing tool may be set at different positions relative to the said line intersecting the center of rotation to grind curves on differently directed radii while still permitting slide 18 to be manipulated to grind the associated angles tangent thereto.

The invention claimed is:

1. A tool forming apparatus comprising a base having a swivel support thereon, a registering calibrated scale about said support and base, means for locking said support to said base in adjusted position, an elongated slide supported for adjustment diametrically of said support, an adjusting screw carried by said support and slide having a scale thereon for indicating the relative positions therebetween, a transverse slide supported for transverse adjustment relative to said elongated slide, means for positioning said transverse slide in prescribed relation thereto, a fixture post extending upwardly from said transverse slide, a height adjustment collar adjustably secured to said post and provided with a scale height adjustment member thereon, a tool supporting fixture secured to said post adjustable thereon to locate said tool in the horizontal plane of a grinding wheel, means for supporting said base in operative relation to said grinding wheel, the adjustments to said slides being operable to project them in predetermined relation to the axial center of said swivel support, and means for feeding the tool into said wheel while oscillating it relative thereto about the axial center of said support.

2. In a tool forming apparatus, the combination with a grinder table and a wheel provided with a grinding edge, of a swivel support secured to said table in axial alignment with the center of curvature to be ground by said wheel, an elongated slide adjustably supported to slide diametrically of said support toward and away from said wheel, a transverse slide adjustably associated with said elongated slide, a fixture post extending upwardly from said transverse slide, a height setting collar slidably adjustable on said post, an adjustable collar rotatable on said setting collar to variable height adjustment with respect thereto, and a tool fixture mounted on said post for height adjustment thereon by supporting engagement with said adjustable collar, whereby the elevation of said tool holder may be positioned and set by said collars relative to the horizontal plane through the axis of said wheel.

3. In a tool forming apparatus, the combination with a grinder table and a wheel provided with a grinding edge, of a swivel support secured to said table in axial alignment with the center of curvature to be ground by said wheel, an elongated slide adjustably supported to slide diametrically of said support toward and away from said wheel, a transverse slide adjustably associated with said elongated slide, a fixture post extending upwardly from said transverse slide, a height setting collar slidably adjustable on said post, an adjustable collar rotatable on said setting collar to variable height adjustment with respect thereto, a tool fixture mounted on said post

for height adjustment thereon by the supporting engagement thereof with said adjustable collar, said adjustable collar being provided with peripheral graduations, and a pointer fixed to said setting collar extending to selective alignment with the graduations on said adjustable collar for indicating the relative position therebetween for setting the tool relative to the horizontal plane through the axial center of the wheel.

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