A. E. PAIGE.

METHOD OF MAKING BIFOCAL LENSES.

APPLICATION FILED MAY 27, 1915.

1,302,960.

Patented May 6, 1919.

8 SHEETS—SHEET 1.

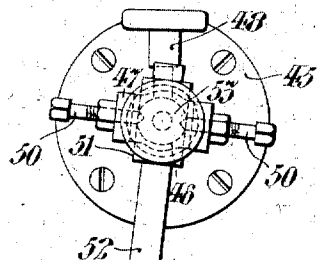


FIG. I.

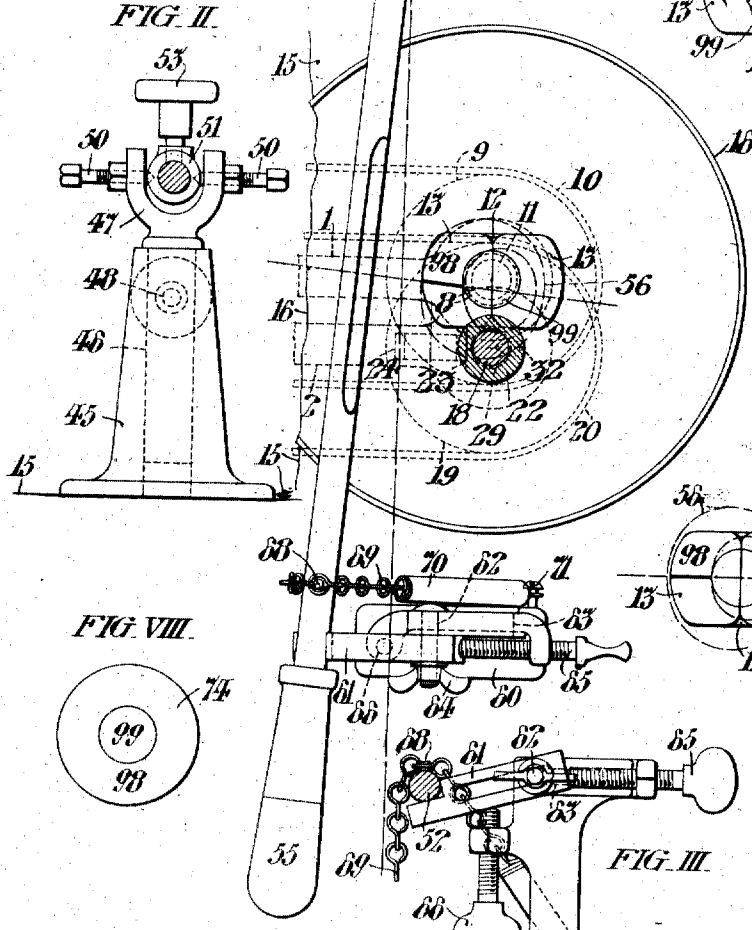


FIG. II.

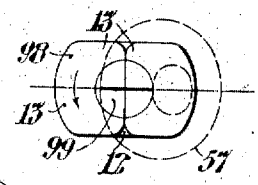


FIG. IV.

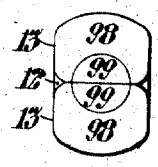


FIG. VI.

FIG. V.

FIG. VIII.

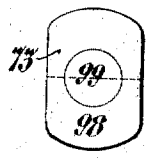


FIG. VII.

FIG. III.

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8 SHEETS—SHEET 2.

FIG. IX

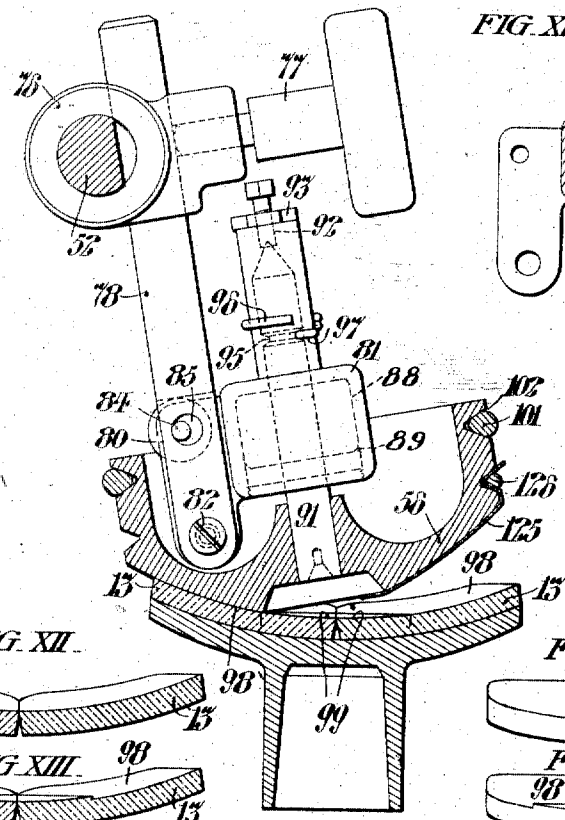


FIG. XI

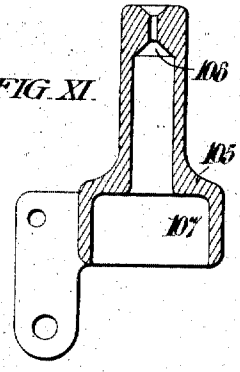


FIG. XII

FIG. XIII

FIG. XIV



FIG. XV

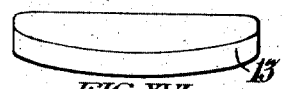


FIG. XVI

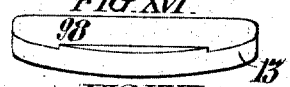


FIG. XVII

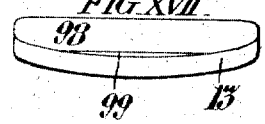
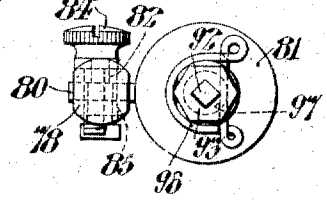


FIG. X



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8 SHEETS—SHEET 3.

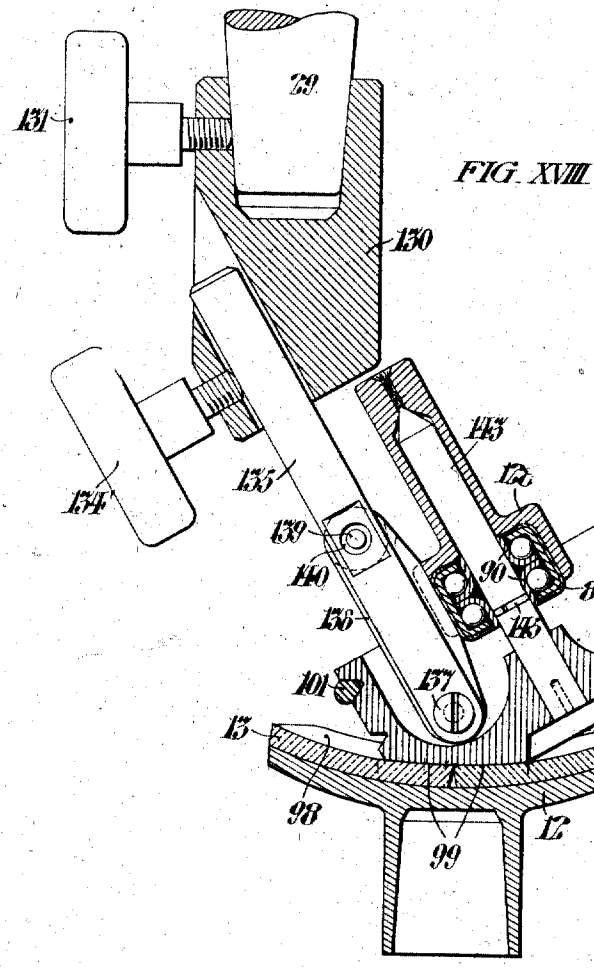
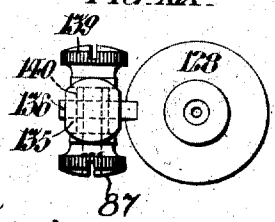


FIG. XVIII.

FIG. XX.



FIG. XIX.



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8 SHEETS—SHEET 4.

FIG. XXI.

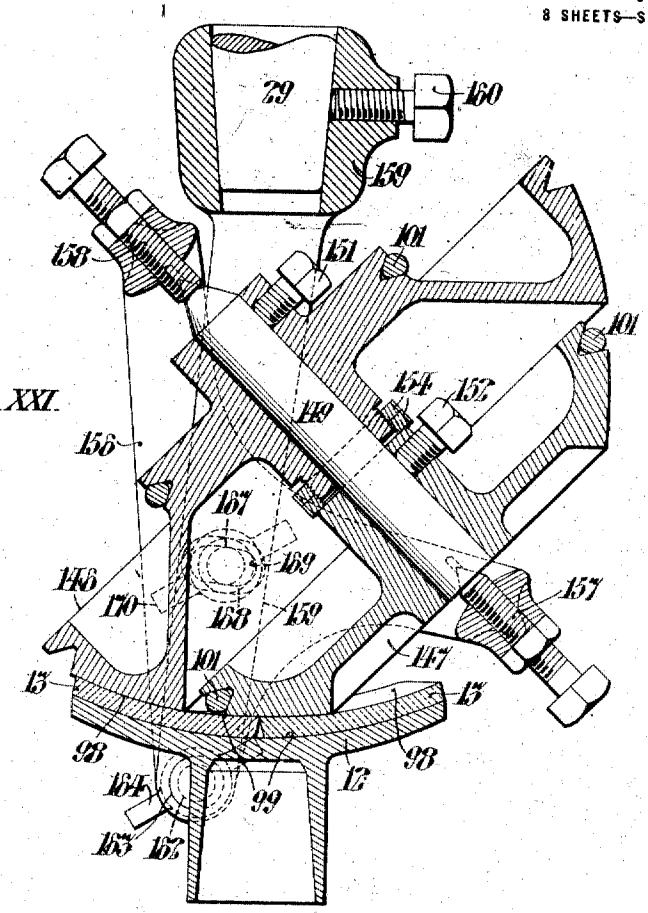
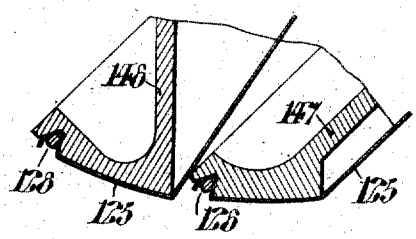


FIG. XXII.



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8 SHEETS—SHEET 5.

FIG. XXIII.

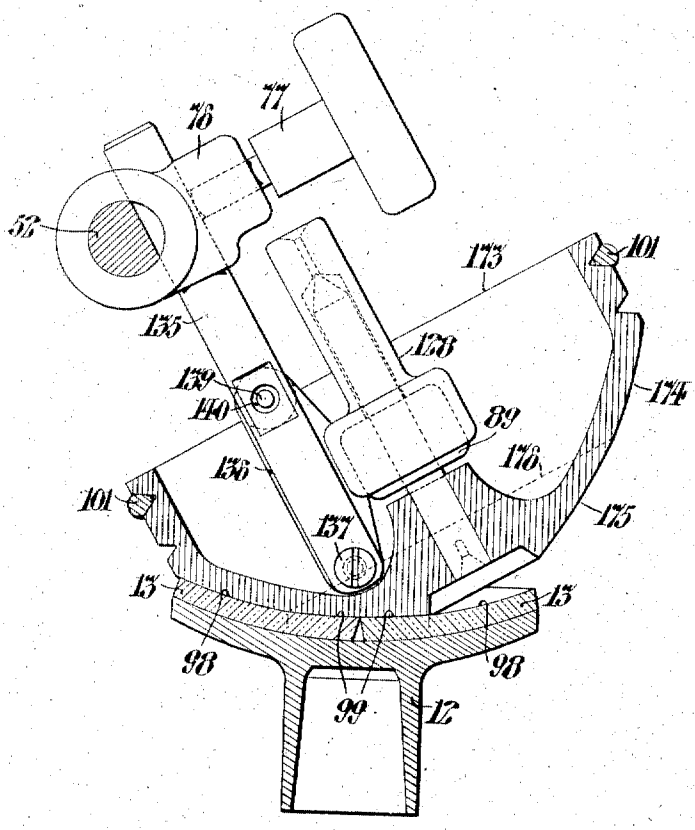
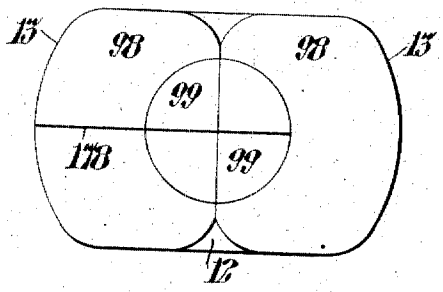


FIG. XXIV.



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8 SHEETS—SHEET 6.

FIG. XXV.

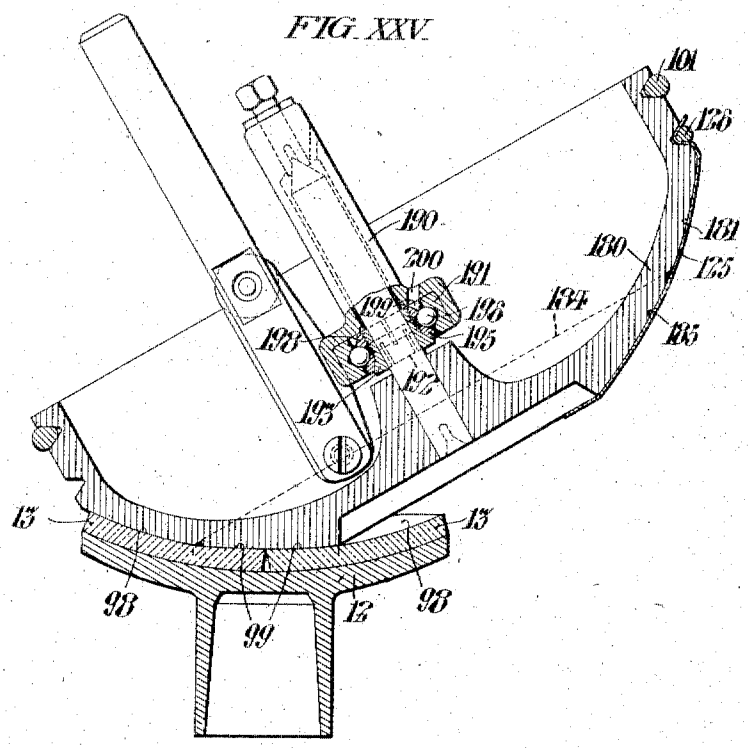
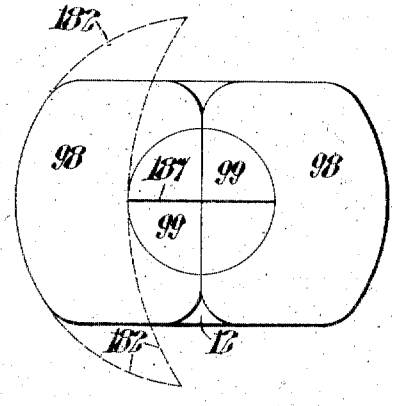


FIG. XXVI.



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8 SHEETS—SHEET 7

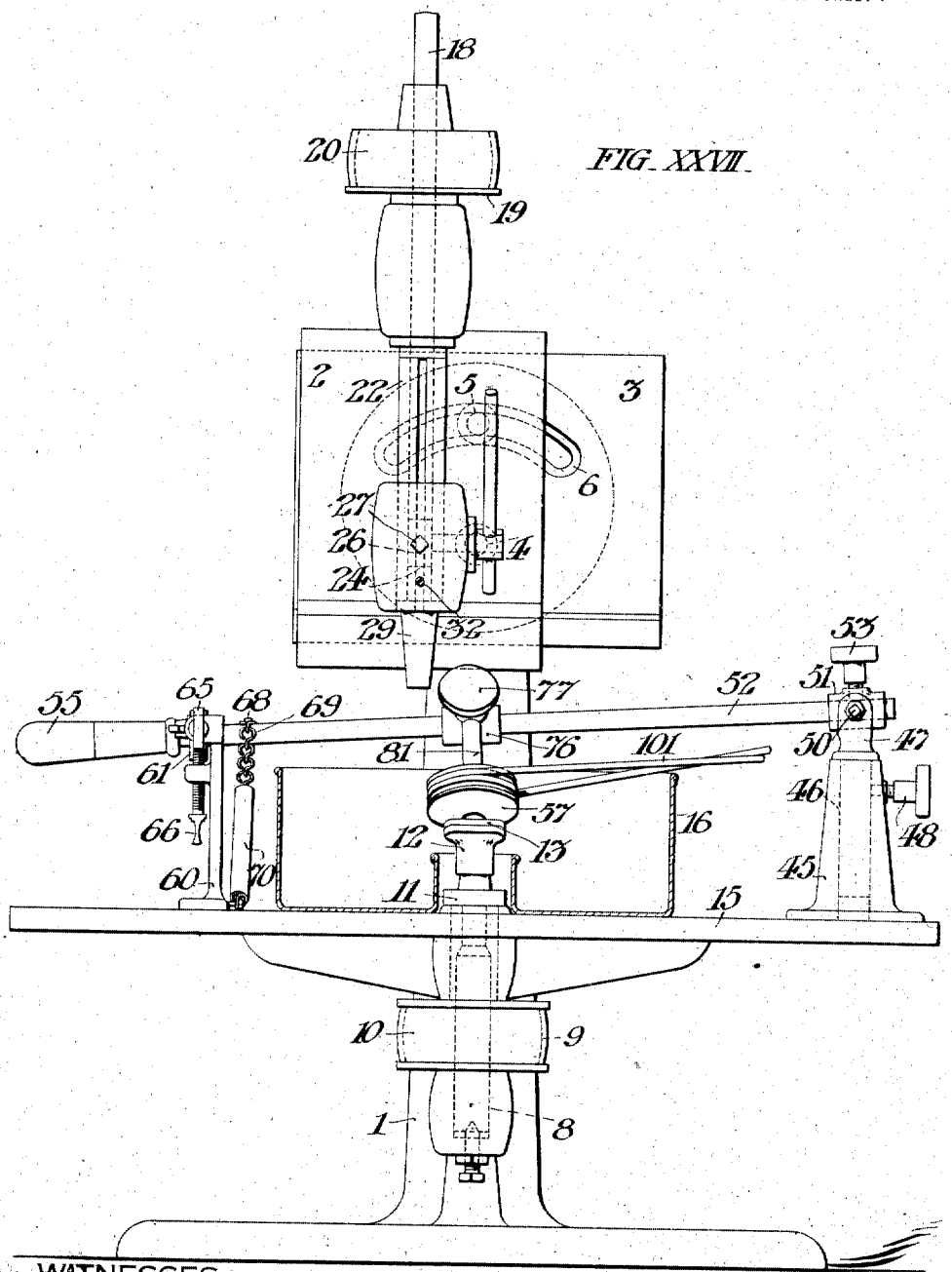


FIG. XXVII.

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METHOD OF MAKING BIFOCAL LENSES.

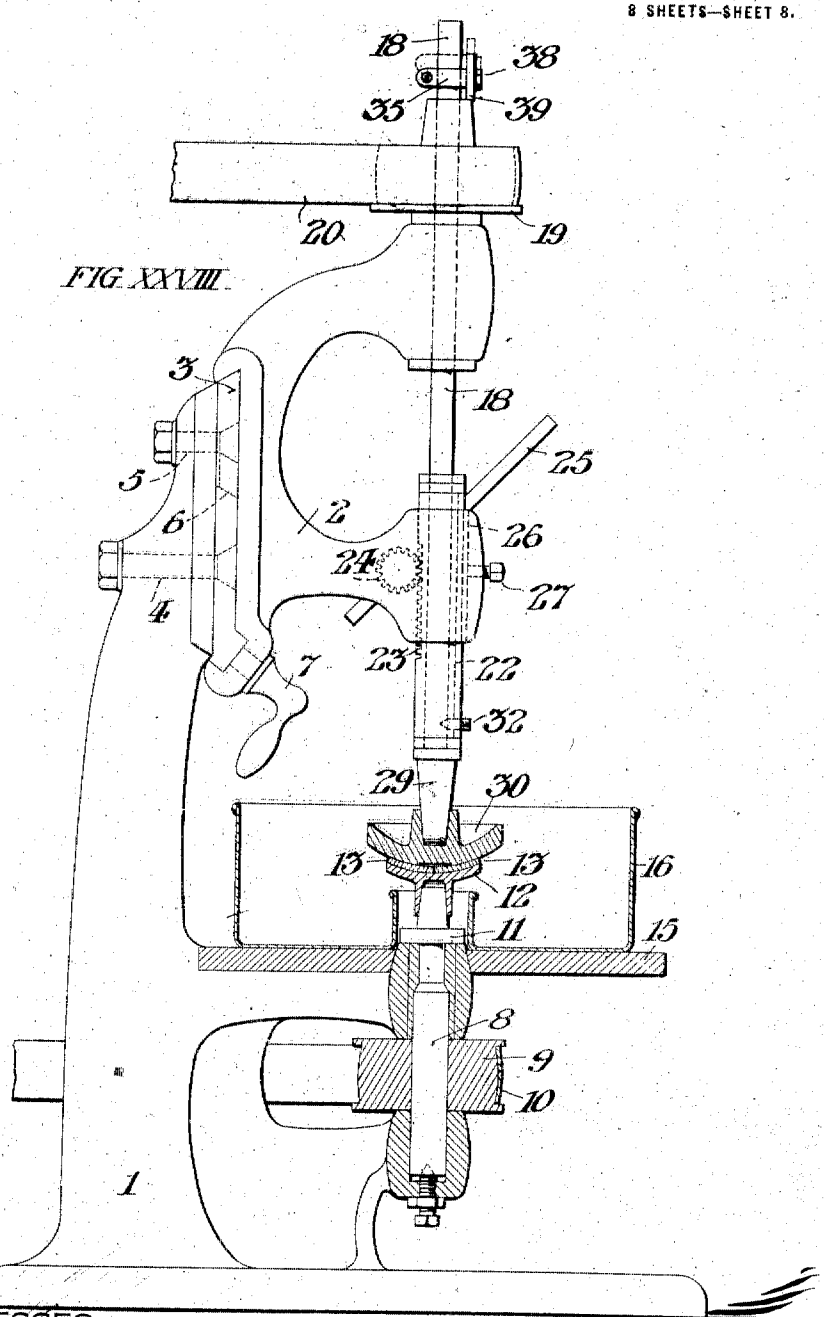
APPLICATION FILED MAY 27, 1915.

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8 SHEETS—SHEET 8.

FIG. XXVIII.



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UNITED STATES PATENT OFFICE.

ARTHUR E. PAIGE, OF PHILADELPHIA, PENNSYLVANIA.

METHOD OF MAKING BIFOCAL LENSES.

1,302,960. Specification of Letters Patent. Patented May 6, 1919.

Original application filed March 4, 1915, Serial No. 12,028. Divided and this application filed May 27, 1915, Serial No. 30,716.

To all whom it may concern:

Be it known that I, ARTHUR E. PAIGE, a citizen of the United States, residing at Philadelphia, in the State of Pennsylvania, have invented a certain new and useful Improvement in Methods of Making Bifocal Lenses, whereof the following is a specification, reference being had to the accompanying drawings.

My invention relates to methods of producing curved surfaces, and particularly such surfaces which adjoin each other and are respectively uniformly curved to the junction line between them, so as to sharply define the latter. As hereinafter described, my method is adapted to surface one side of glass to contemporaneously form a pair of bifocal lenses, the glass being held with the respective minor areas adjoining each other and between their respective major areas and concentrically rotated in coöperative relation with abrading means common to the glass which forms both members of such a pair. Such abrading means may include a lap having an annular abrading surface presenting only a transverse line of contact to the glass and having one circumferential edge of said annular surface presented tangentially to the junction line between the major and minor lens areas, so that that edge of the abrading surface extends obliquely over said junction line from its point of contact with the glass; whereby the glass is abraded in a direction transverse to said junction line, so as to sharply define the latter. As hereinafter described such oblique relation may be determined by having the axes of rotation of the glass and of the lap neither parallel nor at right angles, but in acutely oblique transverse relation, and, although the lap may be maintained in radial relation with the axis of rotation of the glass, and is preferably so maintained in abrading the minor lens surfaces, because the line of contact between the lap and the glass then intersects the center of rotation of the minor lens areas, the axis of rotation of the lap may extend tangentially to a circle described by rotation of any point on the surface of the glass (hereinafter referred to as a circle of rotation of the latter,) and is preferably thus maintained in abrading the major lens surfaces; because the path of the abrading material moved by the lap is then in a direction transverse to the path of the abrading material moved by the glass, thus imparting a compound decussative motion to said material and preventing it from forming concentric ruts or scratches in the glass. Moreover, by presenting the line of contact of the lap with the glass in tangential relation to a circle of rotation of the latter, a spherically curved surface of a given radius may be produced by a lap surface of less radius, which is advantageous in that such a lap may be adjusted to and from radial and tangential position to compensate for wear of its abrading surface. For instance, a lap having a conoidal abrading surface which is circularly arcually curved respectively differently transversely and circumferentially, when presenting a transverse line of contact to the glass in radial relation to the axis of rotation of the latter, produces a spherical surface of precisely the same radius as the transverse curvature of the lap surface, and, as the lap surface is rendered more convex by use, the line of contact may be shifted to tangential relation to a circle of rotation of the glass to produce a spherical surface of the given radius with the lap surface then of a less radius. Of course, such adjustment to and from radial and tangential position is limited to the extent of the radius of the circular perimeter of the minor lens areas.

My invention includes the various novel features of procedure hereinafter more definitely specified.

This is a division of my application Serial No. 12,028 filed March 4, 1915, pursuant to which Letters Patent of the United States 1,269,568 were granted to me June 11, 1918. Letters Patent of the United States 1,260,022 were also granted to me March 19, 1918, pursuant to application Serial No. 178,523, filed July 4, 1917, as another division of said application Serial No. 12,028, and, in both of said Letters Patent mechanism of the character herein described is claimed.

Figure I is a fragmentary plan view of a surfacing machine, including a lever having a universal fulcrum, by which lap elements of my invention may be adjustably supported; one of said lap elements being indicated in dash lines in position to present a transverse line of contact of its annular abrading surface, to the major lens surface of the

glass which is to be abraded, and in tangential relation to a circle of rotation described by any point on the surface of said glass.

Fig. II is an elevation of the universal fulcrum support for the lever shown in Fig. I.

Fig. III is an elevation of the stop mechanism by which the movement of said lever is precisely limited.

Fig. IV is a diagrammatic plan view indicating, in dash lines, a lap having its annular abrading surface presenting a transverse line of contact to said glass, at the minor lens areas of the latter and in radial relation with the axis of rotation of the glass.

Fig. V is a diagrammatic plan view, wherein the lap illustrated in Fig. 1, indicated in dash lines, is shifted to present its line of contact to the glass at the major lens surface of the latter and in radial relation with the axis of rotation of the glass.

Fig. VI is a plan view of a rotary glass holder with a pair of bifocal blanks thereon as in Figs. IX, XIV and XVII.

Fig. VII is a plan view of a single piece of glass, forming a blank for a pair of bifocal lenses, of substantially the same shape as the pairs of lens blanks shown in Figs. I, IV and V.

Fig. VIII is a plan view of a circular piece of glass adapted to form a pair of bifocal lenses, by the employment of the method and means illustrated in the preceding figures.

Fig. IX is a vertical sectional view of the lap, glass, and glass holder arranged to abrade the major lens surfaces in accordance with Fig. V, and illustrating means for supporting said lap in operative connection with the lever shown in Fig. I; said supporting means being capable of oscillatory adjustment in the plane of the line of contact of the lap with the glass.

Fig. X is an upper end view of the lap spindle bearing and its pivot bar shown in Fig. IX.

Fig. XI is a vertical sectional view of a simplified form of lap spindle bearing which may be substituted for that shown in Fig. IX.

Figs. XII, XIII and XIV are diametrical sectional views of pairs of lens blanks such as indicated in Figs. I, IV and V, illustrating successive steps in a method of surfacing the same. Fig. XII shows said blanks primarily surfaced to a uniform curvature throughout the entire area of their upper sides; the curve indicated being minus six diopters. Fig. XIII shows said blanks with their minor areas in the same condition as in Fig, XII but with their major areas further surfaced, at the same curvature, so as to leave the minor areas projecting upwardly therefrom. Fig. XIV shows said pair of blanks with their minor areas surfaced to a curvature of four diopters.

Figs. XV, XVI and XVII respectively show inner edge views of respective individual members of the pairs of blanks shown in Figs. XII, XIII and XIV.

Fig. XVIII is a vertical sectional view similar to Fig. IX but showing the lap spindle bearing supported by a detachable coupling connecting it with the upper spindle of the machine shown in Fig. I; said spindle being rigidly connected with the vertically adjustable quill of said machine when thus used.

Fig. XIX is an upper end view of the lap spindle bearing and its pivot bar shown in Fig. XVIII.

Fig. XX is a sectional view of the lap spindle shown in Fig. XVIII, showing the normal construction and position of the resilient ring carried by said spindle when the latter is withdrawn from the bearing shown in Fig. XVIII.

Fig. XXI is a vertical sectional view showing laps adapted to respectively abrade the major and minor lens surfaces, mounted upon a common spindle, upon which they may be independently rotated at different speeds.

Fig. XXII is a fragmentary sectional view of the laps shown in Fig. XXI, with their abrading surfaces covered by respective sheets of textile fabric secured by elastic sphincteral bands.

Fig. XXIII is a vertical sectional view, similar to Fig. XXI, but showing a single lap having the respectively differently curved annular abrading surfaces for abrading the major and minor lens surfaces.

Fig. XXIV is a plan view similar to Fig. VI but showing that the contact between the lap and the glass arranged as in Fig. XXI is only at a line, which is radial with respect to the lap axis, because both of the annular surfaces of said lap are respectively differently curved transversely and circumferentially.

Fig. XXV is a vertical sectional view similar to Fig. XXIII but showing a lap having an annular abrading surface for the major lens surfaces which is spherically curved *i. e.*, arcually curved the same both transversely and circumferentially, whereas, the annular abrading surface for the minor lens surfaces is arcually curved respectively differently transversely and circumferentially.

Fig. XXVI is a plan view similar to Fig. XXIV but showing that whereas the annular abrading surface of the lap shown in Fig. XXV for abrading the minor lens surfaces presents only a line of contact to the glass, which is radial with respect to the lap axis; the annular abrading surface of said lap for the major lens surfaces presents an

area of contact to the glass which is a lune of a spherical surface.

Fig. XXVII is an elevation, partly in longitudinal section, of the surfacing machine partly shown in Fig. I, looking toward the left in that figure, but with the upper and lower spindles in the position contemplated in Fig. XVIII and showing the lever support and its appurtenances as in Fig. IX.

Fig. XXVIII is an elevation, partly in transverse section, of the surfacing machine partly shown in Figs. I and XXVII.

Fig. I is a fragmentary plan view of a machine which may be conveniently employed in roughing glass blanks, by rotating them and a lap upon a common axis but respectively different spindles which are relatively adjustable both axially and laterally and, preferably, rotated in opposite directions so as to attain the maximum speed of grinding with the minimum centrifugal discharge of the abrading material. In said machine, the lower spindle 8 is journaled in the base frame 1 and has the pulley 9 for rotation by the belt 10, and has the conical cap 11 for detachable engagement with the glass holder 12 upon which the lens blanks 13 are detachably mounted, conveniently with pitch cement. Said base 1 also supports the table 15 upon which the pan 16 is removably supported in concentric relation with said spindle 8. The upper spindle 18 which is journaled in the frame 2, tiltable and capable of straight lateral movement on said base frame 1, is provided with the pulley 19 and belt 20 by which it may be rotated. Said pulley 19 is keyed to said spindle 18 so that the latter may be raised and lowered through it by means of the quill 22 having rack teeth 23 engaging the gear 24 which may be turned by hand. Said quill may be prevented from rotating by a suitable key, adjustable by the set screw 32. Said spindle 18 has at its lower end the conical cap 29 for detachable engagement, directly, with ordinary spherical laps which may be rotated in axial alinement with the spindle 8, and glass holders 12 thereon, when the set screw 32 in the quill is retracted. When said spindle 18 is prevented from rotating it may be used to support the other laps hereinafter described, for instance as shown in Fig. XVIII, to precisely determine the approach thereof to the glass. However, it is to be understood that other means may be employed to effect the grinding of the blanks preliminary to the employment of the laps which have their axes extending obliquely with respect to the axis of rotation of the glass as herein set forth.

Referring to Figs. I to III inclusive, it is to be understood that the universal fulcrum support and the stop mechanism for the lever shown in Fig. I are mounted upon the table 15 upon which the pan 16 rests. As shown in Fig. II said fulcrum support includes the socket base 45 in which the cylindrical shank 46 of the yoke 47 may be turned and vertically adjusted, and clamped by the set screw 48 when in adjusted position; said set screw 48 being in screw threaded engagement with said base 45. Said yoke 47 has the oppositely alined cone pointed screws 50 engaging the sleeve 51 in which the lever 52 may be turned and longitudinally adjusted, and clamped in adjusted position by the set screw 53 which is in screw threaded engagement with said sleeve. However, it may be observed that when said parts are adjusted and clamped by the screws 48 and 53, said lever 52 is free to oscillate in a vertical plane upon the common axis of said screws 50, and said lever is conveniently provided with the handle 55 by which it may be manipulated as a support by which the laps 56 and 57, indicated in dash lines in Figs. I, IV and V, may be presented in operative relation with the pairs of lens blanks 13 supported and rotated by the holders 12 on the spindle cap 11.

Although when clamped by the screws 48 and 53, said lever 52 is ostensibly prevented from moving except in a vertical plane; it is practically impossible to make it so rigid that it cannot be otherwise moved within the limit of its resilience, and, in fact, it may be bent and twisted, without permanent distortion, when clamped by the supporting means above described, to such a degree that I find it convenient to provide stop mechanism at the handle end of said lever by which its movement may be precisely limited. As indicated in Figs. I and III the stop bracket 60, which is conveniently mounted upon said table 15, carries the stop block 61 upon the bolt 62 which has a squared shank mounted to slide in the slot 63 in said bracket and is provided with the wing nut 64 by which said block 61 may be secured in any position of adjustment to which it may be shifted by the thumb screws 65 and 66 which are in screw threaded engagement with said bracket 60. Said lever is conveniently provided with the stud 68 which may be selectively engaged with any link of the chain 69 at the upper end of the spring 70 which is connected with said bracket 60, at its lower end, by the screw 71, and it is to be understood that the approach of the laps 56 and 57 to the glass, both laterally and vertically, is precisely predetermined and limited by the location of said stop block 61. For instance, said lever may be set to present a lap in position to abrade the glass carried by the holder 12 and with a space between the lower side of said lever and the proximate upper surface of the recessed end of said block 61 corresponding with the thickness of the glass which is to be removed, and, said spring 70

being connected with said lever 52 as above described, the abrading operation may proceed without further attention of the operator except as to the maintenance of the proper quantity of abrading material and water or other liquid vehicle between the lap and the glass.

It is to be understood that although I have shown the glass upon the holders 12 in the form of individual lens blanks 13, other forms may be employed with equal facility, for instance, a single piece of glass 73, shown in Fig. VII, of the outer configuration of the holder 12, may be suitably surfaced and subsequently cut apart, on the dotted diametrical line shown in Fig. VII, to form a pair of bifocal lenses. Moreover, a circular glass blank 74 such as shown in Fig. VIII may be thus surfaced and subsequently cut apart, upon any diametrical line, to form a pair of bifocal lenses. Said form 74 is advantageous in that defects due to accidental crumbling of the glass may be avoided in cutting the lenses, and said form 73 is advantageous in that only the minimum amount of glass is required for the same.

Fig. IX illustrates the lap 56, glass 13 and glass holder 12 arranged to abrade the major lens surfaces in accordance with Figs. I and V; said lap being supported in operative connection with said lever 52 by means capable of oscillatory adjustment in the plane of the radial line of contact of the lap with the glass. Such means includes the coupling 76 which is longitudinally adjustable on said lever 52 and has the set screw 77 by which the pivot bar 78 may be rigidly clamped against the flattened side of said lever in any position of adjustment; said bar 78 having its opposite sides flattened as shown in Fig. X. Said bar 78 is bifurcated at its lower end to receive the radial flange 80 of the spindle bearing casing 81, which is pivotally connected therewith by the screw 82 which has a smooth cylindrical portion extending through said flange 80 but is in screw threaded engagement with said bar 78, as indicated in dotted lines in Fig. X. It may be observed that the construction and arrangement of said screw 82 is such that it may be slightly retraced to permit said flange to oscillate freely and be advanced to clamp said flange between the bifurcations of said bar 78. The oscillatory movement of said flange 80 in said bar 78 is limited and the parts clamped in adjusted relation by the screw 84 which extends freely through the openings 85 in said bar but is in threaded engagement with said flange 80. Said screw 84 may be jammed in adjusted position by the nut 87 shown in Fig. XIX.

Said lap spindle bearing casing 81, shown in Figs. IX and X, carries in its socket 88, a ball bearing which is conveniently constructed and arranged as shown in Fig. XVIII, including the outer shell 89 which is tightly but detachably fitted in said casing 81, so that it may be removed and replaced when worn. Said ball bearing includes the sleeve 90 through which the spindle 91 of each lap 56 and 57 may be slid to and from its operative position without lateral lost motion. In operative position the upper cone point of the spindle of each lap 56 and 57 is seated in the cone socket screw 92, which is axially adjustable in screw threaded engagement in said casing 81 and is provided with the nut 93 by which it may be secured in adjusted position.

To prevent accidental displacement of said laps 56 and 57 when raised from contact with the glass, by the lever 52, I find it convenient to provide each spindle 91 with a circumferential groove 95 to receive the latch spring 96 which is carried by the casing 81 and has one limb extending in the slot 97 in the latter in registry with said groove. The construction and arrangement of such resilient retaining means is such that it yields to permit the laps to be manually shifted to and from operative position in said casing 81.

It may be observed that in the position shown in Fig. IV, said lap 57 is so set that the smaller circumferential edge of its abrading surface, which is indicated by the smaller elliptical dash line is in contact with the glass 13, and is tangential to the circular junction line between the major lens areas 98 and the minor lens areas 99. Said junction line is indicated in Fig. IX and in other sectional views of the glass, by short straight lines which extend vertically downwardly from the upper surface of the glass, but which are not intended to indicate any division in the glass, but merely to indicate the position of the laps with reference to said junction lines which are otherwise difficult to locate in the sectional views in view of the slight difference in curvature between the adjoining surfaces. When the line of cooperation of the tool and glass coincides with the axis of rotation of the glass as indicated in Fig. IV, the abrading particles tend to travel tangentially to the circular junction line between the lens areas and across the same in approximately evolute paths, the directions of which vary somewhat with variations in the speed of travel of said particles, which is the resultant of the rotation of both the glass and the abrading tool. When the line of coöperation of the tool and glass is as indicated in Fig. I, the abrading particles travel across the circular junction line between the major and minor areas in paths which are either approximately evolute or involute in accordance with the direction of rotation of the abrading tool. That is to say they travel involutely if said tool is rotated clockwise with reference to Fig. I, and evo-

lutely if said tool is rotated in the opposite direction. In either case the abrading action is transverse, and obliquely transverse, to such junction lines. As the paths of said abrading particles vary from mathematically evolute and involute directions, I prefer to term them "curvilinear." It may be observed that said smaller circumferential edge of the abrading surface of the lap 57, which is indicated by the smaller elliptical dash line in Fig. IV, extends obliquely over said junction line from its point of contact with the glass like the similar edge of the lap 142 shown in Fig. XVIII; whereby the glass is abraded by said lap in a direction transverse to said junction line, so as to sharply define the latter; the glass being rotated in the direction of the arrow in Fig. IV while the lap is rotated in the same direction. Although said lap may be caused to rotate in that direction merely by frictional engagement with the surface of the glass rotating in that direction, I find it preferable to rotate the lap at a higher speed than the glass and this may be conveniently done by the belt 101 engaging the groove 102 in the lap, as shown in Fig. IX, and extending thence around any suitable driving pulley. The reason for rotating the glass, is, of course, to successively present at the line of contact with the lap all of the area of the glass which is to be abraded by the latter. The reason for rotating the lap at a higher speed is to attain the maximum relative movement of the lap and glass surfaces which is possible with the employment of a pulverulent abrading medium; such speed being limited by the centrifugal effect upon said material, for, if the lap is rotated at too great a speed said material will be thrown off the glass upon which it must be retained to have any abrading effect. The reason for rotating the lap in the same direction as the glass is to minimize the chance of producing scratches by irregular particles of the abrading material which might be retained in damaging relation to the glass if the glass and lap are rotated in opposite directions, as the abrading material is then piled up by the opposite feeding movement thereof by the glass and lap.

It is to be noted that the abrasion is not effected by the surface of the lap but by the pulverulent abrading material which is free to move between the adjacent surfaces of the lap and glass, and has a motion which is the resultant not only of the circular rotation of the lap and glass with their axes in the oblique relation described, but of the so called centrifugal force generated by such movement; the effect of said force being always to produce a tangential motion of each particle of the abrading material, outwardly with respect to the axis of rotation of the element supporting said particle at any instant. That the glass is abraded in a direction transverse to said junction line is clearly indicated by the score marks made in the glass by granules of the abrading material. The expression "obliquely transverse" is employed to indicate the contemplated direction more precisely than is indicated by the word "transverse" alone, which is comprehensive of the right angular relation as distinguished from the diagonal or oblique crossing movement contemplated, which is the result of the traverse of the particles of the abrading material in evolute paths, under the several forces acting upon them as aforesaid. Of course, said paths of the abrading material are curvilinear, and eccentric with reference to the axis of rotation of the glass as distinguished from the above contemplated circles of rotation of the latter. Moreover, it is to be particularly noted that by the operation described, the major and minor areas are abraded respectively oppositely transversely to said junction line between them.

Of course, said lever 52, is set in respectively different positions in order to present the annular abrading surfaces of said laps 56 and 57 respectively in operative relation with the major and minor lens surfaces of the glass 13. The dash line which is radial to the center of oscillation of said lever 52 in Fig. I indicates its position when supporting the lap 57, as in Fig. IV. The position of said lever shown in full lines in Fig. I is approximately that which it occupies when supporting said lap 56 as shown in Figs. I, V and IX, it being thus shifted slightly more to the left, to bring the smaller circumferential line of its annular abrading surface tangential to the circle defining the minor lens areas in Figs. I and V.

Fig. XI is a vertical sectional view of a spindle bearing casing 105 which is similar to said casing 81 but of simpler construction in that it has no bearing screw or nut at the upper end thereof; its cone socket 106 being adapted to receive the conical points of the lap spindles and hold them in concentric relation with said casing and the ball bearing which is detachably but tightly fitted in the socket 107 at the lower end thereof.

I find it convenient to prepare the glass for abrasion by the conoidal laps 56 and 57 above described by primarily surfacing the blanks throughout the entire area of their upper sides, for instance, as shown in Figs. XII and XV. Then, either the minor areas may be further surfaced to the desired curvature, thus reducing them to a less thickness than the major areas, or the major areas may be further surfaced to the proper curvature reducing them to less thickness than the minor areas, as shown in Figs. XIII and XVI. In either case, I prefer to effect

such preliminary surfacing with the axes of rotation of the laps eccentric to the axis of rotation of the glass, at the surface of the latter being abraded, although radial with respect to the center of curvature of that surface, to thus make it impossible to produce concentric scratches in the glass. For instance, the upper spherical surface of the glass blanks 13, as shown in Fig. XII, has its center of curvature on a vertical line coincident with the junction line between said blanks and with the axis of rotation of a glass holder 12 upon which said blanks are assumed to be mounted; and a lap, such as indicated at 56 in Fig. IX, may be set on that surface with the inner circular edge of its abrading surface in continuous contact with said glass surface, but eccentric to the axis of rotation of the glass at said spherical surface of the latter being abraded. However, the axis of rotation of said lap will then be radial with respect to said center of curvature of that surface and, if both the glass and the lap are rotated, the glass will be abraded and said spherical surface generated without producing concentric scratches in the glass, because of such eccentric relation of the abrading tool and glass at the surface of the latter being abraded. In either case, the glass may be finally surfaced as shown in Figs. VI, XIV and XVII by the conoidal laps 56 and 57 above described, or laps of similar construction hereinafter described.

It is to be understood that any of said laps may be provided with a cover of textile fabric or other flexible sheet material 125 retained thereon by the elastic sphincteral band 126 as shown in Fig. IX; such covering serving as vehicles to retain the pulverulent abrading material upon the abrading surfaces of the laps.

Fig. XVIII is a vertical sectional view similar to Fig. IX but showing the lap spindle bearing casing 128 supported by a detachable coupling 130 connecting it with the cap 29 of the upper spindle 18 of the machine shown in Fig. I; said spindle 18 being rigidly connected with the vertically adjustable quill 22 when thus used. Said coupling 130 has the set screw 131 for securing it in adjusted position upon said cap 29, so that said coupling may be turned to present the axis of the lap spindle in a plane which is radial to the axis of rotation of the glass holder 12 or in tangential relation to a circle of rotation of the glass as above contemplated. Said coupling 130 also has the set screw 134 by which the pivot bar 135 may be rigidly held in adjusted position; said bar being constructed and arranged like the bar 78 above described, *i. e.*, it is bifurcated at its lower end to receive the radial flange 136 of the spindle bearing casing 128, which is pivotally connected therewith by the screw 137 which has a smooth cylindrical portion extending through said flange 136 but is in screw threaded engagement with said bar 135. The oscillatory movement of said flange 136 in said bar 135 is limited and the parts clamped in adjusted relation by the screw 139 which extends freely through the openings 140 in said bar but is in threaded engagement with said flange 136, like said screw 84 above described.

Said lap spindle bearing casing 128 carries a ball bearing including an outer shell 89 tightly fitted in said casing 128 and a sleeve 90 rotatable in said casing, and the lap 142, which is otherwise constructed and arranged like the lap 57 above described, has its spindle 143 provided with different means for preventing accidental axial displacement of the latter, including the resilient ring 145 which, as shown in Fig. XX, is normally of slightly larger diameter than said spindle but is compressed to frictionally engage said sleeve 90, as shown in Fig. XVIII, when said spindle is thrust through said sleeve 90 into the operative position shown in said figure.

Although I find it convenient to employ the respectively independent laps above described so that the minor and major lens surfaces may be abraded by different operators at different times; it is to be understood that such conoidal laps may be employed to simultaneously abrade both the major and minor surfaces of the same glass. For instance, as shown in Fig. XXI, the laps 146 and 147 which have annular abrading surfaces respectively adapted to abrade the major lens surfaces 98 and minor lens surfaces 99 of the glass 13 which is rotated by the holder 12, shown in said figure, have the common spindle 149 and may be simultaneously rotated, upon the same axis, by the belts 101, at respectively different speeds, if desired, or they may both be rigidly connected with said spindle by their respective set screws 151 and 152 so as to be rotated together. The relative axial position of said laps 146 and 147 may be precisely predetermined by adjustment of the nuts 154 which are in screw threaded engagement with the inner hub of said lap 146. Such construction and arrangement is advantageous in that the laps 146 and 147 may have their abrading surfaces separately ground to a variable extent and yet be precisely adjusted for the desired coöperative effect upon the glass.

Whether rotated independently or clamped together, as above described; said laps 146 and 147 are conveniently mounted for rotation in the spindle bearing pivot frame 156 having the adjustable bearing screws 157 and 158 which may be set to hold said spindle 149, or the spindles of any of the laps

above described. Said pivot frame 156 is conveniently mounted for oscillation in the yoke 159 which has the set screw 160 for securing it in rigid relation with the cap 29 of the spindle 18 above described, and carries at the lower ends of its bifurcations, opposite, axially alined, screws 162 having conical heads 163 fitted in corresponding sockets in said pivot frame 156 and having wing nuts 164, exterior to said yoke 159 so that said frame 156 may be freed for oscillation in said yoke or clamped in rigid relation therewith. I prefer to limit the oscillatory movement of said frame 156 in said yoke 159 by providing the latter with the clamping screw 167 having the conical head 168 extending in the arcual slot 169 in said frame 156; said screw 167 being provided with the wing nut 170 exterior to said yoke, by which said frame 156 may be clamped in rigid relation with said yoke. Of course, if a permanently rigid construction is desired, the bearing screws 157 and 158 may be directly mounted in the yoke 159, without the interposition of the frame 156.

As indicated in Fig. XXII, either or both of said laps 146 and 147 may have its abrading surface provided with a cover of textile fabric or other flexible sheet material 125 retained thereon by an elastic sphincteral band 126.

As shown in Fig. XXIII, my improved surfacing mechanism may be further simplified by providing a single lap 173 having the respectively differently curved annular abrading surfaces 174 and 175, meeting at the circular line indicated at 176 and respectively adapted for abrading the major lens surfaces 98 and minor lens surfaces 99 of the glass 13 which is mounted to be rotated on the holder 12 as above described. Said lap 173 may be mounted for rotation in any of the lap spindle bearings above described but is shown mounted in the bearing 128 supported by the lever 52 with which it is adjustably connected by the coupling 76 above described.

Said lap 173 has annular abrading surfaces which are like those of the laps 56, 57, 117, 121, 146 and 147 in that they are respectively differently curved transversely and circumferentially and, as indicated in Fig. XXI, the annular abrading surfaces 174 and 175 of said lap 173 are in contact with the glass only at a line 178 which is radial with respect to the lap axis.

As the laps above described present only respective lines of contact to the major and minor lens surfaces, and the former are of greater area than the latter, a longer time is required to produce a given surface upon the major areas than upon the minor areas, although the difference is minimized by the relatively greater diameter and consequent surface speed of movement of the annular abrading surfaces of the laps which are applied to the major areas. Therefore, I find it convenient to provide the lap 180 shown in Fig. XXV, which differs from the lap 173 above described in that its annular abrading surface 181 which is presented to the major glass surfaces 98 is spherically curved, *i. e.*, arcually curved the same both transversely and circumferentially; so that, as indicated in Fig. XXVI, said surface 181 presents an area of contact to the glass which is a lune of a spherical surface, the contour thereof, in plan, being indicated by the dash lines 182 in Fig. XXVI. Said spherical abrading surface of the lap 180 terminates at the circle indicated by the dotted line 184 in Fig. XXV, and the adjacent annular abrading surface 185, which is presented to the minor glass areas 99, is arcually curved respectively differently transversely and circumferentially so as to present only a line of contact to the glass as indicated at 187 in Fig. XXVI. Such construction of the abrading surface 185 is necessitated by the fact that its curvature (four dioptric) is of greater radius transversely than the curvature (six dioptric) of said abrading surface 181, and, if spherically disposed (as a zone of a sphere of such greater radius) it would, of course, sweep over the major glass areas 98 and eliminate the desired curvature of the latter.

It may be observed that in the employment of both of the laps 173 and 180 the smaller circumferential edges of the abrading surfaces which are respectively in contact with the major and minor glass areas extend obliquely over the circular junction line between said areas, from respectively opposite sides of said line; whereby the glass is abraded in a direction transverse to said junction line, so as to sharply define the latter.

It is to be understood that said laps 173 and 180 may have their abrading surfaces covered with textile fabric or other flexible sheet material 125 retained thereon by elastic sphincteral bands 126, as indicated in Fig. XXV.

It may be observed that the ball bearings above described have no means for compensating for wear which is incident to the rotation of the laps at high speed, as they are of an ordinary commercial type, and, although they may be readily and cheaply replaced, I prefer to employ in each of the lap spindle bearings above described, ball bearings which are adjustable to not only compensate for wear but compensate for slight differences in the diameters of the lap spindles which are adapted to slide through the sleeves 90 of said bearings, to and from their operative position. Therefore, I have shown in Fig. XXV a lap spindle bearing casing 190 having tightly but

removably fitted therein a ball bearing including the stationary race ring 191 and rotatable sleeve 192; the latter being radially split at both ends so that it may be constricted upon the lap spindles to rigidly engage them, regardless of slight differences in their respective diameters. Said sleeve 192 has its conical end 193 encircled by the double conical annular ball race ring 195 for the balls 196 which are embraced between said ring 195 and the nut 198 which is in screw threaded engagement with the upper end of said sleeve 192. Said nut 198 is a complete annulus but has radial notches 199 which may be engaged by a screw driver or similar implement inserted through the opening 200 in said bearing casing 190 to hold said nut 198 temporarily stationary while the sleeve 192 is being adjusted in engagement therewith. The construction and arrangement above described is such that when said nut 198 is temporarily prevented from rotating with the sleeve 192, and the latter is turned, either by a tool engaging the radial slots therein or by frictional engagement with the lap spindle, said nut 198 is drawn toward the race ring 195 to take up all lost motion. Said screw thread connecting said sleeve 192 with said nut 198 is preferably so inclined as to be tightened by rotation of said sleeve in the direction in which it is rotated with the lap spindle.

Although the supports for the lap spindle bearings above described as capable of oscillatory movement may be rigidly secured when adjusted to the proper angle to produce the desired surface upon the glass, and the curvature of the glass surfaces abraded by the laps thus supported may be precisely predetermined by such adjustment and maintenance of the laps; it is to be noted that ordinarily lens surfacing operations are facilitated by permitting the laps to have such freedom of movement as to accommodate themselves to the curvature of the glass, particularly during the polishing operation. Therefore, it may be observed that the bearings constructed and arranged in accordance with my invention as above described, permit such freedom of movement, and laps embodying my invention may be thus used. For instance, glass which has been surfaced to the desired curvature by any convenient means and requires to be finally finished or polished may be subjected to the operation of the conoidal laps above described, with the latter free to oscillate to such extent as to accommodate themselves to the curvature determined by the glass itself, and, in such use of said laps their effect is rendered as accurate as possible by the fact that their centers of oscillation are nearer the surface of the glass being abraded than the center of curvature of the surface which is being formed; so as to stabilize the laps, with respect to the glass, regardless of their freedom aforesaid. It may be observed that in Fig. XXI the center of oscillation of the laps is below the surface of the glass which is being abraded, as distinguished from the construction and arrangement illustrated in the preceding figures, wherein the centers of oscillation of the respective laps are above the glass; however, in either case, the centers of oscillation are intermediate of the length of the lines of contact of the laps with the glass. Moreover, it is to be noted that when permitted such freedom of oscillation, it is limited to planes which are radial with respect to the laps and coincident with the lines of contact which the laps present to the glass.

I do not desire to limit myself to the precise details of construction and arrangement above described as it is obvious that various modifications may be made therein without departing from the essential features of my invention as defined in the appended claims.

I claim:—

1. The process of surfacing a bifocal lens, which consists in rotating a lens blank while surfacing the major and minor areas thereof at different times; surfacing each of said areas by rotating an annular abrading element, on an axis obliquely transverse to the axis of rotation of said blank while automatically axially moving said abrading element toward said blank, and predetermining the position of the surface when finished, upon each of said areas, by adjustably limiting the freedom of axial movement of the abrading element toward said blank; the axis of said abrading element being differently angularly adjusted with respect to the axis of said blank in accordance with the area thereof being surfaced, and the freedom of axial movement of said abrading element being differently limited in accordance with the area being surfaced; whereby the relative position of the surfaces of said two areas may be predetermined.

2. The process of surfacing which consists in rotating the article to be surfaced; contemporaneously rotating an abrading element on an axis obliquely transverse to the axis of rotation of said article, and in operative relation with said article in a plane radial to the axis of said abrading element and tangential to a circle of rotation of said article; automatically axially moving said abrading element toward said article as the surfacing operation proceeds; and predetermining the position of the surface when finished, by adjustably limiting the freedom of axial movement of the abrading element toward said article.

3. The process of surfacing which consists in rotating the article to be surfaced;

contemporaneously rotating an abrading element on an axis obliquely transverse to the axis of rotation of said article, and in operative relation with said article in a plane radial to the axis of said abrading element; automatically axially moving said abrading element toward said article as the surfacing operation proceeds; and predetermining the position of the surface when finished, by adjustably limiting the freedom of axial movement of the abrading element toward said article.

4. The process of surfacing which consists in rotating the article to be surfaced; contemporaneously rotating an abrading element on an axis obliquely transverse to the axis of rotation of said article, and in operative relation with said article; automatically axially moving said abrading element toward said article as the surfacing operation proceeds; and predetermining the position of the surface when finished, by adjustably limiting the freedom of axial movement of the abrading element toward said article.

In testimony whereof I have hereunto signed my name at Philadelphia, Pennsylvania, this twenty-sixth day of May, 1915.

ARTHUR E. PAIGE.

Witnesses:

FRANK E. PAIGE,

ANNA ISRAELVITZ.