

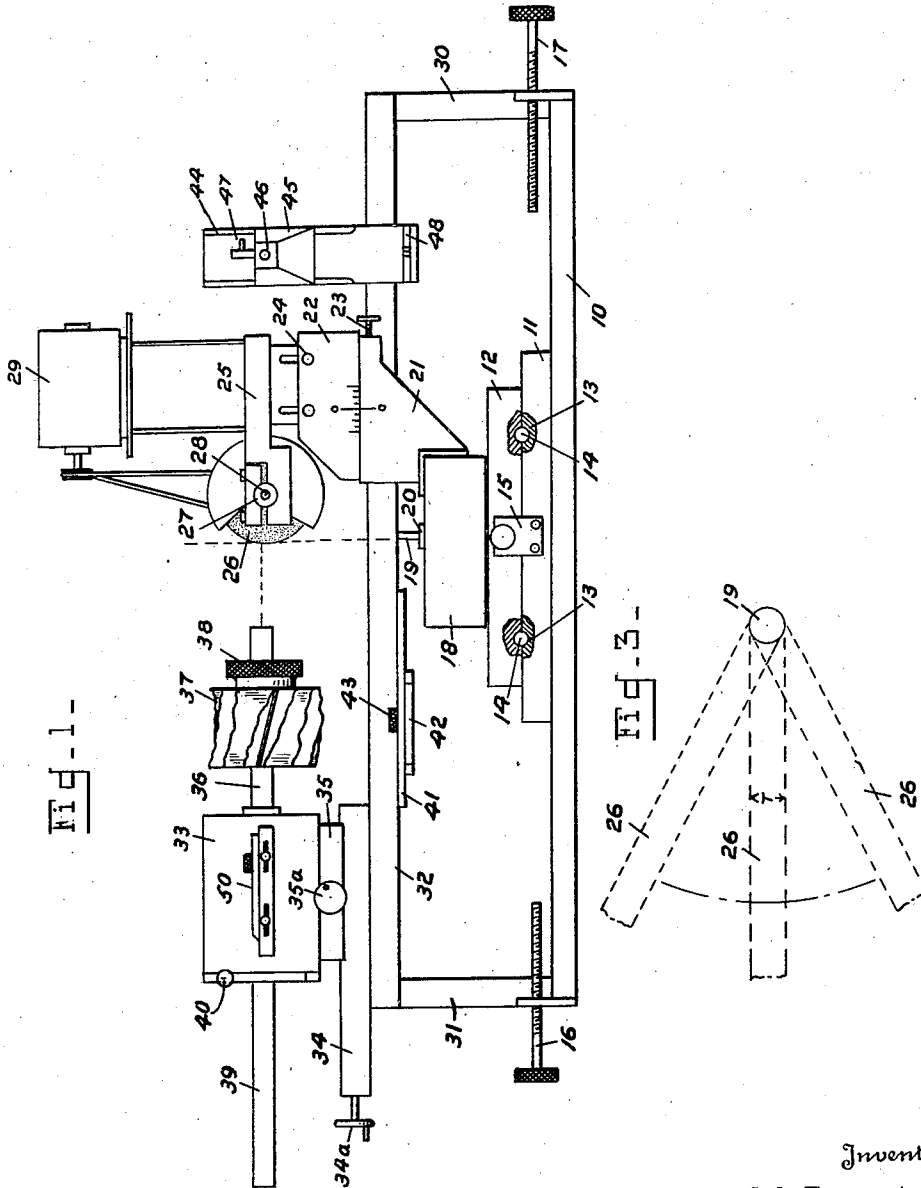
April 29, 1947.

O. M. BRAATEN  
CONTOUR CUTTER GRINDER

2,419,529

Filed July 1, 1942

4 Sheets-Sheet 1



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Fig. 2.

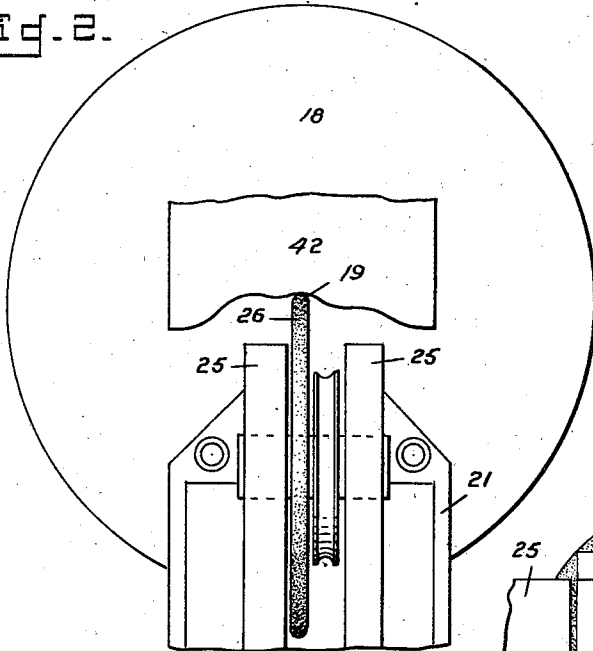


Fig. 5.

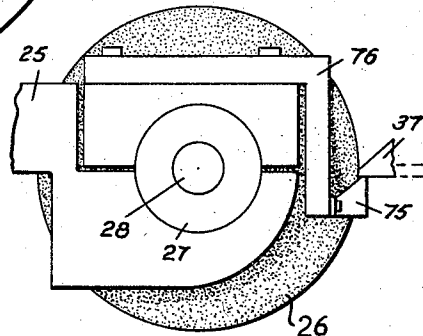
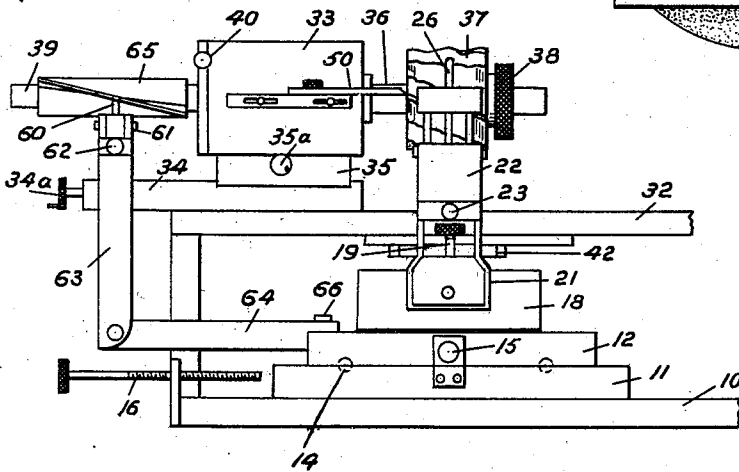


Fig. 4.



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Fig. 6.

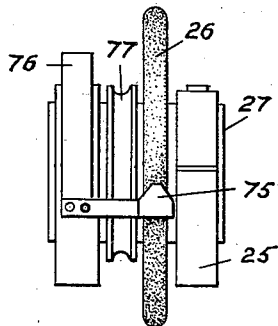


Fig. 6.

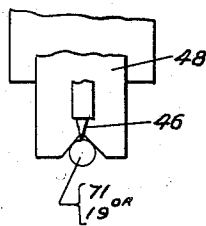


Fig. 7.

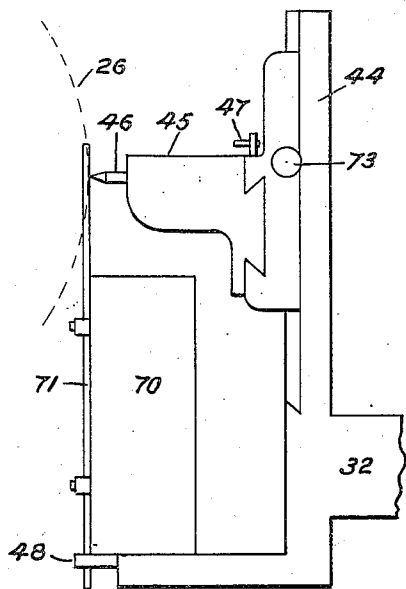
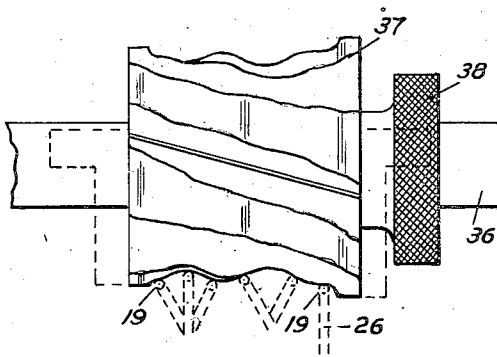


Fig. 8.



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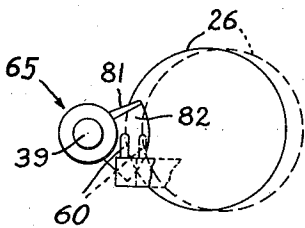
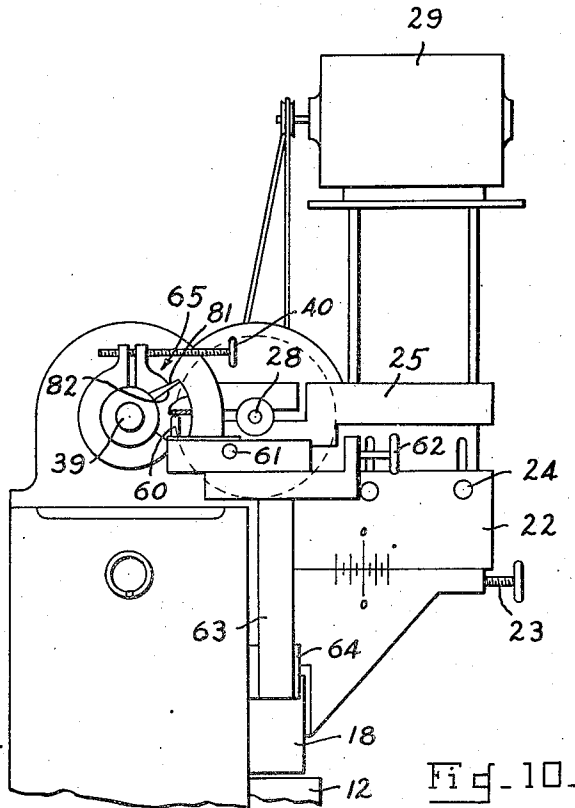
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4 Sheets-Sheet 4



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Fig. 11.

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# UNITED STATES PATENT OFFICE

2,419,529

## CONTOUR CUTTER GRINDER

Oscar M. Braaten, Rock Island, Ill.

Application July 1, 1942, Serial No. 449,311

9 Claims. (Cl. 51—100)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

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The invention described herein may be manufactured and used by or for the Government for governmental purposes, without the payment to me of any royalty thereon.

The present invention relates to a grinding machine and more particularly to a universal contour cutter sharpening machine.

Heretofore in grinding contour cutters with prior art sharpening machines, precisely uniform tooth clearance has been practically impossible to obtain. According to the standard practice recommended by the manufacturers of such sharpening machines, each tooth of the contour cutter was first ground with the grinding wheel spindle parallel to the arbor upon which the cutter was mounted. As the wheel traveled up the side of the contour on each tooth, the cutter lost its clearance, and had no clearance when the grinding was done in a plane parallel to the wheel, the loss of clearance being due to grinding with the side of the wheel instead of its periphery. In order to correct for this loss in clearance it was the practice to swivel the grinding head either to the right or left for approximately 20° and then to grind the rising contour to a cutting edge. In all cases it was the recommended practice to maintain the swivel head fixed rigidly in position during grinding, and therefore each change in the position of the grinding wheel necessitated resetting the swivel head, with the resultant loss of time.

From theoretical considerations it will be apparent that a precisely uniform clearance is obtainable only if the plane of the grinding wheel is maintained at a constant angle with reference to a tangent drawn at every point on the contour. Accordingly, an infinite number of wheel mount resetting is theoretically necessary with prior art machines in order to attain precisely uniform clearance on contour cutters having non-rectilinear contours. In practice, precisely uniform clearance was, of course, never attained and the number of wheel mount resettings actually utilized in any given case was left largely to the discretion of the operator, having regard to the complexity of the contour being ground, the degree of precision desired and the limitations of time. The latter factor was especially important because of the time required for the resetting of the swivel head of prior art machines which were required to be operated with the swivel head rigidly fixed in position.

The object of the present invention is to provide a universal contour cutter sharpening machine so designed as to enable the operator to

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grind any type of contour cutter, either straight, stagger, or spiral flute, and at the same time to obtain proper clearance at all points on the contour, without repeatedly resetting the grinding wheel mount.

Another object is to provide a machine of the character described wherein the axis of rotation of the grinding wheel mount and of a coaxial former pin, is offset from the grinding point of the grinding wheel by a distance equal to the radius of the former pin.

Another object is to provide a work-positioning mechanism for a machine of the character described, which automatically positions spiral tooth contour cutters during sharpening, so that the same clearance is obtained at all points of contour as the grinding wheel is moved across each tooth of the cutter. A further object of this invention is the provision of a work-positioning mechanism particularly constructed to accommodate the in and out movement of the grinding wheel in following the desired contour of the cutter.

Still another object is the provision of a wheel trueing device for properly aligning the diamond point in relation with the periphery of the former pin, and for subsequently dressing or trueing the grinding wheel.

Many other objects and advantages will be apparent as the invention is hereinafter more fully described with reference to the several figures of the drawing, wherein:

Figure 1 is a front elevation of a preferred embodiment of my improved sharpening machine, showing the manner in which the wheel mount is disposed with reference to the former pin.

Figure 2 is a top elevation of a portion of the apparatus shown in Figure 1.

Figure 3 is a top elevation showing the position of the former pin with reference to the grinding wheel in various planes.

Figure 4 is a front elevation of a portion of the sharpening machine shown in Figure 1, with the addition of automatic work-positioning means in accordance with the present invention.

Figure 5 and Figure 6 are side and front elevations, respectively, of the grinding wheel spindle support showing details of construction.

Figure 7 is a detailed side elevation of the wheel trueing device.

Figure 8 is a top elevation of part of the apparatus shown in Figure 7.

Figure 9 is a top elevation showing the relative position of the contour cutter being sharpened,

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the templet or former, the former pin and the grinding wheel.

Figure 10 is a fragmentary end view of the machine shown in Figure 4.

Figure 11 is a schematic view showing the relation between the work-positioning cam and the follow finger during in and out movement of the grinding head.

In order clearly to disclose the principles of the present invention, a specific embodiment in its preferred form will hereinafter be described in detail. It should be understood, however, that this is done purely by way of example and is not to be construed as in any manner restricting the scope or spirit of the invention as described or claimed in the appended claims.

Referring now particularly to Figure 1, the grinding machine of the present invention comprises a machine bed or frame 10 which supports two platforms, viz.; a lower platform 11, and a superimposed upper platform 12. The lower platform 11 is slideably mounted on the bed 10, for example by means of ball bearings (not shown) in hardened and ground ways (not shown) in the upper surface of the machine bed 10 and the lower surface of the lower platform 11, whereby the lower platform 11 may be freely moved in a horizontal plane either to the left or to the right of the position shown in Figure 1. The upper platform 12 is likewise slideably mounted, being supported on ball bearings 13 in hardened and ground ways 14 in the upper surface of the lower platform and the lower surface of the upper platform, whereby the upper platform 12 may be freely moved in a horizontal plane forwardly and backwardly across the lower platform 11. An adjustable stop 15 limits the extent of transverse motion of the upper platform 12 over the lower platform 11. Lateral motion of the lower platform 11 is likewise limited by the adjustable stops 16 and 17 mounted on the ends of the machine bed 10. Because of the manner in which the two platforms 11 and 12 are mounted the upper platform 12 provides freely a floating table, equivalent to a planograph linkage, which may indeed be used in its place, if desired.

The upper platform 12 supports a turntable 18 rotatably mounted thereupon, adapted to rotate about an axis which is coaxial with a former pin 19 removably affixed in the upper surface of the turntable 18 by means of the former pin chuck or holder 20. Rigidly mounted on the periphery of the turntable 18 is a base bracket 21 upon which a wheel mount support 22 is adjustably mounted, adjustment being provided by a transverse mechanism (not shown), actuated by the hand wheel 23, which permits the wheel mount support 22 to be moved radially with reference to the axis of rotation of the turntable 18. The wheel mount support 22 is provided with any suitable elevating adjustment 24. The wheel bearing 25 affixed to the support 22 is provided with a grinding wheel 26, rotatably mounted in a sealed-in type ball bearing 27 rotating around the wheel spindle 28 in the bearing 25. The grinding wheel 26 is adapted to be driven by any suitable power unit 29 which is illustratively shown as an electric motor.

The machine bed or frame 10 is also provided at its lateral extremities with upright brackets 30 and 31 which support a rear shelf or platform 32. Adjustably mounted on the shelf 32 is a work head 33, adjustment thereof being afforded by the traversing mechanism 34 and the cross-feed

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adjustment 35. A work-holding arbor 36, rotatably mounted in the work head 33 by means of a tapered shank (not shown) engaging a complementary socket within said work head, is adapted to carry a work piece 37 illustratively shown as a spiral tooth contour cutter. The work piece is held in position on the arbor 36 by means of the arbor locknut 38. A shaft 39 having a tapered shank (not shown) adapted also to be mounted in a complementary socket in the work head 33, said socket being operatively connected to the socket engaging the shank of the arbor 36 and being so disposed that said shaft 39 extends from said work head in a direction generally opposite to that of the arbor 36, provides a spindle adapted to hold work-positioning mechanism (Figure 4), as hereinafter more particularly described. The work head 33 is provided with a locking device 40 for locking the arbor 36 and its extension 39 rigidly in position when desired.

Affixed to the lower surface of the shelf 32 is a forwardly extending templet or former support 41, to which a templet or former 42, corresponding to the contour of the cutter 37, is removably attached by means of the knurled knob 43. The shelf 32 of the machine is also provided with a wheel truing and dressing apparatus which consists of an upright bracket 44 rigidly mounted thereon. A diamond holder 45, slideably mounted on the upright bracket 44, carries a diamond point 46 for dressing the grinding wheel, as hereinafter more particularly described. Locking means 47 and 73 on the diamond holder 45 are provided to fix the diamond holder 45 in any desired position. The lower extremity of the bracket 44 is provided with a forwardly extending V-block 48, in the same horizontal plane with the former or templet 42, the V-block being adapted to engage the former pin 19 on the turntable 18, when the latter is moved laterally to the right and brought into proper position immediately in front of the V-block 48.

One of the features of the sharpening machine of the present invention resides in the manner in which the grinding wheel and the former pin are aligned. As shown in Figures 1 and 2, the point on the periphery of the grinding wheel which contacts the work piece (hereinafter referred to as the "grinding arc" or the "grinding point") is perpendicularly above, and in alignment with, the former-contacting periphery of the former pin 19. In other words, the grinding point of the grinding wheel 26 is offset from the axis of rotation of the turntable 18 by a distance equal to the radius of the former pin, so that the grinding point is vertically above, and directly in line with, that point on the former 42 which is contacted by the former pin 19 when the former pin 19 is brought into engagement with the former 42. By virtue of this alignment of the grinding point with reference to the former-contacting face of the former pin, the grinding point of the grinding wheel 26 will describe exactly the same path as the former pin when the latter is brought into engagement with the former 42 and moved thereacross.

Referring now to Figure 3, the thickness "T" of the grinding wheel 26 adjacent the periphery thereof is preferably equal to the diameter of the former pin 19. Moreover, the cross section of the grinding wheel 26 is desirably semi-circular in the grinding plane. Thus the grinding wheel is a standard "T-faced" type, whose thickness adjacent the periphery is equal to twice the radius of the former pin selected for a particular grind-

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ing operation. It is, of course, apparent that an offset wheel having a larger thickness adjacent the axis of rotation, may be employed where preferred, as for example, when a former pin of very small diameter is used.

Another feature of the sharpening machine of the present invention relates to a work-positioning mechanism adapted for use in sharpening spiral flute contour cutters. This feature is best illustrated in Figure 4. As shown therein, a spiral tooth contour cutter 37 constituting the work piece, is mounted on the arbor 36, being held in position by means of the arbor locknut 38. The other end of the arbor 39 is provided with a rigidly mounted master cam 65 having an outwardly extending cam section 81, formed generally as a blade or vane. The cam section 81 corresponds to the shape and degree of spiral of a tooth of the spiral flute contour cutter 37 (Figures 4 and 9). As shown, the cutter 37 has no rake; that is, the elements of the advancing face of each tooth lie in planes passing through the axis of rotation of the cutter supporting shaft 36, which is also the axis of the shaft 39. Similarly, elements of the under face 82 of the cam 65 also lie in planes passing through the axis of rotation of the shaft 36, 39. The parts are so arranged that, with the axis of the grinding wheel 26 disposed above or below the level of the axis of shaft 36, 39, the amount necessary to secure the desired clearance, the forwardly-extending cam surface 82 rests lightly upon a rearwardly-extending cam follow finger 60. As best shown in Figures 10 and 11, the weight of the vane or blade 81 is utilized to hold the cam 65 in position, with the under surface 82 resting on the follow finger 60. The cam follow finger 60 is held in position by means of a vertical bracket 63 and a horizontal bracket 64, the latter being rigidly affixed to the upper platform 12. The cam follow finger 60 is provided with a suitable cross-feed adjustment 62 to permit the proper positioning of the cam follow finger for any particular spiral flute contour cutter. The rearwardly-extending cam follow finger 60 may be pivotally mounted about the axis 61 to permit elevational adjustment of the follow finger.

When the arbor locknut 49 is released, thereby permitting the arbor 36 and its extension 39 freely to rotate in the work head 33, any rectilinear motion of the upper platform 12 either laterally or in a fore and aft direction, is transmitted to the cam follow finger 60 through the brackets 63 and 64. Thus, for example, when the upper platform 12 is moved to the right, the follow finger 60 likewise moves a corresponding distance in the same direction, and in so doing presses upwardly against the cam surface 81, thereby rotating the spindle 39 and the arbor 36 through a predetermined arc, depending on the pitch of the cam. Further, in following the contour (see Figure 9) of the tool 37 or, more accurately, following the contour of the former or profile plate 41 (Figure 1), the follow finger 60 moves in and out, that is, radially, with respect to the axis of the shaft 39, but since the planes of the elements of the surface 81 pass through the axis 36, 39, the cam finger 60 holds the cutter 37 against movement, notwithstanding the in and out movement of the grinding head in following the contour. Holding the cutter 37 against rotation during this movement of the grinding head is necessary so as to secure constant clearance in all portions of the cutter. Where the

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rotation of the grinding wheel is downward relative to the cutter tooth, the weight of the vane or blade 81 is sufficient to maintain the cutter in a proper position during grinding. Accordingly, as the grinding wheel 26 moves across a given tooth in the spiral flute contour cutter 37, the cam follow finger and associated parts causes the cam 65 to rotate the work piece through a predetermined arc. If the slope of the cam 65 is identical with the slope of the teeth on the contour cutter 37 both in a radial direction and in an axial direction, precisely the same clearance will be obtained at all points along the teeth of the contour cutter, as the grinding wheel 15 is moved thereacross, provided the plane of the grinding wheel is maintained at a constant angle with reference to a tangent at all points along the contour. Inasmuch as the grinding wheel mount is at all times freely rotatable about the axis of the former pin 19, resetting of the grinding wheel is not required. In other words, using the work-positioning mechanism as shown in Figure 4, spiral flute contour cutters may be speedily and precisely sharpened, with the same clearance at all points of contour being obtained in each horizontal pass or movement of the grinding wheel across a given spiral flute.

In sharpening spiral flute contour cutters with the apparatus as described immediately above, the work piece 37 is first placed temporarily in position on the arbor 36. Thereafter the master cam 65 is rigidly mounted on the spindle 39. After the wheel mount has been moved out of the way (for example, to the extreme right), the work piece 37 is set directly in line above the former 42 by adjustment of the hand wheels 34A and 35A. The wheel mount is then moved back into position so that the grinding wheel 26 is close to the edge of the cutter, whereupon stop screw 15 is adjusted to limit the forward motion of the upper platform 12. The horizontal cam finger bracket 64 is then locked in position on the upper platform 12 by means of the lock screw 65 and the upright cam bracket 63 is fixed in position. With the cam 65 resting lightly on the cam follow finger 60, the elevation of the latter is adjusted to the level of the axis of the arbor and spindle, after which the distance of the cam follow finger from the center of the spindle 39 is adjusted by means of the cross-feed screw 62, the distance being, of course, dependent upon the contour of the particular cutter being sharpened.

After the foregoing adjustments have been made, the arbor 36 is locked in position by means of the arbor lock screw 49 and the centering contour gage finger 50 is moved into the position shown in Figure 4, resting against the edge of one of the flutes. Thereafter the cutter is locked in position on the arbor by means of the work piece locknut 38 and the spindle locknut 40 is loosened to permit the spindle 39 and the arbor 36 to be freely rotatable in the work head 33. The former pin 19 on the turntable 18 is then moved into position against the former 42, and the contour cutter is brought into adjustment with reference to the plane of the grinding wheel 26, by means of the cross-feed adjustment 35A and traversing adjustment 34A. When these adjustments have been made, the former pin 19 is pressed against the former 42 and the wheel mount is rotated on the turntable 18 around the former pin 19 until it is brought into proper

position for the point on the particular tooth being sharpened.

In grinding spiral flute contour cutters it is necessary to select a proper size former pin 19 for the smallest radius on the contour being sharpened. Thus, if the smallest radius on the cutter to be sharpened is  $\frac{1}{2}$  of an inch, a former pin having a diameter of  $\frac{1}{8}$  of an inch is employed for grinding the tooth at the locus of the smallest radius. In other words, the radius of the former pin selected should be equal to the smallest radius on the work piece.

In sharpening stagger-tooth contour milling cutters, a wheel follow finger may desirably be employed in lieu of the cam work-positioning device shown in Figure 4. The wheel follow finger, best illustrated in Figures 5 and 6, is held in position by means of the follow finger support 76 rigidly mounted on the grinding wheel bearing 25. The position of the wheel follow finger 75 with reference to the axis of rotation of the grinding wheel is determined by the nature of the stagger-tooth cutter being sharpened in respect to its clearance. As illustrated in Figure 5, one tooth 37 of the stagger-tooth cutter is shown resting on the wheel follow finger 75. Using the wheel follow finger to position the stagger-tooth cutter, the former pin 19 is moved along the contour of the former 42. As the grinding wheel traverses the cutter, the wheel follow finger 75 moving across and in contact with the lower portion of the stagger tooth, rotates the stagger-tooth cutter 37 and the arbor 36, thereby properly positioning the cutter to obtain the correct clearance at all points on the stagger tooth being sharpened. As the grinding wheel moves across the stagger tooth, the turntable 18 is rotated about the axis in order to maintain the proper angle of approach at all points along the contour of the cutter. Thus, the freely rotatable turntable 18 enables the operator constantly to readjust the plane of the grinding wheel so that said plane is at all times substantially perpendicular to a tangent drawn at the point of contact between the tooth and the grinding point of the wheel 26.

Another feature of the present invention relates to the wheel truing and dressing apparatus illustratively shown in Figures 7 and 8. After the selection of the proper sized former pin 19 for the particular cutter to be sharpened, a gage rod 71 of the same diameter at the point where it contacts the V-block 48 and the diamond point 46, is affixed to the gage block 70 with the lower extremity of the gage rod 71 pressed firmly into the position in the V-block 48 (as shown in Figure 8). Thereafter the diamond holder 45 is adjusted vertically on the upright bracket 44 and locked in position by means of the diamond holder set screw 73, the height of the diamond point 46 above the V-block 48 depending upon the type of cutter being sharpened. Thus, if the cutter tooth is radial, the height of the diamond is the same as the center line of the work piece when mounted on the arbor 36 (Figure 1). If, however, the tooth is a shovel type, the diamond point 46 (Figure 7) is set according to the amount of the tooth angle, as is well known in the prior art.

After the diamond point has been placed in the proper position, the set gage block 70 and the thereunto affixed set rod 71 have been removed from the wheel truing platform adjacent the V-block 48, the wheel mount (Figure 1) is then moved into position in front of the V-block (48)

and the former pin 19 is brought into engagement with the V-lock, in the position shown in Figure 8. This positions the grinding wheel directly in line with the diamond point 46 which has been set for the correct radius of the wheel. In order to obtain the proper clearance on the cutter to be ground, the lock screws 24 on the wheel support 22 are loosened and the wheel head 25 is moved upwardly or downwardly into proper position depending upon the chart furnished with the grinding wheel showing the diameter thereof and the offset required for various degrees of clearance. After the elevation of the grinding wheel spindle 28 has been selected and the wheel mount 25 fixed in position by means of the locknuts 24, the turntable 18 is then rotated around the former pin pressed in the V-block 48, the upper bracket 22 being moved radially by means of the cross-feed adjustment 23 to bring the grinding point of the wheel 26 into contact with the diamond point 46. By rotating the turntable 18 and advancing the wheel mount 22 toward the diamond point 46, the grinding wheel dressing operation is accurately and precisely effected.

It will thus be seen that I have provided a universal contour cutter grinding machine which enables the operator to obtain precisely uniform tooth clearance in grinding any type of contour cutter, whether straight, stagger or spiral flute, without repeatedly resetting the grinding wheel mount. Inasmuch as many variations in detail may be made in the hereinbefore described preferred embodiment of the present invention, I intend to be restricted only in accordance with the following patent claims.

I claim:

1. In a machine of the character described, a supporting frame; a lower traversing platform supported on said frame, movable in one direction in a horizontal plane; an upper traversing platform supported on said lower platform, movable thereover in a horizontal plane in a direction perpendicular to the direction of movement of said lower platform; a turntable rotatably mounted on said upper platform for rotation about a vertical axis; a former mounted at least indirectly on said frame; a cylindrical former pin adapted to contact said former, affixed perpendicularly to said turntable, coaxial with the axis of rotation thereof; wheel supporting means affixed to said turntable; a grinding wheel adapted to contact a work piece, mounted for rotation about a horizontal axis on said wheel support; a work holder affixed to said frame; a work-holding arbor rotatably mounted in said work holder for rotation about a horizontal axis parallel to, but in spaced relation from, the axis of rotation of said grinding wheel; master cam means affixed to said arbor for eccentrically rotating the same and having a generally radially extending vane; and cam actuating means engaging said vane, for transmitting the motion of said upper platform in a lateral direction to said cam, to rotate said arbor in a predetermined, coordinated relation to the composite movement of said upper platform a movement of the upper platform in a direction perpendicular to said lateral direction, causing said cam actuating means to move transversely of said vane without rotating said arbor.

2. A device of the type described adapted to grind a spiral tooth contour cutter or the like comprising a support a pivotally mounted grinding wheel, a base for said grinding wheel, means mounting the base on the support for movement in substantially any direction in a predetermined

plane, a former, a former pin operatively connected to said grinding wheel and being coaxial with the pivot of said grinding wheel, shaft means for rotatably mounting said cutter on the support in operative relation to said grinding wheel, an extension of said shaft coaxial therewith and operatively connected thereto, a vane having a broad elongated surface extending spirally relative to said shaft extension at an incline similar to that of the face of a tooth of said cutter and being at least indirectly connected to said shaft extension, said broad surface lying generally flat, transversely, and being of a width greater than that of said face of said tooth and all points of the said broad surface being disposed in extensions of radii of the axis of said shaft extension, a member adapted to engage said broad surface of the vane to adjust the position of rotation of said shaft and cutter, means for operatively connecting said latter member to said grinding wheel whereby both longitudinal and transverse movement of said grinding wheel in defining the length and contour of said cutter is transmitted to said member causing corresponding motion of said member on said inclined broad surface to at times rotate said shaft and cutter, and grinding wheel dressing mechanism comprising a generally V-shaped locator adapted to engage said former pin during the dressing operation, a normally fixed but adjustable diamond point for dressing the grinding wheel, a removable support member, and shaft structure on said support member having portions of equal diameter coaxially arranged and adapted one to engage said locator and the other to be contacted by said diamond point in the setting of the latter, the arrangement being such that after said diamond point has been set, the latter said shaft structure and its support removed, and the former pin placed in engagement with said V-shaped locator, the grinding wheel will be dressed upon being rotated through an arc on its pivot.

3. In a device of the type described adapted to grind a spiral tooth contour cutter or the like, a rotatable shaft for mounting said cutter, cam structure operatively connected to said shaft and coaxial therewith comprising a vane having a broad elongated surface extending spirally relative to the axis of rotation of said cam at an incline similar to that of the face of a tooth of said cutter, said broad surface lying generally flat, transversely, and being of a width greater than that of said face of said tooth and all points of said broad surface being disposed in extensions of radii of the axis of said cam, a grinding wheel operatively positioned relative to said tooth for movement longitudinally and transversely of said cutter in defining the latter's length and contour, and means operatively connected to said grinding wheel for engaging said broad surface of said vane to regulate the position of rotation of said shaft as said means moves over said inclined broad surface in correspondence with motion of said grinding wheel along said cutter, the arrangement being such that for any given time the interface of said means and said broad surface, the point on the face of said tooth on which the grinding wheel is acting, and the axis of rotation of said shaft are in substantially the same plane, which plane is substantially parallel to the plane of motion of said grinding wheel base.

4. In a device of the type described adapted to grind a spiral tooth contour cutter or the like,

a rotatable shaft for mounting said cutter, cam structure operatively connected to said shaft and coaxial therewith comprising a vane having a broad elongated surface extending spirally relative to the axis of rotation of said cam at an incline similar to that of the face of a tooth of said cutter, said broad surface being of a width greater than that of said face of said tooth, a grinding wheel operatively positioned relative to said tooth for movement longitudinally and transversely of said cutter in defining the latter's length and contour, and means operatively connected to said grinding wheel for engaging said broad surface of said vane to regulate the position of rotation of said shaft as said means moves over said inclined broad surface in correspondence with motion of said grinding wheel along said cutter, the arrangement being such that for any given time the interface of said means and said broad surface, the point on the face of said tooth on which the grinding wheel is acting, and the axis of rotation of said shaft are in substantially the same plane, which plane is substantially parallel to the plane of motion of said grinding wheel base.

5. In a grinding machine having a work spindle, the combination of means for generating a helical grinding path about the axis of said spindle including a grinding wheel, superimposed rectilinearly guided supports for said grinding wheel, the first of said supports being guided for movement normal to the spindle axis and the other for longitudinal movement parallel to said axis, means to mount the grinding wheel on said supports for rotation on its axis and for bodily swinging movement relative to said supports, a fixed control cam, and a follower carried by one of said supports for limiting approach of the grinding wheel to the work spindle to control the radius of said path, a second cam in the form of a wide vane having a right helicoidal face operatively connected to the work spindle, a follower for said second cam, means operatively connecting said last-named follower to the grinding wheel supporting means for response to their rectilinear movements but not to said bodily swinging movement, said second control cam being so positioned on the spindle that it is not responsive to its follower movement imparted solely by the first of said supports but is responsive to all other directions of its follower movement to impart rotation to the work spindle.

6. In a cutter grinding machine of the class described, having a work supporting spindle laterally movable for feeding purposes to determine the amount of stock removal, the combination of a grinding wheel, a pair of superimposed rectilinearly guided supports for the grinding wheel, one of said supports being guided for movement normal to the axis of said spindle and the other guided for longitudinal movement parallel to the axis of the spindle, means for controlling generation of a helical grinding path about the axis of said spindle including a fixed cam, and a follower therefor mounted on said supports, a helicoidal control cam in the form of a wide vane having a right helicoidal face operatively connected to said spindle for controlling rotation thereof during longitudinal movement of the grinding wheel, a follower for determining rotation of said helicoidal cam, means operatively connecting said followers for joint movement, said helicoidal control cam being so positioned relative to the spindle as to be non-responsive to the movement of its follower nor-

mal to the spindle axis whereby the work spindle and cam may be moved laterally for determining or varying the movement of stock removal without causing rotation thereof.

7. In a cutter grinding machine of the class described, having a bed supporting a work spindle for movement laterally of its axis, the combination of means for generating a helically contoured grinding path about said spindle including a grinding wheel, a pair of superimposed slides guided for rectilinear movement normal to one another for supporting the grinding wheel, one of said directions of movement being parallel to the axis of said work spindle, a profile control cam attached to said bed, a follower attached to one of said slides for limiting rectilinear movement of the grinding wheel toward and from the spindle, a helicoidally surfaced control cam operatively connected to the spindle having a follower engaging helicoidal vane surface produced by a radial generatrix element and disposed with its follower engaging a radial element lying in the plane of spindle movement, a second follower engageable with said radial element, and means operatively connecting said second follower for joint movement with the first-named follower whereby the profile control cam determines the direction of movement of the second follower in a plane, said second follower acting to prevent rotation of the work spindle during rectilinear movement of the first follower normal to the axis of the work spindle and to cause rotation of the work spindle during any other direction of follower movement in its operating plane.

8. In a cutter grinding machine having a work spindle whose axis is laterally movable in a feeding plane, the combination of a grinding wheel supported for universal movement in a plane parallel to said feeding plane for generating a helically contoured grinding path about the axis of said spindle and for rectilinear movement normal to the axis of said spindle, means for variably limiting said rectilinear movement for determining the contour of said path, a helical control cam in the form of a wide vane having a right helicoidal surface operatively connected to said spindle having radial elements produced by its generatrix and positioned on said spindle with its follower contacting radial element lying in the feeding plane of said spindle, a follower jointly movable with said grinding wheel and adjusted relative thereto for engagement with said

active radial element for holding the cam against rotation during said rectilinear movement of the grinding wheel and for imparting rotation to the cam during other than radial movement of the grinding wheel to generate said helical path.

9. In a machine of the character described, a supporting frame, a cutter spindle journaled on said frame for lateral feeding movement in a predetermined axial plane, gage means mounted on said supporting frame having a gaging surface fixedly positioned in said plane for positioning a radial element of the cutting edge of a cutter mounted on said spindle in said plane, a grinding wheel supported on said frame for longitudinal and transverse movement and thus positionable in line with said element, a follower carried by the grinding wheel supporting means in spaced relation to the grinding wheel in a direction parallel to the axis of the spindle, a right helicoidal cam mounted on the spindle in concentric relation therewith having a vane with a surface developed by a radial generatrix producing radial elements and rotatably adjustable with respect to a cutter mounted on the spindle, means to adjust the follower into contact with the cam and rotatably adjust the cam with respect to the work to position a radial element of the cam in said feeding plane parallel to a radial element of said cutter and thus maintain the radial element of the cutter in said feeding plane upon removal of said gaging means whereby subsequent movement of the grinding wheel parallel to the axis of the spindle will generate a spiral grinding path about the axis of the spindle and transverse movement of the grinding wheel will vary the radius of said path.

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