March 21, 1961 E. H. PHILLIPS 2,975,565

MACHINE FOR GRINDING AND POLISHING LENSES

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FIG. 1

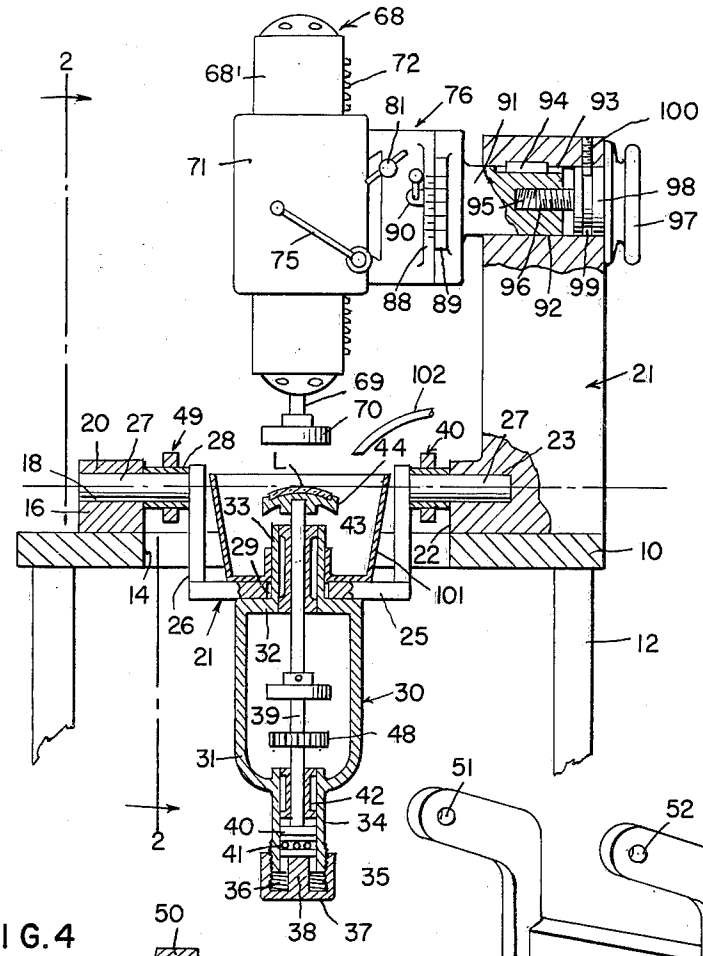


FIG. 4

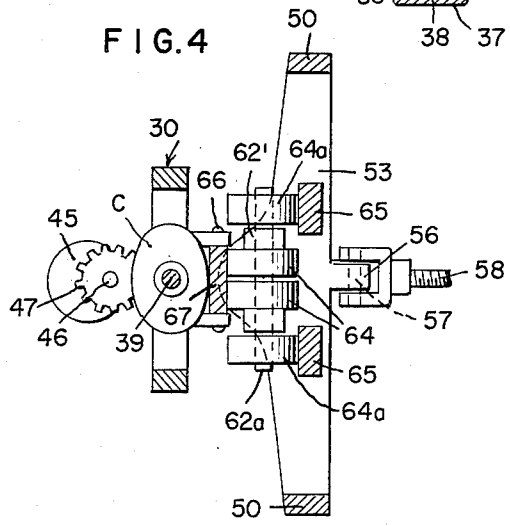
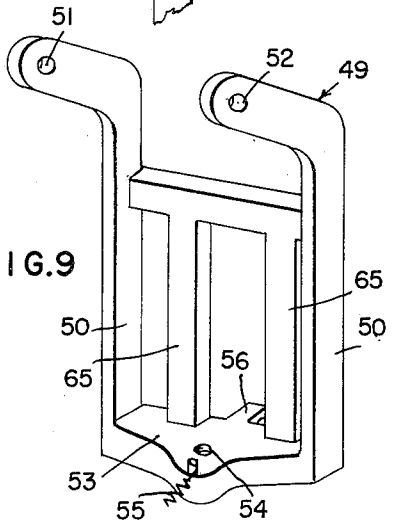


FIG. 9



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FIG.2

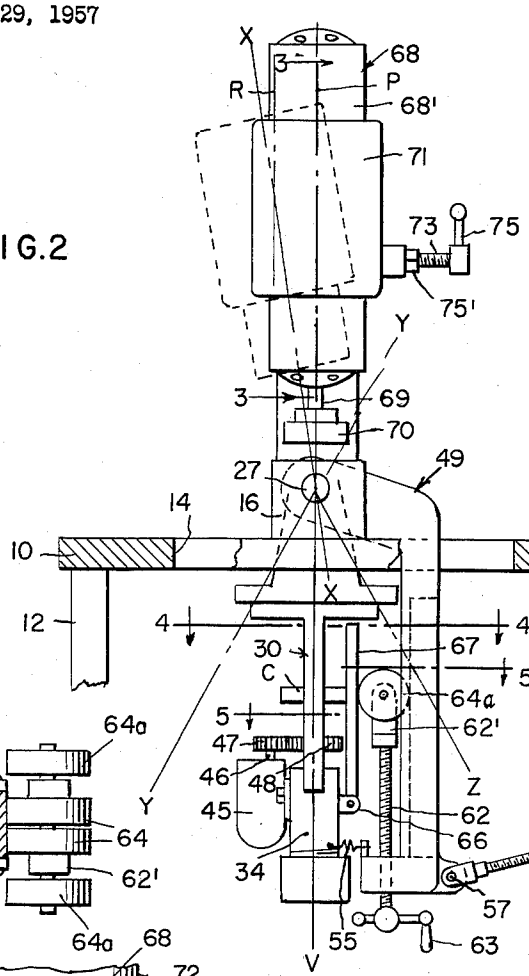
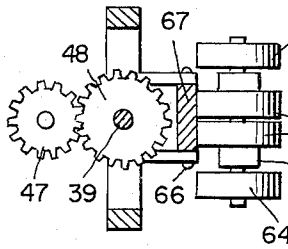


FIG.5



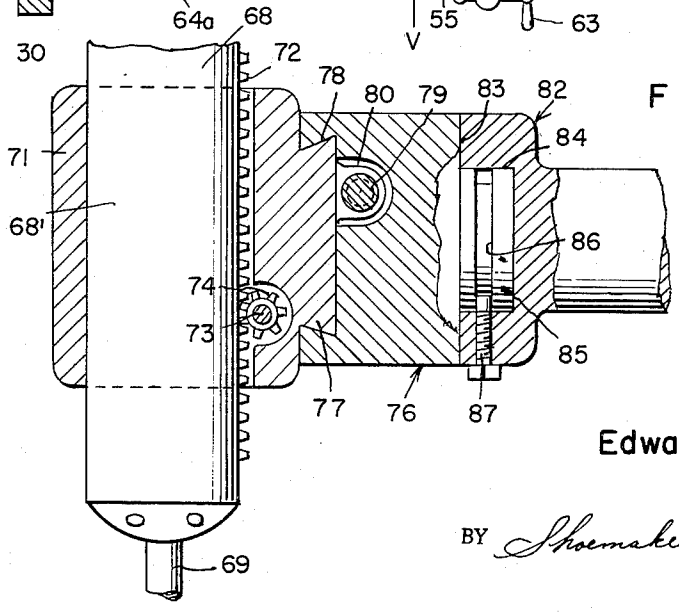


FIG.3

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MACHINE FOR GRINDING AND POLISHING LENSES

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FIG.6

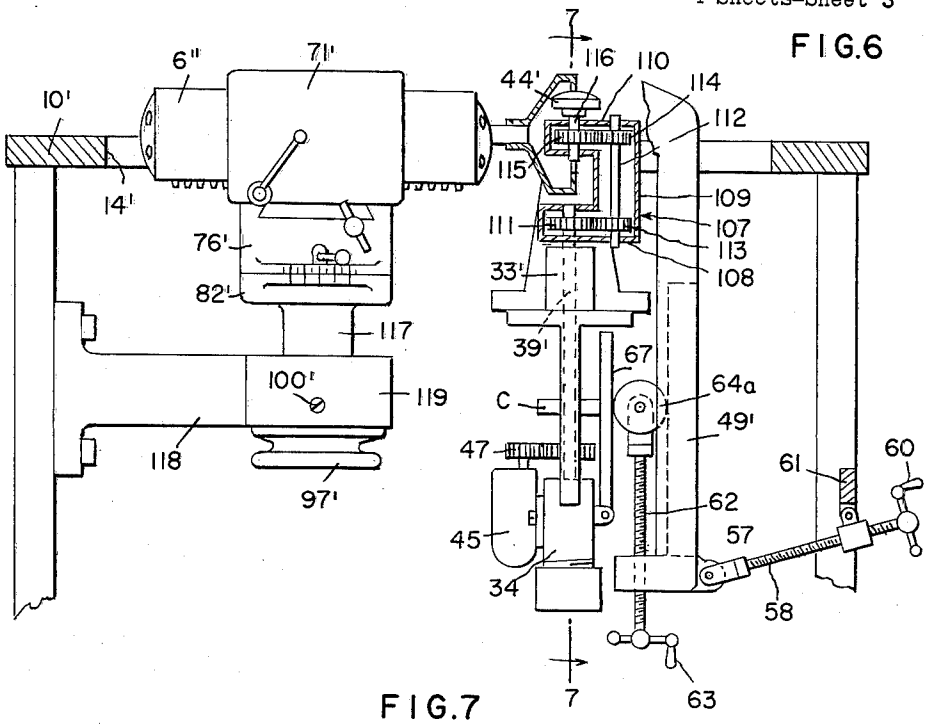


FIG.7

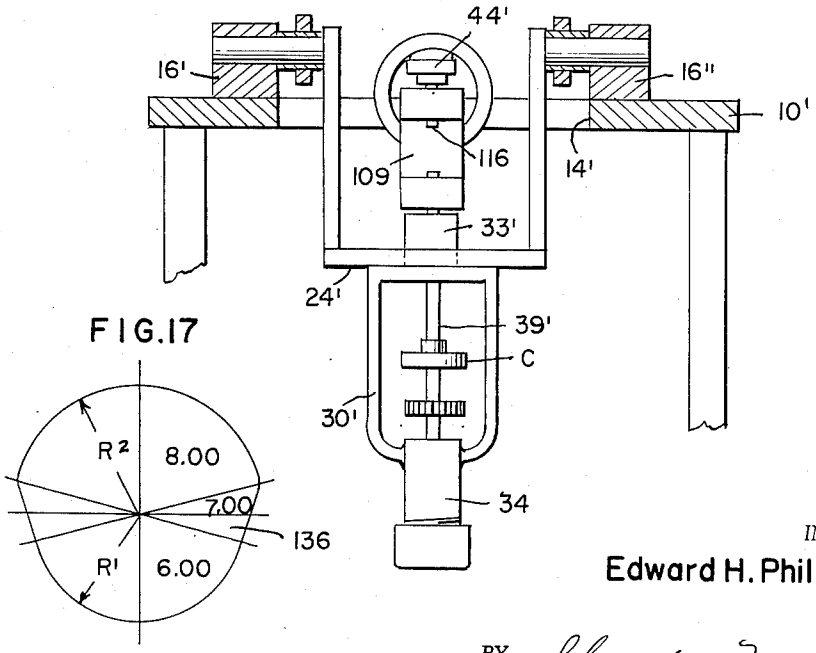


FIG.17

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March 21, 1961 E. H. PHILLIPS 2,975,565

MACHINE FOR GRINDING AND POLISHING LENSES

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FIG.11

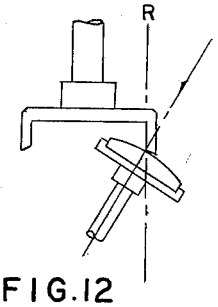


FIG.8

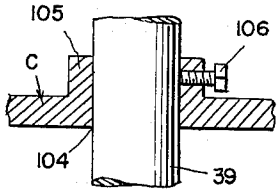


FIG.10

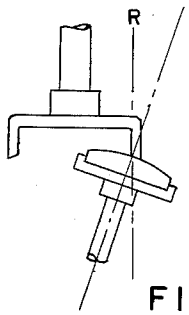


FIG.12

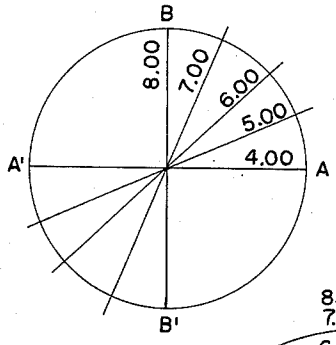


FIG.16

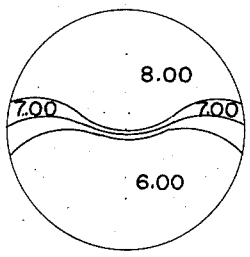


FIG.14

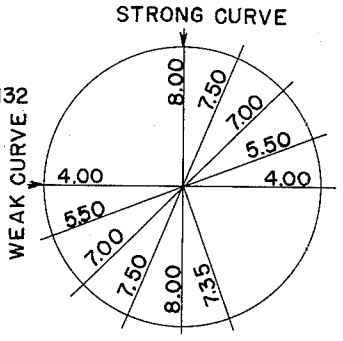


FIG.13

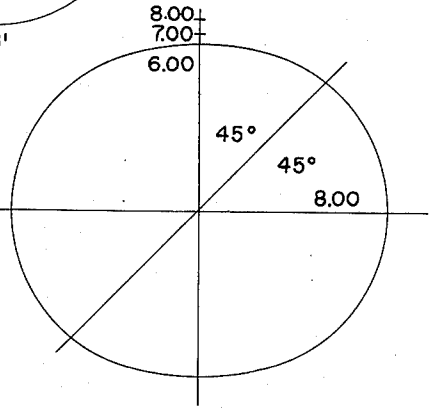


FIG.15

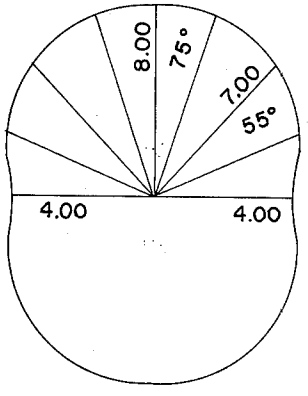


FIG.18

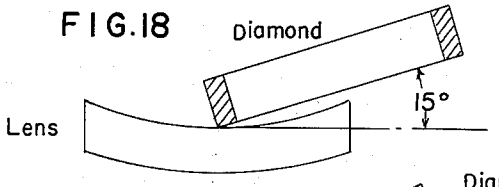
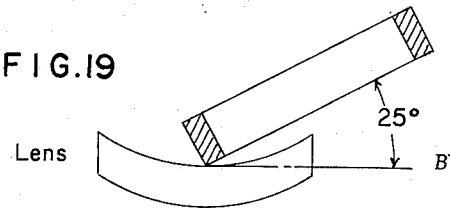


FIG.19



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United States Patent Office

2,975,565

Patented Mar. 21, 1961

2,975,565

MACHINE FOR GRINDING AND POLISHING LENSES

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Filed Oct. 29, 1957, Ser. No. 693,174

13 Claims. (Cl. 51—124)

This invention relates to the art of lens grinding and is directed to a new method and machine for this purpose.

The art of grinding lenses of compound curvature as at present practiced is subject to a number of difficulties which limit the production of lenses of infinite compound combinations, or non-standard compound combinations, as would be desired. Accordingly, in the production of ophthalmic lenses where a specific strength or degree of magnification in a specified area of the lens is desirable, it is not always possible to obtain the desired specified strength by the presently employed conventional methods, but the lens must be ground to a strength nearest to that which is specified or which is most desirable.

Also with lens grinding machines of known design the grinding of compound or multi-compound lenses is associated with certain disadvantages among which is the fact that while one or more operations may be performed to produce one multi-compound lens on the same machine, such machine with the same set-up cannot be employed to make other combinations without changes and considerable effort, which is not only time consuming but requires specialized machines and special equipment.

An object of the present invention, in the light of the foregoing, is to provide, in a manner as hereinafter particularly pointed out, a new machine and method for the production of any and all types of lenses, i.e., toric, multi-compound, multi-focal, spherical or plano, whereby the limitations and disadvantages of present machines and methods are avoided.

Another object of the invention is to provide a new lens grinding machine and method of operating the same whereby the grinding or generation of lenses of any type or any curvature may be carried out in one operation.

Another object of the invention is to provide a new lens grinding machine for producing any one of the stated lens types, which is entirely automatic in operation to continually change the grinding curve with reference to a controlled lens rotation.

Still another object of the invention is to provide a new lens grinding machine wherein the continuous changing relationship between the curve being generated and the lens rotation may be varied at will and while the machine is operating in the making of spherical, toric, compound or multi-compound or multi-focal lenses.

Still another object is to provide a machine for generating lenses of any desired curvature or combination, of curvatures wherein the changing from one curvature to another is an automatic, progressive, stepless operation.

More particularly the present invention has for an object to provide a lens grinding machine employing or adapted to employ control cams in association with a lens blank supporting and rotating means and in a novel operative relationship whereby the generation of any compound lens or of multi-focal lenses may be carried out as a continuous uninterrupted operation.

Other objects and advantages of the invention will become apparent as the description of the same proceeds and the invention will be best understood from a consideration

of the following detail description taken in connection with the accompanying drawings forming part of the specification, with the understanding, however, that the invention is not confined to a strict conformity with the showing of the drawings but may be changed or modified so long as such changes or modifications mark no material departure from the salient features of the invention as expressed in the appended claims.

In the drawings:

Fig. 1 is a view in elevation of one side, as for example the left side, of a machine constructed in accordance with one embodiment of the invention, with parts thereof broken away and in section;

Fig. 2 is a sectional view taken substantially on the line 2—2 of Fig. 1;

Fig. 3 is a sectional view in a vertical plane taken substantially on the line 3—3 of Fig. 2;

Fig. 4 is a sectional view taken substantially on the line 4—4 of Fig. 2;

Fig. 5 is a sectional view taken substantially on the line 5—5 of Fig. 2;

Fig. 6 is a view partly in side elevation and partly in section of a modified or second embodiment of the machine, showing another form of lens supporting and rotating mechanism for use in association with an annular diamond grinding tool;

Fig. 7 is a fragmentary sectional view taken substantially on the line 7—7 of Fig. 6;

Fig. 8 is a detail view partly in section and partly in elevation of a portion of the spindle shaft and of a cam showing one way of mounting the cam on the spindle shaft;

Fig. 9 is a view in perspective of the adjustment bracket which is suspended from the U-frame cradle trunnions;

Fig. 10 is a diagrammatic view illustrating one angular position of the lens supporting spindle with respect to the grinding wheel in the generation of a weak curvature or low diopter curvature;

Fig. 11 is a diagrammatic view corresponding to Fig. 10 and showing a second position for the lens spindle for the formation or generation of a high diopter curvature or strong curvature;

Fig. 12 illustrates diagrammatically and in plan a simple compound or toric lens having the diopter curves indicated thereon;

Fig. 13 is a diagrammatic view of a pattern for the cam employed for developing the lens illustrated in Fig. 12;

Fig. 14 is a diagrammatic plan view of a lens of multi-compound curvature having the diopters designated thereon;

Fig. 15 is a diagrammatic plan view of a pattern for a cam such as would be employed for producing a lens with the diopters as indicated in Fig. 14;

Fig. 16 is a diagrammatic plan view of a multi-sector or bifocal monocentric axis lens of a type similar to that illustrated in Patent 2,743,649 to William Phillips, which may be approximately produced on the machine of the present application;

Fig. 17 is a plan view of a pattern for the cam employed for developing the lens illustrated in Fig. 16.

Fig. 18 illustrates diagrammatically the manner in which the diamond may be canted or tilted for producing a minus lens of a desired diopter as, for example, 6.00 diopters, while Fig. 19 illustrates a more extreme angle position for the diamond for producing a minus lens of a greater diopter, as, for example, 8.00 diopters.

Referring now more particularly to the drawings and to Figs. 1 to 5, the machine here illustrated is shown mounted on a suitable support which may be in the form of a table having a top 10 and supporting legs 12 and the central portion of the table is cut out to form the opening 14.

On one side of the opening 14 there is secured a pillow block 16 formed to provide a bearing 18 which is covered by a conventional bearing cap 20.

At the opposite side of the opening 14 from the pillow block 16 there is a pillow post which is generally designated 21. This pillow post has a bottom inner face 22 in which is formed a bearing socket 23 which is in axial alignment with the center of the bearing 18 in the pillow block 16.

The numeral 24 generally designates a U-frame cradle which embodies a bottom plate 25 to which are joined at opposite ends the upstanding hanger arms 26 and each of these arms at its upper end joins an outwardly directed pivot trunnion 27.

The trunnions 27 have their ends extended into and are supported by the bearings 18 and 23 and the central part of the cradle hangs or depends through the opening 14 for rocking movement therein.

The arms 26 of the cradle are spaced from the opposing faces of the pillow block 16 and pillow post 21 and between each of these faces and the adjacent arm the respective trunnions have thereon and therearound the spacer sleeves 28. These spacer sleeves 28 maintain the cradle properly centered in the opening 14 or, in other words, permit free rocking or swinging of the cradle but prevent movement of the same in the direction of the axis of the trunnions.

The center of the plate 25 forming the bottom of the cradle has an opening therethrough as indicated at 29 and there is suspended from the underside of the plate 25 the spindle bracket which is generally designated 30. This bracket is in the form of an elongate U-shaped frame embodying the spaced parallel side bars 31 which at their top ends join a head plate 32 which is fixed in a suitable manner against the underside of the cradle bottom plate 25 and which has extending upwardly therefrom the centrally located elongate bearing collar 33 which passes upwardly through the opening 29 in the cradle bottom plate 25, as shown.

The lower ends of the bars 31 are joined to opposite sides of a cylindrical housing 34. The bracket 30 and this housing are preferably all cast in one unit. The lower end of this housing is externally threaded as indicated at 35 for engagement with internal threads 36 in a bearing and spindle adjustment cap 37. As shown, this cap receives the lower end of the housing and projecting upwardly from the central part of the cap is a stud 38 which extends into the open lower end of the housing for the purpose about to be described.

The numeral 39 designates a spindle which extends through the length of the spindle bracket 30 and the lower end of this spindle is attached to a supporting foot 40 which is located within the housing 34 and rests upon a thrust bearing 41 which in turn rests upon and is supported by the stud 38 of the adjustment cap 37. Above the spindle foot and located within the housing 34 and surrounding the spindle is a bearing 42 which is of a suitable type to retain a lubricant for application to the spindle so as to maintain a substantially frictionless contact between the bearing and the spindle and the cap 37 may also function, if desired, as a lubricant receptacle for supplying lubricant to the thrust bearing 41.

The spindle which is provided to support the lens to be ground extends upwardly and axially through the collar 33 and projects above the upper end of the collar and the upper end of the spindle is encircled by and supported in a suitable lubricating bearing 43 which is retained within the collar 33.

The numeral 44 designates a conventional blank cup which is mounted upon the upper end of the lens spindle and which supports the lens for grinding.

The lens spindle is of proper height so that when the lens blank cup is mounted thereon and a lens is fixed in the cup the top surface of the lens where the surface is convex will be tangent to the turning axis for the cradle

and spindle bracket or, in other words, to the axis of the aligned trunnions 27 as will be hereinafter more fully described.

The cylindrical bearing housing 34 is formed on a side thereof to facilitate the mounting thereon of a suitable geared reduction motor 45. This motor 45 is of a small horsepower, such for example, as 1/20 H.P., which has an upwardly extending power delivery shaft 46 which carries a spur tooth pinion 47. This pinion 47 is geared to the spur gear 48 which is mounted upon and secured to the lens spindle 39.

The numeral 49 generally designates a hanging bracket which may be defined as a base level control bracket and by means of which certain hand adjustments may be made of the hanging cradle and spindle bracket as hereinafter explained.

This control bracket 49 is generally U-shaped and embodies two long vertical arms 50 each of which terminates at its top end in an obtusely angled extension 51 which has a bearing opening 52 therethrough. The arms 50 are hung from the trunnions 27, each trunnion and the spacer sleeve passing through an opening 52 so that the angular extensions 51 of the arms position the arms in offset relation with a side of the spindle bracket and of the cradle as shown in Fig. 2. As is also shown in this figure, the arms 50 of the bracket are at the side of the spindle bracket opposite from the motor 45.

The lower ends of the arms are connected by a cross bar 53 which is located below the top of the cylindrical housing 34 and embodies a projecting ear 53' intermediate its ends which is directed toward the adjacent cylindrical housing and which has a threaded aperture formed vertically therethrough as indicated at 54.

The ear 53' is attached by a suitable spring 55 to the adjacent housing 34 to normally draw the spindle bracket and the control bracket toward one another.

On the outer or rear side of the bar 53 a lug 56 is formed which is pivotally connected as at 57 with an elongate hand adjustment screw 58. This screw passes through a pivotally suspended nut 59 and at its outer end carries the hand crank 60.

Any suitable means may be provided for supporting the nut 59 between the adjacent table legs 12 as, for example, a suitable transverse bar 61 may be mounted between the legs from which to hang the nut.

Threadably engaged in and extending through the opening 54 in the control bracket bar 53 is a spindle bracket swing or throw control screw 62 which carries on its upper end a fork embodying the two upstanding spaced portions 62' which have extending transversely therebetween and therethrough the pivot pin 62*a*.

The lower end of the control screw 62 carries a hand crank 63 by which the turning of the screw may be effected for advancing or retracting the screw and the rollers about to be described which are carried upon the pivot pin 62*a*.

Between the upstanding portions 62' the pin 62*a* carries a pair of ball bearing fulcrum rollers 64 while upon the outer ends of the pin 62*a*, outwardly from the portions 62' of the bifurcated member on the upper end of the screw 62, the pin 62*a* carries the ball bearing guide rollers 64*a*.

The screw 62 normally is parallel with the spindle 39, that is, when the machine is not operating or when the fulcrum rollers 64 are in one operative position, as hereinafter referred to.

The guide rollers 64*a* are at all times in engagement with track bars 65 which, as shown in Fig. 9, form a part of the bracket 49, being disposed in parallel relation one with the other and between and in parallel relation with the arms 50. These track bars are on the side of the fulcrum rollers 64 opposite or remote from the spindle 39.

The side of the housing 34 adjacent to the screw 62 has pivotally mounted thereon, as at 66, the lower end

of a cam follower in the form of a thrust bar 67. This bar is of a width equal to or slightly greater than the combined widths of the fulcrum rollers 64 as shown in Fig. 4, and extends longitudinally of the spindle between the latter and the fulcrum rollers which are in constant contact with the bar, as shown. The rollers 64 are at all times in contact with the thrust bar 67 and the guide rollers 64*a* are at all times in rolling contact with the track bars 65.

The spindle 39 supports or has mounted thereon, preferably about midway between its ends, a replaceable cam which controls the oscillation of the spindle bracket 30 and the spindle and other parts thereby carried and, of course, also controls the desired rocking motion of the lens supported upon the top end of the spindle in the manner hereinafter set forth. This cam which is representative of any one of different cams which may be used for generating different types of lenses, is generally designated C. Accordingly since it is representative of a number of different forms of cams, it will be understood that the elliptical form shown in Fig. 4 does not necessarily represent the correct form for the production of any specific form or type of lens. The form patterns for the different cams designed to be mounted on the spindle will be hereinafter described.

The cam C when secured in position on the spindle is engaged by the thrust bar 67 and when the machine is in operation the rotating spindle 39 will cause the cam to turn against the thrust bar and the contoured periphery of the cam will act upon the thrust bar to pivot it against the fulcrum rollers 64 and cause the lower end of the thrust bar to be swung back and forth to effect the swinging of the spindle bracket. With the cam located at approximately midway between the ends of the spindle, it will be seen that the action described will take place with the fulcrum rollers above or below the cam level. Thus when the rollers are above the cam level, the linkage multiplies the motion of the spindle bracket and when the rollers are in line with the cam the motion is 1 to 1. Locating the fulcrum rollers below the cam will decrease the motion of the spindle or of the frame structure carrying the spindle or will make the motion less than that described by the cam and finally, by lowering the fulcrum rollers to a location where the centers thereof will be in line with the pivot 66, the motion of the pivot frame or yoke will cease.

It will be understood, of course, that at all times during the operation of the machine the control bracket 49 will remain immovable. This bracket is only moved by the screw 58 at such times as it may be desirable to change the fixed angle of the spindle 39.

The pillow post 21 supports the diamond wheel rotating motor together with the means for shifting the motor and diamond wheel transversely in two directions with respect to the lens spindle axis, and for inclining the rotary axis of the wheel with respect to the lens spindle axis.

The numeral 68 generally designates an elongate D.C. electric motor having a casing or shell 68′ from one end of which extends the armature shaft 69 carrying on its lower end the diamond cutter wheel 70.

The rotational speed of this motor may be varied by a suitable D.C. controller, from 500 to 2000 r.p.m.

This motor body is positioned in or encased in a jacket 71 and on one side of the motor casing or shell 68′ is fixed a rack gear 72 which extends longitudinally of the motor and extending transversely through the jacket and rotatably mounted therein is a shaft 73 carrying a pinion 74 which engages the rack 72 whereby upon rotation of the shaft the motor together with the diamond wheel 70 carried thereby will be axially moved. One end of the shaft 73 carries a suitable crank or handle 75 for turning the shaft and any suitable means may be employed for locking or holding the shaft against rotation when the desired axial adjustment of the motor has been effected as, for example, a lock nut 75′ might be threaded on the shaft to bear against an adjacent part of the jacket to hold the shaft against turning.

The motor jacket 71 is coupled to a swivel head body 76 by the transversely extending dovetail key 77 working in a dovetail slot 78. The key is here shown as forming a part of the jacket and the slot is formed across the end or face of the head 76 which is directed toward the jacket and movement of the motor is effected by a screw 79 extending transversely through the head and passing through an internally threaded collar or lug 80 fixed to the dovetail key 77 and movable in a suitable channel 80′ in the head. One end of the screw carries the crank 81 by which the screw is turned and upon turning of the latter it will be seen that the motor may be moved for adjustment in one plane transversely of the axis of the lens spindle 39.

Swivelly coupled with the head 76 is a swivel body 82 which has a face 83 provided with a socket 84 into which is extended a circular stud 85 having the encircling annular channel 86 therein and the body 82 carries a retaining screw or pin 87 having an inner end engaged in the annual channel 86 to maintain the stud in the socket but while permitting its rotation therein. This swivel coupling provides for the swinging of the motor for disposing the axis of the diamond carrying shaft at an angle to the axis of the lens spindle.

For securing the swivel head in position, the head 76 and body 82 may be provided with suitable coacting means such as the two adjacent ears 88 and 89 and a threaded bolt or pin 89′ passing through the two ears. One end of the bolt may be fixed to one ear and extend through a suitable arcuate slot in the other to permit relative movement of the slotted ear with respect to the bolt. A lock nut or binding nut 90 carried on the end of the bolt adjacent to the slotted ear and provided with a handle functions to secure the two ears against relative movement and thus locking the swivel head in adjusted position.

As shown in Fig. 1, the outer edge faces of the ears 88 and 89 may be provided with suitable cooperating degree scales for indicating the angular disposition of the motor and grinding wheel.

The swivel body 82 carries the elongate support arm 91 which extends into a bore 92 formed across the upper end of the pillar post 21. This arm if circular in cross section is provided with a key-way 93 in which engages a key 94 secured in the bore to prevent rotation of the arm in the bore while permitting axial movement of the arm.

The arm may, of course, be polygonal in cross section and the bore of the same form, in which case the key and key-way would not be required.

The arm has formed axially therein from the free end thereof the threaded bore 95 into which is threadably extended or engaged an adjustment screw 96 carried by an adjustment wheel 97 positioned against the side of the pillar post and covering the end of the bore 92 remote from the swivel body 82. This adjustment wheel has a hub portion 98 rotatably positioned in the adjacent end of the bore 92 and maintained against the axial movement therein by means of the annular slot 99 therearound and one or more set screws 100 carried in the body of the pillar post with their inner ends engaged in the slot. Obviously by rotating the wheel 97 to turn the adjustment screw 96 the arm 91 will be moved axially in the bore 92 for adjusting or moving the motor and the diamond wheel carried thereby in a direction perpendicular to the direction of movement effected by the rotation of the worm screw 79.

From the foregoing it will be seen that four different adjustments of the motor and the diamond wheel carried and rotated thereby are possible, namely, axial adjustment of the diamond wheel by means of the rack and pinion 72—74; rotational adjustment by means of the connection

of the swivel head 76 with the swivel body 82 whereby to swing the diamond wheel in one direction across the upper end of the lens carrying spindle, and horizontal translation of the motor and the diamond wheel along two perpendicular paths by means of the worm screw 79 and collar 80 and by means of the wheel 97.

It will, of course, be understood that in the operation of the machine the spindle 39 will carry upon its upper end the lens cup or lens blank cup 44, as hereinbefore stated, and in accordance with standard practice suitable cooling liquid will be fed to the lens mounted on the cup to facilitate the grinding operation. This liquid will be fed as is conventional, and accordingly means is provided for catching the liquid and ground glass such as, for example, the receptacle 101 which may be supported upon the bottom plate 25 of the cradle in surrounding relation with the collar 33. The numeral 102 designates a suitable tube or pipe for feeding cooling liquid to the lens. Also the pan or liquid receiving receptacle 101 will be provided with means for draining it.

The cams in the several forms in which they are provided for producing the desired lens curvatures are preferably in the form of flat plates which, in most instances, have the peripheries contoured for operative engagement against the follower thrust bar. Any suitable means may be provided for mounting the different cams on the lens spindle and one such means is illustrated in Fig. 8, where the body of the cam illustrated and designated *c* is provided with a central opening 104 to receive the lens spindle 39 and the body is illustrated as carrying a collar 105 which surrounds the opening 104 to encircle the lens spindle and the collar carries a set screw 106 for binding engagement with the spindle.

Also any other suitable means may be employed for mounting the cam on the spindle as, for example, the cam may be divided in two parts so that the two parts can be brought together in encircling relation with the spindle instead of requiring that the spindle be slid through the cam collar.

Figs. 7 and 8 illustrate another arrangement for the lens supporting spindle and the diamond wheel carrying and adjusting mechanism. This second arrangement provides for the use of a ring diamond in place of a cup diamond such as would be employed in the machine as illustrated in Figs. 1 and 2.

In this alternative arrangement of the operating means for the spindle and for rotating the ring diamond, the construction and arrangement of the U-frame cradle, the spindle bracket and parts adjacent thereto is the same as in the first described construction. Accordingly these parts will only be generally referred to hereinafter.

The numeral 24′ generally designates the alternative U-frame cradle and the numeral 30′ generally designates the alternative spindle bracket. For the support of the cradle 24′, the table supports on the top 10′ thereof, on opposite sides of the opening 14′, two pillar blocks 16′ and 16″.

Upon the top of the collar 33′ there is secured and supported a gear housing which is generally designated 107. This housing is of U-form and embodies a lower horizontal disposed arm 108 which is directly positioned upon the top of the collar 33′, the upwardly extending intermediate part 109, and the upper horizontally disposed part 110. The upper end of the spindle which is here designated 39′ terminates in the lower part 108 of the gear housing and carries, within this part, the gear 111. Extending vertically through the part 109 of the housing is a shaft 112 on the lower end of which is a gear 113 which meshes with the gear 111 and on the upper end of which is the gear 114 and this latter gear meshes with the gear 115 secured to the short auxiliary spindle shaft 116 which is rotatably supported by the upper and lower walls of the horizontal upper part 110 of the housing. This auxiliary spindle shaft 116 is in axial alignment with the shaft 39′ and carries on its upper end a suitable lens blank cup 44′.

Positioned to one side of the U-frame cradle and spindle bracket 24′ and 30′, respectively, and on the side of these parts opposite from the control bracket 49′ is the motor supporting standard 117. This standard is suitably supported to be axially adjusted or shifted in the same manner as the arm 91 is shiftable and supports upon its upper end the swivel head supporting body 82′, the swivel head 76′ and the motor encasing jacket 71′. It will be readily apparent that these parts 117 and the parts 82′, 76′ and 71′ are all of the same design and operatively coupled together in the same manner as the hereinbefore described corresponding parts, the difference being that the standard 117 is vertically axially adjustable and that the swivel head turns on a vertical axis instead of a horizontal axis and that the diamond operating or rotating motor which is generally designated 68″ is adjustable axially along a horizontal path instead of in a vertical path.

As stated, the arm 117 may be supported in any suitable manner for axial adjustment and one such supporting means which may be employed is here shown as embodying an arm 118 having an outer end portion 119 formed to receive the lower end of the vertical arm 117 and, of course, it will be understood that the wheel here designated 97′ for effecting the axial movement of the vertical arm 117 will be held in position by one or more set screws 100′ similar to the set screws 100 hereinbefore described. This supporting means consisting of the arm 118 and the outer end 119 is merely illustrative of a support which may be used and obviously any other suitable mounting or supporting means may be employed.

In the operation of the machine, referring particularly to the first described or preferred embodiment thereof as illustrated in Figs. 1 and 2, the relation of the amplitude of spindle oscillation to cam rotation is varied from zero to maximum according to the position of the fulcrum rollers 64 against the thrust bar 67. The zero oscillation occurs when the rollers are in the lowermost position, as stated, and as the rollers are advanced along the thrust bar from the zero position, the cam motion will be less than 1 to 1, as hereinbefore stated, and after the fulcrum rollers have passed the plane of the cam the motion will be multiplied or greater than 1 to 1 motion. Also by changing the position of the cam, that is by placing it higher or lower on the spindle, the change of the range over which the fulcrum rollers are operative can be effected. The lower the cam or the closer it is to the pivot 66, the greater the curve change will be for any one fulcrum roller position. Also if the cam is closer to the pivot 66, movement of the fulcrum roller pivot from top to bottom will produce a wider curve change than if the cam were mounted higher up or near to the top plate 32 of the spindle bracket frame 30. This action may be accomplished while the machine is in operation and the spring 55 keeps the parts loaded or tends to continually draw the parts together so that true following of the fulcrum or thrust bar 67 against the periphery of the cam is assured.

In the operation of grinding a convex or plus lens, the lens blank is set up or mounted in the conventional manner in the blank cup which is mounted in turn upon the upper end of the spindle 39. Proper adjustment of the spindle 39 axially is made so as to bring the top surface of the lens blank at the lens center to the plane of the axis on which the U-frame cradle turns or rocks.

In all operations of grinding, whether the lens being ground is a plus or a minus lens, the lens is positioned in the manner to have the center of the top surface of the lens or of the blank positioned so that the axis line for turning of the cradle meets or substantially meets this surface.

The annular grinding wheel or diamond cup is shifted

so that the axis of the motor shaft will be to one side of the axis of the lens spindle 39 when the latter is vertical, or to approximately the center line R. In preparing for the grinding of a plus lens, the lateral shifting of the motor is carried to an extent where the inside edge or inside corner of the diamond wheel or cup will be brought to the center of the lens blank. If preparation is being made for grinding a minus lens, then the diamond wheel will be moved, by the stated lateral shifting of the motor, to a position where the outside edge of the wheel will be at the center of the lens.

The necessary lowering of the motor is effected by means of the crank 75 to bring the desired part or edge of the diamond into contact with the surface of the lens blank at the center of the latter.

If a flat or plane surface lens is to be ground, then the lens supporting spindle will be maintained vertical and the diamond spindle will also be maintained vertical or parallel with the lens spindle but shifted laterally in the manner stated. For this operation, of course, the fulcrum rollers 64 will be in their lowermost position where the pivot pin will be in line with the pivot of the thrust or fulcrum bar 67 and the control bracket 49 will be maintained in vertical position by the operating or control screw 58.

When the machine is set up for the grinding of a plus or minus lens, the lens spindle must be set at an angle with the diamond spindle. This setting of the angle of the lens spindle is, of course, accomplished by the operation of the screw 58 which, through the medium of the base level control bracket 49, will turn the spindle bracket 30 to the desired angle. The design of the base level control bracket 49 is unique in that regardless of its angular position the distance remains constant between the cam C on the spindle 39, the fulcrum rollers 64 and the bracket 49. This is necessary to maintain linearity in motion between the cam and bracket.

The machine may also be operated to grind any base curve by maintaining the lens spindle vertical and, after laterally setting or shifting the motor carrying the diamond spindle, tilting or cocking the diamond spindle motor to an angle, as indicated in broken lines in Fig. 2 where the axis of the motor is designated *x*.

It will be understood, of course that in Figs. 1 and 2 the adjustment of the diamond or the motor carrying diamond spindle relative to the lens or lens spindle has not been made but the motor will be laterally shifted to bring either the inner or outer corner of the diamond to the center of the lens in the manner previously set forth.

Figs. 10 and 11 illustrate the relationship between the inside edge of the diamond and a lens on the lens spindle in the operation of grinding a plus lens where the diamond spindle is maintained vertical but offset, as previously stated, with respect to the lens spindle and the lens spindle is at an angle or tilted. Fig. 10 shows the minimum angle or tilt for the lens spindle for grinding a flat curve or a curve of low diopter, while Fig. 11 shows the greater or maximum tilt for the high diopter or greater curvature.

Figs. 18 and 19 similarly illustrate two positions which the diamond would assume in the grinding of maximum and minimum extremes of diopters for a minus lens. In this illustration which, as previously set forth, is diagrammatic, the diamond spindle or the motor carrying this diamond spindle has been tilted or cocked while the lens supporting spindle is maintained vertical.

Actually the original or starting grinding position for the lens spindle, with the diamond spindle maintained vertical while it is offset, as stated, would be approximately at or near the axis line Y—Y.

The base level control bracket 49 pivots about the sleeve spacers 28 carried by the trunnions 27, as previously described. Thus the spindle may be moved to any base level angle and the superimposed oscillatory motion of any amplitude will be effected about the bracket pivots.

For the development of the different types of lenses, different cam forms are employed in association with a predetermined setting or disposition of the lens spindle or of the base level bracket 49 and of the fulcrum roller 64 with respect to the fulcrum or thrust bar 67.

OPERATIONS FOR DEVELOPING THE FOLLOWING LENS TYPES

Compound or toric lenses

The compound or toric lens is one which has one curve in one plane and another curve on a plane 90° out of phase with the first. Conventionally these lenses are produced by two methods:

(1) By holding the lens stationary and sweeping it with a rotating diamond;

(2) By swinging the lens in a sweeping plane with its center at some point in space, past a rotating diamond.

The principle of the present invention lies in the rotation of the lens about its own axis while being pivoted or rocked about or with respect to a point on the surface of the lens in a controlled manner relative to its rotation.

By means of the present machine in the different embodiments disclosed, there may be produced plus and minus compound or toric lenses by a completely new method which makes it possible to employ a machine of smaller construction than any heretofore known.

Fig. 12 illustrates a simple compound or toric lens on which are marked diopter curvatures from 4.00 to 8.00, while Fig. 13 illustrates the pattern for a cam suitable for producing a toric lens in the present machine and this cam is marked to indicate the high and low areas which are effective in producing respectively the strong and weak curvatures of the lens.

As an illustration of the action of the substantially elliptical cam shown in Fig. 13, when such a cam is secured on the spindle 39, as the cam and lens rotate 90° from point A to point B, the angle of the spindle shaft and lens changes from, for example, that shown in Fig. 10 to that angle shown in Fig. 11. When the spindle 39 is at the lesser angle to the vertical as shown in Fig. 10, the diamond will be generating a 4.00 diopter curve and as the cam and lens rotate toward the sharper angle as shown in Fig. 11, the diopter curve will change or increase of the greater degree or, for example, to the 8.00 diopter curve. As the cam and lens rotate further from B to D the angle of the bracket and spindle shaft changes or swings back to that shown in Fig. 10 which generates the 4.00 diopter curvature.

Spherical lenses

For the generation of a spherical lens the fulcrum wheel 63 is lowered to a position in which it is directly opposite the pivot 66. Thus there will be no angular displacement of the spindle frame when the spindle and lens are rotated. By the employment of the screw 58 the control bracket 49 and all of the other parts adjacent thereto and below the axis of the trunnions 27 are moved to a selected angle between the center line V on Fig. 2 and the oblique line Y. This will, of course, tip the lens to an angle where it will be held constant. As the lens is slowly rotated by the motor 45 while the diamond is being rotated in contact therewith, a spherical lens will be generated.

The angle of the bracket 49 and parts adjacent thereto may be changed or altered during the grinding operation by means of the crank 60 rotating the screw 58 in the nut 59.

Multi-compound lens

The multi-compound lens in one employing a combination of substantially any two curves for the compound combination. In producing such a lens by present known methods and machines special tools and changes are nec-

essary in the machines. With the present machine substantially any combination of curves may be made by merely changing the diamond diameter, the position of the fulcrum rollers **64** and the spindle bracket angle by the employment of the screw **58**. No smaller radius or higher diopter can be generated with an unshaped diamond ring than that equal to the radius of the ring. For the accomplishment of the best results in grinding compound and multi-compound lenses the diameter of the diamond should be approximately twice that of the lens or greater. The limit on diameter will be the highest diopter or smallest radius desired to be produced on the lens.

The changing of the combination of curves is a progressive stepless operation which is a procedure which has not heretofore been possible to carry out. The effect of changing the position of the fulcrum rollers **64** along the thrust bar is to change the difference between the curves of the compound lens, that is, 4.00 diopters to 5.00 or 6.00 diopters to 8.00, etc. The spindle angle and lens tilt angle controlled by the crank-operated screw **58** varies the level. In other words, if the range should be, for example, 6.00 diopters to 8.00 diopters at 6.00 diopters a spindle angle of 17° to the left of center line V or toward the line Y, operation of the crank would change it to 8.00 diopters at 25° to the left of center line V. This provides an infinitely variable combination which when combined with variously shaped or drastically shaped cams can result in making what may be termed a multi-compound lens.

A multi-compound lens such as is producible by means of the present machine is a definite departure from the convention. It is in effect a compound lens with controlled sectors or controlled intermediate fields. Such a lens has never before been even though or considered to be feasible.

The control of the limits and positions of the intermediate fields or sectors for the production of the multi-compound lens is obtained by the cam shape.

As hereinbefore demonstrated, the employment of a cam of elliptical form will produce a compound lens which is normal with the division or half-split between the two curves occurring at approximately 45° apart. By the employment of a cam form having the ellipse exaggerated or elongated, the position of the change-over between the two curves is altered. Referring to Figs. 14 and 15, for example, Fig. 14 illustrates an ordinary muti-compound lens showing or having indicated thereon dioptic curves progressing from 4.00 to 5.50 to 7.00 to 7.50 and to the stronger curvature of 8.00. The normal case of a compound lens of 4.00 diopters and 8.00 diopters is shown in Fig. 12 with 6.00 diopters approximately in the center of the sector or halfway between 4.00 and 8.00. With a more elongated cam such as that illustrated in Fig. 15 for producing the multi-compound lens illustrated in Fig. 14, it will be seen that the half-split of 6.00 diopters would occur sooner or nearer to the 4.00 diopter curvature. Thus by altering the contour of the cam in the manner illustrated in Fig. 15, the diopter curvatures can be finely controlled and can be made to fall at any place or in any plane between the maximum and minimum.

Most curvatures may be produced with the present machine in one continuous operation. As illustrated, the lens of Fig. 14 is marked to have a 4.00 diopter curvature in one direction and an 8.00 diopter curvature at right angles thereto and between these extremes the curvatures change or may be produced, for example, at 4.25, 4.50, 6.75, and then an extreme curvature of 8.00 diopters, thereafter dropping back to the 4.00 diopter curvature. The cam shape determines the rate of change or change pattern.

Multi-sector or bifocal lens

This is a new type of lens which can be developed or generated with the present machine. In the development of this new type of lens, instead of an elliptical cam being employed, use is made of a double radius round cam (Figure 17) rotating on its center and having in two sectors thereof two tangents for effecting the transfer from one radius (R_1) to the other (R_2). The sphere would be formed or ground by standard procedure as the uniform portion of the cam rotates but when the tangent portion of the cam comes into play, the curve would be changed for that sector. The lens generated by this cam is shown in Figure 16.

A small diamond equal to or slightly larger than the radius of the lens is used for multi-sector lenses. As the lens in Fig. 16 rotates slowly the cam in Fig. 17 will be in operation to lift or change the angle of the lens and the curve of the lens as the radius of the cam goes from R_1 to R_2. R_2 is a bigger radius which is a steeper curve which will generate the 8.00 base curve (Fig. 16). The R_1 radius is short and it slopes the spindle less and thus the 6.00 curve is generated. The width of the tangent sector **136** in Fig. 17 determines the width of the transition field **132** in Fig. 16. These relations of angle and curve are true when grinding concave surfaces as shown in Figs. 18 and 19.

It will be obvious from the foregoing that a plus curve of any type of lens may be generated, with either of the embodiments of the machine illustrated, by displacing the motor head and the grinding diamond with respect to the center line of the lens spindle. In other words, referring more particularly to the form of the machine shown in Figs. 1 and 2, the motor head would be displaced from the center line P to the center line R or to the position where it is illustrated, but kept vertical. The lens L in the blank cup **44** is tilted to get the proper curve and the grinding is done on the inside lip of the diamond wheel as illustrated in Figs. 10 and 11. The spindle shaft **39** is set at any angle between the center line V and the line Y which is oblique thereto.

For the generation of a minus curve while maintaining the motor driven diamond spindle vertical, the motor would be offset so that the center line or the axis of the diamond carrying shaft is at R and the spindle bracket would be swung or rocked by actuating the screw **58** to dispose the spindle **39** at an angle between the center line V and the line Z, which latter line is at the opposite angle to the center line V from the previously referred to line Y. The diamond wheel will then be set to grind the lens or lens blank by the outside edge or lip.

The spring **55** is of sufficient strength to keep the spindle bracket and the bracket **49** in proper position to maintain the fulcrum wheel in contact with the fulcrum or thrust bar **67** and the track **65** between which it is located.

The outside edge of the diamond wheel in generating a minus curvature must always fall at the center of the slowly rotating lens. The necessary adjustment of the wheel may be readily made to so position the edge thereof on the lens by the use of the screw **79** for cross indexing the motor, that is, for shifting the motor and the diamond from the center line P to the center line R.

As previously stated, the grinding surface of the lens should always lie on or near to the axis line for the trunnions **27** supporting the U-frame cradle. Thus swinging or rocking of the spindle bracket **30** will rock the center of the lens on or about a point on the lens surface. This point is at or approximately at the point of intersection of the rotary axis for the spindle **30** and the rotary axis for the U-frame cradle trunnions, which axes are perpendicular to one another at all times.

Vertical adjustment of the spindle to bring the lens into the desired position is effected by means of the adjustment cap **37**. After the various parts of the machine have once been adjusted or set up for any desired curvature and lens thickness, further changes or adjustments would not be required. Grinding of the lens blank initially may be above the center as long as the final

cut approaches the point of intersection of the two axes.

The diamond or grinding wheel rotating motor 68' will be operated at a speed of from 1500 to 2000 r.p.m. while the lens spindle rotation may be from 1 to 60 r.p.m. for rough cuts and faster or from 50 to 100 r.p.m. for final of finished cutting.

It will be seen that the desired initial angular adjustment of the lens spindle is made for effecting the desired rocking of the spindle through the engagement of the edge or periphery of the cam with the fulcrum thrust arm 67.

In addition to the development of the various types of lenses on the present machine by means of the contoured control cams which are interchangeably placed or mounted on the lens spindle, the machine may be used for polishing the various types of lenses produced. For this operation a ⅛ inch thick polishing wheel may be used in place of a diamond with a polishing compound in the liquid replacing the plain cooling water discharged through the tube 102 onto the lens. Obviously polishing will then take place in the same manner as in grinding.

I claim:

1. A machine for generating lenses of the types stated, said machine comprising a substantially U-shaped cradle suspended at opposite sides for rocking on a transverse axis, the cradle having a bottom plate, a spindle bracket suspended from said bottom plate and carrying aligned upper and lower bearings, a spindle supported vertically for rotation in said bearings, means on the upper end of the spindle for supporting a lens blank with the surface thereof to be ground substantially coplanar with said cradle axis, a control bracket suspended on one side of the cradle for turning movement on the axis of the cradle, spring means coupling the lower ends of the spindle bracket and control bracket and yieldingly opposing separation of said ends, means for rotating the spindle, a lens curvature defining cam secured on and rotatable with the spindle, an elongate thrust element pivoted at one end to the lower part of the spindle bracket and engaged against the cam to be swung by and on rotation of the cam, a fulcrum element interposed between and engaged by both the thrust element and the control bracket, means for imparting turning movement to the control bracket, a grinding wheel, means for rotatably supporting the grinding wheel in grinding contact with said surface of the lens blank, and means for rotating the grinding wheel.

2. The invention according to claim 1, wherein the means for imparting turning movement to the control bracket embodies an adjustment screw operatively coupled between the control bracket and an adjacent stationary part of the machine, and means for turning the screw.

3. The invention according to claim 1, with means for changing the point of engagement of the fulcrum element on the thrust element to change the throw imparted to the thrust element by the cam.

4. The invention according to claim 1, wherein said grinding wheel is in the form of an annulus and said rotatable supporting means turns the wheel on an axis perpendicular to the turning axis of the lens, the means supporting the spindle and a lens blank thereon being circumscribed by the grinding wheel annulus.

5. A machine for generating lenses with multiple-compound curvatures, comprising a first means for supporting a lens blank for rotation on an axis passing through the axial center of the lens blank, a second means for supporting the first means and for swinging the first means on an axis perpendicular to and intersecting the axis of rotation for the lens blank at a point on the lens blank surface, a third means pivotally supported adjacent to the second means for transmitting adjusting movement to the second means, a rotatable annular grinder, means for moving said grinder to a position whereby the edge of the grinder may be contacted with said surface of the lens at said point, means for rotating the grinder, means for rotating the lens blank supporting means on the first named axis, adjusting means for swinging the third means on its pivot, a yieldable coupling between the second and third means through which the second means may be swung on its axis by said adjusting means to rock the lens blank carried by the said first means on the edge of the grinder to a selected set position for the starting of the grinding operation, and a means operating continuously with the rotation of the lens blank on the first stated axis to continuously impart swinging movement through a predetermined degree of arc to the second mentioned means only, whereby the lens blank is rocked at said point thereon on the said edge of the grinder.

6. The invention according to claim 5, wherein said third means is supported for coaxial swinging with the second means both conjointly therewith and independently thereof.

7. The invention according to claim 5, wherein said adjusting means is operable to move the second and third means while the last stated means is continuously operating, to rock the lens blank to a different setting with respect to the grinder.

8. The invention according to claim 5, with means operable while the last stated means is continuously operating, to change the preselected degree of arcuate swinging of the second means.

9. The invention according to claim 5, wherein the last stated means comprises a cam on and rotatable with the lens blank supporting means, a fulcrum means carried by said third means, and a follower interclosed between and in engagement with the cam and the fulcrum.

10. The invention according to claim 9, wherein the follower comprises an elongate member pivotally coupled at one end to and carried by the second means to move with the latter, said follower member rocking on said fulcrum in moving with the second means.

11. The invention according to claim 5, wherein said second and third means are in the form of elongate members in juxtaposed relation and swingable both jointly and independently on a common axis, the said adjusting means being constructed to hold the third means only against movement after conjoint adjustment of the second and third means is effected thereby, the said continuously operating means for imparting the swinging movement to the second means comprising; a cam on and rotatable with the lens blank supporting means, a fulcrum member carried by the third means and an elongate follower member pivotally coupled at one end to and carried by and in juxtaposed relation with the second means and interposed between and in engagement with the cam and the fulcrum member, the said follower member rocking on the fulcrum in moving with the second means.

12. The invention according to claim 9, with a motor unit mounted on the second means to swing therewith and a driving connection between said motor unit and the rotatable lens blank supporting means.

13. The invention according to claim 11, with an elongate support element for the fulcrum member attached to the member forming the third means for longitudinal adjustment thereon and longitudinally thereof, and said fulcrum being in the form of a circular body rotatably mounted on said support element with the circular surface of the body engaged by the follower member.

References Cited in the file of this patent

UNITED STATES PATENTS

1,461,094	Pellow	July 10, 1923
2,278,314	Houchin	Mar. 31, 1942
2,291,000	Simpson	July 28, 1942
2,381,449	Holman	Aug. 7, 1945
2,392,478	Holman	Jan. 8, 1946
2,406,789	Bardwell	Sept. 3, 1946
2,747,339	Schelling	May 29, 1956