Feb. 5, 1963 C. W. FOLLEY 3,076,295

GRINDING WHEEL AND DRESSER

Filed Feb. 23, 1962 2 Sheets-Sheet 1

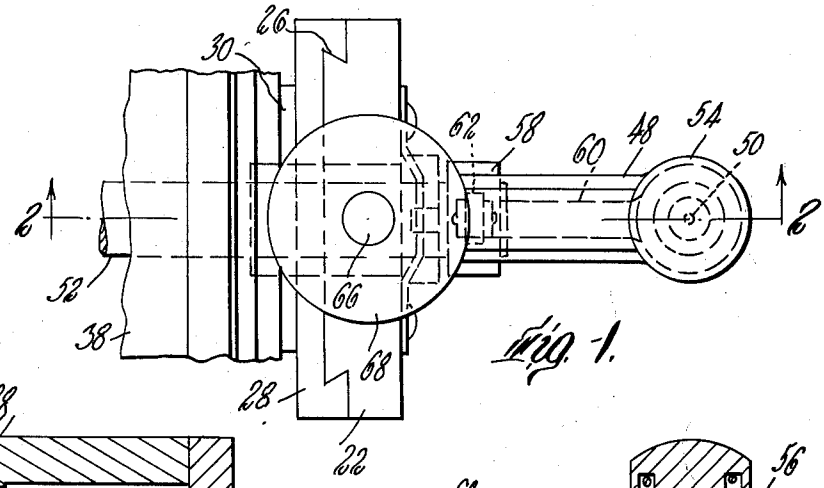


Fig. 1.

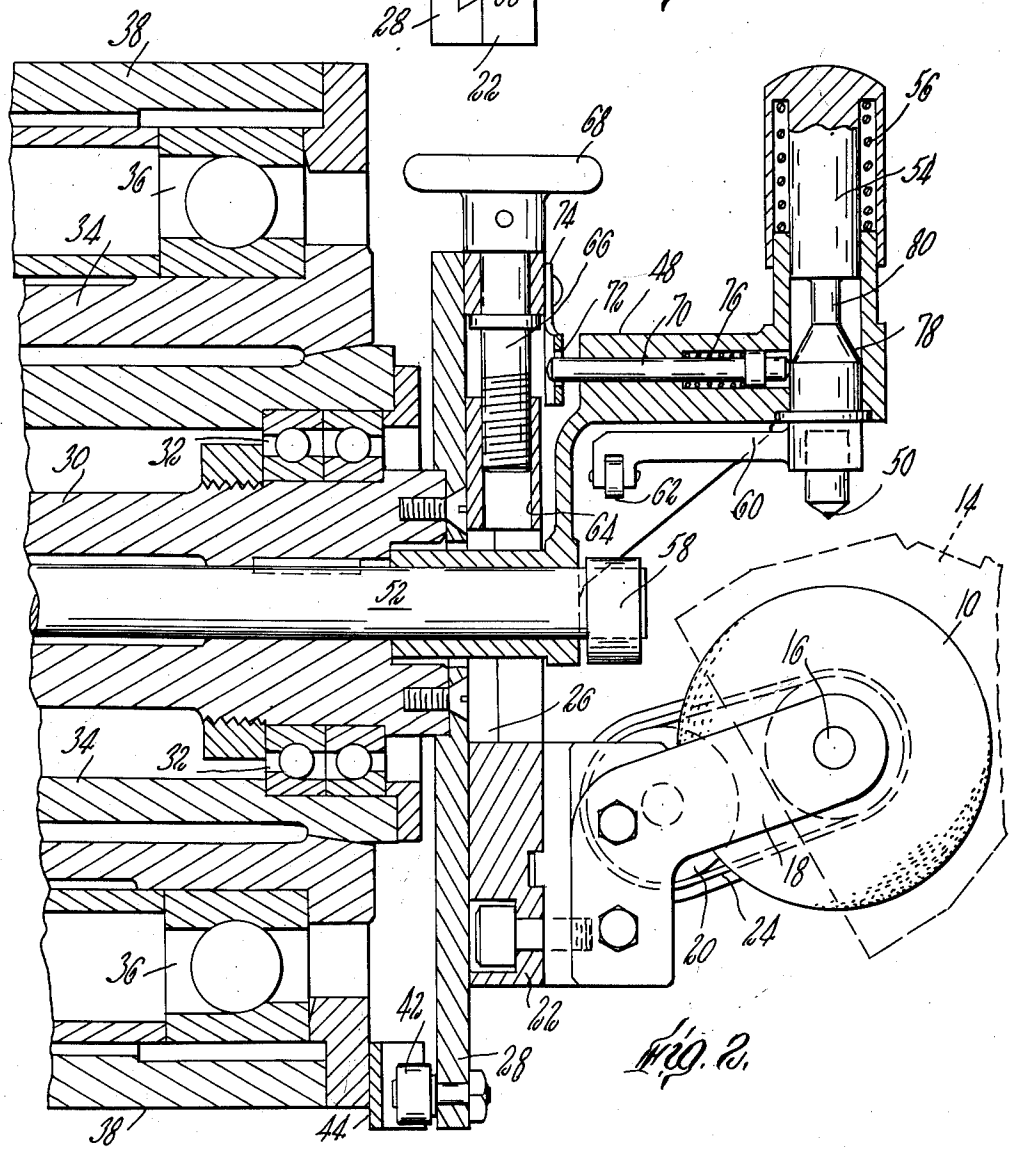


Fig. 2.

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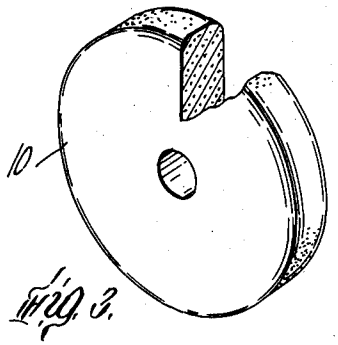


Fig. 3.

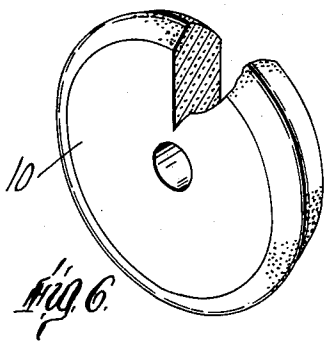


Fig. 6.

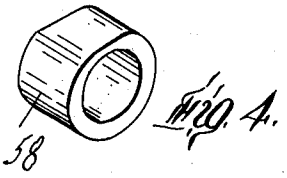


Fig. 4.

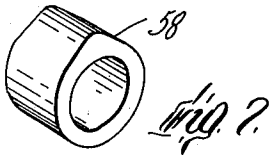


Fig. 7.

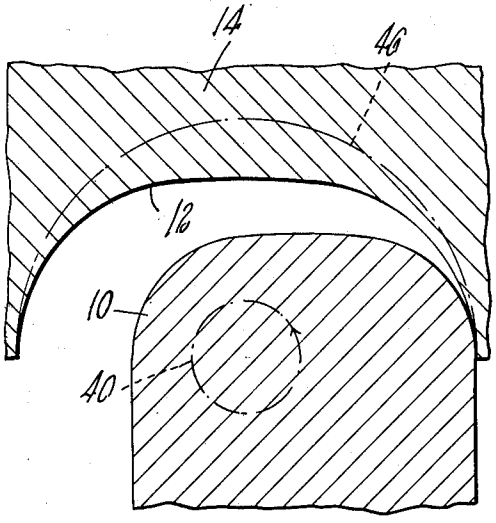


Fig. 5.

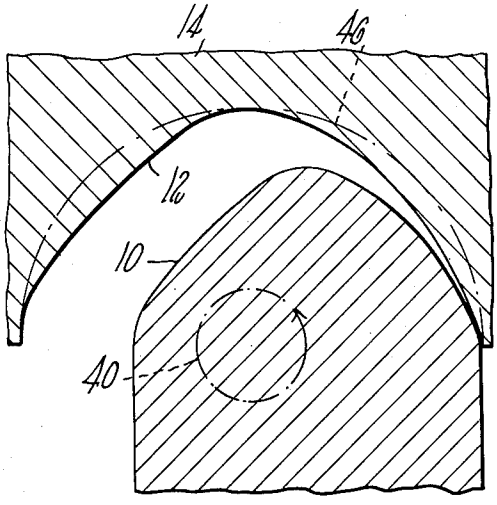


Fig. 8.

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GRINDING WHEEL AND DRESSER

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This invention relates to apparatus for grinding a curved groove having the configuration of a concave toroidal surface. It is particularly concerned with apparatus whereby grooves of prolate semicircular cross sectional form, i.e. not truly semicircular, may be ground in a workpiece. Although the invention may be especially useful for grinding ball races in the cup-like members of Rzeppa constant velocity universal joints, it may be used also in grinding prolate semicircular form toroidal grooves in the outer or inner races of ordinary ball bearings.

In my patent application S.N. 32,238 of May 27, 1960, now Patent No. 3,030,739, dated April 24, 1962, entitled "Grinding Apparatus and Method" I have shown and claimed devices and a manner for grinding toroidal grooves in workpieces such as the cup-like members of Rzeppa universal joints. In that patent, the races or grooves are truly semicircular in cross section in any plane radial to the toriod ring of the groove. The present application is a continuation in part of that earlier case and recognizes that in some instances and for some special purposes, it is desirable that the cross section of the race or groove be modified from the true semicircular form to approach that of part of an ellipse, parabola, or some other conic section not truly circular. Because stretched or distorted from circular, such shapes will be described as "prolate."

One object of the present invention is the provision of apparatus for generating or grinding grooves of toroidal configuration which are not truly orstrictly semicircular in radial cross section. A related object is to provide an arrangement for dressing or defining the surface of the grinding wheel in an oscillating grinder of the character set forth in my above mentioned application so that a prolate demi-ellipsoid generating or grinding surface on the wheel is produced. This noncircular wheel edge surface, when oscillated and rotated against a workpiece will generate a prolate semicircular ground groove surface which approximates or may equal the sum of the grinding wheel shape or extent with the radius of the circular oscillating path superimposed thereon.

Another object of this invention is to provide an improved holder and guide for the dressing tool of a grinder so that the generating edge of the grinder may be dressed in noncircular although curved form. A related further object is to provide such a dressing tool which easily may be brought into accurate position for use when required but which will not interfere with use of the grinding wheel during its groove generating or grinding operation.

These objects, and others, are met by providing a retractable dressing tool holder pivoted to swing in an arc roughly coinciding with the desired cross section of the noncircular groove which is to be produced, and by providing a cam guide for further accurate movement of the dressing tool toward and away from this arc so that the resultant dressed surface of the grinding wheel assumes the proper noncircular or prolate ellipsoid form. This is particularly useful in the dressing of wheels which have the oscillating motion of my aforesaid patent. Means also are provided for locking the dressing tool and its holder in a position clear of the grinding wheel and workpiece when the wheel is generating a groove.

Other objects, advantages and further details of that which is believed to be novel and included in this invention will be clear from the following description and claims, taken with the accompanying drawings in which are illustrated two shapes of grinding wheel with dresser embodying the present invention and incorporating the cam controlled dressing tool.

In the drawings:

FIG. 1 is a top plan view showing the principal parts of a grinding wheel dresser according to the invention;

FIG. 2 is a vertical sectional view on the line 2—2 of FIG. 1 showing not only the dresser but also an oscillating grinding wheel with which it cooperates;

FIG. 3 is a perspective view illustrating one shape of dressed wheel which may be used according to this invention;

FIG. 4 shows a form of cam used in controlling the dressing of a wheel of the contour of FIG. 3;

FIG. 5 is a greatly enlarged radial sectional view through the edge of a grinding wheel formed as in FIG. 3 and showing its cooperation with a workpiece to produce one type of prolate semicircular toroidal groove;

FIG. 6 is a perspective view similar to FIG. 3 but showing another shape of dressed grinding wheel;

FIG. 7 is a perspective view showing a form of cam useful with the dressing tool to produce a grinding wheel edge having the configuration of FIG. 6, and

FIG. 8 is a greatly enlarged sectional view similar to FIG. 5 but showing the generating edge of the wheel formed as in FIG. 6 and the cross-sectional shape of groove which may be generated or ground thereby.

In carrying out the objects of this invention, in one embodiment thereof a grinding wheel or disk 10 is used to generate the toroidal race or groove 12 in a suitably supported workpiece 14. The workpiece may be held and moved against the wheel by any suitable instrumentalities not germane to the present invention, but which may be of the kind shown in my prior patent. It suffices to say that the workpiece, which may be an element of a bearing, may be swung about an axis which is the same as the axis of the toroid ring of the groove. As shown in FIGS. 3 and 5; 6 and 8, the wheel has a free working or groove generating edge of cross-section modified from the truly semicircular and of a total working surface extent substantially less than the width or depth of the groove or race to be generated.

The wheel 10 is driven rotatably about a central shaft 16 positioned parallel to the toroid ring axis on an offset arm 18 which carries a motor or driving wheel 20, the driving wheel and the offset arm both being supported from an adjustable sliding member 22. The grinding disk is driven from the motor or driving wheel 20 as by a suitable belt 24.

When grinding or generating a groove, the slide 22 is fixed and carried in vertical ways 26 of an oscillating supporting plate 28 which is secured to the end of a horizontal hollow oscillating shaft 30 eccentrically mounted as by bearings 32 in a rotary driven drum assembly 34 which is rotatably mounted as by bearings 36 in a fixed portion 38 of the grinding machine frame. The drum 34 may be extended beyond its mounting in the frame 38 and be engaged and driven by any suitable means (not shown) provided with rotary motion. Because the hollow shaft 30 is mounted eccentrically within the drum 34, this shaft will oscillate in a circular fashion, the circle of oscillation being determined by the amount of eccentricity of the center of the shaft 30 with respect to the center of rotation of the driven drum 34. The circle of oscillation is indicated at 40 in the cross-sections of FIGS. 5 and 8 and its axis is in the plane of the center of the toroid groove to be generated. In order to insure that the oscillation is not accompanied by rotation, the shaft 30 is secured at its end to the oscil-

lating plate 28 and this plate is provided with a roller 42 arranged to work back and forth within a vertical guiding channel 44 which is supported on the fixed frame 38.

Because the channel is mounted on the fixed frame, the roller 42 will traverse a vertical path, the line of which coincides with the axis of the circle of oscillation. To the extent that the circle of oscillation departs horizontally from this vertical path line, the supporting plate 28 and the grinding wheel edge will be tilted or tipped from side to side horizontally through a slight angle from the vertical as the plate and wheel oscillate. For this reason the shape of the prolate semicircular groove surface generated by the wheel edge will not be strictly equal to the sum of the grinding wheel prolate demi-ellipsoid edge contour with the radius of the oscillating circle superimposed, but will approach this and also will include the effect of the changing slight angle of tilting of the wheel as it oscillates. If desired, the guiding channel 44 and roller 42 could provide mutually cooperating structures guiding these parts horizontally as well as vertically to move in a circle precisely equal to the circle of oscillation. In that case there would be no tilting of the supporting plate or grinding wheel and the prolate groove generated would be exactly equal to the sum of the radius of oscillation and the dimension from the center of prolate ellipsoid grinding wheel surface.

In operation, the drum 34 will be rotatably driven, causing the shaft 30 to move in its circular oscillatory path, similarly moving the plate 28, gross rotation of the plate being prevented by engagement of the roller 42 in the channel 44. As the supporting plate 28 oscillates it carries with it the adjustable sliding member 22, the offset arm 18 and the grinding wheel 10. The grinding wheel is rotated on its axis at right angles to the axis of oscillation by the driving wheel 20 while it is being oscillated so that the working or generating edge of the wheel moves in the circle of oscillation at the same time that it is being rotated against the workpiece to generate or grind the groove therein. As will be seen from FIGS. 5 and 8, which show a true semicircle 46 in dashed line, the shape of the edge of the oscillating and rotating grinding wheel will determine the shape of the groove 12 in cross section, this prolate semicircular groove shape being the same as the prolate demi-ellipsoid shape of the working edge of the cutting tool plus the radius of the circle of oscillation and with any tilting of the wheel adding slightly to the generated shape. If the shape of the working edge of the grinding tool were truly semicircular, the groove also would be truly semicircular as shown in my application aforesaid, whether some tilting motion is added or not to the oscillation.

To produce a groove shape cross section departing from the truly semicircular, and here called "prolate," the contour of the free edge of the grinding disk is altered accordingly, this being done most readily through control or guidance of the dressing tool holder 48 and its dressing point or diamond 50 which is used from time to time to define or determine the shape of the grinding wheel edge as it becomes worn away from repeated use.

In the form of device shown, a central pivot shaft 52 is keyed or otherwise secured to the hollow shaft 30 so that this pivot shaft oscillates therewith and with the oscillating plate 28. The dressing tool holder 48 is journaled on the pivot shaft 52 so that the diamond 50 may be swung in an arc therearound to dress the side and top grinding or generating faces of the grinding wheel 10. Because the pivot axis is perpendicular to the desired prolate ellipsoid cross-section of the dressed wheel edge, the tool will swing in the plane of this cross-section.

The diamond point 50 is mounted on the end of a retractable plunger 54 on the tool holder normally held or urged toward its retracted or inoperative position as by a spring 56 extending between the plunger and the tool holder body 48. When retracted, the plunger 54 will hold the dressing point 50 sufficiently far away from the free edge of grinding wheel 10 so that a workpiece 14 may be inserted and moved therebetween to grind or generate a groove in the workpiece. However, when it is desired to dress the wheel the workpiece is removed and the plunger is pushed radially inwardly toward the shaft 52 against the force of the spring 56 until the plunger and tool point reach operative position at the limit of their travel. According to the example of the invention here illustrated, the pivot shaft 52 is provided with a cam ring 58 fixed around its outer end and the plunger is provided with an offset follower arm 60 carrying a downwardly extended cam follower in the form of a wheel 62 which will engage against and ride on the cam face when the plunger is depressed. The dressing tool holder is then swung about its pivot on shaft 52 on either side of the grinding wheel to dress it, while the wheel is rotated, being guided in its path toward and away from a truly circular arc by engagement of the cam follower with the prolate ellipsoid cam face while the plunger is held inwardly toward the axis of the shaft 52.

As shown in FIGS. 3, 4, and 5, if a prolate grooove of somewhat flattened form is desired, the cam is correspondingly shaped so that the tool point is guided around the generating edge of the rotating wheel to define or produce the proper flattened dressed shape. On the other hand, if a sharper radius is desired at the bottom of the groove, the cam is accordingly shaped to produce the wanted wheel cross-section as illustrated in FIGS. 6, 7 and 8. Modifications and variations of these shapes also may be obtained by changing the form of the cam ring, in a manner which should be readily apparent.

If the dressing tool tip does not touch the surface of the rotating grinding wheel at some spot during dressing operation, it is obvious that this spot on the wheel has been worn beyond a desirable degree and the dressing tool or the wheel must be adjusted so that full dressing may be accomplished. This adjustment may be made by providing the slide 22 with a screw threaded socket 64 at its top within which the end of an adjustment screw 66, rotatably mounted at the top edge of the supporting plate 28, is threadedly engaged. An adjustment knob 68 on the screw may be turned in the proper direction so that the screw advances the slide 22 in the ways 26 of the plate 28. This will move the wheel 10 radially in a direction along a radius of the toroid ring of the groove to be ground until the depressed dressing tool tip 50, as it swings, is again in dressing contact with all surfaces of the wheel which should be dressed. Retraction of the tool from the dressed wheel will then leave the wheel edge in proper position for further use.

In order to keep the dressing tool holder from swinging or interfering with a workpiece when it is not depressed for dressing the wheel, a lock may be provided in the form of a sliding locking pin 70 in the tool holder, one end of which is engageable within a locking hole 72 on a plate 74 carried by the supporting plate 28. The other end of the locking pin extends against the retractable plunge 54 in the holder 48 and is biased thereagainst by a spring 76. Normally, when the dressing tool is not in use, the spring 56 will raise the plunger 54 so that an enlarged section of the plunger will push the pin 70 into the locking hole 72, holding the tool holder upright. When the plunger is depressed, a tapered section 78 and a reduced diameter section 80 on the plunger will be opposite the inner end of the locking pin so that the pin spring 76 will retract the exposed end of the pin from the locking hole 72, permitting swinging of the tool holder while the plunger is depressed. When dressing has been completed, the tool holder is moved upright and pressure is released from the plunger. The spring 56 will then force the plunger outwardly, the locking pin will ride over the tapered section to the enlarged section of the

plunger and this will slide the pin against the force of its biasing spring **76** so that the outer end of the pin will again be forced outwardly to become engaged in the locking hole.

It should be noted that the axis of the tool dresser pivot shaft, which is the center of the cam guiding surface on the ring **58**, extends through the axis of symmetry of the generating surface of the grinding wheel. Another way of explaining this is to say that this pivot axis is located on a line tangent to the center of the cross-section of the free edge. This relationship between the edge of the wheel and the mounting and guiding means for the dressing tool remains the same no matter what the position of oscillation may be of the wheel, because both the wheel (through the plate **28**) and the tool holder (through the pivot shaft **52**) are fixed with relation to the oscillating shaft **30** and travel in the same circle of oscillation. It is contemplated that for some purposes it might be desirable to obtain the relative oscillatory motion between the grinding wheel and the workpiece by oscillating the workpiece. In such case, the shaft **30** would be fixed with relation to the stationary frame **38** and all of the elements shown as mounted or supported from that shaft also would be stationary. The workpiece holder would be oscillated. In this variation the operation of the dressing tool and adjustment or advance of the grinding wheel to obtain proper full dressing would remain as previously described. Obviously, also, if neither the grinding wheel nor the workpiece are oscillated, dressing of the grinding wheel may be accomplished in the same way and with the same means described, although in that case the advantageous motion of oscillation would not be available to assist in the generation of the desired form of groove in the workpiece unless imposed when using the wheel for grinding.

As will be evident from the foregoing description, certain aspects of this invention are not limited to the particular details set forth, and it is contemplated that various and other modifications and applications of the invention will occur to those skilled in the art. It is therefore intended that the appended claims shall cover such modifications and applications as do not depart from the true spirit and scope of the invention.

What is claimed as new and is desired to be secured by Letters Patent of the United States is:

1. Apparatus for generating a toroidal groove surface of prolate semicircular cross-section on a workpiece, comprising

a rotatable generating element having a prolate ellipsoid generating surface portion in the plane of the groove surface cross-section to be generated,

means supporting said generating element and the workpiece for relative oscillation one with respect to the other in a circular path about an axis in the plane of the center of the toroid groove to be generated,

the sum of the radius of said circular oscillation path and of said prolate ellipsoid generating surface portion being substantially equal to the said prolate semicircular groove cross-section to be generated,

means supporting said generating element for rotation about an axis at an angle to said axis of oscillation, and

means for moving said workpiece relatively to said generating element about the axis of the toroid groove to be generated.

2. Apparatus for grinding a concave toroidal surface of prolate semicircular cross-section on a workpiece, comprising

a rotatable grinding element of disklike shape with a free edge of prolate ellipsoid cross-section,

grinding element support means supporting said rotatable grinding element for oscillation in a circular path about an axis in the plane of the center of the concave toroid surface to be ground, and

for rotation about an axis oscillating with said axis of oscillation and perpendicular thereto and spaced between it and the axis of the toroidal surface,

the sum of the radius of said circular oscillation path and of said prolate ellipsoid free edge cross-section being substantially equal to the said prolate semicircular concave surface cross-section of the toroid to be ground,

workpiece holding means and

means for swinging said workpiece holding means relatively to said means supporting said grinding element about the axis of the toroid ring of the concave toroidal surface portion to be ground.

3. Apparatus as claimed in claim 2 further including

means for advancing said grinding element in a direction along a radius of the toroid ring of said concave surface and

means mounted on said grinding element support means movable between an inoperative position and an operative position defining said prolate ellipsoid cross-section, including

dressing means for said grinding means movable in the plane of the ellipsoid cross-section about an axis perpendicular thereto and

cam means guiding said dressing means in its movement to define said prolate ellipsoid cross-section.

4. Apparatus for defining a prolate ellipsoid cross-section on the free edge of a grinding wheel disk, comprising

a support for the grinding wheel, mounting the wheel for rotation about its center,

a holder mounted on said support movable between an inoperative position away from and an operative position adjacent the free edge of the wheel,

a pivot on said support, supporting said holder for swinging about the free edge of the wheel disk,

a dressing tool carried by said holder and movable therewith about the free edge of the wheel disk when said holder is in operative position and is swung about its pivot,

a cam surface of prolate ellipsoid form mounted on said support,

cam follower means on said holder engaging said cam surface when said holder is moved to its operative position and is swung about its pivot and

means for advancing the wheel on said support in a radial direction toward said operative holder and dressing tool,

whereby said holder is guided to move said dressing tool to define a prolate ellipsoid surface on the free edge of the grinding wheel disk when said holder and tool are swung about said pivot.

5. Apparatus for defining a prolate ellipsoid cross-section on the free edge of a disklike grinding wheel, comprising

a support for the grinding wheel, mounting the wheel for rotation about its center,

means for advancing the wheel on said support in a direction along a radius thereof,

a tool holder mounted on said support movable between an inoperative position away from and an operative position radially adjacent the free edge of the wheel in the path of its advance,

a pivot on said support supporting said holder, when in operative position, for swinging about an axis located on a line tangent to the center of the cross-section of the free edge,

a dressing tool with a point carried by said holder and movable therewith about and against the free edge of the wheel in the plane of the cross-section of the edge when said holder is in operative position and is swung about its pivot,

a cam of prolate ellipsoid form mounted on said support around the said pivot and

a cam follower on said holder engaging and riding on said cam when said holder is moved to its operative position and is swung about its pivot,

whereby said holder is guided by said cam to define a prolate ellipsoid path of movement of said dressing tool point about the free edge of the grinding wheel when said holder is in operative position and said holder and tool are swung about said pivot.

6. Apparatus as claimed in claim 4 further including means for locking said holder against swinging about said pivot when said holder is in its said inoperative position.

7. Apparatus as claimed in claim 5 further including means biasing said tool holder and dressing tool to said inoperative position away from the free edge of the wheel and

means for locking said holder and tool against swinging about said pivot,

said means for locking being actuated by movement of said holder to said inoperative position and being released by movement of said holder to its operative position.

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