

March 5, 1963

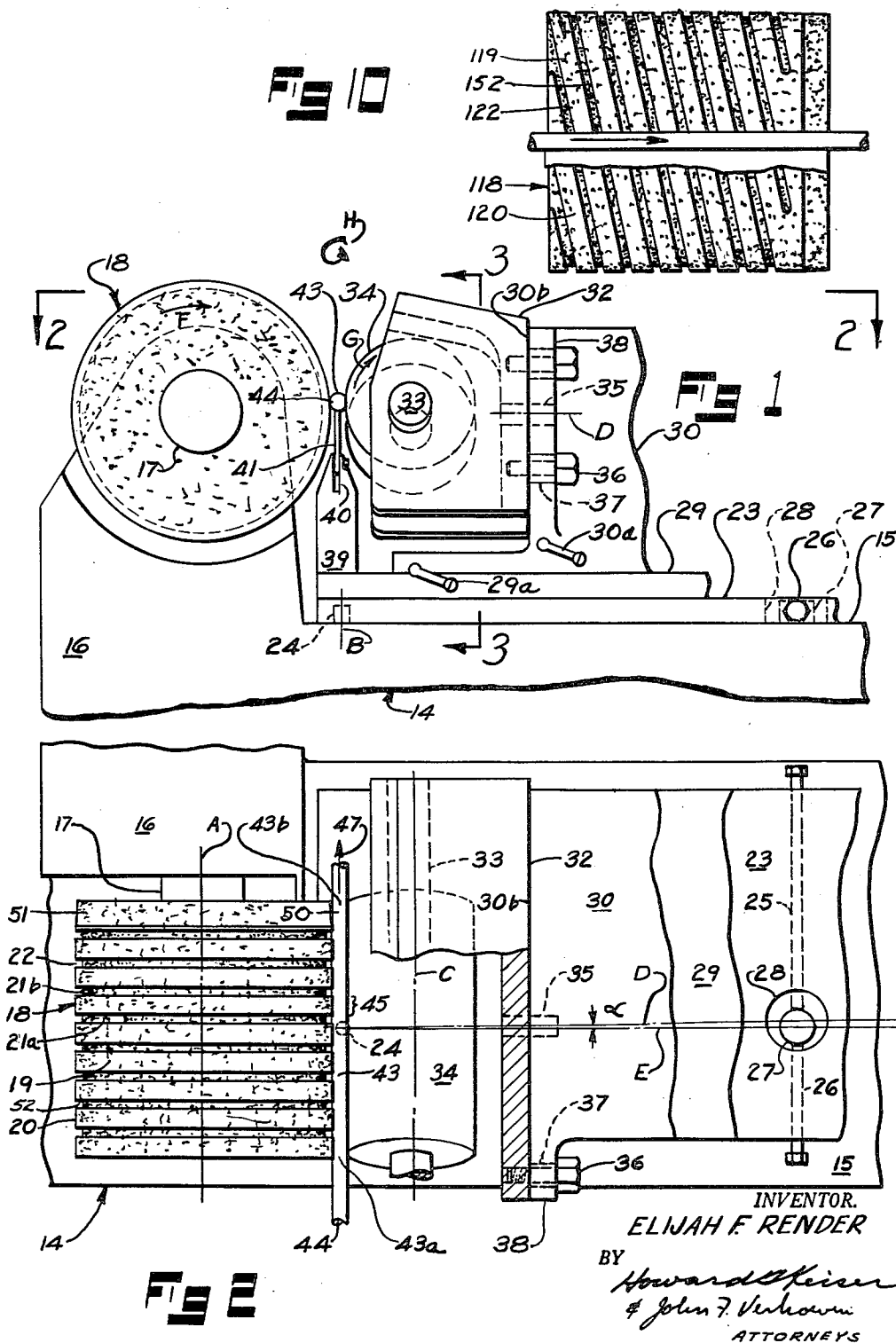
E. F. RENDER

3,079,741

METHOD FOR GRINDING

Original Filed March 27, 1961

3 Sheets-Sheet 1



INVENTOR.
 ELIJAH F. RENDER
 BY
Howard K. Keiser
John F. Verhagen
 ATTORNEYS

March 5, 1963

E. F. RENDER

3,079,741

METHOD FOR GRINDING

Original Filed March 27, 1961

3 Sheets-Sheet 2

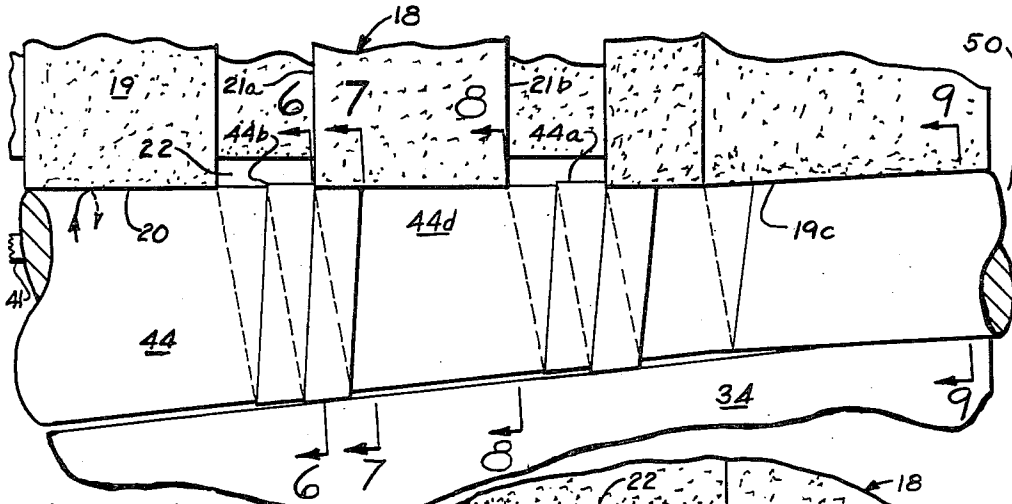


Fig. 4

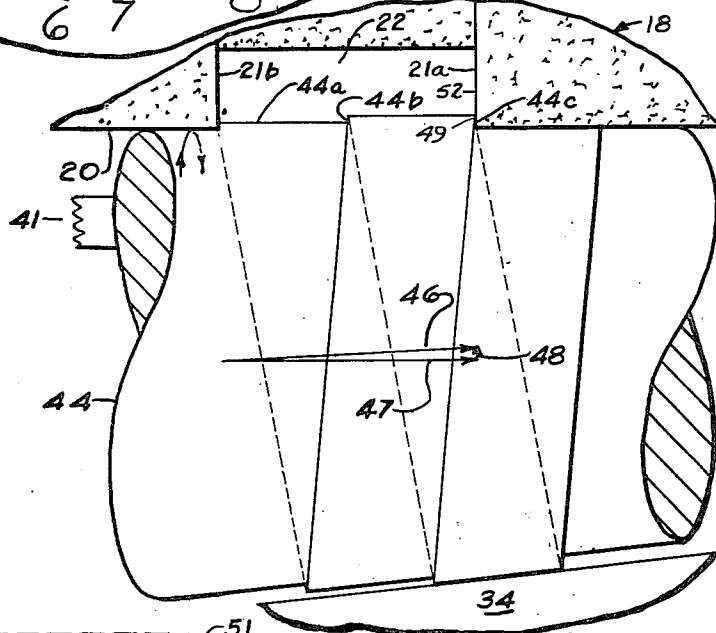
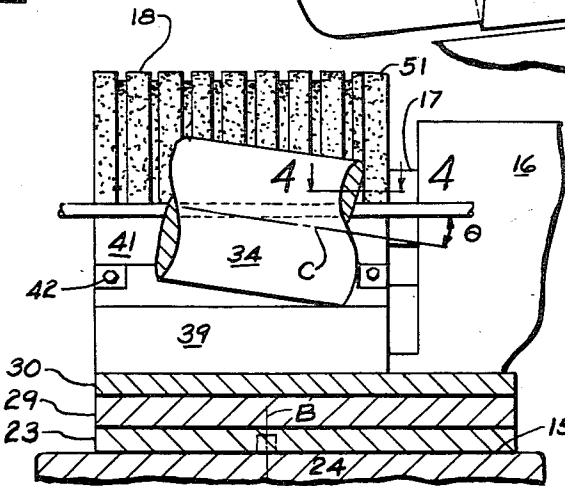


Fig. 5

Fig. 6



INVENTOR.
ELIJAH F. RENDER
BY
Howard Keiser
John F. Verhove
ATTORNEYS

March 5, 1963

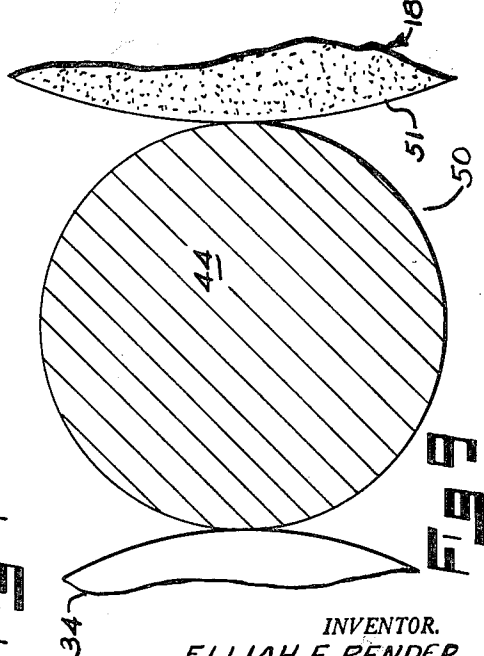
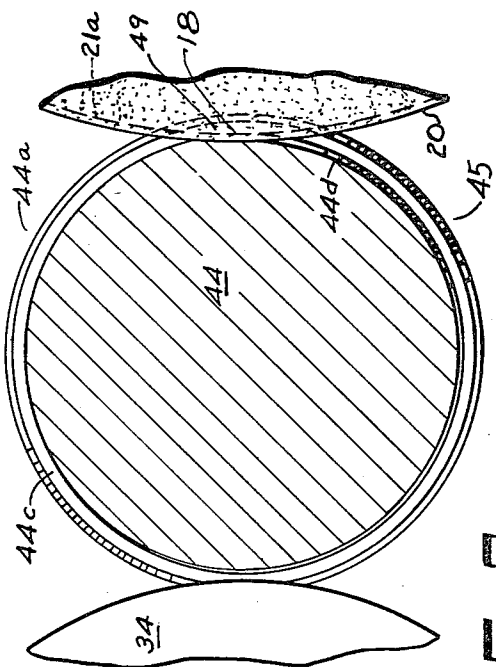
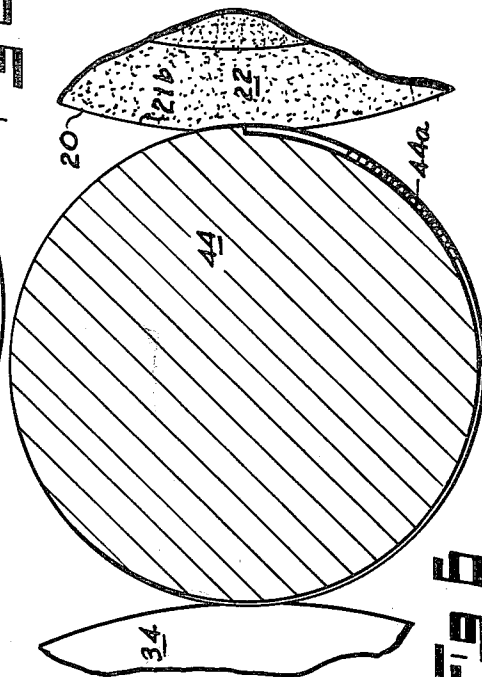
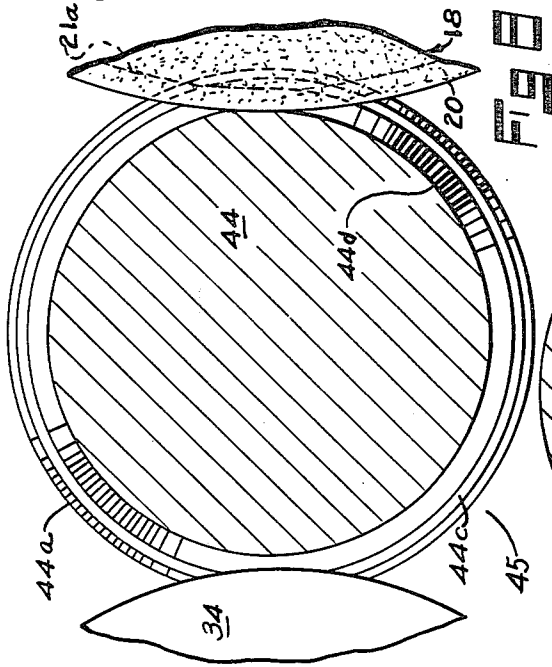
E. F. RENDER

3,079,741

METHOD FOR GRINDING

Original Filed March 27, 1961

3 Sheets-Sheet 3



INVENTOR.
ELIJAH F. RENDER
BY *Howard H. Kiser*
John F. Verhaar
ATTORNEYS

1

3,079,741

METHOD FOR GRINDING

Elijah F. Render, Madeira, Ohio, assignor to The Cincinnati Milling Machine Co., Cincinnati, Ohio, a corporation of Ohio

Original application Mar. 27, 1961, Ser. No. 98,521. Divided and this application Apr. 18, 1962, Ser. No. 188,367

3 Claims. (Cl. 51—289)

The present invention relates to a method of grinding, particularly effective for removing a large amount of stock from a workpiece in a through-feed centerless grinding operation.

This application is a division of application Serial No. 98,521 filed March 27, 1961.

In a conventional through-feed centerless grinding operation a cylindrical workpiece is passed through a grinding throat defined by the grinding wheel and the regulating wheel of the machine. The workpiece, which is supported on a blade in the grinding throat, is held in abrading contact with the rapidly rotating grinding wheel by a more slowly rotating regulating wheel which determines and controls the rate of rotation of the workpiece. The regulating wheel is tilted relative to the upper surface of the blade so that the force imparted to the workpiece by the regulating wheel has a component which moves the workpiece axially along the blade to effect the through-feed thereof. In the usual centerless operation, the wheels are positioned and trued so that the lines of contact between the workpiece and the respective wheels are parallel.

If the speed and tilt of the regulating wheel produces, for example, four rotations of the workpiece as any given cross-section thereof is moved transversely across the grinding wheel, the leading quarter of the grinding wheel will effect the major portion of the cut, assuming the grinding wheel is perfectly true. This is because the workpiece, which is originally larger than the throat, completes one rotation as it traverses the first quarter of the grinding wheel so that each point on the circumference of a given cross-section of the workpiece is ground by the first quarter of the grinding wheel. If the lines of contact made by the two wheels on the workpiece are parallel, subsequent sections of the grinding wheel, while rounding up and finishing the piece, do not remove an appreciable amount of stock therefrom.

With the present invention, the substantial cut taken by the leading portion of the wheel is multiplied many times as a workpiece makes a single pass through the grinding throat. This is accomplished by providing spaced grinding faces which may be formed on a single wheel. There is also provided, in the present invention, a converging grinding throat defined by the spaced grinding faces and the opposite surface or face of the regulating wheel, which face is inclined relative to the grinding faces. The regulating wheel is tilted to provide a transverse, or through, feed movement to the workpiece as in conventional centerless grinding, but in addition, the inclination of the face of the regulating wheel relative to the grinding wheel adds an in-feed movement to the workpiece as it advances through the throat. Thus, as any given cross-section of an advancing workpiece moves transversely from the trailing edge of one grinding face to the leading edge of the following grinding face, it is fed in by the regulating wheel so that a new cut is taken on the piece by each face of the grinding wheel. In this manner, a series of cuts are taken on a workpiece as it makes a single pass through the grinding throat. Moreover, the workpiece is fed into each grinding wheel face as the piece advances through the throat, so that

2

the entire width of each face of the grinding wheel will contribute to the cut taken thereby.

Thus, instead of the single cut taken in conventional centerless grinding operations, in the present invention a series of successive cuts is taken because of the interrupted grinding contact made with the piece and because of the converging throat which progressively feeds the piece into successive grinding faces as the piece advances. With a series of cuts instead of a single cut, more stock can be removed from a workpiece in a single pass and it is therefore one object of the present invention to provide an improved method for centerless grinding operations to effect substantial stock removal from a workpiece. It is another object of the present invention to provide an improved method for grinding stock from a workpiece in a plurality of cuts during a single pass.

Since a given amount of stock can be removed more effectively with less generation of heat by a series of successive cuts than by a single concentrated cut, the present invention can be effectively applied for any desired amount of stock removal. It is therefore another object of the present invention to provide a method for grinding any given amount of stock from a workpiece in a single pass by distributing the stock removal over a series of cuts taken during the pass.

Other objects and advantages of the present invention should be readily apparent by reference to the following specification, considered in conjunction with the accompanying drawings forming a part thereof, and it is to be understood that modifications may be made in the exact details there shown and described, within the scope of the appended claims, without departing from or exceeding the spirit of the invention.

In the drawings:

FIG. 1 is a view in elevation of a centerless grinding machine operable in accordance with the present invention;

FIG. 2 is a plan view taken on the line 2—2 of FIG. 1;

FIG. 3 is a view in elevation taken on the line 3—3 of FIG. 1;

FIG. 4 is an enlarged view taken on the line 4—4 of FIG. 3 (showing an exaggerated angle of inclination of the face of the regulating wheel to the faces of the grinding wheel for clarity);

FIG. 5 is an enlarged view, taken as the view of FIG. 4, showing the workpiece as it traverses the grinding wheel between grinding throat sections;

FIGS. 6, 7, 8, and 9 are views taken on the lines 6—6, 7—7, 8—8, and 9—9 respectively of FIG. 4; and

FIG. 10 is a view of a modified form of grinding wheel.

The centerless grinding machine shown in FIG. 1 has a base 14 with a flat horizontal bed 15 and an upstanding portion 16 in which a grinding wheel spindle 17 is journaled. The spindle 17, which is driven by a motor (not shown), has a grinding wheel 18 mounted thereon for rotation in a direction indicated by arrow F. The grinding wheel 18 has a plurality of sections 19 each with a peripheral grinding face 20. The grinding faces 20, which are of equal diameter, are aligned so that they lie in spaced apart relation in the surface of an imaginary cylinder concentric with the central axis A of rotation of the grinding wheel 18 and spindle 17. Each section has a leading edge 21a (that is the edge first contacted by an advancing workpiece) and a trailing edge 21b (the edge last contacting an advancing workpiece), each of said edges defining a circle lying in a plane normal to the axis A. The grinding wheel may be formed by cutting spaced annular grooves 22 in a single cylindrical grinding wheel.

Mounted on the flat horizontal bed 15 is a swivel plate 23 which pivotally receives vertical pin 24 mounted in and extending from the bed 15. Swivel adjustment screws 25 and 26 are threadably received in swivel plate 23 to

3

engage stud 27 mounted in bed 15 and extending therefrom into hole 28 in the swivel plate. By adjustment of screws 25 and 26, swivel plate 23 can be swiveled on bed 15 about the vertical axis B defined by pin 24 to a desired angular position and locked in that position.

A lower slide 29 is movable on swivel plate 23 towards and away from the grinding wheel 18 by means (not shown) and is locked thereon in an adjusted position by clamping member 29a. Similarly, upper slide 30 is movable on lower slide 29 towards and away from the grinding wheel by means (not shown) and is locked thereon in adjusted position by clamping member 30a. The upper slide carries a regulating wheel housing 32 in which a driven regulating, or control, wheel spindle 33 is journaled. Cylindrical regulating wheel 34 is mounted on spindle 33 concentrically therewith for rotation in a direction indicated by arrow G about central axis C of the spindle 33. The housing 32 pivots on the flat vertical face 30b of the upper slide 30 about a horizontal axis D defined by pivot pin 35, and the housing can be locked in a selected tilted position thereon by bolts 36 threadedly received in the housing 32 and extending through vertically extending slots 37 in flanges 38 of the upper slide. Mounted at the grinding wheel end of the lower slide 29 is a support 39 having a transversely extending upper slot 40 in which a blade 41 is clamped by screws 42. The grinding wheel and the face defined by the peripheral surface of the regulating wheel opposite the grinding wheel define a grinding throat 43. The adjacent blade 41 extends transversely across the wheels therebetween to support a workpiece 44 for rotation in the grinding throat by the regulating wheel (which determines and controls the rotation of the workpiece) in a direction indicated by arrow H and in abrading contact with the grinding wheel. Because the grinding wheel is interrupted, along its width, by the grooves 22 which divide the peripheral face of the grinding wheel into spaced grinding faces 20, the grinding throat 43 is divided into a series of spaced grinding throat sections 45, each grinding throat section defined by a grinding face 20 and the peripheral surface of the regulating wheel opposite said face 20, each grinding throat section extending between leading edge 21a and trailing edge 21b of the grinding face 20.

The axis C of the regulating wheel is at all times at right angles to the axis D of horizontal pivot pin 35 and the swivel plate 23 can be adjusted by screws 25 and 26 to a reference position where axis D is at right angles to axis A of the grinding wheel (and in a vertical plane E passing through the centers of pivot pin 24 and stud 27). When the swivel plate is so positioned, the regulating wheel housing 32 can be tilted about axis D, thereby tilting the axis C of the regulating wheel relative to the top of the blade 41 and the axis A of the grinding wheel. When in this position, the regulating wheel can be trued as in conventional centerless grinding so that a cylinder resting on the blade and contacting the grinding wheel along a line will make contact with the regulating wheel along a line parallel to the line of contact between the grinding wheel and the cylinder. This tilt of the regulating wheel, which is designated as angle θ in FIG. 3, imparts through-feed movement as indicated by arrow 47 to a workpiece on the blade, as in conventional centerless grinding.

In the present invention, however, an infeed component 48 (see FIG. 5) is added to the movement of the workpiece as it traverses the spaced grinding faces 20 so that the workpiece will be continuously and progressively fed into the faces 20. In the mechanism illustrated, this infeed movement is accomplished by adjustment of rods 25 and 26 to swivel the plate 23 about axis B of pin 24 through an angle α from the previously described reference position. This positions axis C of the regulating wheel at an angle α to the axis of the grinding wheel, when viewed in plan (FIG. 2), in addition to the angle θ of tilt relative thereto, as viewed in elevation (FIG. 3). In

4

this manner the surface of the regulating wheel at the grinding throat is inclined at angle α relative to the aligned peripheral faces 20 of the grinding wheel at the throat, and the surface of the regulating wheel near the exit end 43b of the throat will be closer to the grinding wheel than at the entrance end 43a of the throat.

Suppose, for example, that the wheels are 20 inches wide and the regulating wheel is fixed by adjustment of screws 25, 26 at an angle α which equals zero degrees 7 minutes. The throat exit 43b will be approximately .040 inch narrower than the throat entrance 43a. If the lower slide 23 is clamped on the swivel plate at a position relative to the grinding wheel to make the throat entrance the same width as the unground cylindrical piece, .040 inch will be removed from the piece as it traverses the grinding wheel through the throat. If the first, or leading, section of the grinding wheel is 1.5 inches wide, the grind throat section 45 defined by the face 20 of this grinding wheel section 19 will progressively converge in the direction of through-feed travel of the workpiece across the entire grinding wheel section, diminishing approximately .003 inch so that the piece will be continuously ground as it traverses the section. Similarly, all throat sections 45 will be approximately .003 inch narrower at the trailing edge 21b of the face 20 than at the leading edge 21a thereof so that the entire span of all grinding faces 20 continuously remove stock from a traversing workpiece.

Suppose, by way of example, that the regulating wheel is clamped by bolts 36 at a tilt angle θ which will produce 4 revolutions of the workpiece as any given section thereof traverses any grinding face 20 of the grinding wheel. The piece will leave the face 20 with helical beveled surfaces 44a since the piece is continuously fed into face 20 (by virtue of the angle α of the regulating wheel) as the piece rotates in abrading contact with face 20 and advances (by virtue of the tilt θ of the regulating wheel). Even the deepest valley 44b (cut by the trailing edge 21b of the grinding wheel face 20) will, however, be larger than the width of the next throat section 45 at the leading edge 21a of the next grinding wheel face 20. If, for example, the gap 22 defines an interruption in the peripheral face of the grinding wheel 0.75 inch wide, the throat at the leading edge 21a of face 20 will be approximately .0015 inch narrower than the previous throat section 45 at the trailing edge 21b of the face 20 thereof. In other words, any given cross-section of the workpiece, because of the inclination of the face of the regulating wheel relative to the interrupted face of the grinding wheel, moves in a resultant direction 46 comprising the through-feed component 47 parallel to the axis A and grinding faces 20 and the infeed component 48 at right angles to said axis A and grinding faces 20.

Since there is no stock removal from any given section of the workpiece as it traverses the gap 22, a heavier cut will be taken as that section makes its first rotation after contacting the grinding wheel section behind the gap, as shown in FIGS. 6 and 7. This heavier cut at the leading edge 21a of each grinding wheel section produces a shoulder 44c on the workpiece which is continuously ground by the leading side 52 of the grinding wheel section, as at 49 in FIGS. 7 and 5. In addition, since the workpiece is continuously fed into the grinding face 20 as it advances, a beveled surface 44d is cut by face 20 as the workpiece advances across said face. Although after the first quarter of face 20 has been traversed by any given cross section of the piece, the amount of stock removal from that section by that face will be reduced (assuming again that any cross section of the piece makes four revolutions as it traverses the grinding wheel section 19), the remaining three quarters of the grinding wheel section face 20 will continue to remove stock, as shown in FIG. 8, by virtue of the continuous infeeding resulting from the converging throat. With a plurality of grinding faces 20 and grinding throat sections 45 which

5

converge in the direction of movement of the workpiece to provide infeed across the interrupted grinding face, a plurality of shoulders 44c will be ground simultaneously and a plurality of heavy cuts will be taken simultaneously by the leading portions of the grinding wheel sections.

Since, with a throat which converges across the entire width of a grinding face 20, stock will continuously be ground from a piece until it leaves the face 20 (thereby leaving the helical beveled surfaces 44a), it is preferable to provide a grinding throat section, as at 50, of constant width immediately before the grinding throat exit 43b to remove the beveled configuration from the piece, as shown in FIG. 9. This can be done by truing the grinding wheel as at 51.

Another embodiment of the present invention utilizes a different grinding wheel, shown in FIG. 10. In this embodiment the sections 119 of the grinding wheel are helical and may be formed, for example, by cutting one or more helical grooves 122 in a single cylindrical grinding wheel 118. In this modification, also, there are spaced grinding faces 120 which together with a regulating wheel, which may be constructed and positioned as in the embodiment previously described, defines a converging grinding throat. The faces 120 lie in an imaginary cylinder concentric with the axis of the grinding wheel. When the wheel is rotated, these faces sweep along a path at the grinding throat defined by said imaginary cylinder in abrading contact with a workpiece (which is rotated and advanced in the throat along a blade as in the previously described embodiment). If, by way of example, the grinding wheel rotates 10 times for each revolution of the workpiece and the grinding wheel has been formed by cutting five grooves 122 so that five grinding faces 120 will sweep across the piece on each revolution of the grinding wheel, there will be 50 grinding faces 120 sweeping across the piece on each revolution of the piece. Each grinding face 120 will take a separate cut as it sweeps across the workpiece, but since the relative traversing rate between the workpiece and any given grinding face 120 is considerably greater than the relative traversing rate between the workpiece and the corresponding grinding face 20 of the previous embodiment (by virtue of the helical configuration of the sections 119), a greater proportion of the cut will be performed, in this modification, by the leading side 152 of each grinding wheel section 119 and a smaller proportion by the peripheral face 120 thereof. Because the workpiece is continuously fed into the path of the faces 120 by virtue of the inclination of the face of the regulating wheel (at the angle α to the path of the faces 120 of the grinding wheel), each face 120 contributes to the cut taken on the workpiece as the face sweeps thereacross (even if the face 120 sweeps across the workpiece in a groove previously cut by a preceding face 120).

Although, for illustrative purposes, a workpiece longer than the width of the wheels has been shown, pieces shorter than the wheels can also be ground effectively by

6

the method of the present invention. With shorter pieces, several can be passing through the throat, one after the other, at the same time.

I claim:

1. The method of grinding a workpiece in a centerless grinding machine having a workpiece support and a grinding wheel and regulating wheel on opposite sides of the support, the steps of cutting grooves in the grinding wheel to define spaced peripheral grinding faces, tilting the regulating wheel to provide a through-feed component to a workpiece received on the support, inclining the regulating wheel relative to the grinding wheel to provide an in-feed component to a workpiece moving along the support, and depositing a workpiece on the support for rotating movement along the support by the regulating wheel and successive abrading contact with the spaced peripheral grinding faces.

2. The method of grinding a workpiece in a centerless grinding machine having a grinding wheel with an interrupted surface, a regulating wheel opposite the grinding wheel to define a grinding throat therebetween, and a workpiece supporting blade in the throat, the steps comprising tilting the regulating wheel relative to the top of the blade for imparting a through-feed travel to a workpiece received on the blade, inclining the regulating wheel relative to the grinding wheel to define therewith a plurality of spaced throat sections, each throat section converging in the direction of workpiece through-feed and each successive throat section smaller than the preceding throat section relative to the direction of through-feed travel, and placing a workpiece on the blade in the large end of the throat for feed movement along the blade and grinding in each throat section.

3. The method of grinding a workpiece in a centerless grinding machine having a grinding wheel with an interrupted surface, a regulating wheel opposite the grinding wheel to define a grinding throat therebetween, and a workpiece supporting blade in the throat, the steps comprising tilting the regulating wheel relative to the top of the blade for imparting a through-feed component to a workpiece received on the blade, inclining one of said wheels relative to the other to define therebetween a plurality of spaced throat sections, each throat section converging in the direction of workpiece through-feed and each successive throat section smaller than the preceding throat section relative to the direction of through-feed travel, and placing a workpiece on the blade in the large end of the throat for feed movement along the blade and grinding in each throat section.

References Cited in the file of this patent

UNITED STATES PATENTS

2,855,729 Render Oct. 14, 1958

FOREIGN PATENTS

120,800 Great Britain Nov. 28, 1918
801,193 Germany Dec. 28, 1950