

Dec. 6, 1966

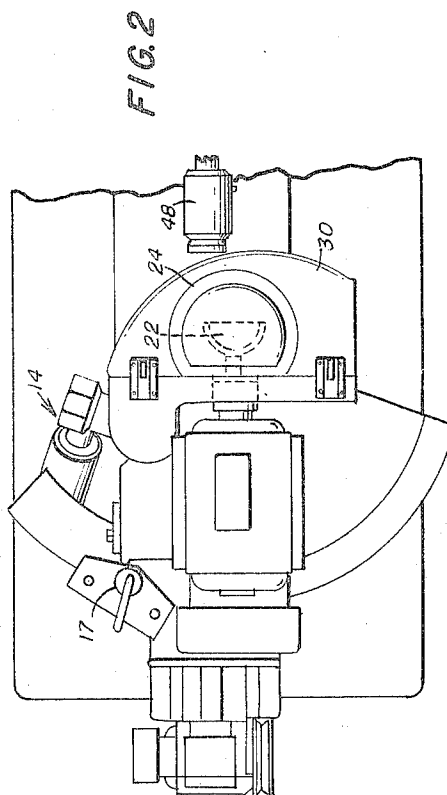
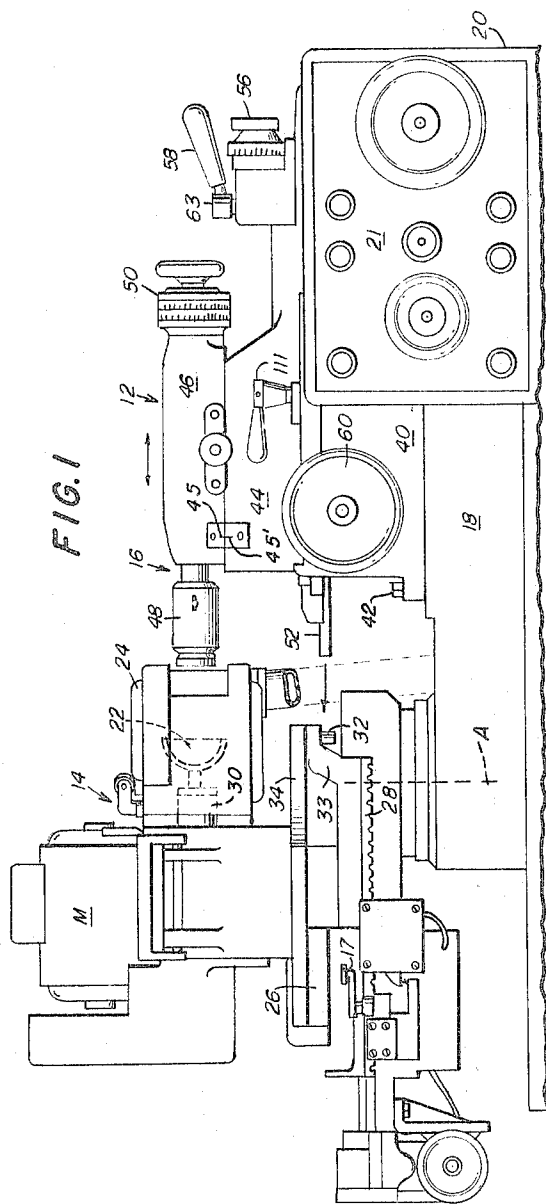
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3,289,355

AUTOMATIC LENS GRINDING MACHINE

Original Filed Dec. 16, 1960

4 Sheets-Sheet 1



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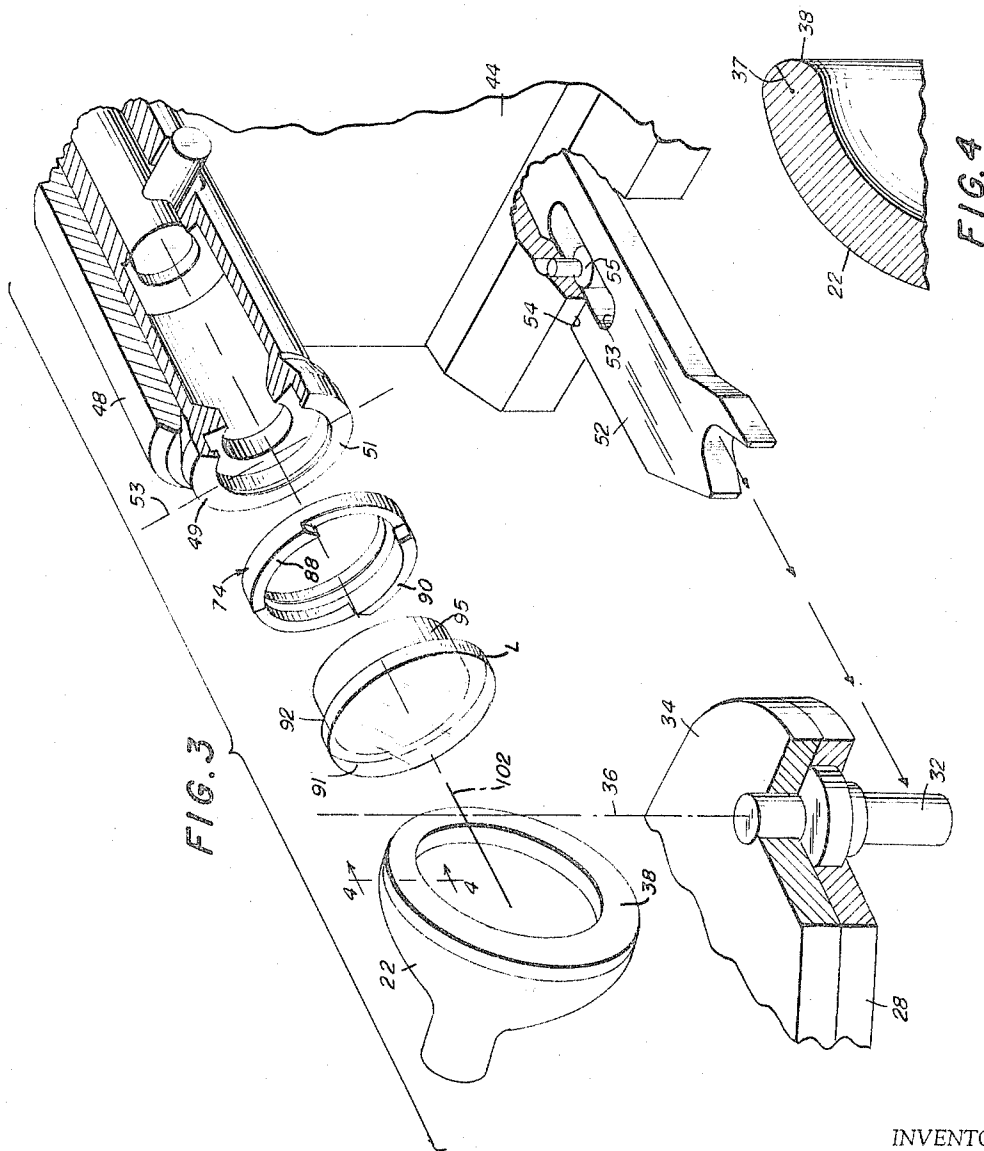
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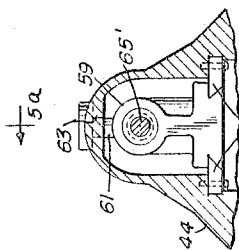
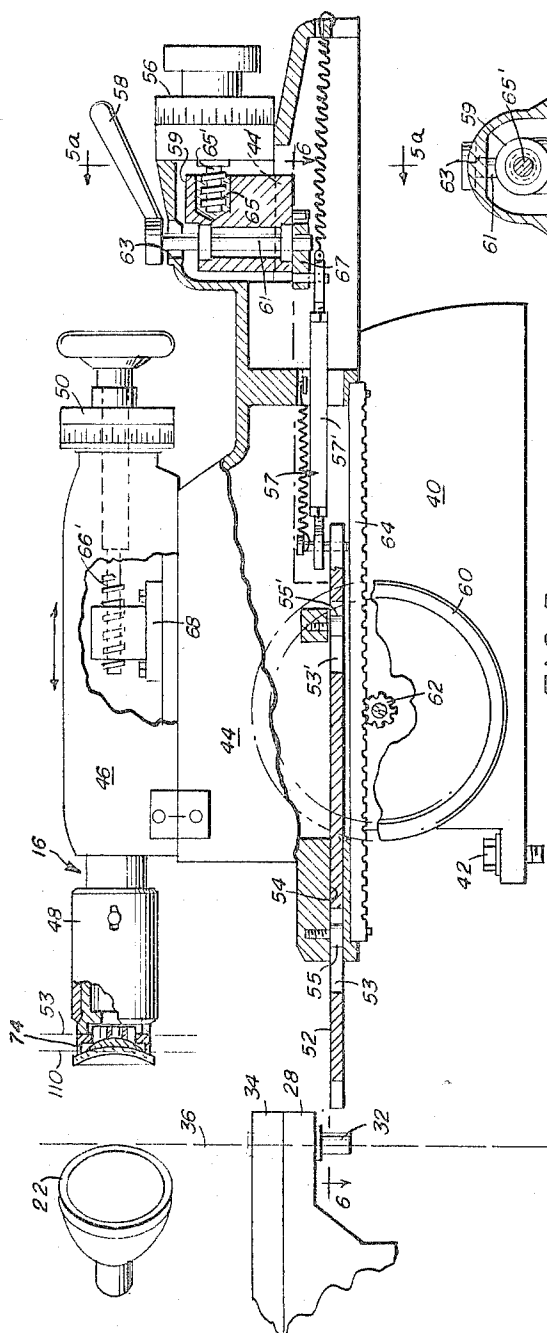
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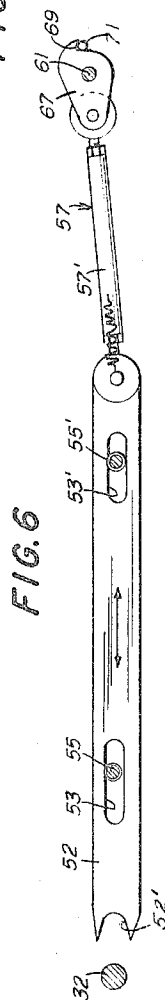


FIG. 6

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4 Sheets-Sheet 4

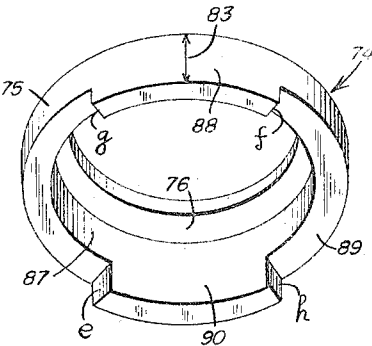


FIG. 7

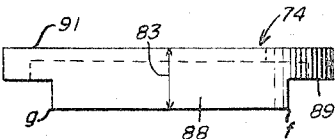


FIG. 8

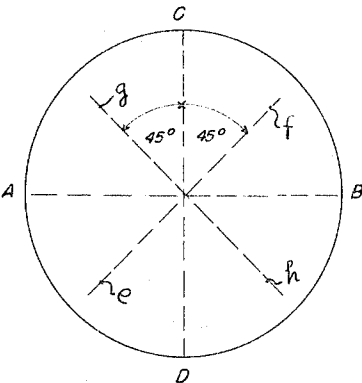


FIG. 9

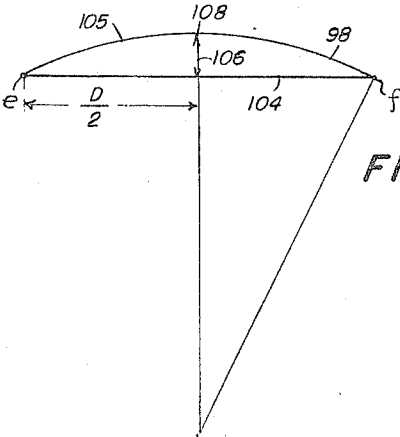


FIG. 10

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AUTOMATIC LENS GRINDING MACHINE

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Continuation of application Ser. No. 76,196, Dec. 16, 1960. This application Apr. 22, 1963, Ser. No. 285,167
4 Claims. (Cl. 51—33)

This is a continuation of the application Serial No. 76,196, filed December 16, 1960, and now abandoned.

This invention relates to an improved apparatus for positioning ophthalmic lenses for grinding and specifically relates to apparatus which automatically situates a lens blank with respect to a grinding tool in a manner which will eliminate many of the inaccuracies and time-consuming steps incident to apparatus available prior to this invention.

In the past it has been necessary to the operation of ophthalmic lens grinding machines, to measure or caliper the lens blank thickness to be ground, compute the amount to be removed, subtract this amount from the original thickness for desired center thickness, and the remaining figure would represent the amount of glass to be removed. If a mistake leading to over-grinding is made in the above outlined procedure, the blank becomes useless and must be discarded.

Therefore, it is an objective of this invention to eliminate the steps of measuring and calipering the lens blank prior to the grinding operation. The invention permits the machine operator to set his machine for grinding without knowledge of the original lens blank thickness. The operator must only know the base curve of the lens and how much glass is to be left at the center thereof. These, of course, are items of information obtained directly from the lens prescription.

Another objective of this invention is to provide a fiber ring support so dimensioned that it will support a lens blank at a given distance from a reference face of the support means such that the exact distance of the apogee of the supported lens surface is automatically determined with respect to the reference face.

A further objective of this invention is to provide such a ring which will support lens blanks in the prescribed manner whether they have a spherical or toric configuration. This is accomplished by a novel four point support means more fully described hereinbelow.

A further objective of this invention is to provide a ring-type support that is capable of being chucked against a spherical or cylindrical surface in such a manner as to eliminate any unwanted prism in the finished lens after grinding.

A still further objective of this invention is to provide means which permit unskilled operators to position a lens blank so that it is accurately situated with respect to an abrading tool so that a desired center thickness of the finished lens is automatically obtained.

Another very important objective of this invention is to provide apparatus by which the lens support assembly may be readily referenced with respect to the abrading tool, regardless of adjustments so that the path of the abrading tool will always be accurately set with respect to the stationary block.

Still another object of the invention is to provide micrometer dials for manually setting two known dimensions so that the thickness of the blanks after grinding will be of a predetermined center thickness regardless of the original thickness.

This invention relates to that type of equipment wherein the generation of a toric surface is accomplished by relatively moving a rotating abrasive wheel of a cup-shape

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design past a stationary lens blank. The arc defined by the swing of the abrading tool will be referred to as the base curve and the curve determined by the angle between the axis of the lens blank and the abrading tool axis will be referred to as the cross-curve.

The particular structure and methods of setting a swing curve to the abrading tool and setting a desired cross-curve on the tool itself is the subject of many ingenious devices, some of which are covered by U.S. patents. The structure for making such paths of travel by itself does not come within the scope of this invention. For instance, an example of a piece of equipment suitable for setting the swing curve and angular attitude of an abrading tool with respect to a lens blank, which would be suitable for use with the instant invention, is described in a United States patent to O. W. Coburn, No. 2,806,327, issued September 17, 1957.

Still another important objective of this invention is to provide apparatus whereby a reference plane between the tool holding assembly and the work holding assembly is established and the two assemblies are capable of movement away from this plane, the setting necessary for the completed lens may be set therein, and the two assemblies moved back into operating positions with the tool and lens in the desired position for grinding.

In general, this machine embodies a positioning system wherein an operator, by merely rotating two dials on a lens holding assembly, to desired curve and thickness settings, according to the prescription of the lens, causes the machine to adjust itself for the proper distance between lens and tool. Another important objective of this invention is to provide a reference point in the same plane as the abrading edge of the tool and associated structure on the lens holding assembly whereby the necessary setting can be made on the machine with respect to the reference point.

A still further objective of this invention is to provide an apparatus for forming compound surfaces on a lens blank of the type having means for presenting an abrading tool transversely of the article to be ground wherein the sweep of the tool produces a base curve along a major curve, and a minor curve is struck, depending on the angle in which the cup-shaped abrading tool is angularly set relative to the lens blank during said major curve sweep. With the above and other objects in view, the invention consists in the novel features of construction and the methods herein set forth and described, the preferred construction and process only being set forth by way of illustration, it being understood that modifications may be made in the construction or in the process without departing from the spirit of the invention as set forth in the accompanying claims.

Referring to the drawings:

FIGURE 1 is an elevational view of one side of the invention;

FIGURE 2 is a fragmentary top view of FIG. 1;

FIGURE 3 is a fragmentary exploded perspective view with portions broken away to disclose operation;

FIGURE 4 is a view along lines 4—4 of FIG. 3;

FIGURE 5 is a further elevational view partly in section clarifying the operation of the invention;

FIGURE 6 is a floating sectional view of a positioning yoke along lines 6—6 of FIG. 4;

FIGURE 7 is a perspective view of a lens support ring;

FIGURE 8 is an elevational view thereof;

FIGURE 9 is a plan view of a lens blank showing the points of contact thereon; and

FIGURE 10 is a schematic view showing diagrammatically the meaning of the term "sagitta."

Referring now specifically to the drawings where like elements indicate like parts, the numeral 12 indicates the lens grinding apparatus of this invention. The apparatus

consists basically of a tool supporting assembly 14 and a lens supporting assembly 16. The two assemblies are supported by a housing 18, the lower part of which is not shown. The housing 18 includes the various motors, generators and hydraulic equipment necessary to drive many of the moving components of this invention. A second housing 20, having a sloping control panel 21, is attached to the housing 18 and provides convenient motor and pressure controls, and the indicating devices for determining proper mechanical operation.

The assembly 14 mounts a cup-shaped abrading tool 22. The assembly carries conventional apparatus to chuck and rotate the abrading tool 22 at speeds and angles desired by the operator. The assembly further includes an oil bath housing 24 to lubricate the surface being ground. The assembly 14 also has means to cause the tool 22 to travel a selected swing. As is conventional in this type of machine, the abrading tool support assembly swings about an axis A during a grinding sweep. The assembly still further has means by which the angular attitude of the tool with respect to its arcuate curve travel may be varied. As mentioned previously, this type of assembly has been the subject matter of many techniques known to the prior art, and by itself is not within the scope of this invention. It should merely be stated that assembly 14 is of a type which supports the equivalent of a cup-shaped abrading tool in a rotatable manner, and has means associated therewith to vary the arc of travel of said abrading tool and its angular attitude with respect to that arcuate path.

Also conventional with assemblies such as 14 is a means whereby the assembly may be made to move in and out of contact with a lens support assembly such as 16. Referring to numeral 28 there can be seen tracks by which the assembly 14 is longitudinally adjustable with the assembly 16 for base curve settings, and a lock such as the hydraulic clamp 17, for firmly affixing the assembly once a longitudinal position is selected. The base curve is determined, of course, by the horizontal distance between the axis A and the grinding edge of tool 22.

The important features of the assembly 14 as it relates to the instant invention, are the manner and position in which the quill or holding means 30 supports a tool 22 directly over what is termed a reference pin 32. The reference pin 32 is fixedly secured to a framing member 33 of assembly 14, in such a manner that the axis of pin 32 is always in fixed relationship with the center for the pitch radius 37 of abrading tool 22. The top deck 34 receives the upper end of the pin and is pivotable thereabout. After the cross curve is set by moving deck 34, the clamp 17 holds it in position.

Referring specifically to FIGS. 3 and 4, it can be seen that a straight line extension of the axis 36 of the reference pin 32, is the axis of the semi-circle defined by the rounded edge 38 of cup-shaped abrading tool 22. The radius 37 is normally $\frac{1}{8}$ " in length.

FIG. 4 is a cross-sectional view of the edge surface 38 of abrading tool 22. It can be seen that the axis 36 travels both through the axis of pin 32 and the center of the circle defined by the arc 38 of grinding tool 22. No matter what arcuate curve tool 22 is set to travel, or its angular relationship (cross-curve setting), or whether it is longitudinally toward or away from assembly 16 (base curve setting), the axis of pin 32 remains constant in its relationship with the grinding edge 38 of tool 22.

The lens holder assembly is comprised of three principal elements, a stationary platform 40, a slidable carriage 44, and an adjustable tailstock 46. The platform 40 is secured to the base 18 by bolts or the like 42. The carriage assembly 44 is received on platform 40, and the tailstock section 46 on the carriage assembly, by machine slides or rails of conventional design. The tailstock is equipped with an hydraulic chuck 48 at one end thereof, and a micrometer dial and wheel 50 at the other end thereof.

Slidably received in slides 54 of carriage assembly 44 is a positioning yoke 52.

As seen best in FIGS. 1, 5 and 6, the positioning yoke 52 is under the control of a second micrometer dial 56 and an associated cam lever 58. As will become more apparent hereinafter, the yoke 52 is one of the principal elements in referencing the two assemblies with each other.

As seen best in FIGS. 5 and 6, the yoke 52 has longitudinally shaped slots 53 and 53' along its length. A pair of guide rollers 55 and 55', which depend from carriage 44, are received in the slots and aid in accurately controlling the movement of the yoke. The yoke 52 is connected to the micrometer mechanism by linkage 57.

The micrometer mechanism is comprised of a journal block 59 which is slidably received in the rear portion of carriage 44 in slides 44'. An operating rod 61 is rotatably journaled in block 59. The upper end of rod 61 extends through the longitudinally shaped slot 63 and is connected to an operating handle 58 which is adapted to rotate the operating rod.

A receiving thread 65 accepts a worm 65' which is affixed to the micrometer knob 56. A rotation of knob 56 and thus worm 65' causes a lateral sliding movement in journal block 59 either toward or away from the assembly 14 and tool 22. Likewise, rod 61 will move longitudinally within slot 63.

After dial 56 has been moved from a zero setting and block 59 positioned, operating rod 61 is turned in a clockwise direction. Affixed to and rotatable with the operating rod 61, is a cam 67 having a contact face 69 thereon. The rod 61 is turned until the face 69 firmly contacts a lug 71. Cam 67 is rotatably secured to the linkage arm 57'. In operation, the block 59 is positioned, the lever 58 is rotated in a clockwise direction, and the positioning yoke 52 is extended an amount toward the assembly 14 directly dependent on to the micrometer setting on 56. In other words, since the extended linkage distance remains constant, the relationship between surface 52' of yoke 52, and the pin 32 is dependent on the setting on dial 56.

After the grinding tool assembly 14 is locked in position, the yoke 52 is extended, and the assembly 12 is moved until recess 52' engages pin 32. The recess has a central axis which coincides with the axis 36 when the pin 32 is received therein. The carriage assembly 44 may be moved with respect to base 40 by way of the pinion 62 and the rack 64. The rack 64 comprises a part of the assembly 44 and pinion 62 is operatively connected with a handwheel 60. As can be seen from FIG. 5, a mere turning of the wheel 60 will position the carriage 44 with respect to platform 40 until pin 32 is engaged.

The movement of the tailstock assembly 46 in relation to the carriage 44 is through the action of the micrometer lens thickness mechanism 50. As seen in FIG. 5, the micrometer 50 is associated with a worm 66' which is received by a block 68 which is firmly affixed to carriage 44. Therefore, a rotary movement of the lens thickness dial 50 will laterally move tailstock 46 toward or away from the grinding tool assembly 14. Of course, once the position of assembly 14 and the carriage 44 is fixed, the position of chuck 48 with respect to tool 22 will depend directly on the setting on dial 50. Each of the above movable assemblies has conventional clamping means to lock them into place when desired.

Before considering the purposes of the settings on dials 50 and 56 and sequence of operation of the major assemblies of the lens support structure, the particular immediate lens support structure 48 shown in FIGS. 3 and 5 should be examined carefully. Also examined concurrently therewith, the particular geometry of the chuck assembly and lens must be understood.

Referring now to FIG. 3, there is shown an exploded view of the immediate lens blank support structure. A

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lens blank L having a convex surface 92 and a concave surface 91, has a conventional pitch block 95 fixedly secured to said convex surface.

The means of support and the position of the lens blank with respect to the other structure is an important aspect of the invention. The hydraulic chuck 48, has a series of circumferential clamping fingers 49, which secure the blank to the assembly by engaging the pitch block. The outboard vertical faces 51 of fingers 49 all lie in a transverse plane 53 which for purposes of discussion will be called the main reference plane.

The lens blank L is supported in the chuck by fingers 49 clamping the peripheral surface of block 95. A ring 74 is placed between the chuck and the lens so that the lens will be supported a precise distance from the reference plane 53.

The ring, best shown in FIG. 7, may be constructed of rigid or compressed fiber or a like temperature stable material, and is manufactured with dimensions having very close tolerances. The ring is comprised of a main cylinder section 87 having longitudinally extending projections 88 and 90 extending from one outboard rim 89, and has a flange 76 projecting inwardly from the inboard (chuck side) rim 91. The inner periphery of flange 76 defines a circle which closely engages the periphery of block 95 when it is inserted therethrough.

The ring is slipped over the pitch block until projections 88 and 90 engage the convex surface of the lens. That portion of the pitch block extending beyond the flange 76 is then clamped into the chuck so that the innermost rim 91 of ring 74 is in contact with the outboard faces 51 of the fingers 49 in a common plane 53.

The arcuate projections 88 and 90 are so machined that their respective ends *e*, *f*, *g* and *h* are spaced 90° from each other, along diameters using the axis of the ring as a center. These points *e*, *f*, *g* and *h* provide a four-point contact with the convex surface 92. The longitudinal central axis of the chuck 48, the ring 74 and the lens blank L are denoted by the numeral 102.

FIG. 9 is a plan view of a lens which we may assume is toric having a major curve A-B and a minor curve C-D.

The lens blank is positioned against fiber ring 74, such that points *e*, *f*, *g* and *h* are exactly 45 degrees from the major and minor curves. Therefore, if curve A-B is 6 diopters and curve C-D is 8 diopters, the curves defined by the arcs (along the convex surface) connecting points *e*-*f*, and *g*-*h*, respectively, will be 7 diopters.

A section of the lens blank 92 which is defined by the plane running through points *e*, *f*, *g* and *h* is shown in solid lines in FIG. 10. FIG. 10 is a cross-section through the points *e* and *f*. A cross-section through *g* and *h* would be identical. These points define a chord 104 between which an average curve 105, connects points *e* and *f*. A perpendicular 106 running from the apogee 108 of the curve 105 to chord 104, defines a distance which is called a "sagitta" value in the optical art. The apogee is that point on the arc which is the greatest perpendicular distance from chord 104. The sagitta value may be mathematically determined from the formula:

$$S = r - \sqrt{r^2 - (D/2)^2}$$

wherein *S* equals the sagitta, *r* equals the radius of curvature of 105 and *D*/2 equals the semi-diameter of the lens as defined by the curve *e*-*f*.

The importance of these dimensions is apparent when re-examining the structure previously described. The micrometer base curve compensating dial 56 has indicia thereon indicating the mean diopter of curves *e*-*f* and *g*-*h* and is so dimensioned that a lineal sagitta value is transmitted to positioning yoke 52. For any given dioptric major and minor curves, the sagitta value for the lens as it is held in the fiber ring (points *e*, *f*, *g* and *h*) may be easily computed and related to the base curve compensating dial 56.

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The micrometer 50, on the other hand, has indicia of lens thickness in millimeters, and a rotation thereof transmits a setting directly into a lineal distance or motion in tailstock 46.

For an understanding of the machine it is necessary to understand that the depth 83 of ring 74 is fixed so that plane 110 through points *e*, *f*, *g* and *h*, is constantly parallel with and located a known distance from the plane 53 of the chuck face. From plane 110, the sagitta value of the lens is a factor which can be computed if the mean base curve is known, and this computed factor is adjusted for in the positioning of yoke 52.

In operation, the grinding tool support assembly 14 is set in its desired position along rails 28 and locked for base curve. Cross-curve is set by positioning the structure about pin 32 and locked. It is next necessary then to position the assembly 16 with respect to the point of intersection where the grinding tool traverses the lens axis so that a proper lens thickness will result. The lens is secured to the chuck in the manner described, and the operator sets the mean or average diopter value for the subject lens L on the micrometer 56. The handle 58 is turned to extend yoke 52 to its outward position. The setting on dial 56 prevents the positioning yoke 52 (and consequently blank L) from extending toward pin 32, an amount equal to the sagitta value. Wheel 60 is then turned causing the carriage 44 to move to the left (as viewed in FIG. 1) until the positioning yoke 52 snugly engages reference pin 32.

As previously mentioned, the plane 110 is defined by a plurality of points supporting the curved convex surface of the lens. From this plane the sagitta or distance to the apogee of the lens is determined. Therefore, this sagitta value must be compensated for when adjusting assemblies 14 and 16 with each other. The sagitta value is compensated for by dial 56 and yoke 52. Thus, with dial 50 on zero, dial 56 set with the proper mean diopter curve, positioning yoke 52 extended and engaging pin 32 and hash marks 45 and 45' aligned, the machine is constructed so that the apogee 108 of the lens will be 7 millimeters from the deepest point of sweep of the abrading tool 22. It should be understood, that this distance can be set into the machine during manufacture.

Now, only lens thickness must be set. Handle 58 is turned counter clockwise to retract positioning yoke 52. Assembly 14 is moved to the position at the beginning of an abrading sweep so that abrading tool 22 will clear the lens chuck. The micrometer lens thickness dial 50 is set on a figure representing the desired lens thickness. This causes tailstock 46 to travel toward the sweep of tool 22 an amount equal to the desired lens thickness subtracted from the 7 millimeters. This causes the deepest point of the abrading tool's sweep to travel exactly the desired lens thickness away from the lens apogee as the axis 102 is traversed.

The movement of the tailstock is toward the arc of grinding tool 22, whereas the movement caused by dial 56 held the chuck assembly away from the sweep of the abrading tool. The machine set in this position causes the tool 22 to traverse across the lens L keeping the exact desired distance from the apogee of the lens as it swings therepast. As a result, an accurate center thickness control is maintained throughout the grinding stroke.

Although prior art machines disclose structure wherein there is a first position having a fixed distance between the grinding tool (the closest point of its arcuate sweep) and the lens blank holder, there have been no teachings of a method or means to account for the variations in placement of the apogee with respect to the chuck or holder caused by variations in lens curvature. The subject matter of this invention compensates for such variation so that accurate center lens thickness is obtained by accounting for this variation.

It can be seen that we have described an apparatus which allows an unskilled operator to employ the ma-

chine without knowing the original thickness of the lens blank nor the necessity of performing any measuring operation. He must only know the mean curve of the major and minor axes and how much glass is to be left at the center thereof. This is information that he will have available to him from the prescription. It can also be seen that the machine will work equally well for spherical or toric configurations. Unwanted prism is reduced to a minimum due to the accurate control maintained between the grinding mechanism and the lens chuck assembly. It will be clear to those skilled in the art that convex curves can be just as easily generated, when opposing indicia are placed on dials 50 and 56.

In a general manner, while we have, in the above description, disclosed what we deem to be a practical and efficient embodiment of our invention, it should be well understood that we do not wish to be limited thereto, as there might be changes made in the arrangement, disposition and forms of the parts without departing from the principle of the present invention as comprehended within the scope of the accompanying claims.

We claim:

1. An improvement in a lens grinding machine of a type for abrading the concave side of a lens blank having a known, mean curve on the convex side thereof, said blank having a center axis extending through the apogee of said convex surface, a base, a tailstock supporting assembly mounted on said base, a chuck mounted on said assembly for supporting said lens blank and having a chuck face in a plane transverse to said center axis when said lens blank is supported by said chuck, an abrading tool having an arcuate grinding edge, a support pivotally mounted on said base for swinging said grinding edge through an abrading sweep which intersects said axis, said improvement comprising:

an annular spacer of known dimensions between said convex surface and said chuck face,

said spacer having a first end in contact with said chuck face and a second end contacting said blank at a plurality of points on said convex surface in a second plane parallel to said first plane,

said points of contact being of equal and known radial distances from said center axis such that said apogee is supported a known distance from said first plane an amount equal to the distance between the first and second ends of said spacer minus the distance defined by a normal from said apogee to said second plane,

a pin supported along the same vertical axis as said abrading edge,

a positioning yoke slidably received in said tailstock for horizontal movement toward and away from said pin,

positioning means for locating said yoke a fixed distance from said first plane whereby when said tailstock carries said yoke into engagement with said pin, said first plane is said fixed distance from said point of intersection, and

second means for visually representing and retracting said face from said point an amount equal to said distance defined by said normal.

2. The improvement in a lens grinding machine defined in claim 1 wherein said annular spacer is made from a material which is relatively dimensionally stable during temperature variations.

3. The improvement in a lens grinding machine defined in claim 2 wherein said spacer is made from a rigid fiber.

4. An improvement in a lens grinding machine of a type for abrading the concave side of a lens blank having a known, mean curve on the convex side thereof, said blank having a center axis extending through the apogee of said convex surface, a base, a tailstock supporting assembly mounted on said base, a chuck mounted on said assembly for supporting said lens blank and having a chuck face in a plane transverse to said center axis when said lens blank is supported by said chuck, an abrading tool having an arcuate grinding edge, a support pivotally mounted on said base for swinging said grinding edge through an abrading sweep which intersects said axis, said improvement comprising: an annular spacer of known dimensions between said convex surface and said chuck face, said spacer having a first end in contact with said chuck face and a second end contacting said blank at a plurality of points on said convex surface in a second plane parallel to said first plane, said points of contact being of equal and known radial distances from said center axis such that said apogee is supported a known distance from said first plane an amount equal to the distance between the first and second ends of said spacer minus the distance defined by a normal from said apogee to said second plane, a pin supported along the same vertical axis as said abrading edge, a positioning yoke slidably received in said tailstock for horizontal movement toward and away from said pin, positioning means for locating said yoke a fixed distance from said first plane whereby when said tailstock carries said yoke into engagement with said pin, said first plane is said fixed distance from said point of intersection, and second means for visually representing and retracting said face from said point an amount equal to said distance defined by said normal,

said spacer being made from a rigid fiber which is dimensionally stable during temperature variations and is comprised of a cylindrical base ring, one end of which is terminated by said first end and having oppositely disposed lugs extending from the other end thereof, the ends of said lugs defining said plurality of points.

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