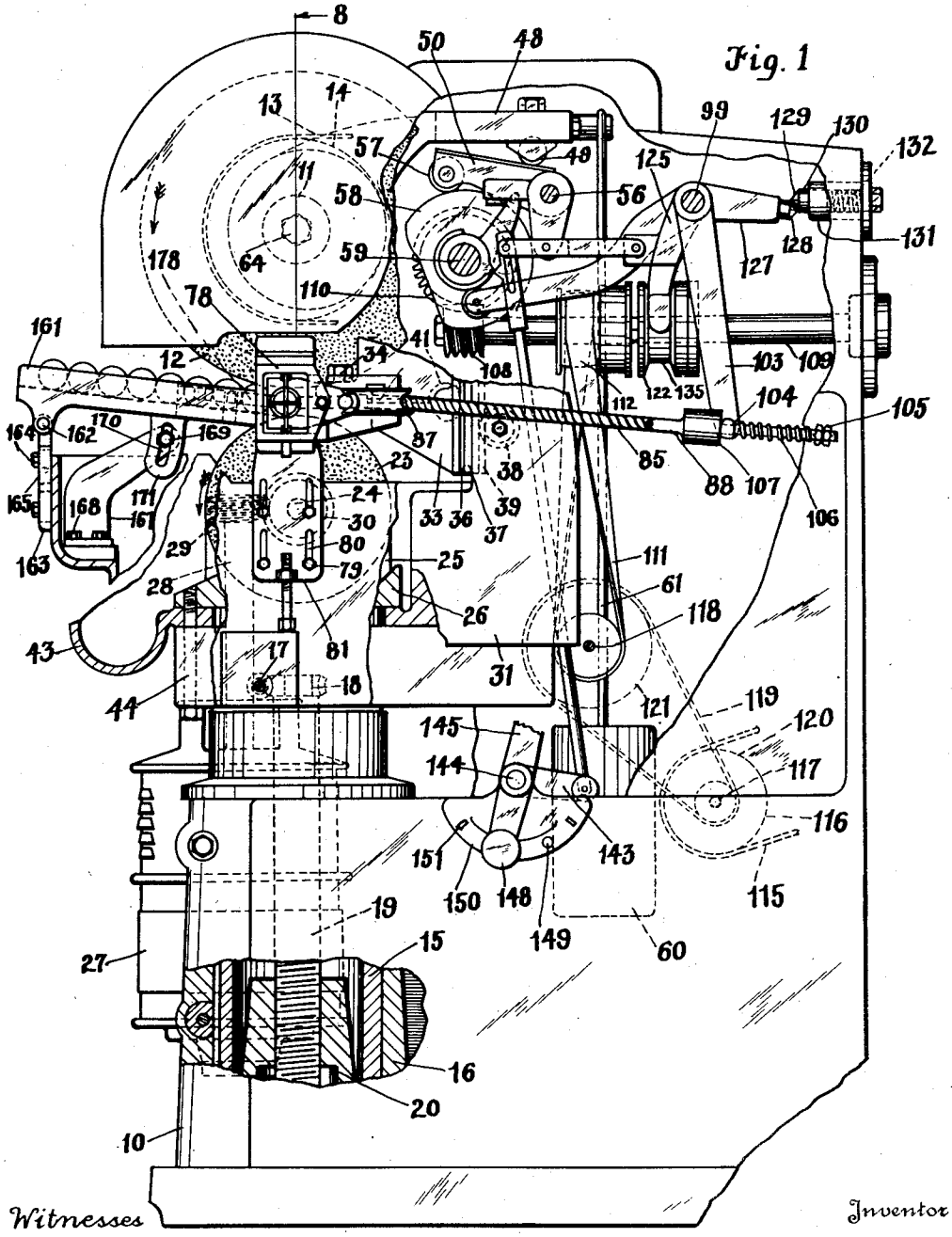
Oct. 22, 1929. H. W. HOLMES 1,733,097

CENTERLESS GRINDING MACHINE

Original Filed Feb. 3, 1926 3 Sheets-Sheet 1

Fig. 1



Witnesses

Chas. H. Richards

J. Harold Boss

Inventor

Harold W. Holmes

By Clayton R. Jenkins

Attorney

Oct. 22, 1929. H. W. HOLMES 1,733,097

CENTERLESS GRINDING MACHINE

Original Filed Feb. 3, 1926 3 Sheets-Sheet 2

Fig. 3

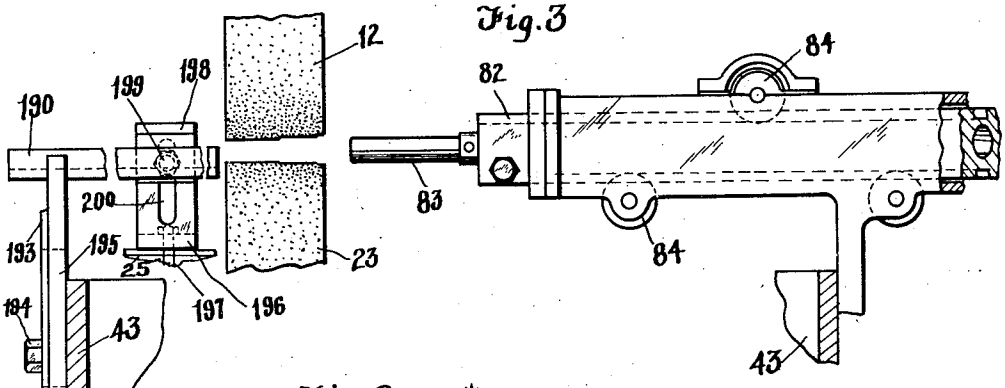


Fig. 2

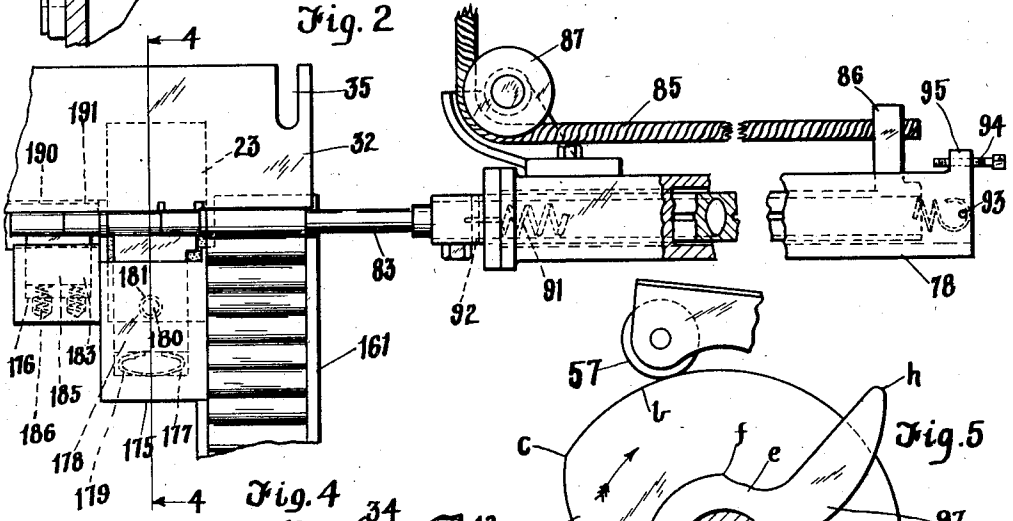


Fig. 4

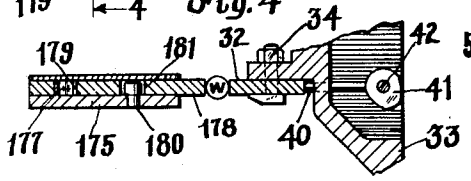


Fig. 5

Fig. 10

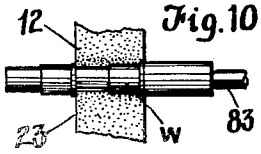


Fig. 11

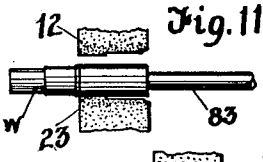
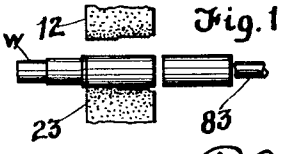


Fig. 12



Witnesses
Chas. M. Richards
Harold Boss

Inventor
Harold W. Holmes

By Clayton R. Jenkins
Attorney

Oct. 22, 1929. H. W. HOLMES 1,733,097

CENTERLESS GRINDING MACHINE

Original Filed Feb. 3, 1926 3 Sheets-Sheet 3

Fig. 6

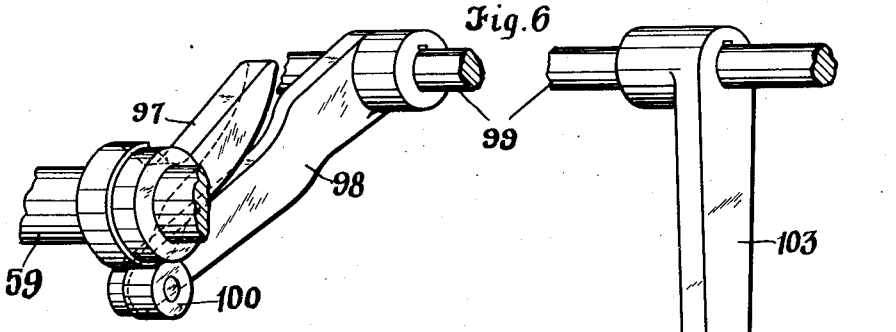
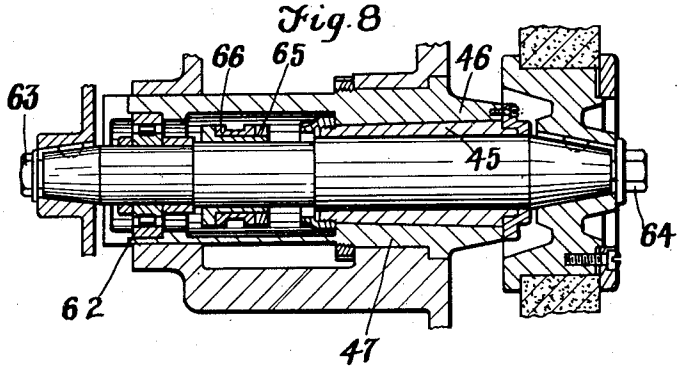


Fig. 8



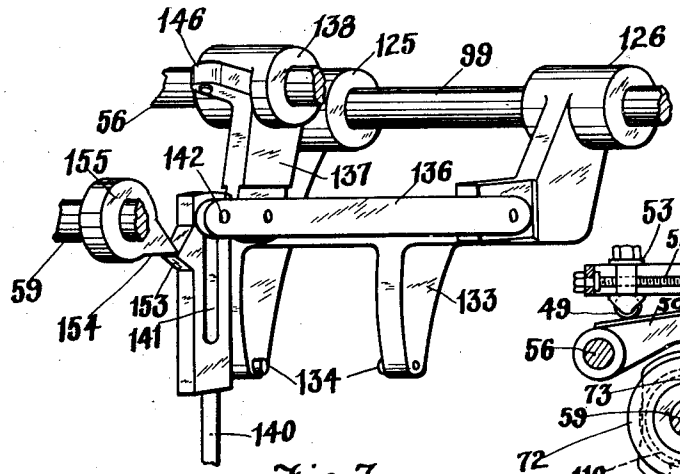
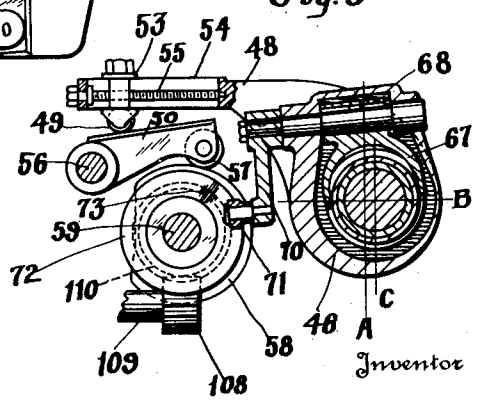


Fig. 7

Fig. 9



Witnesses

Chas. H. Richards

J. Harold Rose

Inventor

Harold W. Holmes

By Clayton R. Bryant

Attorney

Patented Oct. 22, 1929 1,733,097

UNITED STATES PATENT OFFICE

HAROLD W. HOLMES, OF DETROIT, MICHIGAN, ASSIGNOR, BY MESNE ASSIGNMENTS, TO CINCINNATI GRINDERS INCORPORATED, OF CINCINNATI, OHIO, A CORPORATION OF OHIO

CENTERLESS GRINDING MACHINE

Application filed February 3, 1926, Serial No. 85,799. Renewed March 1, 1929.

This invention relates to grinding and more particularly to apparatus for grinding cylindrical work or work pieces of round section wherein the work is held or supported between a grinding wheel and a work regulating wheel for respective grinding and rotating action thereon.

It has been heretofore proposed to grind cylindrical work in a grinding machine of the above-mentioned general character and it has been found that such a machine, having a grinding wheel rotated rapidly for performing the grinding operation and a work regulating wheel, rotated slowly to control the rotation of the work while the grinding wheel grinds the work supported therebetween, is characterized by a great many very important practical advantages, particularly where the cylindrical work pieces are fed axially past the grinding wheel by the regulating wheel; one of the dominant aims of this invention is to provide a grinding apparatus in which such advantages as high accuracy and high speed of grinding, characteristic of the above-mentioned apparatus, may be dependably achieved where the work pieces are of special shape or form, for example, such as work pieces of round section having two or more sections or portions thereof of different diameters. Another object is to provide an apparatus of the above-mentioned nature whereby high speed and substantial continuity of grinding, together with a high degree of accuracy may be achieved in a thoroughly practical and commercial way, even though the work pieces operated upon might necessarily have peculiar shape or form.

Another object is to provide a grinding apparatus of the above-mentioned nature in which dependability in operation, ruggedness of construction and great flexibility of control and operation are combined in a thoroughly practical manner in order thus readily to meet the varying conditions of practical use. Another object is to provide an apparatus of the above-mentioned nature which will be thoroughly automatic in action and well adapted to safeguard not only the work operated upon but also the operative handling the apparatus.

Another object is to provide a grinding apparatus in which not only a high degree of accuracy of grinding of the work pieces of peculiar or special shape or form may be achieved but also a high degree of finish of the ground surface.

Another object of this invention is to provide a grinding apparatus in which the specially shaped work piece may be accurately and reliably related operatively to the grinding wheel and the regulating wheel and, moreover, in such a manner as to insure a high and dependable degree of uniformity of grinding throughout successive work pieces operated upon.

Another object is to provide a grinding apparatus for carrying out the objects noted above and in which, while the apparatus is capable of operating fully automatically, a reliable and dependable manual control may nevertheless be exercised in a thoroughly practical way.

Another object of this invention is to provide a grinding apparatus for carrying out such objects as have just been pointed out but in which many additional and thoroughly practical advantages may be achieved in arranging the work regulating wheel substantially underneath the grinding wheel.

Other objects will be in part obvious or in part pointed out hereinafter.

The invention accordingly consists in the features of construction, combinations of elements, and arrangements of parts as will be exemplified in the structure to be hereinafter described and the scope of the application of which will be indicated in the following claims.

In the accompanying drawings, in which is shown by way of example an illustrative embodiment of my invention,

Fig. 1 is a side elevational view, with parts broken away, of a centerless grinding machine embodying the invention;

Fig. 2 is a diagrammatic plan view showing the various mechanisms and arrangement for feeding a row of work pieces through the grinding zone;

Fig. 3 is a diagrammatic elevational view of the mechanisms for propelling and guiding the row of work pieces towards and away from the grinding zone;

Fig. 4 is a sectional elevational view taken upon the line 4—4 of Fig. 2;

Fig. 5 is a detail view showing the shape and relative positions of the cams controlling the movement of the grinding wheel and the movement of the reciprocatory mechanism;

Fig. 6 is a detail view of part of the mechanism shown in Fig. 1;

Fig. 7 is a detail view of a portion of the tripper mechanism;

Fig. 8 is a sectional elevational view taken along the line 8—8 of Fig. 1;

Fig. 9 is a sectional view of part of the mechanism shown in Fig. 1 along a longitudinal vertical plane through the trunnion arm; and

Figs. 10 to 12 inclusive are diagrammatic views indicating the relative positions of the movable wheel, row of work pieces, and plunger mechanism.

In the drawings I have illustrated a preferred embodiment of my invention in which, as shown, the apparatus is automatic in operation throughout but, as will be readily made clear hereafter, may be operated in a semi-automatic manner. This illustrative embodiment of my invention includes a frame 10 (Fig. 1) within an upper part of which is mounted a grinding wheel spindle 11 carrying a grinding wheel 12. The grinding wheel spindle is rotated rapidly from any suitable source of power by means of a belt 13 passing over a pulley 14 secured upon the spindle 11. The grinding wheel 12 may thus be given a suitable grinding speed, it being further noted that the grinding wheel is rotated or driven in the direction of the arrow shown in Figure 1.

A column 15 is mounted to be moved vertically within a cylindrical guiding portion 16 of the frame 10, to which it is splined. A hand wheel (not shown) is keyed to the shaft of a worm 17 meshing with a worm wheel 18 fixed to a screw shaft 19; the latter engages threads in a boss 20 integral with the frame. Rotation of screw shaft 19 by the hand wheel thus brings about a raising or lowering of the column 15. A work regulating wheel 23 is mounted, beneath and peripherally opposed to the grinding wheel, upon a spindle 24 supported for rotation in suitable bearings (not shown) enclosed within the bearing casing 25 supported upon the block 26 mounted upon the upper portion of the column 15. The regulating wheel 23 may be rotated relatively slowly in the direction of the arrow (Fig. 1) from any suitable source of power, such as a motor 27 connected directly to a shaft 28 having a worm 29 thereon meshing with a worm wheel 30 upon the wheel spindle 24.

An auxiliary frame 31 fixed on the column 15 extends upwardly in the rear of the regulating wheel 23. A work holding member or blade 32 (see also Figs. 2 and 4) is fastened to a carriage 33 by means of bolts 34 passing through slots 35 in the blade. The carriage 33 is provided with a portion 36 adapted to move in the vertical slideways 37 in the support 31. The carriage 33 may be moved vertically by means of a pinion 38 meshing with the rack 39 secured upon the carriage. The work holding member 32 may be suitably adjusted and maintained with its work contacting edge preferably parallel to the axis of the grinding wheel 12, such as by means of a pair of pins 40, Fig. 4, slidably supported in the carriage 33 and engaging the member 32 at one end and a cam 41 at the other end secured upon a rotatably mounted shaft 42, thereby assuring that the guiding surface of the work holding member 32 is always parallel to the axis of the grinding wheel as it is moved in and out when thus adjusted for work of different sizes. The cam arrangement just described is not per se my invention, but is described in detail and claimed in the co-pending application Serial No. 91,861 of Fred M. Kern and Ernest R. Seward, filed March 3, 1926, and to that application reference may be had for further details of the construction and action thereof. A water pan 43 (Fig. 2) is mounted upon the top of the column 15 and is secured to the block 26 by means of bolts 44.

The grinding wheel spindle 11 and the work regulating wheel spindle 24 may bear a fixed relation, but it is my preferred practice to construct the machine so that one of the wheels may be moved towards or away from the other wheel to facilitate moving work in between the wheels and subsequently discharging the ground work. Thus, I may mount the grinding wheel 12 so that it may be moved periodically towards and away from the other wheel. Thus, the grinding wheel spindle 11 carried in a tapered split bearing 45 (Fig. 8) is adjustably mounted within the trunnion 46 and has its axis located eccentric to that of the trunnion. The latter is mounted in a cylindrical bearing surface 47 in the frame 10 for rotative oscillation about its axis (Figs. 8 and 9) and is provided with a rearwardly extending arm 48 (Figs. 1 and 9) having an adjustable roller 49 positioned therein adapted to ride upon an arm 50. The roller 49 is held by a member 53 which is adapted to be moved within a slot 54 in the arm 48 by means of an adjusting screw 55. The arm 50 is pivoted at one end to turn about a shaft 56 and has a cam roller 57 at the other end adapted to ride upon the peripheral surface of a cam 58 fixed upon the cam shaft 59. The inter-relation and coaction of the arm 48 with the arm 50 and immediately associated

parts, and the wide variability of action of the fixed cam 58 that may be achieved by varying the position of the roller 49 lengthwise of the arm 48 are not per se my invention but permit the achievement, in coaction with the other parts of the apparatus herein described, of many important advantages and they are described in detail and claimed in the co-pending application Serial No. 85,790 of Fred M. Kern, filed February 3, 1926, and to that application reference may be had for further details of the construction and action thereof. A relatively heavy weight 60 (Fig. 1) is suspended by a rod 61 from the end of the arm 48 and serves to hold the cam follower 57 upon the cam 58.

The thrust upon the grinding wheel spindle 11 due to the pull of the belt 13 upon the pulley 14 is taken by a roller race or bearing 62 (Fig. 8) suitably positioned in the trunnion 46 as illustrated. The pulley 14 is secured upon one tapered end of the grinding wheel spindle 11 by means of a nut 63, and the grinding wheel 12 is secured upon the other end by means of a nut 64 in accordance with the usual practice.

In order that the grinding wheel 12 may be moved axially through a slight distance to eliminate grain markings on the work, the spindle 11 is mounted for reciprocation lengthwise through the bearing 45. This movement is caused preferably, by a cam connected through a rocking arm and yoke to the spindle. As illustrated, the spindle has a yoke collar 65 which fits thereon, and this collar is provided with a bushing 66 having a groove for the insertion of a yoke 67 (Fig. 9) which is keyed to a shaft 68 and supported for rocking movement in a bearing in the trunnion 46. A crank arm 70 is keyed to one end of the shaft 68 and is provided with a cam roller 71 which is adapted to engage the radial or side face of a cam 72 mounted upon the camshaft 59. The radial face is provided with a raised portion 73 suitably placed thereon to move the grinding wheel spindle axially, by way of the arm 70, shaft 68 and yoke 67, during grinding of a work piece. Preferably, I provide but one raised portion 73 and the remainder of the cam face is plane so that toward the end of the grinding operation the wheel will be given a single, quick, short, axial movement to smooth over the work surface. The arm 70 is held by suitable means such as a spring (not shown) so that the cam roller 71 presses against the cam face and the wheel is held in one position except as moved by the raised portion on the cam.

A row of axially positioned work pieces may be moved in any appropriate manner in an axial direction in a path through the grinding zone to feed successive work pieces separately to the same position between the wheels for grinding action by the grinding wheel 12 and rotation by the regulating wheel 23. A preferred mechanism for this purpose comprises a horizontally disposed casing 78 (Figs. 2 and 1) mounted to the water pan 43 and parallel to the axis of the grinding wheel 12 by means of bolts 79 (Fig. 1) passing through slots 80 in a bracket 81. A sliding member 82 (Fig. 3) carrying a plunger 83 is adapted to move within the casing 78 between rollers 84, and is moved towards the wheels by means of a flexible member, such as a rope 85 (Fig. 2), secured at one end to an ear 86 on the movable member 82 and passing over a pulley 87 to a rod 88 (Fig. 1) to which the other end is secured. The plunger 83 is operated against the tension of a spring 91 (Fig. 2) secured at one end to a pin 92 in the plunger and at its other end to a pin 93 in the casing. The member 82 is preferably hollow (see Figs. 2 and 3) and houses therein the spring 91. The position of rest of the plunger 83 may be varied by means of an adjustable stop screw 94 (Fig. 2) threaded in a projection 95 in the casing and engaging an ear 86 on the plunger 83.

The rod 88 and the rope 85 are actuated by a cam 97 (Fig. 5) mounted upon the camshaft 59. An arm 98 is keyed at one end to a shaft 99 (Fig. 1) and is provided at the other end with a cam roller 100 adapted to engage the peripheral surface of the cam 97. A second arm 103 also is keyed at one end to the shaft 99 and is provided at the other end with a block 104 pivoted in the arm 103 to slidably engage the rod 88. The rod 88 is threaded at its free end for adjustable nuts 105 which hold a spring 106 against the block 104 to press the latter against an enlargement 107 on the rod 88. The spring 91 (Fig. 2) of the reciprocable plunger mechanism also serves the function of holding the cam roller 100 against the peripheral surface of the cam 97.

The camshaft 59 may be rotated by means of a worm 108 (Fig. 1) on a shaft 109 meshing with a worm wheel 110 fixed upon the camshaft 59. The shaft 109 may be rotated from any appropriate source of power by means of a belt 111 passing over a clutch pulley 112 on the shaft 109.

One of the wheels, preferably the grinding wheel, as above pointed out, may be moved towards and away from the other wheel at any desired rate and in timed relation with the movement of the reciprocable plunger just described towards and away from the wheels. For this purpose suitable means may be provided for rotating the drive shaft 109 and consequently the camshaft 59 at different speeds. Thus, a belt 115, driven from any appropriate source of power, passing over a pulley 116 may be employed to rotate a shaft 117 at any desired speed. The power thus applied to the shaft 117 may be transmitted to a shaft 118, and consequently to the belt 111, through the instrumentality of a belt 119 connecting cone pulleys 120 and 121.

A suitable toothed clutch 122, which is splined to the shaft 109, is provided for connecting the clutch pulley 112 with the worm 108.

Clutch 122 may be moved to engage or disengage the pulley 112 by a manually controlled device. Such a mechanism (Figs. 1 and 7) may include a clutch yoke having hubs 125 and 126 pivotally mounted upon the shaft 99. An arm 127 (Fig. 1) extends rearwardly from the hub 125 and is provided with a V-shaped projection 128 on its end (Fig. 1). The projection 128 is adapted to contact with the V-shaped end projection 129 on a pin 130 slidably mounted in a boss 131 in the frame of the machine. A spring 132 maintains a contact between the V surfaces of the end projections 128 and 129. A fork 133 (Fig. 7) extends downwardly and forwardly from the hubs 125 and 126 and carries a pair of pins 134 (Fig. 7) adapted to ride in a groove 135 in the clutch 112 (see Fig. 1). A double link 136 (Fig. 7) projects forwardly and is secured at one end to the fork 133 and supported at the other end by a downwardly extending arm 137 of a bell crank 138 pivotally mounted upon the shaft 56. A vertically extended rod 140 having a slot 141 is mounted to slide upon a pin 142 in the forward end of the double link 136. The rod 140 is secured at its lower end to a link 143 (Fig. 1) which is keyed to a shaft 144 suspended in the frame of the machine for rotary movement. A clutch operating lever 145 is secured upon shaft 144 so that movement in counter-clockwise direction, as viewed in Fig. 1, will move the rod 140 upward relative to the double link 136 to strike against the forwardly extending arm 146 of the bell crank 138, and thereby turn the bell crank to move the double link and the fork 133 forward and bring the clutch 122 into engagement with the pulley 112 to rotate the camshaft 59. The lever 145 is provided with a spring plunger 148 (Fig. 1) which may engage openings 149 in a plate 150 secured upon the outside of the frame of the machine. The plate 150 may be provided also with a pair of stops 151 (Fig. 1).

If it is desired to stop the machine automatically at the end of a single cycle of operations, the lever 145 may be moved so as to bring the rod 140 to a higher position whereby a projection 153 thereon is positioned in an appropriate part of the path circumscribed by a projection 154 on a tripper cam 155 which is secured to and rotated with the camshaft 59. With the rod 140 in such a position, the projection 154 engages the projection 153 to move the double link 136 horizontally and thereby disengage the clutch 122 from the pulley 112.

A new work piece may be supplied automatically to the row of work pieces being moved progressively through the grinding zone when the reciprocable plunger is withdrawn. A preferred mechanism for this purpose comprises a relatively shallow U-shaped feed trough 161 (Fig. 1) mounted at one end to turn about a pivot 162 in a bracket 163 which is secured to the water pan 43 by means of bolts 164 passing through slots 165. A bracket 167 is secured to the water pan 43 by means of bolts 168 and is provided with a bolt 169 which is adapted to pass through a slot 170 in a depending arcuated brace 171 integral with or otherwise appropriately secured to the feed trough 161, so that the rear end of the feed trough 161 may be adjustably supported in a suitable position opposite the work holding member 32, (see Fig. 2).

A horizontally disposed plate 175 (Fig. 2) having a slot 176 and a slot 177 is formed integral with or otherwise appropriately secured to the feed trough 161. A front work holding member or blade 178 is slidably mounted in the slot 177 against a spring 179, and is limited in its movement by a pin 180 (see also Fig. 5) secured in the plate 175 and extending into a relatively large hole 181 in the front work holding member or blade 178. The member 178 has its work engaging face or edge shaped to conform substantially to the contour of the work to be positioned between the wheels. A friction device, such as a plate 185 (Fig. 2) is positioned in the slot 176 and is actuated by being pressed rearwardly by means of the springs 186 to push the ground work pieces against the work holding member or blade 32 acts to retard the movement of the work pieces between the wheels and thereby to cooperate with the reciprocable plunger 83 in preventing any slight axial movement of the work pieces during the grinding operation.

A V-shaped trough 190 (Figs. 3 and 2) is disposed horizontally adjacent to the wheels and in alignment with the plunger 83, and is provided with a cut away portion 191 so as to fit beneath and support work pieces in their travel between the rear work holding member 32 and the friction plate 185 (see Fig. 2). The trough 190 is supported at one end by means of a bracket 193 (Fig. 3) which is secured to the water pan 43 by means of bolts 194 passing through slots 195. The other end of the trough is supported by means of a bracket 196 secured near its bottom portion to the bearing casing 25 by means of bolts 197; the top portion of the bracket 196 being secured to an ear 198 which is integral with the trough 190 by means of bolts 199 passing through a slot 200 in the bracket 196.

The grinding wheel 12 and the regulating wheel 23 are preferably given such a shape at their operative faces as to substantially match the contour to which the work pieces are to be ground, where the latter are of special shape, as has been hereinabove noted; by way of illustration, I have shown the two

wheels shaped in such a way as to give the finished or ground work piece three different diameters. This shaping of the two wheels is clearly shown in Figures 3, 10, 11 and 12 of the drawing, and may be achieved in any suitable way. In Figures 10, 11 and 12 I have illustrated a work piece *w* which will be seen in the drawings to have three successive portions, each of a different diameter and the two wheels are shaped as will be clear from Figure 10 in which the work piece *w* is shown in operative contact with both wheels and practically reduced to the desired extent by the grinding wheel 12, to substantially match the contour (in an axial direction of the work piece *w*) which it is desired that the finished or ground work piece is to have. It is to be understood that the shape of the wheels shown in the drawings is merely illustrative and may be varied to meet the conditions which any other specially formed or shaped work piece may impose.

Considering now the operation of the machine, the grinding wheel 12 is rotated to give it an appropriate grinding speed, in the direction indicated by the arrow in Fig. 1, from any appropriate source of power by means of a belt 13 passing over the pulley 14 on the grinding wheel spindle 11. The work regulating wheel 23 is rotated relatively slowly in the direction indicated by the arrow, through shaft 28, worm 29, and worm wheel 30 by means of the motor 27, and acts to control the rotation of the work piece. With the pulley 112 rotating at a desired speed (determined by the belt 119 and cone pulleys 120 and 121), the camshaft 59 may be set in rotation by pulling the lever 145 to the left, or in counter-clockwise direction, as viewed in Fig. 1; this action raises the rod 140 to strike against the arm 146 of the bell crank 138. The resulting swinging of the latter throws the double link 136 forward to the left and brings the clutch 122 into engagement with the pulley 112.

With the lever 145 in this position it will be noted that the projection 153 on rod 140 is above and out of the path circumscribed by the projection 154 of the tripper cam 155 so that the machine may operate completely automatic. Thus, the camshaft 59, together with the cams 58, 72 and 97 thereon, may rotate uniformly and continuously with the cam rollers 57, 71, and 100 in contact therewith respectively to actuate their various mechanisms, namely, for moving the grinding wheel 12 towards and away from the work regulating wheel 23, for reciprocating the grinding wheel axially during the grinding of the work, and for reciprocating the plunger 83.

It will be noted that rotation of the cam 58 raises and lowers the cam roller 57 (Figs. 9 and 1) to raise and lower the free end of the pivoted arm 50 which in turn raises and lowers the cam roller 49. The latitude of movement of the arm 48 may be reduced or increased by adjusting the position of the cam roller 49 on the arm 48 by turning the adjusting screw 55 to move the member 53 within the slot 54. The movement of the arm 48 causes a turning movement of the trunnion 46 to change the position of the axis of the grinding wheel spindle 11 which is eccentrically mounted in the trunnion 46, thereby causing the grinding wheel 12 to move cyclically towards and away from the other wheel.

The cam roller 71, Fig. 9, is maintained in contact with the projection 73 and the radial face of the cam 72 by means of a spring (not shown). The cam 72 controls the reciprocation of the arm 70 and the yoke 67, and consequently the axial reciprocation of the grinding wheel spindle 11 of a character depending upon the shape of the cam face. In the preferred form of mechanism illustrated in the drawing, the grinding wheel 12 moves directly (downwardly as viewed in Fig. 1) into the work without axial oscillation. The cam which controls the movement of the wheel into the work is so shaped as to give a continuous feeding motion downwardly to the wheel 12 and then at the end of the feeding motion to give a dwell to the wheel which allows any spring of the machine to be taken out, and also allows a sparking out operation that tends to produce a better finish. During the time that the grinding wheel is held against the work, or during this period of dwell of the cam, the grinding wheel spindle is oscillated by the cam 72. However, there is preferably one oscillation; that is, while the grinding wheel is dwelling against the work it is moved about 1/8″ away from the shoulder on the work, if grinding shouldered work, and again brought back to position. This tends to take out any scratches or wheel markings on the work.

At the same time the cam 97 (Fig. 5) is rotated uniformly with the cam roller 100 in contact therewith, thereby causing reciprocation of the arm 98, turning the shaft 99, and reciprocation of the arm 103 to move the rod 88 and rope 85, and consequently the plunger 83 to move the row of work pieces between the wheels and then withdraw to permit replacement of ground work.

It will be observed that the center of the eccentric trunnion 46 (indicated at the intersection of the lines A and B, Fig. 9) is between the center of the grinding wheel spindle (indicated by the intersection of the line B and C) and the cam 58, and that the parts are so arranged that rocking movement of the trunnion moves the grinding wheel in the substantially vertical portion of an arc. The cam 58, as shown diagrammatically in Fig. 5, is so shaped as to cause the grinding wheel to move abruptly into an approximate grinding position and there-

after advanced gradually to grind the work, the work being rotated by the regulating wheel 23; the grinding wheel 12 is then withdrawn quickly to its initial position. This cam may be shaped in accordance with the type of operation desired, but as illustrated in its preferred form it has a spiral face which, when rotated in the direction of the arrow (Fig. 5), causes the cam roller 57 to move from a point *a* to a higher point *b* to feed or move the grinding wheel into the work and commence the grinding of the latter. The grinding wheel then dwells upon the work while the cam roller 57 contacts with the portion between the points *b* and *c* which are substantially equidistant from the camshaft 59. It is during this dwell that the reciprocation of the grinding wheel 12 preferably takes place. From the points *c* to *d* on the cam 58, cam roller 57 drops away rapidly to retract the wheel 12 from the work and then climbs the incline *d*—*a* thus moving the grinding wheel rapidly towards the work, whence the portion *a* to *b* again comes into action.

The cam 97 (Fig. 5) is so shaped and so located upon the camshaft 59 relative to the cam 58 that the plunger 83 is actuated so as to remain axially immovable against the end of the row of work pieces while the grinding wheel is in operative contact with one work piece *w*, as indicated in Fig. 12, and then to move forward to push the row of work pieces axially as the grinding wheel moves away from the other wheel (as indicated in Fig. 11), and then withdraw (as indicated in Fig. 12) to permit placing of a new work piece in the row in advance of the plunger 83. The plunger 83 then moves forward slightly to the position shown in Fig. 10 to move the row a slight distance to bring the work piece to be ground accurately to the proper position between the wheels for grinding.

As shown in Fig. 5, when the camshaft 59 with the cam 97 is rotated, the roller 100 is affected first by that portion of the peripheral surface of the cam 97 from *e* to *f* causing the plunger 83 to move forward a slight distance (from the position shown in Fig. 12 to the position shown in Fig. 10). The plunger under the control of portion *f* to *g* then remains in that position until the roller 100 is reached by the point *g*. As the roller 100 is acted upon by the portion from the point *g* to point *h*, the row of work pieces is moved forward axially (Fig. 11) to discharge ground work piece and move a new work piece between the wheels into approximate position for grinding. The plunger 83 is then withdrawn (Fig. 12) as the roller 100 is acted upon by that portion of cam 97 from *b* to *e* so that another work piece may be placed in the row, and in advance of the plunger 83 and then moves forward a very slight distance (about 3/16 of an inch to the position indicated in Fig. 10) as the roller 100 is acted upon by the portion from the point *e* to point *f* to accurately position the next work piece between the wheels for grinding.

The speed of the automatic movements above described may be increased or decreased by adjusting the belt 119 in an appropriate position upon the cone pulleys 120 and 121. Thus, the work pieces may be ground at a suitable rate depending upon the character of the work and such variable factors as will be readily understood by those skilled in the art.

The normal positions of rest of the grinding wheel 12 and the plunger 83, when the automatic movements are stopped, are indicated in Fig. 11. If it is desired to operate the machine automatically for one complete cycle and then stop the automatic movements with the plunger 83 withdrawn and the grinding wheel 12 away from the work regulating wheel 23, the lever 145 is moved to bring the projection 153 on the rod 140 to a predetermined location within the path circumscribed by the projection 154 on the tripper cam 155. Thus, with the tripper cam 155 in the proper position upon the camshaft 59 relative to the cams 58 and 97, the movement of the plunger 83 and the grinding wheel 12 may be brought to a position of rest as the projection 154 comes in contact with the projection 153 to move the double link 136 and the clutch yoke to the right as viewed in Fig. 1 to disengage the clutch 122 from the pulley 112.

When the machine may be operated automatically or semi-automatically as previously described, work pieces are placed in the trough 161, as indicated in Figs. 1 and 2, so that a new work piece will roll against the rear work holding member or blade 32 when the plunger 83 is withdrawn. The plunger 83 then moves forward a very slight distance so as to bring one of the work pieces into a correct position for grinding and into exactly the same position as that occupied by the piece previously ground. The grinding wheel 12 then moves towards the regulating wheel into operative grinding contact with the work piece. The friction plate 185 is held by the springs 186 in contact with the work pieces, thereby urging the latter against the work holding member 32 and tending to retard any forward axial movement; and in thus cooperating with the plunger 83 (see Fig. 2) it acts to prevent creeping of the work during grinding. The grinding wheel then moves away from the work and the plunger moves forward (to the left as seen in Fig. 2) to discharge the ground work and move another work piece into approximate grinding position. The plunger is then withdrawn, due to the action of the spring 91, so that a new work piece is permitted to roll down the trough 161 and take its place in the row of

work pieces. The plunger 83 then starts on a new cycle and moves forward a slight distance so as to move the row of work pieces forward axially so as to bring the new work piece into accurate position for grinding, where it is held accurately due to the cooperation of the plunger 83 and the friction device 185.

It will thus be seen that there has been provided in this invention an apparatus in which the several objects above noted as well as many others, together with a great many thoroughly practical advantages are successfully achieved. It will be seen that the apparatus is of rugged construction throughout and of thoroughly dependable and reliable action, and that, even though fully automatic and thus capable of high speed of operation and high rate of production of ground articles, the apparatus is manually controllable in a thoroughly practical and dependable way. It will furthermore be seen that the apparatus is well adapted to grind to a high degree of accuracy work pieces of special shape or form, an illustrative shape of work piece having been above described and shown in the drawings as comprising a cylindrical work piece having three portions of different diameters, each portion being of a predetermined length in an axial direction; and it might further be pointed out that, in making certain that each successive work piece to be ground is accurately positioned and dependably held in the same position in the grinding throat as its predecessor, a dependable and commercially practicable uniformity of grinding of such specially formed work pieces is brought about. It will furthermore be seen that the highly important advantages and results flowing from the control of the rotation of the work piece by the regulating wheel have been dependably achieved even though the work piece is of special form or shape and has several portions of differing diameters and that such work pieces may be effectively ground to a high degree of accuracy while at the same time achieving a high degree of finish of the ground surfaces.

It will further be seen that there has been provided in this invention a grinding machine which is readily adaptable for grinding a large variety of cylindrical work pieces, particularly work pieces of peculiar or special shape or form, in a more economical and satisfactory manner than has heretofore been possible. Successive work pieces of the same type are brought to the same position between the wheels for grinding action thereon by the grinding wheel and rotation thereof by the regulating wheel and are held accurately in that position throughout the grinding operation, thereby assuring that no irregularities will be formed upon the work due to movement of the work out of the intended or most suitable grinding position. The machine is particularly adapted for the grinding and handling of cylindrical work of special form, such as cylindrical work pieces each of which have two or more portions of slightly different diameters. Heretofore it has been impossible to grind work of this character on an efficient production basis.

The terms "regulating wheel" and "slowly rotated regulating wheel" are to be construed in the now commonly accepted understanding of those skilled in the centerless grinding art, as the latter is defined and set forth in Heim Reissue Patent No. 15.035. The speeds of both the grinding wheel and the regulating wheel must necessarily be varied in accordance with the type and nature of the work to be ground as well as the particular operation to be performed. The grinding wheel is to be rotated at a speed found suitable for grinding the work and the regulating wheel is to be given such a speed that the work will rotate during the grinding operation at that rate which is found desirable for the particular operation to be performed. Without reference to the theory of operation, the regulating wheel serves to control the speed of the work and the work may be given a faster or slower speed by increasing or decreasing the speed of the regulating wheel respectively; and by "speed" of the work is meant the rate of rotation thereof.

As many possible embodiments may be made of the above invention and as many changes might be made in the embodiment above set forth, it is to be understood that all matter hereinbefore set forth or shown in the accompanying drawings, is to be interpreted as illustrative and not in a limiting sense.

Having described my invention, what I claim as new and desire to secure by Letters Patent is:

1. A centerless grinding machine comprising a slowly rotated work regulating wheel and a rapidly rotated grinding wheel, means for holding work therebetween for grinding action by said grinding wheel and for rotation by said regulating wheel, means for moving one of the wheels towards and away from the other, a positively actuated mechanism operating in timed relation with said wheel movement to move a row of axially arranged work pieces progressively forward axially in a path through the grinding zone while the wheels are separated to feed successive work pieces separately to the same position between the wheels for grinding action by said grinding wheel and for rotation by said regulating wheel and then withdrawn, and automatically operated means for replacing ground work when said mechanism is withdrawn.

2. A centerless grinding machine comprising a slowly rotated work regulating wheel and a rapidly rotated grinding wheel, means mounting one of said wheels to permit its movement toward or away from the other,

means for holding work therebetween for grinding action by said grinding wheel and for rotation by said regulating wheel, a reciprocating plunger adapted to move work axially into the grinding zone while the wheels are separated and then withdrawn, and means to relatively approach the wheels to permit the grinding wheel to grind the work during rotation of the work by the regulating wheel and then to relatively separate said wheels, whereby during each cycle of operations a new work piece is moved into the grinding zone and the ground work is pushed axially from the grinding zone.

3. A centerless grinding machine comprising a slowly rotated work regulating wheel and a rapidly rotated grinding wheel, means for holding work therebetween for grinding action by said grinding wheel and for rotation by said regulating wheel, means for moving one of the wheels towards and away from the other wheel, and a reciprocating plunger adapted to move a row of work pieces progressively forward axially to feed each piece to the same grinding position and move ground work axially from the grinding zone when the wheels are separated and remain axially immovable while the wheels are in operative contact with one work piece and then withdraw.

4. A centerless grinding machine comprising a slowly rotated work regulating wheel and a rapidly rotated grinding wheel, means for holding work therebetween for grinding action by said grinding wheel and for rotation by said regulating wheel, means for moving one of the wheels toward and away from the other wheel, and a reciprocating plunger adapted to move a row of work pieces progressively forward axially to feed each piece to the same grinding position when the wheels are separated and remain axially immovable while the wheels are in operative contact with one piece and then withdraw, and means operating automatically for placing a new work piece in the row when said plunger is withdrawn.

5. A centerless grinding machine comprising a slowly rotated work regulating wheel and a rapidly rotated grinding wheel, means for holding work therebetween for grinding action by said grinding wheel and for rotation by said regulating wheel, means for moving one of the wheels towards and away from the other wheel, a reciprocating mechanism adapted to remain axially immovable in contact with a row of axially positioned work pieces while the wheels are in operative contact with one piece and to move the row axially forward to feed another piece to the same grinding position when the wheels are separated and then withdraw, and means cooperating with said mechanism to maintain said row of work pieces axially immovable during grinding.

6. A centerless grinding machine comprising a slowly rotated work regulating wheel and a rapidly rotated grinding wheel, means for holding work therebetween for grinding action by said grinding wheel and for rotation by said regulating wheel, means for moving one of the wheels towards and away from the other wheel, a reciprocating plunger adapted to remain axially immovable against one end of a row of axially positioned work pieces while the wheels are in operative contact with one piece and to move the row axially forward to feed another piece to the same grinding position and push ground work axially from the grinding zone when the wheels are separated and then withdraw, and a friction device cooperating with said row of work pieces and opposed to the action of said mechanism to maintain said row of work pieces axially immovable during grinding.

7. A centerless grinding machine comprising a rapidly rotated grinding wheel, a slowly rotated work regulating wheel below the grinding wheel, an adjustably mounted guide blade for holding work therebetween for grinding action by said grinding wheel and for rotation by said regulating wheel, means for moving one of the wheels towards and away from the other and a positively actuated reciprocating mechanism operated in timed relation with said wheel movement to move a row of work pieces progressively forward axially in a path through the grinding zone while the wheels are separated to feed the work pieces separately to the same position between the wheels for operation thereon by said wheels and then withdraw.

8. A centerless grinding machine comprising a rapidly rotated grinding wheel, a slowly rotated work regulating wheel mounted below the grinding wheel, means for holding work therebetween for grinding action by said grinding wheel and for rotation by said regulating wheel, means for moving one of the wheels towards and away from the other, a mechanism adapted to be reciprocated and operating in timed relation with said wheel movement to move a row of work pieces progressively forward axially in a path through the grinding zone while the wheels are separated to feed successive work pieces separately to the same position between the wheels for operation thereon by said wheels and then withdraw, and automatically operated means for replacing ground work when said mechanism is withdrawn.

9. A centerless grinding machine comprising a rapidly rotated grinding wheel, a slowly rotated work regulating wheel below the grinding wheel, means for holding work therebetween for grinding action by said grinding wheel and for rotation by said regulating wheel, means for moving one of the wheels towards and away from the other

wheel, a reciprocating plunger adapted to remain axially immovable in contact with one end of the row of axially positioned work pieces while the wheels are in grinding contact with one piece and to move the row axially forward to feed another piece in the same grinding position and push ground work axially from the grinding zone when the wheels are separated and then withdraw, and means cooperating with said plunger to maintain said row of work pieces axially immovable during grinding.

10. In grinding apparatus, in combination, a four-sided grinding throat in which work of round section is received for simultaneous grinding and rotation, said grinding throat including a grinding wheel rotatable at a relatively high speed, a regulating wheel rotatable at relatively low speed, said wheels being adapted to present adjacent operative surfaces traveling in opposite directions, a member for holding the work in operative relation to said two wheels and adapted to take up the thrust of the grinding wheel on the work, and a member spaced from said first-mentioned member for taking up the oppositely directed thrust of the regulating wheel on the work, one of said members being yieldably urged toward the other; and means for moving a work piece in an axial direction relative to said grinding throat and between said relatively yieldable members.

11. In grinding apparatus, in combination, a four-sided grinding throat in which work of round section is received for simultaneous grinding and rotation, said grinding throat including a grinding wheel rotatable at relatively high speed, a regulating wheel rotatable at relatively low speed, said wheels being adapted to present adjacent operative surfaces traveling in opposite directions, a member for holding the work in operative relation to said two wheels and adapted to take up the thrust of the grinding wheel on the work, and a member spaced from said first-mentioned member for taking up the oppositely directed thrust of the regulating wheel on the work, one of said members being yieldably urged toward the other; means for separating and approaching one of said two wheels relative to the other; and means for effecting movement of a work piece in an axial direction between said relatively yieldable work holding members and between said wheels.

12. In grinding apparatus, in combination, a four-sided grinding throat in which work of round section is received for simultaneous grinding and rotation, said grinding throat including a grinding wheel rotatable at relatively high speed, a regulating wheel rotatable at relatively low speed, said wheels being adapted to present adjacent operative surfaces traveling in opposite directions, a member for holding the work in operative relation to said two wheels and adapted to take up the thrust of the grinding wheel on the work, and a member spaced from said first-mentioned member for taking up the oppositely directed thrust of the regulating wheel on the work, one of said members being yieldably urged toward the other; means for separating and approaching one of said two wheels relative to the other; and means operative when said wheels are relatively separated for moving a work piece in an axial direction between said relatively yieldable members and relative to the grinding throat, said means being ineffective when one wheel is approached toward the other.

13. In grinding apparatus, in combination, a four-sided grinding throat in which work of round section is received for simultaneous grinding and rotation, said grinding throat including a grinding wheel rotatable at relatively high speed, a regulating wheel rotatable at relatively low speed, said wheels being adapted to present adjacent operative surfaces traveling in opposite directions, a member for holding the work in operative relation to said two wheels and adapted to take up the thrust of the grinding wheel on the work, and a member spaced from said first-mentioned member for taking up the oppositely directed thrust of the regulating wheel on the work, one of said members being yieldably urged toward the other; power actuated means for relatively separating and approaching said wheels in recurring sequence; and means acting in timed relation to said last-mentioned means for moving a work piece in an axial direction between said relatively yieldable members and relative to the grinding throat.

14. In grinding apparatus, in combination, a four-sided grinding throat in which work of round section is received for simultaneous grinding and rotation, said grinding throat including a grinding wheel rotatable at relatively high speed, a regulating wheel rotatable at relatively low speed, said wheels being adapted to present adjacent operative surfaces traveling in opposite directions, a member for holding the work in operative relation to said two wheels and adapted to take up the thrust of the grinding wheel on the work, and a member spaced from said first-mentioned member for taking up the oppositely directed thrust of the regulating wheel on the work, said last-mentioned member being mounted to be yieldably urged toward said first-mentioned work holding member; and means for moving a work piece in an axial direction between said two members and said wheels.

15. In grinding apparatus, in combination, a four-sided grinding throat in which work of round section is received for simultaneous grinding and rotation, said grinding throat including a grinding wheel rotatable

at relatively high speed, a regulating wheel rotatable at relatively low speed, said wheels being adapted to present adjacent operative surfaces traveling in opposite directions, a member for holding the work in operative relation to said two wheels and adapted to take up the thrust of the grinding wheel on the work, and a member spaced from said first-mentioned member for taking up the oppositely directed thrust of the regulating wheel on the work; mechanism having an operative stroke in the direction of said grinding throat equivalent substantially to the length of a work piece to be operated upon and adapted to move a work piece in an axial direction into the grinding throat; means operative when said mechanism is withdrawn to position a work piece in advance thereof, said mechanism being adapted to move said last-mentioned work piece into the grinding throat and to move a ground work piece out of the grinding throat; and means for holding said ground work piece axially immovable after it is moved out of operative relation from the grinding wheel.

16. In grinding apparatus, in combination, a four-sided grinding throat in which work of round section is received for simultaneous grinding and rotation, said grinding throat including a grinding wheel rotatable at relatively high speed, a regulating wheel rotatable at relatively low speed, said wheels being adapted to present adjacent operative surfaces traveling in opposite directions, a member for holding the work in operative relation to said two wheels and adapted to take up the thrust of the grinding wheel on the work, and a member spaced from said first-mentioned member for taking up the oppositely directed thrust of the regulating wheel on the work; mechanism having an operative stroke in the direction of said grinding throat equivalent substantially to the length of a work piece to be operated upon and adapted to move a work piece in an axial direction into the grinding throat; means operative when said mechanism is withdrawn to position a work piece in advance thereof, said mechanism being adapted to move said last-mentioned work piece into the grinding throat and to move a ground work piece out of the grinding throat; and means for yieldably holding said ground work piece axially immovable after it is moved out of operative relation from the grinding wheel and adapted to permit its subsequent discharge upon the completion of the grinding of said second-mentioned work piece.

17. In grinding apparatus, in combination, a four-sided grinding throat in which work of round section is received for simultaneous grinding and rotation, said grinding throat including a grinding wheel rotatable at relatively high speed, a regulating wheel rotatable at relatively low speed, said wheels being adapted to present adjacent operative surfaces traveling in opposite directions, a member for holding the work in operative relation to said two wheels and adapted to take up the thrust of the grinding wheel on the work, and a member spaced from said first-mentioned member for taking up the oppositely directed thust of the regulating wheel on the work; mechanism having an operative stroke in the direction of said grinding throat equivalent substantially to the length of a work piece to be operated upon and adapted to move a work piece in an axial direction into the grinding throat; means operative when said mechanism is withdrawn to position a work piece in advance thereof, said mechanism being adapted to move said last-mentioned work piece into the grinding throat and to move a ground work piece out of the grinding throat, one of said work holding members having a portion extended beyond the grinding wheel; and means for gripping a ground work piece moved out of the grinding throat against said extended portion to hold it axially immovable.

18. In grinding apparatus, in combination, a work regulating wheel rotatable at relatively low speed, a grinding wheel rotatable at relatively high speed, said wheels presenting adjacent operative surfaces traveling in opposite directions and said regulating wheel acting to control the rotation of work of round section interposed between said two wheels, means for holding work of round section between said wheels; power actuated mechanism including a clutch for moving a work piece in an axial direction relatively to said grinding and regulating wheels; and means for controlling said clutch.

19. In grinding apparatus, in combination, a work regulating wheel rotatable at relatively low speed, a grinding wheel rotatable at relatively high speed, said wheels presenting adjacent operative surfaces traveling in opposite directions and said regulating wheel acting to control the rotation of work of round section interposed between said two wheels, means for holding work of round section between said wheels; power actuated mechanism for moving a work piece in an axial direction relative to said grinding and regulating wheels, and means for controlling at will said power actuated mechanism.

20. In grinding apparatus, in combination, a work regulating wheel rotatable at relatively low speed, a grinding wheel rotatable at relatively high speed, said wheels presenting adjacent operative surfaces traveling in opposite directions and said regulating wheel acting to control the rotation of work of round section interposed between said two wheels, means for holding work of round section between said wheels; power actuated mechanism for moving a work piece in an axial direction relative to said grinding and regulating

wheels and means actuated by said mechanism for controlling the operativeness of the latter.

21. In grinding appartus, in combination, a work regulating wheel rotatable at relatively low speed, a grinding wheel rotatable at relatively high speed, said wheels presenting adjacent operative surfaces traveling in opposite directions and said regulating wheel acting to control the rotation of work of round section interposed between said two wheels, means for holding work of round section between said wheels, said wheels having their adjacent operative surfaces stepped so that the grinding wheel will reduce one portion of the work piece to a different diameter from that of another portion of the work piece, means for relatively separating and approaching said wheels and means operable when said wheels are relatively separated to move a work piece relative to said work holding means and to a predetermined position relative to the stepped adjacent surfaces of said wheels.

Signed at Worcester, Massachusetts, this 30th day of Jan., 1926.

HAROLD W. HOLMES.