Dec. 1, 1964 W. E. REASER 3,158,967

MACHINE AND METHOD FOR EDGE GRINDING LENS BLANKS

Filed Feb. 1, 1963 6 Sheets-Sheet 1

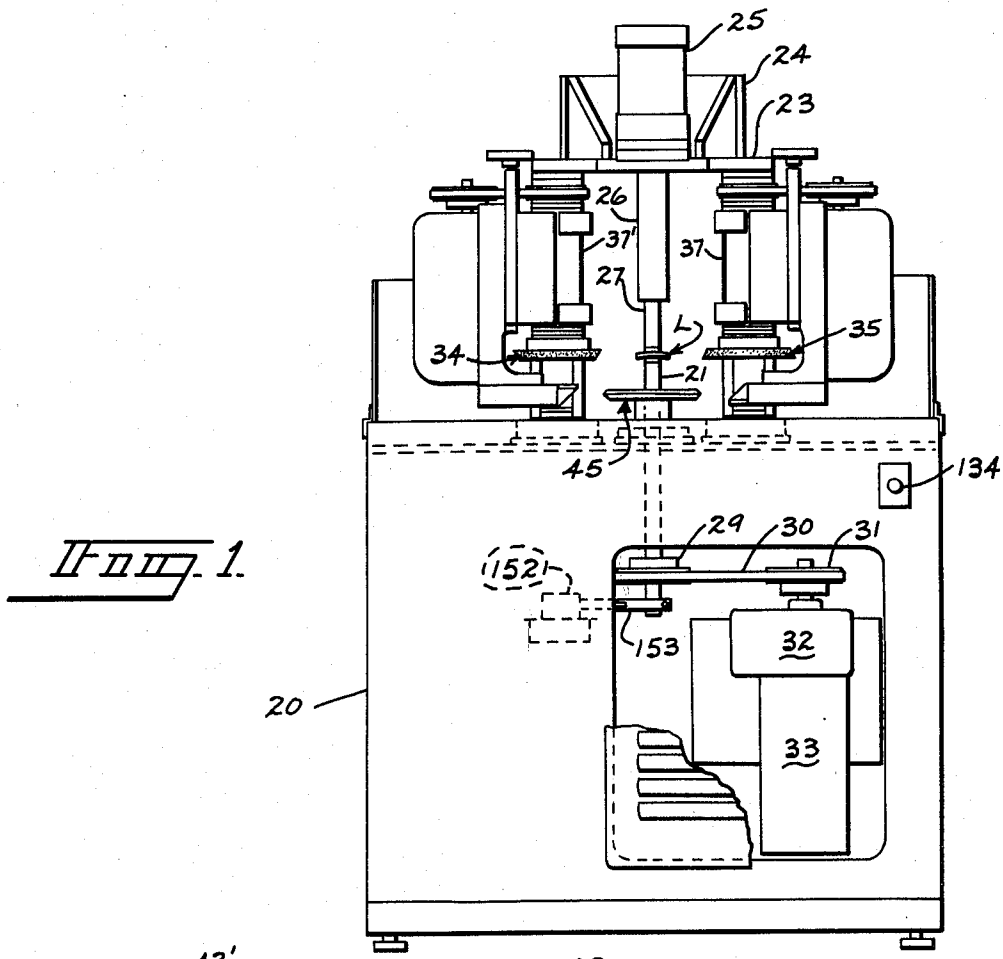


FIG. 1.

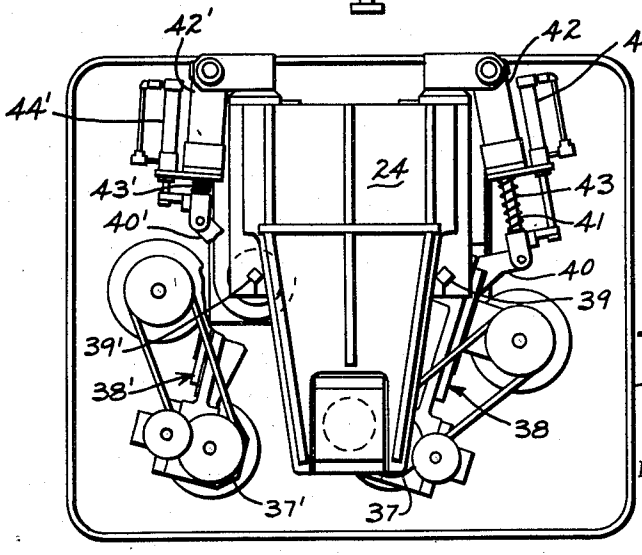


FIG. 2.

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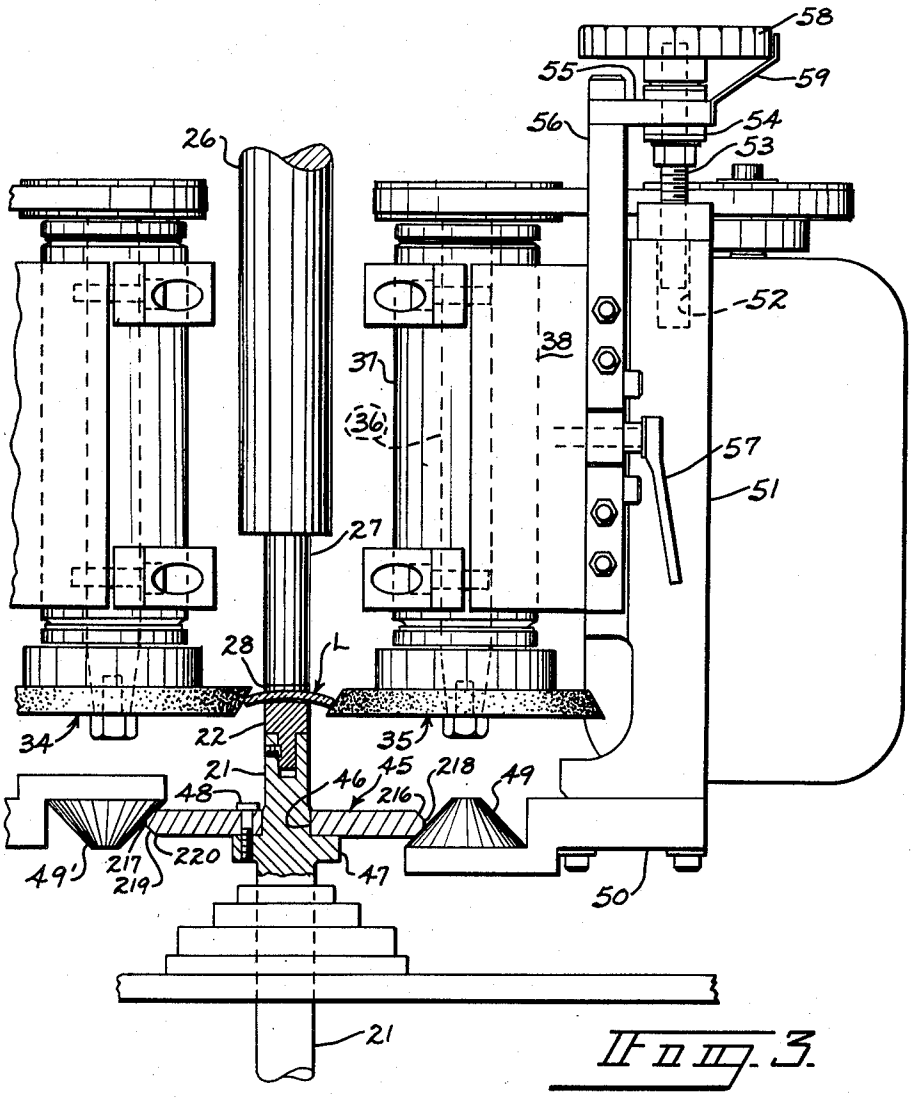


FIG. 3.

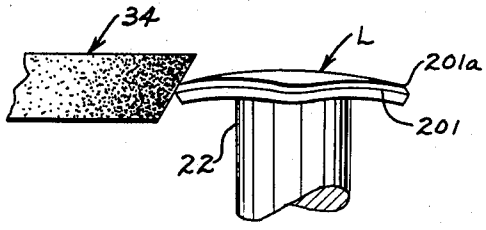


FIG. 8.

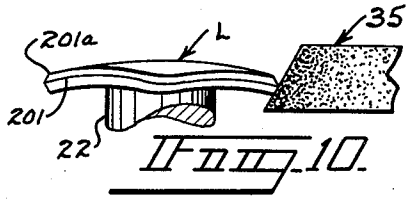


FIG. 10.

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MACHINE AND METHOD FOR EDGE GRINDING LENS BLANKS

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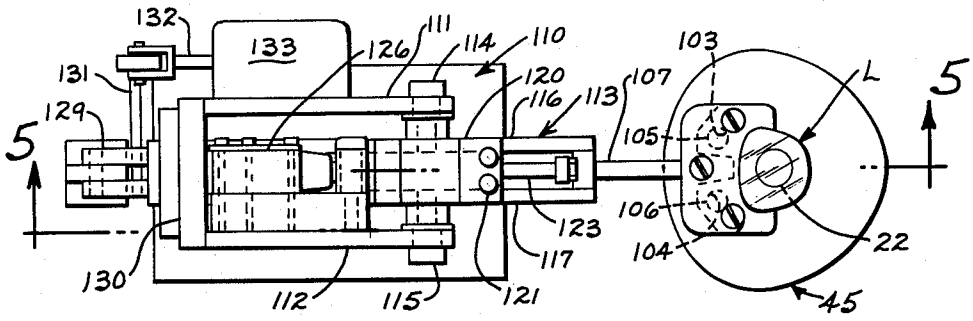


Fig. 4.

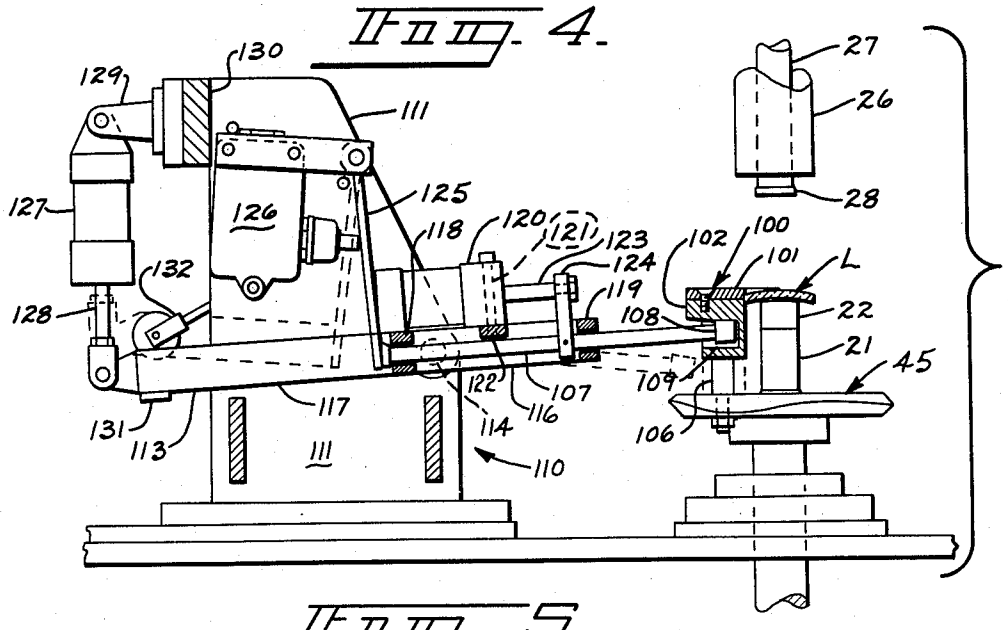


Fig. 5.

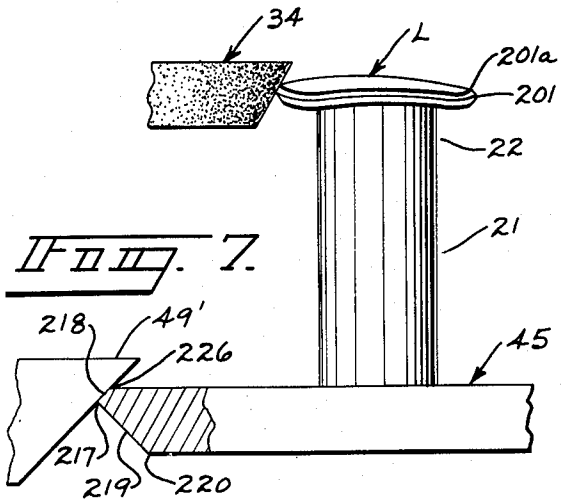


Fig. 7.

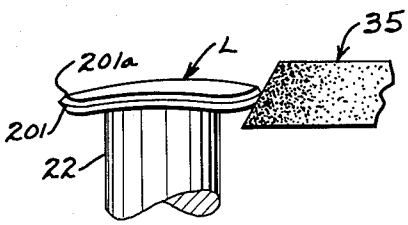


Fig. 9.

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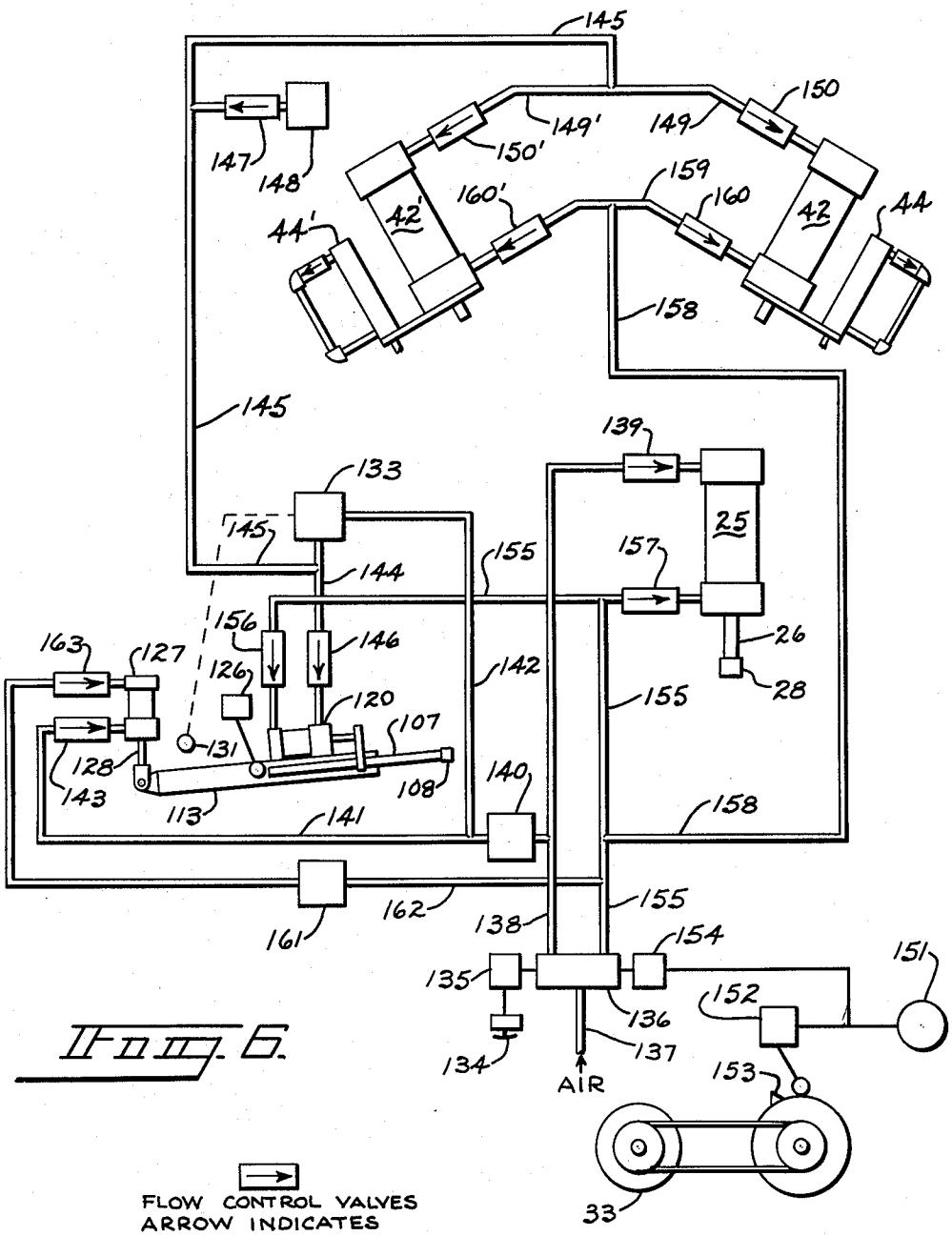


FIG. 6.

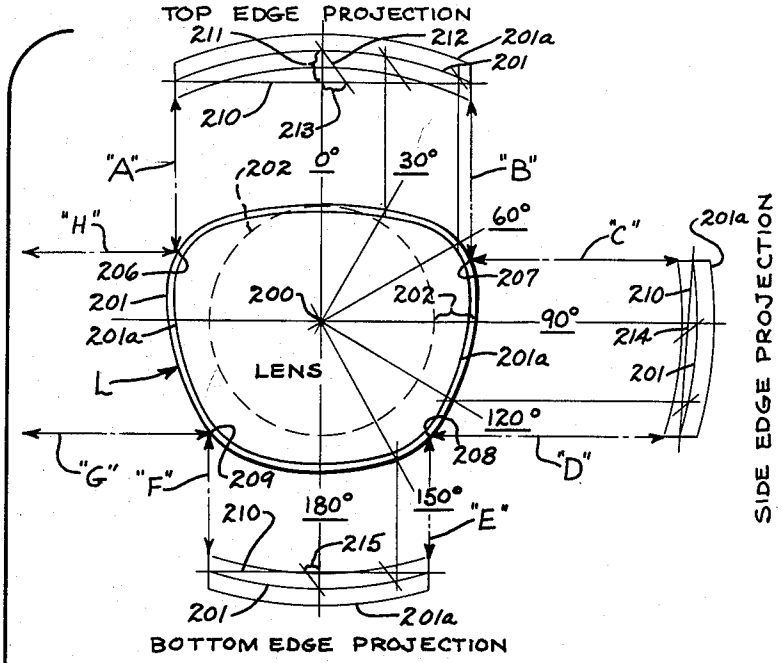
FLOW CONTROL VALVES
ARROW INDICATES
DIRECTION OF FREE FLOW

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Dec. 1, 1964 W. E. REASER 3,158,967

MACHINE AND METHOD FOR EDGE GRINDING LENS BLANKS

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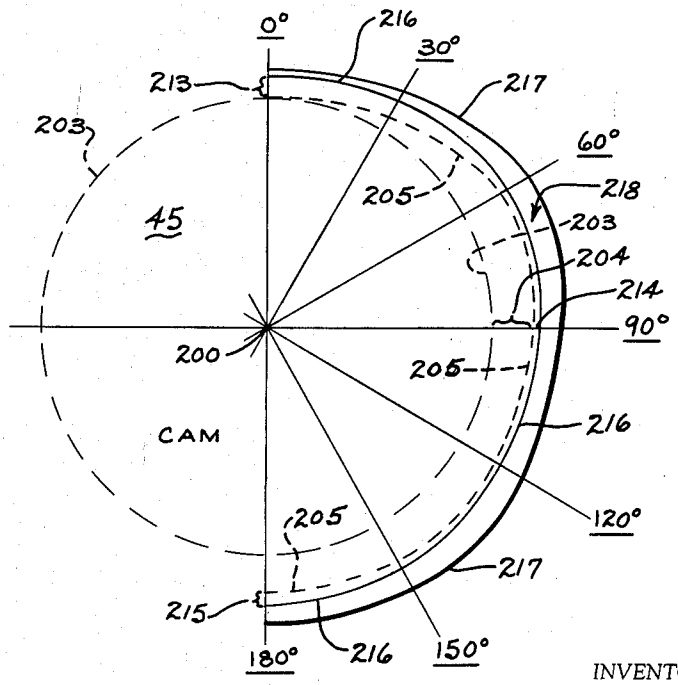


FIG. 11.

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MACHINE AND METHOD FOR EDGE GRINDING LENS BLANKS

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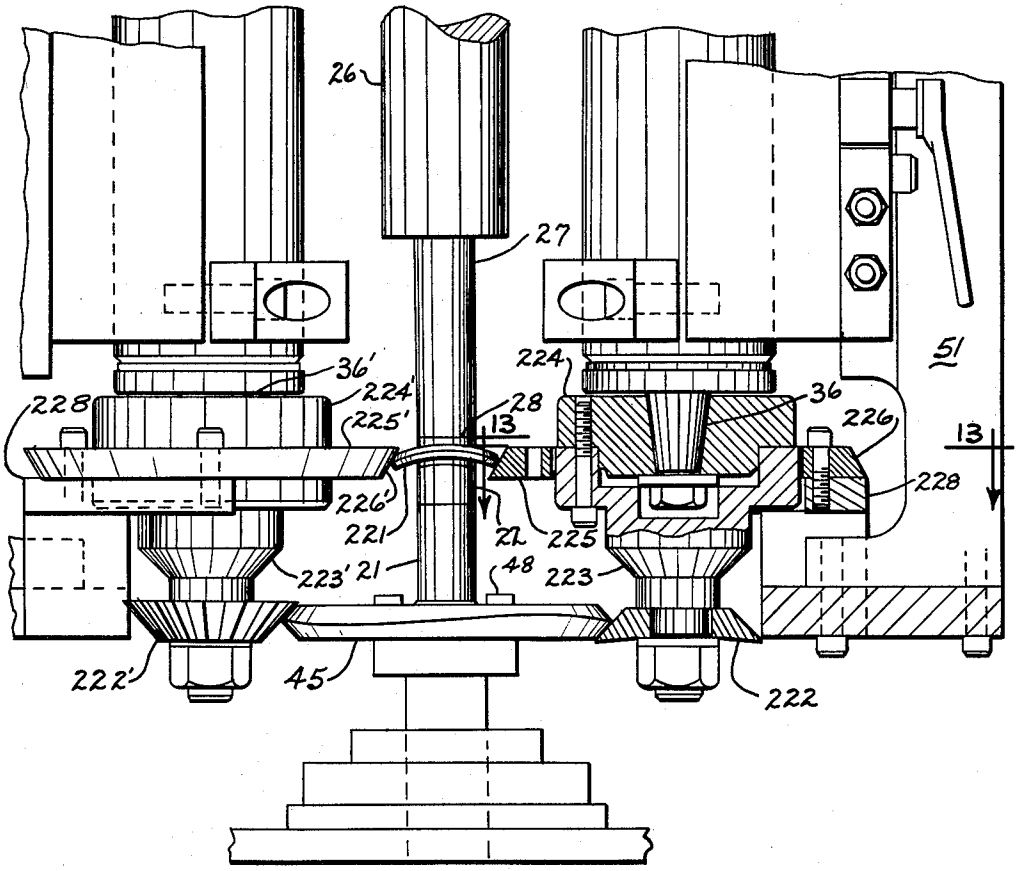


FIG. 12.

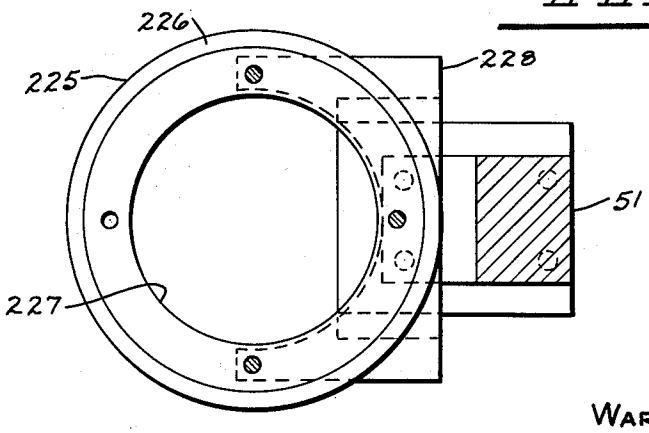


FIG. 13.

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United States Patent Office 3,158,967
Patented Dec. 1, 1964

3,158,967

MACHINE AND METHOD FOR EDGE GRINDING LENS BLANKS

Warren E. Reaser, Toledo, Ohio, assignor to The Sun Tool and Machine Company, Toledo, Ohio, a corporation of Ohio

Filed Feb. 1, 1963, Ser. No. 255,488
12 Claims. (Cl. 51—89)

The present invention relates to a machine and method for forming upper and lower bevels on the peripheral edges of eye glass lens blanks and like shaped work pieces.

The upper and lower surfaces of eye glass lenses are convex and concave, respectively, and the peripheral edges of the lens blanks usually are beveled in order that the lenses can be mounted in eye glass frames. The periphery of an eye glass lens usually is not circular but is wide at the top, having a slightly curved upper edge, terminating in corners of small radius, the corners blending into downwardly converging sides, with lower corners of small radius and a curved bottom of larger radius. The sides of a single lens often are not even curved the same.

Because of the non-circular shape of the lens, the distances along radii leading from its periphery to any "center" within its borders, of course, are not equal. In considering such a lens, the "center" shall mean that point around which the lens is rotated during grinding of its peripheral edge and should be so positioned that the radial distances from various points on the periphery of the lens vary as little as possible.

When such a lens is laid on a planar surface with its convex surfaces extending upwardly therefrom, because of the shape described, the lens usually contacts the surface at four points centered on the small corner curves and the periphery of the lens arches upwardly between such contact points. The peripheral edge of the lens therefore describes a three-dimensional curve. In discussing the lens and in the following specification, the term "base plane" for the lens shall mean the plane of such a flat surface upon which the lens could be laid. The "axis of rotation" of the lens shall mean that axis passing through the "center" of the lens generally perpendicular to the said "base plane."

The principal object of the present invention is the provision of a new and improved lens beveling machine which will bevel edges of a three-dimensional curved periphery of a lens by means of a cam and cam follower arrangement which provides relative movement of the lens and beveling grinder in but a single plane.

Another object of the present invention is the provision of a new and improved lens beveling machine wherein the bevel cutting element has a height greater than the combined height and vertical displacement of the bevel of the lens which it forms and wherein the cutting surface of the cutting element extends over the top of the lens at a constant angularity relative to the base plane of the lens so that points on the periphery of the lens above the base plane contact points on the cutter at a similar height above the base plane, and the correct contour of the lens is controlled by only generally radial movement of the cutter.

A further object of the present invention is the provision of a new and improved lens beveling machine in which both the upper and lower edges of the periphery of the lens are beveled at the same time by bevel cutting elements of the above described type whose radial movement is controlled by respective cam followers each of which contacts one of the upper and lower beveled edges of a single cam.

A still further object of the present invention is the provision of a new and improved method of generating the cam for a machine of the above described type wherein a finished beveled lens template is inserted into the machine in place of a lens blank to be beveled, the normally used lens beveling element is replaced by a template follower, a cam blank to be contoured is installed in place of the cam, and a cam cutting element is installed in place of the normally used cam follower. Such operation cuts the cam to such a contour that when the cam is later inserted in the machine, the lens blank beveling element will bevel a lens blank to the same contour as the template.

The invention resides in certain constructions and combinations and arrangements of parts; and further objects and advantages of the present invention will become apparent to those skilled in the art to which it relates from the following description of a preferred embodiment described with reference to the accompanying drawings forming a part of this specification, and in which:

FIG. 1 of the drawings is a front elevational view of a machine embodying the present invention, and in which a portion of the front cover is broken away to better show the motor and drive structure;

FIG. 2 is a plan view of the machine shown in FIG. 1.

FIG. 3 is an enlarged, fragmentary front view of a portion of the machine shown in FIGS. 1 and 2 which holds a lens blank to be ground on an axis with a control cam—the view further showing a pair of grinding wheels grinding the upper and lower bevels of the lens blank and cam followers which engage upper and lower bevels on the cam to control the movement of the grinding wheels toward and away from the lens blank;

FIG. 4 is a plan view of lens positioning fixture, as well as a structure utilized to move the fixture between a blank loading position where the fixture will center a lens blank on a work support shaft and an out-of-the-way position spaced toward the cam from the blank loading position—the view being taken on the center line of the machine behind the structure shown in FIG. 3.

FIG. 5 is a cross sectional view taken approximately on the line 5—5 of FIG. 4;

FIG. 6 is a schematic flow diagram of the controls which actuate the machine to cause the machine to go through a grinding cycle automatically once it is started;

FIG. 7 is an enlarged fragmentary view showing the manner in which the grinding wheel contacts one of the high points on the upper periphery of the lens blank during the grinding operation;

FIG. 8 is an enlarged fragmentary view showing the manner in which a grinding wheel contacts a low point of the upper periphery of the lens blank during the grinding operation;

FIG. 9 is an enlarged fragmentary view showing the manner in which another grinding wheel contacts a high point on the lower periphery of the lens blank during the grinding operation;

FIG. 10 is a fragmentary enlarged view showing the manner in which the grinding wheel of FIG. 9 contacts a low point of the lower periphery of the lens during the grinding operation of the lower bevel of the lens blank;

FIG. 11 is a graphic presentation of the relationships between a lens and a cam for controlling the machine shown in the drawings;

FIG. 12 is a view similar to FIG. 3 but showing a master lens positioned in the machine in place of the lens blank to be ground, a pair of cam followers abutting the contour of the master lens, and a pair of cam cutters fastened to the grinding wheel spindles in place of their normally used cam followers to automatically

contour the cam to the shape necessary for grinding the lens blanks; and

FIG. 13 is a fragmentary cross sectional line taken approximately on the line 13—13 of FIG. 12.

The lens beveling machine shown in the drawing generally comprises a frame 20 having a vertically extending work support shaft 21, the upper end of which has a rubber lens table 22 upon which a lens blank L is positioned for grinding. The frame of the machine includes an upright portion 23 and a head portion 24 which extends over the top of the work support shaft 21 a considerable distance above the lens table 22. An air cylinder 25 is mounted in axial alignment with the work support shaft 21, and its piston (not shown) is attached to a quill 26 for moving the quill toward and away from the lens table 22. The quill 26 includes an axially extending lens holddown shaft projecting therefrom, which holddown shaft 27 is journaled within the quill for rotational movement with respect to the quill. The lower end of the lens holddown shaft 27 also has a rubber grip 28 thereon. Air pressure fed to the top of the air cylinder 25 extends the lens holddown shaft 27 down upon the upper surface of a lens positioned on the lens table 22 to clamp the lens for rotation with the work shaft 21.

In the embodiment shown in the drawing, however, the shaft 21 is rotated while the grinding wheels which bevel the lens remain in the same general radial location relative to the shaft 21 and are moved generally radially inwardly and outwardly relative to the lens. The lower end of of the shaft 21 is journaled and provided with a pulley 29 that is driven by a belt 30 that in turn is driven by a pulley 31 on a gear reducer 32. The gear reducer 32 is integrally attached to an electric motor 33 and the gear reducer and the motor are mounted on the frame 20 of the machine.

The machine shown in the drawing is designed to simultaneously bevel both the top and the lower edges of the periphery of the lens blank L. The upper bevel of the lens is ground by a grinding wheel 34 and the lower periphery of the lens L is beveled by a second grinding wheel 35. In order that the grinding wheels 34 and 35 can bevel the edge of the lens blanks L at the desired angles, it is necessary that the grinding periphery of each grinding wheel engages the blank along a straight line of contact, an extension of which intersects a plane normal to the axis of the work support shaft 21 at the desired angle of bevel for each bevel to be formed. In the embodiment shown in the drawing the grinding wheels 34 and 35 are supported upon axes which are parallel to the axis of the work support shaft 21, and the edges of the grinding wheels are beveled.

Inasmuch as the periphery of the lens blank L is not of constant radius relative to the axis of the work shaft 21, the grinding wheels 34 and 35 must be moved radially toward and away from the work shaft 21. The grinding wheels 34 and 35 can be guided for movement in a radial direction relative to the work support shaft 21 in any suitable manner, and as shown in the drawing are pivotally supported for arcuate movement generally radially of the work shaft 21. The means used for supporting the grinding wheel 34 is generally identical to that used for supporting the grinding wheel 35 excepting that it is of opposite hand. Only the supporting structure for the grinding wheel 35, therefore, will be described in detail, and it will be understood that the corresponding portions of the supporting structure for the grinding wheel 34 will be designated by a like reference numeral characterized further in that a prime mark is affixed thereto.

The grinding wheel 35 is bolted on the lower end of a spindle 36 which is journaled within a spindle housing 37 (FIGS. 2 and 3). The spindle housing 37 is clamped to the front inner side of a swinging frame 38 which is pivotally mounted on a wing of the upright frame portion 23 by a vertical shaft 39. The frame 38 has a rear leg 40 to which one end of a piston rod 41 of an air cylinder 42 is yoked. The rear end of the air cylinder 42 is pivotally mounted on the rear side of the upright frame portion 23.

A spring 43 surrounds the piston rod 41 and cushions retractile movement of the piston rod 41 into the cylinder 42. When it is desired to move the grinding wheel into engagement with the lens L, air under pressure is admitted to the rear end of the air cylinder to force the piston rod 41 outwardly of its cylinder 42 and thereby swing the frame 38 in a clockwise direction (FIG. 2). A single acting dash pot 44 is connected between the piston rod 41 and the housing of the air cylinder 42 to cushion the engagement of the grinding wheel 35 with the lens L. When it is desired to retract the grinding wheel 35 out of engagement with lens L, air is admitted to the front end of the air cylinder to swing the frame 38 in a counter clockwise direction (FIG. 2) to move the spindle 36 generally radially away from the work support shaft. The swinging frame 38 is shown in FIG. 2 in its inner or grinding position with the spring 43 extended while the swinging frame 38' is shown in its outer or retracted position with the spring 43' compressed.

The extent of the grinding which is done upon the lens blank L is controlled by means of a generally disc shaped cam 45 which is positioned normal to the shaft 21 beneath the lens table 22. The cam 45 has a central axis around which its periphery extends and the cam is mounted coaxially with respect to the lens L on the work support shaft 21. The cam 45 has a central opening 46 so that it can be slipped down over the end of the shaft 21 to rest on a circular support flange 47 to which it is bolted by a plurality of bolts 48, only one of which is shown.

The inward movement of the frame 38 under the action of the air cylinder 42 and thus the engagement of the grinding wheel 35 with the lens L and the finished shape of the lens L is controlled by means of a conical cam follower 49 which is mounted on a bracket 50. The bracket 50 is bolted to the lower end of a vertical slide 51 which slides in vertical guideways (not shown) on the outer side of the frame 38. The upper end of the slide 51 has a vertical threaded socket 52 into which a lead screw 53 extends. A grooved collar 54 is rotatably received on the lead screw 53 near its upper end and is held against movement axially with the screw 53 by a yoke 55 which engages the collar 54 and is mounted on the upper end of a strut 56 bolted to the frame 38. The slide 51 is held in position on the swinging frame 38 by a clamp 57. The position of the conical cam follower 49 vertically relative to the grinding wheel 35 can be changed by loosening the clamp 57 and turning a hand wheel 58 that is attached to the upper end of the lead screw 53 to raise or lower the cam follower 49 as desired. The position of the cam follower 49 is indicated by an index finger 59 which lies adjacent the wheel 58. Such an adjustment is made to compensate for changes in the diameter of the grinding wheel 35, for example when the wheel 35 is refaced which reduces its size. In such a case, the cam follower 49 is lowered so that it engages the cam 45 at the same time that the grinding wheel 35 is positioned at the desired radial distance from the axis of the work support shaft 21. It should be noted that the cam follower 49' is inverted relative to the cam follower 49 in order to agree in relationship with the respective grinding wheel 34.

The lens blanks L are always positioned in the same manner relative to the cam 45 each time one is placed in the machine for grinding, by means of a lens positioning fixture 100 which is mounted on, and rotates with, the cam 45. The lens fixture 100 is movable between an upper position, shown in solid lines in FIG. 5 and a lower position, shown in dotted lines in FIG. 5, in which it is clear of a lens blank L when the blank is clamped on the lens table 22, so that the lens blank can be engaged by the grinding wheels 34 and 35. At the end of each grinding

cycle, the work support shaft 21 is stopped in a predetermined position by means of mechanism which will later be described, the air cylinders 42 are actuated to back the grinding wheels 34 and 35 away from the lens, and the lens hold down shaft 27 is raised so that the ground lens can be removed. Simultaneously with the moving of the grinding wheels 34 and 35 back out of engagement with the lens blank L, the fixture 100 is raised to its upper position. The fixture 100 has a generally C-shaped plate 101 of such size and shape as to closely embrace the top and upper corners of a lens blank L and to centrally position the blank L on the lens table 22. In the embodiment shown in the drawing, the plate 101 is mounted on a block 102 which has a pair of vertical guide holes 103 and 104 in its body, the holes 103 and 104 being parallel to the axis of the work support shaft 21. Guide pins 105 and 106 are bolted to the cam 45 and project into the holes 103 and 104, respectively, of the block 102, so that the block 102 is guided for vertical movement along an axis parallel to the axis of the work support shaft 21 and the plate 101 is maintained in accurate angular relationship of the cam 45.

The lens positioning fixture 100 is movable between its lowered position in which it rests on the flat top of the cam 45 and its upper position in which it surrounds the lens table 22 for positioning a lens L on the lens table 22. A tilt arm 107 has a plunger 108 which is engageable in a rearwardly open socket 109 in the block 102 that is located between the guide holes 103 and 104. The tilt arm 107 is actuated by the mechanism illustrated in FIGS. 4 and 5. A support 110 has a pair of vertically extending side plates 111 and 112 positioned on opposite sides of the center line of the machine and rearwardly of the work support shaft 21. A tilting frame 113 is pivoted between the upright side plates 111 and 112 by trunnion pins 114 and 115 which extend through the respective side plates 111 and 112 and into respective side bars 116 and 117 of the tilting frame 113. The tilting frame 113 has two longitudinally aligned bearings 118 and 119 which guide the tilt arm 107 for longitudinal motion. The tilt arm 107 is moved to engage and disengage its plunger 108 with the socket 109 in the block 102 by an air cylinder 120 which is secured by bolts 121 to a cross brace 122 between the bars 116 and 117. The piston rod 123 of the cylinder 120 is bolted to an arm 124 that in turn is pinned to the tilt arm 107. The rear end of the tilt arm 107 is engaged by an actuator 125 of a micro switch 126. When the tilt arm 107 is in its forward position, shown in solid lines in FIG. 5, the switch 126 is open and when the tilt arm 107 is in its rearward position, shown in dotted lines in FIG. 5, the micro switch 126 is closed. As will later be explained, the micro switch 126 controls the circuit to the motor 33 which rotates the vertical work support shaft 21 in order to prevent its rotation whenever the plunger 108 of the tilt arm 107 is inserted into the socket 109 in the block 102.

The tilting frame 113 is movable between its positions by an air cylinder 127 whose piston rod 128 is yoked to the rear end of the tilting frame 113. The upper end of the air cylinder 127 is pivotally mounted by a clevis 129 on a cross member 130 extending between the side plates 111 and 112. A laterally extending finger 131 projecting from the rear end of the tilting frame 113 contacts an actuator 132 of a two-way valve 133 that is mounted on the side plate 111. When the tilting frame 113 is swung into the dotted position shown in FIG. 5, the actuator 132 is moved upwardly by the finger 131 to shift the two-way valve 133 for reasons which will later be explained.

The machine shown in the drawings is designed to carry out individual lens blank grinding cycles, the operator inserting an unground lens blank before starting the machine and removing the ground lens at the end of each cycle. After an unground lens blank is placed on the lens table 22, the operator actuates a push button 134, FIG. 6, to energize a solenoid 135 to shift a two-way air valve 136 to connect an air supply line 137 to an air header 138. Air in the line 137 may be at say, 60 p.s.i.g. The header 138 leads to a flow control valve 139 which regulates air flow to the top side of the air cylinder 25 to cause its quill 26 to be extended and thereby to clamp the lens L in position on the lens table 22. When the air pressure in the air header 138 reaches a predetermined pressure, an air sequence valve 140 opens to feed air to branch headers 141 and 142. Air supplied to the branch header 141 flows through a flow control valve 143 to the bottom side of the air cylinder 127 to pivot the tilting frame 113 in a clockwise direction and to swing the tilt arm 107 to its lower position to move the lens positioning fixture 100 to its lower position, out of the way of the grinding wheels 34 and 35. Those flow control valves shown in FIG. 6 by a box with an arrow provide unrestricted flow in the direction of the arrow, and restrict flow in the reverse direction.

When the rear end of the tilting frame 113 is swung upwardly, it moves the actuator 132 to open the normally closed two-way air valve 133 to supply air to conduits 144 and 145. Conduit 144 communicates with a flow control valve 146 which supplies air to the front side of the air cylinder 120 to retract the tilt arm 107 back out of engagement with the socket 109 in the fixture block 102. When the tilt arm 107 is fully retracted, it contacts the actuator 125 to close the limit switch 126 which is in the electrical "start" circuit to the motor 33.

The conduit 145 leads through a flow control valve 147 that communicates with a pressure switch 148. The pressure switch 148 is in series with the switch 126 in the circuit for the motor 33 and closes to start the motor 33 only after all cylinders including cylinders 42 and 42' have bottomed and the air pressure in the switch 148 builds up to a predetermined value. The air conduit 145 also branches into lines 149 and 149' which communicate through flow control valves 150 and 150' with the air cylinders 42 and 42' which swing the frames 38 and 38' to move the grinding wheels 35 and 34, respectively, into engagement with the lens blank.

Because the grinding wheels 34 and 35 are fed into the lens blank L by air under pressure in cylinders 42 and 42', and because it is desirable that each grinding wheel 34 or 35 passes around the edge it is beveling more than once in order to insure a smooth, continuous surface, each cycle of the machine normally includes more than one revolution of the work shaft 21 and the lens L. To this end, the length of a grinding cycle for any particular lens L is controlled by an adjustable timer 151 which causes the motor 33 to be energized for a predetermined period of time. In order that the work support shaft 21 will be stopped in predetermined angular position so that the tilt arm 107 can enter the socket 109 of the lens fixture block 102, a limit switch 152 is located adjacent the work shaft 21 and is contacted by a sharp lobe 153 on the shaft 21 to open the switch 152 once each time that the shaft 21 revolves. The limit switch 152 is connected in a parallel electrical circuit with the timer 151. After the timer 151 opens its branch of the circuit, the motor 33 will be stopped the next time that the lobe 53 opens the switch 152. The parallel circuit that includes the timer 151 and switch 152 is in series electrical circuit with switches 126 and 148. The timer 151 and the limit switch 152 also control a solenoid relay 154 which is actuated by the opening of both the timer 151 and switch 152 to shift the two-way air valve 136 to supply air from the supply line 137 to an air header 155 and simultaneously to close off the air to the air header 138.

Air supplied to the header 155 flows through a flow control valve 156 to the rear side of the air cylinder 120 to cause the tilt arm 107 to extend forwardly into engagement with the socket 109 of the fixture block 102. At the same time, air from the header 155 is communicated through an air control valve 157 to the bottom side of the air cylinder 25 to cause the lens holddown shaft 27

to move upwardly and make possible the removal of the finished lens from the work table 22. At the same time, air is also supplied through a conduit 158 to branch lines 159 and 159' and through flow control valves 160 and 160' to the cylinders 42 and 42' to retract the grinding wheels 34 and 35. As previously described, the springs 43 and 43' cushion the retractile movements.

When the air pressure in the header 155 reaches a predetermined pressure, a sequence valve 161 connected thereto by a branch header 162, is actuated to supply air through a flow control valve 163 to the top end of the air cylinder 127 to extend its piston 128 and swing the tilt arm 107 upwardly. Upward movement of the tilt arm 107 raises the lens positioning fixture 100 to its upper position. The cycle for the machine is now complete and the operator takes out the ground lens L and inserts a blank in position on the lens table 22.

In the following description of the way in which a cam, such as the cam 45, controls a machine embodying the invention to grind the finished plan contour and beveled edges of a lens, and in order to explain the geometrical relationships of the two-dimensional cam to the three dimensional curved edge of the lens, certain reference lines and planes will be used.

The intersection of the upper bevel with the generally axially extending side surfaces of the periphery of the lens will be called the "line of intersection of the upper bevel." The term "reference plane for the upper beveled edge" of the lens shall mean that plane normal to the "axis of rotation" of the lens which passes through the lowest point of the "line of intersection of the upper bevel." The axial displacement of any point on the "line of intersection of the upper bevel" from the "reference plane for the upper beveled edge" will be called the "vertical displacement" of the upper bevel at that point.

The intersection of the lower bevel with the generally axially extending side surfaces of the periphery of the lens will be called the "line of intersection of the lower bevel." The term "reference plane for the lower beveled edge" of the lens shall mean that plane normal to the "axis of rotation" of the lens which passes through the uppermost point of the "line of intersection of the lower bevel." The axial displacement of any point on the "line of intersection of the lower bevel" from the reference plane for the lower bevel will be called the "vertical displacement of the lower bevel" at that point.

As previously indicated, the grinding wheel 34 grinds the top bevel on the lens L and the grinding wheel 35 grinds the lower bevel on the lens L. FIGURE 7 of the drawings shows the grinding wheel 34 in contact with the center of the top of the edge of the lens, i.e., at a part of the lens indicated at 0° in FIG. 11, which is a high point on the lens, and shows the grinding wheel contacted at approximately two-thirds of the way up its height. FIGURE 8 of the drawing shows the grinding wheel 34 grinding a bevel on one of the corners of the lens and shows the grinding wheel contacted at approximately half way of the way up its height. It can, therefore, be seen that as the shaft 21 revolves to bring different points of the periphery of the lens into position to be ground by the grinding wheel 34, the grinding wheel 34 must be moved radially toward and away from the lens blank not only increments which are functions of the radial distances of the points on the periphery being ground from the center of the lens, but also additional increments which compensate for the vertical displacement of the periphery of the lens from its reference plane.

First, considering only changes in the distance of the periphery of the lens from its center, it is necessary only to move the grinding wheel toward and away from the center in order to grind off excess glass. This is controlled by decreasing and increasing the radius of the cam 45 at the same angular positions to move the grinding wheel in directly proportional distances.

Second, considering the vertical displacement of the periphery of the lens, and assuming for discussion that the lens is circular in plan so that its radius is constant, when the periphery of the lens rises, it is necessary to move the grinding wheel away from the center of the lens. This can be seen by comparing the points of contact of the grinding wheel 34 with the lens in FIGS. 8 and 7. Conversely, if the vertical displacement of the lens periphery decreases (i.e., it gets lower relative to the grinding wheel 34), the wheel 34 must be moved toward the center of the lens to maintain a constant radius of the lens. Movements of the grinding wheel 35 to provide for vertical displacement of the lens periphery are, of course, reversed because it grinds on the under side and its bevel is reversed.

FIGURE 9 of the drawing shows the grinding wheel 35 contacting the bottom bevel of the lens at the same high point on the periphery thereof that is shown in FIG. 7. The lens having been rotated approximately 180° from its position in FIG. 7 because the grinding wheels 34 and 35 contact the lens on opposite sides. FIGURE 10 shows the grinding wheel 35 contacting the same lowermost point of the periphery of the lens L as is shown in FIG. 8.

Because of the conical shape of the cam followers 49 and 49', the upper and lower edges of the cam 45 are similarly beveled and although any complementary bevels may be employed, it is convenient to use 45 degrees. It should also be noted that the actual plan profile of the cam 45 is not important. The upper and lower bevels of the cam are the control surfaces and they may meet at a sharp angle or the cam material may be cut away to provide a peripheral surface extending between the bevels that is parallel to the axis of rotation of the cam 45.

FIGURE 11 of the drawings shows the development of the upper bevel and resulting edge contour of the cam that is necessary for grinding the top bevel of a lens by the grinding wheel 34. It is assumed that the lens L is supported for rotation on an axis 200 normal to the plane of the paper and that its shape is that shown by the solid line indicated by the reference number 201 in the upper figure marked "LENS" in FIGURE 11, and also shown in FIGS. 7–10, inclusive. The inner edge of the upper bevel of the lens is shown by a line indicated by the reference number 201*a* and is at a substantially constant distance from the edge 201 determined by the angularity of the grinding wheel 34 by which it is ground (as can best be seen in FIGS. 7—10). A base circle indicated by the reference number 202 is drawn around the axis 200 so that it is tangent to the contour line 201 at the radial line marked 0°. In similar fashion, a base circle 203 is constructed about the axis 200 for the cam 45, the radii of the circles 202 and 203 being proportional to the radii of the cam follower 49' and the grinding wheel 34. Corresponding radial lines, such as those indicated at 30°, 60°, 90°, 120°, 150°, and 180° are drawn for the lens and for the cam, and the distances along the radial lines from the base circle 202 to the plan edge 201 of the lens L, as for example the distance indicated by the bracket 204, are brought down and plotted on the cam as radial distances out from the base circle 203. A line, indicated by the reference number 205, connecting the points thus established delineates the edge of the cam which would properly grind the lens if it were flat and not curved in three dimensions.

As can best be seen in FIGS. 7–10, the angles of the beveled faces of the grinding wheels 34 and 35 are identical and are selected to produce upper and lower bevels, respectively, at the desired angle on the peripheral edges of the ground lens. Both of the grinding wheels project inwardly toward the center of the lens beyond the edge contour 201. The upper bevel grinding wheel 34 must be moved away from the lens center an additional increment when the vertical displacement of the periphery of the lens increases and the lower bevel grinding wheel 35

must be moved toward the lens center when the vertical displacement increases.

This vertical displacement increment may be calculated in the following manner:

The lowest points on the "line of intersection of the upper bevel," in this case at the "corners" of the lens indicated by the reference numbers 206, 207, 208, and 209 (upper part of FIG. 11), are established and reference lines "A"–"H" are drawn to points on "projections" of the curved elevation of the lens, such as the "Top Edge Projection," to which reference lines "A" and "B" lead from the corners 206 and 207. The intersections of the reference lines "A" and "B" with the edge 201 are the lowest points of the "line of intersection of the upper bevel" which establish the "reference plane for the upper bevel," indicated by the number 210, above which the periphery of the lens rises as its "vertical displacement" increases and toward which the periphery returns as its "vertical displacement" decreases.

At the intersection of the radial line marked "0°," the "vertical displacement" is the distance from the reference plane 210 to the edge 201, this distance being indicated by the bracket 211. Because the "reference plane" 210, by definition, is normal to the axis of rotation of the lens and normal to the axis of rotation of the grinding wheel 34, the angle of the edge of the grinding wheel 34 may be plotted directly on the "Top Edge Projection" at the reference plane 210, and such grinding wheel edge is indicated by the line 212.

It follows that the grinding wheel 34 must be moved outwardly away from the center of the lens by an additional increment, indicated by the distance marked in order to grind the upper bevel at the greater "vertical displacement" indicated by the bracket 211. This distance is plotted on the "0°" radial line of the cam development as an addition to the radius of the upper bevel of the cam at that point and is indicated by the bracket 213 on the "CAM" in FIG. 11.

The same procedure is carried out to derive other "vertical displacement" increments, such as that indicated by the reference number 214 at the "Side Edge Projection" of the "LENS" and the right side of the "CAM" in FIG. 11. The "vertical displacement" increment 214 is added to the increment 204 to produce retraction of the grinding wheel 34 to reflect the greater radius of the lens at the "90°" radial line (increment 204) and the "vertical displacement" of the lens periphery at the "90°" radial line (increment 214).

Similar indications are included on the "LENS" and "CAM" in FIG. 11, for the radial line at 180° on the "Bottom Edge Projection" in which the "vertical displacement" increment is indicated by the brackets 215. Construction lines are also shown from the 30° and 60° radial lines to the "Top Edge Projection," from the 120° radial line to the "Side Edge Projection" and from the 150° radial line to the "Bottom Edge Projection." In addition, of course, a left "Side Edge Projection" would also be plotted and intervening construction lines as needed at intervening radii drawn to the proper "projections."

Connecting the outer ends of all of the "vertical displacement" increments such as those indicated by the reference numbers 213, 214, 215 produces the inner edge of the upper bevel of the cam that is necessary to grind the three-dimensionally curved bevel on the upper peripheral edge of the lens L, such line being indicated in FIG. 11 and in FIGS. 3 and 7 by the reference number 216.

The outermost periphery of the cam 45, indicated by the reference number 217 in FIGS. 3, 7, and 11, is formed by the intersection of the upper beveled camming surface 218 which extends outwardly and downwardly from the inner edge 216 of the bevel with a lower beveled camming surface 219 of the cam 45. The upper and lower beveled surfaces 218 and 219 are cut to be complementary to the surfaces of the conical cam followers 49' and 49.

The principles and procedures discussed are also employed for laying out the shape of the inner edge 220 (FIGS. 3 and 7) of the lower bevel camming surface 219 of the cam 45.

While the procedure outlined can be utilized to develop and lay out the contours of the upper and lower bevels 218 and 219 of the two-dimensional cam 45 which is used to grind the three-dimensionally curved periphery of the lens L, according to further principles of the present invention, the cam 45 can be and usually is contoured in the machine itself, using a replica 221 (FIG. 12) of a finished ground lens L as a template. As shown in FIG. 12, the bevels on the cam 45 may be ground by removing the grinding wheels 34 and 35 from the spindle 36' and 36 substituting beveled milling cutters 222 and 222'. The cutters 222 and 222' are mounted on the lower ends of arbors 223 which are bolted to tapered collars 224. The collars 224 are secured to the lower ends of the spindles 36 and 36'. The milling cutters 222 and 222' are conical, having the same taper as the conical cam followers 49 and 49', so that their lines of cutting contact shape the same bevels on the blank for the cam 45. Annular template followers 225 and 225' which have tapered edges 226 and 226' of the same angularity as the bevels on the template 221 and on the grinding wheels 34 and 35 have central openings 227 that are slightly larger than the largest diameter of the arbors 223. Each of the template followers 225 or 225' is supported in position for contact with the respective bevel on the template 221 by a U-bracket 228 to which it is bolted. The brackets 228 are removably mounted on the lower ends of the vertical slides 51 in the same manner as brackets 50 for the cam followers 49 and 49'.

By substituting the template 221 for a lens blank and reversing the positions of the followers and the cutters, the machine of the invention directly produces cams 45 properly contoured for repetitively grinding lenses L to contours identical with the template 221.

Having described my invention, I claim:

1. A machine for cutting a bevel of constant angularity on one peripheral edge of a work piece that has a non-circular periphery that extends around an axis of the work piece and the vertical displacement of which periphery measured from a base plane normal to said axis varies at different locations of the periphery around the axis, said machine comprising: a generally disc-shaped control cam having an axis generally normal to said generally disc-shaped cam and about which axis the periphery of said cam extends; an axially extending work support shaft; means for supporting a work piece and said cam coaxially on said work shaft at axially spaced positions; a machine spindle positioned to one side of the axis of said work support shaft; a spindle support mounting said machine spindle for translation toward and away from said work shaft, a cam follower carried by said spindle support for engaging said cam, a circular cutter mounted on said spindle for engaging a work piece, said circular cutter having a periphery defined by revolving a straight line about the axis of said spindle and which periphery of said cutter engages said work piece on a line which extended intersects the axis of said work support shaft at the desired predetermined angle of bevel for the work piece, said periphery of said cutter having an axial dimension relative to said work support which is greater than the total vertical displacement of the periphery of said work piece so that points on said periphery of said work piece at various vertical displacements above said base plane contact points on the periphery of said cutter at various vertical displacements above a cutter base plane normal to the axis of said spindle, means for urging said spindle support toward said work support shaft to bring said cam follower into engagement with said cam, means for rotating said spindle, and means for producing relative

rotation of said work support shaft and spindle support about the axis of said work support shaft, the inner plan edge contour of said cam being described by a line connecting points each of which is spaced along a radius from the axis of said work support shaft a distance which is the sum of an increment which is a function of the distance from said axis of said work support shaft along a corresponding radius of the work piece to the periphery thereof, and an increment which is proportional to the vertical displacement of the periphery of the work piece at such radius relative to said base plane of the work piece.

2. A machine for cutting a bevel of constant angularity on one peripheral edge of a work piece that has a non-circular periphery that extends around an axis of the work piece and the vertical displacement of which periphery measured from a base plane normal to said axis varies at different locations of the periphery around the axis, said machine comprising: a generally disc-shaped control cam having an axis generally normal to said generally disc-shaped cam and about which axis the periphery of said cam extends; an axially extending work support shaft; means for suporting a work piece and said cam coaxially on said work shaft at axially spaced positions; a machine spindle positioned to one side of the axis of said work support shaft; a spindle support mounting said machine spindle for translation toward and away from said work shaft, a cam follower carried by said spindle support for engaging said cam, a circular cutter mounted on said spindle for engaging a work piece, said circular cutter having a periphery defined by revolving a straight line about the axis of said spindle and which periphery of said cutter engages said work piece on a line which extended intersects the axis of said work support shaft at the desired predetermined angle of bevel for the work piece, said periphery of said cutter having an axial dimension relative to said work support which is greater than the total vertical displacement of the periphery of the work piece so that points on said periphery of the work piece at various vertical displacements above said base plane contact points on the periphery of said cutter at various vertical displacements above a cutter base plane normal to the axis of said spindle, means for urging said spindle support toward said work support shaft to bring said cam follower into engagement with said cam, means for rotating said spindle, and means for producing relative rotation of said work support shaft and spindle support about the axis of said work support shaft, the inner plan edge contour of said cam being described by a line connecting points each of which is spaced along a radius from the axis of said work support shaft a distance which is the sum of an increment which is a function of the distance from said axis of said work support shaft along a corresponding radius of said work piece to the periphery thereof, and an increment which is proportional to the vertical displacement of the periphery of the work piece at such radius relative to said base plane of the work piece, and a work piece alignment fixture carried by said axially extending work shaft for axial movement between a position radially opposite said position of the work piece wherein the work piece is positioned to be abutted by said circular cutter, and a position spaced axially therefrom where said fixture is out of the way of said circular cutter.

3. A machine for cutting a bevel of constant angularity on one peripheral edge of a work piece that has a non-circular periphery that extends around an axis of the work piece and the vertical displacement of which periphery measured from a base plane normal to said axis varies at different locations of the periphery around the axis, said machine comprising: a generally disk-shaped control cam having an axis generally normal to said generally disk-shaped cam and about which axis the periphery of said cam extends; an axially extending work support shaft; means for supporting a work piece and said cam coaxially on said work shaft at axially spaced positions; a machine spindle positioned parallel to the axis of said work support shaft; a spindle support mounting said machine spindle for translation toward and away from said work shaft, a cam follower carried by said spindle support for engaging said cam, a conical cutter mounted on said spindle for engaging a work piece on said support shaft, the periphery of said conical cutter being a supplement to the angularity of the desired bevel of the work piece, said periphery of said conical cutter having an axial dimension relative to said work support which is greater than the total vertical displacement of the periphery of said work piece so that points on said periphery of said work piece at various vertical displacements above said base plane contact points on the periphery of said cutter at various vertical displacements above a cutter base plane normal to the axis of said spindle, means for urging said spindle support toward said work support shaft to bring said cam follower into engagement with said cam, means for rotating said spindle, and means for producing relative rotation of said work support shaft and spindle support about the axis of said work support shaft, the inner plan edge contour of said cam being described by a line connecting points each of which is spaced along a radius from the axis of said work support shaft a distance which is the sum of an increment which is a function of the distance from said axis of said work support shaft along a corresponding radius of said work piece to the periphery thereof, and an increment which is proportional to the vertical displacement of the periphery of said work piece at such radius relative to said base plane of said work piece.

4. A machine for simultaneously cutting bevels of desired pre-selected constant angularity on the upper and lower peripheral edges of a work piece that has a non-circular periphery that extends around an axis of the work piece and the vertical displacement of which periphery measured from a base plane normal to said axis varies at different locations of the periphery around the axis, said machine comprising: a generally disc-shaped control cam having an axis generally normal to said generally disc-shaped cam and about which axis the periphery of said cam extends; an axially extending work shaft; means supporting a work piece and said cam coaxially on said work shaft at predetermined axial positions; the upper and lower edges of the periphery of said cam being oppositely beveled relative to said axis of said work support shaft; first and second spindles; first and second spindle supports each one of which mounts a respective one of said spindles for translation toward and away from said work shaft; first and second cam followers each mounted on a respective one of said spindle supports; one of said cam followers having a surface which engages one of the beveled edges of said cam, and the other of said cam followers having a surface which engages the other of said beveled edges of said cam; first and second circular cutters each mounted on a respective one of said spindles for rotation therewith, said first circular cutter having a periphery defined by revolving a straight line about the axis of said spindle and which periphery engages the work piece on a line which extended intersects the axis of said work support shaft at the same angularity of said desired upper bevel of the blank, and said second circular cutter having a periphery defined by revolving a straight line about the axis of said spindle and which periphery engages the work piece on a line which extended intersects the axis of said work support shaft at the same angularity of said desired lower bevel of the work piece; said peripheries of said cutters having an axial dimension relative to said work support shaft which is greater than the total vertical displacement of the periphery of the bevel to be formed on the work piece so that points on said periphery of the work piece at various vertical displacements above the reference plane for the respective bevel of the work piece contact points on the periphery of the respective cutter at various vertical displacements above a respective cutter base normal to the axis of said spindle; means for urging said

spindle supports toward said work support shaft to bring said cam followers into engagement with said cam; means for rotating said spindle; means for producing relative rotation of said work support shaft and said spindle supports about the axis of said work support shaft, the inner plan edge contour of said bevel of said cam contacted by said one of said cam followers being described by a line connecting points each of which is spaced along a radius from the axis of said work support shaft a distance which is the sum of an increment which is a function of the distance from said axis of said work support shaft along a corresponding radius of the work piece to the periphery thereof, and an increment which is proportional to the vertical displacement of the upper bevel of the work piece at such radius relative to the reference plane for said upper bevel; and the inner plan edge contour of said bevel of said cam contacted by said other one of said cam followers being described by a line connecting points each of which is spaced along a radius from the axis of said work support shaft a distance which is the sum of an increment which is a function of the distance from said axis of said work support shaft along a corresponding radius of the work piece to the periphery thereof, and an increment which is proportional to the vertical displacement of the lower bevel of the work piece at such radius relative to the reference plane of said lower bevel.

5. A machine for simultaneously cutting bevels of desired pre-selected constant angularity on the upper and lower peripheral edges of a work piece that has a non-circular periphery that extends around an axis of the work piece and the vertical displacement of which periphery measured from a base plane normal to said axis varies at different locations of the periphery around the axis, said machine comprising: a generally disc-shaped control cam having an axis generally normal to said generally disc-shaped cam and about which axis the periphery of said cam extends; an axially extending work shaft; means supporting the work piece and said cam coaxially on said work shaft at predetermined axial positions; the upper and lower edges of the periphery of said cam being oppositely beveled relative to said axis of said work support shaft; first and second spindles; first and second spindle supports each one of which mounts a respective one of said spindles for translation toward and away from said work shaft; first and second cam follows each mounted on a respective one of said spindle supports; one of said cam followers having a surface which engages the upper bevel of said cam and the other of said cam follows having a surface which engages the lower bevel of said cam; first and second circular cutters each mounted on a respective one of said spindles for rotation therewith, said first circular cutter having a periphery defined by revolving a straight line about the axis of said spindle and which periphery engages the work piece on a line which extended intersects the axis of said work support shaft at the same angularity of said desired upper bevel of the work piece, and said second circular cutter having a periphery defined by revolving a straight line about the axis of said spindle and which periphery engages the work piece on a line which extended intersects the axis of said work support shaft at the same angularity of said desired lower bevel of the work piece; said peripheries of said cutters having an axial dimension relative to said work support shaft which is greater than the total vertical displacement of the periphery of the bevel to be formed on the work piece so that points on said periphery of the work piece at various vertical displacements above the reference plane for the respective bevel of the work piece contact points on the periphery of the respective cutter at various vertical displacements above a respective cutter base plane normal to the axis of said spindle; means for urging said spindle supports toward said work support shaft to bring said cam followers into engagement with said cam; means for rotating said spindles; means for producing relative rotation of said work support shaft and said spindle supports about the axis of said work support shaft, the inner plan edge contour of said bevel of said cam contacted by one of said cam followers being described by a line connecting points each of which is spaced along a radius from the axis of said work support shaft a distance which is the sum of an increment which is a function of the distance from said axis of said work support shaft along a corresponding radius of the work piece to the periphery thereof, and an increment which is proportional to the vertical displacement of the upper bevel of the work piece at such radius relative to the reference plane for said upper bevel, and the inner plan edge contour of said bevel of said cam contacted by the other one of said cam followers being described by a line connecting points each of which is spaced along a radius from the axis of said work support shaft a distance which is the sum of an increment which is a function of the distance from said axis of said work support shaft along a corresponding radius of the work piece to the periphery thereof, and an increment which is proportional to the vertical displacement of the lower bevel of the work piece at such radius relative to the reference plane of said lower bevel, and a work piece alignment fixture carried by said axially extending work shaft for axial movement between a position generally radially opposite said circular cutters for aligning the work piece relative to said cam, and a position spaced axially therefrom where said fixture is out of the way of said circular cutters.

6. A machine for simultaneously cutting bevels of desired pre-selected constant angularity on the upper and lower peripheral edges of a work piece that has a non-circular periphery that extends around an axis of the work piece and the vertical displacement of which periphery measured from a base plane normal to said axis varies at different locations of the periphery around the axis, said machine comprising: a generally disc-shaped control cam having an axis generally normal to said generally disc-shaped cam and about which axis the periphery of said cam extends, an axially extending work shaft, means supporting the work piece and said cam coaxially on said work shaft at predetermined axial positions, the upper and lower edges of the periphery of said cam being oppositely beveled relative to said axis of said work support shaft, first and second spindles positioned parallel to the axis of said work support shaft, first and second spindle supports each one of which mounts a respective one of said spindles for movement radially toward and away from said work shaft, first and second cam followers each mounted on a respective one of said spindle supports; said first cam follower having a surface which engages the upper bevel of said cam along a line of contact which corresponds in angularity relative to said axis of said work support shaft to that of said upper bevel of said cam and said second cam follower having a surface which engages the lower bevel of said cam along a line of contact which corresponds in angularity relative to said axis of said work support to that of said lower bevel of said cam, first and second conical cutters each mounted on a respective one of said spindles for rotation therewith, the periphery of said first conical cutter being a supplement to the angularity of the desired upper bevel of the work piece and the periphery of said second conical cutter being supplementary with the angularity of the desired lower bevel of the work piece, said first and second cutters being spaced axially of said work shaft so that said first cutter engages the upper peripheral edge of the work piece and said second cutter engages the lower peripheral edge of the work piece, said peripheries of said cutters having axial dimensions greater than the total vertical displacement of the periphery of the work piece so that points on said periphery of the work piece at various vertical displacements above the reference plane for the respective bevel of the work piece contact points on the periphery of respective cutters at various vertical displacements above a respective cutter base plane normal to

the axis of said spindle, means for urging said spindle supports toward said work support shaft to bring said cam followers into engagement with said cam, means for rotating said spindles, and means for producing relative rotation of said work support shaft and said spindle supports about the axis of said work support shaft, the inner plan edge contour of said upper bevel of said cam being described by a line connecting points each of which is spaced along a radius from the axis of said work support shaft a distance which is the sum of an increment which is a function of the distance from said axis of said work support shaft along a corresponding radius of the work piece to the periphery thereof and an increment which is proportional to the vertical displacement of the upper bevel of the work piece at such radius relative to the reference plane for said upper bevel, and the inner plan edge contour of said lower bevel of said cam being described by a line connecting points each of which is spaced along a radius from the axis of said work support shaft a distance which is the sum of an increment which is a function of the distance from said axis of said work support along a corresponding radius of the work piece to the periphery thereof, and an increment which is proportional to the vertical displacement of the lower bevel of the work piece at such radius relative to the reference plane of said lower bevel.

7. An edge beveling machine for blanks having opposed generally disc-shaped surfaces: a generally disc-shaped cam having an axis about which the periphery of said cam extends, a rotatable work support shaft extending along said axis of said cam, first means for supporting a work blank on said work shaft in a first axial direction from said cam and generally parallel to said cam, said means being adapted to rotate with said shaft to hold the blank nonrotatably relative to said work support shaft, a rotatable work machining element adapted to contour the peripheral edge of a blank supported in said means when said blank is rotated past said machining element by said rotatable work support shaft, a blank locating structure carried by said work support shaft for axial movement from a normal position spaced in one axial direction from the plane in which a work blank is supported by said first means to a position where a work blank is abutted and located by said blank locating structure when properly supported by said first means, said blank locating structure having an opening extending generally normal to and away from said shaft, cyclic means for causing said work supporting shaft to rotate a generally predetermined number of times and stop in a predetermined location after each cycle, an extensible shifting arm actuated by said cyclic means, said extensible shifting arm having an end adapted to project into abutment with the sidewalls of said opening in said blank locating structure, and means extending said shifting arm into said opening and thereafter shifting said blank locating structure from its normal position to its blank locating position each time said cyclic means stops said work supporting shaft in said predetermined position.

8. A machine for contouring a peripheral edge of a work piece that has a non-circular periphery that extends around an axis of the workpiece, said machine comprising: a generally disc-shaped control cam having an axis generally normal to said generally disc-shaped cam and about which axis the periphery of said cam extends; an axially extending work support shaft; means for supporting a work piece and said cam coaxially on said work shaft at axially spaced positions; a machine spindle positioned to one side of the axis of said work support shaft; a spindle support mounting said machine spindle for translation toward and away from said work shaft, a cam follower carried by said spindle support for engaging said cam, a circular cutter mounted on said spindle for engaging a work piece, means for urging said spindle support toward said work support shaft to bring said cam follower into engagement with said cam, means for rotating said spindle, means for producing relative rotation of said work support shaft and spindle support about the axis of said work support shaft, and a work piece alignment fixture carried by said axially extending work shaft for axial movement between a position radially opposite said position wherein said work shaft supports the work piece in a position to be abutted by said circular cutter, and a position spaced axially therefrom where said fixture is out of the way of said circular cutter.

9. The method of machining the edges of work blanks having opposed generally disc-shaped surfaces, said method comprising: supporting a master work blank and a cam blank on a common predetermined axis and spaced a generally predetermined axial distance apart with both the cam and work blank extending generally transversely of said axis, mounting a first cam follower and a first rotary cutting element on a spindle in axially spaced positions and moving the spindle in a predetermined path so that said cam follower contacts the master work blank on a line of contact which is fixed relative to the spindle and said rotary cutting element contacts the cam blank on a line of contact which is fixed relative to the spindle, providing relative rotation between said axis and said spindle while said cam follower is in contact with said finished master blank and said rotary cutting element is in contact with said cam blank to generate the desired contour on said cam blank, replacing said first cam follower with a second rotary cutting element having a line of cutting contact that is fixed with respect to said spindle in the same relationship as was the line of contact of said first cam follower, replacing said first rotary cutting element with a second cam follower having a line of contact which is fixed with respect to said spindle in the same relationship as was the line of contact of said first cam follower, replacing the master work blank with a work blank to be machined, moving said spindle along said predetermined path to bring said second cam follower into contact with the machined cam blank while said second rotary cutting element engages the work blank to be machined, and producing relative rotation between said axis and said spindle, whereby blanks placed in the position of said finished machine blank are contoured to the identical shape of said finished machined master work blank.

10. The method of beveling the outer and inner peripheral edges of eye glass lens comprising: supporting a master lens the outer and inner peripheral edges of which have been beveled to a desired contour and a cam blank transversely of and generally centrally located on a common predetermined axis and with the lens lying in a first axial direction from the cam blank; mounting a first cam follower and a first rotary cutting element on a first spindle in an axial spaced apart relationship, and moving said first spindle in a predetermined path so that said first cam follower contacts the outer peripheral beveled edge of the master lens on a line of contact which is fixed relative to the first spindle and said first rotary cutting element contacts one peripheral corner edge of the cam blank on a line of contact which is fixed relative to the spindle; mounting a second cam follower and a second rotary cutting element on a second spindle in an axially spaced apart relationship, and moving said second spindle in a predetermined path so that said second cam follower contacts the inner peripheral beveled edge of the master lens on a line of contact which is fixed relative to the second spindle and said second rotary cutting element contacts the other peripheral corner edge of the cam blank on a line of contact which is fixed relative to the spindle; providing relative rotation between said axis and said first and second spindles while said first and second cam followers engage the outer and inner beveled edges of the finished beveled lens; replacing said first and second cam followers with respective first and second rotatable grinding wheels the lines of cutting contact of which coincide with the respective lines of contact of respective first and second cam followers; replacing said first and second cut-

ting elements with respective third and fourth cam followers the third of which engages the cam along a line of contact oriented identically with the cutting line of contact of said first work cutting element and the fourth of which engages the cam along a line of contact oriented identically with the cutting line of contact of said second work cutting element; replacing the master lens with a lens to be beveled; moving said first and second spindles along said predetermined paths to bring said third and fourth cam followers into contact with the machine blank while said first and second grinding wheels engage the lens to be beveled; and producing relative rotation between said axis and said first and second spindles while said third and fourth cam followers engage said cam, whereby lens blanks placed in the position of said finished lens are contoured to the identical shape of said finished beveled lens.

11. In a machine for contouring a peripheral edge of a work piece that has a non-circular periphery that extends around an axis of the work piece, a work support shaft, means for coaxially supporting a work piece and a generally disc-shaped cam in axially spaced apart relationship on said work support shaft, a machine spindle positioned to one side of said work support shaft, a movable support mounting said machine spindle for movement toward and away from said work shaft along a predetermined path, a first cam follower adapted to be detachably fixed to said movable support for engaging a work piece supported on said work support shaft, said first cam follower having a surface for contacting said work piece along a line of contact which is fixed relative to said spindle, a first rotary cutting element adapted to be detachably fixed to said spindle in position to contact and machine said cam along a line of contact which is fixed relative to said spindle, means for producing relative rotation of said work support shaft and said machine spindle, a second rotary cutting element adapted to be detachably fixed to said spindle in place of said first cam follower for contacting a work piece supported on said work support shaft along a line of contact which is identical with said line of contact of said first cam follower, a second cam follower adapted to be detachably fixed to said movable support in place of said first rotary cutting tool for contact with said cam along a line of contact identical with that of said first rotary cutting element, whereby said cam can be given a contour determined by a finished machined work piece using said first cam follower and first rotary cutting element, and thereafter work pieces can be substituted for the finished machined work piece and given a contour identical to that of said finished machined work piece using said second cam follower and said second rotary cutting element.

12. In a machine for beveling the outer and inner peripheral edges of eye glass lenses that have a noncircular periphery that extends around an axis of the lens, a work support shaft, means for coaxially supporting a lens and a generally disc-shaped cam in axially spaced apart relationship on said work support shaft, first and second machine spindles positioned laterally of said work support shaft, first and second movable supports mounting respective first and second machine spindles for movement along respective paths toward and away from said work shaft, first and second cam followers adapted to be detachably fixed to respective first and second movable supports so that said first cam follower engages the outer peripheral edge of an eye glass lens supported by said work support shaft along a line of contact fixed relative to said first spindle, and said second cam follower engages the inner peripheral edge of the eye glass lens along a line of contact fixed relative to said second spindle, first and second rotary cutting elements adapted to be detachably fixed to respective first and second spindles in position so that said first cutting element engages one peripheral corner edge of said generally disc-shaped cam along a line of contact fixed relative to said first spindle and said second cutting element engages the other peripheral corner edge of the cam along a line of contact fixed relative to said second spindle, said lines of contact forming bevels on said cam, means for providing relative rotation between said work support shaft and said first and second spindles, third and fourth rotary cutting elements adapted to be detachably fixed to respective first and second spindles in place of respective first and second cam followers for contacting a lens blank supported by said work support shaft along lines of contact which are identical with said lines of contact of respective first and second cam followers, third and fourth cam followers adapted to be detachably fixed to respective first and second supports in place of respective first and second rotary cutting elements for contact with said cam along lines of contact which are identical with those of respective first and second rotary cutting elements, and whereby said cam can be given top and bottom peripheral beveled edge contours determined by the beveled edges of a finished beveled lens using said first and second cam followers and rotary cutting elements, and thereafter other lens blank substituted for the finished beveled lens can be identically beveled using said third and fourth cam followers and rotary cutting elements.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,158,967 December 1, 1964

Warren E. Reaser

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, line 3, for "line" read -- view --; column 12, line 74, after "base" insert -- plane --; column 13, line 3, for "spindle" read -- spindles --; lines 45 and 48, for "follows", each occurrence, read -- followers --.

Signed and sealed this 13th day of July 1965.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

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