

April 10, 1951

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2,548,418

SURFACING MACHINE

Filed Dec. 19, 1947

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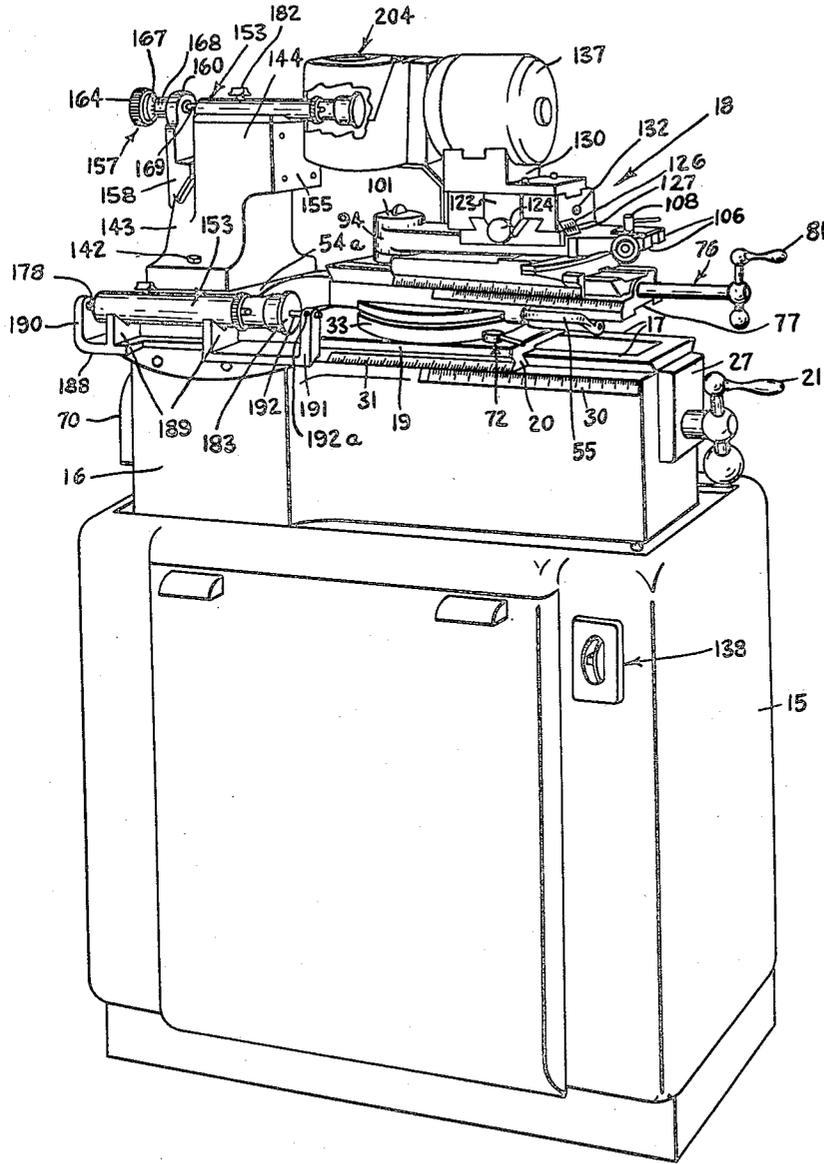


Fig. 1

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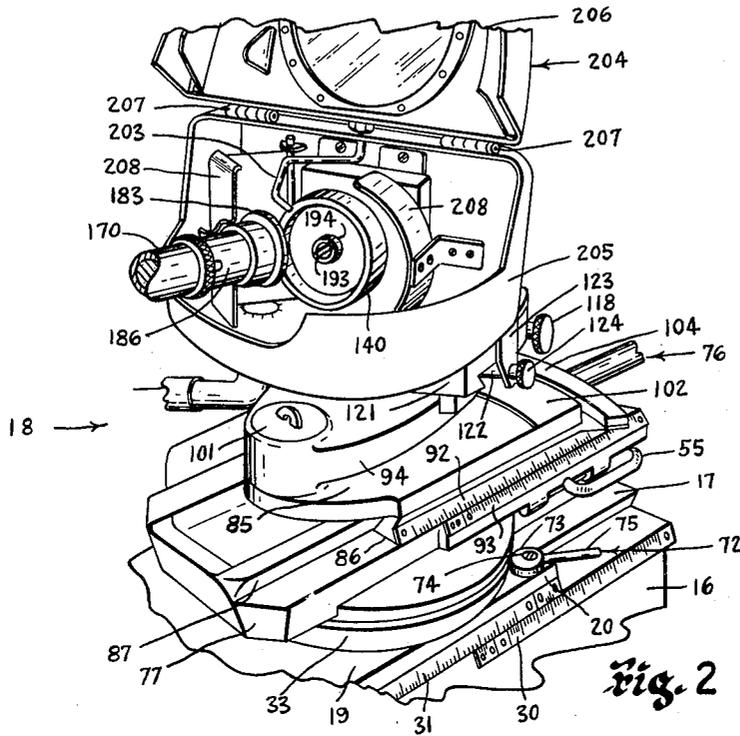


Fig. 2

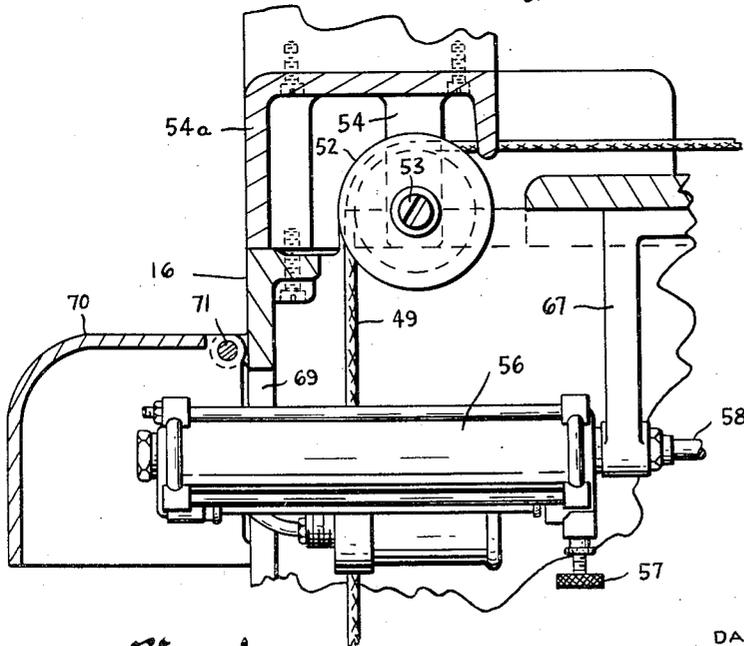


Fig. 4

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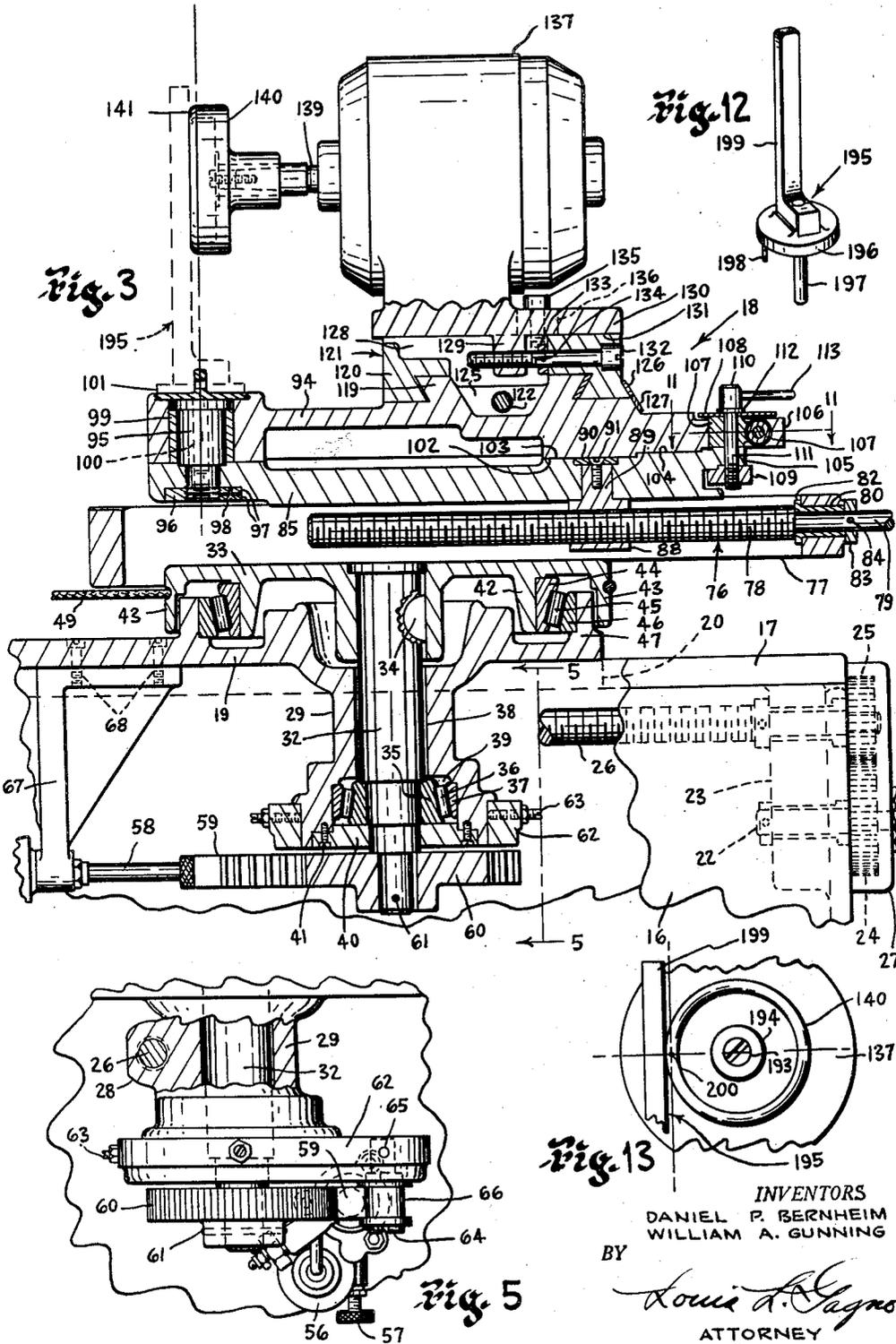


Fig. 13

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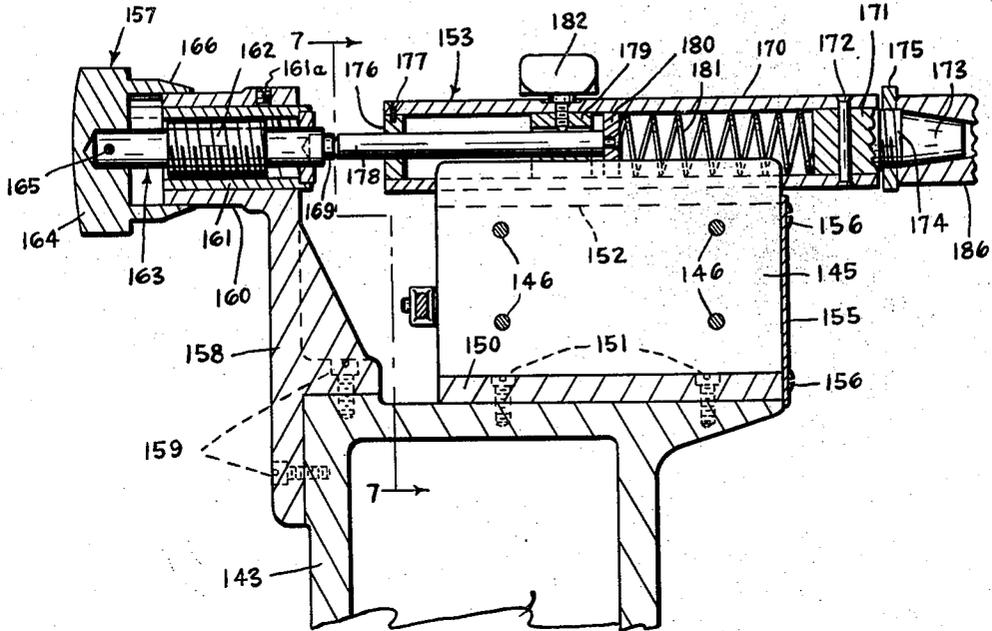


Fig. 6

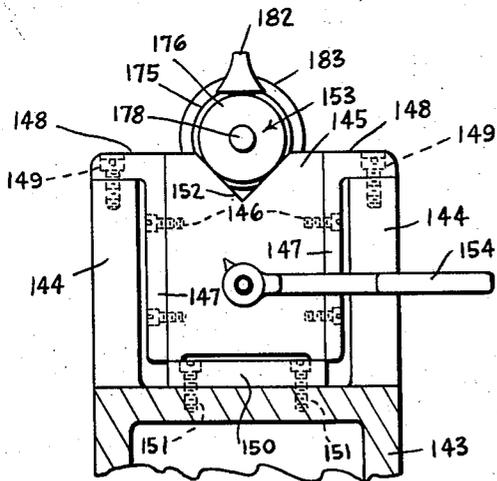


Fig. 7

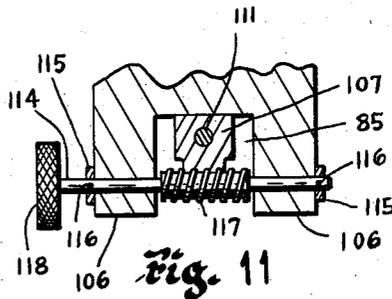


Fig. 11

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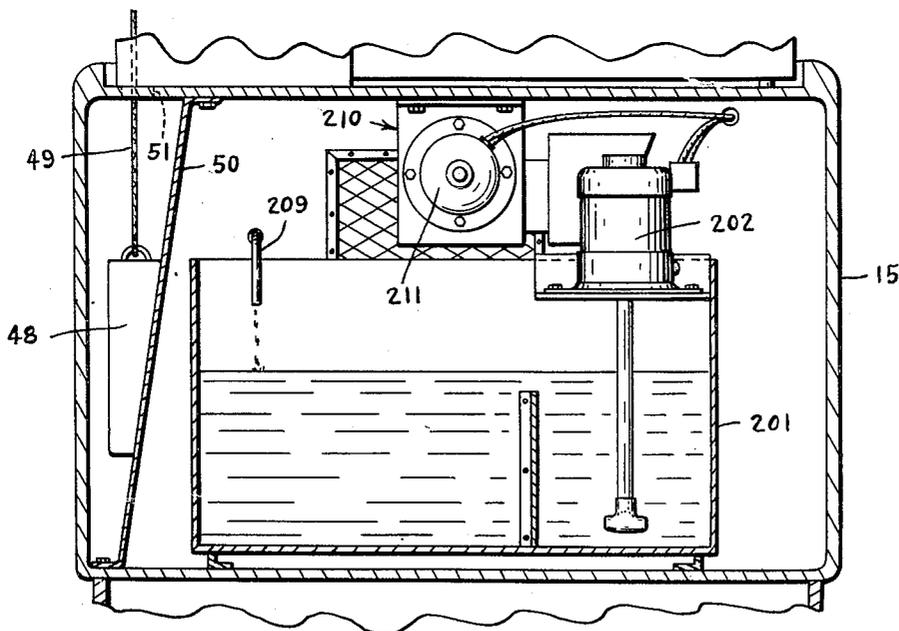
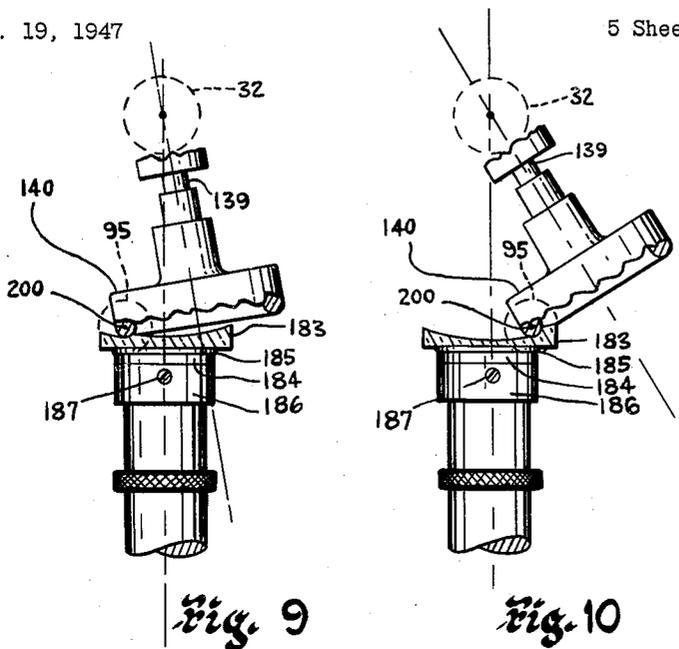


Fig. 8

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UNITED STATES PATENT OFFICE

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SURFACING MACHINE

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Application December 19, 1947, Serial No. 792,668

17 Claims. (Cl. 51—55)

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This invention relates to surfacing machines and has particular reference to an improved apparatus for producing lenses and similar articles having surfaces of single or compound curvatures and to an improved process for producing said lenses and similar articles.

One of the principal objects of the invention is to provide improved means for surfacing articles such as lenses to various surface formations including single and compound curvatures, and an improved process of abrading whereby the resultant surfaces will have a relatively smooth and fine texture.

Another object is to provide a surfacing machine of the above character embodying means for feeding a cup-type abrading tool transversely of an article to be abraded, such as a lens, to abrade a surface on said article of a single or compound curvature, said surface curvature or curvatures depending upon the angle at which said abrading tool is disposed relative to the article and the radius of curvature about which the abrading tool is moved transversely of the article.

Another object of the invention is to provide a surfacing machine of the above character having means for controlling the rate of transverse movement of the abrading tool relative to the article to be abraded whereby the tool will be fed transversely of said article at a speed substantially equal to the rate of removal of portions of the surface of said article by the abrading surface of said tool.

Another object is to provide a surfacing machine of the above character which will generate surface shapes of negative forms of various different single or compound curvatures.

Another object is to provide a surfacing machine of the above character with a cup or ring-type abrading tool so supported that it may be disposed at various different angles relative to the article to be abraded with substantially no change of the positional relation of the tool with respect to the article.

Another object is to provide a surfacing machine of the above character having its abrading tool and article to be abraded confined within a housing, in combination with improved means for directing a lubricant to the engaging surfaces of said tool and article, with the housing confining the lubricant and material removed from the article within said housing and preventing said material and lubricant from gaining access to other working parts of the machine.

Another object is to provide an improved

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vacuum system to draw the mist formed by contact of the lubricant with the engaging surfaces of the tool and article from the housing to prevent the mist from gaining access to other parts of the machine or to the area outside the machine.

Another object is to provide a floating feed arrangement for moving the abrading tool transversely of the article to be abraded.

Another object is to provide a feed arrangement for moving the abrading tool transversely of the article to be abraded which embodies means for causing the tool to be floatingly moved in said transverse direction in combination with variable cushioning means acting in opposition to said first named means.

Another object is to provide a feed arrangement for moving the abrading tool transversely of the article to be abraded, which feed arrangement embodies a weight suspended upon a cord connected with the tool support for imparting said transverse movement, in combination with adjustable pneumatic means also connected with said tool support in such a manner as to resist the gravital pull of the weight and which also functions as shock absorbing or cushioning means.

Another object is to provide a machine of the above character with means for adjusting the abrading tool relative to the article to be abraded and the article relative to the tool, with said adjustment means embodying an arrangement whereby the major adjustments may be quickly and easily performed, and more accurate and finer adjustments may be subsequently performed.

A further object is to provide a rotating lap together with means for adjusting the lap both radially and angularly with respect to a pivot post and a diameter running through said pivot post respectively.

A still further object is to provide means for supporting the article which may be adjusted radially of the pivot post whereby said article may be brought into contact with the rotating lap and the amount of material to be removed from said article may be controlled.

A still further object is to provide yielding means for swinging said lap or tool on said pivot post and to provide means for controlling the rate of said swinging movement.

A further object is to support the tool in operative relation with the work whereby the tool is free to permit manual manipulation in a direction transversely of the work.

Another object is to provide separate work supporting means which may be initially adjusted so as to assume an accurate positional relation and alignment with the curve generating mechanism of the tool when supported in operative position relative to said tool.

Another object is to provide manually operable means by which the depth of cut or amount of material removed during the transverse movement of the tool relative to the work may be positively controlled.

Another object is to provide adjustable means for locating the effective abrading position of the tool in accurate position with respect to the curve generating mechanism of the tool whereby any shift of position due to change in diameter of the tool may be compensated for, thereby permitting tools of various different diameters to be used and also affording means for obtaining the optimum degree of accuracy of curve generation.

Still another object is to provide means for the preliminary positioning or gauging of an article to be abraded prior to locating said article in abrading position in the machine, said means being adapted to position an article while a previously positioned article is being abraded.

Another object is the provision of a surfacing machine utilizing a magnetic chuck for efficiently retaining an article to be abraded while the abrading operation is being performed.

Further objects are to provide in a manner as hereinafter set forth a surfacing machine which is comparatively simple in its construction, durable, thoroughly efficient in its use, and readily set up and adjusted for abrading articles having various surface characteristics.

Other objects and advantages of the invention will become apparent from the following description taken in connection with the accompanying drawings, in which:

Fig. 1 is a perspective view of a surfacing machine embodying the present invention;

Fig. 2 is a fragmentary perspective view of the movable head illustrating particularly the mechanism for imparting a transverse rotating movement thereof during operation of the machine;

Fig. 3 is a fragmentary view partly in section taken vertically through the head and associated mechanism and including a portion of the machine bed;

Fig. 4 is a fragmentary sectional view of the feed control parts within the forward portion of the bed;

Fig. 5 is a fragmentary sectional view taken on line 5—5 of Fig. 3 looking in the direction of the arrows;

Fig. 6 is a fragmentary sectional view of the spindle holding means for the article to be abraded;

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

Fig. 8 is a fragmentary sectional view of the machine base illustrating the operative parts therein;

Figs. 9 and 10 are diagrammatic top plan views illustrating positions of an abrading tool with relation to an article being abraded during an abrading operation;

Fig. 11 is a fragmentary sectional view taken on line 11—11 of Fig. 3;

Fig. 12 is a perspective view of the gauge used for aligning an abrading tool in the machine; and

Fig. 13 is a fragmentary side view illustrating the tool aligning operation.

Prior to the present invention it has been the

usual practice to reduce lens blanks or articles of a similar nature to substantially the finished thickness desired just prior to performing the final polishing or other finishing operations of the surface thereon by hand abrading operations or by slow inefficient mechanical methods. Hand abrading methods were not only slow but also undesirable from a standpoint of cost and such operations depended greatly upon the accuracy and skill of the operator. Prior mechanical abrading methods, while a considerable improvement over hand methods, have been slow due in great part to the time required between abrading operations to position an article to be abraded and the abrading tool with respect to one another whereby the article will be abraded to have the surface characteristics desired. One method for mechanically grinding and polishing the surfaces of optical lenses and like articles employs what is known as the lap system. This is in effect a curve transference, the lap transferring to the article that is being ground, a curvature controgeneric to that of the lap. The grinding of these articles by laps, particularly the rough grinding before the smoothing and polishing operations take place, is slow due to the fact of the restricted number of articles in some instances that can be worked on at one time by a single lap. This lap system also requires an exceedingly large number of tools, it being necessary in fact to provide a separate tool to each curvature which is to be placed on the article thus requiring a very large investment in tools for the manufacture of articles such as optical lenses.

Prior mechanical methods employing the generative system, that is, the system whereby the curve that is formed on the article to be abraded is not transferred as by a lap but is generated as the grinding proceeds, also have sometimes proved to be inefficient because of the somewhat complicated nature of the devices used to adjustably position an article in abrading position in an abrading machine and to adjust the abrading tool for proper engagement with the article to be abraded so that said article will after abrading have the desired surface characteristics.

The present invention eliminates the above undesirable features through the provision of a single cup-type abrading tool and associated mechanism whereby surfaces of single or compound curvatures may be quickly and easily generated by said tool by improved mechanical means, and the process may be speeded by the provision of means for gauging an article to be abraded while a similar previously gauged article is in the process of being abraded, together with simple and efficient adjusting means forming a part of the machine whereby the article and the abrading tool may be mechanically positioned with relation to one another without depending upon the skill and accuracy of the operator. With the present invention a single tool is employed to generate a wide range of curvatures and the article to be abraded may be quickly, easily and accurately positioned in proper abrading relation with the tool.

Referring more particularly to the drawings wherein like characters of reference designate like parts throughout the several views the invention comprises a machine for generating or surfacing articles with minus curvatures and comprises a hollow machine base 15 supporting a bed 16 provided on its upper surface with spaced tracks or guideways 17 on which is slidably located the machine head mechanism 18, the head mechanism 18

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being provided with a supporting plate 19 having spaced tracks 20 on its under side adapted to interfit with the tracks 17, the engaging surfaces of the tracks 17 and 20 being machined so that the head 18 may be moved on the tracks 17 with ease and accuracy. The means for slidably moving the head on the tracks 17 includes a manually operable handle member 21 rotatably mounted by its shaft 22 in a bracket 23 (Fig. 3) formed on the inside of the end wall of the bed 16, the shaft 22 carrying a gear wheel 24 adapted to mesh with the gear wheel 25 positioned on the end of a transversely disposed threaded shaft 26. A gear box 27 is suitably positioned on the end of the bed 16 to cover the gear wheels 24 and 25. The threaded shaft 26 has a bearing in the bracket 23 near the end carrying the gear 25 and is adapted to threadably engage a protruding portion 28 of a tubular depending member 29 formed integral with the under side of the supporting plate member 19 (Fig. 5). Thus by manual rotation of the handle 21 the entire head mechanism 18 can be moved longitudinally of the bed 16 on the tracks 17. A scale 30 graduated in millimeters is fixedly secured to the edge of the front track 17 on the bed 16 and has its reading edge aligned with an index mark on the reading edge of a scale 31 graduated in diopters which scale in turn has its reading edge aligned with an index mark on the millimeter scale, the dioptic scale being secured to the outer edge of the forward track 20 on the supporting plate 19. By this means the extent of the sliding movement of the head mechanism 18 on the bed 16 may be determined.

The entire head mechanism with the exception of the plate 19 may be rotated about a given axis on a pivot post 32 which has its upper end positioned in a vertical opening in the base plate 33 and held from rotation therein by a key member 34. The post 32 is headed at its upper end and has mounted thereover in its lower regions the inner race 35 of a roller bearing unit 36, the post 32 being rotatable within a vertical opening 38 in the tubular depending member 29 formed on the supporting plate 19. The roller bearing unit 35 has its outer race 37 located on the inner wall of an enlarged opening 39 in the tubular member 29 and concentric with the opening 38, and thereby provides means whereby the base plate 33 and the head mechanism mounted thereon may more easily and unrestrainedly rotate. A washer-like retaining member 40 is secured by means such as screws 41 over the end of the depending member 29 and with the head of the post 32 serves to prevent vertical displacement of the post.

The base plate 33 is formed with downwardly extending spaced inner and outer flanges 42 and 43 respectively, the inner flanges 42 being adapted to engage the inner race 44 of a roller bearing unit 45, the outer race 46 of the bearing unit 45 being adapted to snugly reside within an upwardly extending flange 47 formed on the supporting plate 19. This roller bearing unit 45 serves to minimize friction between the base plate 33 and supporting plate 19 when the base plate 33 is rotated.

The base plate 33 and parts of the head mechanism 18 mounted thereon may be rotated in one direction by means of the gravital pull of a weight 48 (Fig. 8) carried by a cord 49, the weight 48 being disposed within the machine base 15 and adapted to slidably engage an inclined motion reducing plate member 50, the plate member 50 being secured at its upper and lower ends to portions of the base 15. The cord 49 is

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connected at one end to the weight 48 and extends upwardly through an opening 51 in the top of the base 15, and passes over a pulley 52 rotatably mounted by stud 53 on a bracket 54 depending from an overlapping housing member 54a fixedly located on the bed 16. The cord 49 is adapted to reside within a circumferential groove provided in the outer surface of flange 43 of the base plate 33 and has its other end fixedly secured by suitable means to the base plate 33. Thus the cord 49 will respond to the gravital pull of the weight 48 and the head mechanism 18 is free to swing about the center of the pivot post 32. A suitably disposed handle member 55 may be used to manually return the head mechanism to such a position that upon release of the handle 55 the weight 48 will cause the head mechanism to again be rotated. This handle also affords means whereby the head may be manually swung on the pivot post with the pulley suspension of the weight permitting free manual manipulation. This permits the tool to be manually fed transversely of the work.

The gravital pull of the weight 48 is resisted by means of a suitable motion dampening device such as the dashpot 56. This dashpot 56 is of a conventional design employing a piston adapted to oscillate within a fluid filled chamber, the oscillating thereof being controlled by suitable means such as the valve control 57, the plunger rod 58 of the dashpot device 56 having its outer end connected to a toothed rack 59, the rack 59 being adapted to mesh with a gear 60 suitably secured as by pin 61 to the lower end of the pivot post 32. A ring member 62 is adjustably secured by studs 63 to the outer surface of the lower end of the depending member 29 formed on supporting plate 19 and serves to carry a downwardly extending roller carrying stud 64, the stud 64 being secured to the ring member 62 by means such as pin 65 and having mounted thereover a roller 66, the roller 66 being adapted to engage the rear surface of the rack 59 to maintain the rack in mesh engagement with the gear 60. By proper adjustment of the valve control 57 the resistance of the dashpot device 56 may be regulated and the rate of swing of the base plate 33 and the entire assembly mounted thereon may be yieldably controlled. This provides a motion dampening arrangement which not only functions in opposition to the gravital pull of the weight 48 but also acts as a shock absorbing means. It is to be understood that the controlling of the rate of swing of the base plate 33 can be controlled by the dashpot device 56 to retard the rate of swing from a fast swing caused by the weight 48 being unrestrainedly permitted to cause rotation of the base plate 33 to a rate of swing so small that the eye cannot observe the rotation of the base plate. It is also to be understood that the dashpot 56 is rigidly mounted in a bracket 67 secured to the under surface of the supporting plate 19 by bolts 68 and thus is adapted to move with the plate 19 longitudinally of the bed 16. The bed 16 has an opening 69 in its end wall through which the dashpot 56 may pass, as shown in Fig. 4, and a cover 70 is hinged as by the hinge pin 71 to the bed 16 to conceal and protect the device.

The base plate 33 may be prevented from rotating by means of a friction lock 72 comprising a cam member 73 (Fig. 2) rotatably mounted by means of stud 74 on the supporting plate 19 adjacent the base plate 33 and adapted to be manually rotated by a handle 75 attached thereto to

frictionally engage the outer surface of the base plate 33 to render it immobile.

The head mechanism mounted on the base plate 33 may be moved longitudinally with respect to the plate 33 by means of an operating shaft 76 which is adapted to extend through an opening in one end of a hollow table 77 formed integral with the upper surface of the base plate 33. The shaft 76 is provided with a threaded portion 78 which is adapted to be entirely positioned within the table 77 and an end portion 79 of smaller diameter than the threaded portion 78, the shaft being rotatably mounted in a bushing 80 located in the opening in the end of the table 77; the rotation thereof being manually controlled by a handle 81. The bushing 80 is formed with a flanged portion 82 adapted to engage the inner surface of the end wall of the table 77 and a stop plate 83 is secured to the shaft portion 79 by a pin 84, the flange 82 and stop plate 83 cooperating to prevent longitudinal displacement of the shaft 76.

The head mechanism mounted on the table 77 includes a slidable base member 85 having tracks 86 formed longitudinally on its lower surface, the tracks 86 being adapted to slidably engage tracks 87 formed on the upper surface of the table 77. An operating member 88 is secured to the under side of the base member 85, being provided with an upwardly projecting portion 89 which is positioned within a vertical opening in the base member 85 and held immovably in place by a retaining plate 90 and screw 91. The member 88 has a longitudinally threaded opening for reception of the threaded portion 76 of the operating shaft 76. Thus, by operation of handle 81 rotation of shaft 76 will cause the base member 85 and the parts of the head mechanism mounted thereon to slide longitudinally of the table 77 on the tracks 86 and 87, the engaging surfaces of the tracks 86 and 87 being machined similar to tracks 17 and 20 to provide ease and accuracy of movement of the sliding member. A diopter scale 92 is secured to the edge of the forward track 86 and a millimeter scale 93 is secured to the edge of the table 77 and are adapted to be read similar to the scales 31 and 30. The scales 92 and 93 are similar to the scales 31 and 30 respectively except that the scales 92 and 93 are graduated reversely to the graduations on scales 31 and 30.

A quadrant-shaped plate 94 is movably mounted on the upper surface of the base member 85 and is adapted to pivot about an axis formed by a pivot stud 95. The pivot stud 95 is inserted in a vertical opening in the quadrant-shaped plate 94, the opening in plate 94 having an enlarged lower portion for reception of a lock nut 96, the lock nut 96 being threadedly mounted over the end of the pivot stud 95 and having bifurcated portions 97 securedly connected by screw 98 in such a manner that when screw 98 is tightened the bifurcated portions 97 will tend to abut and thus will lock the lock nut 96 on the end of stud 95. The quadrant-shaped plate 94 is provided near one end with a vertical opening in which is located a bushing 99, the pivot stud 95 being disposed within the bushing 99. A vertical opening is provided in the pivot stud 95 for insertion of an alignment member as will be hereinafter described, the alignment member to be used in setting up the machine. Since it is important that the opening 100 as well as the stud 95 should be protected from possible damage a cap member 101 is threadedly in-

serted in an enlarged upper portion of the vertical opening in the quadrant-shaped plate 94.

The upper surface of the base member 85 has an arcuate machined surface portion 102 corresponding to a similar adjacent surface portion 103 formed on the under side of the quadrant-shaped plate 94. This provides constantly accurate positioning of the plate 94 on the base member 85, the base member 85 also being provided with a graduated scale 104 so that the amount of rotary movement of the quadrant-shaped plate 94 with respect to the base member 85 may be indicated.

The base member 85 has a flanged portion 105 formed on its outer end and the plate 94 is provided with a pair of spaced bifurcations 106 (Figs. 3 and 11). A movable block 107 is positioned between the bifurcations 106 and is adapted to reside on the upper surface of the base member 85. A cover plate 108 covers the upper surface of the bifurcations 106 and block 107 and a clip 109 is adapted to reside against the under surface of the flanged portion 105 of base member 85. A clamp 110 is provided with a vertical shaft 111 adapted to extend downwardly through concentric openings in the cover plate 108, block 107 and flanged portion 105 and is threadedly inserted in the clip 109. The shaft 111 is provided with a peripheral flange 112 and a handle 113 whereby upon manual manipulation of the handle 113 the shaft 111 can be made to turn to tighten the clip 109 against the under surface of the flanged portion 105 of the base member 85, and the flange 112, cover plate 108 and block 107 will also be forced downwardly against the upper surface of the flanged portion 105. To perform a major change in adjustment with respect to the relationship of the quadrant-shaped plate 94 to the base member 85, the clamp 110 is operated to release the pressure upon the block 107 and clip 109, permitting the plate 94 to be manually swung about the pivot stud 95 to a position approximate the final adjustment desired as indicated by the scale 104. The clamp 110 may then be again manipulated to lock the block 107 immovably against the upper surface of the base member 85.

To obtain the finer adjustment there is provided an operating shaft 114 horizontally disposed and adapted to extend through both bifurcations 106 of the quadrant-shaped plate 94, the shaft being maintained in position by retaining washers 115 secured to the shaft 114 adjacent the outer surfaces of the bifurcations 106 as by pins 116. A worm gear 117 is fixedly located on the shaft 114 between the bifurcations 106 and is adapted to mesh with threads formed on the outer surface of the block 107, and a knurled knob 118 is located on the end of the shaft 114 for manual operation of the device. Thus, since the block 107 is immovably positioned on the base member 85, when the knob 118 is turned to rotate the worm gear 117 the action of the gear 117 against the block 107 will cause the bifurcations 106 and consequently the quadrant-shaped plate 94 as well as the portions of the head mechanism mounted thereon to move slightly about the axis formed by the pivot stud 95, thereby providing the final adjustment of the position of the quadrant-shaped plate 94 with respect to the base member 85.

The upper surface of the quadrant-shaped plate 94 carries an integral horizontal set of tracks or guideways 119 which are adapted to slidably support engaging tracks 120 formed on the under side of a motor support 121. A rotat-

able shaft 122 is adapted to threadedly engage a depending portion 123 on the front of the motor support 121, the shaft extending between the tracks 119 and carrying on its forward end a knurled operating knob 124 and having its rear end rotatably disposed in an upwardly extending portion 125 of the plate 94. Thus, by rotation of the knob 124 and shaft 122 the motor support 121 can be made to slide on tracks 119 in a manner similar to the movement of the supporting plate 19 on the bed tracks 17. The amount of the movement of the motor support 121 on tracks 119 is indicated by adjoining scales 126 and 127 located on the outer surface of one of the tracks 120 and adjacent surface of the plate 94 respectively.

The motor support 121 is formed with a hollow portion 128 in which is adapted to project a downward extension 129 formed integral with the under side of a motor base 130. The motor base 130 is provided with a longitudinal machined portion 131 which is adapted to slidably reside in a groove machined in the upper surface of the motor support 121. An adjusting screw 132 is rotatably mounted through a portion of the motor support 121 and has a portion thereof threaded into an opening in the extension 129, the screw 132 having a slotted head at its outer end and being provided adjacent the inner surface of the wall of the support 121 with a retaining washer 133 connected thereto by a pin 134 to prevent lateral displacement thereof. Thus, by rotation of the screw 132 by a screw-driver or similar means the motor base 130 and mechanism mounted thereon can be made to slide in the groove in the motor support 121. Threaded bores are provided in the motor support 121 for reception of locking bolts 135, the bolts 135 being adapted to extend downwardly through slotted openings 136 in the motor base 130 and into the bores so that when the motor base 130 has been positioned as desired by the adjusting screw 132 the bolts 135 may be tightened to maintain the base 130 in its set position on the support 121.

Fixedly located on the motor base 130 is a motor 137 which is suitably connected to a source of current (not shown) and controlled by a switch device 138 disposed on the machine housing in any suitable location easily accessible to the machine operator such as shown in Fig. 1. The motor 137 drives a shaft 139 to which a cupped or ring-type abrading tool 140 is secured. The tool 140 is preferably of a diamond impregnated or charged type and has its abrading portion 141 formed with a curved cross-sectional shape.

The housing 54a on the bed 16 has fixedly secured thereto by bolts 142 a head 143 which is adapted to carry the work to be abraded. The head 143 is provided with a pair of spaced upwardly extending supporting arms 144 between which is carried a chuck 145, the chuck 145 being of any suitable conventional type but preferably of a magnetic type. The chuck 145 has supporting members 147 secured to each side thereof by bolts 146, the members 147 being provided with flanges 148, the flanges 148 being adapted to extend over the top surfaces of the arms 144 and to be secured thereto by means of bolts 149. To assist in supporting the chuck 145 a supporting plate 150 is provided between the lower surface of the chuck 145 and the top of the head 143, the plate 150 being secured to the head 143 by bolts 151. The chuck 145 has formed in the top surface thereof a longitudinal V-groove 152 having its opposed surfaces precision machined so that

a work-carrying spindle 153 when disposed in the groove will extend in a true horizontal direction and when removed from the groove the same spindle, or another similar spindle, may be replaced in the groove without requiring any realigning operations to locate the spindle in its original position. The chuck 145 illustrated in the drawings is of the permanent magnetic type and is provided with an operating lever 154 so that when the lever 154 is turned to the "on" position the magnetic field of the chuck will attract the spindle 153 in such a manner that the spindle will be fixedly retained in the V-groove 152 until such a time as the lever 154 is turned to the "off" position to change the field of the chuck 145 and thereby permitting the spindle to be removed. A suitable cover plate 155 may be secured as by screws 156 over the ends of the chuck 145 and supporting plate 150 for appearance.

An adjustment device 157 (Fig. 6) similar to a micrometer is located in the upper end of a bracket 158 secured to the edge of the head 143 adjacent the chuck 145 by bolts 159. The bracket 158 is provided with an enlarged supporting portion 160 having a horizontal bore in which is adjustably located a bushing 161, the bushing being threaded on its internal surface and adapted to receive the threaded portion 162 of an operating member 163. The bushing is held in adjusted position by a set screw 161a and provides adjustment to compensate for wear and to enable a zero setting to be made. The outer end of the operating member 163 is of smaller diameter than the threaded portion 162 and has a knurled operating knob 164 secured thereto by a pin 165, the knob being spaced from the end of the bracket 158 and bushing 161 and having a peripheral flange portion 166 adapted to extend over the end of the supporting portion 160 of the bracket 158, the flange portion 166 having micrometer markings 167 therearound (Fig. 1) cooperating with markings 168 on the supporting portion 160. The other end of the operating member 163 is also of smaller diameter than the threaded portion 162 and carries in its extreme end a hardened contact member 169, the member 169 being immovably positioned in the end of the member 163 (Fig. 6).

A jig 188 is used in setting up the work holding device, the jig being disposed in some easily accessible location such as by attaching it to the front of the machine bed 16 as shown in Fig. 1. The jig 188 is shaped to support the spindle 153 and includes spaced supporting arms 189 having V-grooves therein and an upwardly extending arm 190 at one end thereof, with a corresponding arm 191 at its opposite end. The arm 191 carries an adjustable pin member 192 which is threadedly connected to the upright arm 191 and is adapted to be locked in adjusted position by a set screw 192a. This pin member is engaged by the article to be abraded such as the lens blank 193, and the adjustment thereof is to enable a standard gauge length to be set up and to provide means to compensate for wear of the parts.

The spindle 153 is comprised of a tubular body 170 having a plug 171 fixedly secured in the forward end thereof by means such as pin 172 (Fig. 6). The plug 171 is formed with a tapered shank portion 173 and has a threaded portion 174 about midway thereof and adjacent the end of the body 170, the threaded portion carrying a knurled nut 175. A bushing 176 is provided in the end of the body 170, being held therein by a

screw 177, and serves to slidably support a plunger rod 178 adjacent one end thereof, the rod 178 being slidably disposed near its other end in a second bushing 179. The inner end of the rod 178 carries a washer-like piston 180 which is adapted to be engaged by one end of a coil spring 181 which is inserted in the tubular body 170 between the piston 180 and the plug 171.

An article such as a lens blank 183 which is to be abraded is adhesively secured to a block 184 by means of a layer of pitch or other suitable adhesive 185 (Figs. 9 and 10). The block 184 is secured to an adapted 186 as by adjusting screws 187, the adapter 186 being provided with a rearwardly extending portion which is adapted to be fitted snugly over the tapered shank portion 173 of the plug 171 in the spindle 153. The knurled nut 175 on the threaded portion 174 of plug 171 is for the purpose of easily removing an adapter 186 from the tapered shank portion 173.

When the spindle is properly seated in the V-grooves of the jig 188 it is to be understood that the distance between the end of the contact member 169, when the micrometer adjusting device 157 is set at zero, and the abrading surface of the tool is known. Therefore, by adjusting the adjustable pin member 192 the distance between the pin member 192 and the jig arm 190 can be made to exactly correspond to the distance between the contact member 169 and the abrading surface of the tool. After locking the pin member 192 by set screw 192a the spindle 153 carrying the lens blank 183 is located in the V-grooves of the jig 188 with the surface to be abraded of the blank 183 in abutment with the end of the adjusting pin member 192. With the spindle in this position the spring 181 will tend to force the piston 180 and plunger rod 178 outwardly of the body 170 in a direction toward the jig arm 190 and into abutment therewith. A set screw 182 inserted through the body 170 and bushing 179 may then be manually turned by its upper portion into engagement with the plunger rod 178 to retain the rod in its set position.

In positioning an article to be abraded such as the lens blank 183 in abrading position in the machine, the blank is attached as described to the spindle and the spindle gauged in the jig 188. The properly gauged spindle with the lens blank 183 attached is then inserted in the V-grooves 152 of the demagnetized chuck 145 with the end of the plunger rod 178 in abutment against the end of the friction pin 169 of the micrometer adjusting device 157 which device has been previously set at zero on the markings 167 and 168. With the spindle in this position the operating lever 154 can be turned to the "on" position causing the chuck to attract the spindle thereto with sufficient force to prevent the spindle from becoming displaced during an abrading operation. By this means the lens blank will be properly and accurately supported during the abrading thereof. It will also be understood that since the combined spindle and lens blank unit has been previously gauged in the jig 188 to compensate for the thickness of the lens blank to be abraded, the lens blank when properly seated in the V-groove of the chuck 145, and with the micrometric device set at zero, will be in alignment with the arc described about the pivot post 32. It is also to be understood, however, that the micrometer adjusting device will be able to cause the spindle to slide longitudinally within the V-groove 152 when the knob 164 is manually turned. The inward movement of the operating

member 163 upon turning of the knob 164 will, through the plunger rod 178, cause the entire spindle unit including the lens blank to be moved in the chuck and toward the abrading tool an amount as indicated by the scale markings 167 and 168, and controls the amount of material to be removed by the abrading tool during the abrading operation. By first having knowledge of the initial thickness of the blank, this adjustment enables the final thickness of the blank to be controlled.

In setting up and operating a surfacing machine of the preferred type, a tool 140 of the desired size is first attached to the rotor drive shaft 39 by means of a threaded bolt 193 and washer 194 (Fig. 2) and the tool is then aligned with respect to the axis of the pivot stud 95. This is done by removing the cap member 101 from its position covering the pivot stud 95 and inserting the gauge 195 illustrated in Fig. 12. The gauge 195 is formed with a disc-shaped body portion 196 having pin members depending therefrom, a main pin member 197 being centrally disposed with respect to the undersurface of the body portion 196 and being of such size and shape as to reside snugly within the vertical opening 100 in the pivot stud 95. One or more supplementary aligning pins 198 also depending from the underside of the body portion 196 are adapted to be inserted within smaller vertical bores (not shown) in the pivot stud 95 to position the gauge in such a manner that an upright 199 supported upon the upper surface of the body portion 196 will be engaged by the abrading portion of the tool 140, as shown in dotted outline in Fig. 3. By turning the adjusting screw 132, the motor 137 and tool 140 may be moved longitudinally until the tool is in desired contact with the gauge upright 199.

The same gauge 195 may be used to align the tool 140 horizontally by inserting the gauge at an angle ninety degrees from the position shown in Fig. 3, positioning the gauge in such a manner that the center of the cutting portion of the tool may be aligned with the edge of the upright 199, as shown in Fig. 13. To horizontally align the tool with the edge of the upright 199, the shaft 122 may be rotated to cause the motor support 121 to slide horizontally on the quadrant-shaped plate 94.

It is to be understood that the center 200 of the curved face of the tool 140 should be adjusted so as to be coaxial with the axis of the pivot stud 95 (Figs. 9 and 10). The longitudinal adjustment therefor provides means for compensating for wear of the surface of the cutting edge of the tool and this feature should be checked periodically so that as the cutting edge of the tool 140 is worn down this wearing action may be compensated for so that articles such as optical lenses will be surfaced accurately. After aligning the tool the gauge 195 may be removed and the cap member 101 replaced.

The abrading tool 140 may be then adjusted to the desired distance from the axis of the pivot post 32 to control the arc of the curve to be generated in the horizontal meridian of the article to be surfaced. This is accomplished by first operating the handle 21 to cause the supporting plate 19 to be slidably moved on the bed 16 to an extent as indicated by the scales 30 and 31. For example, if a six diopter curve is to be generated on the surface of an article such as a lens blank 183, the supporting plate 19 will be slidably moved on bed 16 to a position where the

scales 30 and 31 will indicate that a curve of six diopters will be generated. Then the handle 81 may be operated to slidably move the base member 85 and the parts of the head mechanism mounted thereon longitudinally of the table 77 on the tracks 86 and 87 to a position where the scales 92 and 93 will render an indication similar to the scales 30 and 31. This latter adjustment is a compensating adjustment which initially enables the tool to be adjusted in a direction away from the work an amount sufficient to permit the scale settings to be made on the scales 30 and 31. The tool may then be moved toward the work and to its final desired position as determined by the scales 92 and 93.

It is particularly pointed out that the curve which is generated will be of the concave or negative form and the radius of curvature is dependent upon the distance at which the cutting edge of the tool 140 is adjusted with respect to the longitudinal axis of the pivot post 32. This arrangement, therefore, provides for various differently controlled curves to be formed in the horizontal meridian.

The curve generated in the vertical meridian of the lens blank or other article to be surfaced is controlled by the tilting of the tool 140 relative to the position which the longitudinal axis or plane of the blank assumes when supported in operative relation with respect to the tool. This is accomplished by loosening the clamp 110 and adjusting the quadrant-shaped plate 94 upon the base member 85 about the axis of the pivot stud 95. After adjusting the plate 94 to the approximate desired position as indicated by the scale 104, the clamp 110 is tightened and the knob 118 is then operated to obtain the finer adjustment necessary to position the quadrant-shaped plate 94 as desired.

If the curve to be generated on the lens blank or other article 183 is to be a single spherical type curve, the tool 140 is angled so as to generate a curve in the vertical meridian of the blank which corresponds in radius to the curve generated by the swing of the tool in a horizontal direction about the center of the pivot post 32. The two curves, therefore, will be of the same radius and will thereby generate a single spherical curve. If the surface is to have a compound curvature, then the adjustments are made so as to introduce the different radii of curvatures desired in the respective vertical and horizontal meridians.

After the above-mentioned adjustments have been made, the article or blank 183 carried by the spindle 153 may be inserted in the chuck 145, the spindle having been previously adjusted in the jig 188 as described so that the particular thickness of the lens blank 183 to be surfaced may be accommodated. It will be understood that in inserting the spindle 153 in the chuck 145, the rod 178 will be placed in abutment with the contact member 169, the micrometer adjustment having been previously set at zero. At this time current may be applied to magnetize the chuck 145 so that the spindle 153 will be securely held in the V-groove 152 thereof. The amount of material to be removed from the lens blank may be then controlled by operation of the micrometer adjusting device 157 to cause the operating member 163 and contact member 169 to urge the spindle 153 toward the surfacing tool 140, the amount of material to be removed being determined by the micrometer markings 167 and 168. It is to be understood that the initial thick-

ness of the blank has been determined and that the final desired thickness is known.

Prior to making the fine adjustment for determining the amount of the material to be removed from the blank, the tool 140 is swung in a sidewise direction about the axis of the pivot post 32 to a position out of engagement with the blank. It may be held in this position by means of the cam locking device 72 pivotally connected to the supporting plate 19 and adapted to frictionally engage the edge of the base plate 33.

After adjusting the micrometer device 157 and releasing the locking device 72 the tool 140 may then be fed transversely of the article or blank 183 by means of the gravital pull of the weight 48 carried by the cord 49 which is secured to the base plate 33, the dashpot dampening device 56 being adjusted to regulate the rate of swing of the plate 33 and the entire assembly disposed thereon. This dashpot arrangement not only functions in opposition to the gravital pull of the weight 48 but also acts as a shock absorbing means to prevent vibratory movement of the tool 140 relative to the lens blank 183 during the abrading operation, and the entire feed may be adjusted so as to substantially keep pace with the rate of removal of the cutting tool, thereby enabling the forming of a very finely abraded surface having a relatively smooth and fine texture. This yieldable control is a strong feature in the cutting of the lens blank as heretofore a positive advance of the tool often caused breakage or chipping of the blank and also a rough finished surface. As the most uniform glass never cuts at exactly the same rate of speed, the yieldable control drive of the tool across the face of the article or lens blank is a positive feature in producing a true and relatively smooth cut.

The above arrangement also permits the tool to be manually swung in a direction transversely of the tool either for prelocating the tool relative to the work or for making an initial cut or the entire abrading cycle may, if desired, be manually performed.

A lubricant or coolant is fed onto the engaging portions of the tool and article being surfaced from a supply tank 201 disposed in the machine base 15 by means of a pump 202, the pump 202 being of any conventional type adapted to force liquid from the tank 201 through a pipe line (not shown) to the conduit 203 (Fig. 2) where it will be expelled onto the tool and article. The tool and article to be surfaced, as shown in Figs. 1 and 2, have a housing 204 surrounding the same to confine the flow of the lubricant and material removed from the article within the housing, and for preventing the lubricant from being splashed or otherwise gaining access to other working parts of the machine. The housing 204 has a base portion 205 and a top portion 206, the top portion 206 being hinged to the base portion 205 so as to be swung vertically upon hinges 207. Within the housing 204 are splash guards 208 which are secured to the inner walls of the base portion 205 of the housing and positioned in relatively intimate or closed relation about the said tool and article to confine the lubricant to the desired engaging surfaces of the tool and article.

The lubricant will be drawn by gravity out of the base portion 205 of the housing 204 and expelled into the tank 201 from the conduit 209. It may be desired to use a vacuum system to draw the mist formed by the lubricant upon engaging the rotating tool and article being abraded from within the housing 204, such a vacuum system

being referred to in Fig. 3 by the numeral 210 and includes a motor 211 which is adapted to set up a suction to draw the mist from the interior of the housing 204 into the conduit 211 and to expel it into the lubricant in the tank 201.

From the foregoing description, it will be seen that simple, efficient and economical means have been provided for accomplishing all of the objects and advantages of the invention. By providing the improved features described, it can be seen that the present invention is not only a considerable improvement over hand surfacing operations but also an improvement over prior mechanical devices by the provision of means for presetting an article to be surfaced before installing it in abrading position thus considerably speeding up the surfacing operations of such articles as optical lenses and also by the provision of simple and easily operated adjusting means for positioning an abrading tool with respect to the article to be abraded, and means for magnetically holding an article to be surfaced in abrading position in the machine.

Although a variable field type magnetic chuck 145 has been disclosed herein as a preferred type of chuck any other known type of magnetic or mechanical chuck may be employed as, for example, in the latter instance a chuck embodying a V-block in combination with suitable clamping mechanism may be employed.

While certain novel features of the invention have been shown and described and are pointed out in the annexed claims, it will be understood that various omissions, substitutions and changes in the forms and details of the device illustrated and in its operation may be made by those skilled in the art without departing from the spirit of the invention.

We claim:

1. A surfacing machine comprising a base having a work supporting head fixedly secured adjacent one end thereof and having a slideway extending in a direction longitudinally thereof, a slide member on said slideway movable toward and away from said work supporting head, a rotatable portion pivotally secured to said slide member for movement about an axis disposed normally to the direction in which said slide member is movable and having a second slideway thereon, a second slide member mounted on said second slideway movable toward and away from said axis and having a tool supporting head pivotally attached thereto for movement about a second axis disposed substantially parallel to said first axis, a cupped type abrading tool having its effective abrading surface in the form of an arc whereby the tool may be moved about said second axis as a center to different angular positions, means carried by said tool supporting head for rotating said tool and adjustment means carried by said work supporting head for moving an article to be abraded into alignment with the effective abrading portion of the tool and for controlling the depth of the abrading action of the tool on the article, whereby the tool may be swung about the first axis as a center to cause the effective abrading portion of the tool during the rotation thereof to move transversely of the article and cause the shape of the resulting abraded surface on said article to have a curvature in one meridian thereof controlled by the adjusted angle of the tool about the second axis and in the major meridian thereof controlled by the arc of swing of the tool about said first axis.

2. A surfacing machine comprising a base having a supporting means thereon for supporting work in a predetermined position and having a slideway to one side of said work supporting means, a slide member mounted on said slideway for movement toward and away from said work pivot means on said slide member, a rotatable supporting member having a second slideway thereon and being pivotally connected to said pivot means, a scale and indicator means carried by said first slide member and the base adapted to function cooperatively to indicate the position of the pivot means with respect to the work, a second slide member mounted on said second slideway and having a tool supporting head pivotally connected thereto, an abrading tool rotatably supported by said tool supporting head and being adjustable toward and away from said work by adjusting the slide members to controlled positions longitudinally of the slideways to vary the related position of the tool supporting head, means for retaining said tool supporting head in adjusted position, and means for swinging said tool about said first pivot in an arc controlled by adjustment of the tool relative to the axis of said first pivot, said work supporting means including a work holder and an adjustable contact member for engaging the work holder and moving said work holder toward the tool to control the amount of material to be removed from the work by the tool scale and indicator means associated therewith for determining the position of adjustment of the work holder and the amount of removal the relation of the tool to the work will permit.

3. In a device of the character described means for retaining a work holder on a work supporting head and for supporting an article to be carried by said work holder to be abraded by an abrading tool supported in adjacent operative relation with said work supporting head, said work supporting head having an adjustable contact member and having means for controlling and indicating the extent of adjustment of said contact member, said work holder having means for supporting an article to be abraded adjacent one end thereof and having an adjustable portion adjacent its opposed end adapted to engage the adjustable contact member of said head when located in operative position in said head, the distance between said contact member and the effective abrading portion of the tool being a determinable distance when the contact member is set at zero position and the distance between the outer end of the adjustable portion of the work holder and the exposed surface of the article to be abraded in the use of the device being controlled so as to be substantially equal to said determinable distance.

4. In a device of the character described, the combination of a rotatable cupped abrading tool, means for angling said tool relative to the work to be abraded, means for feeding said angled tool in an arcuate path about a given axis and transversely of the work along a meridian substantially normal to the angling of the tool, means for moving said axis toward and away from the work to vary the curvature formed on the surface of the work by the abrading tool, means for adjustably supporting the work comprising a chuck having a V-groove therein, a work carrying spindle member positioned in said V-groove to carry said work in a horizontal plane with respect to the abrading tool, and micrometric

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means for advancing said work toward said tool in accordance with the amount of material to be removed from the surface thereof.

5. In a surfacing machine of the character described, the combination of a rotatable abrading tool, supporting means for carrying an article for engagement with the tool comprising a chuck having a V-groove formed therein, independent article-carrying means positioned in said V-groove comprising a holding member adapted to carry said article in a horizontal plane with respect to said abrading tool, and having adjustable contact means, and feed means for engaging said contact means and advancing said article toward said tool in accordance with the amount of material to be removed from the surface thereof.

6. In a surfacing machine, the combination of a work supporting head, a tool supporting head carrying an abrading tool for location adjacent said work supporting head, a chuck fixedly supported on said work supporting head, a longitudinally adjustable spindle positioned in said chuck, said spindle having one end portion adapted to carry said article and its opposed end portion adjustable toward and away from said first portion to vary the length of the spindle, and micrometric means carried by said work supporting head and having an adjustable contact portion for contacting the opposed end portion of the spindle and advancing said spindle and article carried by the first end portion thereof toward said abrading tool whereby the surface of said article may be positioned relative to the tool so as to be abraded to depths as governed by said micrometric means.

7. A surfacing machine comprising the combination of a tool supporting head and a work supporting head, said work supporting head having a V-groove therein, a spindle member seatable in said groove for adjustably carrying an article to be surfaced at one end thereof, and feed means adapted to move said spindle and article carried thereby longitudinally in said V-groove in accordance with the amount of material to be removed from the surface of said article, said tool supporting head supporting an abrading tool adjacent the article to be surfaced and being rotatable about a given pivot, adjustment means for moving said pivot toward and away from the work and for correspondingly changing the amount of separation of the tool from said pivot, said tool supporting head having means associated therewith for angularly adjusting the abrading tool relative to the article about a second pivot lying on an axial line extending through the abrading surface of the tool, and means for yieldably feeding said angled tool transversely of the article and along an arc defined by said first pivot as a center.

8. A surface abrading machine of the character described comprising holding means for supporting work having a surface to be abraded, a rotatable tool having an abrading surface thereon, and adjustable means for supporting the tool with its surface in abrading relation with the surface of the work to be abraded, said adjustable supporting means including a table rotatable about an axis disposed substantially parallel to the general plane of said surface of the work to be abraded, said table being adjustable in a direction toward and away from said general plane of the surface of the work to be abraded to vary the related position of said axis of the table to the work, a supporting portion mounted on said table and adjustable toward and away

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from the axis of said table, together with a second supporting portion mounted on said first supporting portion, with said second supporting portion carrying the tool and being adjustable about an axis disposed substantially parallel to the axis of the table and substantially intersecting the abrading surface of the tool.

9. A surface abrading machine of the character described comprising holding means for supporting work having a surface to be abraded, a rotatable tool having an abrading surface thereon, and adjustable means for supporting the tool with its surface in abrading relation with the surface of the work to be abraded, said adjustable supporting means including a table rotatable about an axis disposed substantially parallel to the general plane of said surface of the work to be abraded, said table being adjustable in a direction toward and away from said general plane of the surface of the work to be abraded to vary the related position of said axis of the table to the work, a supporting portion mounted on said table and adjustable toward and away from the axis of said table, together with a second supporting portion mounted on said first supporting portion with said second supporting portion carrying the tool and being adjustable about an axis disposed substantially parallel to the axis of the table and substantially intersecting the abrading surface of the tool, and means for rotating said table to cause the tool to traverse the surface of the work.

10. A surface abrading machine of the character described comprising a supporting member having a seat therein, movable means mounted on the seat for supporting work having a surface to be abraded, a rotatable tool having an abrading surface thereon, and adjustable means for supporting the tool with its surface in abrading relation with the surface of the work to be abraded, said adjustable supporting means including a table rotatable about an axis disposed substantially parallel to the general plane of said surface of the work to be abraded, said table being adjustable in a direction toward and away from said general plane of the surface of the work to be abraded, so as to vary the related position of said axis of the table to the work, a supporting portion mounted on said table and adjustable toward and away from the axis of said table, together with a second supporting portion mounted on said first supporting portion with said second supporting portion carrying the tool and being adjustable about an axis disposed substantially parallel to the axis of the table and substantially intersecting the abrading surface of the tool, together with means for rotating the table to cause movement of the tool transversely of the surface of the work to be abraded, and control means for urging the movable work supporting means toward the abrading tool according to the amount of material desired to be removed from the work by said transverse motion of the tool.

11. A surface abrading machine of the character described comprising holding means for supporting work having a surface to be abraded, a rotatable tool having an abrading surface thereon, and adjustable means for supporting the tool with its surface in abrading relation with the surface of the work to be abraded, said adjustable supporting means including a supporting member movable toward and away from the work to be abraded, pivot means on said supporting member, a rotatable member pivotally

connected with said pivot means, the axis of said pivot means being disposed substantially parallel to the general plane of said surface of the work to be abraded, a supporting portion mounted on said rotatable member and adjustable toward and away from the pivot means to which said rotatable member is pivotally connected, together with a second supporting portion mounted on said first supporting portion, said second supporting portion carrying the tool and means for rotating the tool with its axis of rotation substantially normal to the axis of the pivot means, and said second supporting portion being adjustable about an axis disposed substantially parallel to the axis of the rotatable member and substantially intersecting the abrading surface of the tool.

12. In a device of the character described, the combination of an abrading tool and supporting means for maintaining work in controlled abrading relation therewith, said supporting means including a main support having a seat therein, a work holder mounted in said seat and movable along said seat toward and away from the tool, means adjacent the side of the work holder toward the tool for supporting the work to be abraded, and an adjustable contact portion adjacent the opposed side of the work holder movable toward and away from the work holding means for varying the distance between the work to be abraded and the contact portion of the work holder, locking means for retaining said contact portion in adjusted relation, and adjustable means having an engagement portion for engaging said contact portion and moving the work holder along said seat toward the abrading tool to control the amount of material removable from the work by the tool, and means for locking the work holder in a given position along said seat.

13. In a device of the character described, the combination of an abrading tool and supporting means for maintaining work in controlled abrading relation therewith, said supporting means including magnetic chuck means having a V-shaped longitudinal seat therein, a work holder mountable in said seat and movable toward and away from the tool, means carried by the work holder adjacent one end thereof for supporting the work to be abraded, a contact portion adjacent the opposed end and adjustment means for varying the distance of separation of the contact portion from the work supporting means, and feed means for engaging said contact portion and moving the work holder bodily along said seat controllable amounts toward the abrading tool according to the amount of material desired to be removed from the work by the abrading action of the tool thereon, said work holder being of a material magnetically attractable by the magnetic chuck means and means for energizing and de-energizing the magnetic chuck means so as to lock and unlock the work holder in a given position in said seat.

14. In a device of the character described, the combination of a rotatable abrading tool, supporting means for work having a surface to be abraded and adjustable means for supporting the tool with its abrading surface in controlled abrading relation with the work, said supporting means including a main support having a seat therein, a work holder mounted in said seat and movable toward and away from the tool, means adjacent the side of the work holder toward the tool for supporting the work to be abraded, a contact portion adjacent its opposed end and means for vary-

ing the distance between the work to be abraded and the contact portion of the work holder, said adjustable supporting means for the rotatable tool including a table rotatable about an axis disposed substantially parallel to the general plane of said surface of the work to be abraded, said table being adjustable in a direction toward and away from said general plane of the surface of the work to be abraded so as to vary the related position of said axis of the table to the work, a supporting portion mounted on said table and adjustable toward and away from the axis of said table, together with a second supporting portion mounted on said first supporting portion, with said second supporting portion carrying the tool and being adjustable about an axis disposed substantially parallel to the axis of the table and substantially intersecting the abrading surface of the tool, means for rotating said table, and means for moving the work holder along said seat of the main support toward the abrading tool to control the amount of material removable from the work by the tool during the abrading action thereof on the surface of the work.

15. In a surface abrading device of the character described, the combination of an abrading tool, a spindle having holding means adjacent one end for supporting work having a surface to be abraded, and having contact means adjacent its opposed end, said contact means being adjustable relative to the spindle for varying the distance between said contact means and the work holding means, feed means having an engagement portion for engaging said contact means of the spindle so as to permit operation of the feed means to move the spindle and work carried thereby into effective abrading relation with the abrading tool, and gauge means for indicating a standard of distance between the initial position of the engagement portion of the feed means and the abrading tool whereby the distance between the contact means and work holding means of the spindle may be adjusted to compensate for different thicknesses of work so as to permit predictable amounts of material to be removed from the work under control of the feed means.

16. In a surface abrading device of the character described, the combination of an abrading tool, a support having a seat therein, and a removable spindle positionable in said seat, said spindle having holding means adjacent one end for supporting work having a surface to be abraded, and having movable contact means adjacent its opposed end, spring means for urging said contact means in a direction away from the work holding means, and locking means for maintaining said movable contact means in adjusted relation, feed means having an engagement portion for engaging said contact means of the spindle so as to permit operation of the feed means to move the spindle and work carried thereby into effective abrading relation with the abrading tool, and gauge means for indicating a standard of distance between the initial position of the engagement portion of the feed means and the abrading tool whereby the distance between the contact means and work holding means of the spindle may be adjusted to compensate for different thicknesses of work so as to permit predictable amounts of material to be removed from the work under control of the feed means.

17. In a surface abrading device of the character described, the combination of an abrading tool, a spindle having holding means adjacent one end for supporting work having a surface to

be abraded, and having contact means adjacent its opposed end, said contact means being adjustable relative to the spindle for varying the distance between said contact means and the work holding means, feed means having an engagement portion for engaging said contact means of the spindle so as to permit operation of the feed means to move the spindle and work carried thereby into effective abrading relation with the abrading tool, and gauge means for indicating a standard of distance between the initial position of the engagement portion of the feed means and the abrading tool whereby the distance between the contact means and work holding means of the spindle may be adjusted to compensate for different thicknesses of work so as to permit predictable amounts of material to be removed from the work under control of the feed means, said gauge means comprising a seat for the spindle, a stop member adjacent one end, and an adjustable member adjacent the opposed end movable toward and

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away from said stop member to adjust the distance of separation of said adjustable member from the stop member according to said standard.

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