

Sept. 10, 1957

H. A. SILVEN
GRINDING MACHINE

2,805,524

Filed Aug. 16, 1956

5 Sheets-Sheet 1

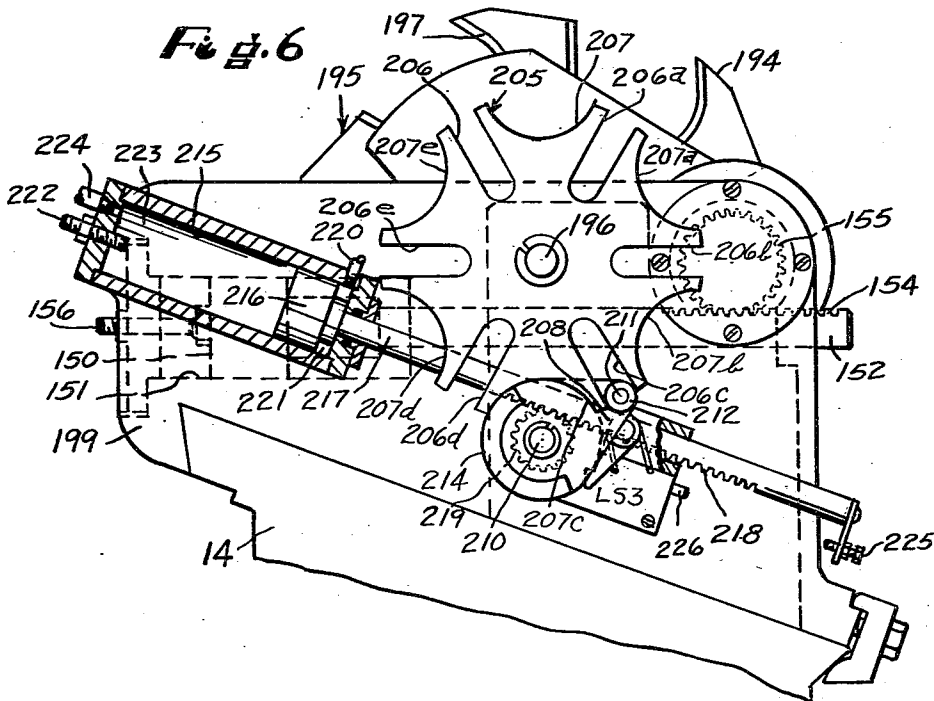
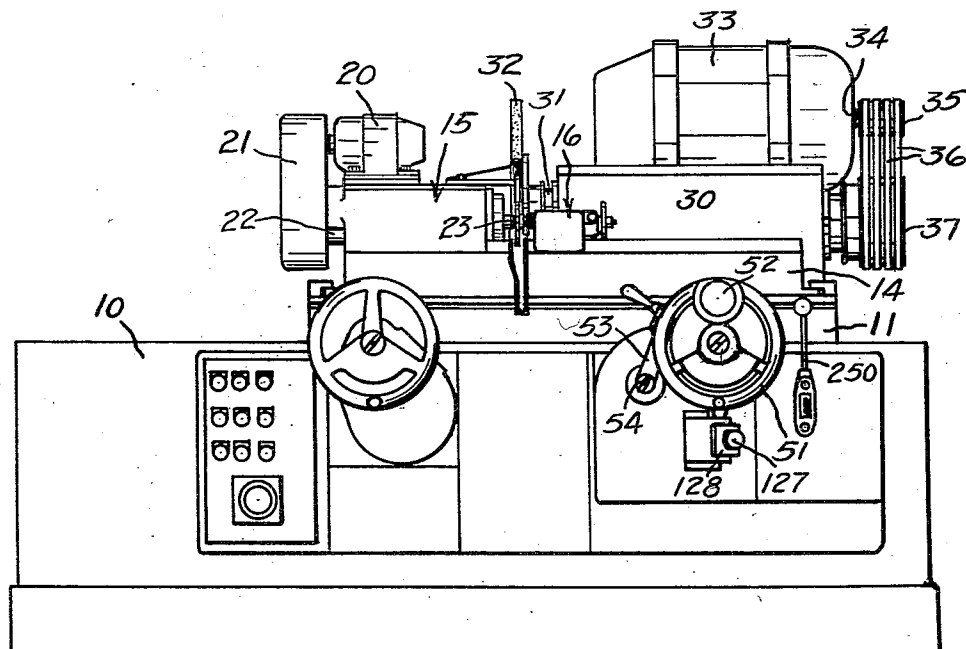


Fig. 1

INVENTOR
HERBERT A. SILVEN
BY
Harold W. Eaton
ATTORNEY

Sept. 10, 1957

H. A. SILVEN
GRINDING MACHINE

2,805,524

Filed Aug. 16, 1956

5 Sheets-Sheet 2

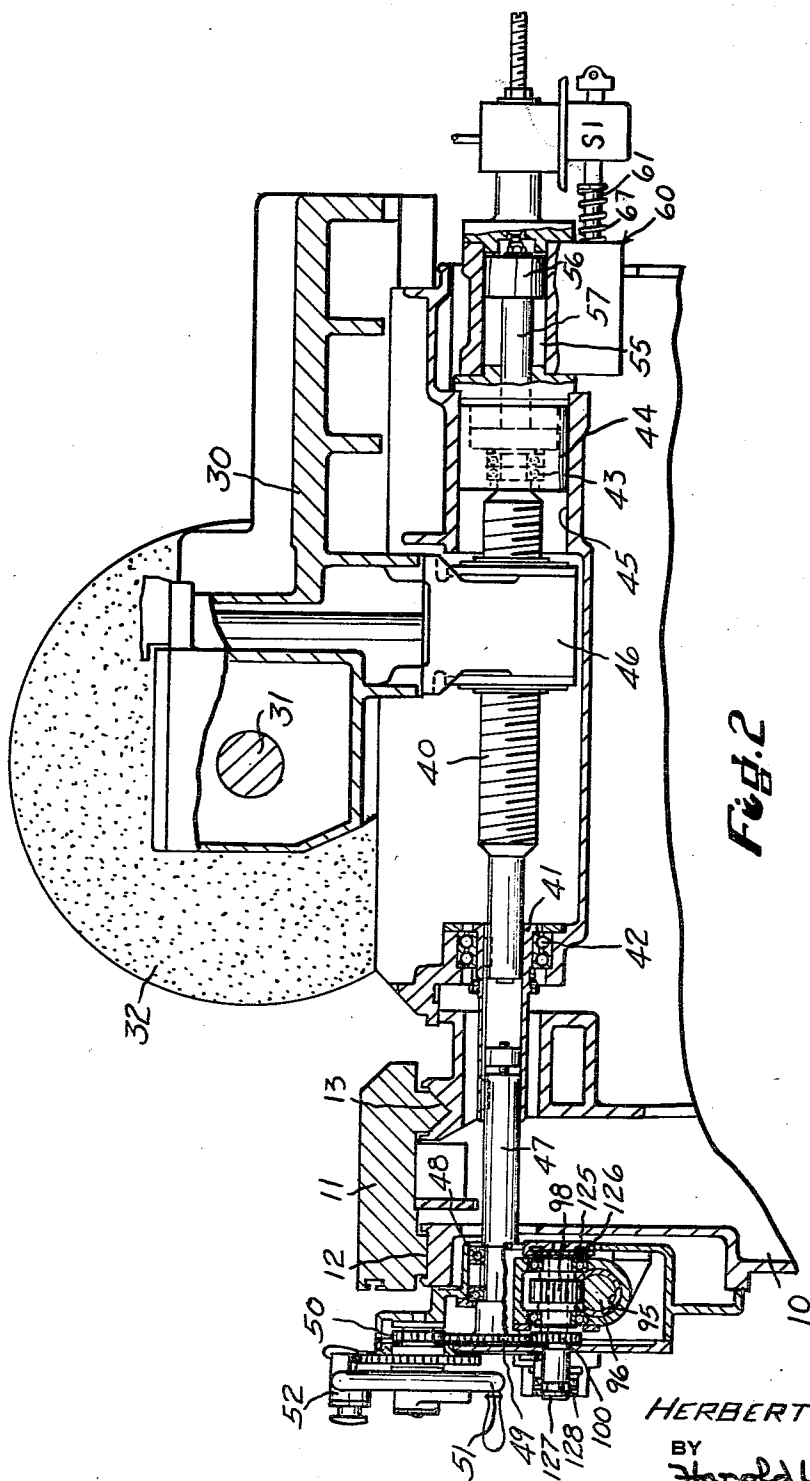


Fig. 2

INVENTOR
HERBERT A. SILVEN
BY
Harold W. Eaton
ATTORNEY

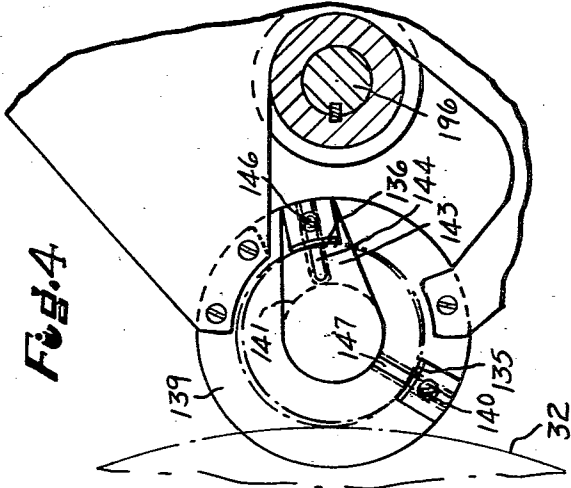
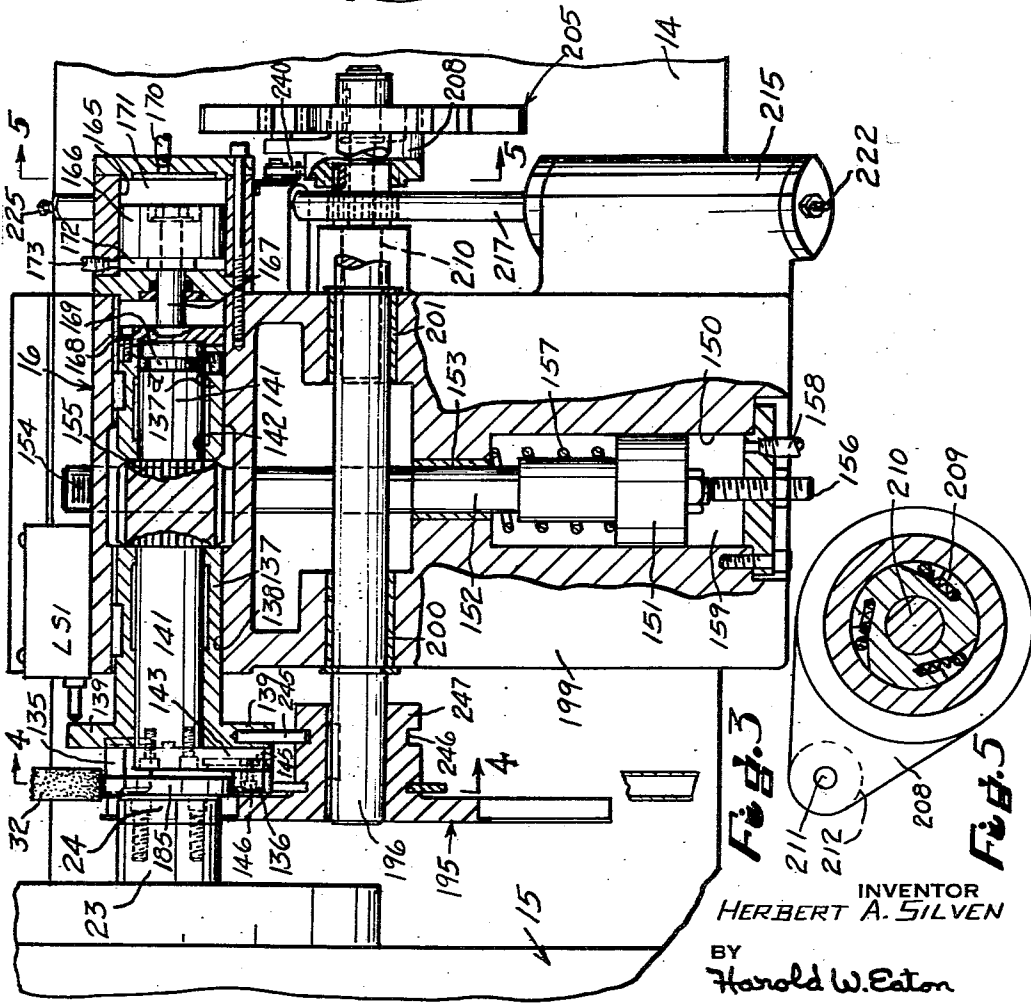
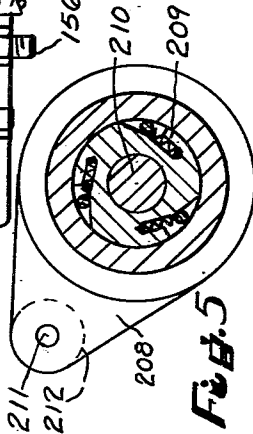
Sept. 10, 1957

H. A. SILVEN
GRINDING MACHINE

2,805,524

Filed Aug. 16, 1956

5 Sheets-Sheet 3



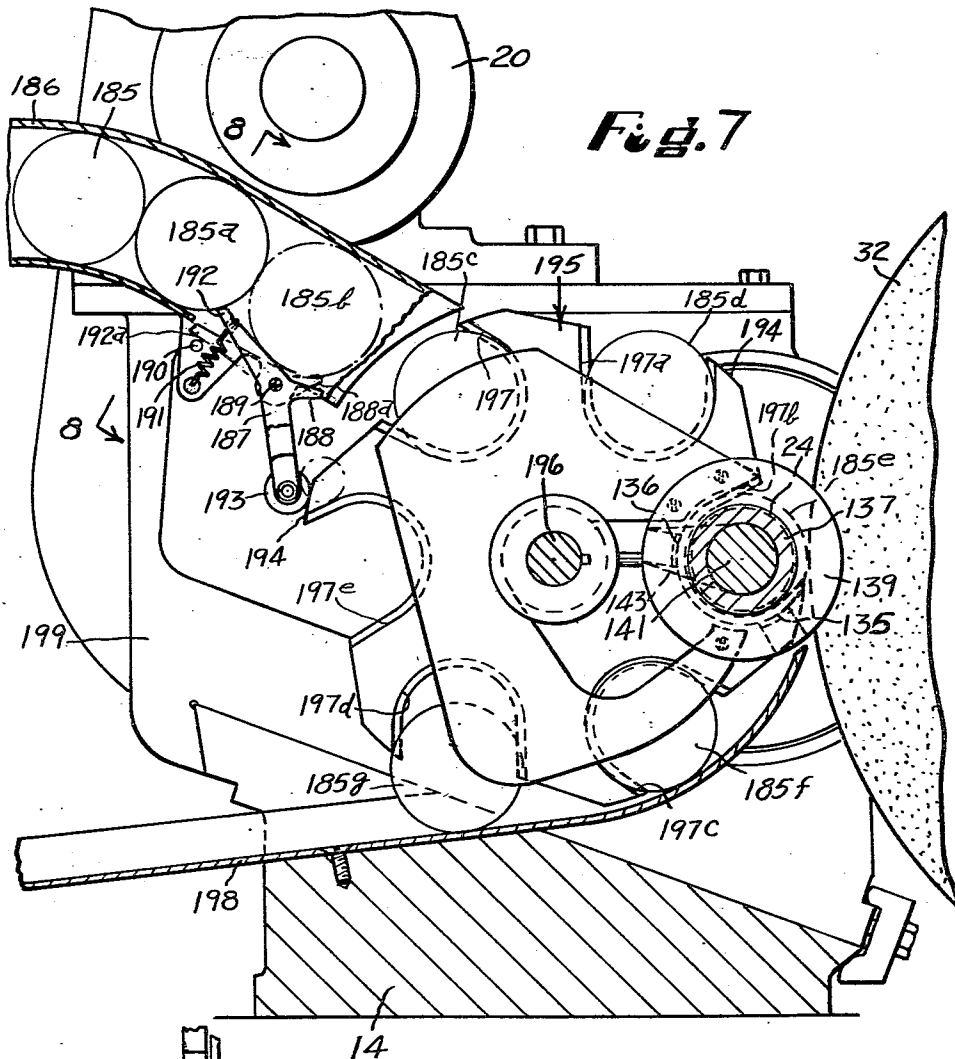
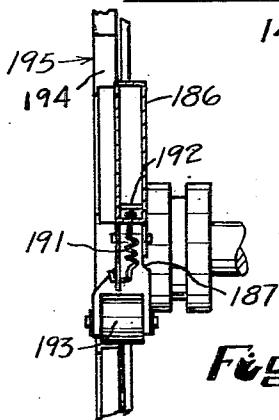
Sept. 10, 1957

H. A. SILVEN
GRINDING MACHINE

2,805,524

Filed Aug. 16, 1956

5 Sheets-Sheet 4



INVENTOR
HERBERT A. SILVEN
BY
Harold W. Eaton
ATTORNEY

Sept. 10, 1957

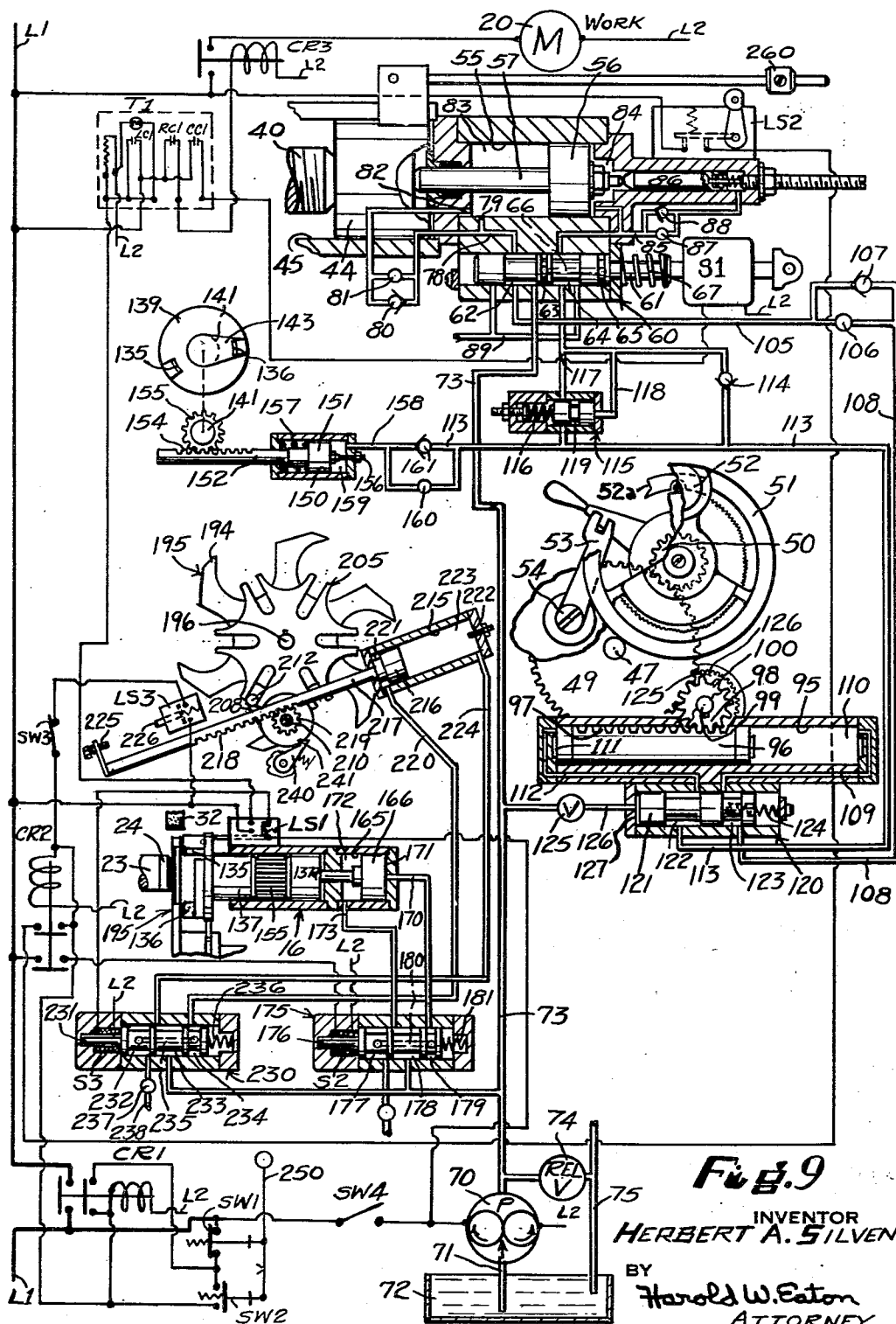
H. A. SILVEN

2,805,524

GRINDING MACHINE

Filed Aug. 16, 1956

5 Sheets-Sheet 5



1

2,805,524

GRINDING MACHINE

Herbert A. Silven, West Boylston, Mass., assignor to Norton Company, Worcester, Mass., a corporation of Massachusetts

Application August 16, 1956, Serial No. 604,378

11 Claims. (Cl. 51—103)

The invention relates to grinding machines, and more particularly to a centerless-type grinding machine.

One object of the invention is to provide a simple and thoroughly practical automatically operated centerless grinding machine. Another object is to provide a centerless grinding machine in which successive work pieces are supported by a pair of spaced work shoes and driven by a rotatable driving element. Another object is to provide a pair of work supporting shoes, one of which is fixed and the other is movable toward the fixed shoe in an arcuate path to facilitate rounding-up the work piece being ground. Another object is to provide a shoe moving mechanism for imparting a control led arcuate movement to the movable work supporting shoe by and in timed relation with the infeeding movement of the grinding wheel.

A further object is to provide an automatically operated work loading mechanism for conveying successive work pieces into operative grinding position. Another object is to provide an automatically indexed work loading turret for conveying successive work pieces to and from a grinding position. Another object is to provide means for moving the work supporting shoes to and from an operative position to facilitate actuation of the work loading turret. Other objects will be in part obvious or in part pointed out hereinafter.

In the accompanying drawings in which is shown one of various possible embodiments of the mechanical features of this invention;

Figure 1 is a front elevation of the improved grinding machine;

Figure 2 is a fragmentary vertical sectional view on an enlarged scale, through the grinding machine showing the wheel feeding mechanism;

Figure 3 is a fragmentary horizontal section view, on an enlarged scale through the work head;

Figure 4 is a fragmentary left hand end elevation, on an enlarged scale, taken approximately on the line 4—4 of Fig. 3, showing the arrangement of the work supporting shoes;

Figure 5 is a fragmentary sectional view on an enlarged scale taken approximately on the line 5—5 of Fig. 3 through a portion of the work loading turret actuating mechanism;

Figure 6 is a right hand end elevation of the work turret indexing mechanism, as shown in Fig. 3;

Figure 7 is a vertical sectional view, through the work loading mechanism including the work chute and loading turret;

Figure 8 is a fragmentary sectional view, taken approximately on the line 8—8 of Fig. 7; and

Figure 9 is a combined hydraulic and electric diagram of the actuating mechanisms and the controls therefor.

A grinding machine has been illustrated in the drawings comprising a base 10 which supports a longitudinally movable work table 11 on the usual flat way 12 and the V-way 13 (Fig. 2) formed on the upper surface of the base 10. The table 11 serves as a support for swivel

2

table 14 which carries a headstock unit 15 and a footstock unit 16.

The work head 15 is provided with a suitable driving mechanism including an electric motor 20 mounted on the upper surface of the head 15. The motor 20 is connected by a multiple V-belt drive (not shown) contained within a belt guard 21 to drive a rotatable shaft 22. The shaft 22 is operatively connected to impart a rotary motion to a work driving spindle 23. The work spindle 23 serves as a support for a frictional-type work driver, such as a permanent magnet chuck 24 which is arranged in a manner hereinafter described to impart a rotary motion to the work piece to be ground.

The base 10 also supports a transversely movable wheel slide 30 on the conventional flat way and V-way (not shown). The wheel slide 30 is provided with a rotatable wheel spindle 31 which supports a grinding wheel 32 at its left hand end (Fig. 1). A grinding wheel driving mechanism is provided comprising an electric motor 33 mounted on the upper surface of the wheel slide 30. The motor 33 is provided with a motor shaft 34 which supports a multiple V-groove pulley 35. The pulley 35 is connected by multiple V-belts 36 with a multiple V-groove pulley 37 mounted on the right hand end of the wheel spindle 31 (Fig. 1).

A feeding mechanism is provided for imparting a transversely feeding movement to the wheel slide 30. A screw 40 (Fig. 2) is provided for transmitting a traverse feeding movement to the wheel slide 30. The left hand end of the feed screw 40 is slidably keyed within a rotatable sleeve 41 which is journaled in anti-friction bearings 42 which are fixedly supported relative to the base 10. The right hand end of the feed screw 40 is supported by anti-friction bearings 43 which are carried by a slidably mounted sleeve 44. The sleeve 44 is arranged to slide transversely within a cylindrical aperture 45 formed in fixed relation to the base 10. The wheel slide 30 is provided with a depending bracket 46 which contains a rotatable feed nut (not shown) which meshes with or engages the threads on the feed screw 40. A rotatable shaft 47 is slidably keyed within the left hand end of the sleeve 41. The left hand end of the shaft 47 is journaled in anti-friction bearings 48. A gear 49 mounted on the left hand end of the shaft 47 meshed with a gear 50. The gear 50 is operatively connected to be rotated by a manually operable feed wheel 51 which is supported on the front of the machine base 10. The feed wheel 51 is provided with the well-known micrometer feeder adjusting mechanism 52. A feed pawl 53 is pivotally supported by a stud 54 on the front of the machine base. An adjustable stop abutment 52a (Fig. 9) carried by the feed wheel 51 is arranged to engage the end face of the pawl 53 to facilitate positively stopping the end feeding movement of the wheel slide 30.

A hydraulically operated mechanism is provided for imparting a rapid positioning movement to the wheel slide 30 to facilitate rapidly moving of the grinding wheel 32 into an engagement with the work piece being ground and to rapidly withdraw the grinding wheel to an inoperatively positioning after a grinding operation has been completed. This mechanism comprises a cylinder 55 which is arranged in axial alignment with the feed screw 40 and the sleeve 44. The cylinder 55 contains a slidably mounted piston 56 mounted on the right hand end of a piston rod 57 (Fig. 2 and 9). The left hand end of the piston rod 57 is operatively connected to move the sleeve 44 so as to transmit a corresponding movement to the feed screw 40, the wheel slide 30, and the grinding wheel 32.

A feed control valve 60 is provided for controlling the admission to and exhaust of fluid from the cylinder 55. The control valve 60 is a piston type valve compris-

3

ing a slidable valve member 61 having a plurality of spaced valve pistons formed integrally therewith to form spaced valve chambers 62, 63, 64 and 65. The slidably mounted valve member is provided with a central passage 66 which interconnects the valve chamber 63 with the valve chamber 65. A compression spring 67 serves normally to hold the valve member 61 in a right hand end position. A solenoid S1 is provided which when energized serves to shift the valve member 61 toward the left so as to reverse the flow of fluid to the cylinder 55.

A fluid pressure system is provided for supplying fluid under pressure to the various actuating mechanisms of the machine. This system comprises a motor driven fluid pump 70 which draws fluid through a pipe 71 from a reservoir 72 and passes fluid under pressure through a pressure pipe 73. A relief valve 74 is connected with the pipe 73 to facilitate exhausting excess fluid under pressure directly through a pipe 75 into the reservoir 72 thereby maintaining a substantially constant fluid pressure with the system.

In the position of the valve 60 (Fig. 9) fluid under pressure from the pressure pipe 73 enters the valve chamber 62 and passes through a passage 78 and through a port 79 into a cylinder chamber 83 formed at the left hand end of the cylinder 55. Fluid under pressure passing through the passage 78 also passes through a ball check valve 80 and a throttle valve 81 into the cylinder chamber 83 to move the piston 56 toward the right (Fig. 9) into a rearward position thereby moving the wheel slide 30 and the grinding wheel 32 away from engagement with the work piece being ground. During this movement of the piston 56, fluid within a cylinder chamber 84 exhausts through a passage 85 into the valve chamber 64 and exhaust through a pipe 89 into the reservoir 72. A dash pot piston 86 is provided to facilitate slowing down and cushioning the movement of the piston 56 as it approaches a right hand end position. Fluid within a dash pot exhausts through a throttle valve 87 into the passage 85. By manipulation of the throttle valve 87, the rate of movement of the dash pot piston 86 toward the right may be regulated as desired. A ball check valve 88 is provided in the passage 85 to facilitate by passing the throttle valve 87 when fluid under pressure is passed through the passage 85 to cause movement of the piston 56 toward the left.

When the solenoid S1 is energized and the valve member 61 is shifted to a left hand end position, fluid under pressure from the pipe 73 enters the valve chamber 64 and passes through the passage 85 into the cylinder chamber 84 to cause a rapid movement of the piston 56 toward the left thereby rapidly moving the wheel slide 30 and the grinding wheel 32 forward into a grinding position. At the same time fluid under pressure passing through the passage 85 passes through the ball check valve 88 and the throttle valve 87 to reset the dash pot piston 86, that is, move it toward the left (Fig. 9). During the rapid work movement of the piston 56 toward the left fluid within the cylinder chamber 83 may exhaust through the port 79, through the passage 78 and also exhausts through the port 82 and the throttle valve 81 into the passage 78 and into the valve chamber 62. Fluid exhausting into the valve chamber 62 may then pass through the exhaust pipe 89 into the reservoir 72. The rapid movement of the piston 56 toward the left continues until the piston 56 closes the port 79 so that thereafter fluid exhausting from the cylinder chamber 83 must pass through the port 82 and the throttle valve 81 to facilitate cushioning the rapid approach movement of the wheel slide 30 and the grinding wheel 32. It will be readily apparent from the foregoing disclosure that manipulation of the throttle valve 81 serves to regulate the rate of slow down movement of the piston 56 as it approaches the left hand end of its stroke.

A fluid pressure operative mechanism is provided for controlling the infeeding movement of the grinding wheel

4

32 during the grinding operation. This mechanism comprises a feed cylinder 95 which contains a slidable piston 96. The piston 96 is provided with rack teeth 97 which mesh with a gear 98 which is keyed onto a rotatable shaft 99. The shaft 99 is also provided with a gear 100 which meshes with the gear 49.

The feed control valve 60 in addition to controlling the admission to and exhaust of fluid from the cylinder 55 is operatively connected to control the admission to and exhaust of fluid from the feed cylinder 95. In the position of the valve 60 (Fig. 9) fluid under pressure entering the valve chamber 62 passes through a pipe 105, through a throttle valve 106 and a ball check valve 107 through a pipe 108, through a passage 109 into a cylinder chamber 110 to move the piston 96 toward the left into the position illustrated in Fig. 9. During this movement, fluid within a cylinder chamber 111 at the left hand end of the cylinder 95 exhausts through a passage 112, through a pipe 113, through a ball check valve 114 into the valve chamber 64 and exhausts through the pipe 89 into the reservoir 72.

A sequence valve 115 is provided so that when the valve 60 is reversed, a slight delay is obtained before fluid may be passed through the cylinder chamber 111 to initiate movement of the pistons 96 toward the right. A compression spring 116 serves normally to hold the sequence valve 115 in a right hand end position. When the solenoid S1 is energized and the valve member 61 is shifted in a left hand end position, fluid under pressure entering the valve chamber 64 passes through a pipe 117. The ball check valve 114 is closed so that fluid under pressure passing through the pipe 117 must pass through a pipe 118 into the right hand end of the sequence valve 115. Pressure builds up in the right hand end of the sequence valve against the compression of the spring 116 until a chamber 119 moves toward the left a sufficient distance so that fluid passing through the pipe 117 may pass through the valve chamber 119 into the pipe 113, through the passage 112 into the cylinder chamber 111 to move the piston 96 toward the right thereby imparting a rotary motion to the feed screw 40 to feed the wheel slide 30 and the grinding wheel 32 into the work piece being ground. During this movement fluid within the cylinder chamber 110 may exhaust through the passage 109, through the pipe 108, through the throttle valve 106 into the valve chamber 62 and exhaust through the pipe 89. By manipulation of the throttle valve 106, the rate of movement of the piston 96 toward the right may be readily controlled to produce the desired rate of infeed of the grinding wheel 32.

It may be desirable at times to feed the grinding wheel 32 by manual actuation of the feed wheel 51 without the interference of the fluid pressure system. A by-pass valve 120 is provided comprising a slidably mounted valve member 121 having a plurality of spaced valve pistons formed integrally therewith to form spaced valve chambers 122 and 123. The valve 120 is normally held in a left hand end position by a compression spring 124. In this position, the pipe 108 is connected with the valve chamber 123 which connects with the passage 109. Similarly the pipe 113 is connected through the valve chamber 122 with the passage 112. When it is desired to shift the valve 120 to a by-pass position, a valve 125 may be opened to pass fluid under pressure from the pipe 73 through a pipe 126 into a chamber 127 formed at the left hand end of the valve 120 to move the valve member 121 toward the right against the compression of the spring 124. In the right hand end position the valve pistons block the ports at the ends of the pipes 108 and 113 and the passages 109 and 112 are both connected to the valve chamber 122. In this position of the parts the grinding wheel 32 may be fed in either direction by manual actuation of the feed wheel 51 without the necessity of overcoming fluid under pressure within the system. During a manual actuation of the feed wheel 51 fluid may readily

by-pass directly from the cylinder chamber 110 into the cylinder chamber 111 and vice versa. The wheel feeding mechanism above described is substantially identical with that disclosed in the U. S. patent to H. A. Swainey No. 2,693,563 dated May 26, 1953.

A manually operable clutch is provided for disconnecting the hydraulic feed mechanism when desired. This mechanism, as shown in Fig. 2 comprises an external gear 125 which is fixedly mounted to rotate with the gear 98. The gear 98 is rotatably supported in anti-friction bearings. A shaft 127 passes through a central aperture within the gear 98 and is provided at right hand end thereof with an internal gear 126 which is arranged to mesh with the external gear 125, as shown in Fig. 2. A yoked member 128 is provided for axially moving the shaft 127 relative to the gear 98. When it is desired to declutch the feed piston 96, the yoked member 128 is actuated to move the shaft 27 axially toward the right so that the internal gear 126 moves out of mesh with the external gear 125. When the clutch is disengaged, the feed wheel 51 may be rotated to impart the rotary feeding movement to the feed screw 40 during which movement the feed piston 96 remains stationary.

In order to attain the main object of this invention a centerless type work support is provided for supporting a work piece during a grinding operation. This work support comprises a work shoe 135 (Fig. 4) which is arranged to support the work piece to be ground at a point below the work axis and adjacent to the periphery of the grinding wheel 32. A second work supporting shoe 136 is provided to support the work piece at a point diametrically opposite to the line of contact between grinding wheel 32 and the work piece being ground. This shoe 136 is a preferably movable shoe which initially engages the work piece being ground at a point above the horizontal plane passing through the axis of the grinding wheel and the work piece being ground. As the grinding on the work piece proceeds, the work shoe 136 is moved at a very slow rate in a clockwise direction as the work piece is reduced in size. The work shoes 135 and 136 are supported by the footstock 16 in a manner to be hereinafter described. The footstock 16 is provided with axially movable sleeves 137 and 137a which is slidably keyed with an aperture 138 formed in the footstock housing (Fig. 3). The left hand end of the sleeve 137 is provided with an integral flange 139 which supports the fixed steady rest shoe 135. The shoe 135 is arranged so that it may be clamped to the flange 139 by a clamping screw 140. A rotatable spindle 141 is rotatably supported within an aperture 142 formed in the sleeve 137a. An arm 143 is fixedly mounted on the left end of the spindle 141. The arm 143 serves as a support for the work rest shoe 136. The arm 143 and the left hand side face of the gear 155 serve to take up end thrust of the sleeve 137 during axial movement of the spindle 141. The arm 143 is provided with a radially extending T-slot 144. A nut 145 fits within the T-slot 144. A clamping screw 146 carried by the work shoe 136 meshes with the nut 145 to facilitate a radial adjustment of the work shoe 136. A similar T-slot 147 is provided to facilitate adjustment of the work shoe 135 in a radial direction.

A hydraulic operated mechanism is provided for imparting a controlled swinging movement of the work shoe 136. This mechanism comprises a cylinder 150 (Figs. 3 and 9) which contains a slidably mounted piston 151. The piston 151 is connected to the end of a piston rod 152 which is slidably supported in a bearing 153. The piston rod 152 is provided with rack teeth 154 which meshes with a gear 155 formed integral with the spindle 141. A stop screw 156 serves to limit the movement of the piston 151 in one direction. A compression spring 157 serves normally to hold the lower end of the piston rod 152 (Fig. 3) in an engagement with the stop screw 156. When it is desired to impart a control swinging movement to the work shoe 136, fluid is passed through

a pipe 158 into a cylinder chamber 159 to move the piston 151 toward the left (Fig. 9) against the compression of the spring 157. This movement causes the rack teeth 154 to impart a clockwise rotary motion to the gear 155 thereby imparting a rotary motion to the spindle 141 to move the work shoe 136 in a clockwise direction (Fig. 4).

The swinging movement of the work shoe 136 is preferably in timed relation with the feeding movement of the piston 96 so that fluid under pressure passes through the chamber 119 into the pipe 113 to initiate the feeding movement of the piston 96, fluid is also passed through a throttle valve 160, through the pipe 158 into the cylinder chamber 159 at a rate controlled by the throttle valve 160. It will be readily apparent from the foregoing disclosure that by manipulation of the throttle valve 160 the rate of swinging movement of the work shoe 136 may be varied as desired. A ball check valve 161 is provided so that when the feed piston 96 is reset after a grinding operation has been completed, that is, moved toward the left, the release compression of the spring 157 may exhaust fluid from the cylinder chamber 159 through the pipe 158 and through both the throttle valve 160 and the ball check valve 161 at a substantially unrestricted rate.

The hydraulically operated mechanism is provided for moving the sleeve 137 and the spindle 141 in an axial direction to facilitate a loading operation. A cylinder 165 is arranged in an axial alignment with the spindle 141 and the sleeve 137 and contains a slidably mounted piston 166. The piston 166 is connected to the right hand end of a piston rod 167. The left hand end of the piston rod 167 is provided with a flanged head 168 which is fastened to the end of the sleeve 137a. The sleeve 137a is provided screw threaded stud which engage an annular groove 169 formed in the spindle 141 (Fig. 3). When fluid under pressure is passed through a pipe 170 into a cylinder chamber 171, the piston 166 together with the sleeve 137 and spindle 141 are moved toward the left into a work supporting position for a grinding operation. A control valve 175 is provided for controlling the admission to and exhaust of fluid from the cylinder 165. The valve 175 is a piston-type valve having a slidably mounted valve member 176 which is provided with a plurality of spaced valve pistons forming a plurality of spaced valve chambers 177, 178 and 179. The valve member 176 is provided with a central passage 180 which interconnects the valve chamber 177 with the valve chamber 179. A compression spring 181 serves normally to hold the valve member 176 in a left hand end position. A solenoid S2 is provided which when energized serves to shift the valve member 176 into a right hand end position so as to reverse the flow of fluid under pressure to the cylinder 165. In the position of the parts as shown in Fig. 9, fluid under pressure from the pipe 73 enters the valve chamber 178 and passes through the pipe 173 into the cylinder chamber 172 to move the piston 166 together with the sleeve 137 and spindle 141 toward the right into a loading position to facilitate a loading operation. When the solenoid S2 is energized, the valve member 176 is moved toward the right so that fluid under pressure is passed from the valve chamber 178, through the pipe 170 into the cylinder chamber 171 to move the piston 166 together with the sleeve 137 and spindle 141 toward the left into a piston for a grinding operation with the work shoes 135 and 136 supporting a work piece to be ground.

A work loading and discharging mechanism is provided automatically to convey work pieces to be ground to and from a grinding position. A plurality of work pieces 185 are loaded into a work chute 186 (Fig. 7). An escapement lever 187 is provided for controlling the intermittently successive work pieces to roll into a turret to be hereinafter described. The lever 187 is provided with an arm 188 which is normally held in a broken line position 188a to retain a work piece 185b in the end portion of the chute 186. The lever 187 is pivotally supported by a stud 189. A stop stud 190 is provided to limit the swinging

movement of the lever 187 in a counter clockwise direction. A tension spring 191 is provided normally to hold an arm 192 of the escapement lever 187 in a broken line position 192a. The lower end of the lever 187 is provided with an actuating roller 193 which is arranged to be engaged successively by a plurality of cam surfaces 194 formed on the periphery of a rotatable turret wheel 195. The turret wheel 195 is fixedly keyed onto the left hand end of the rotatable shaft 196 (Fig. 3) which is journaled in spaced bearings 200 and 201 supported by a housing 199 which is clamped onto the swivel table 14 (Fig. 7). The turret wheel 195 is provided with a plurality of symmetrically arranged work apertures 197, 197a, 197b, 197c, 197d, and 197e which are arranged to receive successive work pieces 185 from the loading chute 186 and to convey them into a grinding position and thereafter to discharge ground work pieces into a discharge chute 198.

As the turret wheel 195 is intermittently indexed, a cam face 194 formed on the periphery of the turret wheel 195 engaged the actuating roller 193 to swing escapement lever 187 in a clockwise direction so as to allow the work piece 185b to roll into the work aperture 197 in the turret wheel 195. The rocking of the escapement lever in a clockwise direction raises the arm 192 into the full line position (Fig. 7) so that it engages the work piece 185a to hold it from rolling down the loading chute 186.

An indexing mechanism is provided for intermittently indexing the turret wheel 195 after each grinding operation. This mechanism is preferably a geneva-type indexing mechanism including a geneva plate 205 which is mounted on the right hand end of the shaft 196 (Fig. 3). The geneva plate 205 is provided with a plurality of symmetrically arranged radial slots 206, 206a, 206b, 206c, 206d and 206e and is also provided with a plurality of partial cylindrical holding surfaces 207, 207a, 207b, 207c, 207d, and 207e.

An actuating arm 208 is rotatably supported by a one-way type ball clutch 209 which is in turn supported on a shaft 210. The arm 208 is provided with a stud 211 which supports a roller 212 (Fig. 5). When the arm 208 is revolved in a counter clockwise direction the roller 212 rides into one of the radial slots 206 into a geneva plate 205. As the roller 212 rides into the slot 206 a partial cylindrical holding surface 214 moves out of engagement with the holding surface 207c on the geneva plate 205. Continued movement of the arm 208 in a counter clockwise direction moves the roller within the radial slot 206c to impart a clockwise indexing movement to the geneva plate 205 and to the turret wheel 195.

A hydraulically operated mechanism is provided for actuating the arm 208 comprising a cylinder 215 (Fig. 6) which contains a slidably mounted piston 216. The piston 216 is connected to the left hand end of the piston rod 217. A plurality of rackteeth 218 are formed on the piston rod 217 which mesh with a gear 219 which is fixedly mounted on the shaft 210. When it is desired to index the turret wheel 195, fluid under pressure is passed through a pipe 220 into a cylinder chamber 221 to move the piston 216 toward the left (Fig. 6). The movement of the piston 216 toward the left continues until the piston 216 engages a stop screw 222 mounted within the left hand end of the cylinder 215. During this movement of the piston 216, fluid within a cylinder chamber 223 exhausts through a pipe 224. The stop screw 222 is adjusted to determine the indexing stroke of the piston 216 so that the roller 212 will impart a rotary indexing movement to the geneva plate 205 which continues until the partial cylindrical surface 214 on the arm 208 rides into engagement with the stop surface 207b.

As the piston rod 217 approaches the left hand end of its stroke, a stop screw 225 carried by the piston rod 217 engages the actuating plunger 226 of the limit switch LS3 which functions in a manner to be hereinafter described.

A control valve 230 is provided for controlling the admission to and exhaust of fluid from the cylinder 215.

The valve 230 is a piston type valve having a slidably mounted valve member 231 having a plurality of spaced valve pistons forming spaced valve chambers 232, 233 and 234. The valve member 231 is provided with a central passage 235 which interconnects the valve chamber 232 with the valve chamber 234. A compression spring 236 serves normally to hold the valve member 231 in a left hand end position. A solenoid S3 is provided which when energized serves to shift the valve member 231 in a reverse position to pass fluid through the pipe 220 to initiate an indexing movement of the work turret 195.

When the solenoid S3 is energized fluid under pressure from the pipe 73 enters the valve chamber 233 and passes through the pipe 220 into the cylinder chamber 221 to start an indexing movement. During the indexing movement fluid within the cylinder chamber 223 exhausts through the pipe 224 into the valve chamber 232 and passes out through a throttle valve 237 and exhausts through a pipe 238 into the reservoir 72. It will be readily apparent from the foregoing disclosures that by manipulation of the throttle valve 237, the rate of the indexing movement may be readily controlled.

A holding pawl 240 is arranged to engage a notch 241 formed in the geneva arm 208 so that the arm 208 is held against movement in the opposite direction during a resetting movement of the index piston 216. During the resetting movement of the piston 216 (Fig. 6), after an indexing of the turret 195 has been completed, the piston 216 moves in a direction toward the right. During this movement the ball clutch 209 allows the shaft 210 to rotate without transferring any motion to the arm 208.

During a grinding operation, the work loading turret 195 is positioned in a left hand end position (Fig. 3) so that the turret is out of engagement with the work piece being ground. After a work piece has been ground, the shaft 196 together with the work turret 195 are moved toward the right (Fig. 3) before an indexing movement of the work turret 195 takes place. This movement of the turret 195 toward the right is accomplished by and in timed relation with the movement of sleeve 137. As illustrated in Fig. 3, the flange 139 is provided with a radially projecting pin 245 which engages a groove 246 formed in a hub 247 which is formed integrally with the turret 195. When the turret 195 is moved toward the right the work piece 185 is held by the permanent magnet chuck 24 and the work shoes 135—136 move toward the right out of engagement with the periphery of the work piece 185 which has been ground so that the work piece is again supported in one of the pockets 197 in the loading turret 195. The turret 195 may then be indexed to present the next work piece 185 into axial alignment with the work shoes 135 and 136 after which the piston 166 moves the spindle 141 and the sleeve 137 toward the left so that the work shoes 135 and 136 slide into supporting engagement with the work piece 185 as the turret wheel 195 is moved toward the left (Fig. 3) out of engagement therewith. The permanent magnet chuck then grips the work piece 185 and serves to drive the same during the grinding operation. The work supporting shoes 135 and 136 are beveled on the side adjacent to the turret so that the work piece will slide into supporting engagement therewith as the shoes are moved toward the left. The work shoes 135 and 136 are adjusted so that at the start of the grinding operation, the axis of the work piece to be ground is located slightly above the axis of rotation of the work driving spindle 23 and the permanent magnet chuck 24. The magnetism of the work driver 24 is sufficient to impart the desired rotary motion to the work piece 185 during a grinding operation. The magnetism of the driver 24, however, is such that the work piece 185 may shift laterally relative to the driver, that is, in a direction normal to its axis of rotation so that the work

piece is maintained in operative engagement with the work supporting shoes 135 and 136.

A cycle control lever 250 is pivotally mounted on the front of the machine base. When the lever 250 is rocked in a clockwise direction (Fig. 9) a normally open start switch SW2 is closed to start a grinding cycle. A normally closed cycle stop switch SW1 is provided which may be opened by a counter clockwise movement of the cycle control lever 250 to stop the cycle of the machine at any time desired.

Referring now to Fig. 9, the electric power is off and the electric switches and controls are as follows:

Switches

Switch SW1 is closed and serves to provide a holding circuit to maintain relay switch CR1 closed as soon as the power is turned on.

Switch SW2 is opened. This switch is a momentary start switch which serves when closed to energize the relay switch CR1.

Switch SW3 when closed serves to automatically recycle the machine. If a manual control is desired the switch SW3 may be left open.

Switch SW4 is opened and the hydraulic pump motor stops.

Solenoids

Solenoid S1 is deenergized and the wheel slide 35 is in a rearward or inoperative position with the piston 56 positioned as shown in Fig. 9. The feed piston 96 is in a reset position and the movable work shoe 136 in an uppermost or start position.

Solenoid S2 is deenergized and the work turret 195 is in a loading position, that is, toward the right as viewed in Fig. 3 with the work shoes 135 and 136 out of engagement with the work.

Solenoid S3 is deenergized with the turret index piston 216 in a reset position (Fig. 9). The normally open limit switch LS1 is held closed by movement of the flange 139 toward the right (Fig. 3). The normally closed contacts of limit switch LS1 are held open. When the flange 139 moves toward the left (Fig. 3) the normally closed contacts close to energize the electric timer T1, the relay switch CR3 to that the work drive motor 20, and to energize the solenoid S1 to start a feeding cycle of the grinding wheel 32.

The normally closed contacts of limit switch LS2 are closed. Used as a holding circuit to hold relay switch CR2 and solenoid S2 energized. The switch LS2 is momentarily open during the rearward movement of the wheel slide 30 to break the holding circuit.

The limit switch LS3 is normally open. When closed by movement of the turret index piston 216 it automatically starts the cycle again provided the switch SW3 is closed. Otherwise the cycle start lever 250 must be actuated to momentarily close the switch SW2 to start each cycle of operation.

The relay switch CR1 serves as a holding relay to supply power to the machine.

The time delay relay TD2 is energized by either the switch SW2 or the limit switch LS3 and is held energized by the limit switch LS2 to maintain the solenoid S2 energized. The relay switch CR3 is energized by the closing of contacts RC1 of the timer T1 when the timer T1 is energized by the closing of the normally closed contacts of the limit switch LS1 to start the work drive motor 20.

The operation of the improved grinding machine will be readily apparent from the foregoing disclosure. A plurality of work pieces 185 to be ground are loaded in the loading chute 136. The switch SW4 is closed to start the hydraulic pump 70 and to start an indexing movement of the turret 195 by energizing the solenoid S3, through the normally closed contacts of the limit switch LS1. The cycle start lever 250 is rocked in a clockwise

direction to momentarily close the start switch SW2 so as to energize the relay switch CR1. The normally closed switch SW1 serves to set up a holding circuit to maintain the relay switch CR1 energized. The closing of contacts of the relay switch CR1 serves to supply power to the various mechanisms of the machine. The closing of the switch SW1 also energizes the relay switch CR2 and the normally closed contacts of the limit switch LS2 maintains the relay switch CR2 energized. When the contacts of relay switch CR2 close a circuit is completed to energize the solenoid S2 which serves to move the piston 166 toward the left to move the work shoes 135 and 136 into supporting engagement with the work piece to be ground as the work turret 195 moves out of engagement therewith. As the work shoes 135 and 136 move to an operative position, the normally open contacts of the limit switch LS1 open to deenergize the solenoid S3 and the work turret index piston 216 moves toward the left (Fig. 9) to reset the parts for the next operation. This movement serves to open the normally open contacts of the limit switch LS3.

When the work shoes 135 and 136 are moved in an operative position, the normally closed contacts of the limit switch LS1 close to energize the timer T1 thereby closing the timer contacts LC1, RC1, and CC1. The timer contacts LC1 serves to close a holding circuit to maintain the timer T1 energized. The closing of the timer contacts RC1 serves to energize the relay switch CR3 to start the work drive motor 20 and the closing of the contacts CC1 serve to energize the solenoid S1 to start movement of the feed piston 56 toward the left to move the grinding wheel rapidly into grinding engagement with the work piece to be ground.

When the solenoid S1 is energized fluid under pressure is passed to move the wheel slide piston 56 to cause a rapid approaching movement of the grinding wheel 32. After the sequence valve 115 opens, fluid under pressure is passed to start movement of the feed piston 96 toward the right to start a grinding feed and at the same time fluid is passed to the shoe actuating cylinder 150 to move the piston 151 toward the left (Fig. 9) to start a slow downward movement of the work shoe 136 during the grinding operation. When the timer T1 times out the contact LC1, RC1 and CC1 open to deenergize the relay switch CR3 thereby stopping the work drive motor 20 and also to deenergize the solenoid S1 which shifts the feed control valve 60 to cause a rapid rearward movement of the piston 56 and a rapid resetting movement of the feed piston 96 toward the left to reset the feed wheel 51. During the rearward movement of the feed slide 30, an adjustable collar 260 (Fig. 9) momentarily opens the limit switch LS2 to break the holding circuit to deenergize the relay switch CR2. The contacts of relay switch CR2 open thereby deenergizing the solenoid S2. The deenergizing of the solenoid S2 serves in a manner previously described to move the work turret 195 together with the work supporting shoes 135 and 136 toward the right into a loading position. During this latter movement, the normally closed contacts of the limit switch LS1 open to reset the timer T1 when the work turret 195 has completed its movement toward the right into its loading position. The normally open contacts of the limit switch LS1 close so as to energize the solenoid S3 to move the turret index piston 216 toward the right (Fig. 9) to index the work turret 195 in a manner previously described to present a new work piece 185 to be ground into a grinding position. When the piston rod 217 moves toward the right to index the work turret 195, it closes the normally open limit switch LS3 to energize the relay switch CR2 so as to energize the solenoid S2 thereby starting the next machine grinding cycle.

It will thus be seen that there has been provided by this invention apparatus in which the various objects hereinabove set forth together with many thoroughly practical advantages are successfully achieved. As many

possible embodiments may be made of the above invention and as many changes might be made in the embodiment of the 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 in a limiting sense.

I claim:

1. In a grinding machine having a base, a transversely movable rotatable grinding wheel, a rotatable work spindle having a work driver to rotate a work piece during a grinding operation, a fixedly mounted work steadying shoe to engage the periphery of a work piece at a point below the work axis and adjacent to the line of contact between the grinding wheel and the work piece, a second work steadying shoe to support the work piece diametrically opposite to the grinding wheel at a point above a horizontal plane passing through the work axis, a feeding mechanism to feed the grinding wheel transversely in either direction, and means to impart an arcuate motion to said second shoe toward said fixed shoe by and in timed relation with the infeeding movement of the grinding wheel.

2. In a grinding machine, as claimed in claim 1, in combination with the parts and features therein specified of means to move the work steadying shoes in a direction parallel to the axis of said spindle to and from an operative position, and means including a rotatable work loading turret automatically to position successive work pieces into operative position relative to said chuck.

3. In a grinding machine, as claimed in claim 1, in combination with the parts and features therein specified of means to move said work steadying shoes in a direction parallel to the axis of said spindle to and from an operative position, means including a rotatable work loading turret automatically to position successive work pieces into an operative position relative to said chuck, and means including an indexing mechanism intermittently to index said turret by and in timed relation of movement of said shoes to an inoperative position.

4. In a grinding machine as claimed in claim 1, in combination with the parts and features therein specified of means including a piston and cylinder to move said work steadying shoes in a direction parallel to the axis of said spindle to and from an operative position, a rotatable work loading turret automatically to position successive work pieces into an operative position relative to said chuck, an index mechanism for said turret, and means including a piston and cylinder to actuate said index mechanism in timed relation of movement of the work shoes to an inoperative position.

5. In a grinding machine, as claimed in claim 1, in combination with the parts and features therein specified of means including a piston and cylinder to move said work steadying shoes in a direction parallel to the axis of said spindle to and from an operative position, a control valve therefor, a rotatable work loading turret automatically to position successive work pieces into an operative position relative to said chuck, an index mechanism for said turret, means including a piston and cylinder to actuate said index mechanism, a control valve therefor, and means actuated by and in timed relation with movement of said shoes to an inoperative position to actuate said latter valve to initiate an indexing movement of said turret.

6. In a grinding machine having a base, a transversely movable rotatable grinding wheel, a rotatable work spindle having a permanent magnet work driver to rotate a work piece during a grinding operation, a fixedly mounted work steadying shoe to engage the periphery of the work piece at a point below the work axis and adjacent to the line of contact between the grinding wheel and the work piece, a second work steadying shoe to support the work piece

diametrically opposite the grinding wheel at a point slightly above a horizontal plane passing through the work axis, a feeding mechanism including a piston and cylinder to feed the grinding wheel transversely in either direction, and means including a piston and cylinder operatively connected to impart an arcuate motion to said second shoe toward said fixed shoe by and in timed relation with the infeeding movement of the grinding wheel.

7. In a grinding machine having a base, a transversely movable, rotatable grinding wheel, a rotatable work spindle having a plane-faced permanent magnet work driver to rotate a work piece during a grinding operation, means including a motor to rotate said spindle, an axially movable non-rotatable sleeve, a fixedly mounted work steadying shoe supported on the end of said sleeve which is arranged to engage the periphery surface of the work piece at a point below the work axis and adjacent to the line of contact between the grinding wheel and the work piece, an axially movable rotatable spindle within said sleeve, a work steadying shoe adjustably mounted on end of said spindle which is arranged to engage the periphery of the work piece at a point diametrically opposite the grinding wheel above a horizontal plane passing through the work axis, said shoes being arranged to support the peripheral surface of a work piece during the grinding operation with its axis above the axis of the work driving spindle, and means actuated in timed relation with the infeeding movement of the grinding wheel to impart a rotary motion to said spindle to cause a gradual arcuate movement of said second shoe toward the fixed shoe as the work is reduced in size to facilitate rounding-up the work.

8. In a grinding machine, as claimed in claim 7, in combination with the parts and features therein specified of a gear on said spindle, a rack-bar meshing therewith, and means including a piston and cylinder to move said rack-bar so as to impart a rotary motion to said gear and said spindle to move the work shoe supported thereby toward the fixedly mounted shoe during a grinding operation.

9. In a grinding machine as claimed in claim 7, in combination with the parts and features therein specified of means including a piston and cylinder operatively connected to feed said grinding wheel transversely in either direction, a control valve operatively connected to control the admission to and exhaust of fluid from said cylinder, a gear on said spindle, a rack-bar meshing therewith, a piston and cylinder operatively connected to move said rack-bar to impart a rotary motion to said spindle so as to move the work shoe supported thereby, and operative connections between said control valve and said latter cylinder to move said shoe relatively toward and from the fixed shoe by and in timed relation to the feeding movement of the grinding wheel.

10. In a grinding machine as claimed in claim 7, in combination with the parts and features therein specified of means including a piston and cylinder operatively connected simultaneously to move said work shoes to and from an operative position to facilitate a loading and unloading operation.

11. In a grinding machine as claimed in claim 7, in combination with the parts and features therein specified of means including a rotatable work loading turret automatically to position successive work pieces into an operative position relative to said chuck, and means including a piston and cylinder operatively connected to simultaneously move said spindle and sleeve in an axial direction to move the work shoes into an operative position to support the periphery surface of a work piece during a grinding operation.

No references cited.