United States Patent [19]

Hannaman

[11] **3,798,844**

[45] **Mar. 26, 1974**

[54] **LENS GRINDING APPARATUS**

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[73] Assignee: **Rigel Mfg., Inc.,** Whitehall, Mich.

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[21] Appl. No.: **246,692**

[52] **U.S. Cl.** ..... **51/101 LG**

[51] **Int. Cl.** **B24b 9/16,** B23q 35/04

[58] **Field of Search** ..... 51/101 R, 101 LG, 34, 127, 51/47, 48, 50, 284

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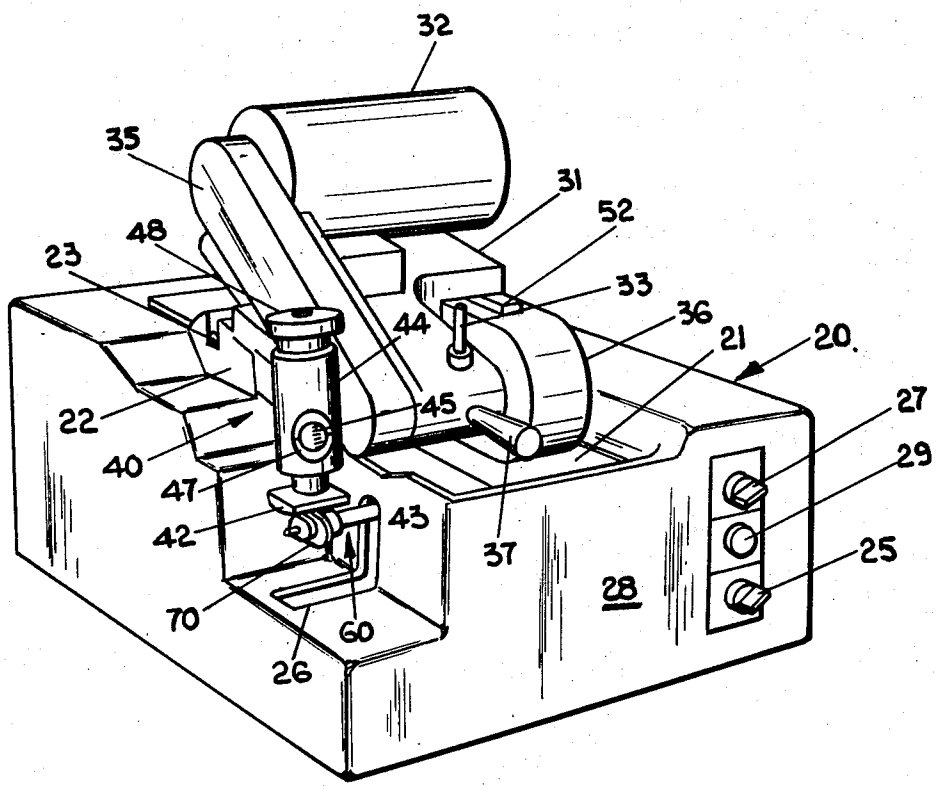
Primary Examiner—Othell M. Simpson

Attorney, Agent, or Firm—Price, Heneveld, Huizenga & Cooper

[57] **ABSTRACT**

An apparatus for grinding the edges of eyeglass lenses includes a base pivotally and slidably supporting a head assembly which includes rough and fine grinding wheels. The base includes a holder for selectively rotating the lens under the grinding wheels and transport means for automatically raising, shifting and lowering the head assembly from a rough grinding position to a fine grinding position after a predetermined number of revolutions of the lens under the rough grinding wheel. An edge follower assembly accurately positions the fine grinding wheel relative to the lens at a selectable position for beveling the lens in any desired manner. After a predetermined number of revolutions of the lens holder under the fine grinding wheel, the head is automatically raised and shifted to a starting position.

35 Claims, 20 Drawing Figures



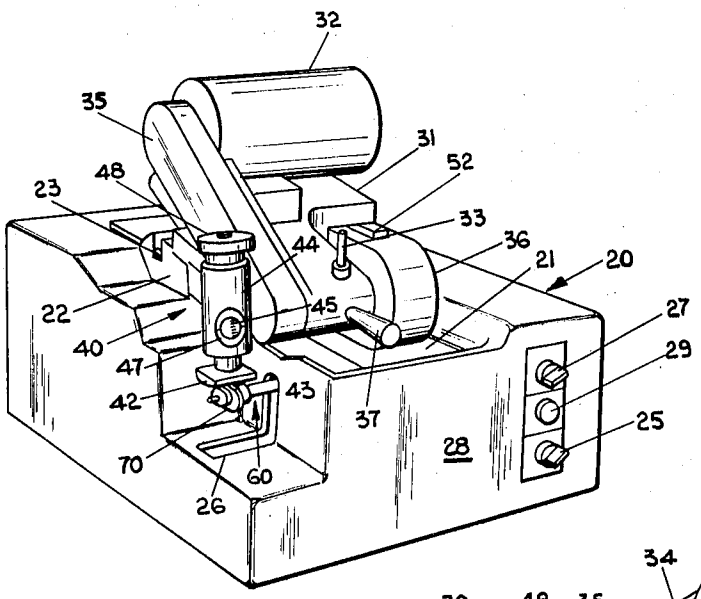


FIG. 1

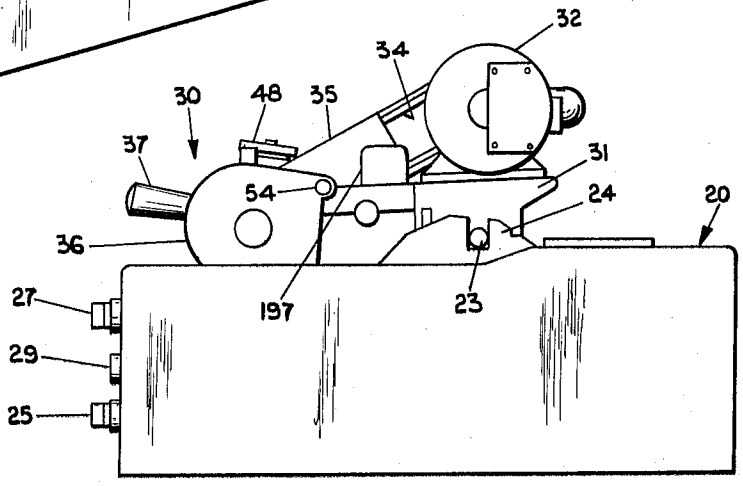


FIG. 2

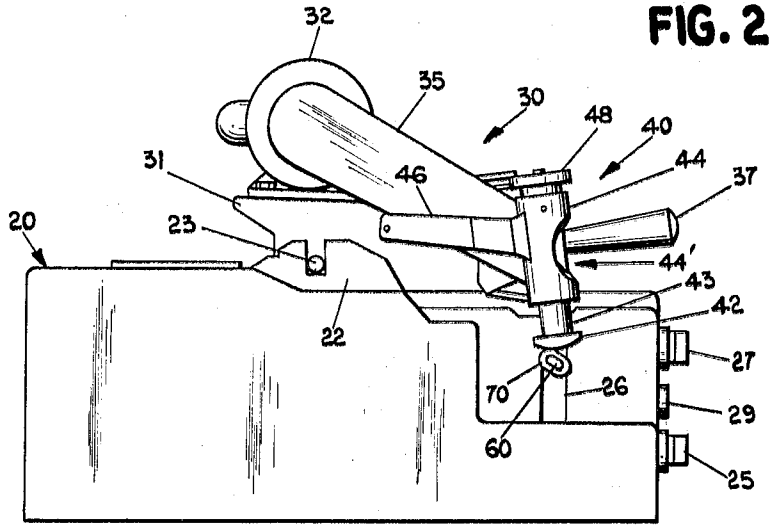


FIG. 3

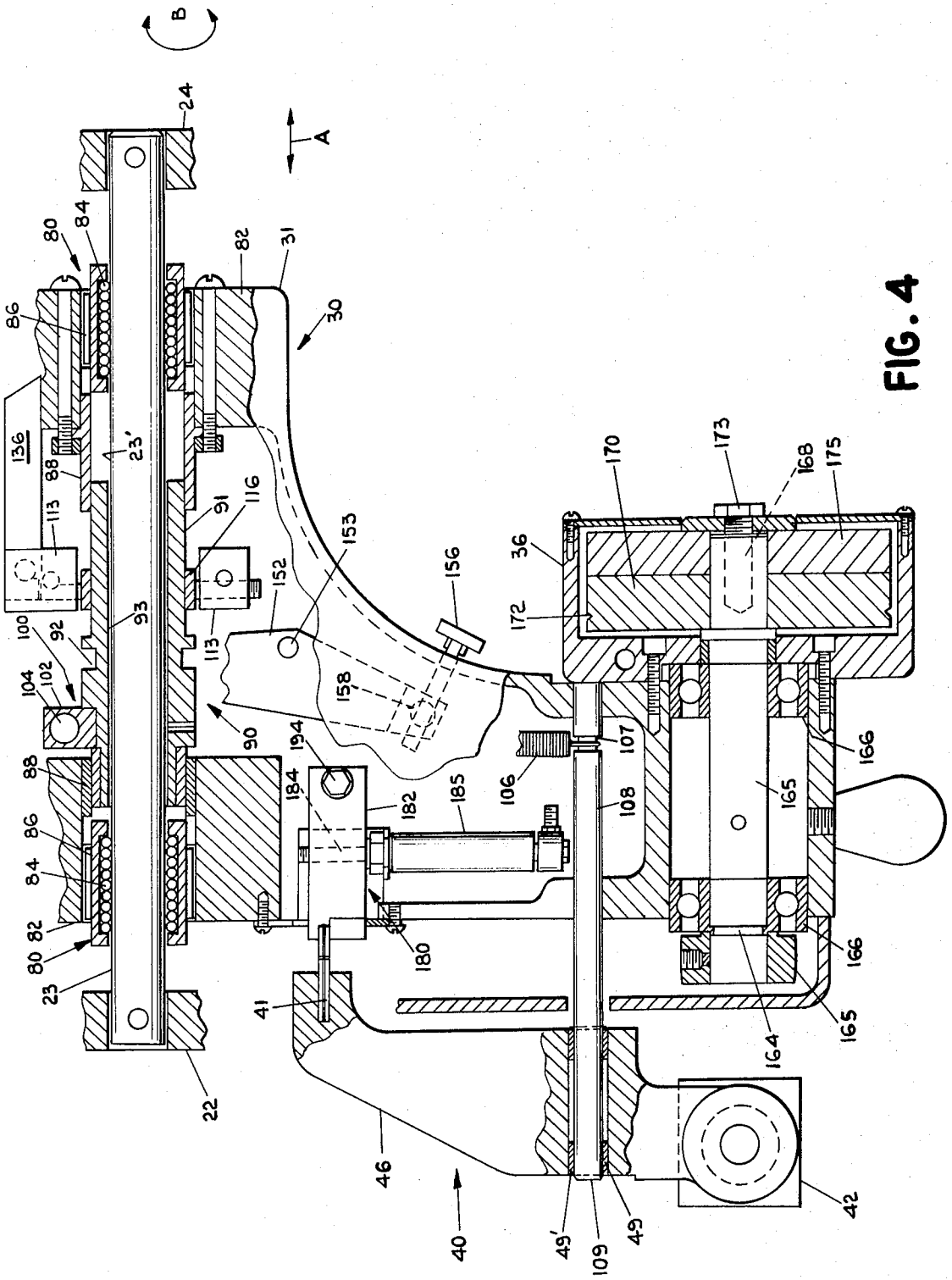

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FIG. 4

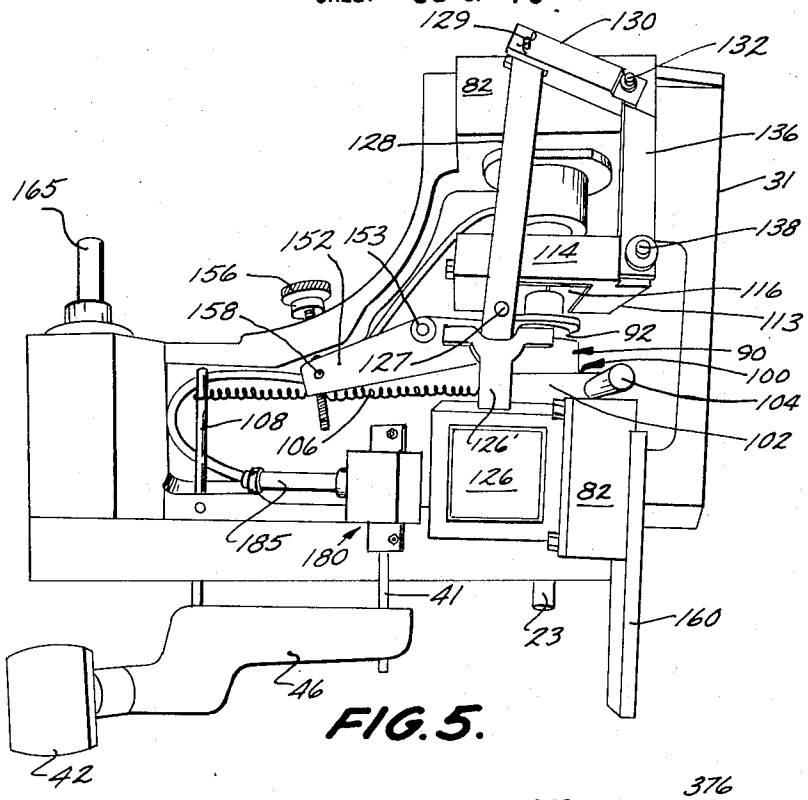

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FIG. 5.

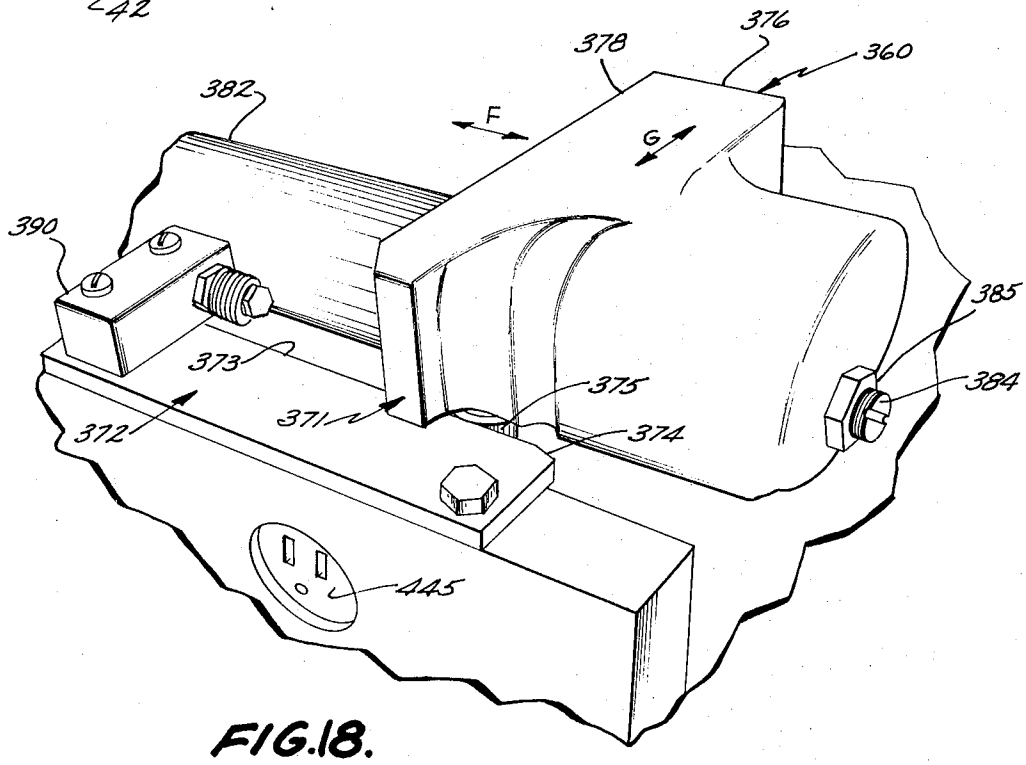

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FIG. 18.

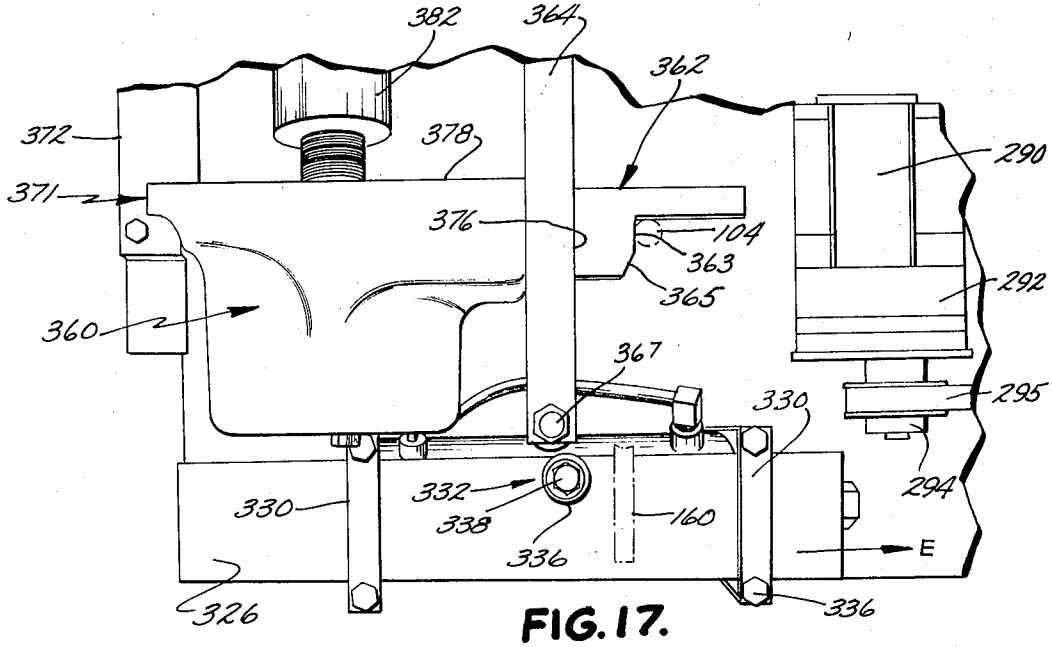


FIG. 17.

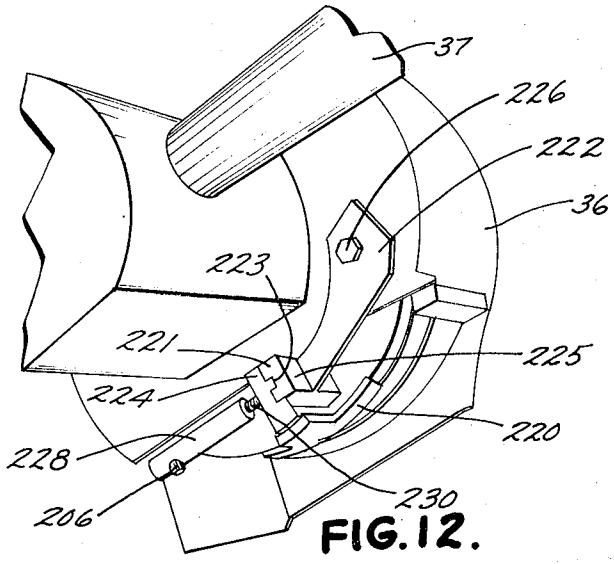


FIG. 12.

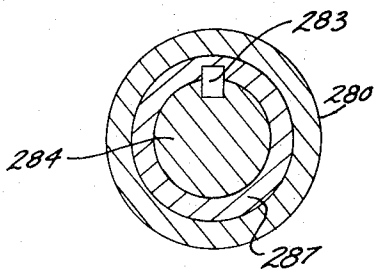


FIG. 14.

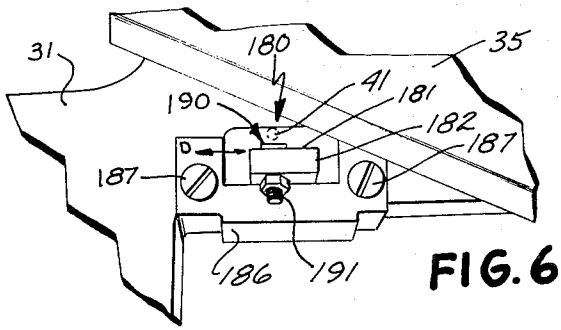


FIG. 6.

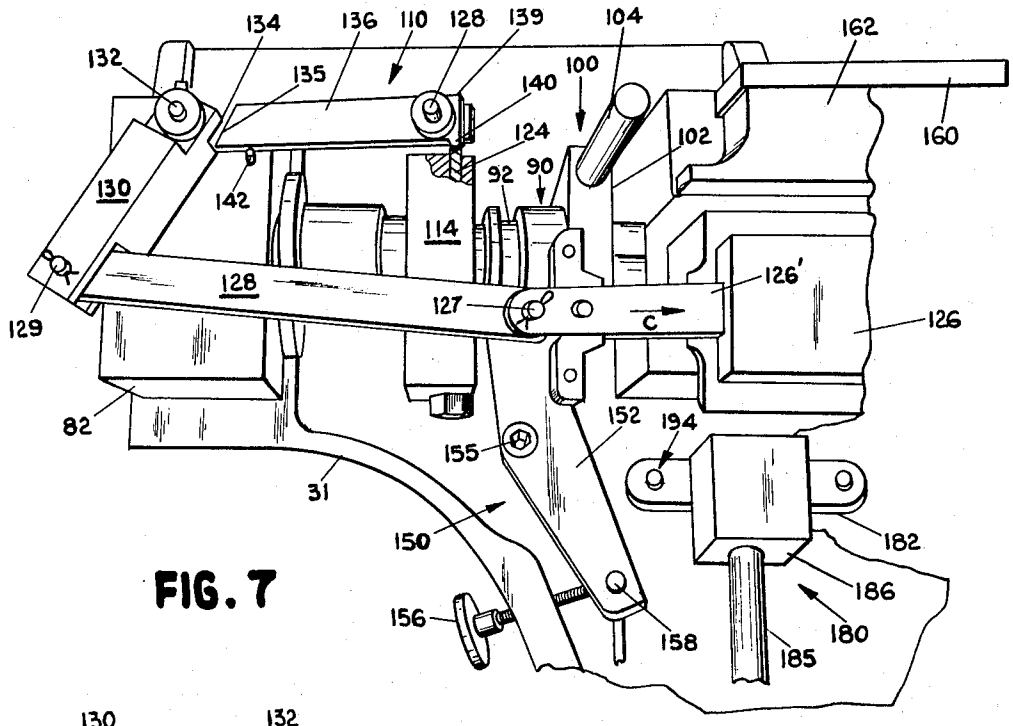

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FIG. 7

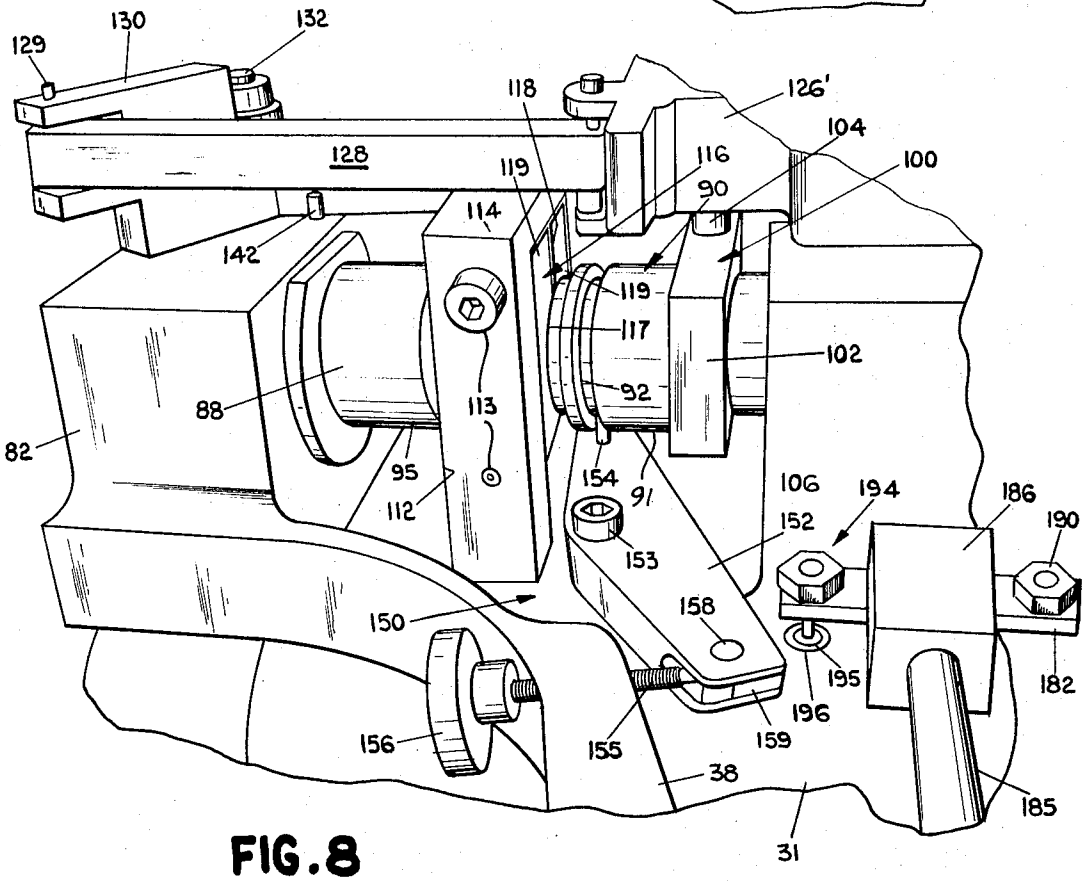

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FIG. 8

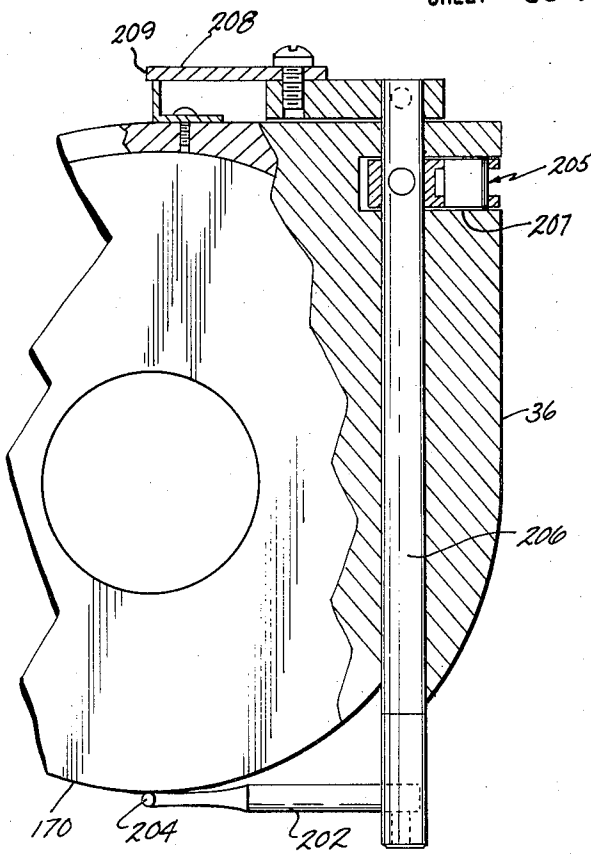


FIG. 9.

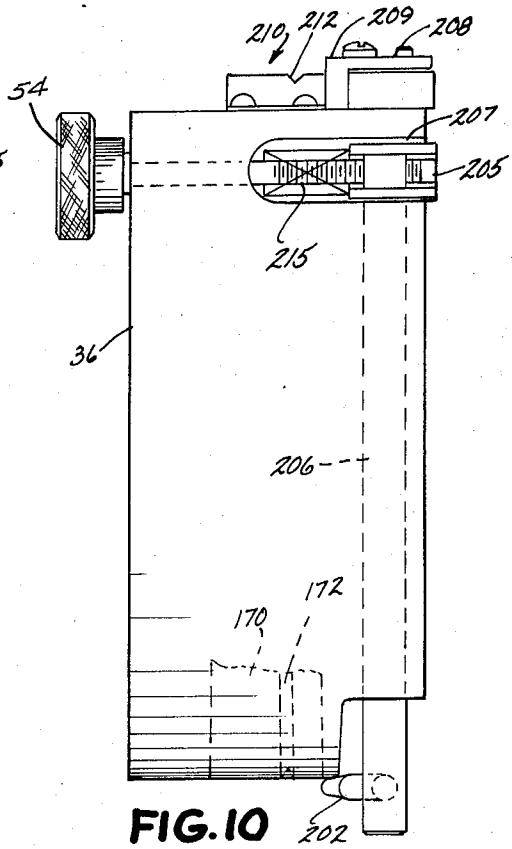


FIG. 10

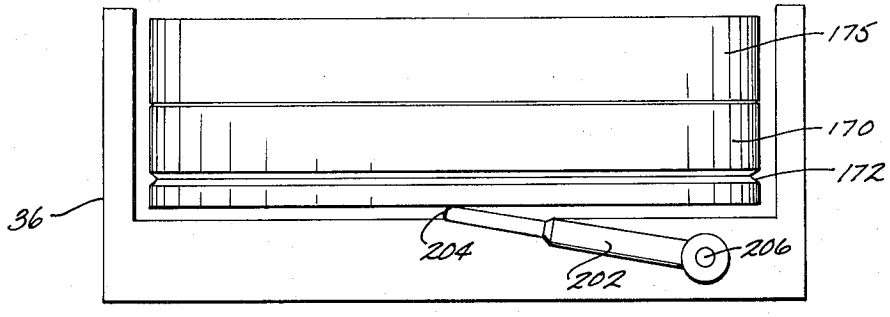


FIG. 11

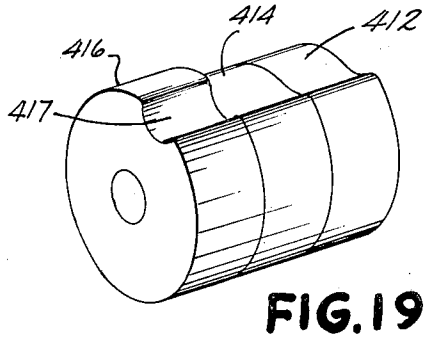


FIG. 19

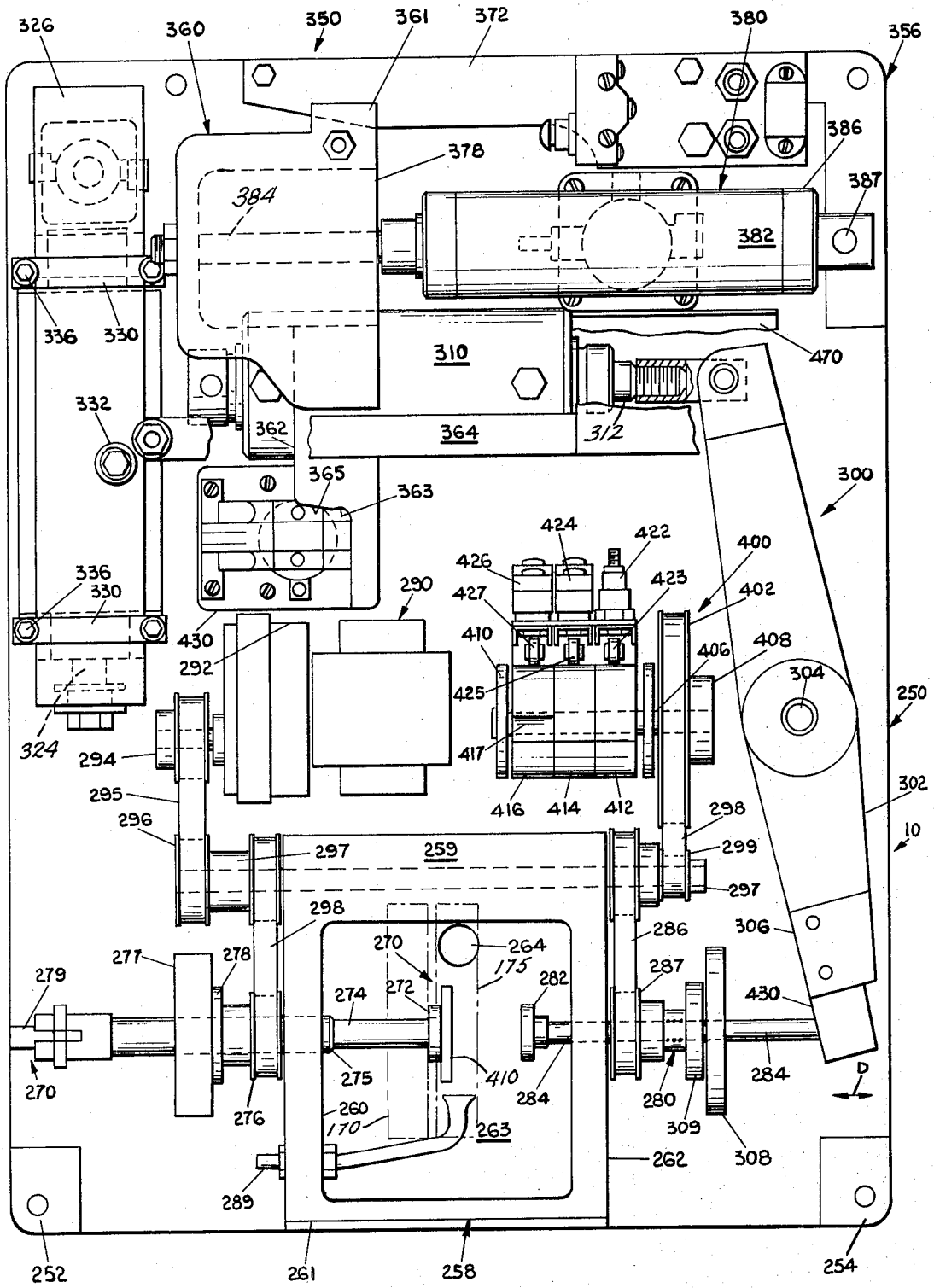

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FIG. 13

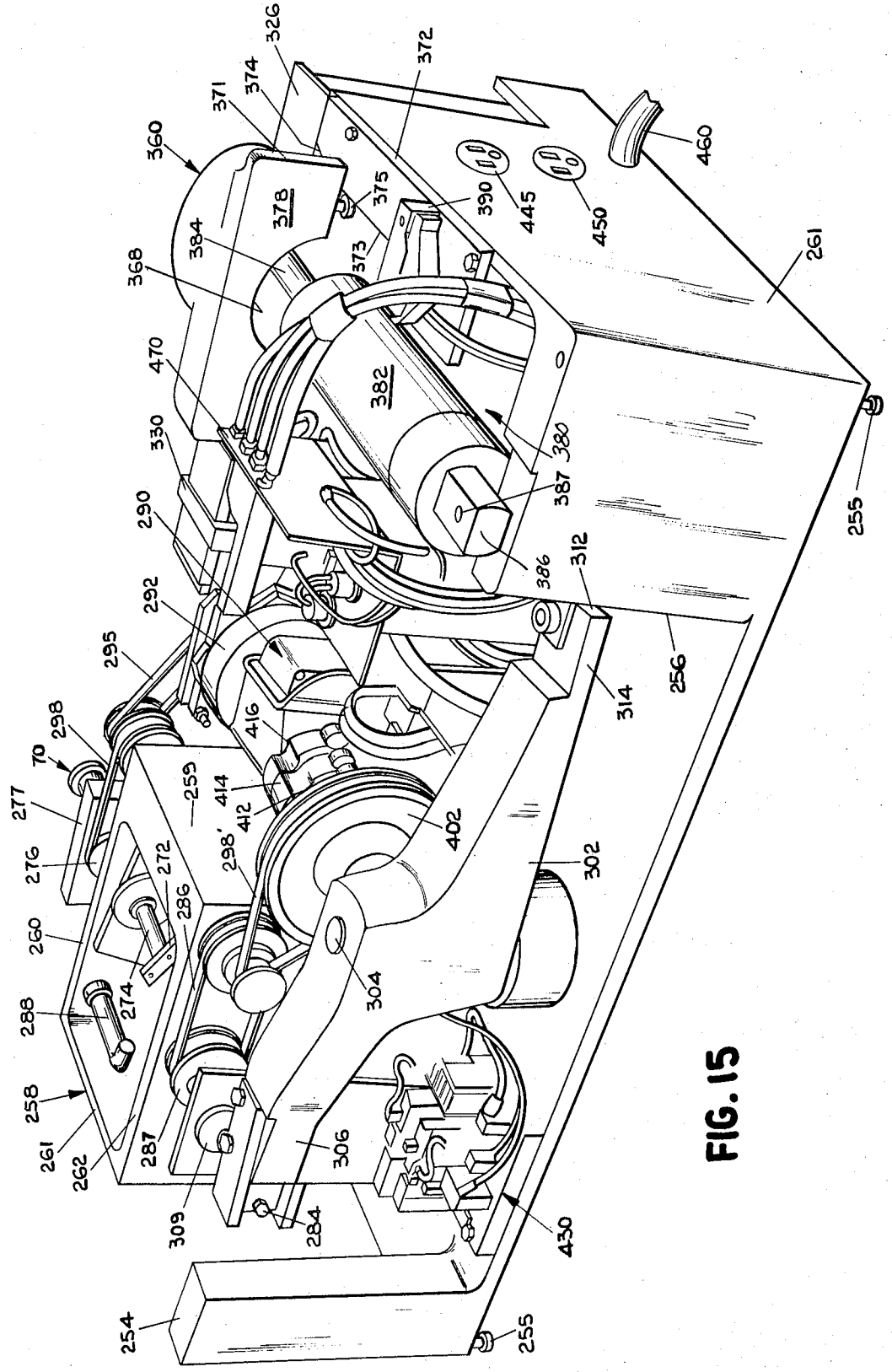

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FIG. 15

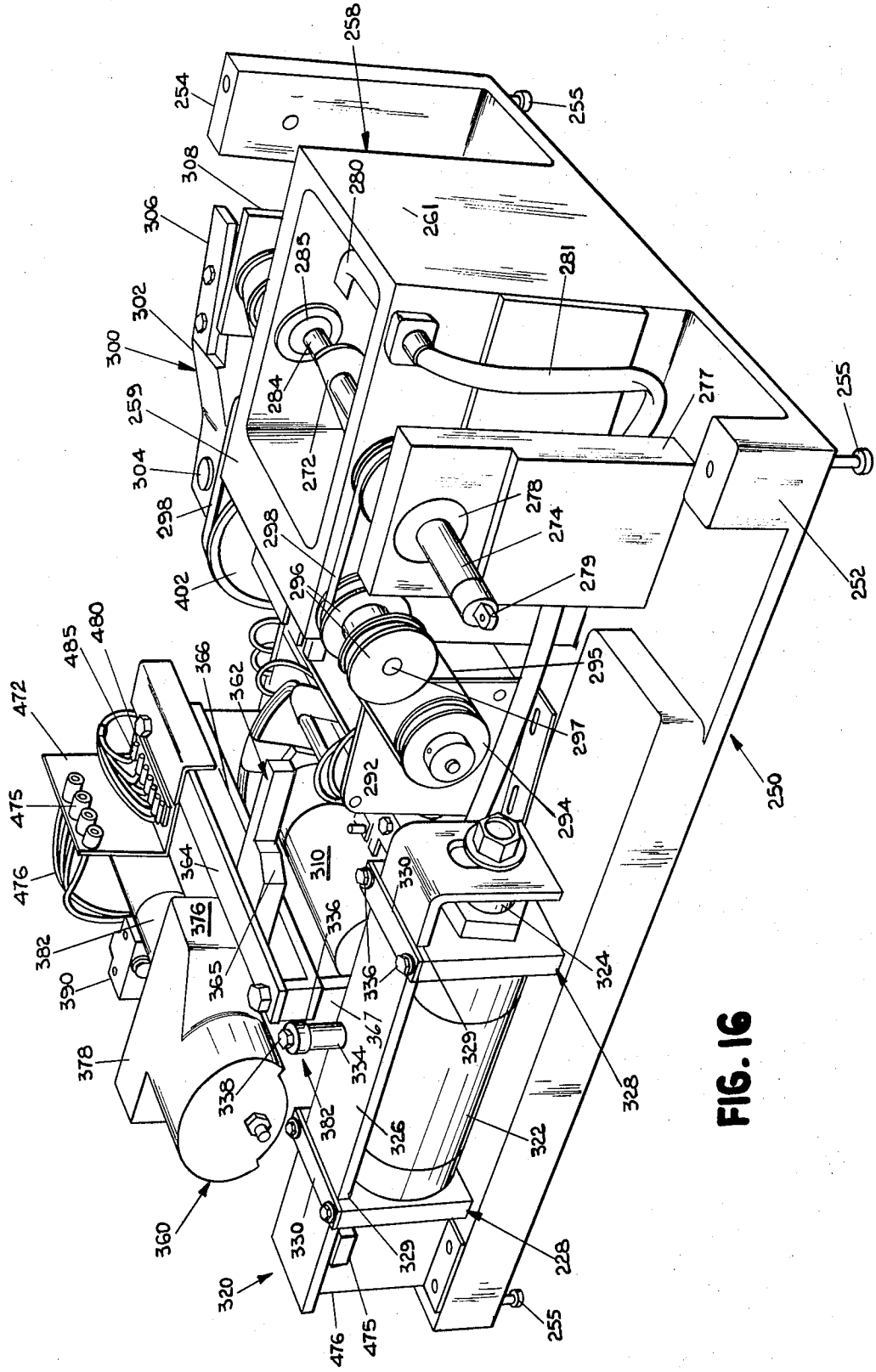

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FIG. 16

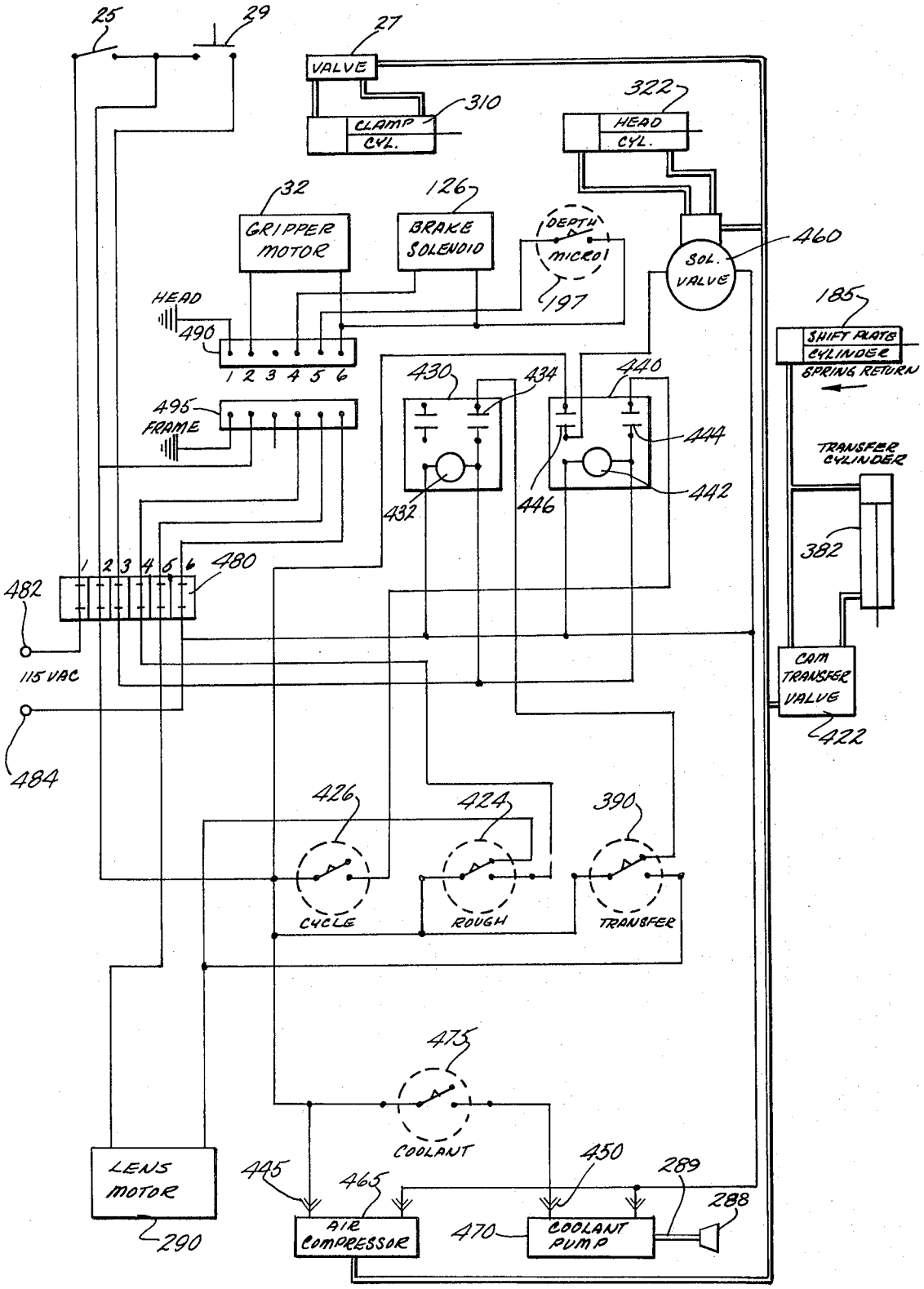

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29
27
VALVE
310
CLAMP CYL.
322
HEAD CYL.
32
GRIPPER MOTOR
126
BRAKE SOLENOID
DEPTH MICRO!
197
460
SOL. VALVE
185
SHIFT PLATE CYLINDER
SPRING RETURN
TRANSFER CYLINDER
382
HEAD
490
1 2 3 4 5 6
495
FRAME
430
434
440
444
442
432
446
480
482
115 VAC
484
CAM TRANSFER VALVE
422
426
424
390
CYCLE
ROUGH
TRANSFER
475
COOLANT
LENS MOTOR
290
445
465
AIR COMPRESSOR
450
289
288
470
COOLANT PUMP

FIG. 20.

LENS GRINDING APPARATUS

BACKGROUND OF THE INVENTION

The present invention relates to a lens grinding apparatus, and specifically to an eyeglass lens edging machine for shaping the boundary of eyeglass lenses in accordance with predetermined patterns.

When shaping eyeglass lens blank to fit desired frames, the lens is first rotated under a rough grinding wheel while simultaneously moved toward and away from the grinding wheel in accordance with a pattern shaped in the configuration of the desired frame. The lens is then moved under a fine grinding wheel and again rotated in a path determined by the pattern shape to finish the edging of the lens and bevel the lens as desired for fitting into the frame. Many existing lens grinding machines must be manually operated for shifting the lens from the roughing wheel to the fine grinding wheel. In most existing automatic machines, the lens, rather than the grinding head, is shifted to accomplish the rough grinding and fine grinding cycles of operation. Although such machines have proven relatively efficient in the number of lenses they can handle per unit time, the accuracy of positioning the bevel on the edge of the lens has been less than desired. Also, these machines frequently lack flexibility in handling a variety of lens shapes and/or different types of bevels. Additionally, many existing machines are bulky and take up considerable space in an optical shop as well as being expensive.

One commercially available lens grinding machine manufactured by Wernicken Company or Dusseldorf, Germany, and sold under the trademark WECO, employs a head assembly which is raisable and lowerable as well as shiftable from roughing to fine grinding positions. This machine must be manually aligned for the initial roughing operation and cannot automatically shift to a variety of presettable beveling positions for fine grinding of hidden bevels. In addition, this machine is controlled by complex and costly electrical and mechanical components.

SUMMARY OF THE INVENTION

The apparatus of the present invention overcomes the difficulties of existing lens grinding machines and, in addition, provides a greater degree of automation and flexibility in operation while simultaneously being significantly less costly.

Due to the simplified construction as compared with the relatively complex existing machines, the apparatus of the present invention is easier to operate and has fewer maintenance problems.

It is an object, therefore, of the present invention to provide an improved lens grinding apparatus.

It is an additional object of the present invention to provide a lens grinding apparatus which automatically cycles through rough and fine grinding operations by moving a grinding head assembly relative to a lens.

It is a further object of the present invention to provide a lens grinding apparatus which has presettably registered roughing and fine grinding positions for automatically grinding a variety of selected beveled lens edges.

It is still a further object of the present invention to provide a lens grinding apparatus with unique controllable mechanical components to accurately and automatically position rough and fine grinding wheels with respect to a lens.

Apparatus embodying the present invention include a base assembly to which is slidably and rotatably mounted a grinding head assembly including rough and fine grinding wheels. The base assembly includes means for rotatably holding a lens under one of the grinding wheels. Transport means shift the head assembly from a presettable roughing position to a presettable fine grinding position after a predetermined number of lens revolutions. Means are provided for actuating the transport means to automatically accomplish the rough and fine grinding operations.

The invention can best be understood by referring to the following drawings and accompanying description thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of the grinding apparatus embodying the present invention;

FIG. **2** is a side elevational view of the right side of the apparatus shown in FIG. **1**;

FIG. **3** is a side elevational view of the left side of the apparatus shown in FIG. **1**;

FIG. **4** is a detailed partial plan view of the grinding head assembly partially in cross section;

FIG. **5** is a bottom view of the grinding head assembly with the guiding wheels removed;

FIG. **6** is an enlarged detailed view of one portion of the grinding head assembly;

FIG. **7** is an enlarged view of a portion of the bottom of the grinding head assembly showing the brake mechanism in detail;

FIG. **8** is an enlarged perspective view of the brake mechanism shown in FIG. **7**;

FIG. **9** is a side elevational view partially in cross section of the left side of the edge follower assembly on the grinding head assembly;

FIG. **10** is a detailed rear elevational view of the edge follower assembly;

FIG. **11** is a detailed bottom view of the edge follower assembly;

FIG. **12** is a perspective view of an alternative embodiment of the edge follower assembly;

FIG. **13** is a detailed plan view of the base assembly;

FIG. **14** is an enlarged cross section view of a portion of the base assembly;

FIG. **15** is a right rear perspective view of the base assembly;

FIG. **16** is a left front perspective view of the base assembly;

FIG. **17** is an enlarged detailed plan view of a portion of the base assembly showing a portion of the transfer mechanism;

FIG. **18** is a detailed perspective view of a portion of the transfer assembly shown in FIG. **17**;

FIG. **19** is an enlarged perspective view of the timing cam mechanism positioned on the base assembly; and

FIG. **20** is an electrical and pneumatic diagram partially in schematic and block form showing the control circuits and pneumatic components for the lens grinding apparatus.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIGS. 1 through 3, there is shown an exterior view of an assembled lens grinding apparatus embodying the present invention which includes a cover 20 mounted over a base assembly 10 (not shown). A grinding head assembly 30 is pivotally, slidably, and removably mounted to the base assembly 10 by means of an axle 23 extending through the head assembly and supported at opposite ends on seats 22 and 24 positioned on cover 20.

The head assembly 30 includes a motor 32 mounted to a frame 31 of the head assembly. Drive means such as a belt 34 couple a rotating shaft of motor 32 to the grinding wheels within a grinding wheel housing 36. A protective cover 35 is positioned over the drive belt 34. A weight post 33 mounted to frame 31 is provided for holding annular shaped weights as desired for increasing the grinding pressure of the grinding wheels against the lens. A handle 37 is attached to the grinding head frame 31 for use in raising and lowering the grinding head assembly manually if desired although the machine is completely automatic in operation. A rectangular aperture 21 in cover 20 provides access to the lens holding means in the base assembly.

A follower shoe assembly 40 includes a follower shoe 42 mounted on the end of a cylinder 43 which is movably positioned within a sleeve 44. Sleeve 44 is attached to an arm 46 which is pivotally coupled to the frame 31 of the grinding head assembly. The sleeve 44 includes an open recessed area 44' such that graduated marks 45 on cylinder 43 are exposed. These marks can be aligned with indexing marks 47 on sleeve 44 by rotating an adjustment knob 48 to move the cylinder 43 within sleeve 44 for setting positive and negative lens deviations when standard lens grinding patterns are employed with the device.

Pattern holding means 60 extends from a slotted aperture 26 in the cover 20 and includes means thereon for attaching a lens pattern 70 which is held under the follower shoe 42. The pattern holding means rotates together with lens holding means described in detail below to control the position of the grinding head assembly and therefore the grinding wheels thereon relative to the position of the lens held within the machine.

Positioned on the grinding wheel housing is a control 54 for indexing the fine grinding wheel to place a bevel on the lens in any desired position. An indicator 52 on the top of housing 36 provides a visual reference for the operator in setting the bevel position. The edge follower mechanism associates with the control and the indicator is described in detail below.

On the front surface 28 of the cover 20 there is included an on-off electrical switch 25, a lens holding pneumatic control 27, and a start switch 29 which are operated in that sequence to initiate the automatic operation of the lens grinding machine. Having briefly described the exterior portions of the apparatus and some of the major components, a detailed description of the head assembly, the base assembly and the control apparatus will be presented in that order. These descriptions will be followed by a detailed description of the operation of the machine.

Referring now to FIGS. 4 through 12 and specifically to FIGS. 4 and 5, there is shown the head assembly 30 including the follower shoe assembly 40. The entire grinding head assembly 30 is pivotally and slidably mounted on the axle 23, as noted above, by means of bearing assemblies 80 (FIG. 4), one of which is fitted within each of a pair of raised shoulders 82 on either side of the rear portion of the frame 31 of the grinding head assembly. The bearing assemblies 80 each include ball bearings 84 which permit longitudinal motion of the grinding head assembly 30 indicated by the arrow A and needle bearings 86 which permit rotational motion of the grinding head assembly 30 on axle 23 as indicated by the arrow B.

Also mounted within each of the shoulders 82 of frame 31 are sleeve bushings 88 within which is slidably and rotatably mounted a cylindrical sleeve assembly 90. Sleeve assembly 90 includes a sleeve 91 concentrically positioned within the bushings 88 and having an inner diameter which permits clearance between the inner surface 93 of sleeve 91 and the outer surface 23' of the axle 23. The sleeve 91 is therefore free to slide within the bushings 88 in a longitudinal direction, also indicated by the arrow A, as well as rotate within the bushings in a direction also indicated by arrow B.

The sleeve 91 includes an annular groove 92 formed around its outer circumference. Additionally, a follower pin assembly 100 is positioned on sleeve 91 and includes a block 102 rigidly attached to sleeve 91, and a follower pin 104 extending downwardly from the head to contact the head transfer mechanism on the base assembly as described in detail below.

A brake assembly 110 is also positioned on the underside of the head assembly 30 and includes a U-shaped brake shoe frame 112 (FIGS. 7 and 8) having downwardly depending legs 113 and a cross member 114. The end of the downwardly depending legs remote from the cross member 114 are rigidly attached to the frame 31 of the grinding head assembly. A brake shoe 116 is held within the frame 112 by means of suitable holding pins 120 and 122 which extend into slots in the edges of the shoe (not shown). Shoe 116 is formed of a rectangular member having an aperture 117 which receives the sleeve 91 such that when the braking means 110 is in the unlocked position, the outer surface 95 of sleeve 91 is free to move within aperture 117. The shoe 116 includes a slot 118 such that the ends 119 of shoe 116 can be compressed inwardly closing the slot 118 and causing the brake shoe to bind against the outer diameter of sleeve 91. Pin 122 is adjustable to vary the gap of slot 118 to provide a brake adjustment. The actuating means for the brake shoe will now be discussed.

A pin 124 (FIG. 7) is slidably mounted within an aperture 125 in the rear leg 113 of the brake frame 112 and has an end which contacts one side of the brake shoe near the end of slot 118 adjacent cross member 114 of the frame. Movement of the pin 124 inwardly toward the brake shoe causes the shoe to clamp the sleeve 91 (and the follower pin 104) with respect to the head assembly. This feature is employed for raising the head after the rough grinding cycle, transferring the head to the fine grinding position and lowering the head as explained in detail below.

Means for actuating the braking means by moving the pin 124 includes a solenoid 126 having a movable plunger 126' which is attached to a first pivot arm 128 by means of a pivotable coupling 127. Arm 128 is coupled to a second pivot arm 130 by means of a pivotable

connection 129. Member 130 is pivotally attached to shoulder 82 of the frame 31 by means of a pivot pin 132. A tapered recess 134 is formed in one corner of member 130 as shown in FIG. 7 and receives a tapered end 135 of third arm 136. Arm 136 is pivotally coupled to the frame 112 of the braking means by means of a pivot pin 138. The end 139 of arm 136 includes a protruding ear 140 which is adapted to contact the end of pin 124. Pin 124 can be spring-loaded to hold the arm 136 against an arm stop 142 on shoulder 82. The braking mechanism is shown in FIG. 7 in its unlocked position. When the solenoid 126 is actuated, the plunger 126' of the solenoid moves in a direction indicated by arrow C to cause the arm 130 to pivot about pin 132 in a counterclockwise direction thereby forcing the arm 136 away from a stop pin 42 by means of the recessed slot 134 in arm 130. Arm 130, which rotates in a clockwise direction about pin 138, forces the pin 124 against the brake shoe 116. In this manner, the actuation of the solenoid 126 causes the brake means to lock the sleeve 91 relative to the housing 31. When the solenoid 126 is not actuated (during the rough grinding), the follower assembly 100 is free to rotate together with the sleeve 90. The follower pin 104 is biased in a rearward position by means of a bias spring 106 which extends between the block 102 and a follower arm pivot pin 108 as seen in FIGS. 4 and 5. A recess 107 on pin 108 accommodates the end of spring 106 to hold it in a fixed position.

An adjustment means 150 (FIGS. 7 and 8) is provided for sliding sleeve 91 with respect to the housing 31 in a manner which, as explained below, indexes the rough grinding wheel to the lens. The adjustment means 150 includes a pivot arm 152 which is pivotally mounted to the head assembly frame 31 by means of a pin 153. A pin 154 extending from end 151 of arm 152 fits within the annular groove 92 in sleeve 91 to cause the sleeve 91 to shift laterally (arrow A in FIG. 4) as arm 152 is pivoted about point 153. An adjustment screw 155 is threadably mounted through the edge 38 of frame 31 and has an end pivotally mounted to an end 157 of arm 152 by means of a pivot pin 158 and screw receiving slot 159. An adjustment knob 156 is provided on the opposite end of the screw 155.

The head assembly 30 further includes a head raising and lowering cam follower plate 160 (FIGS. 5 and 7) which extends outwardly from one side of the head assembly. When the head assembly is mounted to the base assembly as described below, this plate will contact a roller cam follower coupled to a movable member on the base for raising and lowering the grinding head assembly. Plate 160 is mounted to the shoulder 82 on the frame 31 by means of suitable mounting bolts (not shown).

A grinding wheel shaft 165 is rotatably mounted in the forward end of frame 31 of the grinding head assembly by means of a pair of spaced bearings 166 fitted in the frame 31. A pulley 167 at end 164 of the shaft is adapted to receive the drive belt 34 (FIG. 2) which is coupled to the grinding wheel drive motor 32.

A fine grinding wheel 170 is mounted on the opposite end of shaft 165 and a rough grinding wheel 175 is positioned outwardly from wheel 170. Both of these wheels are rigidly attached to shaft 165 by means of a suitable mounting bolt 172 secured to a threaded aperture 168 in the end of shaft 165. It is noted that the fine grinding wheel 170 includes an annular V-shaped notch 172 therearound for beveling edges of the lenses as described below.

The follower shoe assembly 40 is pivotally coupled to the grinding head assembly 30 by means of an aperture 49 in the arm 46 and bushings 49' within aperture 49 that are adapted to receive in pivotal engagement therewith, the end 109 of pivot pin 108. A follower pin 41 extends inwardly toward the grinding head assembly from the end of arm 46 opposite the follower shoe 42. This pin contacts sensing means 180 (FIGS. 4 through 6) to provide means for actuating the sensing means to cause the rotatable lens holding means (described below) to stop and start rotation of the lens blank as the continuously rotating grinding wheel removes lens material from the lens.

The sensing means is best shown in FIGS. 4 and 6 and includes a slidable plate 182 coupled to the shaft 184 of a spring-loaded pneumatic cylinder 185. The shaft 184 is pivotally movable in cylinder 185 thereby allowing plate 182 to pivot about the axis of shaft 184 as well as slide in a direction indicated by arrow D when the shaft 184 moves in and out of cylinder 185. Plate 182 is shown in the forward position in FIG. 6 and moves rearwardly when the cylinder is actuated. The air cylinder 185 is attached to a mounting bracket 186 which in turn is attached to frame 31 by suitable bolts 187.

Adjustable camming means 190 comprise a threaded member 191 fitted through the end 183 of plate 182. Member 191 has a flat head or cam surface 192 which is positioned to contact the pin 41 of the follower shoe assembly as shown in FIG. 6 during the roughing cycle of operation when the air cylinder 185 is not actuated and the plate 182 is in its forward position. During the fine grinding operation, cylinder 185 is actuated to slide the plate 182 rearwardly such that pin 41 will contact the upper surface 181 of plate 182 forward of member 190. As explained in detail, the differential distance between the cam surfaces 192 and plate surface 181 allows the fine grinding wheel to remove approximately 2 mm of additional lens material during the fine grinding cycle of operation.

The end of plate 182 opposite end 183 includes an adjustable follower 194 (FIG. 8). Member 194 has a surface or head 195 which extends through an aperture 196 in the frame 31 of the grinding head assembly to contact a follower arm (not shown) of electrical switch 197 (FIG. 2) mounted on the top of frame 31. The actuation of this switch as the follower arm assembly pivots about pin 108 due to the rotation of pattern 70 under follower shoe 42 causes the lens holding motor (described below) to be selectively actuated as the lens material is removed by the grinding wheel during the rough and fine grinding cycles. The operation of this control is explained in greater detail below. In addition to the follower shoe assembly, the sensing means, the transport engaging means, the braking means, and the grinding wheels; the grinding head assembly 30 further includes edge following means 200 which is attached to the grinding wheel housing 36 and is shown in detail in FIGS. 9 through 12.

In the embodiment shown in FIGS. 9 through 11, the edge following means includes a follower shoe in the form of an arm 202 having a rounded end 204 adapted to contact the edge of a lens held by the lens holding means under the grinding wheel. The arm 202 is supported under and movably adjacent the fine grinding wheel 170 by means of a shaft 206 which extends up-

wardly through the housing **36** and is rotatable therein to adjust the position of end **204** with respect to the notch **172** in wheel **170.**

At the top of the housing **36,** there is provided an indicator **210** including an indicator arm **208** also coupled to the shaft **206** and movable therewith. A guide **212** is rigidly attached to the top of the housing **36** and has a notch **213** therein which corresponds in vertical alignment to the notch **172** in wheel **170.** The indicator arm **208** has a pointer end **209** which corresponds to and tracks the position of the end **204** of arm **202.** An adjustment screw **215** is coupled to a pivot coupling **205** movably positioned in a recess **207** in housing **36** to rotate the shaft **206** for providing an adjustment for positioning the bevel with respect to the lens in a manner described in detail below. An adjustment knob **54** is positioned on the end of screw **215.**

In the FIG. **12** embodiment, the arm **202** is replaced by an arcuate-shaped follower shoe **220** which is adapted to contact the edge of a lens and is attached to a block **224** having a dovetailed tongue **221** coupling block **224** to a correspondingly shaped notch **223** in an end block **225** of a mounting bracket **222.** Bracket **222** is rigidly attached to the inner wall of the housing **36** by means of a bolt **226.** The shaft **206** which extends upwardly through the housing **36** is identical to the shaft described in conjunction with the embodiment shown in FIGS. **9** through **11** as are the indicator and adjustment means. Shaft **206,** however, is coupled to block **224** by means of a pivot arm **228** and a springable connection **230** which couples the end of the shaft **228** remote from its junction with shaft **206** to the sliding block **224.** In one embodiment, the block **224** had a rectangular aperture formed therein and the end of member **230** was tapered to fit within the aperture such that, as shaft **206** is rotated during adjustment, the rotational motion is converted into a linear motion which causes the follower shoes **220** to move inwardly in a direction vertical to the plane of grinding wheel **170.** The FIG. **12** embodiment provides linear motion of the follower shoe as compared to the rotational counterpart shown in FIGS. **9** through **11.**

Having described in detail the construction of the grinding head assembly and its subassemblies, a description of the base assembly to which the grinding head assembly is slidably and pivotably coupled is now presented.

The base assembly shown in FIGS. **13** through **19** includes a frame **250** having front corner posts **252** and **254** and an L-shaped upstanding rear corner member **256.** Centrally located toward the front edge of the frame **250** is an open rectangular housing **258** having a rear wall **259,** a left side wall **260,** a front wall **261,** a right side wall **262,** and a floor **263.** An aperture **264** in the floor **263** provides a drain for liquid coolants and lubricants employed with the lens grinding apparatus. Extending in the housing **258** is the lens holding means **270** which includes a left lens mounting bracket **272** mounted on a shaft **274** which extends through the left side wall **260** of housing **258** by means of a suitable bearing or bushing **275.** The lens holding means **270** further includes a right lens mounting bracket **282** attached to a shaft **284** extending through the right side wall **262** of container **258** by means of a suitable bushing or bearing **285** (FIG. **15**) which permits shaft **284** to rotate as well as move laterally through wall **262** as indicated by arrow D. The specific details of the shaft arrangement are described below.

Shaft **274** has a cog belt pulley **276** attached thereto to be rotatably driven by means of a lens holder drive motor **290** which includes a gear reduction box **292** attached thereto with an output cog pulley **294.** A first cog belt **295** couples pulley **294** to one of a pair of cog pulleys **296** mounted on a shaft **297** which extends through the rear wall **259** of container **258** and is rotatably mounted thereto by means of suitable bearings (not shown). A second drive belt **298** couples the inner pulley **296** to the pulley **276** mounted on the shaft **274** adjacent the left wall **260** of container **258.** In the embodiment shown, the shafts **297** and **274** driven by motor **290** are rotated at a speed of **10** rpm when the motor **290** is actuated.

Shaft **284** is a solid shaft which extends through a hollow shaft **280** which is supported at one end by the bearing **285** in wall **262** and at the other end by a bearing **309** in a vertical support bracket. Shaft **280** includes a bushing **282** therein (FIG. **14**) which is keyed to shaft **284** by means of key **283** such that shaft **284** can slide within shaft **280** and will be rotatably driven thereby. Shaft **280** is rotatably driven by a third cog belt **286** coupling a cog pulley **287** attached to the shaft **280** adjacent side wall **262** of housing **258** and a cog pulley **288** on shaft **297.** A fourth cog belt **298'** is positioned over a cog pulley **299** at the right end of shaft **297** for driving a cam timing means **400** at a one-to-six reduced speed ratio in the preferred embodiment. The timing cams will be described in greater detail below.

It is seen with the structure shown, the lens clamping means **272** and **282** are coupled to shafts **274** and **284** which are rotatably driven at approximately **10** rpm when motor **290** is actuated. The left end of shaft **274** extends through a shoulder **277** by means of a bearing **278** therein and includes the pattern holding means **70** such as a spring ball mounting bracket **279** on which a standard lens grinding pattern can be detachably coupled. The pattern, therefore, will be rotated at the same speed as the lens since they are mounted on a common shaft.

A coolant nozzle **288** is mounted in the housing **258** through the left side wall **260** and is coupled to a suitable source of coolant and lubricating fluid by means of a hose **289.** The nozzle **288** is positioned to direct coolant under pressure over the lens held between the jaws **272** and **282** during the lens grinding operation. The coolant is then drained by means of the aperture **274** in the floor of the housing.

Clamping means **300** is provided for securely clamping a lens blank between jaws **272** and **282.** Means **300** includes a pivotable arm assembly which comprises a lever arm **302** pivotally mounted to the frame **250** by means of a bolt **304.** The forward end **306** of arm **302** is pivotally coupled to the right end **284'** of shaft **284** (FIG. **15**). A pneumatic cylinder **310** has a shaft **312** pivotally coupled to the opposite end **314** of arm **302.** As cylinder **310** is actuated, shaft **284** is moved inwardly or outwardly in the direction indicated by arrow D to clamp the jaws **282** and **272** together in a lens holding position or a lens releasing position respectively. In addition to the rotatable lens holding means and the lens clamping means including associated actuating means, the base assembly **10** further includes head raising and lowering means **320.**

The head raising and lowering means is best shown in FIG. 16 and comprises a pneumatic cylinder 322 having a shaft 324 adjustably but fixedly clamped to an end slot of an L-shaped slide 326 formed from flat stock. The slide 326 is positioned above the cylinder 322 by means of a pair of spaced brackets 328. Each of the brackets 328 includes a rectangular slot 329 for slidably and guidably holding the slide 326 and a cover plate 330 which extends over the slide 326. Suitable lubrication can be provided on the plate 326 and around the apertures 329 of brackets 328 to facilitate the movement of the slide plate 326 as the cylinder is actuated. A roller cam 332 shown in FIGS. 15 and 16 comprises a post 334 to which is attached a roller bearing 336 by means of a suitable bolt 338.

The head raising and lowering means 320 is shown with the slide 326 in its rearward position which corresponds to the head lowered position. The cam follower plate 160 shown in FIGS. 5 and 7 and shown in phantom form in FIG. 17 is adapted to be contacted by the roller cam 332 when the cylinder 322 is actuated. Thus, when the head is to be raised to a starting position prior to the grinding operation, the slide plate 326 will be moved in a direction indicated by arrow E in FIG. 17 such that the roller cam 322 contacts plate 160 and moves the plate forward thereby raising the grinding head assembly which pivots about the axle 23 seated in the cover seating brackets 22 and 24 (FIGS. 1 through 3). As the grinding apparatus is operated, the cylinder 322 is actuated by a two-way valve 460(FIG. 20) to cause the shaft 324 to move in a direction opposite arrow E thereby lowering the head until the cam following plate 160 no longer contacts the roller cam 332 thereby providing free floating of the head assembly without interference from the head raising and lowering mechanism 320. The head raising and lowering mechanism 320 is actuated therefore only at the beginning of the grinding operation and at the end of the fine grinding cycle of operation.

The base assembly 10 further includes head transport means 350 (FIGS. 13, 15 through 18) which are utilized to shift the head from a rough grinding position to the fine grinding position. This involves a laterally shifting motion of the grinding head assembly 30 as well as the raising and lowering of the assembly. The head transport means 350 includes a housing 360 having a forwardly protruding L-shaped member 362 that extends between two parallel guide tracks 364 and 366 (FIG. 16). The follower pin 104 of the head assembly 30 is adapted to rest within a notch portion 363 of the L-shaped member 362 as shown in FIG. 17 (during the roughing cycle of operation). The open edge 365 of notch 363 is tapered as shown in FIGS. 13 and 17 for the purpose described below. Plates 364 and 366 are supported on the base 250 of the base member 10 by means of suitable support brackets 367. The rear edge 361 of housing 360 has a lip portion 371 (FIG. 17) which extends over a guide and camming plate 372 mounted on the rear shoulder 356 of the base 250 such that the housing 360 is supported between the parallel guide rails 364 and 366 and the rear plate 372. Under the lip 371 is positioned a roller cam follower 375 (FIG. 18) which is adapted to contact the leading edge 373 of plate 372. The right end 374 of edge 373 is tapered somewhat as shown in FIG. 18 for the purpose described below. Housing 360 has a central recessed or open area 368 (FIG. 15) to permit the housing to clear the actuation cylinder 382 forming a part of the actuating means 380 for the transfer means 350.

In the mounting arrangement for the housing 360, it is seen that it is slidably positioned such that it can move transversely, as indicated by the arrow F in FIG. 18. The shaft 384 of cylinder 380 is attached to the end of the housing 360 by means of a nut bolt 385 (FIG. 18). The opposite end 386 of cylinder 382 is pivotally mounted to the shoulder 256 on base 250 by means of a pivot pin 387. Thus, cylinder 382 is permitted to pivot about point 387. The spacing between the front surface 376 (FIG. 16) of housing 360 which abuts the rear sides of the guide rails 364 and 366 and the roller cam 375 which abuts the leading edge 373 of plate 372 permits the housing 360 to move fore and aft slightly as indicated by the arrow G in FIG. 18. The pivotal mounting of the end 386 of cylinder 380 permits such motion of the housing 360 which is rigidly attached to the shaft 384 of cylinder 382. As seen in FIG. 17, the follower pin 104 which is spring-biased in a rearward position by means of the spring 106, will normally hold a housing 360 in its rearward position against the plate 272.

In the roughing position, the housing 360 will be in the extreme left position as shown in FIG. 17 and pin 104 will be seated firmly in the corner of notch 363 of the L-shaped bracket 362 extending from housing 360. When transferring the head from the roughing position to the fine grinding position, cylinder 382 is actuated to draw the housing 362 toward the cylinder which in turn causes the roller cam 375 to travel along the tapered end 374 of plate 372 thereby forcing the housing 360 toward the front of the lens grinding apparatus. This pushes pin 104 forwardly in a manner to raise the grinding wheel approximately 1 mm. This results since the brake means 110 is in a locked position during the transfer and movement of pin 104 rotates the grinding head assembly to raise the grinding wheel. Cylinder 382 includes speed regulating means such that when actuated, it will move slowly. As the housing 360 continues its motion to the right, the edge follower shoe 220 (FIG. 12) which is coupled to the grinding wheel housing, contacts the edge of the lens thereby preventing additional motion of the grinding head assembly on axle 23. This causes pin 104 to slide out of the notch 363 in member 362 and drop off the tapered end 365 thereof to lower the grinding head assembly which is now indexed in a preset position such that the fine grinding wheel is positioned over the lens in accordance with the setting of the edge following indicator. Since the grinding head assembly slides very freely on axle 23, pin 104 will follow member 362 until the edge follower contacts the lens.

Thus, it is seen that the transport mechanism 350 initially raises the head at the end of the rough grinding, shifts the head laterally into alignment for fine grinding, and finally, lowers the head into the fine grinding position. The novel construction of the head transport apparatus provides these functions at a minimal expense and complexity of the mechanism. An electrical switch 390 (FIG. 18) is positioned on the end of the plate 372 such that the right surface 378 of the housing 360 will actuate the switch when the housing has moved to its right position corresponding to the fine grinding position of the head. The actuation of this switch will condition the lens grinding motor 290 to be actuated on demand for rotating the lens during the fine grinding cycle of operation.

The base assembly **10** of the lens grinding apparatus additionally includes a timing cam means **400** (FIGS. **13, 15, 19**) which is mounted behind the lens housing **258.** The timing cam means **400** includes a cog pulley **402** which is driven by the motor **290** via belt **298'** which extends between the pulley **402** and pulley **299** on shaft **297.** The pulley **402** is six times greater in diameter than pulley **299** thereby providing a one-to-six reduction in speed therebetween. Thus, for each complete revolution of the pulley **402,** the lens blank **410** (shown in FIG. **13** attached to jaw **272** for illustrative purposes) has rotated six times. Pulley **402** is mounted on a shaft **404** and supported in rotatable engagement to the base **250** by means of a suitable mounting bracket **408** with bearings (not shown) therein. Also mounted to shaft **404** are three cams **412, 414,** and **416.** As seen in FIGS. **13** and **19,** cams **412** and **414** are identical and have raised and lowered surfaces which each span approximately 130° of the cam surface. Cam **416** on the other hand, has a single depressed region **417** for only approximately 15° of the cam surface. Mounted in proximity to the cams **412, 414,** and **416** are three cam operated controls comprising a pneumatic switch **422** having a roller follower **423** which contacts the surface of cam **412,** an electrical switch **424** having a roller cam follower **425** which contacts the surface of cam **414,** and an electrical switch **426** having a roller follower **427** which contacts the surface of cam **416.** With the gear reduction ratio selected as described in the preferred embodiment, after approximately two and one-half revolutions of the lens under the lens grinding wheel, the cams **412** and **414** will actuate the valve **422** and switch **424** respectively to cause the head transferring mechanism **350** to be actuated as well as the braking mechanism in the head assembly and the sliding cam plate **182** in the sensing mechanism **180** (in the head assembly). The lens driving mechanism is also deactivated during the period of time when the grinding head assembly is shifting from the rough to fine grinding position.

Once the transfer switch **390** (FIG. **18**) is actuated, motor **290** is restarted and the cam shaft **406** is restarted to selectively continue its rotation on demand until the sixth rotation of the lens has been completed thereby causing cam **416** to actuate switch **426.** As this occurs, the head is raised by the actuation of raising member **320,** the motor **290** is shut off as is the cooling motor; and the grinding head assembly is returned to its start position by the actuation of cylinder **382.** This operational sequence is discussed in greater detail below. Thus, it is seen that the timing cam mechanism **400** together with the switches coupled thereto provide complete and automatic control of the various components shown and described which are mounted in the grinding head assembly **30** and the base member **10.**

In addition to the mechanism previously described, control relays **430** and **440** are mounted on the base **250** as shown in FIG. **13.** The rear shoulder **256** includes a pair of power outlet jacks **445** and **450** which are employed to provide switched power outlets to control an air compressor **465** (FIG. **20**) for the lens grinding apparatus and a coolant pump **470** (FIG. **20**) for the apparatus as described below. A **115** volt AC input power to the control apparatus is provided by means of the power cord **460** shown in FIG. **15.** Suitable electrical and pneumatic connections between the base member **10** and the grinding head assembly **30** is provided by means of a bracket **472** (FIGS. **15** and **16**) having a plurality of pneumatic couplings **475** together with their associated hoses **476** and an electrical terminal board **480** together with various electrical terminals **485** thereon. Mating plugs and jacks **490** and **495** respectively (FIG. **20**) are provided to allow the quick disconnection of the head from the base.

The bracket **472** and terminal board **480** can be positioned as shown in the figure on the top surface of the guide plate **364** at the right end where it does not interfere with the movement of the grinding head assembly. It is noted here that the base platform or frame **250** can be cast to form the various support shoulders or brackets as well as the lens housing and other mounting structure for remaining components. Likewise, the housing **360** can be cast from suitable material such as steel. The frame **250** includes adjustable legs **255** positioned on the four corners to provide leveling of the apparatus on a work table or the like.

Having described the mechanical construction of the lens grinding apparatus embodying the present invention, a description of the operation of the device together with the electrical and pneumatic controls is presented in conjunction with FIG. **20.** It is noted here that the reference numerals assigned the various switches, valves, relays, and other components are identical in FIG. **20** to those assigned in the previous figures.

OPERATION

First, a pattern **70** is selected for a desired eyeglass frame shape and snapped over the pattern holding means **60.** The pattern will indicate the positive or negative correction factor which must be entered into the machine by means of the adjustment **48** (FIG. **1**) to the pattern follower assembly **40.** The graduated scale **45** is aligned with the indicator marks **47** for the desired correction factor.

The position of the roughing wheel which is shown in phantom form in FIG. **13** is next adjusted in relation to the position of the lens blank held by the jaws **272, 282.** Knob **156** shown in FIGS. **7** and **8** and which is on the right underside of the lens grinding head is used for this adjustment and indexes the position of the rough grinding wheel relative to the lens blank. Normally, this adjustment need only be made after the roughing wheel has become worn and it is desired to move the head assembly over slightly to compensate for this wear. The lens bevel indexing is then programmed into the machine by the adjustment screw **54** on the right side of the housing **36** over the grinding wheels. The indicator arm **208** on the top of the housing **36** will indicate the indexed position of the edge of the lens blank with respect to the notch bevel in the guide **212** adjacent the indicator. Thus, by adjusting knob **54,** any desired bevel position on the lens can be preset such that the grinding head assembly will automatically shift to the desired position after the roughing cycles of operation to fine grind the edge of the lens and simultaneously bevel the lens at the desired position.

The air compressor **465** which is shown in FIG. **20** in block diagram form, and which is used to supply pneumatic pressure for the various cylinders in the apparatus can be operated by plugging the electrical supply line for the compressor into the switched plug **445** at the rear of the lens grinding apparatus. Likewise, a coolant pump and fluid supply **470** can similarly be

powered by connecting the coolant pump to the switched output jack **450** at the rear of the lens grinding apparatus.

Once the initial adjustments for the roughing position and the lens bevel position have been preset as well as the pattern correction factor, the power on-off switch **25** (FIGS. **1** and **20**) is switched to the "on" position which actuates the continuously running grinding motor **32** as well as the air compressor. As the air pressure builds up once the air compressor is actuated, the head lift cylinder **322** will move in the direction indicated by arrow E in FIG. **17** to raise the head assembly **30.**

Next, the lens blank **410** is clamped within the jaws by operating the pneumatic valve **27** on the front panel **28** of the apparatus. When this valve is actuated, the pneumatic cylinder **310** is supplied air pressure to cause the shaft **284** to clamp the lens blank into position. The cylinder **310** remains actuated until valve **27** is again switched to the "open" position at the end of the lens grinding operations. With the adjustments set and the lens in place, the only remaining operator step is to momentarily depress the start switch **29.** Actuating switch **29** initiates a sequence of operations which automatically effect the rough and fine grinding of the lens to shape the lens blank in conformity with the desired pattern.

Depressing the start button **25** actuates the relays **430** and **440** by applying power from input terminals **482** and **484** through coils **432** and **442** respectively. Relay **430** has a pair of contacts **434** which close to apply power to the lens motor via switches **197, 390** and **424.** Relay **440** has a pair of contacts **444** and **446** which close to apply power to the cycle switch **426** and to a solenoid valve **460** which applies pressurized air to the head moving cylinder **322** to cause it to move rearwardly (in the opposite direction of arrow E in FIG. **16**). At this occurs, the follower plate **160** mounted to the frame of the head assembly follows the roller cam **322** on the slide plate **326** such that the head is lowered gradually with the roughing wheel being positioned above the edge of the lens blank. As the slide plate **326** of the head lowering mechanism **320** moves rearwardly, the coolant microswitch **475** which is positioned on bracket **476** rearward of cylinder **322** as shown in FIG. **15** is actuated to actuate the coolant pump **470** which supplies a lubricating coolant to the lens blank via nozzle **280.**

The depth microswitch **197** which is in series with the lens motor **290** circuit is normally in an open position. Thus, as the grinding head assembly is lowered and contacts the lens blank, the blank will be stationary until the rough grinding head lowers (by grinding away lens material) until the cam pin **41** on the follower shoe assembly has contacted the camming surface **192** (FIG. **6**) of the sensor such that the plate **182** will pivot to cause the microswitch **197** to close. As this occurs, the lens motor **290** is actuated and rotates the lens holding means bringing new lens material under the rough grinding wheel and lifting the head such that the microswitch **197** again opens.

It is noted here that the grinding pressure is due to the weight of the grinding head which can be adjusted by placing annular shaped weights over post **52** (FIG. **1**). By use of depth switch **197,** the rotation of the lens blank is controlled by demand in a pulsating manner to grind the edge of the material on the lens blank. The follower shoe which rides on the pattern **70** will raise and lower the entire grinding head assembly by means of its connection with shaft **108** such that the grinding head can only be lowered to a predetermined desired position relative to the center of the lens grinding shaft **274.** This assures that a desired lens configuration will be obtained. Since the braking means is not actuated, the follower pin **104** is free to rotate on sleeve **92** thereby allowing the grinding head to track the pattern and lens blank during roughing.

The rotation of the lens blank within the lens holding means also rotates the cam assembly **400** which controls the cam transfer valve **422,** the roughing microswitch **424,** and the cycle microswitch **426.** The cams are shaped to provide approximately two and one-half revolutions of the lens blank before the cams **412** and **414** actuate valve and microswitch **422** and **424** respectively.

The roughing microswitch **424** closes to actuate the brake solenoid **126** which, as described above, causes the downwardly depending pin **104** to be rigidly positioned with respect to the grinding head assembly to permit the transfer and raising and lowering of the grinding head assembly during the transfer from rough to fine operation. It is recalled that during the roughing cycle of operation, the pin **104** and the sleeve **90** to which the pin is rigidly positioned are freely rotatable within the bushings **88** (FIG. **4**). Moving of the roughing switch **424** disconnects the lens drive motor **290** and, at the same time, it actuates the brake solenoid **126.** Cam **412** at approximately the same time actuates the cam transfer valve **422** mounted adjacent thereto at approximately the same time to actuate the transfer cylinder **382** as well as the spring-loaded plate cylinder **185.** Since these cylinders are pneumatically operated, and the brake is electrically actuated; the brake will be fixed to lock the following pin **104** with respect to the head assembly before the transfer valve **382** begins moving the housing **360** and the head assembly therewith transversely from the rough to the fine grinding position. The plate cylinder **185** causes the plate **182** of the sensing means **180** to move such that the cam pin **41** will no longer contact the raised camming surface **192** but rather will contact the top surface **181** of the plate **182.** This allows the fine grinding wheel to penetrate a slightly greater depth (approximately 2 mm) into the lens shape for the fine grinding operation. Cam surface **190** can be adjusted by means of the screw **191** as well as the cam **194** which contacts the follower on the depth microswitch **197** to assure that the finding grinding wheel removes the desired amount of lens material from the edge of the lens after the rough grinding to accomplish the desired bevel and finishing surface.

As the transfer cylinder **382** is actuated, it slowly begins moving from left to right to shift the fine grinding wheel **170** into position over the lens. As this occurs, it is recalled that cam follower **375** on the housing **360** causes the housing **360** and therefore the head assembly via its connection with follower pin **104,** to move slightly thereby raising the head sufficiently to insure that the fine grinding wheel will clear the lens as the transfer takes place. As the housing **360** moves toward the cylinder, the pin **104** which rides in the notch **363** of the housing **360** (FIG. **17**) has sufficient weight against the edge of the notch to allow the head to freely slide over the axle **23** by means of the bearings **84** until

the shoe **220** of the edge follower assembly contacts the edge of the lens blank. This prevents further motion of the head assembly which then causes the pin **104** to slide away from the notch **363** as cylinder **382** continues moving the housing **360** toward the right.

Since the end **365** of the L-shaped bracket **362** is tapered, the continuously rotating grinding head is gradually lowered onto the lens. At approximately the same time, the surface **378** of housing **360** contacts the transfer microswitch **390** which changes its position to provide a current path which actuates the lens motor **290** which then allows the rotation of the lens blank when the depth microswitch **197** is closed thereby providing the same pulsating grinding of the lens during the fine grinding cycle of operation as was provided in the rough grinding operation with the exception of the additional 2 mm guiding depth provided by the shifting plate **182.**

The fine grinding cycle provides approximately three and one-half revolutions of the lens under the fine grinding wheel indexed with respect to the notch **172** in the fine grinding wheel in accordance with the preset and indexed position of the lens edge following apparatus. After the sixth complete revolution of the lens, cam **416** actuates the cycle switch **426** and cams **414** and **412** return the rough switch **424** and cam transfer valve **422** to their original position. Relay **400** is deactivated thereby removing power from the head lifting solenoid valve **460** to move plate **326** forwardly thereby raising the grinding head assembly. As plate **326** clears the switch **475,** the coolant supply cuts off. The actuation of cam transfer valve **422** moves the L-shaped bracket **362** to the left or roughing position such that it once again engages the follower pin **104.** Likewise, the slide **182** of the depth sensing and control means **180** returns to the roughing position by means of its spring return cylinder **185.** As the rough switch **424** is actuated, the brake mechanism also releases the pin **104** from its previously locked position in relation to the head grinding assembly. Thus, after the fine grinding cycle has been completed, the head raises and moves to its roughing position and the controls are reset to initiate a new cycle. The completed lens is then removed from the apparatus by switching valve **27** to its "open" position to cause the clamp cylinder **310** to move shaft **284** outwardly thereby releasing the lens.

It is seen therefore, that by incorporating the apparatus of the present invention, a completely automatic lens grinding machine is provided which indexes the rough grinding wheel for the roughing operation and automatically transfers the grinding head assembly to position the fine grinding wheel in an indexed position for providing a variety of presettable bevels for the lens being ground. Once the roughing and fine grinding cycles have been completed, the lens grinding apparatus returns to a starting position such that a new cycle of operation can be initiated on a different lens blank. It is apparent that various modifications to the present invention can be made by those skilled in the art without departing from the spirit or scope of the invention as defined in the appended claims.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows.

1. A lens grinding apparatus for holding a lens and performing rough and fine grinding operations thereto comprising:

a base assembly including rotatable lens holding means;

a grinding head assembly including rough and fine grinding wheels thereon, said grinding head assembly movably mounted to said base assembly for alternately positioning one of said grinding wheels in contact with a lens positioned in said holding means; and

means for moving said head assembly relative to said base to position one or the other of said grinding wheels into contact with a lens by sequentially raising, shifting, and lowering said grinding wheels relative to said lens holding means and in presettable registration therewith.

2. The apparatus as defined in claim **1** and further including means for controlling the grinding depth of said grinding wheels in accordance with a preselected pattern comprising:

means for rotating a pattern in predetermined relationship with the rotation of said lens;

sensing means coupled to said pattern and to said grinding head assembly for detecting the relative position of said grinding head assembly with respect to said lens for a given rotational position of said lens and said pattern; and

control means for rotating said lens and said pattern when said sensing means detects that said grinding wheel has removed material from said lens to a depth corresponding to said pattern.

3. The apparatus as defined in claim **2** wherein said moving means includes a follower member pivotally mounted to said grinding head assembly and releasably clamped thereto and extending toward said base assembly; and transport means movably positioned on said base assembly and including receiving means for releasably holding said follower member such that when said follower is clamped to said grinding head assembly and said transport means is actuated, said transport means moves to carry said follower and said grinding head assembly from a rough grinding to a fine grinding position whereupon said follower is released from said receiving means to lower said grinding head assembly for fine grinding.

4. The apparatus as defined in claim **3** wherein said transport means includes camming means for moving said follower in a direction to raise said grinding head assembly as said transport means begins to move and wherein said receiving means comprises a member having a tapered open-ended notch to allow said grinding head assembly to gradually lower when said transport means approaches a fine grinding position.

5. The apparatus as defined in claim **4** and further including an edge follower adjustably positioned on said grinding head assembly for contacting an edge of a lens as said grinding head assembly is transferred to the fine grinding position to prevent further transfer of said grinding head assembly thereby indexing the position of said fine grinding wheel relative to said lens.

6. A method of shaping lenses rotatably held in position by grinding the lens edge with a shiftable grinding head assembly having rough and fine grinding wheels, comprising the steps of:

indexing a rotating rough grinding wheel relative to a lens;

rotating the lens while controllably positioning the grinding wheel to contact an edge of the lens to follow a desired pattern;

moving the rough grinding wheel away from the lens after a predetermined rotation of the lens;

shifting the grinding head assembly to index a fine grinding wheel relative to the lens;

rotating the lens while controllably positioning the fine grinding wheel to contact an edge of the lens according to the desired pattern to remove an additional differential amount of lens material from the periphery of the lens; and

moving the grinding head assembly away from the lens after a predetermined rotation of the lens and shifting the grinding head assembly to the rough grinding position.

7. The method as defined in claim **6** and including the steps of:

sensing the position of the rough grinding wheel in contact with the lens;

comparing the position of the rough grinding wheel with the pattern; and

rotating the lens pattern when the relative positions reach a first predetermined relationship.

8. The method as defined in claim **7** including the steps of: sensing the position of the fine grinding wheel in contact with the lens;

comparing the position of the fine grinding wheel with the pattern; and

rotating the lens and pattern when the relative positions reach a second predetermined relationship.

9. A lens grinding apparatus comprising:

a base assembly including lens holding means for rotatably holding a lens;

a grinding head assembly including rough and fine grinding wheels rotatably mounted thereto;

means for mounting said head assembly to said base assembly in transversely movable and pivotable relation to said base;

means for adjustably positioning said head assembly relative to a lens in said lens holding means for indexing each of said rough and said fine grinding wheels to a lens;

transport means coupled between said base assembly and said head assembly for moving said head assembly between a predetermined rough grinding position and a pre-determined fine grinding position; and

control means for actuating said transport means.

10. The apparatus as defined in claim **9** wherein said grinding head assembly includes a follower member extending toward said base assembly and slidably and pivotally positioned on said grinding head assembly and wherein said transport means includes a member slidably positioned on said base assembly and including means for receiving said follower member in releasable engagement therewith.

11. The apparatus as defined in claim **10** and including means for moving said receiving means in a direction to push against said follower member of said grinding head assembly to tend to pivot said follower member in relation to said grinding head assembly.

12. The apparatus as defined in claim **11** wherein said grinding head assembly includes braking means for selectively fixing the pivotal position of said following member with respect to said grinding head assembly such that when said receiving means pushes against said follower member, said grinding head assembly pivots with respect to said base assembly.

13. The apparatus as defined in claim **12** wherein said means for indexing said fine grinding wheel comprises an edge follower adjustably positioned on said grinding head assembly and including a follower shoe extending in spaced relationship from the fine grinding wheel to contact an edge of a lens in said lens holding means thereby limiting the transverse motion of said grinding head assembly when said grinding head assembly moves from roughing to fine grinding positions to position the fine grinding wheel in predetermined relationship to the lens.

14. The apparatus as defined in claim **13** wherein said means for indexing said rough grinding wheel includes means for adjustably fixing the slidable position of said follower member with respect to said grinding head assembly.

15. The apparatus as defined in claim **14** wherein said follower shoe is adjustable in a linearly movable path toward and away from said fine grinding wheel.

16. The apparatus as defined in claim **15** wherein said control means includes timing cam means movable with said lens rotation and having control elements actuated by camming surfaces thereon.

17. An apparatus for grinding the edge of a lens to conform to a predetermined pattern comprising:

a base assembly including means for rotatably holding a lens;

a grinding head assembly including rough and fine grinding wheels positioned on a rotatable shaft, said assembly movably positioned with respect to said base assembly;

a follower member extending from said grinding head assembly toward said base assembly and releaseably clamped to said grinding head;

transport means movably positioned on said base assembly and including means for releaseably receiving said follower member of said grinding head; and

control means for selectively rotating said lens holding means and actuating said transport means for alternately positioning the rough and fine grinding wheels over a lens to grind the lens.

18. The apparatus as defined in claim **17** wherein said grinding head apparatus is pivotally and slidably mounted to said base assembly to be movable toward and away from a lens held by said lens holding means.

19. The apparatus as defined in claim **18** wherein said follower member is pivotally mounted to said grinding head assembly and slidably adjustable therewith, and wherein said grinding head assembly includes braking means for fixing the pivotal position of said follower member with respect to said grinding head assembly.

20. The apparatus as defined in claim **19** wherein said transport means is a housing slidably positioned between guide means to move transversely between rough and fine grinding positions at opposite limits of travel, and wherein said guide means includes camming means for moving said housing in a direction generally orthogonal to its sliding movement as it travels from the rough grinding position.

21. The apparatus as defined in claim **20** wherein said receiving means comprises an open-ended notched member extending from said housing and having a surface against which said follower member is seated, said surface being tapered away from said follower at the open end of said notch.

22. The apparatus as defined in claim 21 wherein said apparatus includes stop means positioned on said grinding head assembly and adapted to contact a lens in said lens holder for limiting the transverse motion of said grinding head assembly toward said lens and said control means actuates said braking means and drive means for moving said housing to cause said grinding head assembly to raise, move transversely toward the lens, and lower as the follower slides along said seating surface of said receiving means when said stop means contacts said lens.

23. A transport assembly for use in shifting the position of a head assembly slidably and pivotally mounted to a base member between first and second predetermined positions comprising:

a base member including means for holding an article;

a head assembly including means for performing a machining operation on the article held by said base, said assembly transversely slidably, and pivotally mounted to said base member and including transport engaging means extending therefrom;

a transport assembly positioned on said base assembly and including a housing with a receiving member adapted to releasably hold said transport engaging means of said head assembly;

bias means holding said transport engaging means in contact with said receiving member when said head is in a first position;

guide means for loosely supporting said housing in slidable engagement relative to said base member;

means for sliding said housing along said guide means;

camming means positioned on said base member for moving said housing in a direction to raise said head assembly as said housing assembly moves from an end position corresponding to said first position of said head assembly; and

stop means positioned on said head assembly to limit the travel of said head assembly thereby forcing said transport engaging means from said receiving member in a manner to lower said head assembly.

24. The apparatus as defined in claim 23 wherein said receiving member is an L-shaped member having a seating surface against which said transport engaging means is positioned, said seating surface being tapered away from said transport engaging means at the open end of said member to gradually lower said head assembly as said transport engaging means slides out of said L-shaped member to said second position.

25. A lens edge grinding apparatus for shaping a lens blank in accordance with a preselected lens pattern comprising:

a base member including means for holding and rotating a lens blank and a lens pattern;

a grinding head assembly movably positioned with respect to said base member and including rough and fine grinding wheels rotatably mounted thereto;

means for shifting the position of said grinding head assembly to alternately position said rough and fine grinding wheels over said lens blank;

a movable follower assembly coupled to said grinding head assembly and having a follower shoe contacting said pattern, said follower assembly including a cam extending therefrom;

sensing means positioned on said grinding head assembly and movable between first and second positions, said sensing means including first and second cam surfaces adapted to alternately contact said cam of said follower assembly when said sensing means is in said first or second positions respectively;

control means coupled to said sensing means to be selectively actuated by movement of said sensing means for selectively actuating said lens rotating means when the lens blank has been ground by one of said grinding wheels to a predetermined dimension at a peripheral point on the edge of the lens; and

additional control means for shifting the grinding head assembly to position the other grinding wheel over the lens blank and to shift the position of the sensing means such that the cam contacts the other of the cam surfaces to actuate said control means to actuate said lens rotating means to remove a different amount of lens material from the lens blank.

26. The apparatus as defined in claim 25 wherein said sensing means comprises a plate having an adjustable surface at one end forming said first cam surface and a fixed surface at the same end spaced from said first cam surface, said fixed surface forming said second cam surface, said plate pivotally mounted to said grinding head assembly with said one end extending into contact with said cam of said follower assembly and an opposite end contacting said sensing means.

27. The apparatus as defined in claim 26 wherein said plate is positioned on a movable shaft of an actuatable cylinder to permit said plate to pivot about the longitudinal axis of said shaft and shift to position a different one of said first or second cam surfaces in contact with said cam when said cylinder is actuated.

28. A lens grinding apparatus comprising:

means for rotatably holding a lens, said holding means including a base assembly having lens holding jaws coupled to a rotatable shaft;

means for slidably and pivotally supporting a pair of grinding wheels in relationship to said holding means, said supporting means including a grinding head assembly including bearing means for supporting said assembly on said base in pivotable and slidable relation therewith;

transport means including means for releaseably engaging said support means for moving said support means relative to said holding means wherein said grinding head assembly of said supporting means further includes a follower member adapted to extend into releaseable contact with said transport means; and

means for disengaging said support means from said transport means when a grinding wheel is positioned in a predetermined relationship to a lens in said holding means.

29. The apparatus as defined in claim 28 wherein said transport means is slidably positioned on said base, and wherein said releaseable engaging means is adapted to receive said follower means extending from said grinding head assembly.

30. The apparatus as defined in claim 29 wherein said releaseable engaging means comprises a notched mem-

ber having an open end for allowing said follower to disengage from said notched member at said open end.

31. The apparatus as defined in claim **30** wherein said disengaging means comprises a stop for limiting the motion of said grinding head assembly thereby forcing said follower out of said notched member when said grinding head assembly has reached a predetermined position relative to a lens within said holding means.

32. For use in a lens grinding apparatus including a grinding head which has a follower member pivotally attached to the head and extending into releaseable contact with receiving means on a transversely movable transport means positioned on a lens holding base, a method of transferring the grinding head between two lens grinding positions comprising the steps of:

locking the follower member in a fixed position relative to said grinding head;

moving the transport means from a first position to transversely move the grinding head while simultaneously raising the grinding head by forcing the follower pin in a direction lateral to the transverse movement of the transport means; and

limiting the motion of the grinding head to slide the follower member from the receiving means in a manner which allows the grinding head to lower.

33. The method as defined in claim **32** and including the additional steps of:

returning the transport means to the first position;

raising the grinding head such that the follower member seats in said receiving means; and

unlocking said follower member to permit said member to rotate relative to said grinding head.

34. In a lens grinding apparatus having a grinding head assembly pivotally and slidably positioned on a lens holding base assembly, means for transferring the grinding head assembly to alternately position one of two grinding wheels thereon in alignment with a lens, said means comprising:

a transport movably positioned on said base assembly and including receiving means thereon;

a sleeve pivotally positioned on said grinding head assembly and including a follower pin extending into releaseable contact with said receiving means;

means for actuating said transport means to transversely move said transport and simultaneously shift said grinding head assembly transversely from a first position;

cam means coupled to said transport means for forcing said follower pin in a direction which tends to raise said grinding head assembly as said transport means moves from said first position;

braking means for locking the pivotal position of said sleeve relative to said grinding head assembly, and

control means for actuating said braking means such that said cam means raises said grinding head assembly as said transport means shifts said grinding head assembly.

35. The apparatus as defined in claim **34** wherein said braking means comprises a shoe assembly rigidly positioned on said grinding head assembly and including a brake shoe movable into contact with said sleeve to fix the relative position of said sleeve and said grinding head assembly when said control means actuates said braking means.

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