March 9, 1954 P. A. GROBEY 2,671,293

INTERNAL GRINDING MACHINE

Filed Aug. 23, 1949 6 Sheets-Sheet 1

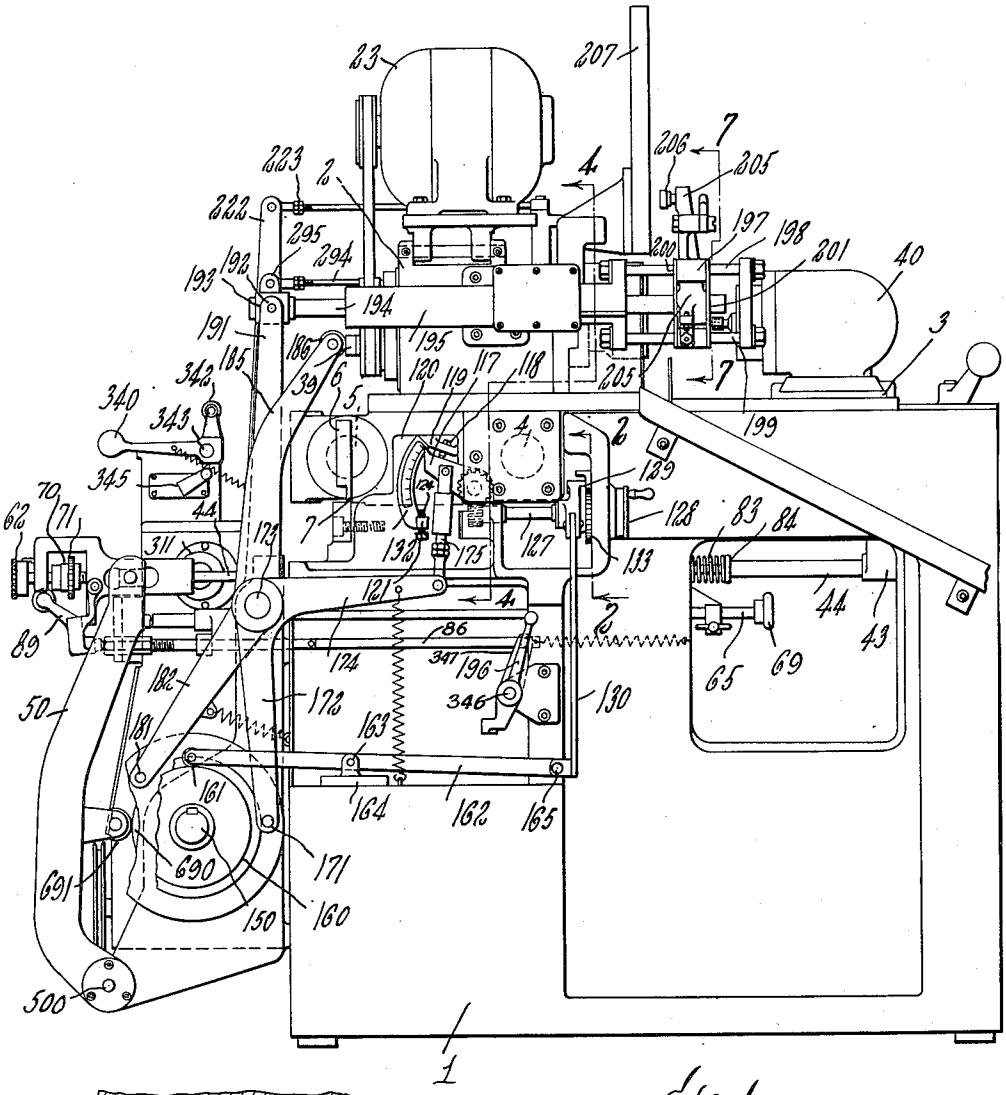


Fig. 1.

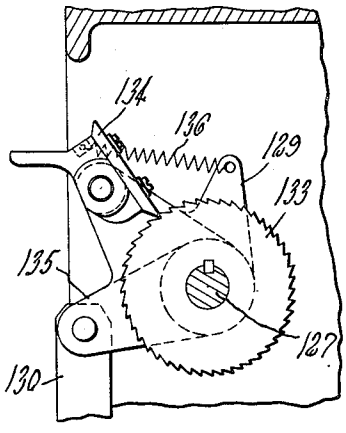


Fig. 2.

Inventor
Paul A. Grobey
by Wright Brown Quinby & May
Attys.

March 9, 1954 P. A. GROBEY 2,671,293

INTERNAL GRINDING MACHINE

Filed Aug. 23, 1949 6 Sheets-Sheet 2

Fig. 3.

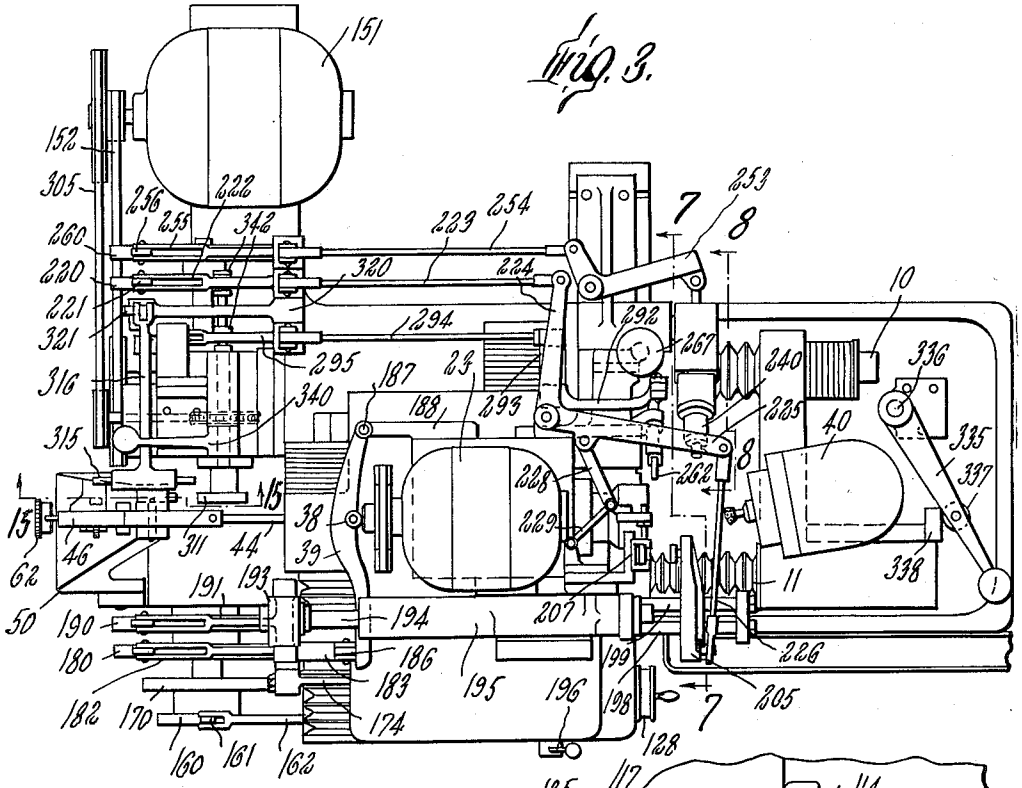


Fig. 4.

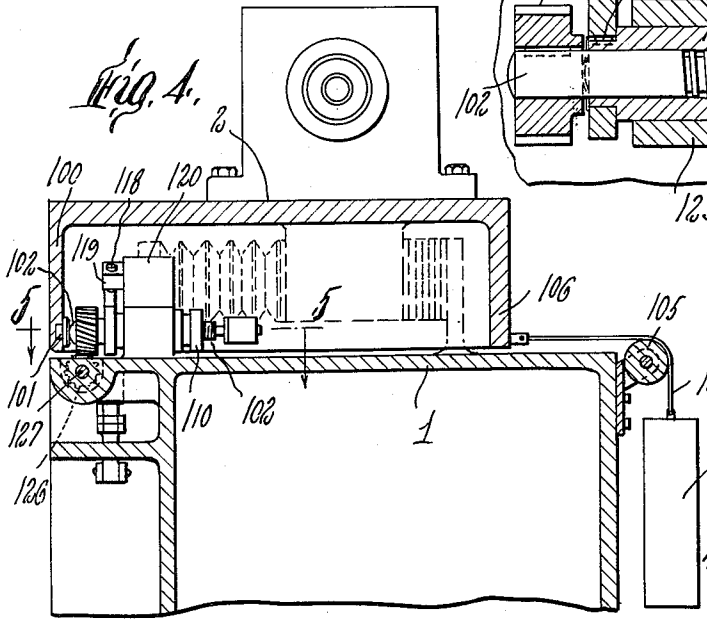
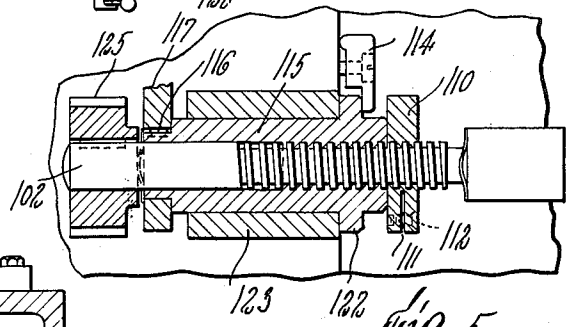


Fig. 5.



Inventor
Paul A. Grobey
by
Wright Brown Quinby & Clay
Attys.

March 9, 1954 P. A. GROBEY 2,671,293

INTERNAL GRINDING MACHINE

Filed Aug. 23, 1949 6 Sheets-Sheet 3

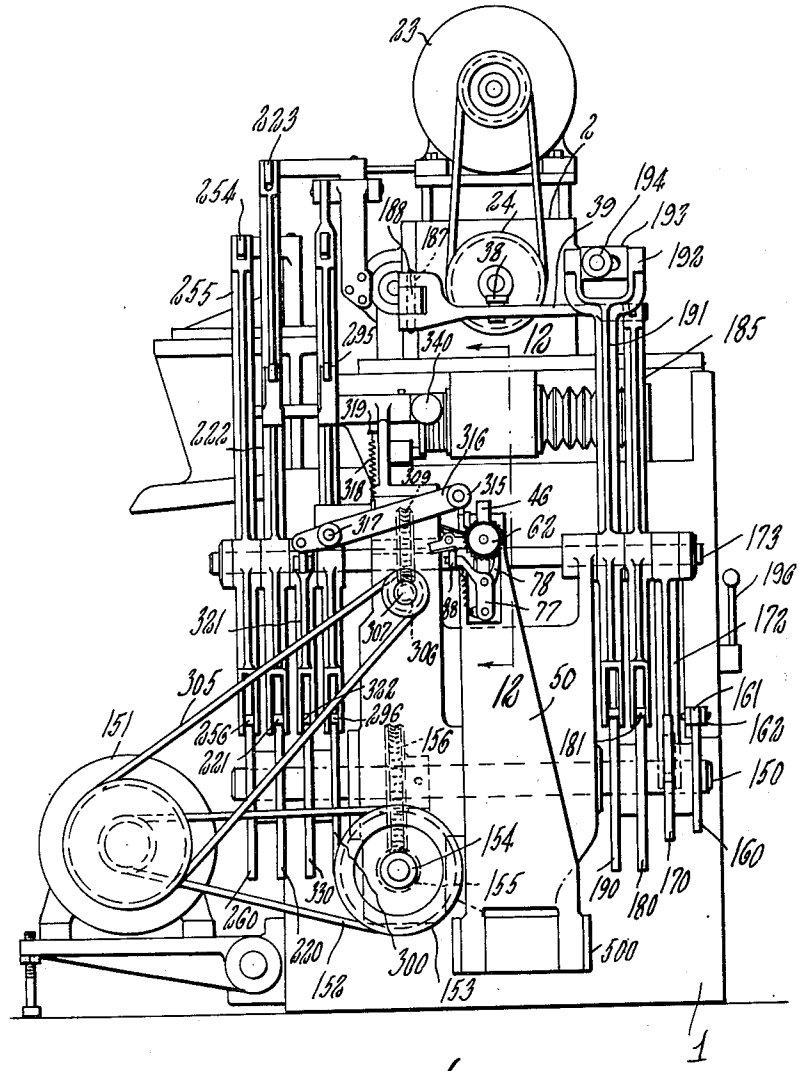


Fig. 6.

Inventor
Paul A. Grobey
by Wright Brown Quinby & Clay
Attys.

March 9, 1954 P. A. GROBEY 2,671,293

INTERNAL GRINDING MACHINE

Filed Aug. 23, 1949 6 Sheets-Sheet 4

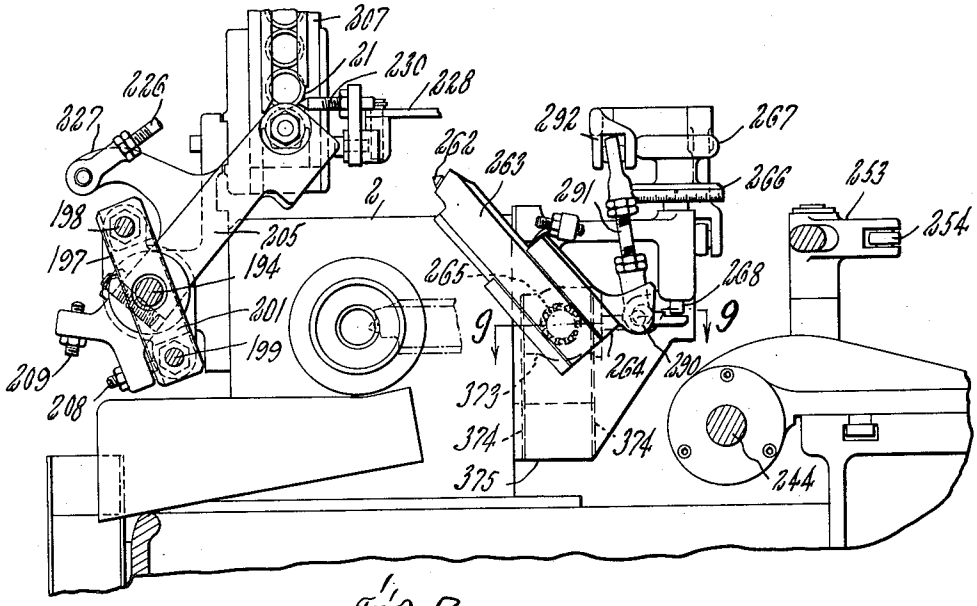


Fig. 7.

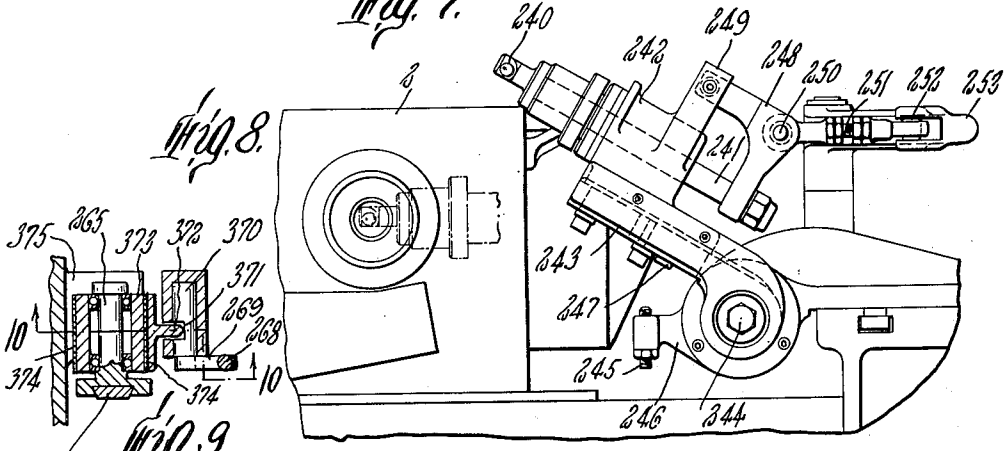


Fig. 8.

Fig. 9.

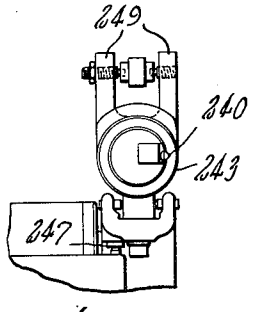


Fig. 11.

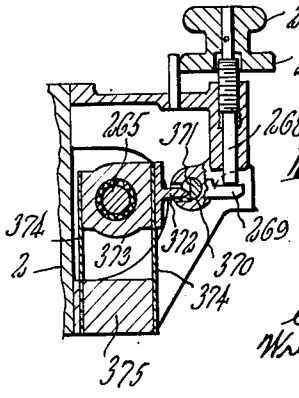


Fig. 10.

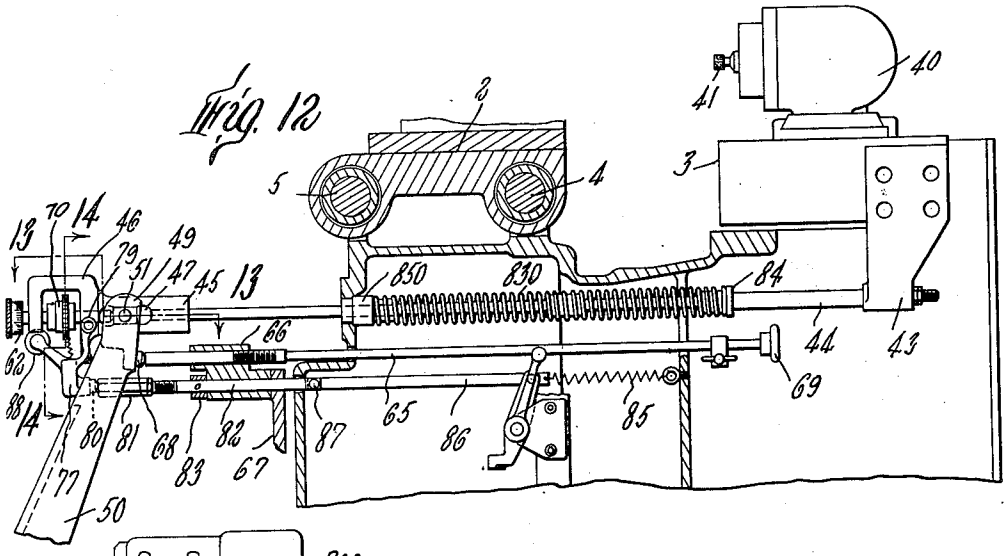
Inventor
Paul A. Grobey
by Wright Brown Quinby & May
Attys.

March 9, 1954 P. A. GROBEY 2,671,293

INTERNAL GRINDING MACHINE

Filed Aug. 23, 1949 6 Sheets-Sheet 5

Fig. 12



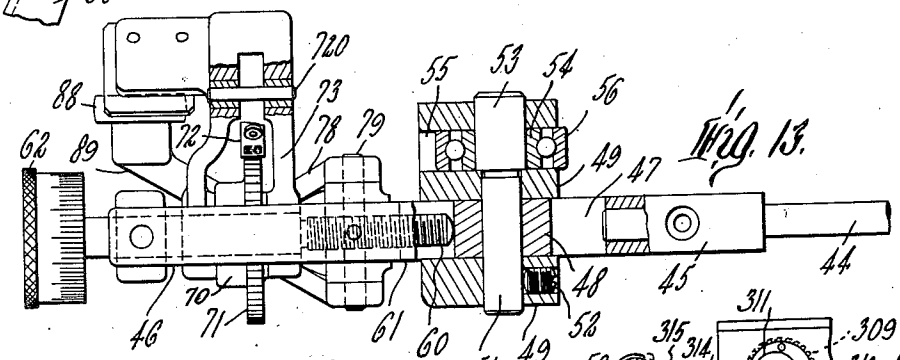


Fig. 13.

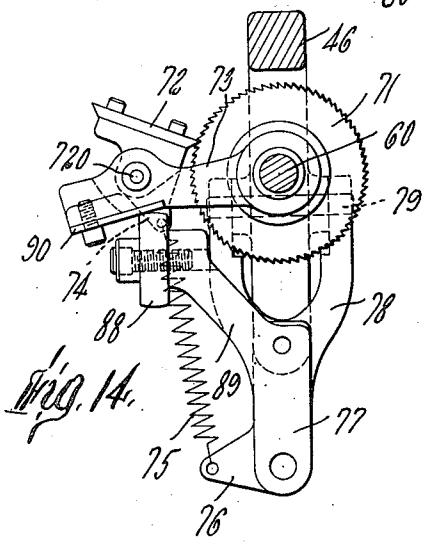


Fig. 14.

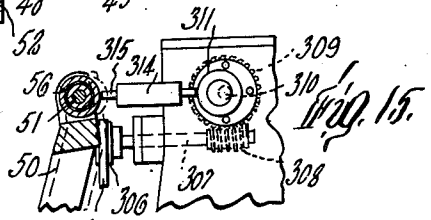


Fig. 15.

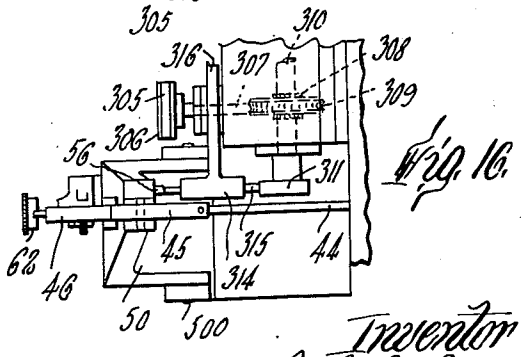


Fig. 16.

Inventor
Paul A. Grobey
By Wright Brown Quinby & Otis
Attys

March 9, 1954 P. A. GROBEY 2,671,293

INTERNAL GRINDING MACHINE

Filed Aug. 23, 1949 6 Sheets-Sheet 6

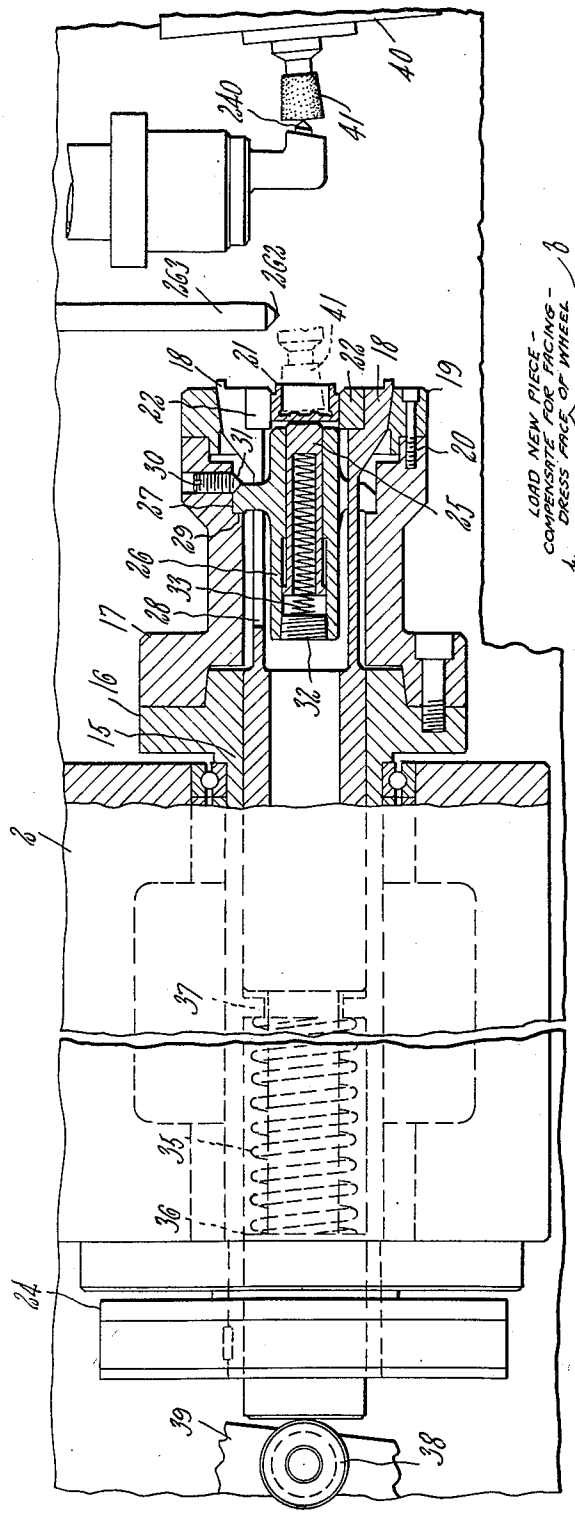


Fig. 17.

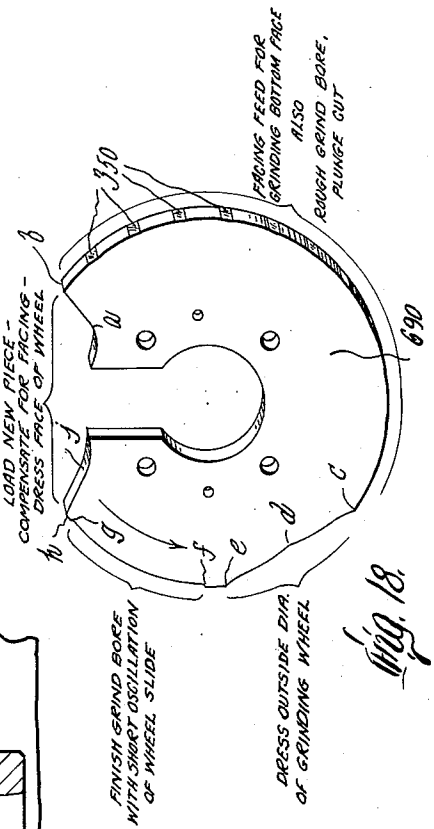


Fig. 18.

Inventor
Paul A. Grobey
by
Wright Brown Quinby & Clay
Attys.

Patented Mar. 9, 1954

2,671,293

UNITED STATES PATENT OFFICE

2,671,293

INTERNAL GRINDING MACHINE

Paul A. Grobey, Springfield, Vt., assignor to Bryant Chucking Grinder Company, Springfield, Vt., a corporation of Vermont

Application August 23, 1949, Serial No. 111,779

13 Claims. (Cl. 51—50)

1

This invention relates to internal grinding machines and has for one object to provide a machine having an automatic cycle of operations, the automatic cycle being controlled mechanically by cams, thus eliminating the complications incident to hydraulic and electrical controls and presenting a machine which can be serviced by mechanically trained men without requiring special knowledge of hydraulic or electrical equipment.

A further object of the invention is to provide a machine particularly suitable for grinding the interior side face and the base of a cup-like member, the base being ground by a grinding wheel mounted for plunge cutting and the interior side wall being ground by the same wheel while it is being given a rapid traverse motion.

Other objects and advantages will appear from a description of an embodiment of the invention shown in the accompanying drawings in which

Figure 1 is a front elevation of the machine.

Figures 2 and 4 are detail sectional views on lines 2—2 and 4—4, respectively, of Figure 1.

Figure 3 is a top plan view of the machine.

Figure 5 is a detail sectional view on line 5—5 of Figure 4.

Figure 6 is a left end elevation of the machine.

Figure 7 is a detail sectional view on line 7—7 of Figures 1 and 3.

Figure 8 is a detail sectional view on line 8—8 of Figure 3.

Figure 9 is a detail sectional view on line 9—9 of Figure 7.

Figure 10 is a detail sectional view on line 10—10 of Figure 9.

Figure 11 is a fragmentary end elevation showing the facing diamond holder.

Figure 12 is a detail sectional view on line 12—12 of Figure 6.

Figures 13 and 14 are detail sectional views to a larger scale on lines 13—13 and 14—14, respectively, of Figure 12.

Figure 15 is a detail sectional view on line 15—15 of Figure 3, but showing the wheel slide in advance position and the rapid traversing mechanism in operative condition.

Figure 16 is a fragmentary top plan view of the parts shown in Figure 15.

Figure 17 is a fragmentary view partly in top plan and partly broken away and in section through the work spindle and to a larger scale than Figure 3.

Figure 18 is a perspective view of one of the controlling cams and showing by legends the angular positions of the cam corresponding to

2

various portions of a suggested cycle of operation.

Referring first to Figures 1, 3 and 6, the machine comprises a base 1 on which is mounted for linear motion a work head 2 and a wheel head 3. The work head 2, as shown, is mounted for sliding motion on a pair of spaced bars 4 and 5, the bar 4 being rigidly supported on the base 1 and the bar 5 being carried by a pair of vertical supports 6 mounted for yielding motion toward and from the bar 4 as at their weakened portions 7. Preferably one of these bars 4 or 5 is provided with spaced sets of balls and the other provided with a single set of balls for supporting the work carrier 2. However, this particular mounting of the carrier is not per se part of the present invention, forming subject matter of Arms et al., United States Letters Patent No. 2,631,067 granted March 10, 1953, for Carriage Mounting.

The wheel head is similarly mounted but for motion at right angles to the line of motion of the work head on a pair of bars 10 and 11 and in a manner similar to mounting of the work head. This mounting provides for relative motion between the work and wheel heads in directions at right angles to each other. The direction of motion of the work head is at right angles to the axis of a rotary work spindle 15 carried thereby and shown best in Figure 17.

This work spindle is provided with a spindle nose 16 at its forward end for the reception of a work-holding chuck 17. As shown in Figure 17, this work-holding chuck is provided with collet jaws 18 cooperating with matingly inclined faces of a ring 19 secured to the chuck body 17 as by screws 20, axial motion of the jaws 18 serving to clamp or release a work piece 21 between jaw elements 22 carried by the jaws 18. A spring pressed work ejector plunger 25 is slidably mounted in a holder 26 having radially extending fingers 27 projecting through slots 28 in the jaw members 18 and engaged in an annular socket 29 in the chuck body by set screws 30, each having a tapered inner end 31 adapted to wedge the fingers 27 back into the annular socket 29. A plug 32 threaded into the rear end of the member 26 provides an abutment for a spring 33 which tends to press the ejector 25 outwardly and throw the work piece out from the chuck as soon as it has been released. The clamping jaws 18 are moved axially in directions to tighten the jaws against the work by a coil spring 35 reacting against a shoulder 36 thereon and an annular shoulder 37 projecting inwardly

from the spindle 16. The rear end of the portion 36 projects from the rear end of the head 2 and is adapted to be engaged at suitable times by a roller 38 on an actuating lever 39, pressure to the right of which as viewed in Figure 17, serving to push the clamping jaws 18 forwardly, releasing the work by the inherent bias of these jaws 18 outwardly. The work spindle 15 is rotated by any suitable means, a motor 23 being shown for the purpose, belt connected to the spindle pulley 24.

The wheel head 3 carries a motor 40 to the armature of which may be secured a grinding wheel 41. This motor 40 with the grinding wheel may be mounted for adjustment angularly on the support 3 so as to bring the wheel axis parallel to the axis of the work spindle, in which case the periphery of the wheel will be cylindrical as shown in Figures 1 and 12, or at an angle to this axis in which case the wheel periphery will be tapered as shown in Figures 3 and 17.

Means are provided for relatively moving the wheel head and the work head between positions at which the wheel is in operative relation to the work and positions wherein the wheel is retracted from the work, and means are provided for advancing the wheel toward the work to effect a plunge cut thereon so that the end face of the grinding wheel arranged transverse to the axis of rotation of the work spindle grinds an end face of the work and to produce a rapid oscillation of the wheel relative to the work while the side face of the wheel is in engagement with the side face of the work. This means as shown is connected to move the wheel head. As shown best in Figures 12 and 13, the wheel head 3 is provided with a downwardly extending bracket 43 to which is attached an end portion of a rod 44. This rod 44 passses beneath the work head mounting and at its opposite end it is pinned into a member 45 provided with a yoke portion 46. The member 45 is provided intermediate its ends with a transverse slot 47 within which rides a block 48 held within the slot by the two portions of the forked extremity 49 of an actuating lever 50. The two prongs of the extremity 49 straddle the member 45 and the block 48 is held therebetween, being journaled on a pin 51 secured in one of the extremities of the fork as by a set screw 52. The pin 51 has an enlarged diameter portion 53 which carries the inner raceway 54 of a ball bearing within a slot 55 of one of the forked extremities 49. The outer raceway 56 of this ball bearing projects outwardly from one side of its supporting fork for a purpose which will later appear. The position of the block 48 longitudinally of the slot 47 may be adjusted by turning a shaft 60 threaded through a nut portion 61 of the member 45 and bearing at its inner end against a side face of the block 48.

This shaft 60 extends through the yoke 46 and outwardly thereof may carry a graduated hand wheel 62 by which it may be turned by measurable angular distances determined by reference to the graduations on the wheel 62. The inner limit of motion of the lever 50, which determines the retracted limit of motion of the grinding wheel, is determined by a stop bar 65 threaded through a block 66 which may engage a fixed wall member 67. The left hand end of the bar 65 may be adapted to be engaged by a stop abutment 68 on the lever 50. By turning the bar 65 as by turning of the hand wheel 69 thereon, the retracted limit of motion of the lever 50 may be adjusted as desired. This lever 50 is fulcrumed to the bed at its lower end at 500 and intermediate its ends it carries a cam follower roll 691 bearing against an edge cam 690 on the shaft 150. The cam 690 which controls the motion of the wheel slide may be contoured as shown in Figure 18, and the various portions of a possible machine cycle, using this cam, are indicated by legends as the corresponding angular portions of this cam come into action. Since the end face of the grinding wheel is employed to grind an inner end face of the work piece, the position of this end face of the grinding wheel is important and as this face must be trued from time to time, provision is made by which this end face after truing is in a predetermined position when in retracted position and because of the uniform plunge stroke imparted thereto, the advance limit of motion of this grinding wheel face is also accurately determined.

To provide for wear and truing of the end face of this grinding wheel, means are provided for automatically adjusting the position of the block 48 prior to a truing operation. To this end the shaft 60 is provided between its ends with a hub member 70 having a ratchet wheel portion 71. This ratchet wheel portion is adapted to be engaged by a ratchet dog 72 pivoted at 720 on a forked arm 73 rockably mounted on the shaft 60. The dog 72 has a tail portion 74 connected through a spring 75 with a bracket portion 76 on an arm 77 integral with a forked member 78 which is pivoted on a pivot shaft 79 to the member 45. The arm 77 has an abutment 80 in position to strike against the adjustable abutment sleeve 81 threaded onto a rod 82 which passes through the block 66 and is held to its right hand position as far as permitted by a collar 83 pinned thereto and abutting against the block 66 by a spring 85 secured to a rod 86, which is pivoted at 87 to the rod 82. This spring is anchored at its opposite end to the machine bed and tends to hold the collar 83 in the position shown in Figure 12. The wheel head is yieldingly pressed toward its retracted position by a coil spring 830 which surrounds the rod 44 and reacts between a collar 84 secured to this rod and a fixed collar 850.

Whenever the lever 50 is swung to the right, as viewed in Figures 1, 12 and 13, by the action of the spring 830 the abutment 80 is brought into contact with the abutment sleeve 81, and the forked member 78 is rocked in a clockwise direction, bringing a follower roll 88 carried by an arm 89 thereof into contact with an extension 90 from the fork 73, rocking this fork 73 in a clockwise direction as viewed in Figure 14 and causing the dog 72 to engage and step around the ratchet wheel 71 thus to turn the shaft 60 in a direction to advance slightly the retracted position of the wheel head so that when the wheel end is trued it will take the same position regardless of wheel wear and truing preparatory to a subsequent advance movement toward the work. Reverse direction of rocking of the fork 73 returns the dog 72 without affecting the wheel 71.

The work head is arranged to be moved transverse to the direction of motion of the wheel head previously mentioned, and this transverse motion, which is a feed and retracting motion, is controlled by mechanism shown best in Figures 1, 5 and 6. As shown in Figure 4, the work head 2 has a vertical wall portion 100 provided with a hardened abutment 101 which is pressed against the rounded end of a feed shaft 102 (see also Figure 5) and this is accomplished by means

of a weight 103 connected through a flexible element 104 which passes over a pulley 105 to a wall member 106 of the work head. The feed shaft 102 is threaded for a portion of its length and engaging the threaded portion is a nut 110, and for the purpose of taking up backlash between the mating threads of the nut and threaded portion of the shaft, a portion of this nut is split as at 111 and the split parts are joined by a screw 112, by the tightening of which the split portions may be brought together and take up any lost motion between the mating threads. This nut 110 butts against and acts as a lock nut for an internally threaded sleeve 115 which is provided with a reduced diameter portion 116 keyed into an arm 117 which may be caused to oscillate as will later appear. One limit of such oscillation is provided by a screw 118 threaded into a lug 119 on a bracket 120 extending upwardly from the machine bed 1 and the other limit by a stop screw in the lug 121 as shown best in Figure 1. The sleeve 115 is held against axial motion by a clamp plate 114 which holds a flange 122 on the sleeve against a stationary bearing portion 123.

The feed shaft 102 has keyed thereto a spiral gear 125 with which meshes a spiral gear 126 carried by a shaft 127. This shaft 127, as shown best in Figure 1, has a hand wheel 128 by which it may be turned as desired. It is also arranged for automatic intermittent turning motion by means of a ratchet and pawl feed mechanism 129 shown best in Figure 2 and comprising a ratchet wheel 133 fixed to the shaft 127 and a ratchet dog 134 pivoted to one arm of a bell crank lever 135 fulcrumed on the shaft 127 and yieldingly pressed against the ratchet wheel 133 by a spring 136 connected to an arm 129 of the bell crank lever 135 which is actuated by up and down motion of a link 130.

By raising and lowering of the link 130, the shaft 127 is turned intermittently in one direction which turns the feed screw 102 in a corresponding direction and produces intermittent feed of the work head transverse to the axis of rotation of the work and compensates for wear and truing of the periphery of the grinding wheel. Also by rocking the arm 117, which is connected to the nut 115, the feed shaft 102 may be caused to move axially in one and then in the opposite direction by a small amount, producing a corresponding feed and retraction of the work holder. The amount of this feed and retraction may be indicated by the extent of movement of the arm 117 across a graduated arcuate scale 132, as shown in Figure 1, which extent may be regulated by adjustment of the stop screw in the lug 121.

The various motions of the work head and wheel head are produced by cams fixed to a rotary shaft 150. This shaft is driven from a motor 151 through a belt 152 which engages about a pulley 153 carried by a shaft 154. The shaft 154 carries a worm 155 which meshes with a worm wheel 156 fixed to the cam shaft 150. A cam 160 carried at the right hand end of the shaft 150, as viewed in Figure 6, actuates a follower 161 (Figure 1) on a lever arm 162 fulcrumed at 163 on a bracket 164 carried on the machine bed and this lever 162 is pivoted at 165 to the lower end of the link 130. A cam 170 adjacent to the cam 160 and also carried by the shaft 150 cooperates with a follower roll 171 on a bell crank lever 172 fulcrumed on the fulcrum shaft 173, the other arm 174 of this bell crank lever being connected through an adjustable link 175 to the arm 117. This produces an intermittent feed and retraction of the work holder with reference to the wheel. Next to the cam 170 is a cam 180 which acts upon a follower roll 181 on a lever arm 182. This arm is also fulcrumed on the fulcrum shaft 173 and its upper extension 185 carries a roll 186 which engages the free end portion of the lever 39 carrying the follower roll 38 which acts at suitable times in the cycle to open the chuck for the discharge of the finished work piece and the reception of a work piece to be ground. As shown best in Figures 3 and 6, the arm 39 is fulcrumed at 187 to a bracket 188 carried by the work head 2.

Next left to the cam 180 is a cam 190 engaging a follower on the lower end of a lever 191. The upper end of this lever 191 is forked as at 192 where it is pivotally connected to a block 193 having a pin and slot connection to the end of a bar 194 which passes through a guide member 195 mounted on the work head 2. At the forward end of the bar 194 it engages a crosshead 197 which is mounted for sliding motion on a pair of spaced stationary guide bars 198 and 199 (see Figures 1 and 7). Between end plates 200 and 201 of this crosshead the bar 194 has pivoted thereon an arm 205 and at its upper end this arm is provided with a work piece loading plunger 206 formed with a yieldable periphery which may be engaged in the hole of an unground work piece. This loading plunger is actuated by axial motion of the rod 194 and rocking motion produced by means which will later appear, to engage in the lowest cup-shaped work piece 21 arranged in a stack in a magazine 207 of U cross section, the plunger 206 being arranged to engage in such a work piece, remove it from the lower end of the magazine 207 and present it into the chuck into the position shown in Figure 17. The extent of rocking motion is adjustably fixed by the screw stops 208 and 209 which may engage portions of the cross head 197.

The rocking motion of the loading arm 205 is produced by the action of another cam 220, also fixed to the cam shaft 150, and in the left hand group of cams shown in Figure 6. This cam 220 acts on a follower roll 221 at the lower end of a lever 222 also fulcrumed on the shaft 173. The upper end of the lever 222 is connected to the rear end of a link 223, the forward end of which is connected to a bell crank lever 224 (see Figure 3), one arm 225 of which is connected through a link 226 to an extension 227 of the arm 205 (see Figures 3 and 7). The arm 225 of the bell crank lever 224 is also connected through the connecting pivot of a pair of toggle links 228 and 229, to a divider pin carrier having a divider pin 230 which enters into the space between the lowest work piece 21 in the supply magazine and the one just above, and lifts the one just above with those above it sufficiently for the lowest work piece to be removed, after which the divider pin is retracted sufficiently to allow the work pieces above it to descend to bring the lowest work piece into position to be removed on the next actuation of the work feed device.

Since the grinding wheel periphery operates upon the inside face of a work piece, and its end face operates on the base of the hole within the work piece, a truing mechanism for each of these portions of the wheel is provided. The end face truing device, which is shown best in Figures 3 and 8, is mounted in fixed axial relation to the work piece and is swung down and across the

end face of the wheel when this wheel is retracted. This truing device 240 is carried at the end of a bar 241 mounted for axial sliding motion within a casing 242, this casing being secured to an arm 243 pivoted to rock about an axis 244. An adjustable stop screw 245 carried in a fixed arm 246 may be contacted by an abutment 247 on the arm 243 to limit the downward swing of the arm 243 to a position where the dressing diamond 240 is substantially in the horizontal axis of the work piece as shown in dotted lines in Figure 8. The rear end of the bar 241 has fastened therewith one arm of a bracket 248, another arm sliding between forks of a bracket 249 extending from the casing 242. The bar 241 is thereby held against turning about its longitudinal axis.

The bracket 248 is connected at 250 to a link 251 of adjustable length which, in turn, is pivoted as on the pin 252 to one arm of a bell crank lever 253 (see particularly Figure 3). The other arm of this lever 253 is connected by a link 254 with the upper end of a lever arm 255 fulcrumed on the pivot shaft 173 and carrying at its lower end a follower roll 256 bearing on a cam 260 which is the outermost cam in the group of cams at the left hand portion of the cam shaft 150 as viewed in Figure 6. When this lever 255 is rocked to dress, moving the link 254 to the right, as shown in Figure 3, the first action is to depress the casing 242 from the upwardly inclined position shown in full lines in Figure 3 to a substantially horizontal position, bringing the abutment 247 into contact with the adjustable stop 245. Further motion of the lever 255 in the same direction causes the bar 241 to be moved lengthwise within the casing 242, causing the truing device to be passed across the end face of the grinding wheel from its periphery to substantially its axis of rotation. Swinging of the cam lever 255 in the reverse direction causes the bar 241 to be retracted axially and then the bar and the casing 242 to be tilted up out of the way into the full line position of Figure 8.

The truing device or diamond for truing the outside diameter of the grinding wheel is shown at 262. It is mounted on a slide 263 in a holder 264 fulcrumed on a shaft 265 to be swung between the upwardly extended position shown in full lines in Figure 7 and the substantially horizontal dotted line position shown in this figure, where it is in position to be contacted by the periphery of the grinding wheel as it is being moved from its advanced to its full retracted position. Means are provided for adjusting the diamond holder 264, such means comprising a graduated disk 266 provided with a hand wheel 267 secured to a threaded shaft 268. This shaft bears against a flat portion of an arm 269 extending from a rockably mounted shaft 370. This shaft 370 has a cut away portion 371 within which engages a projection 372 from a block 373 carrying the fulcrum shaft 265. This block 373 is supported on a pair of spaced reeds 374 carried by a bracket 375 fixed to the work head 2. As the graduated disk 266 is turned the shaft 370 is turned and the block 373 is correspondingly moved about one-sixth the distance of the screw adjustment toward or from the work axis.

The outside diameter truing device holder is rocked between its two positions and for this purpose the rear end of the holder 264 is pivoted as at 290 to a link 291 of adjustable length, the upper end of which is pivoted to one arm of a bell crank lever 292. The other arm 293 of this bell crank lever is pivotally connected by a link 294 to the upper end of an arm 295, which is fulcrumed on the pivot shaft 173 and which carries at its lower end a follower roll 296 which bears against a cam 300 also secured to the cam shaft 150.

As before noted, means are provided for producing a rapid oscillatory traverse motion of the grinding wheel relative to the work when the periphery of the grinding wheel is acting upon the side wall of the work piece at which time the grinding wheel does not quite reach its end facing position. To this end the motor 151 is connected by a belt 305 to a pulley 306 (see Figure 6). This pulley 306 is carried at the outer end of a shaft 307 (see particularly Figures 13 and 15) provided with a worm 308 at its inner end. This worm meshes with a worm wheel 309 carried by a shaft 310 arranged at right angles to the shaft 307. This shaft 307 carries on its outer end an eccentric cam 311 which may have its peripheral portion formed as the outer raceway of a ball bearing. This portion is in the same plane with the ball bearing raceway 56 of the wheel traversing mechanism shown in Figures 13, 15 and 16 and when it is desired to produce the oscillatory traverse, which is when the grinding wheel is in its advanced position, a spacing bar 315 mounted for axial motion in a sleeve 314 is interposed between the eccentric cam, which is continuously rotated, and the raceway 56. This causes the rotation of the eccentric cam to impart an oscillatory longitudinal motion to the bar 44 and thus an oscillatory traverse to the grinding wheel. The sleeve 314 which carries the spacing bar 315 is mounted on an arm 316. This arm 316 is fulcrumed at 317 (see Figure 6) and is normally held with the bar 315 elevated in inoperative position by a spring 318 secured at its lower end to the arm 316 and at its upper end to a fixed point 319. The opposite end of the arm 316 has bearing thereon the rear end of an arm 320 which is pivoted at its upper end to an arm 321 having a cam follower 322 riding on a cam 330 also carried by the cam shaft 150. This cam 330 is so shaped that at suitable times in the cycle it interposes the bar 315 between the raceway 56 and the eccentric cam 311. Each of the lever arms 172, 182, 191, 222, 255, 295 and 321 fulcrumed on the shaft 173 is pressed with its follower roll toward its actuating cam by individual coil springs attached to the lever arms at one end and to a fixed portion of the bed at the opposite end.

For the purpose of dressing the outside diameter or periphery of a new grinding wheel, it is necessary to move the wheel carrier from its retracted position toward its advanced position by hand and this may be done by swinging to the left, as viewed in Figure 3, a hand lever 335 fulcrumed at 336 on the top of the machine base and having a roll 337 which engages a lug 338 upstanding from the wheel carriage. When this is done, however, it is important that the outside diameter truing diamond 262 be down and that the loader arm be raised out of the way. The latter two functions are accomplished by the operator swinging a hand lever 340 (see Figures 1 and 6) from the position shown in Figure 1 to bring the projections 342 on its pivot shaft 343 over against the arms 222 and 295, thus holding their followers out of contact with their cams. At the same time that this is done, a part on the handle 340 engages a stop switch 345 which throws off the power to the machine except for

the wheel motor **40** which continues to operate. The end facing diamond is up at this time but may be brought down and across the end face of the grinding wheel by pulling on the lever **253** by hand while the wheel slide is in its retracted position. A facing feed is applied by rocking the lever **196** carried by a rock shaft **346** connected through an arm **347** to the link **86**.

In order that the end face of the work piece which is ground may have a superior finish, the grinding wheel axis may be adjusted at a slight angle to the work axis as shown in Figures 3 and 17. This cuts down the area of contact between the end of the work and the wheel and theoretically to a straight line. The face truing device will then true off the end of the wheel in a flat cone shape which will engage the work on one side only of its axis, and the outside diameter truing device will true the wheel tapered with its larger diameter facing the work. A cylindrical wheel with its axis parallel to the work axis is shown in Figures 1 and 12. Particularly where a considerable amount of stock has to be removed from the bottom face of the work, there has been found a tendency to burn the work where the plunge cut is unrelieved. This can be avoided and an improved finish produced by retracting the wheel from this face at short intervals which allows the coolant to get in between the wheel and the work for washing and cooling. This may be done by providing a series of flats or scallops on the wheel slide actuating cam **690** as shown at **350** in Figure 18.

The machine may be operated in accordance with various cycles as desired, depending upon the contours of the cams used and their relative angular relationships on the cam shaft **150**. One such cycle, starting from fully retracted position of the wheel head and with a work piece in the closed chuck may be as follows.

The wheel slide cam **690** moves the wheel slide from retracted position into grinding position through the cam rise *a* to *b*. A gradual rise on the cam from *b* to *c* causes the grinding wheel to plunge grind the bottom face of the work, the flats or scallops **350** relieving the end face of the wheel from the work periodically as previously described. During this portion of the cycle, the feed cam **170** actuates the cross feed for plunge grinding of the internal diameter of the work piece to rough size. The cross feed then backs off and the wheel slide moves to the right from *c* to *d*, and the outside diameter of the wheel is trued by the truing diamond **262** which comes down and goes back again as the wheel proceeds back into the work from *d* to *e* when dressing has been completed. The cam **330** now causes the lever **316** to descend and interposes the spacer **315** between the eccentric **311** and the wheel slide lever **50**, the wheel slide retracting slightly to allow the eccentric **311** to take charge between *f* and *g*, while final grinding of the inside diameter of the work piece is effected and while the feed cam **170** feeds the work up to finish size, the bottom face of the work not being touched during this final grinding. The wheel slide is now retracted from *h* to *j* to its extreme right hand position where the facing diamond **240** moves across the end face of the grinding wheel immediately after the facing compensator has acted to advance the full retracted position of the wheel. At the same time the chuck is opened and the finished work piece ejected, after which the loader inserts a new piece to be ground.

From the foregoing description of an embodiment of this invention, it will be evident to those skilled in the art that various changes and modifications may be made without departing from its spirit or scope.

I claim:

1. A grinding machine having a work head, rotatable chuck means on said head for supporting a work piece for rotation about the axis of rotation of said means, a grinding wheel head, a grinding wheel mounted for rotation on said wheel head and having an end face arranged to grind a surface perpendicular to said axis as said wheel is rotated, means for moving said wheel head parallel to said axis between an advanced wheel head position in which a wheel carried by said wheel head is operative on work on said work head and a retracted position wherein said wheel is removed from the work, a wheel truing device mounted in fixed axial relation to said chuck means for motion transverse to said axis and positioned to true off said end face of said wheel when said wheel head is in retracted position and said truing device is so moved, and means for adjusting said moving means to advance the wheel toward the work preparatory to a wheel dressing operation whereby after said dressing operation said trued end face will be in predetermined relation to the work piece when said wheel is returned to said advanced position.

2. A grinding machine having a work head, means on said head for supporting a work piece for rotation about an axis, a grinding wheel head, means for moving said wheel head between an advanced wheel head position in which a wheel carried by said wheel head has an end face in predetermined relation to a work piece on said work head with said end face arranged to grind a surface of the work piece perpendicular to the axis of rotation of said work piece and a retracted position wherein said wheel is removed from the work, said moving means including a member adjustable in effective length secured at one end to said wheel head and an actuating element operatively engaging the opposite end of said member, means connected thereto for moving said element through a path of definite extent to thereby move said wheel head between advanced and retracted positions, a truing device mounted for motion across the end face of said grinding wheel at a predetermined distance from said work head, and means operatively connected thereto for adjusting the effective length of said member when said wheel head is retracted to adjust said wheel end face toward advanced position by a corresponding amount providing on a truing motion of said truing device compensation for wheel wear and truing of said end face preparatory to moving said wheel head to advanced position.

3. A grinding machine including a work head, a grinding wheel head, a grinding wheel on said grinding wheel head, a rotary work spindle on said work head, a chuck carried by said spindle, means for opening and closing said chuck, means for moving said heads relatively, means for truing said wheel, a cam shaft, and cams on said shaft operatively connected thereto for actuating said chuck opening and closing means, said head moving means, and said truing means.

4. A grinding machine including a work head, a grinding wheel head, a grinding wheel on said grinding wheel head, a rotary work spindle on said work head, a chuck carried by said spindle, means for opening and closing said chuck, means for moving said heads relatively, means for tru-

ing said wheel, a cam shaft, cams on said shaft operatively connected thereto for actuating said chuck opening and closing means, said head moving means, and said truing means, follower-carrying levers for said cams, and a shaft on which a plurality of said levers are fulcrumed.

5. A grinding machine including a work head, a grinding wheel head, a grinding wheel on said grinding wheel head, a rotary work spindle on said work head, a chuck carried by said spindle, means for opening and closing said chuck, means for moving said heads relatively, means for truing an end face of said wheel, means for truing a side face of said wheel, a cam shaft, and cams on said shaft operatively connected thereto for actuating said chuck opening and closing means, said head moving means, and said truing means.

6. A grinding machine including a work head, a grinding wheel head, a grinding wheel on said grinding wheel head, a rotary work spindle on said work head, a chuck carried by said spindle, means for opening and closing said chuck, means for moving said heads relatively, means for truing an end face of said wheel, means for truing a side face of said wheel, a cam shaft, and cams on said shaft operatively connected thereto for actuating said chuck opening and closing means, said head moving means, and said truing means.

7. A grinding machine for grinding the internal side wall and inside base of a cup-shaped work piece, which comprises a rotary work holder for holding such work piece with its cup portion outwardly extended, a rotary grinding wheel having grinding side and end faces, means supporting said holder and grinding wheel for relative motion to cause said grinding wheel to enter the work piece and grind the side wall of said work piece with the side face of said wheel and grind the base of said work piece with said wheel end face, and means operatively connected to said supporting means for producing a relative feed between said work piece and wheel laterally of the axis of rotation of said work piece.

8. A grinding machine including a work head, a grinding wheel head, a grinding wheel on said grinding wheel head, a rotary work spindle on said work head, a chuck carried by said spindle, a cam having a cam face, a follower engaging said cam face and operatively connected to one of said heads and operative to move said heads relatively parallel to said spindle to produce a plunge grind by the end face of said grinding wheel, said cam face having spaced portions in said face each contoured to cause a corresponding motion of said follower effective to produce slight withdrawal of said wheel from the work during such plunge cut.

9. A grinding machine including a work head and a grinding wheel head, means operatively connected thereto for moving one of said heads relative to the other in traverse direction between an inoperative wheel retracted relation and an operative wheel advanced relation, a rotary cam, an abutment element, a sleeve through which said abutment element is axially movable, means supporting said sleeve for motion laterally of said axial motion to interpose said abutment element between said cam and one of said heads or to retract said element, means acting when said heads are in advanced relation to actuate said supporting means to so interpose said element, means yieldingly holding said element against said cam when so interposed, and means for rotating said cam, said cam being contoured to move said element axially when said element is so interposed.

10. A grinding machine including a work head and a grinding wheel head, means operatively connected thereto for moving one of said heads relative to the other in traverse direction between an inoperative wheel retracted relation and operative wheel advanced relation, a rotary cam, an abutment element, a sleeve through which said abutment element is axially movable, an arm supporting said sleeve, means pivotally supporting said arm for motion transverse to said relative traverse direction between an angular position in which said abutment element is interposed between said cam and said movable head and a position in which said abutment element is not so interposed, yielding means tending to hold said arm in the latter of said positions, means effective when said heads are in said relative advanced relation for moving said arm into the other of said positions, yielding means tending to hold said abutment element against said cam, and means for rotating said cam, said cam being contoured to cause reciprocation of said abutment element with corresponding reciprocating traverse between a grinding wheel on said wheel head and a work piece on said work head.

11. A grinding machine including a work head having a rotary work carrier, and a grinding wheel head, means including a link connected to one of said heads for moving said heads relatively in line with the work carrier rotational axis to move a wheel carried by said wheel head and work carried by said work carrier relatively between advanced and retracted relations, yielding means acting thereon pressing said link in one direction, a movable member connected to said link, means acting on said member for moving said member between a normally operative advanced condition in which said work and wheel heads are in advanced relation and a retracted condition wherein said heads are in retracted relation, a rotary cam, means for rotating said cam, an abutment, means supporting said element for motion from and to a position between said member and cam, and means operatively connected to said abutment for interposing said abutment in said position in contact with said member and cam and there holding it while said heads are in advanced relation whereby rotation of said cam produces traverse between the wheel and the work.

12. A grinding machine including a work head having a rotary work carrier, and a grinding wheel head, movable means connected to one of said heads for moving said heads relatively laterally of the axis of said work carrier, means including a link connected to one of said heads for moving said heads relatively in line with the work carrier rotational axis to move a wheel carried by said wheel head and work carried by said work carrier relatively between advanced and retracted relations, yielding means acting thereon pressing said link in one direction, a movable member connected to said link, means acting on said member for moving said member between a normally operative advanced condition in which said work and wheel heads are in advanced relation and a retracted condition wherein said heads are in retracted relation, a rotary cam, means for rotating said cam, an abutment, means supporting said abutment for motion from and to a position between said member and cam, means operatively connected to said abutment for interposing said abutment in said position in contact with said member and cam and there holding it while said heads are in advanced relation whereby rotation

of said cam produces traverse between the wheel and the work, and means connected thereto for actuating said lateral moving means during such traverse to feed said wheel against the work.

13. A grinding machine having a work head, means on said head for supporting a work piece for rotation about an axis, a grinding wheel head, means for moving said wheel head between an advanced wheel head position in which a wheel carried by said wheel head has an end face in predetermined relation to a work piece on said work head and a retracted position wherein said wheel is removed from the work, said moving means including a member adjustable in effective length secured at one end to said wheel head and an actuating element operatively engaging the opposite end of said member, means connected thereto for moving said element through a path of definite extent to thereby move said wheel head between advanced and retracted positions, a truing device mounted for motion across the end face of said grinding wheel at a predetermined distance from said work head, means for adjusting the effective length of said member when said wheel head is retracted to adjust said wheel end face toward advanced position by a corresponding amount providing on a truing motion of said truing device compensation for wheel wear and truing of said end face preparatory to moving said wheel head to advanced position, said member comprising a pair of parts threaded together, a ratchet mechanism for turning one of said parts relative to the other of said parts, a fixed abutment, and ratchet actuable means carried by said member and contacting with and moved by said abutment as said wheel head is moved to fully retracted position to rotate said one part relative to the other by a predetermined amount.

PAUL A. GROBEY.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
302,525	Stehli	July 22, 1884
550,477	Bradley	Nov. 26, 1895
888,675	Ward	May 26, 1908
1,226,302	Brightman	May 15, 1917
1,412,140	Schreier	Apr. 11, 1922
1,559,206	Van Norman	Oct. 27, 1925
1,602,680	Knowles	Oct. 12, 1926
1,812,313	Arter	June 30, 1931
1,933,213	Guild	Oct. 31, 1933
2,070,283	Lewis	Feb. 9, 1937
2,127,210	Dunbar	Aug. 16, 1938
2,154,681	Jeffries	Apr. 18, 1939
2,187,227	Flanders	Jan. 16, 1940
2,285,717	Indge	June 9, 1942
2,293,100	Baumgold	Aug. 18, 1942
2,414,182	Wessman	Jan. 14, 1947
2,429,830	Ljunggren	Oct. 28, 1947
2,431,671	Arms	Dec. 2, 1947
2,442,683	Green	June 1, 1948

FOREIGN PATENTS

Number	Country	Date
573,117	Germany	Mar. 28, 1933
596,378	Germany	May 14, 1934