

June 16, 1942.

L. W. GODDU

2,286,361

ABRADING MACHINE

Filed March 27, 1939

8 Sheets-Sheet 1

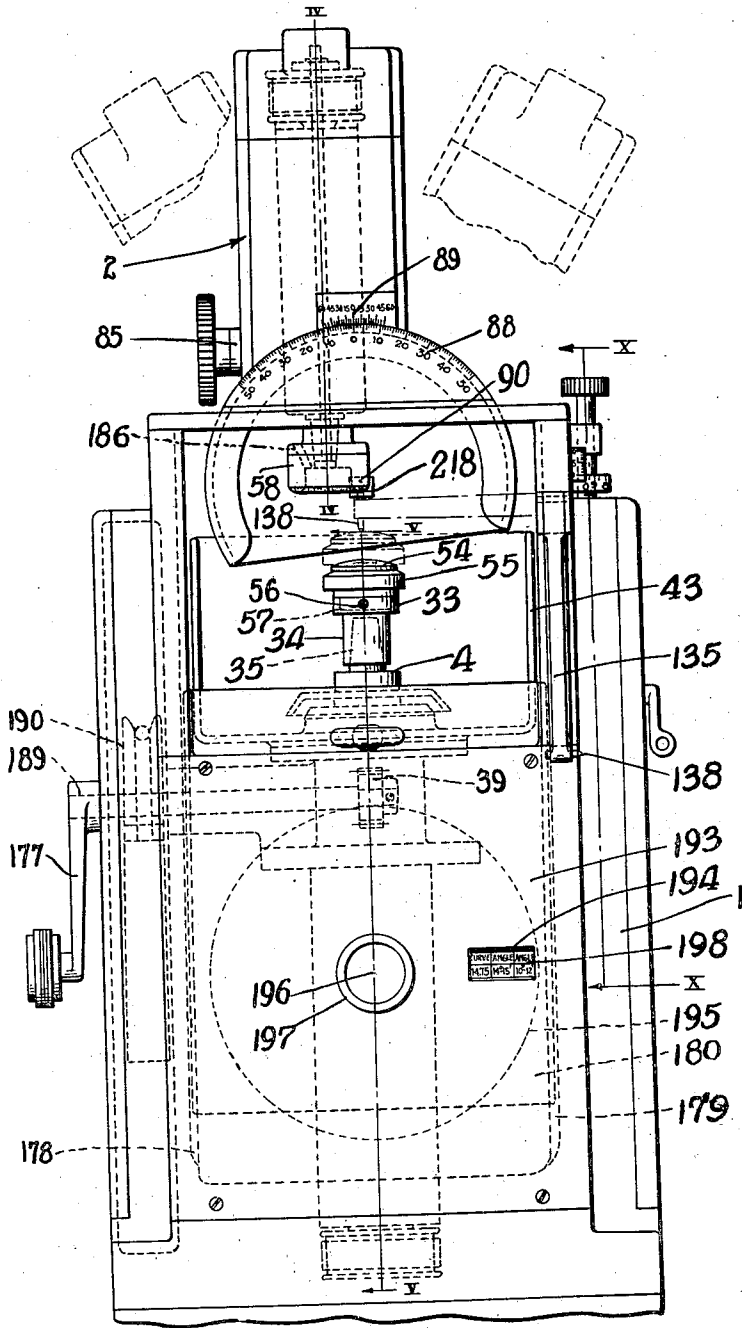


Fig. I

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8 Sheets-Sheet 2

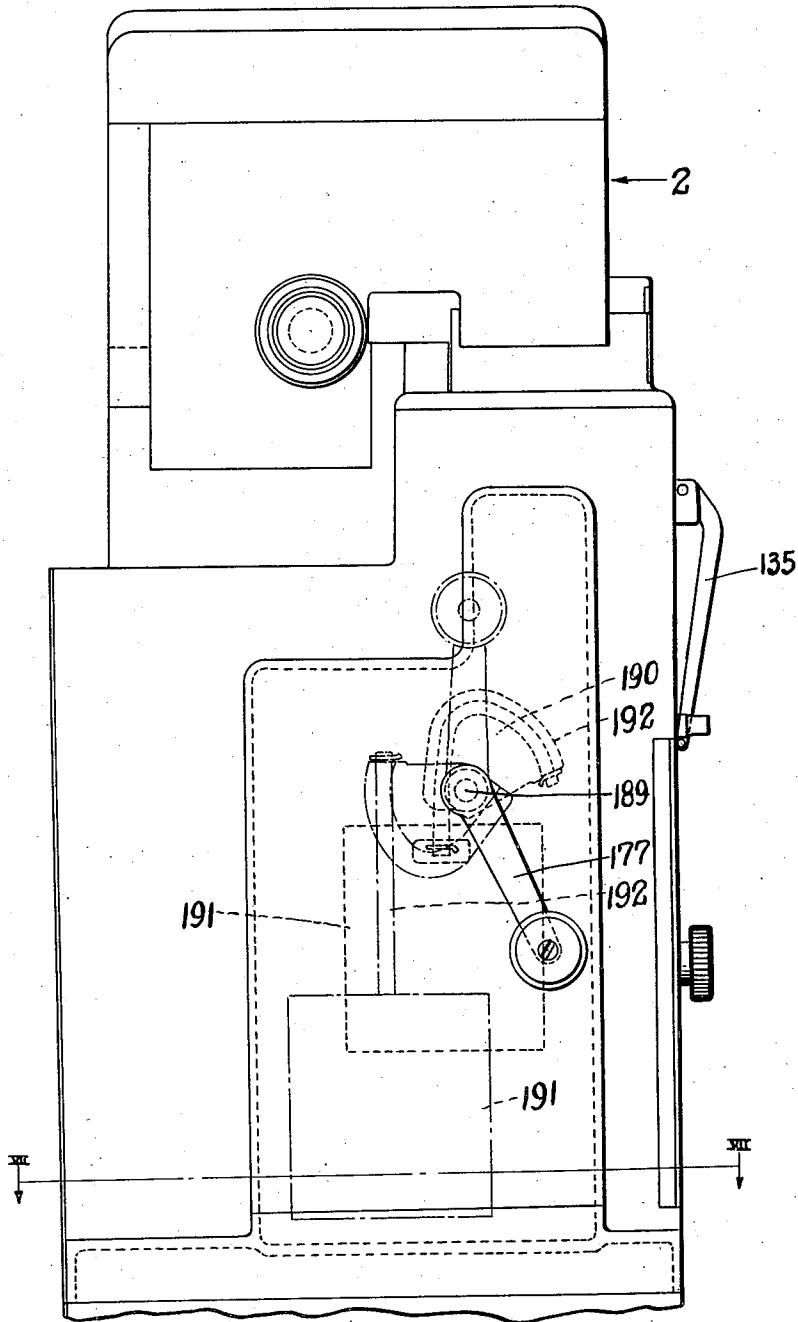


Fig. II

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8 Sheets-Sheet 3

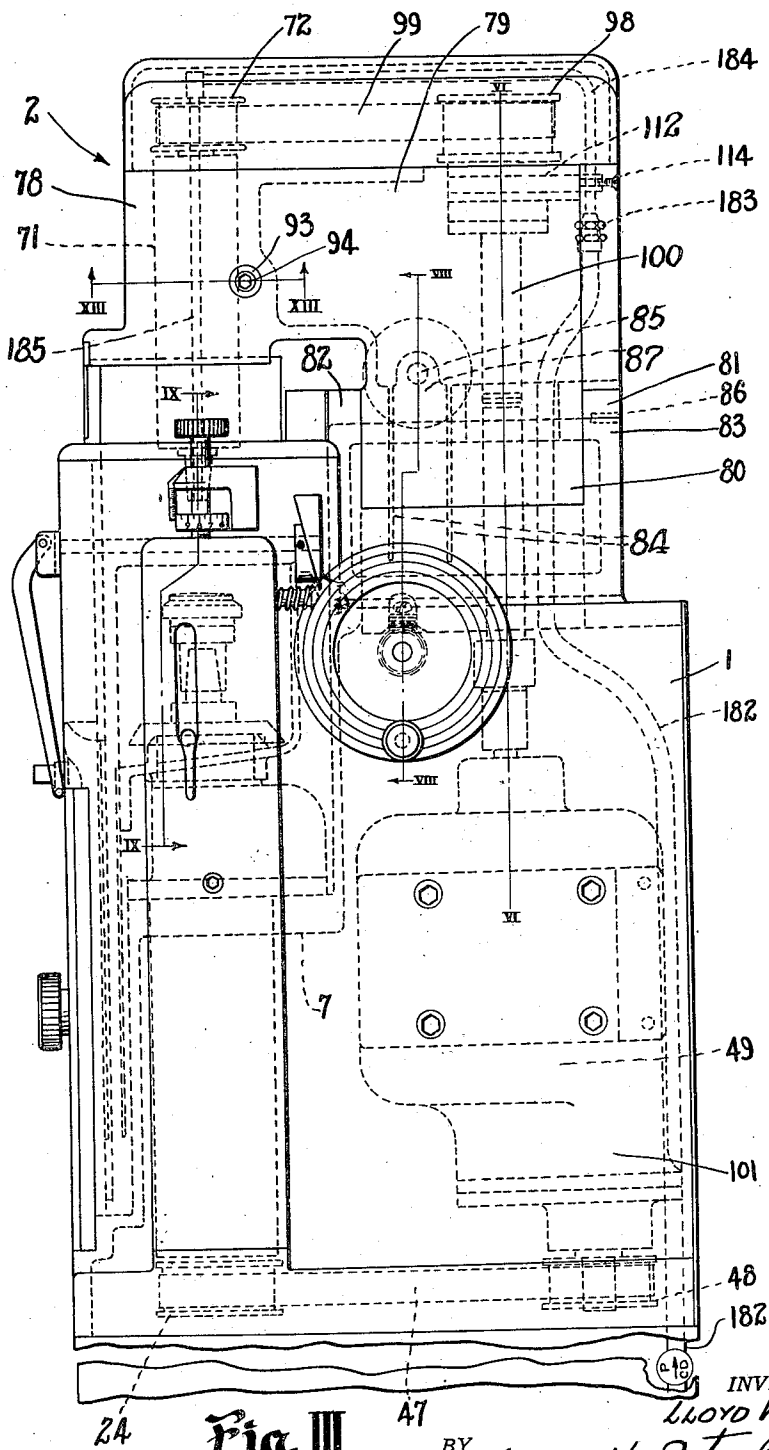


Fig. III

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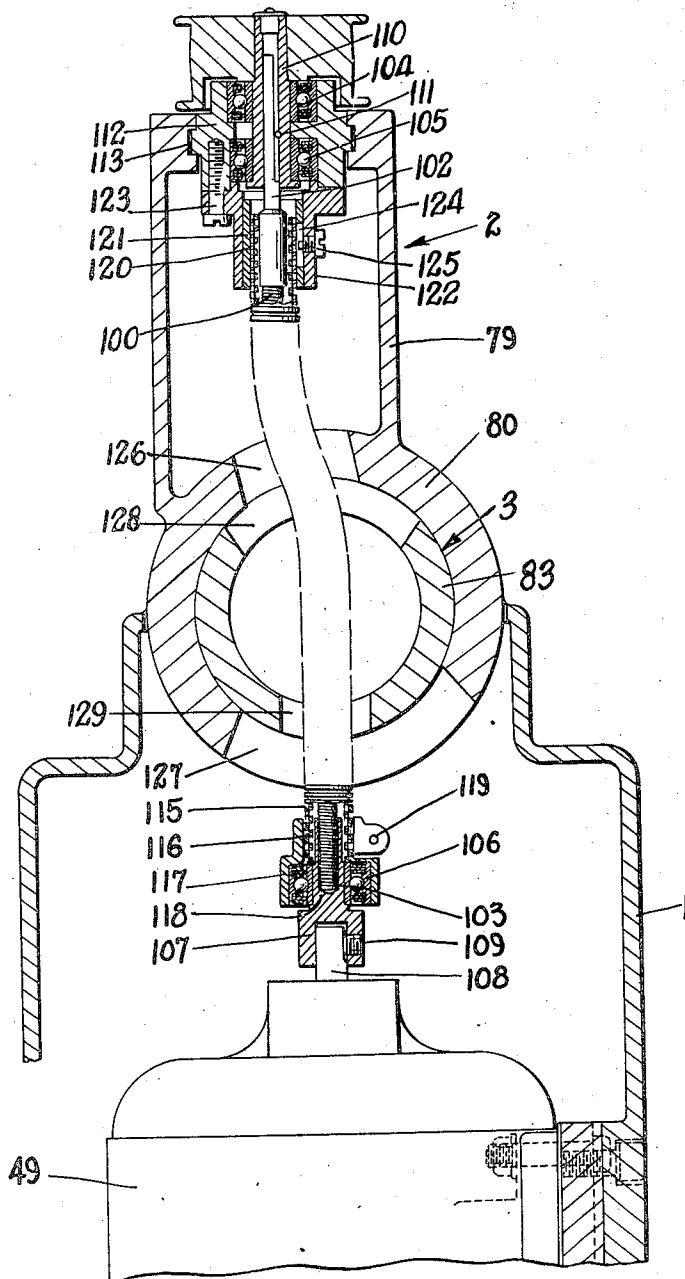


Fig. VI

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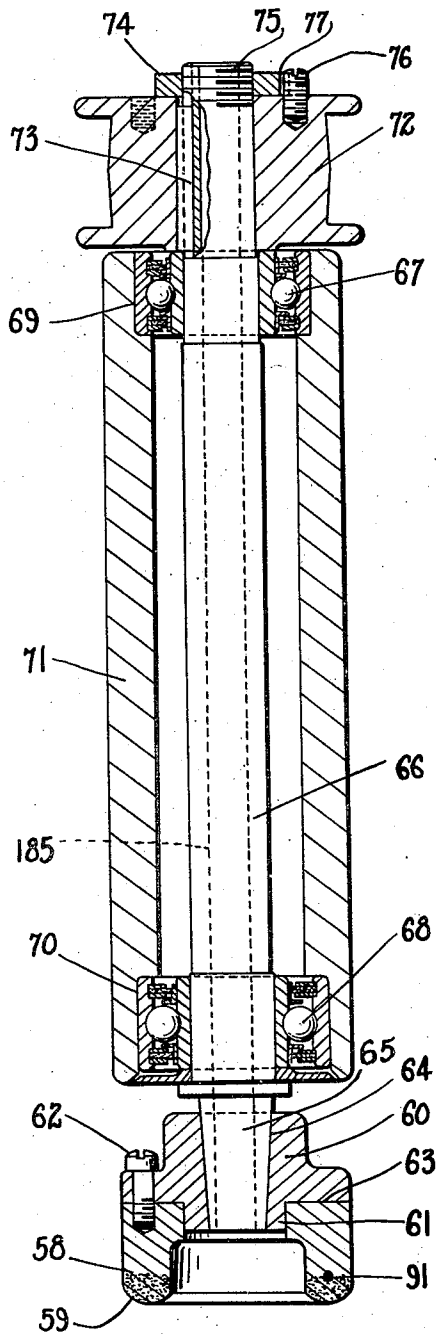


Fig. IV

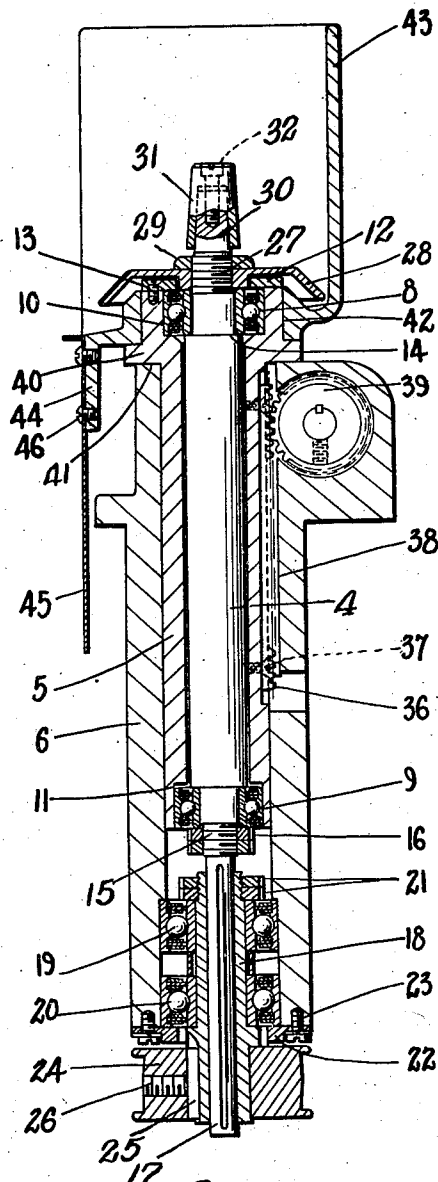


Fig. V

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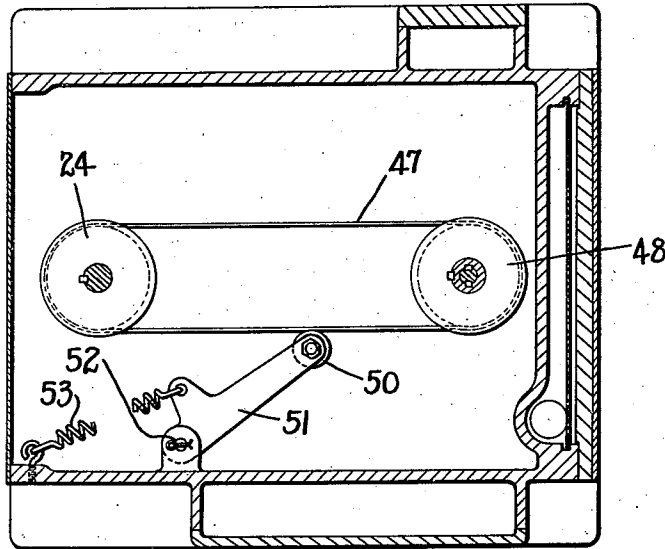


Fig. VII

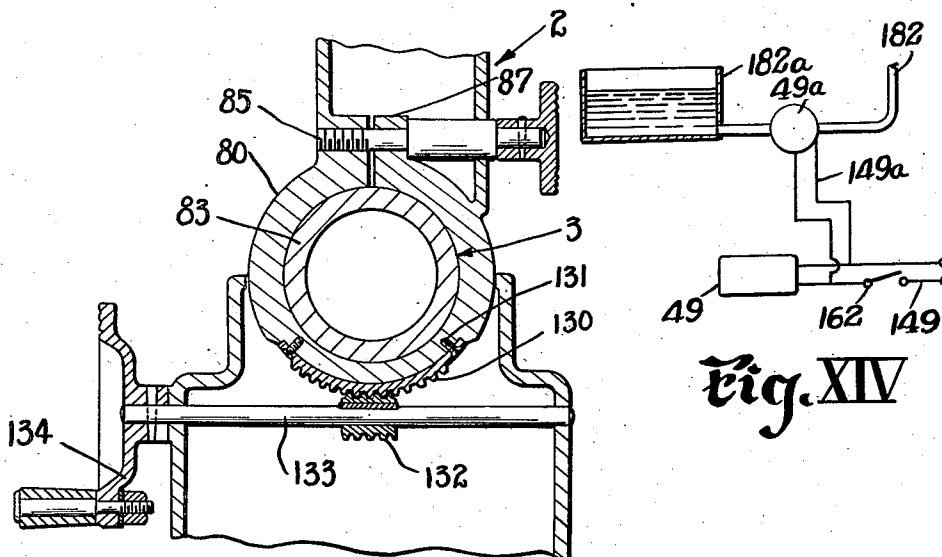


Fig. XIV

Fig. VIII

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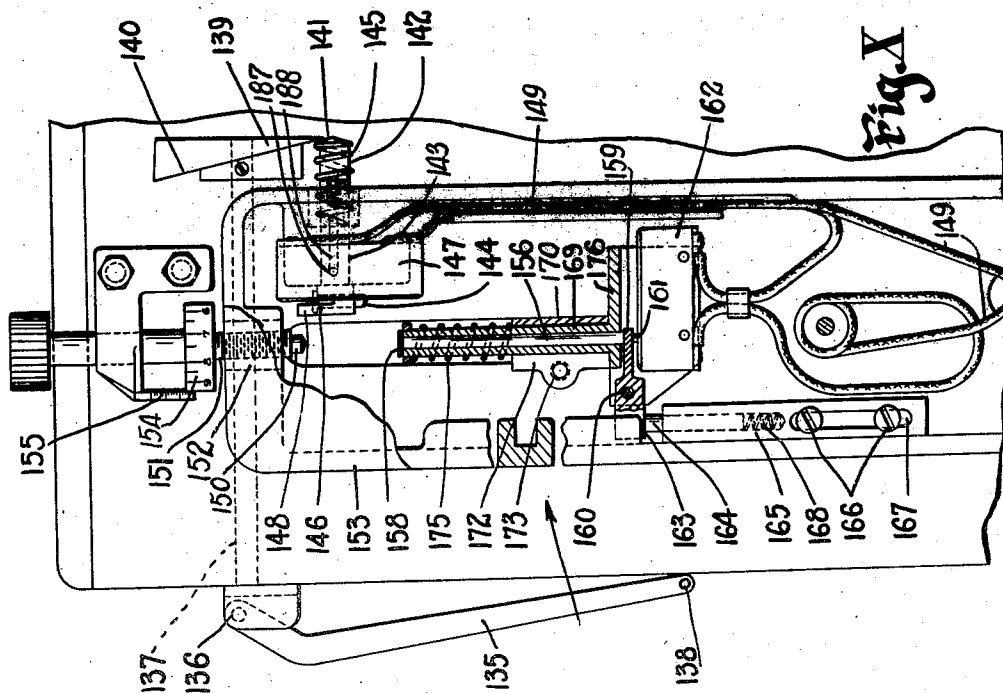


Fig. X

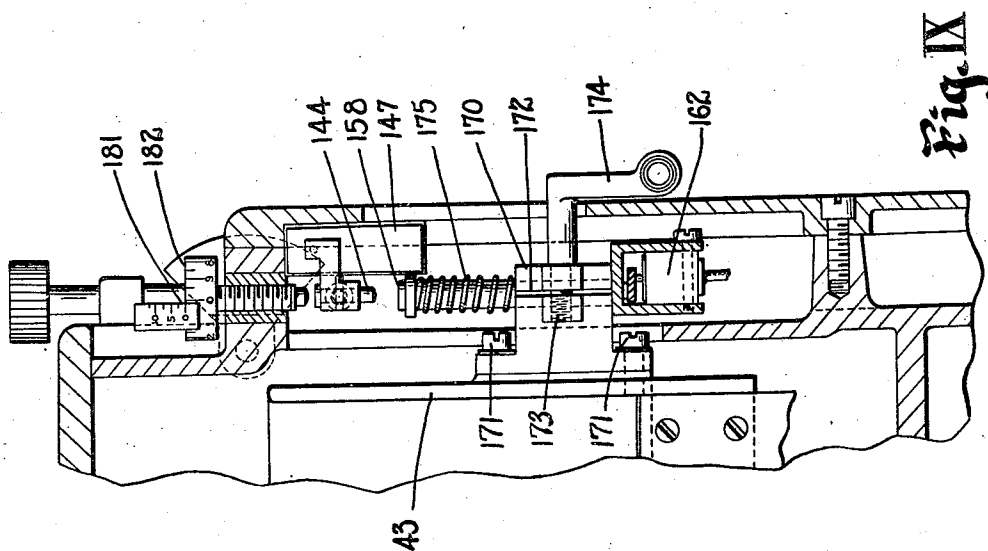


Fig. IX

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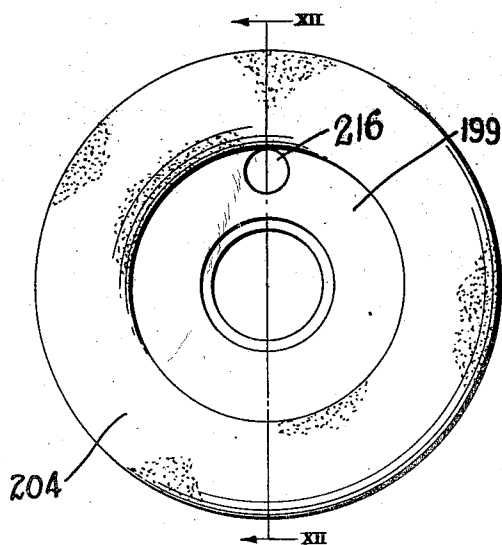


Fig. XI

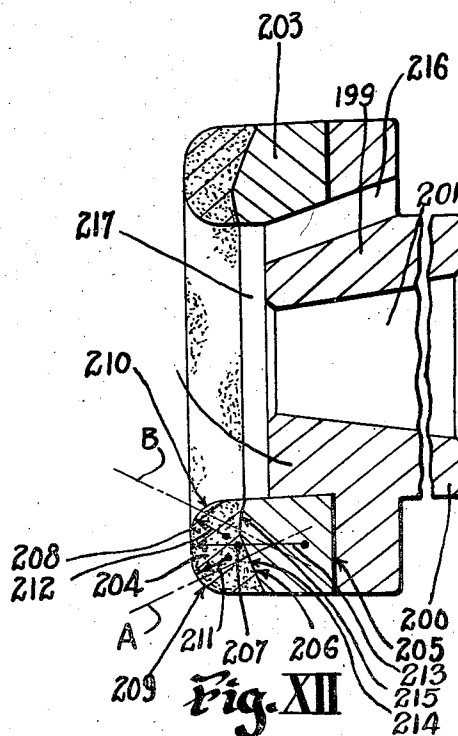


Fig. XII

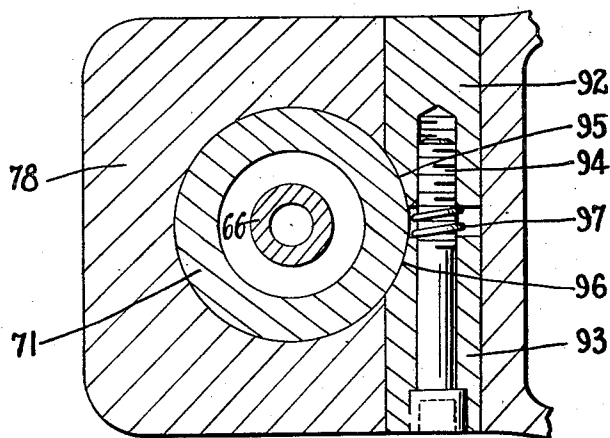


Fig. XIII

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UNITED STATES PATENT OFFICE

2,286,361

ABRADING MACHINE

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Application March 27, 1939, Serial No. 264,329

9 Claims. (Cl. 51—131)

This invention relates to improvements in abrading devices and has particular reference to improved means and method of abrading lenses.

One of the principal objects of the invention is to provide an abrading machine whereby several different curve generations may be obtained with a single generating tool in a minimum amount of time, in a simple and efficient manner and with extreme accuracy.

Another object of the invention is to provide a cupped type abrading tool and associated mechanism whereby the abrading tool may be tilted to different controlled angles for generating surfaces of different curvature and has particular reference to novel means for obtaining the initial adjusted position of the tool and the work whereby the amount removed during the abrading is definitely controlled.

Another object is to provide an abrading machine of the above character whereby a cooling and lubricating liquid may be set onto the tool and work during the abrading operation and be confined to said working parts of the tool.

Another object is to provide means for automatically stopping the machine at the completion of the abrading operation.

Another object is to provide a machine of the above character whereby the source of power for operating the machine is confined within the machine as an integral unit.

Another object is to provide a machine of the above character which is relatively simple and durable in construction and the parts thereof which are adjustable relative to each other are positively and rigidly supported during the abrading operation and with which extreme accuracy of curve generation is obtained.

Another object is to provide a machine of the above character having a tilting head for supporting the tool generally carried by a relatively large surface bearing for the elimination of looseness and play during the abrading operation and to reduce wear over a relatively long period of use.

Another object is to provide an abrading tool having a curved abrading surface for disposing a different effective portion of the tool to the work when set for different curve generations and associated mechanism for supporting said tool whereby the said tool will be tilted substantially about the center of the curved abrading surface of the tool.

Another object is to provide an abrading tool of the above character and associated mechanism for supporting said tool whereby the cen-

ter of curvature of the tool may be adjusted relative to the center about which the tool is tilted to compensate for wear of the effective abrading surface of the tool.

Another object is to provide an abrading tool, for machines of the above character, which is constructed according to the average percentage of surfaces, plus and minus, to be formed by said tool so that the tool will perform its maximum efficiency as regards the generation of both types of curvature prior to fulfilling the extent of its usefulness for the generation of any one of said curvatures.

Another object is to provide associated mechanism for tools of the above character whereby the said tool may be supported substantially about the center of curvature of the effective abrading surface of the tool.

Another object is to provide an arrangement in devices of the above character whereby the tools may be quickly and easily interchanged when worn and which may be simply and easily adjusted to abrading position.

Another object is to provide a novel method of accomplishing all of the features set forth above.

Other objects and advantages of the invention will become apparent from the following description taken in connection with the accompanying drawings and it will be apparent that many changes may be made in the details of construction, arrangement of parts and methods shown and described without departing from the spirit of the invention as expressed in the accompanying claims. I, therefore, do not wish to be limited to the exact details of construction, arrangement of parts and methods shown and described as the preferred form only has been given by way of illustration.

Referring to the drawings:

Fig. I is a front elevation of the device embodying the invention;

Fig. II is a left side elevation of the device illustrated in Fig. I;

Fig. III is a right side elevation of the device illustrated in Fig. I;

Fig. IV is an enlarged fragmentary sectional view taken as on line IV—IV of Fig. I;

Fig. V is a slightly enlarged fragmentary sectional view taken as on line V—V of Fig. I;

Fig. VI is a slightly enlarged fragmentary sectional view taken as on line VI—VI of Fig. III showing the relatively large surface bearing supporting the tilting head of the device and the associated driving mechanism.

Fig. VII is a fragmentary sectional view taken as on line VII—VII of Fig. II showing the lower drive connection and means for taking up looseness and play in the driving belt;

Fig. VIII is an enlarged sectional view taken as on line VIII—VIII of Fig. III showing the associated mechanism for tilting the head of the device;

Fig. IX is an enlarged fragmentary sectional view taken as on line IX—IX of Fig. III and looking in the direction indicated by the arrows;

Fig. X is an enlarged fragmentary sectional view taken as on line X—X of Fig. I and looking in the direction indicated by the arrows;

Fig. XI is an enlarged face view of a modified form of abrading tool;

Fig. XII is a fragmentary sectional view of the tool illustrated in Fig. XI;

Fig. XIII is a sectional view taken as on line XIII—XIII of Fig. III; and

Fig. XIV is a schematic diagram of the oil supply and pump in connection with the electric circuit therefor.

Prior to the present invention, it has been usual to reduce lens blanks to substantially the finished thickness desired just prior to the forming of the finished optical surface thereon by hand abrading operations requiring the use of a plurality of roughing laps of different surface curvatures and loose abrasives. Such abrading operations not only were undesirable from the standpoint of cost, inherent to the requirement of a plurality of different laps, but also depended greatly upon the accuracy and skill of the operator. Such abrading operations were also inefficient due to the great amount of time required in reducing the blanks to the thickness required and also, due to its depending upon the skill of the operator, introduced inaccuracies which oftentimes resulted in the loss of the blank and therefore introduced wastage and extra cost of production.

One of the prime factors, therefore, of the present invention is to eliminate all of the above procedure through the provision of a single abrading tool and associated mechanism whereby surfaces of different curvatures may be quickly and easily formed by said tool without the necessity of the use of loose abrasives and without depending upon the skill and accuracy of the operator.

Referring more particularly to the drawings wherein like characters of reference designate like parts throughout the several views the device embodying the invention comprises a housing 1 having a head 2 pivotally attached thereto by a relatively large surface bearing 3, see Figs. VI and VIII.

The housing 1 has a work supporting spindle 4 rotatably mounted therein. The spindle 4 is rotatably supported in a sleeve 5 longitudinally movable in a bearing 6 supported by a web 7 internally of the housing 1. The spindle 4 is supported adjacent its opposed ends by ball bearings 8 and 9 mounted internally of the shouldered recesses 10 and 11 in the sleeve 5. The spindle 4 is held against longitudinal movement in the sleeve 5 by a plate 12 attached to the upper end of said sleeve by screws or like means 13. The plate 12 overlies the bearing 8 which, in turn, engages an upper shouldered edge 14 on the spindle 4 adjacent the upper end of said spindle 4. The lower end of the spindle 4 is provided with a reduced threaded portion 15 on which a pair of lock nuts 16 are threadedly at-

tached. The said nuts 16 are adapted to retain the bearing 9 in desired relation with the spindle 4. The spindle 4 is provided with a reduced extension 17 fitted within a sleeve-like bearing member 18 supported internally of spaced ball bearings 19 and 20. The reduced extension 17 is keyed to the sleeve-like bearing 18 so as to rotate as an integral unit, and to permit longitudinal movement of said reduced extension 17 internally of said sleeve-like bearing 18. The sleeve-like bearing 18 is held in desired relation with the spaced ball bearings 19 and 20 by a pair of lock nuts 21 adjacent the upper end thereof and a plate 22 adjacent the lower end thereof. The plate 22 is secured to the bearing 6 by means of a plurality of screws or the like 23. The sleeve-like bearing 18 has a drive pulley 24 attached thereto by a slot and key connection 25. The pulley 24 is secured to the sleeve-like bearing 18 by means of a set screw or the like 26.

The upper end of the spindle 4 is provided with a threaded portion 27 on which a shield 28 is fitted and held thereon by means of a nut 29. Directly above the threaded portion 27 the spindle 4 is provided with a tapered end 30. The tapered end 30 has an interchangeable hardened tapered nose 31 secured thereto by a screw or the like 32. The tapered nose 31 is preferably hardened to resist wear and is adapted to support the block adapter 33, see Fig. I. The block adapter 33 is provided with a shank 34 having a tapered recess 35 therein which is fitted on and frictionally binds with the tapered nose 31.

Referring back to Fig. V, the sleeve 5 is provided with a rack 36 secured thereto by screws or the like 37. The rack is fitted within a suitable slotted recess in the side of the sleeve 5. The rack 36 has a dual function. One of its functions is a key-like member interengaging with the side walls of a longitudinal slot 38 formed in the bearing 6 for holding the said sleeve 5 against rotation and its other function is to cooperate with a pinion 39 by which the sleeve 5 may be moved longitudinally of the bearing 6. The upper end of the sleeve 5 is provided with a flange-like shoulder 40 which is adapted to engage the upper end 41 of the bearing 6 for limiting its downward movement. The upper end of the sleeve 5 is provided with a seat 42 to which a splash guard or pan 43 is attached. The splash guard or pan 43 has a depending lip 44 to which a suitable apron 45 is attached, as by screws or the like 46. The splash guard 43 and depending apron 45 together with the shield 28 are adapted to prevent the abrasive from flowing in the bearing. The spindle 4 is rotated by means of the pulley 24 which is connected through a belt 47, through a similar pulley 48, driven by a motor 49 supported in the housing 1, see Figs. III and VII. The belt 47 is held taut by means of a spring pressed roller 50 carried by a link 51 pivotally attached at 52 to the inner wall of the housing and held under tension by a spring 53.

The lens blank 54 to be abraded is secured to the block 55 as by pitch or other suitable adhesive. The block 55, in turn, is mounted and held in the adapter 33, as by screws or the like 56. The adapter 33 is provided with a shouldered recess 57 in which a reduced shank on the block 55 is fitted. The shank is held in the shouldered recess by screws or the like 56, see Fig. I.

The abrading tool 58, as shown in Figs. I and IV, is of an annular shape having a curved abrading portion 59 preferably formed of metal or of a

plurality of abrasive particles, such as crushed diamonds, sapphires, or any other desired abrasive particles. The annular body portion 58 of the tool is secured to a hub 60 having a reduced extension 61 extending within the central opening of the annular body portion 58. The portion 58, as shown in Fig. IV, is secured to the hub 60, as by screws or the like 62. It is to be understood, however, that the contiguous surfaces 63 may be joined with each other as by solder or the like. The hub 60 is provided with a tapered opening 64 which fits on and binds with the tapered end 65 of a driving spindle 66. The spindle 66 is mounted in spaced ball bearings 67 and 68. The said ball bearings are supported in shouldered recesses 69 and 70 internally of a sleeve or quill 71. The spindle 66 has a pulley 72 keyed thereto, as illustrated at 73, and is held thereon by means of a nut 74 threadedly connected with the threaded end 75 of the spindle 66. The nut 74 is adapted to take up any looseness or end thrust play in the spindle 66 and is adjustable to compensate for wear. A suitable screw 76, cooperating with serrations 77 formed in the periphery of the nut 74, is provided to lock the said nut in adjusted position. The quill or sleeve 71 is adjustably supported in the hollow bore of the front portion 78 of the head 2. The portion 78 of the head 2 is integrally joined with a hollow casing 79 which, in itself, is integrally joined with a bearing member 80, see Fig. VI. The bearing member 80, as shown in Figs. II, III and IV, is fitted between the spaced bearings 81 and 82 on the upper portion of the housing 1. Said bearing 80 and spaced bearings 81 and 82 are provided with aligned relatively large openings in which is fitted a hollow bearing pin 83, see Figs. III and VI. The hollow bearing pin 83 is preferably pressed into binding relation with the walls of the openings of the spaced bearings 81 and 82 for retaining it in position. The bearing 80 is preferably split, as illustrated at 84, so as to provide portions which, through a suitable binding screw 85, may be drawn into clamping relation with the hollow bearing pin 83. To insure the hollow bearing pin 83 against movement in the spaced bearings 81 and 82, suitable means, such as a key or the like 86, is provided. It is to be understood that both of the bearings 81 and 82 may be provided with similar keys if desired. The lock screw 85 is adapted to lock the head 2 in desired angular position. When it is desired to move the head 2 to a different angular position, the screw 85 is slightly loosened and the head 2 is tilted to a desired position determined by a suitable degree scale 88 and vernier 89, see Fig. I, and the said screw 85 is then tightened.

It is to be noted, by reference to Fig. I, that the head 2 pivots about an effective center 90, which center is preferably located in axial alignment with the center of curvature 91 of the curved abrading surface 59 of the tool 58. The center 91 is initially positioned in axial alignment with the effective center of rotation 90 of the head 2 by adjusting the quill or sleeve 71 longitudinally of the hollow bore in the front portion 78 of the head 2. The quill or sleeve 71, as illustrated in Figs. III and XIII, is held in adjusted position in the front portion 78 of the head 2 by means of spaced wedge blocks 92 and 93 which are drawn into binding relation with each other by means of a suitable screw or the like 94. The wedge blocks 92 and 93 move in a direction transversely of the longitudinal axis of the sleeve 71 and are each provided with curved

bearing surfaces 95 and 96 which are adapted to be moved into and out of binding relation with the side surface of the sleeve 71. When it is desired to adjust the sleeve 71 longitudinally of the front portion 78 of the head 2, the screw 94 is loosened and the sleeve 71 is moved an amount sufficient to substantially position the center 91 of the curved face 59 of the tool in axial alignment with the effective center of rotation 90 of the head 2. The wedge blocks 92 and 93 are normally urged in a direction away from each other by means of a suitable spring or the like 97.

It is to be noted that by supporting the center 91, of the curved face 59 of the abrading tool substantially in axial alignment with the center of rotation 90 of the head 2, the tool will remain in constant relation with the work or lens blank 54 to be abraded, that is, there will be no change of the tool relative to the lens in a sidewise direction brought about by angling the head. This arrangement also causes a different portion of the effective abrading surface 59 of the tool to move into abrading relation with the blank when the said head 2 is adjusted to different angular positions and thereby causes the said abrading surface to be more durable and efficient as the entire effective abrading surface of the tool is utilized during the abrading of different curved surfaces.

It is to be understood that the present abrading machine is designed particularly for forming rough ground surfaces so that the absolute aligning of the centers 90 and 91 is not necessary but should be within workable limits; a slight error can be tolerated as the forming of the finished surface on the lens can be made to compensate for such slight errors, if they exist.

The spindle 66 is rotated through the pulley 72 which is connected with a similar pulley 98 through a belt or the like 99. The pulley 98 is driven through a flexible shaft 100 by the motor 49. It is to be understood that the speed of rotation of the spindle 66 is greater than the speed of rotation of the spindle 4. This is effected through a direct driving connection with a motor 49 and through the use of a reduction gearing 101 between the rotor of the motor 49 and the associating driving mechanism of the spindle 4. The reduction gearing 101 is of the usual conventional type and is not shown in detail, it is merely located at 101 within the housing of the motor.

The flexible shaft 100 has coupling ends 102 and 103. The end 103 is preferably integrally connected with a coupling member 107 rigidly secured to the stem 108 of the motor 49, as by a set screw or the like 109 and its opposite end 102 is slidably keyed within a bearing 110. The bearing 110 is rotatably supported within spaced bearings 104 and 105. The end 102 is adapted to have a sliding movement in the bearing 110 and is locked against rotation therein by means of a suitable key or the like 111.

The spaced bearings 104 and 105 are carried by a slide block 112 mounted in a slideway 113 in the upper portion of the hollow casing 79. The slide block 112 is adjusted toward and away from the sleeve 71 by means of a screw or the like 114, see Fig. III. The purpose of this slide block is to provide means for adjusting the pulley 98 in a direction away from the pulley 72 to keep the belt 99 taut.

The flexible shaft 100 is provided with a flexible casing 115 which is clamped, as illustrated

at 116, internally of a housing 117 fitting about the outer portion of a bearing 106 carried by the reduced extension 118 of the coupling member 107. The reduced extension 118 is provided with a recess in which the end of the flexible shaft 100 is integrally connected, as by soldering or the like. The clamping of the outer flexible casing 115 is brought about by a suitable clamp screw or the like 119. The upper end of the flexible casing 115, as illustrated at 120, is fitted within a sleeve 121 slidably supported within a bearing 122 attached to the slide block 112, as by screws or the like 123. The sleeve 121 is provided with a slot 124. A suitable key member 125, mounted on the bearing 122, has an end extending into the slot 124 to hold the said sleeve against rotation and yet permit it to move longitudinally within the bearing 122. The longitudinal movement of the sleeve 121 and the end 102, relative to the respective bearings 122 and 110, is to allow free swinging movement of the head 2 and to compensate for any slight variations in the length of the shaft 100 at different tilted positions. The flexible shaft 100 and casing 115, in this particular instance, extend through suitable diametrically opposed openings 126, 127, 128 and 129, in the bearing 80 and hollow bearing pin 83. The angling of the head 2 is effected by means of a section of worm gear 130 secured to the bearing member 80 by means of screws or the like 131, as illustrated at Fig. VIII. The worm sector 130 meshes with a worm 132 carried by the shaft 133 rotated by a hand wheel or the like 134. Prior to manipulating the hand wheel 134 the clamp screw 85 is loosened to release the gripping section of the lips 87 with the hollow bearing pin 83. The adjustment is made through the cooperating degree scale 88 and vernier 89 which determines the angular set and the screw 85 is then tightened to hold the adjustment.

To determine the initial position of the tool relative to the work and to control the amount of glass which is to be removed during the abrading operation there is provided a mechanism such as illustrated in Figs. IX and X. This mechanism comprises a gauge arm 135 pivotally connected at one of its ends, as illustrated at 136, to a shaft 137 and having at its opposite end a gauge pin 138. The shaft 137 has a side cam member 139 on its end opposite the pivotal connection 136. The side cam 139 is provided with a cam surface 140 which is adapted to engage the end 141 of a spring pressed pin 142. The spring pressed pin 142 is slidably supported in a bearing 143 in the side of the housing 1. The inner end of the pin 142 has a gauge pin 144 thereon of the same exact length as the gauge pin 138. A suitable spring 145 is provided for constantly urging the pin 142 toward the cam surface 140 and also to compress the operating plunger 146 of a safety switch 147. The inner end of the pin 142 is provided with a lip 148 which is adapted to engage the plunger 146 of the switch 147 when the pin 142 is moved toward the cam surface 140 by the resilient means 145. When the plunger 146 is in this compressed position the circuit through the lead wires 149 is closed. It is to be noted, therefore, that when the plunger 146 is not compressed the circuit is normally open.

The pin 144 when moved inwardly is adapted to assume a position in axial alignment with a contact 150 on the micrometer screw 151. The micrometer screw 151 is threaded into the bush-

ing 152 carried by the upper part of a protruding portion 153 of the housing 1. The micrometer screw 151 has a scale 154 cooperating with a suitable scale indicator 155. Directly in alignment with the micrometer screw 151 is a plunger 156 slidably supported in a bearing 160. The plunger 156 is provided at its upper end with a contact face 158 adapted to engage with the lower end of the gauge pin 144. The upper end of the gauge pin 144 is adapted to engage with the end 150 of the micrometer screw 151. The plunger 156 at its lower end engages with a lever 159 pivoted at 160. The lever 159 engages with a plunger 161 of a suitable switch 162 adjacent one end thereof and engages, as illustrated at 163, with a spring pressed plunger 164 carried by a suitable member 165 secured to the housing 1 by means of screws or the like 166. The screws 166 extend through a longitudinal slot 167 formed in the adjustable member 165 so that when the said screws are loosened the adjustable member 165 may be moved upwardly or downwardly to increase or decrease the tension on the spring 168. The said spring 168, in turn, operates the plunger 164. The pin 156 is mounted in a bearing 169 slidably mounted in an outer bearing 170. The outer bearing 170 is secured to the side of the splash pan 43 by means of screws or the like 171. The bearing 170 is split, as illustrated at 172, and is provided with a lock screw 173 operated by a lever 174. The bearing 169, therefore, is free to move longitudinally of the outer bearing 170 when the clamping action of the screw 173 is released and is adapted to be locked against longitudinal adjustment when the clamping screw 173 is tightened. A coil spring 175 normally urges the bearing 169 in an upward direction. The lower end of the bearing 169 has a saddle-like member 176 thereon which straddles the switch 162. The switch 162 is connected with the circuit, composed of lead wires 149, which is connected with the drive motor 49. The switches 147 and 162 are connected in series. The switch 147 functions merely as a cut off switch when the initial thickness setting is being determined. The switch 162 is normally closed so as to keep the circuit with the motor 49 and provides means for cutting off the power to the motor when the abrading operation is completed. Referring to Figs. I and V the pinion 39 which meshes with the rack 36 is operated by means of a hand lever 177. When the hand lever 177 is moved in an upward direction the spindle 4 is raised and thereby moves the lens blank 54 toward the abrading tool 58 and vice versa.

The front of the housing 1 is provided with spaced guideways 178 and 179 in which is slidably mounted a baffle plate 180. The baffle plate is adapted to be moved upwardly to close the front of the device. The purpose of this baffle plate is to confine the fluid used during the abrading within the housing 1.

Referring again to Figs. IX and X the method of determining the amount of material to be removed from the blank 54 during the abrading operation is substantially as follows:

Assuming that the tool 58 has been adjusted so that the center of its curved face 91 is moved into alignment with the axis 90 about which the head 2 swings and that the lens blank to be abraded and holder are positioned on the spindle 4 ready for the abrading operation and that the amount which is to be removed from the blank has been determined, the micrometer screw 151 is adjusted to position the zero gradu-

ation of the micrometer scale 154 in alignment with the gauge edge 181 of the scale indicator 155 and the upper surface 182 is positioned in alignment with the zero indication on the scale indicator 155. The gauge arm 135 is swung upward and downward so that the gauge pin 138 is in substantial alignment with the axis of the spindle 4. This movement of the gauge arm 135 simultaneously imparts movement to the cam 139 whereby the cam surface 140 which engages the end 141 of the pin 142, will move the gauge pin 144 on said member 142 into substantial alignment with the longitudinal axis of the micrometer screw 151 and plunger 156. Movement of the spring pressed pin 142 inwardly, as described above, simultaneously causes the lip 148 to move away from the plunger 146 of the switch 147 opening the circuit 149. This opening of the circuit insures that the motor will not operate during the initial setting of the device.

The hand lever 177 is then operated to move the spindle 4 carrying the lens holder and blank upwardly so that the upper surface of the blank will engage the lower end of the pin 139 with the upper end of said pin simultaneously engaging the effective abrading portion of the tool 58. It is to be understood that the tool 58 has been previously angled to generate the curvature desired. This angling being accomplished by loosening the screw 85 and thereafter tilting the head 2 to the desired amount which is determined by the protractor 88 and vernier scale 89. The screw 85 is then tightened to retain the tool in this angular position.

This movement of the spindle 4 in an upward direction simultaneously moves the splash pan 43 upwardly and by reason of the fact that the bearing 170 is connected with said splash pan the plunger 158 and associated mechanism is also moved upwardly. It is assumed that the hand lever 174 has been moved so as to loosen the screw 173 which will permit the outer bearing 170 to move freely upwardly of the bearing 169. This upward movement of the outer bearing 170 tends to impart a compressing action to the spring 175 which, in turn, raises the bearing 169 and plunger 156. This upward movement under the resilient action of the spring 175 causes the face 158 to engage the lower end of the gauge pin 144 with the upper end of said pin engaging the end 150 of the micrometer screw 151. The contact pin 144 has a floating connection with the spring pressed pin 142 so that engagement of both of the contact faces 158 and 150 is insured. The gauge pin 144, being of the same length as the gauge pin 138, spaces the end 150 and contact face 158 an amount substantially equal to the space between the engaged surface of the blank 54 and the abrading tool 58 as determined by the gauge pin 138. The screw 173 is then moved so as to secure the outer bearing 170 in binding relation with the bearing 169 and thereby locks these parts in rigid relation with each other. The hand lever 177 is then operated to lower the spindle 4 and move the blank 54 from engagement with the gauge pin 138. The gauge arm 135 is then swung outwardly and downwardly to a position, such as illustrated in Fig. X, whereby the rise of the cam surface 140 is moved out of engagement with the end 141 of the spring pressed pin 142 causing said pin 142 to be moved outwardly and simultaneously move the gauge pin 144 out of alignment with the longitudinal

axis of the micrometer screw 151. This outward movement of the spring pressed pin 142 simultaneously moves the lip 148 into engagement with the plunger 146 of the switch 147 and closes the said circuit 149 through the switch 147. The micrometer screw 151 is then backed off an amount substantially equal to the amount of glass to be removed from the blank. This is determined by the scale 154 and scale indicator 155. The baffle plate 180 is then raised to close the front of the device and the hand lever 177 is operated to move the blank 54 upwardly into engagement with the abrading tool 58. This upward movement of the hand lever 177 simultaneously moves the splash pan 43 upwardly and the bearing connected with said pan in said direction. This upward movement of the outer bearing 170 simultaneously moves the contact face 158 of the plunger 156 in an upward direction. It is to be noted that when the plunger 156 is moved upwardly the associated bearing 169, saddle-like member 176 and switch 162, carried by said saddle, are also moved upwardly as a single unit. This upward movement of the saddle 176, by reason of the fact that the arm 159 is pivotally attached to said saddle at 160, also moves the said arm in an upward direction. This relieves the pressure of the spring pressed plunger 164 on the contact face 163 of said rock arm 159 and allows the spring pressed plunger 161 of the switch 162 to rock the arm 159 about its pivot 160 in an upward direction and simultaneously move the plunger 156 upwardly internally of the bearing 169. This automatically closes the switch 162 and the circuit 149 starting the motor which, in turn, rotates the abrading tool 58 and lens blank 54.

Suitable oil supply means may be used, such as an oil well 182a and a pump 49a. This means may be connected with a pipe line 182 which, as shown by the dotted lines in Fig. III, extends upwardly internally of the housing 1 and is connected through a coupling 183 to another pipe line 184 extending to and connected with an opening 185 internally of the tool supporting spindle 66. When the switch 162 is closed to energize the motor circuit 149, a similar circuit 149a connected with the electrically operated pump 49a is simultaneously closed causing the pump to operate and direct the lubricant upwardly of the pipe line 182 and through the central opening 185 in the spindle 66. The fluid flows outwardly of the spindle 66 internally of the annular tool 58 and is thereby directed onto the face of the blank 54 which is being abraded. The tool 58 and its associated hub is provided with a vent opening 186 to relieve excess pressure internally of the tool during the abrading operation and thereby eliminating undue backing up of the fluid in the feed line.

When the blank 54 is moved into engagement with the abrading tool 58 the contact face 158 and the plunger 156 are spaced from the end 150 of the micrometer screw an amount determined by the amount of glass to be removed from the blank 54. The abrading action, therefore, removes said desired amount of glass from the blank and simultaneously allows the contact face 158 to move into engagement with the end 150 of the micrometer screw compressing the plunger 156 which, in turn, moves the rock arm 159 into engagement with the spring pressed plunger 161 of the switch 162 so that when the abrading is completed this pressure would auto-

matically open the switch 162 and likewise open the circuit to the drive motor 49 and lubricant pump mentioned above. This function automatically stops the motor 49 and the lubricant pump and simultaneously stops rotation of the tool 58 and blank 54.

When the operation of the motor 49 is stopped the lever 174 is rotated to release the pressure of the outer bearing 172 on the inner bearing 69. The hand lever 177 is then operated to move the spindle 4 and the blank 54 downwardly away from the abrading surface of the tool 58. The baffle plate 180 is then lowered and the blank 54 removed from the spindle 4.

To generate surfaces of different curvatures the head 2 is angled, as specified above, and the various adjustments are repeated.

It is to be noted that the spring pressed pin 142 is located against rotation by means of a slot and pin connection 187 and 188. This is to maintain the gauge pin 144 in a vertical position.

It is also to be noted that the shaft 189 carrying the pinion 39 and hand lever 177, as illustrated in Figs. I and II, is provided with a cam sheave 190 to which is attached a weight 191 through a flexible cord or the like 192. When the hand lever 177 is operated to move the spindle 4 in an upward direction, to engage the blank 54 with the tool 58, the cam sheave 190 is rotated to a position illustrated by the dot and dash lines in Fig. II. This moves the weight in a downward direction so that the pull of the weight on the cord 192 exerts a lever action on the cam member 190. This lever action on the cam 190 constantly tends to urge the pinion in a direction which will move the spindle 4 upwardly. This upward urging of the spindle 4 exerts a constant pressure on the blank 54 of the tool 58. When the lever 177 is operated to move the spindle 4 downwardly the cam sheave 190 is moved to a position illustrated by the dotted lines in Fig. II, whereupon the weight 191 is raised and held in an upward direction. This is by reason of the fact that the cord 192 is moved to a position adjacent the shaft 189 and no lever action on the cam sheave 190 exists.

The front plate 193 of the device has a window opening 194 therein and also has a disc 195 pivotally attached thereto, as illustrated at 196. An operating knob 197 is provided for rotating the disc 195. The disc 195 is positioned internally of the front plate 193 of the device and is located between said front plate and the baffle 180. The disc 195 is provided with a chart 198 having portions thereof rotatable into alignment with the window opening 194. This chart 198 has indicia thereon which indicates the angle at which the head 2 is to be positioned for any particular curve. Suitable indications designating said curve are also visible through said window opening so that when the disc is rotated to select any particular curve the angle at which the head 2 is to be set to obtain said curve is also indicated. One of the angle indications is in red and the other in black. The red designating minus curves and the black designating plus curves. It is to be understood that any suitable arrangement may be used for indicating the plus and minus angles.

In Figs. XI and XII there is illustrated a modified form of abrading tool and support comprising a hub 199 having a shank 200 with a tapered opening 201 therein and a reduced extension 202. The reduced extension 202 is adapted to extend

within the central opening of the base 203 of the main annular portion of the tool. The base 203 of the main annular portion 204 of the tool is joined into the hub 199, as by soldering or the like, along the adjacent surfaces 205. The said soldering may be in the form of a sweating operation wherein only a minimum amount of solder is necessary and whereby only a small amount of heat will soften said solder. The main annular portion 204 is preferably formed of fine particles of metal having a plurality of abrasive particles mixed therewith and held by sintering said particles of metal with each other. The base 203 is preferably formed only of particles of metal while the main abrading portion 204 is preferably formed of particles of abrasive, such as crushed diamonds, sapphires or the like, distributed throughout the effective abrading portion of the tool. It is to be understood that any other suitable bonding material might be used and the particles of abrasive held in said material by means other than sintering, as for example, the said bonding material may be in the form of a plastic having characteristics of methyl methacrylate, Bakelite and so forth, or may have cementitious characteristics or the like. The base 203 and main annular portion 204 are so formed as to be in integral relation with each other along an annular intermediate surface 206 which forms a surface of division between the base of the tool formed preferably only of sintered particles of metal and the main abrading portion formed of a mixture of sintered metal and particles of abrasive. The particles of abrasive are distributed throughout the particles of metal or other bonding material of the main grinding element 204 of the tool in such a manner as to increase the thickness of the main grinding element 204 in different directions of greater wear during the use of the tool, as illustrated by the dot and dash lines A and B.

The tool, like the tool 58, is supported for angular movement substantially about the center of rotation 207 of the curvature 208 of the effective abrading surface of the tool. The tool, during use, is supported to pivot about the center 207 so that the effective abrading surface of said tool may be disposed at different angles, with respect to the work, to change the arc of the curve generated on said work, with substantially no change in the relation of the work relative to the abrading face of the tool.

Abrading tools of this character are designed to form plus and minus surfaces, that is, concave and convex surfaces. When forming concave or minus surfaces the effective portion of the tool substantially along the dot and dash line A is used. When forming plus or convex surfaces the effective portion of the tool substantially along the dot and dash line B is used. It has been found from practice that, in the general run of the work, more minus or concave surfaces are required than plus or convex surfaces so that the main grinding or abrading element is increased in thickness along the line A more than along the line B by an amount determined according to the average percentage of surfaces to be formed by the tool so that the said thicknesses are balanced according to the amount of surfaces to be formed thereby and so that each tool will perform its maximum efficiency both as regards the generation of plus and minus curvatures prior to the discarding thereof. The tool is so designed that it will not perform the extent of its usefulness, for example, in forming

concave or minus surfaces prior to its reaching the extent of its usefulness in forming plus or convex surfaces. In other words when the tool is forming concave or minus surfaces it will readily be seen that the outer and thicker portions of the grinding material will be the portions which come in contact with the lens. Since in normal use in the art the concave surfaces have been found to be in the majority as opposed to the number of convex surfaces which are ground in machines of this type. When convex surfaces are ground by this tool it will be readily understood that the inner portions, or those not so thick, of the grinding material will be in contact with the convex lens. It will therefore be readily understood that the outer portions of the grinding material are built up so as to be able to grind more surfaces than the inner portions so that over a period of time in the normal use of this tool more concave surfaces are ground than convex and the varied thickness of the grinding material of this tool is such that when the limit of the life of the tool has been reached the grinding material will be worn down to the support 203 substantially uniformly throughout its interface therewith. The effective abrading surface of the tool, in order to increase the life and durability thereof particularly for rough curve generation, is built up slightly along the lines A and B, as indicated at 209 and 210. These built up portions, although at the start of the use of the tool introduce a slight error in curvature, are practical for rough or semi-finished curve generation. It has been found that the error introduced by such built up portions 209 and 210 is negligible and can, if necessary, be compensated for during the initial setting up of the abrading machines. The built up portions 209 and 210 each have a curved surface thereon of a relatively short radius of curvature, as indicated by the arrows 211 and 212. The surfaces 210 and 211, which are of relatively short radius of curvature, are joined centrally by a longer radius of curvature, such as illustrated by an arrow 213. The curvature 213 is substantially tangent with the arc of curvature 208 along the line of which the effective abrading surface of the tool is moved when the tool is tilted about the center 207. The annular intermediate surface 206 is composed of two differently curved areas, 214 and 215. The area 214 is of a relatively long radius of curvature and the area 215 is of a relatively short radius of curvature but slightly less than the radius of curvature 213.

The hub 199 and the base 203 are provided with an aligned opening 216 whose axis is disposed at an angle relative to the longitudinal axis of the shank 200 of the hub. This opening 216 communicates with the recessed area 217 of the main annular portion of the tool and it is adapted to provide a vent through which lubricant fed into the recessed area 217 through the hollow shaft 66 may flow outwardly and thereby avoid having an excessive internal pressure built up in said recessed area during the abrading operation.

When the main abrading portion 204 of the tool has become worn and inefficient for use the said portion may be removed from the base 203 and a new portion secured thereto by the application of heat sufficient to soften the bonding means holding said main abrading portion 204 to the base 203.

The tool set forth above theoretically has an

abrading surface lying substantially in the line of the arc 208 although during the initial use of the tool the built up portions 209 and 210 do depart slightly from said arc. This slight departure may be compensated for during the setting up adjustment of the machine, if desired. The hub 199 is preferably formed of relatively inexpensive material whereas the material necessary for bonding the particles of abrasive together is comparatively expensive so that by forming a tool, as specified above, the resultant cost of the tool is greatly decreased as a less amount of expensive bonding material is required.

Although the base 203 is specified as being secured to the hub 199, as by soldering, it is to be understood that it may be secured by other bonding means.

As the abrading tool wears, and yet retains its abrading surface in the same curvature, it will be understood that the center of curvature 91 will gradually move away from its original position. To compensate for this movement, and to avoid error in positioning the center of curvature 91 of the abrading surface 59 in axial alignment with the effective pivot 90 of the head 2, a guide mark 218 (Fig. 1) is provided on the head 2 in such a position that, regardless of the wear of the tool, as long as the abrading surface is aligned with the mark 218, the tool is in the proper operating position. The guide mark 218 is positioned on the head 2 a distance from the effective pivot 90 equal to a radius of the abrading surface 59, and the abrading surface is usually aligned with the guide mark 218 by placing a sharp, flat, tool horizontally on the mark and bringing the abrading surface to rest thereon.

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.

Having described my invention, I claim:

1. In a device of the character described the combination of a hollow housing having a work supporting spindle rotatably and slidably mounted therein and a head pivoted thereto, said pivot connection having a relatively wide surface bearing with means associated therewith for locking the head in different angular positions, a tool supporting spindle rotatably mounted in said head having an abrading tool attached thereto and adapted to be tilted through the tilting action of said head to different angular positions with respect to the longitudinal axis of the work supporting spindle, said hollow housing having an open wall portion and means for closing said opening for confining the abrading tool and work carried by said work supporting spindle internally of said housing.

2. In a device of the character described the combination of a hollow housing having a work supporting spindle rotatably and slidably mounted therein and a head pivoted thereto, said pivot connection having a relatively wide surface bearing with means associated therewith for locking the head in different angular positions, a tool supporting spindle rotatably mounted in said head having an abrading tool attached thereto and adapted to be tilted through the tilting action of said head to different angular positions with respect to the longitudinal axis of the work supporting spindle, said hollow housing having an open wall portion, means for closing said opening for confining the

abrading tool and work carried by said work supporting spindle internally of said housing and means for urging said work supporting spindle towards said tool supporting spindle.

3. In a device of the character described the combination of a hollow housing having a work supporting spindle rotatably and slidably mounted therein and a head pivoted thereto, said pivot connection having a relatively wide surface bearing with means associated therewith for locking the head in different angular positions, a tool supporting spindle rotatably mounted in said head having an abrading tool attached thereto and adapted to be tilted through the tilting action of said head to different angular positions with respect to the longitudinal axis of the work supporting spindle, said hollow housing having an open wall portion, means for closing said opening for confining the abrading tool and work carried by said work supporting spindle internally of said housing and means for simultaneously rotating said work and tool supporting spindles.

4. In a device of the character described the combination of a hollow housing having a work supporting spindle rotatably and slidably mounted therein and a head pivoted thereto, said pivot connection having a relatively wide surface bearing with means associated therewith for locking the head in different angular positions, a tool supporting spindle rotatably mounted in said head having an abrading tool attached thereto and adapted to be tilted through the tilting action of said head to different angular positions with respect to the longitudinal axis of the work supporting spindle, said hollow housing having an open wall portion, means for closing said opening for confining the abrading tool and work carried by said work supporting spindle internally of said housing, means for urging said work supporting spindle towards said tool supporting spindle and means for simultaneously rotating said work and tool supporting spindles.

5. Gauge means for use with an abrading machine of the above character having a tool supporting spindle and a work supporting spindle cooperatively related with each other, and means for urging one of said spindles towards the other, said gauge means having a spacer portion adapted to be disposed between the work and an abrading tool carried by said respective spindles for positioning said work and tool in positive spaced relation with each other and having automatic stop means for controlling the extent of abrading, said automatic stop means comprising a contact adjustable to a relatively set position and a movable contact, means adapted to be positioned between said contacts which is of substantially the same length as the spacer portion for obtaining an initial setting of said movable contact and mechanical means correlating said respective means which are adapted to be positioned between the tool and work and the contact members for simultaneously moving said means into and out of operative position and scale and indicator means associated with said adjustable contact for controlling the adjustment thereof relative to said initial set position of the movable contact for predetermining the amount of material to be removed from the work during said abrading operation.

6. Gauge means for use with an abrading machine of the above character having a tool supporting spindle and a work supporting spindle cooperatively related with each other, means for

urging one of said spindles towards the other, and means for imparting a rotary movement to said spindles, said gauge means having a spacer portion adapted to be disposed between the work and an abrading tool carried by said respective spindles for positioning said work and tool in positive spaced relation with each other and having automatic stop means for controlling the extent of abrading, said automatic stop means comprising a contact adjustable to a relatively set position and a movable contact, means adapted to be positioned between said contacts which is of substantially the same length as the spacer portion for obtaining an initial setting of said movable contact and mechanical means correlating said respective means which are adapted to be positioned between the tool and work and the contact members for simultaneously moving said means into and out of operative position, scale and indicator means associated with said adjustable contact for controlling the adjustment thereof relative to said initial set position of the movable contact for predetermining the amount of material to be removed from the work during said abrading operation and switch means associated with one of said contacts and adapted to be operated thereby for automatically shutting off the means for driving said spindle.

7. Gauge means for use with an abrading machine of the above character having a tool supporting spindle and a work supporting spindle cooperatively related with each other, means for urging one of said spindles towards the other, and electrically operated means for rotating said spindles having a circuit connection with electrical energy, said gauge means having a spacer portion adapted to be disposed between the work and an abrading tool carried by said respective spindles for positioning said work and tool in positive spaced relation with each other and having automatic stop means for controlling the extent of abrading, said automatic stop means comprising a contact adjustable to a relatively set position and a movable contact, means adapted to be positioned between said contacts which is of substantially the same length as the spacer portion for obtaining an initial setting of said movable contact and mechanical means correlating said respective means which are adapted to be positioned between the tool and work and the contact members for simultaneously moving said means into and out of operative position, scale and indicator means associated with said adjustable contact for controlling the adjustment thereof relative to said initial set position of the movable contact for predetermining the amount of material to be removed from the work during said abrading operation, switch means associated with one of said contacts and adapted to be operated thereby for automatically shutting off the means for driving said spindle and means for opening the circuit of said electrically operated means when the spacer means is between the work and tool and for closing said circuit when said means is moved from between said work and tool.

8. In a device of the character described the combination of a hollow housing having a work supporting spindle rotatably mounted therein and a head pivoted thereto, said pivot connection having a relatively wide surface bearing with means associated therewith for locking the head in different angular positions, a tool supporting spindle rotatably mounted in said head having an abrading tool attached thereto and adapted to be

tilted through the tilting action of said head to different angular positions with respect to the longitudinal axis of the work supporting spindle, one of said spindles being slidably supported for movement toward the other of said spindles to move the work and tool carried by said respective spindles into engagement with each other, said hollow housing having an open wall portion, means for closing said opening for confining the abrading tool and work carried by said work supporting spindle internally of said housing and means for urging one of said work and tool supporting spindles toward the other of said spindles.

9. Gauge means for use with an abrading machine of the above character having a tool supporting spindle and a work supporting spindle cooperatively related with each other, means for urging one of said spindles towards the other, said gauge means having a spacer portion adapted to be disposed between the work and an abrading tool carried by said respective spindles for positioning said work and tool in positive

spaced relation with each other and having automatic stop means for controlling the extent of abrading, said automatic stop means comprising a pair of contact members, one of said contact members being adjustable to a relatively set position and the other being movable, means adapted to be positioned between said contact members which is of substantially the same length as the spacer portion for obtaining an initial set position of one of said contact members relative to the other, and mechanical means correlating said respective means which are adapted to be positioned between the tool and work and the contact members for simultaneously moving said means into and out of operative position, and means for adjusting one of said contact members relative to the other for varying the relation thereof as determined by said initial set position for predetermining the amount of material to be removed from the work during said abrading operation.

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