

Jan. 5, 1937.

S. EINSTEIN

2,066,677

GRINDING MACHINERY

Filed Oct. 26, 1931

6 Sheets-Sheet 1

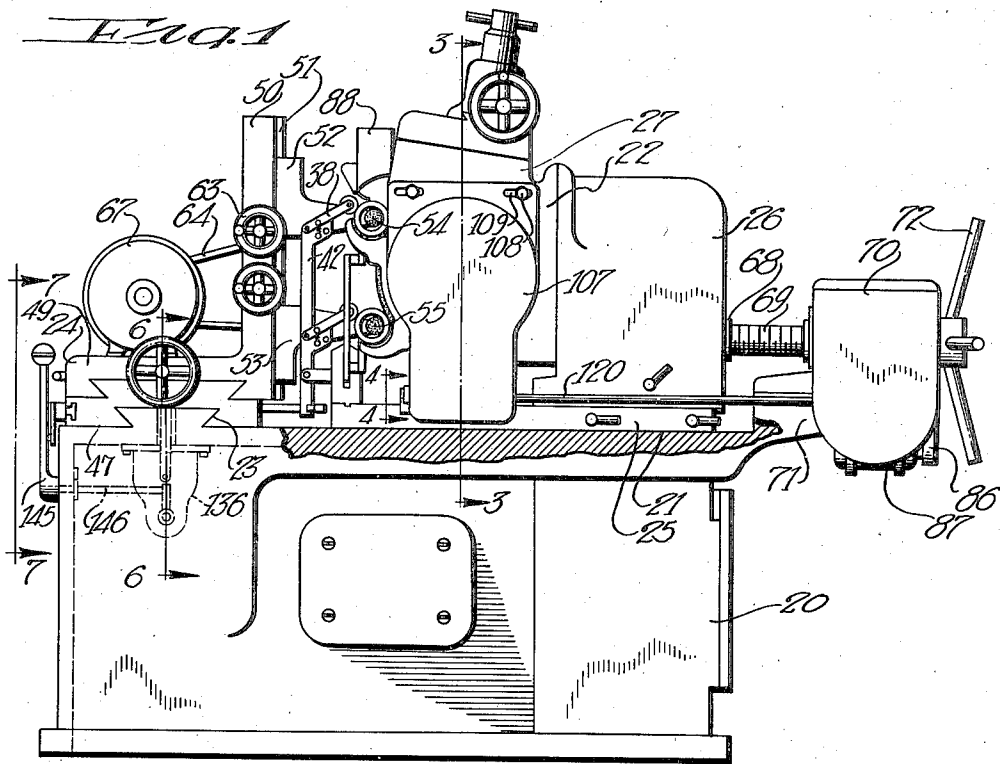
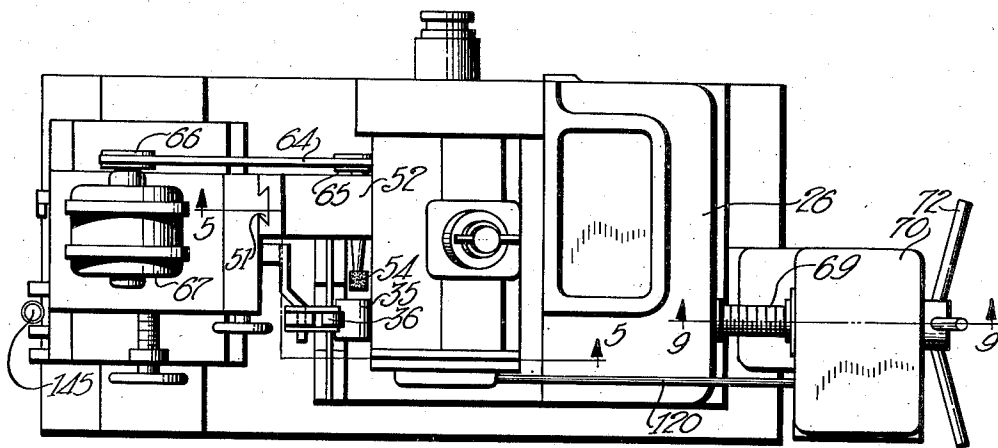


Fig. 2

Inventor

SOL EINSTEIN

OK Parsons
Attorney

Attorney

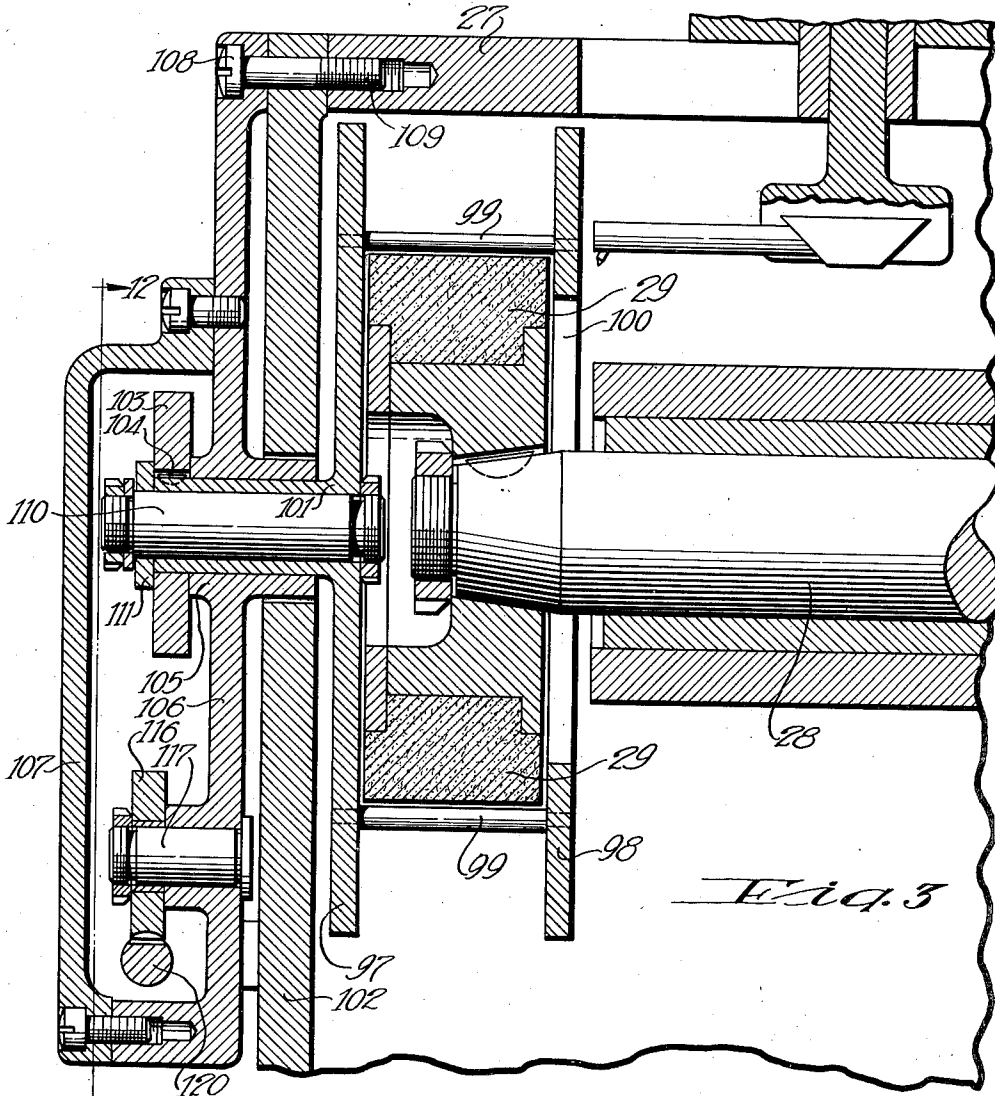
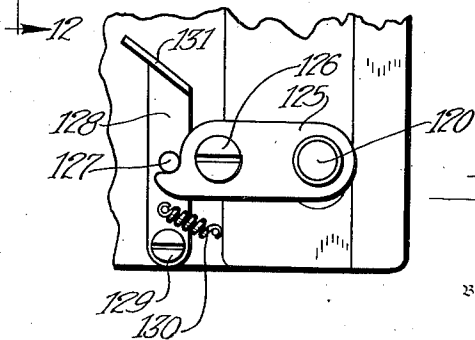
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6 Sheets-Sheet 2



Inventor
SOL EINSTEIN

Attorney
H. K. Parsons

Jan. 5, 1937.

S. EINSTEIN

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6 Sheets-Sheet 3

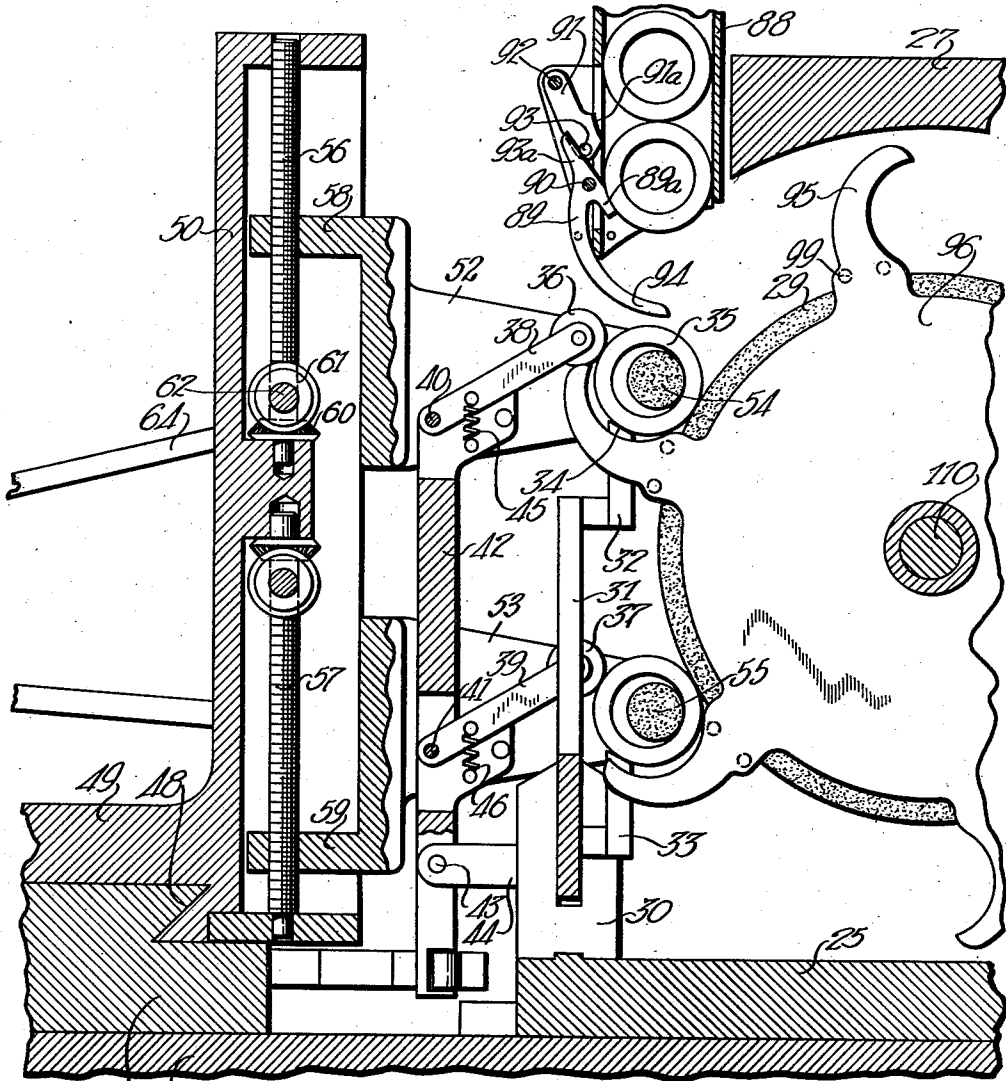


Fig. 5

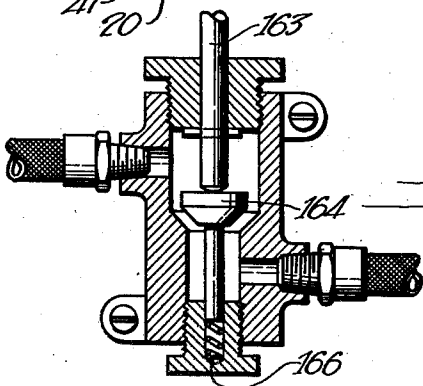


Fig. 8

By

Inventor
SOL EINSTEIN
W. H. Parsons
Attorney

Jan. 5, 1937.

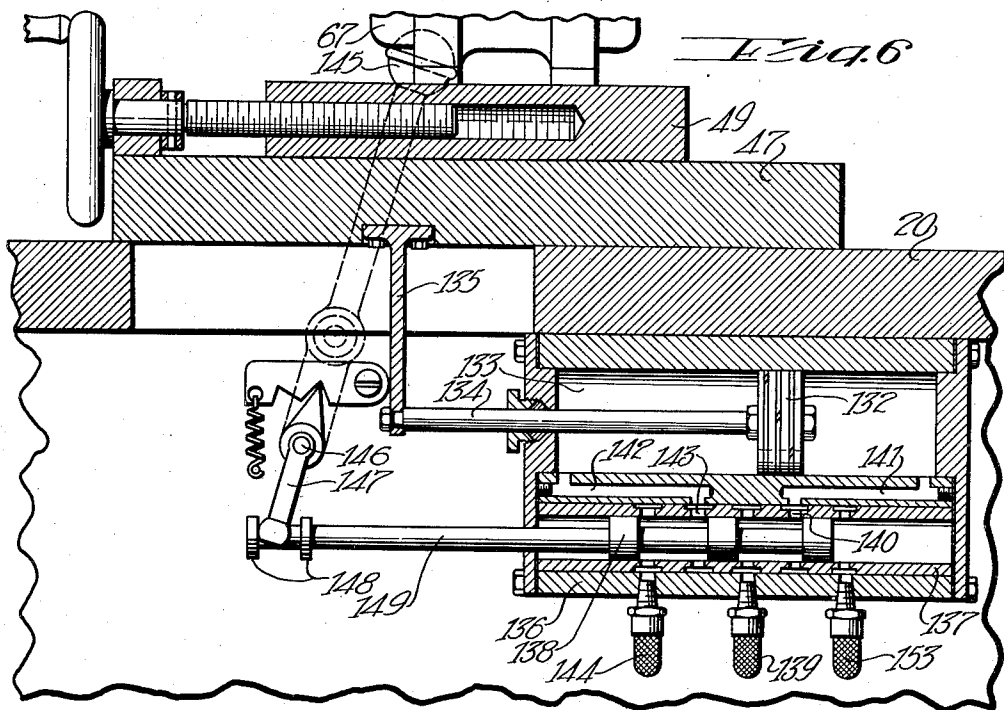
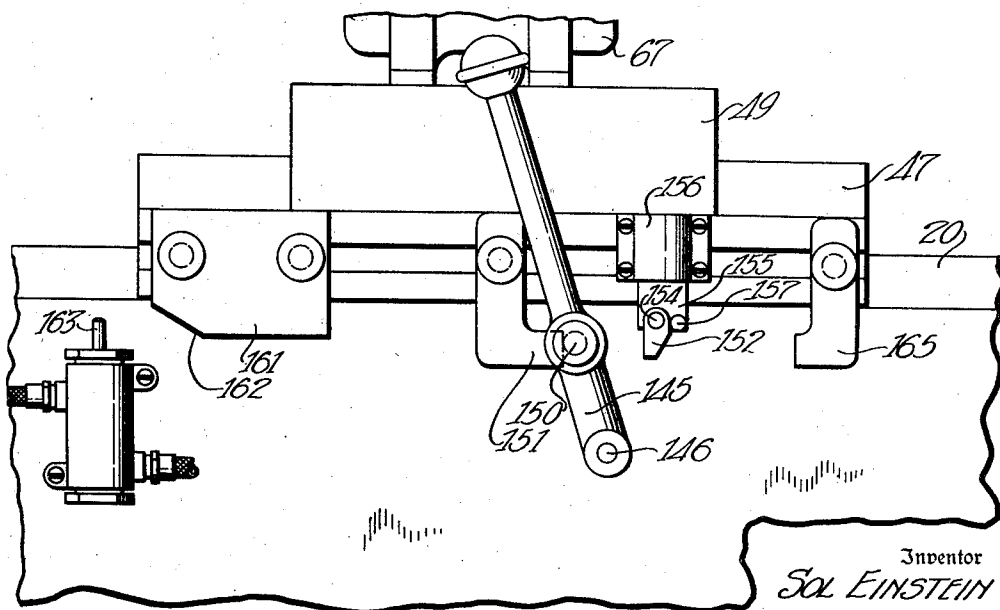
S. EINSTEIN

2,066,677

GRINDING MACHINERY

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6 Sheets-Sheet 4



Inventor

SOL EINSTEIN

By

H. H. Parsons

Attorney

Jan. 5, 1937.

S. EINSTEIN
GRINDING MACHINERY
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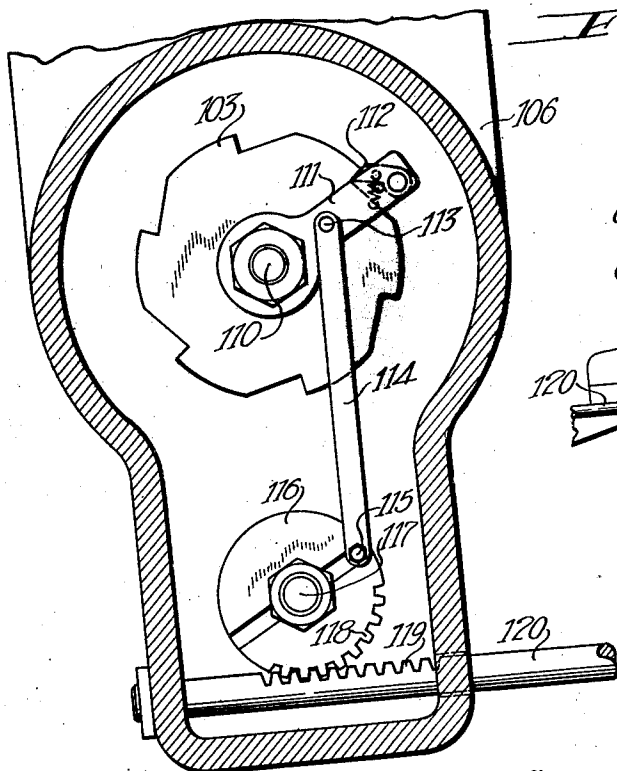


Fig. 12

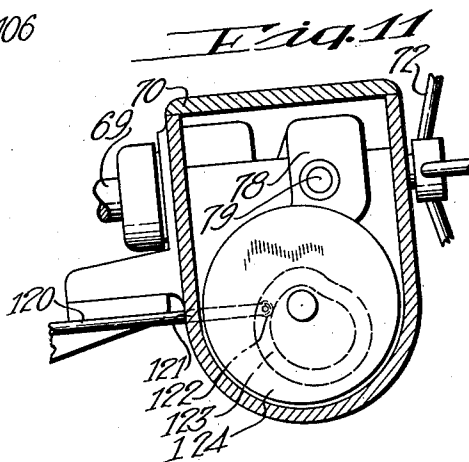


Fig. 11

Fig. 9

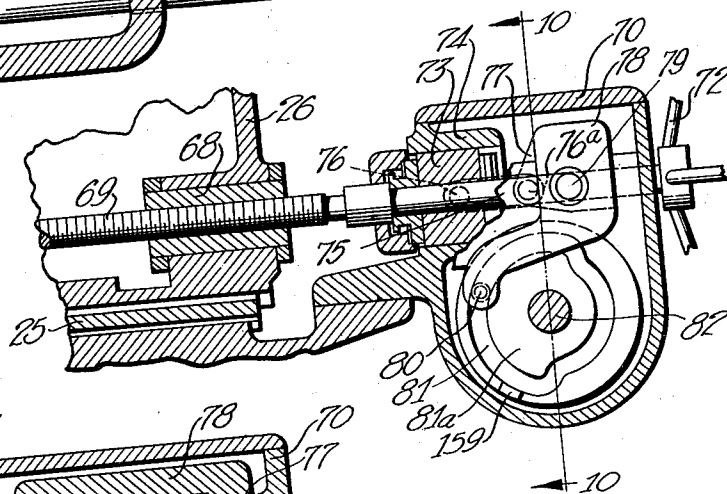
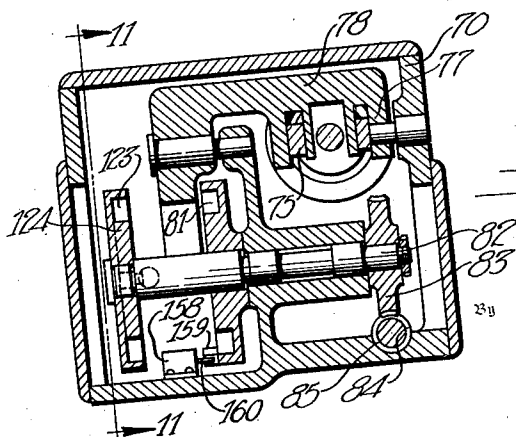


Fig. 10

Inventor

SOL EINSTEIN

CHAS. Parsons

Attorney

Jan. 5, 1937.

S. EINSTEIN

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Fig. 13

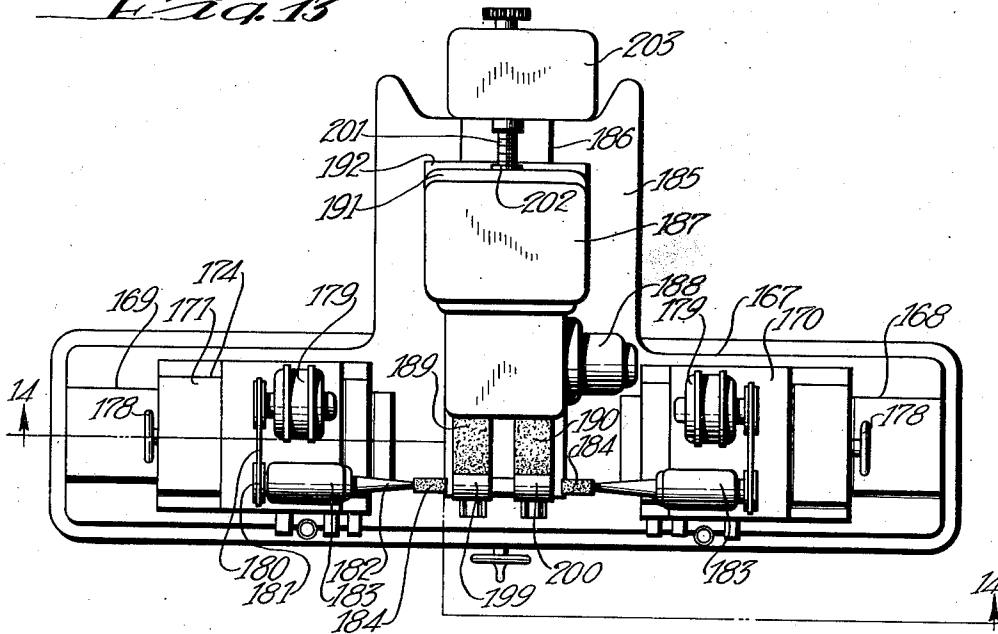
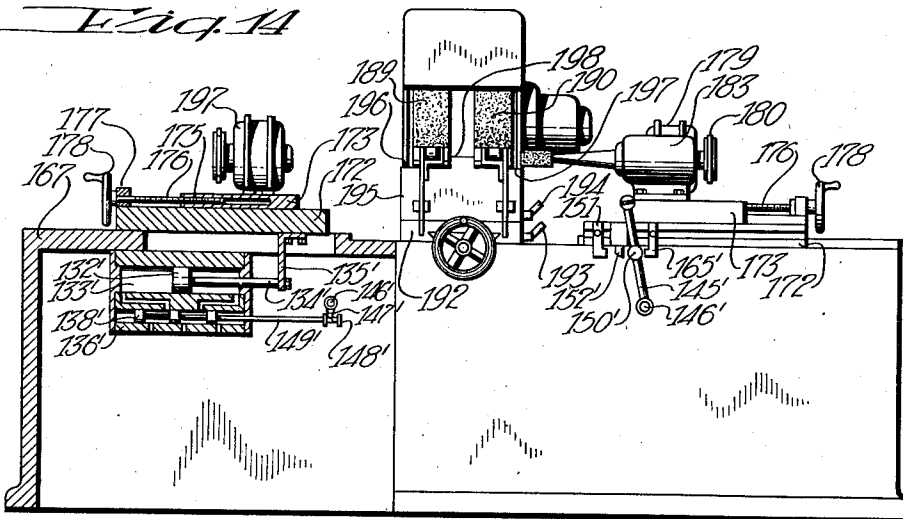


Fig. 14



Inventor

SOL EINSTEIN

234

OK Parsons

Attorney

UNITED STATES PATENT OFFICE

2,066,677

GRINDING MACHINERY

Sol Einstein, Cincinnati, Ohio, assignor, by mesne assignments, to The Heald Machine Company, Worcester, Mass., a corporation of Massachusetts

Application October 26, 1931, Serial No. 571,029

36 Claims. (Cl. 51—103)

This invention relates to improvements in machine tools and especially to improvements in grinding machinery.

An object of this invention is the provision of an improved grinding machine for grinding or generating the hole or bore in hollow work pieces.

Another object of the invention is the provision of an improved internal grinding machine operating on centerless principles for simultaneously grinding or finishing a plurality of work pieces.

A further object of the invention is the provision of a grinding machine for simultaneous rough and finish grinding of work pieces on a single machine, embodying an improved work supporting and rotating mechanism whereby the work may be advanced from one support to another and rotated about the same axis, a result which was extremely difficult with multiple internal grinding machines of previous constructions.

A still further object of the invention is a provision of a multiple spindle, internal grinding machine operated in accordance with well established centerless grinding principles that is automatic in nature for continuously finishing work pieces and thereby reducing idle time of the machine to the absolute minimum.

Other objects and advantages of the present invention should be readily apparent by reference to the accompanying drawings illustrating one possible embodiment of the invention and described in the following specification and it is to be understood that any modifications may be made in the exact structural details there shown and described without exceeding the spirit of the invention as defined in the appended claims.

In the drawings:

Figure 1 is a front elevation of a grinding machine embodying the improvements of this invention.

Figure 2 is a top plan view of the machine illustrated in Figure 1.

Figure 3 is a sectional view taken on line 3—3 of Figure 1.

Figure 4 is an elevational view of certain parts shown in Figure 1 and as seen particularly from line 4—4 thereon.

Figure 5 is a fragmentary sectional view taken on line 5—5 of Figure 2, certain parts being shown in elevation.

Figure 6 is a fragmentary sectional view through the grinding wheel slide as seen from line 6—6 of Figure 1.

Figure 7 is an elevational view of the control

parts for the slide as seen from line 7—7 of Figure 1.

Figure 8 is a vertical sectional view through a hydraulic valve forming a detail of the slide control mechanism.

Figure 9 is a sectional view taken on line 9—9 of Figure 2.

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

Figure 11 is a sectional view taken on line 11—11 of Figure 10.

Figure 12 is a sectional view taken on line 12—12 of Figure 3 illustrating the indexing mechanism for automatically advancing work pieces relative to the grinding throat.

Figure 13 is a top plan view of a modified machine embodying the principles of the invention.

Figure 14 is an elevational view of the machine shown in Figure 13 being partly in section as seen from line 14—14 of Figure 13.

Throughout the several views of the drawings similar reference characters are employed to denote the same or similar parts.

In the past internal grinding machines have been provided for grinding or finishing the internal surface of the bore of cylindrical work pieces. These machines were of the chuck type in which the work was clamped or secured and rotated with the chuck about the axis of the shaft or spindle to which the chuck was secured. The work piece could not be removed from the chuck and later reinserted therein and rotated about the identical axis each time nor could the work be transferred from one machine to another and rotated about the identical axis. The inability to mount a work piece in a chuck with the bore of the workpiece exactly concentric to the axis of rotation of the chuck has made impossible, in precision grinding, the rough grinding of a workpiece by a wheel of the proper grade and the subsequent repositioning of the workpiece in the same or another machine for a finish grinding operation by a second wheel of a suitable grade to provide the desired finish on the workpiece. Accurate grinding to a predetermined diameter has necessitated in the past the complete grinding of the work at the initial chucking and was done by a grinding wheel that was a compromise between the proper roughing wheel and the proper finishing wheel.

By the invention here disclosed the work is rotated on its previously finished external surface so that the said work may be shifted from machine to machine or from position to position in the same machine and still rotate about a single

identical axis. By this method the work may be first rough ground at one station of a single machine, for example, and then advanced to another station for a semi-finishing or a finishing operation thereon. In this way the objections above noted have been eliminated and work pieces having a satisfactory finish produced.

A device for accomplishing this result may comprise a bed 20, having formed on its upper surface ways 21 for the work supporting and controlling unit 22 and additional ways 23 for supporting and guiding the grinding wheel head 24. As will be noted in Figure 1 the ways 21 and 23 are at right angles to one another, whereby the work may be positioned so that the operator can readily observe the action of the grinding wheels on the work.

The work holding unit 22 consists of a lower slide 25 mounted upon the ways 21 and supporting an upper slide 26 superimposed thereon. The slide 26 in turn supports a head 27 in which is journaled a spindle 28, (see Figure 3). The spindle 28 has secured to its free end a regulating wheel 29 composed of suitable abrasive material for frictionally engaging and controlling the rotation of the work. The lower slide 25 has secured to it at its inner end a block 30, Fig. 5, from which rises a bracket 31 supporting at spaced intervals thereon work rest blades 32 and 33. The work rest blades 32 and 33 are each provided with an inclined upper surface 34 inclining in the direction of the active face of the regulating wheel 29 and forming therewith work receiving troughs. As seen in Figure 5, the work 35, herein illustrated as a hollow cylindrical bushing, simultaneously engages the surface 34 of the blades and the adjacent surface of the regulating wheel 29. The said work pieces are held or retained in their respective positions by means of pressure rolls 36 and 37, respectively rotatably supported by arms 38 and 39, each pivoted as at 40 and 41 to a bracket 42 which is in turn pivoted at 43 to arm 44 carried by the block 30. Springs 45 and 46 are provided for respectively actuating the arms 38 and 39 toward the work pieces.

The wheel head 24 consists of a main or lower slide 47, Fig. 5, engaging with the way 23, and is provided on its upper surface with a way 48 for the supplemental or upper slide 49. This slide 49 has rising from it a vertical column 50 provided on its forward face with a dovetailed guide 51 on which are mounted a pair of heads 52 and 53, Fig. 1, each head having journaled therein a spindle for supporting the grinding wheels 54 and 55 respectively.

The grinding wheels 54 and 55 are adapted to simultaneously enter the bores in the work pieces supported by the blades 32 and 33 respectively. The heads 52 and 53 are adjustable independently relative to the column 50 by means of screws 56 and 57 respectively, Fig. 5, received in threaded bosses 58 and 59 extending respectively from the heads 52 and 53. Each adjusting screw has secured thereto a bevel gear 60, meshing with a complementary gear 61 on the end of a shaft 62, said gears being operated by hand wheels 63, Fig. 1. The grinding wheels 54 and 55 are adapted to be rotated at a high grinding rate of speed by means of a belt or like 64 extending about pulleys 65 on the ends of the grinding wheel spindles, the belt deriving its power from a pulley 66 secured to and driven by motor 67 mounted on the upper side of slide 49.

The work is adapted to be automatically fed radially into the grinding wheel through the fol-

lowing mechanism. The upper slide 26 has secured thereto a nut 68, Figs. 1 and 9, receiving the threaded end of an adjusting cross feed screw 69 which passes through the housing 70 secured to the bed as at 71. The screw 69 has secured thereto exteriorly of the housing 70 a pilot or hand wheel 72 whereby the screw may be rotated for adjusting the slide. Interiorly of the housing 70 the screw has secured to it the slide block 73, Fig. 9, guided in the bearing 74 integral with said housing. Pitmans 75 are pivoted at one end as at 76, to the slide block 73 and at their other ends by pins 76a to lugs 77 extending from the arm 78. The arm 78 is in turn pivoted at 79 to housing 70 and carries at its lowermost end a roller 80 received in cam groove 81 of the cam 81a carried by the cam shaft 82. The cam shaft 82 has secured to it a worm wheel 83, Fig. 10, meshing with a worm 84 on worm shaft 85 driven through suitable transmission means 86, Fig. 1, 20 from the motor or prime mover 87 secured to the housing 70 at its lowermost surface.

From the foregoing it will be noted that rotation of the cam 81a will oscillate the arm 78 for effecting an axial shifting of the cross feed screw 69 and slide 26 for effecting a feed of the work toward the grinding wheel to effect a stock removal therefrom. The rotation of cam 81a also provides for a withdrawal of the workpieces from engagement with the work rests 32 and 33 and pressure rolls 36 and 37 to make possible the movement of the workpieces from one grinding position to the next. The movement of the regulating wheel 29 to withdraw the workpieces from the work rests and pressure rolls renders the yielding holding means, that is, the pressure rolls, inoperative while the workpieces are moved from one grinding position to the next.

As will be noted from the drawings two workpieces will be operated upon simultaneously, one having a roughing cut performed while the other is having the internal bore thereof finish ground. The work pieces are advanced from the roughing to the finishing station automatically and an unground workpiece automatically brought to the rough grinding position. The mechanism for accomplishing this result comprises a magazine 88, Fig. 5, in which are loaded the workpieces or to which they may be fed by a hopper and are retained therein by means of a spring pressed trigger 89 pivoted as at 90 to the regulating wheel head 27. An arm 91 pivoted at 92 cooperates with the trigger 89 and holds the work pieces in the magazine during the discharge of the lowermost work piece from the magazine. This is accomplished through a pin 93 carried by the arm 91 engaging with the tail 93a of the trigger 89. For this purpose the arm 91 has an arcuate seat 91a for engagement with the second lowermost work piece. The operation of these parts is as follows: The trigger 89 is actuated in a clockwise direction to withdraw the lug 89a of the trigger 89 from the lowermost work piece and allow same to drop from the magazine. This movement of the trigger 89 carries with it the tail 93a which pushes on the pin 93 extending from arm 91 and actuates it in a counter-clockwise direction to shift the arcuate seat 91a into holding engagement with the second lowermost work piece.

The trigger 89 terminates in a long curved finger 94 adapted to be engaged by the carrying arms 95 of work carrying frame or drum indicated generally in Figure 5 by the numeral 96. As seen in Figure 3 the frame or drum 96 comprises end plates 97 and 98 joined together by suitable con-

necting pins 99. The plate 98 is provided with an enlarged bore 100 surrounding and spaced from the regulating wheel spindle 28 and lying to the rear of the back face of the said regulating wheel 29 when seen from the front of the machine. The plate 97 is on the forward side of the regulating wheel 29 and has extending from it a sleeve 101 which passes through the cover 102 of the head 27. The sleeve 101 has secured to its forward end a ratchet 103 being held against relative movement as by the key 104. The sleeve 101 in addition is journaled in a bearing 105 of an adjustable supporting plate bracket 106 to which is secured a cover 107 enclosing the ratchet 103. The bracket or plate 106 is held in adjusted position by means of bolts 108 which extend through elongated perforations 109 in the forward end of the head 27. The plate sleeve 101 has loosely journaled therein a shaft 110 to the end of which is secured the arm 111, Figs. 3 and 12, bearing spring pressed pawl 112 for engagement with the teeth of ratchet 103. One end of a link 114 is pivoted at one end to the arm 111 and has its other end adjustably pivoted at 115 to a plate 116 secured to the end of a stub shaft 117. The stub 117 is rotatably journaled in the bracket 106 near its lowermost end. The plate 116 is provided on its circumferential surface with gear teeth 118 meshing with rack teeth 119 of rack bar 120. This bar 120 extends longitudinally on the front face of the machine and is guided at its rear end in a bearing 121, Fig. 11, integral with the housing 70. The terminus of the bar 120 is within the housing 70 and carries a roller 122 received in a cam slot 123 formed in the face of the cam 124 which is secured by any desirable means to the cam shaft 82.

From the foregoing it will be noted that the work carrying frame or drum 96 is actuated in timed relation to the in and out movement of the slides 25 and 26. This is accomplished by mounting the cams 81 and 124 on the same shaft so that they are rotated in unison and kept in timed relation. The cam 124 in rotating with the shaft 82 effects the axial shifting through the roller 122 of the rack bar 120 thereby oscillating the plate 116 first in a clockwise direction and then in a counter-clockwise direction. This effects through the link 114 similar oscillation of the arm 114 carrying the pawl 112 into engagement with successive teeth on the ratchet 103.

As the plate 116 and arm 111 are actuated counter clockwise, the ratchet 103 is similarly shifted, rotating the work carrying drum in a counter clockwise direction. This causes the fingers 95 to successively engage with the finger 94 of the trigger 89 for relieving the pressure against the lowermost work piece in the magazine and permitting it to drop into position for conveyance to the roughing station for the first operation thereon. At this time the workpiece previously roughed is carried down to the finishing station from which the previous workpiece has been discharged. It should be noted that this loading and ejecting of the workpiece takes place when the slides 25 and 26 are in their fully retracted position.

In order that the slides may be manually adjusted for setting up purposes and the like, the rack bar 120 is so mounted or constructed as to have the rack teeth 119 thereof disengaged from the rack teeth 118 of the disc 116 during this adjustment. A readily releasable support is provided which may comprise, as seen in Figure 4, an arm 125 pivoted at 126 to the adjustable plate

or bracket 106. The arm 125 is so mounted that the weight of the rack bar 120 tends to oscillate it about its pivot in a clockwise position as seen in Figure 4, but this tendency is restrained by means of the pin 127 extending from a latch 128 pivoted at 129 to the plate 106. A spring 130 having opposite ends secured to the latch 128 and the plate 106, effectively holds the latch and arm 125 in position to maintain proper driving engagement between the rack bar teeth 119 and the disc teeth 118. In order to break this driving connection it is merely necessary to exert a force on the finger piece 131 of the latch 128 to overcome the resistance of spring 130, whereupon the bar 120 drops by gravity breaking the connection with the plate 116.

The grinding wheels are axially reciprocated during the grinding operation in order to break up grinding lines on the work and provide the most desirable finish thereon. This reciprocation of the wheels is accomplished by the reciprocation of slides 47 and 49 together with the parts carried thereby by hydraulic pressure acting on opposite sides of a piston 132 contained within the cylinder 133. The piston 132 has extending from it the piston rod 134 connected to the lower end of the arm or bracket 135 secured to the under surface of the lower slide 47. The said bracket 135 extends through a suitable opening in the upper surface of the bed 20 to the interior thereof where there is mounted the block or bracket 136 containing the cylinder 133. The block or bracket 136 further has pressed into it, beneath the cylinder 133, a bushing 137 forming a sleeve for the spool valve 138 acting as a reversing valve for controlling the direction of flow of the hydraulic pressure. As seen in Figure 6 the hydraulic pressure is conveyed to the valve by means of conduit 139 and is directed to the port 140 connected with channel 141 terminating at the right hand end of the cylinder 133 as seen in Figure 6. This causes the pressure to actuate the piston 132 to the left as seen in said figure discharging the hydraulic medium ahead of the piston through the channel 142 to the port 143 where it enters the valve bushing 137 and is directed by the valve 138 to the exhaust conduit 144. In response to this movement of the piston 133 the slides 47 and 49 are actuated to the left therewith until the valve 138 is reversed or shifted to its extreme right hand position which is opposite to that illustrated in Figure 6. This is accomplished through a reversing lever 145 secured to a shaft 146, journaled in the walls of bed 20 and carrying on its inner end a valve shifter arm 147, the end of which is positioned between collars 148 at the end of the piston rod 149 for the valve 138.

The lever 145 has extending from it intermediate its end a pin 150 adapted to be normally engaged by adjustable dogs 151 and 152 which normally determine the limits of the reciprocatory stroke of the grinding wheels through the work. After the valve 38 has been shifted for reversing the flow of fluid the said flow will be from the conduit 139, port 143, and channel 142, to the left hand end of the cylinder 133, for actuating the piston 132 therein to the right as seen in Figure 6 and exhausting the hydraulic medium therein through the channel 141, port 140, valve chamber 137 and branch exhaust conduit 153.

The normal reciprocation of the grinding wheels which takes place during the actual grinding operation does not completely withdraw the said wheels from bore of the work so that additional movement must be given the wheels at the

time the workpieces are shifted from one station to the next. For this reason the reversing dog 152 is pivotally mounted at 154 on the slidable core 155 of a solenoid 156 which is adjustably carried by the lower slide 47. The solenoid 156 is included in a normally interrupted electrical circuit whereby the dog 152 lies in a position to engage the reversing pin 150 and the said dog 152 is held against movement about its pivot in one direction by a stop 157 extending from the core 155. The circuit of the solenoid 156 is completed at the time that the cross feed mechanism is procuring retraction of the cross feed movement, said solenoid being energized by the closing of a switch 158, Fig. 10, in the circuit through the cam 159 depressing the movable switch member 160. The energization of the solenoid 156 retracts the dog 152 from alinement with the pin 150 so that the slides 47 and 49 continue on past their normal reversing point retracting the grinding wheels completely from bore of the work, and shifting of the work from one station to the other thus takes place without interfering with said grinding wheels. The mechanism is so timed that the slides continue in a retracting direction and carry with them a cam 161, Fig. 7, which engages through its inclined face 162 a depressible valve actuator 163 for closing a needle valve 164, Fig. 8, in the feed line through which the hydraulic medium flows. This needle valve is normally open a definite amount to determine the rate of the hydraulic medium and the normal rate of reciprocation of the slides. The closing or partial closing of this valve 164 reduces the flow of the hydraulic pressure or medium and thereby slows up the rate of movement of the slides. The slow movement continues until the reversing lever pin 150 is engaged by the dog 165 which is also carried by the slide 47 whereupon the reversing of valve takes place. The return movement of slide 47 is at first a slow one until the cam face 162 rides off the valve actuator 163 whereupon the previously compressed spring 166 expands and returns the valve 164 to its normal proper operating position. At this time the work pieces have been properly positioned so that the grinding wheels now enter the bores therein and the grinding operation is resumed.

During the operation of the machine, the member 42 is held against movement and the feeding action between the grinding wheel and the work piece is procured by an advancing movement of the regulating wheel 29 toward the left, Fig. 1, which urges the work pieces against the grinding wheels. With the machine in the position of Fig. 5, the grinding operation on the work pieces continues with the grinding wheels 54 and 55 cutting deeper and deeper into the work piece as a result of the forward movement of the wheel 29 until the latter is advanced to a predetermined point as determined by the cam 81 on the rotating shaft 82. As the regulating wheel reaches its forward position, the cam 159 which rotates with the cam 81 operates the switch 158, thereby withdrawing the grinding wheels 54 and 55 toward the rear of the machine for positioning said wheels in spaced axial relation to the bores of the work pieces. During the axial separation of the grinding wheels, the regulating wheel 29 is withdrawn to the right by the cam 81 to separate said wheel from the work supports 32 and 33 and from the pressure wheels 36 and 37, this retracting movement being sufficient to permit the upper work piece 35 to move downwardly between the support 32 and the regulating wheel. As the

grinding wheel reaches its retracted position, the cam 124 on the shaft 82 procures, through the pawl 112 and the ratchet wheel 103, a counterclockwise movement of the carrier 96, thereby shifting the upper work piece 35 downwardly into a position for engagement with the grinding wheel 55 during a subsequent advance of the regulating wheel and releasing the lowermost work piece from the magazine 88 and positioning said work piece for engagement with the upper grinding wheel 54. After the counterclockwise advance of the carrier 96, the regulating wheel 29 is again advanced by the cam 81 bringing the spaced work pieces into engagement with the supports 33 and 34 and the pressure wheels 36 and 37 for centerless rotation of the work pieces during the subsequent grinding operation. During the advance of the work pieces from one grinding station to the next, the carriage 49 carrying the grinding wheels moves slowly toward the rear of the machine, the direction of movement being reversed by the dog 165 so that when the work pieces are in the position of Fig. 5, during the advance of the regulating wheel 29, the grinding wheels 54 and 55 are returned axially toward the work pieces for entry within the bores thereof. The grinding operation is then repeated as above outlined.

The modification shown in Figures 13 and 14 embodies the same principles as above described and includes a bed 167 of a substantial T-shape. The arm of the bed has formed on its upper surface, and extending from opposite ends toward the center thereof, guides 168 and 169 on which are respectively mounted wheel heads 170 and 171. As above, the wheel heads consist of a pair of slides 172 and 173, the former being guided by the guide ways 168 and 169, the latter being guided on additional ways 174 formed on the slide 172. The upper slide 173 is provided with a threaded portion 174 receiving the screw 176 rotatably journaled in block 177 extending upward from the slide 172. Secured to the screw of 176 whereby it may be operated is a hand wheel 178. The upper slide 175 supports a motor 179 geared or belted as by means of belt 180 to a pulley 181 on the end of a grinding wheel spindle 182 journaled in bearing box 183. The motor 179 is rotated at a high rate of speed for properly rotating the spindle 182 and small internal grinding wheel 184 secured thereto.

The stem or bed extension 185 is provided with a guide way 186 for guiding the work driving and controlling head 187. The head 187 has journaled in the bearing 188 a spindle to which is secured a pair of regulating wheels 189 and 190. The wheel head 187 is secured to or formed integral with a slide 191 superimposed on a lower or second slide 192 that engages with the guide 186. Clamps 193 and 194 may be provided for connecting the slides to one another for movement as a unit relative to the bed and for securing the lower slide to the bed for independent actuation of the slides. The lower slide 192 carries at its foremost end a work rest 195 having a pair of supporting surfaces 196 and 197 spaced from one another by a center upstanding lug 198 which limits the movement of the work pieces 199 and 200 toward one another.

The slides are independently and jointly adjusted by means of a screw 201 threaded into a nut 202 carried by the rear portion of the upper slide 191 in a manner similar to the mounting of nut 68 as shown in Figure 9. The screw is journaled in a box 203 carried by the bed extension 185.

sion 185 in a manner similar to the mounting of the adjusting screw 69 in box or housing 70. The same mechanism is inclosed within the box or housing 203 as above described in connection with the box or housing 70 so that the screw 201 is axially shifted to effect a relative feed between the grinding wheels 184 and the work to effect the proper stock removal therefrom.

The slides 172 and 173 are reciprocated relative to the bed 167 and the ways 168 and 169 by the hydraulic means illustrated in connection with Figures 1 to 12 inclusive, the corresponding parts being indicated with prime characters in Figures 13 and 14.

The operation of the modified disclosure is as follows: A work piece is placed on the work supporting surface 196 and the machine started in operation which consists in axially shifting the head 171 from the position shown in Figure 13 to insert the wheel within the bore in the work piece 199. The work head 187 is then actuated toward the front of the machine to feed the work piece and grinding wheel into one another, the grinding wheel reciprocating continuously while in contact with the work. As soon as the work head has been shifted the full amount as determined by the cam within the housing 203, it is retracted to separate the wheel and the work. Simultaneously the stroke of the grinding wheel is extended through the retraction of the normal stroke limiting dog whereupon the grinding wheel of the wheel head 71 passes completely out of the work.

The work piece 199 is now placed in the position of the work piece 200 and a new unfinished work piece placed on the supporting surface 196 whereupon both wheel heads 170 and 171 are actuated towards one another. At this time the wheel head 171 is roughing, in the same manner as above described, the new work piece on the supporting face 196 while the grinding wheel of the head 170 is finishing the previously roughed work piece.

It will be noted, however, that in both modifications illustrated in the drawings, the work pieces are rotated about an axis determined by the finished supporting surfaces of the work pieces so that they may be advanced from machine to machine or from station to station in the same machine as above described.

What is claimed is:

1. An internal grinding machine for grinding the bore of hollow cylindrical work pieces comprising a bed, a plurality of work supports on the bed for peripheral engagement with work pieces, a rotary drive wheel frictionally engaging the peripheries of the work pieces for effecting their rotation, a plurality of pressure members adjacent said work supports for holding the work pieces against the drive wheel, and a grinding wheel for each work support carried by the bed and reciprocable relative to the work pieces.

2. An internal grinding machine for grinding the bore of hollow cylindrical work pieces comprising a bed, a plurality of work supports on the bed for peripheral engagement with work pieces, a rotary drive wheel frictionally engaging the peripheries of the work pieces for effecting their rotation, a grinding wheel for each work support carried by the bed and reciprocable relative to the work pieces on said supports, and means for effecting a relative feeding movement between the grinding wheels and the work pieces on the work supports to reduce the work pieces correspondingly.

3. In a grinding machine, the combination of a plurality of work supports, an opposed regulating wheel forming, with the work supports, work receiving troughs at points peripherally spaced along the regulating wheel surface, a plurality of grinding wheels corresponding in spacing to the work supports for grinding the internal bore of work pieces on the work supports simultaneously, and means for holding the work pieces in the work receiving troughs and against the regulating wheels.

4. In an internal grinding machine the combination of a bed, grinding wheels carried thereby, a slide carried thereby and translatable relative thereto, a bracket on the slide, a plurality of work rests on the bracket, a regulating wheel opposed to the work rests and forming work receiving troughs thereby, means mounting the regulating wheel on the slide, pressure means for urging work pieces on each of said work rests into engagement with the regulating wheel, and means for actuating the slide and parts supported thereby toward the grinding wheels for effecting a stock removal from the work.

5. In an automatic internal grinding machine the combination of a bed, a rotatable friction drive wheel carried by the bed for movement relative thereto, a hopper, a work carrier, a plurality of work supports peripherally spaced about the friction drive wheel and defining spaced grinding stations, and means carried by the hopper and carrier cooperating with one another to release workpieces from the hopper and advance same to the several grinding stations.

6. In an automatic internal grinding machine the combination of a bed, a rotatable friction drive wheel carried by the bed for movement relative thereto, a hopper, a work carrier, a plurality of work supports peripherally spaced about the friction drive wheel and defining spaced grinding stations, means carried by the hopper and carrier cooperating with one another to release workpieces from the hopper and advance same to the several grinding stations, means for intermittently actuating the work carrier, and means for holding the workpieces in frictional engagement with the friction drive wheel.

7. In an automatic internal grinding machine the combination of a bed, a rotatable friction drive wheel carried by the bed for movement relative thereto, a hopper, a work carrier, a plurality of work supports peripherally spaced about the friction drive wheel and defining spaced grinding stations, means carried by the hopper and carrier cooperating with one another to release workpieces from the hopper and advance same to the several grinding stations, means for intermittently actuating the work carrier, means for holding the work piece in frictional engagement with the friction drive wheel, a grinding wheel for each grinding station, means for reciprocating the grinding wheels within the bore of the work pieces being operated upon, and additional means for extending the reciprocatory stroke of the grinding wheels prior to the shifting of the work pieces from the hopper and from station to station.

8. A wheel head for internal grinding machines comprising a slide, a bed supporting the slide, a second slide superimposed on the main slide, a column rising from the second slide, a plurality of wheel heads on the column, means for adjusting the wheel heads relative to the column, means for adjusting the slides relative to one another, and means coupled with the main

slide for effecting the reciprocation thereof and parts carried thereby.

9. A wheel head for internal grinding machines comprising a slide, a bed supporting the slide, a second slide superimposed on the main slide, a column rising from the second slide, a plurality of wheel heads on the column, means for adjusting the wheel heads relative to the column, means for adjusting the slides relative to one another, means coupled with the main slide for effecting reciprocation thereof and parts carried thereby, said means comprising a piston, a piston rod connected to the slide, an hydraulic pressure source for axially actuating the piston, a valve operable to control the direction of flow of the hydraulic medium and consequently the direction of reciprocation of the slide, and dog means for determining the length of stroke of the piston.

10. A wheel head for internal grinding machines comprising a slide, a bed supporting the slide, a second slide superimposed on the main slide, a column rising from the second slide, a plurality of wheel heads on the column, means for adjusting the wheel heads relative to the column, means for adjusting the slides for effecting reciprocation thereof and parts carried thereby, said means comprising a piston, a piston rod connected to the slide, an hydraulic pressure source for axially actuating the piston, a valve operable to control the direction of flow of the hydraulic medium and consequently the direction of reciprocation of the slide, dog means for determining the length of stroke of the piston, and means for rendering the dog means inoperative to effect an extended stroke of the slide and parts carried thereby.

11. An internal grinding machine for roughing and finishing work pieces comprising a regulating wheel, a slide supporting said wheel, a bracket on the slide having a plurality of work rest blades secured thereto and cooperating with the regulating wheel for forming work receiving troughs defining spaced grinding stations, a second slide on the bed and shiftable transversely thereof, a grinding wheel for each work support carried by the second slide, means for actuating the first slide to effect a relative feed between the regulating and grinding wheels, and means for advancing work pieces from station to station at the conclusion of each grinding operation.

12. An internal grinding machine for roughing and finishing work pieces comprising a regulating wheel, a slide supporting said wheel, a bracket on the slide having a plurality of work rest blades secured thereto and cooperating with the regulating wheel for forming work receiving troughs defining spaced grinding stations, a second slide on the bed and shiftable transversely thereof, a grinding wheel for each work support carried by the second slide, means for actuating the first slide to effect a relative feed between the regulating and grinding wheels, means for advancing work pieces from station to station at the conclusion of each grinding operation, said means for feeding the work and wheel toward one another and for advancing the work from station to station comprising a cam shaft, and a pair of cams on the cam shaft each having operative connections respectively with the work advancing means and the feeding means.

13. An internal grinding machine for grinding the bore of hollow cylindrical work pieces comprising a bed, a plurality of spaced work supports on the bed for peripheral engagement with

work pieces, a rotary drive wheel frictionally engaging the peripheries of the work pieces for effecting their rotation, a plurality of spaced grinding wheels carried by the bed and reciprocable relative to the work pieces, means to withdraw said grinding wheels from operative relation to the work, and means for procuring advancement of the work pieces from one work support to the next while said grinding wheels are in inoperative position.

14. An internal grinding machine for grinding the bore of hollow cylindrical work pieces comprising a bed, a plurality of spaced work supports on the bed for peripheral engagement with work pieces, a rotary drive wheel frictionally engaging the peripheries of the work pieces for effecting their rotation, a plurality of spaced grinding wheels carried by the bed and reciprocable relative to the work pieces, means for effecting a radial feeding movement between the grinding wheels and the work pieces to reduce said work pieces, means to procure withdrawal of said grinding wheels relative to the work pieces to inoperative position, and means to advance the work pieces to the successive work supports while said grinding wheels are in inoperative position.

15. An internal grinding machine for grinding the bore of hollow work pieces comprising a bed, a plurality of spaced work supports on the bed for peripheral engagement with work pieces, a rotary drive wheel frictionally engaging the peripheries of the work pieces on said work supports for effecting a rotation of said work pieces, a plurality of spaced grinding wheels carried by the bed, means for withdrawing said grinding wheels from operative relation to the work pieces, and means for advancing the work pieces from one work support to the next while said grinding wheels are in inoperative position.

16. An internal grinding machine for grinding the bore of hollow work pieces comprising a bed, a plurality of spaced work supports on the bed for peripheral engagement with work pieces, a rotary drive wheel frictionally engaging the peripheries of the work pieces on the work supports for effecting a rotation of said work pieces, a plurality of spaced grinding wheels carried by the bed, means for effecting a radial feeding movement between the grinding wheels and the work pieces for grinding the latter, means to procure withdrawal of said grinding wheels relative to the work pieces to inoperative position, and means to advance the work pieces to the successive work supports while said grinding wheels are in inoperative position.

17. An internal grinding machine for grinding the bore of hollow cylindrical work pieces comprising a bed, a plurality of spaced work supports on the bed for peripheral engagement with work pieces, a rotary drive wheel frictionally engaging the peripheries of the work pieces for effecting their rotation, a plurality of spaced grinding wheels carried by the bed and reciprocable relative to the work pieces, means to withdraw said grinding wheels from operative relation to the work, and means for procuring advancement of the work pieces from one work support to the next while said grinding wheels are in inoperative position, and for simultaneously placing an unground work piece on the first work support.

18. In a grinding machine, the combination of a plurality of work supporting members, an opposed regulating wheel forming, with the work supporting members, work receiving troughs at

points peripherally spaced about the regulating wheel surface, a plurality of grinding wheels corresponding in spacing to the work supporting members for grinding the internal bore of work

5 pieces on each supporting member simultaneously, means for holding the work pieces in the work receiving troughs and against the regulating wheel, and a work carrier for advancing the work pieces from one support to the next.

10 19. An internal grinding machine comprising a bed, a plurality of spaced work supports on the bed for peripheral engagement with work pieces, a rotary drive wheel frictionally engaging the peripheries of the work pieces on the work supports for effecting the rotation of said work

15 pieces, a plurality of spaced grinding wheels carried by the bed, means for effecting a radial feeding movement between the grinding wheels and the work pieces for grinding said work pieces, means operating in timed relation to the feeding means for procuring separation between said grinding wheels and the work pieces, and means for advancing the work pieces to the successive work supports while said grinding wheels are in

20 inoperative position.

20. An internal grinding machine comprising a bed, a plurality of spaced work supports on the bed for peripheral engagement with work pieces, a rotary drive wheel frictionally engaging the peripheries of the work pieces on the work supports for effecting the rotation of said work

30 pieces, a plurality of spaced grinding wheels carried by the bed, means for effecting a radial feeding movement between the grinding wheels and the work pieces for grinding said work pieces, and a work carrier actuated in timed relation to the feeding means for advancing the work pieces from one work support to the next.

21. An internal grinding machine comprising a bed, a plurality of spaced work supports on the bed for peripheral engagement with work pieces, a rotary drive wheel frictionally engaging the peripheries of the work pieces on the work supports for effecting the rotation of said work

40 pieces, a plurality of spaced grinding wheels carried by the bed, means for effecting a radial feeding movement between the grinding wheels and the work pieces and a subsequent retraction of the feeding movement, means to procure axial separation between the grinding wheels and the work pieces, and a work carrier for advancing the work pieces from one work support to the next while said grinding wheels are axially withdrawn from the work pieces, said carrier being actuated in timed relation to the radial feeding means.

22. An internal grinding machine for grinding bores of hollow cylindrical workpieces, comprising a base, a plurality of work supports on the base for peripheral engagement with workpieces, a rotary drive wheel frictionally engaging the peripheries of the workpieces on the several supports for rotation thereof, means for holding the workpieces against said work supports and drive wheel, and a grinding wheel for each support carried by the base.

23. An internal grinding machine for grinding the bores of hollow cylindrical workpieces, comprising a base, a plurality of work supports on the base for peripheral engagement with workpieces, a rotary drive wheel frictionally engaging the peripheries of the workpieces for a rotation thereof, and a grinding wheel for each work support carried by the base and movable relative to said work supports.

24. An internal grinding machine for grinding the bores of hollow cylindrical workpieces, comprising a base, a plurality of work supports on the base for peripheral engagement with workpieces, a rotary drive wheel frictionally engaging the peripheries of the workpieces for a rotation thereof, a grinding wheel for each work support carried by the base and movable relative to said work supports for withdrawing the wheels from the bores of the workpieces, and means for advancing the workpieces from one work support to the next.

25. An internal grinding machine comprising a base, a plurality of centerless work supporting structures on said base, each of said structures having a plurality of supporting members engageable with the periphery of a workpiece, a grinding wheel for each of said structures carried by the base and movable relative to the structures, and a carrier for advancing workpieces from one supporting structure to the next.

26. An internal grinding machine comprising a base, a plurality of centerless work supporting structures on said base, each of said structures having a plurality of supporting members engageable with the periphery of a workpiece in said structure, one of said members being common to all said structures, a grinding wheel for each of said structures carried by the base and movable relative to the structures, and a carrier for advancing workpieces from one supporting structure to the next.

27. An internal grinding machine comprising a base, a rotary drive wheel on said base, a magazine, a plurality of work supports peripherally spaced about the rotary drive wheel and defining spaced grinding stations, a grinding wheel for each grinding station, a work carrier for advancing workpieces from one station to the next, and cooperating means on the magazine and carrier for releasing workpieces from said magazine.

28. An internal grinding machine comprising a base, a rotary drive wheel on said base, a magazine, a plurality of work supports peripherally spaced about the rotary drive wheel and defining spaced grinding stations, a grinding wheel for each grinding station, a work carrier for advancing workpieces from one station to the next, cooperating means on the magazine and carrier for releasing workpieces from said magazine, and means for intermittently actuating the carrier.

29. In a grinding machine, a base, a plurality of centerless work-supporting structures on said base, each of said structures comprising a plurality of supporting members engageable with the periphery of a workpiece, a grinding wheel on said base for each of said structures, said wheels corresponding substantially in spacing to the spacing of the supporting structures, and a carrier for advancing workpieces from one structure to the next.

30. In a grinding machine, a base, a plurality of centerless work-supporting structures on said base, each of said structures comprising a plurality of supporting members engageable with the periphery of a workpiece, a grinding wheel on said base for each of said structures, a magazine, and a carrier for advancing workpieces from the magazine to the structures and from each structure to the succeeding structure.

31. In an internal grinding machine, a plurality of work-supporting structures comprising a regulating wheel and a plurality of work supports peripherally spaced about the regulating wheel and defining spaced grinding stations, a plurality of

grinding wheels corresponding in spacing substantially to the spacing of the work supports, a slide, and means for actuating said slide for a relative axial movement between the grinding
5 wheels and workpieces on said work supports, and a second slide for procuring a transverse movement between said wheels and workpieces.

32. An internal grinding machine comprising a base, a plurality of centerless work-supporting
10 structures on said base, each of said supporting structures comprising a plurality of work-supporting members engageable with the periphery of a workpiece, one of said members being positively rotated for a rotation of the workpieces, a
15 plurality of spaced grinding wheels carried by the base, means for withdrawing said grinding wheels from operative relation to the workpieces in the work-supporting structures, and means for advancing the workpieces from one supporting
20 structure to the next while said grinding wheels are in inoperative position.

33. An internal grinding machine for grinding the bore of hollow cylindrical workpieces comprising a bed, a plurality of spaced work supports on
25 the bed for peripheral engagement with workpieces, a rotary drive wheel frictionally engaging the peripheries of the workpieces for effecting their rotation, a plurality of spaced grinding wheels carried by the bed and movable relative
30 to the workpieces, means for effecting a radial feeding movement between the grinding wheels and the workpieces to reduce said workpieces.

34. An internal grinding machine comprising a base, a plurality of centerless work-supporting
35 structures on said base, each of said supporting structures comprising a plurality of work-supporting members engageable with the periphery of a work-piece, one of said members being positively rotated for a rotation of the workpieces, a
40 plurality of spaced grinding wheels carried by the base, means for effecting a radial feeding movement between the grinding wheels and the workpieces in the supporting structures, means for withdrawing said grinding wheels from operative relation to the workpieces in the work-supporting
45 structures, and means for advancing the workpieces from one supporting structure to the

next while said grinding wheels are in inoperative position.

35. In an internal grinding machine, a plurality of spaced grinding wheels, means for supporting and rotating an annular workpiece during a
5 grinding operation on the bore thereof by each of said wheels successively, said means including a regulating wheel and at least one work rest, said regulating wheel and work rest being engageable with the periphery of the workpiece, 10
means operative at the end of each grinding operation for procuring a relative axial withdrawal movement between the operative grinding wheel and the workpiece engaged thereby for removing the wheel from the bore of the workpiece, and 15
means for advancing said workpiece relative to said grinding wheels between successive grinding operations and while the previously operative grinding wheel is withdrawn from the bore of the workpiece, said advancing means positioning said
20 workpiece in a position for engagement by the succeeding grinding wheel.

36. In an internal grinding machine, a plurality of spaced grinding wheels, means for supporting and rotating an annular workpiece during a
25 grinding operation on the bore thereof by each of said wheels successively, said means including a regulating wheel and at least one work rest, said regulating wheel and work rest being engageable with the periphery of the workpiece, means operative at the end of each grinding operation for
30 procuring a relative axial withdrawal movement between the operative grinding wheel and the workpiece engaged thereby for removing the wheel from the bore of the workpiece, and means 35
for advancing said workpiece relative to said grinding wheels between successive grinding operations and while the previously operative grinding wheel is withdrawn from the bore of the workpiece, said advancing means positioning said
40 workpiece in a position for engagement by the succeeding grinding wheel, said advancing means also placing an unground workpiece in position for engagement by the previously operative grinding wheel during the successive grinding opera-
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