April 9, 1935. M. ROMAINE 1,997,551

GRINDING MACHINE

Filed Dec. 5, 1932 9 Sheets-Sheet 1

Fig. 1

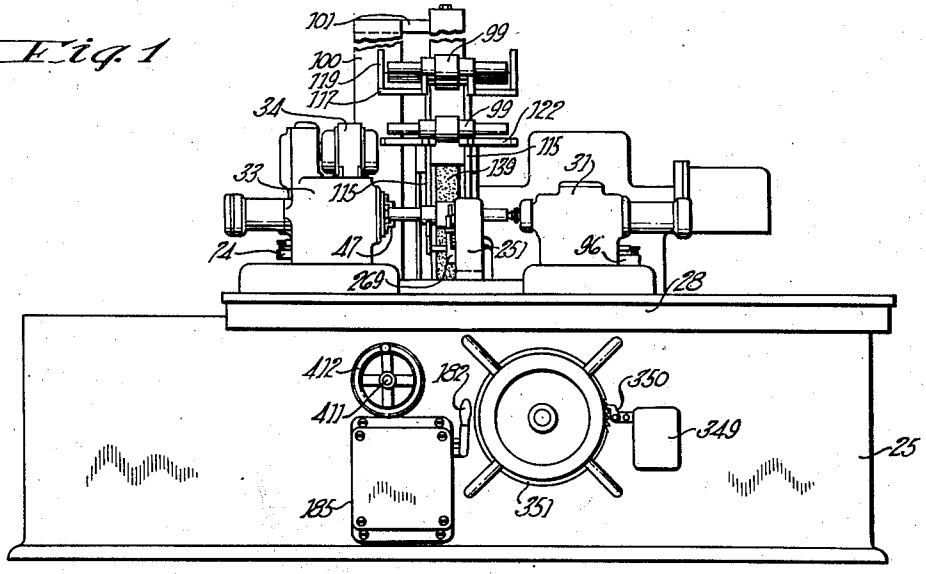
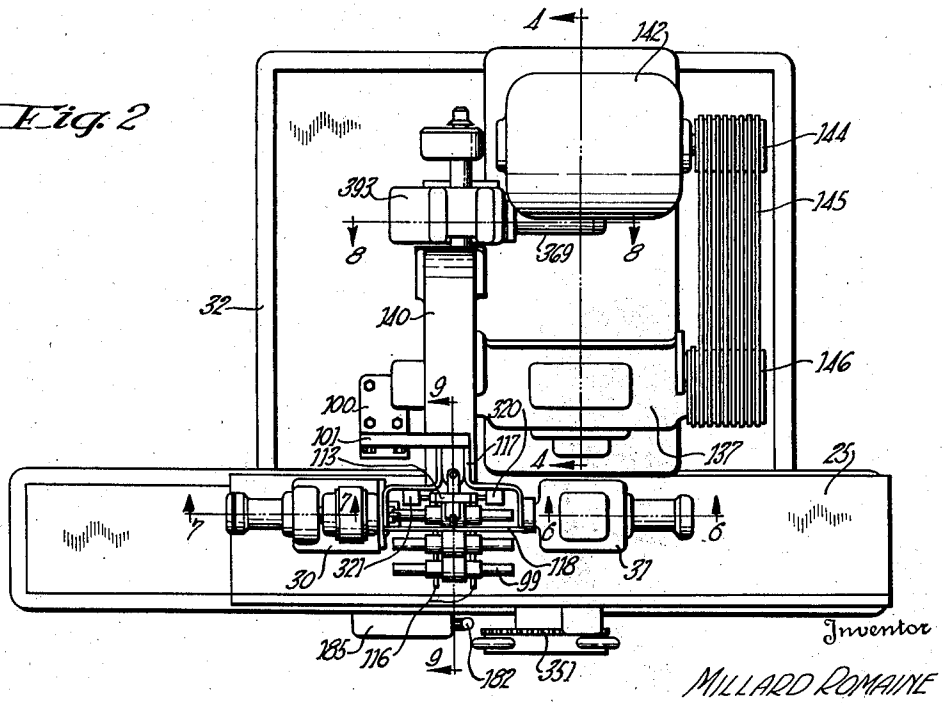


Fig. 2



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GRINDING MACHINE

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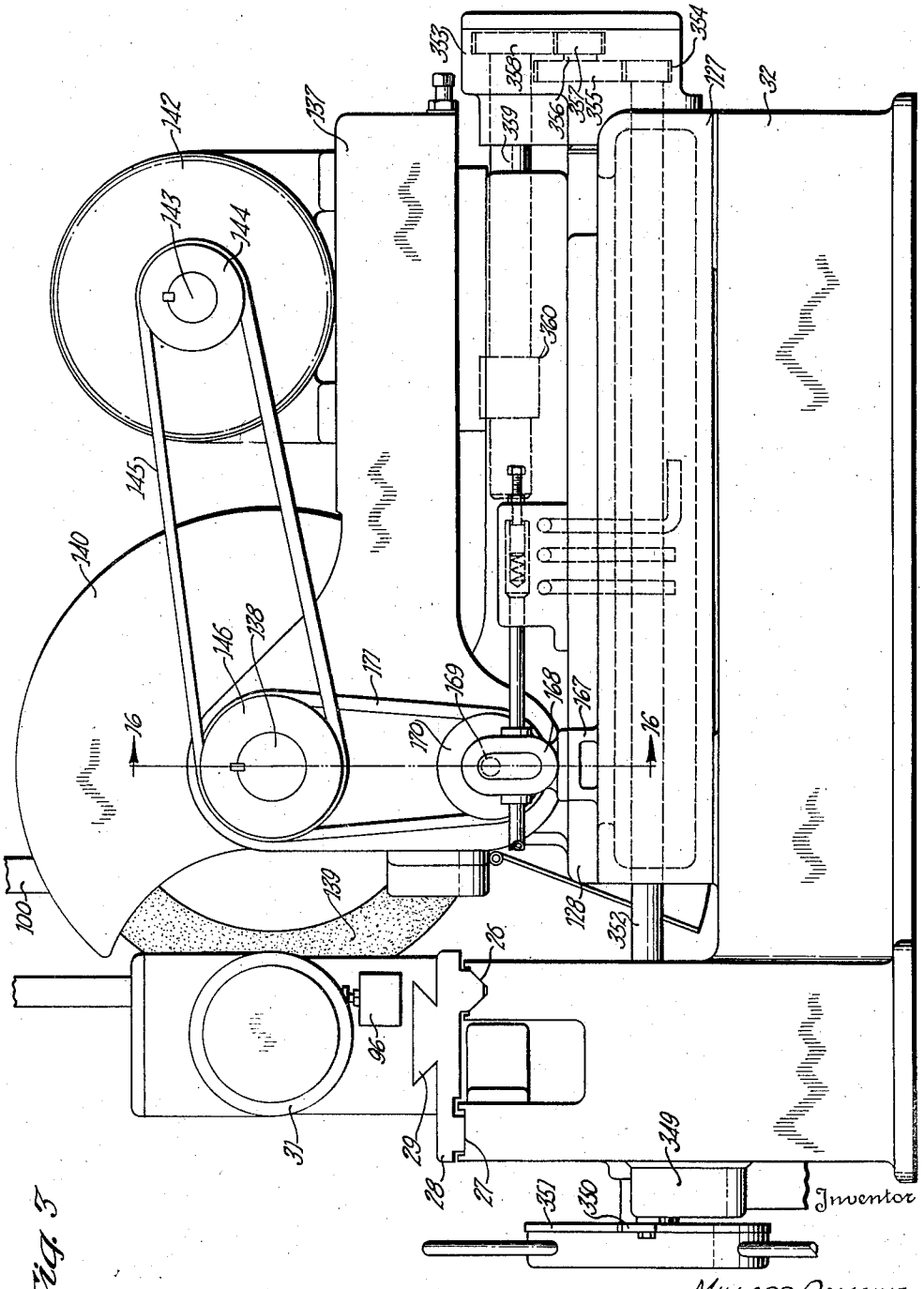

Fig. 5

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GRINDING MACHINE

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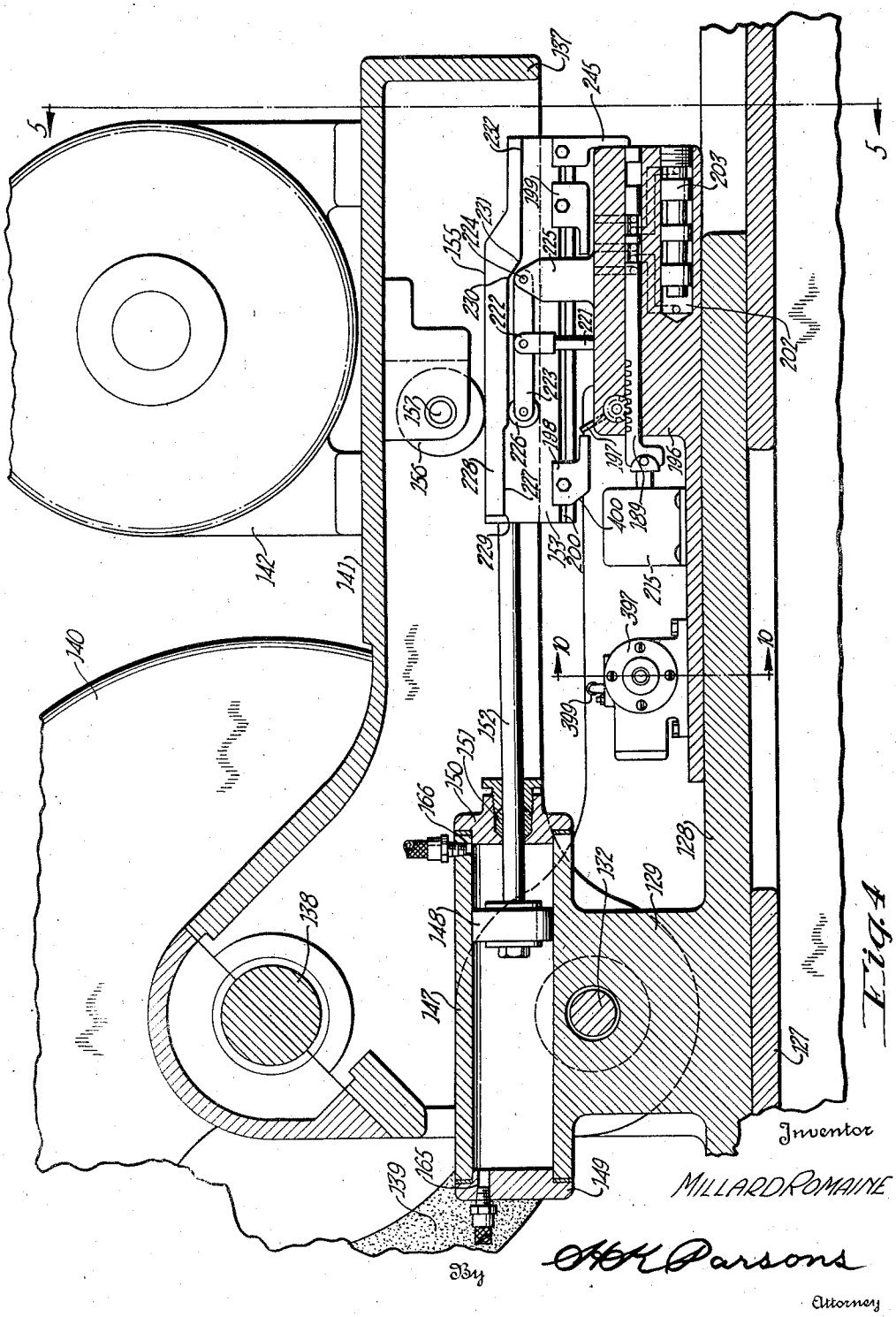

Fig. 4

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GRINDING MACHINE

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Fig. 5

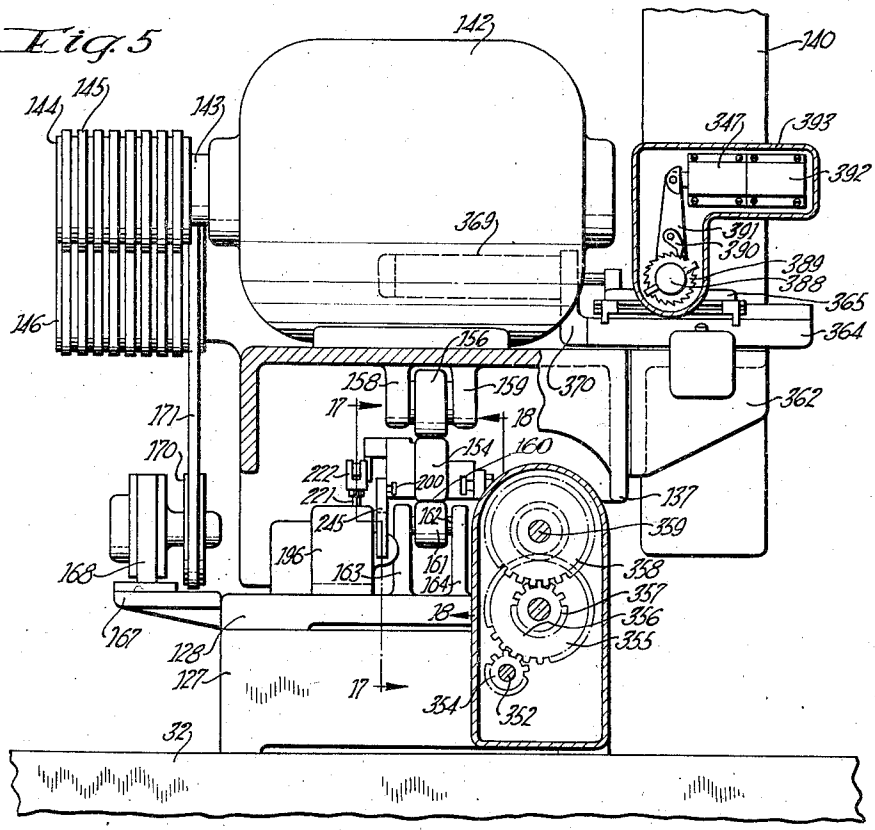
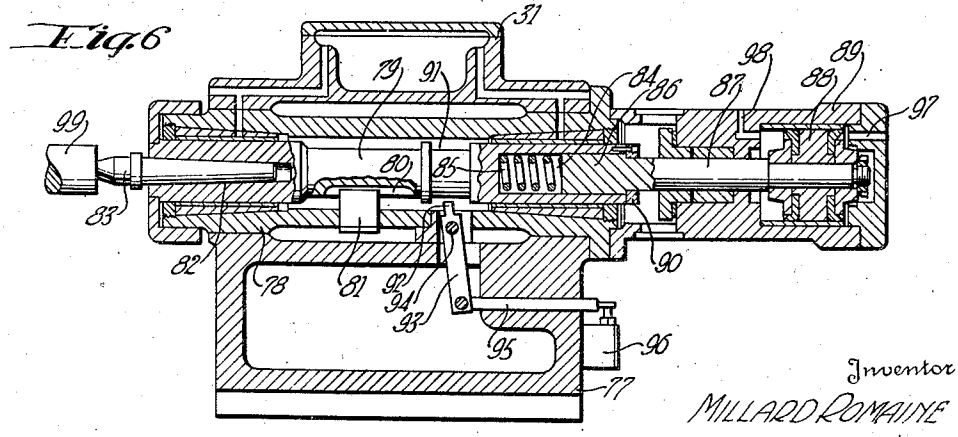


Fig. 6



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GRINDING MACHINE

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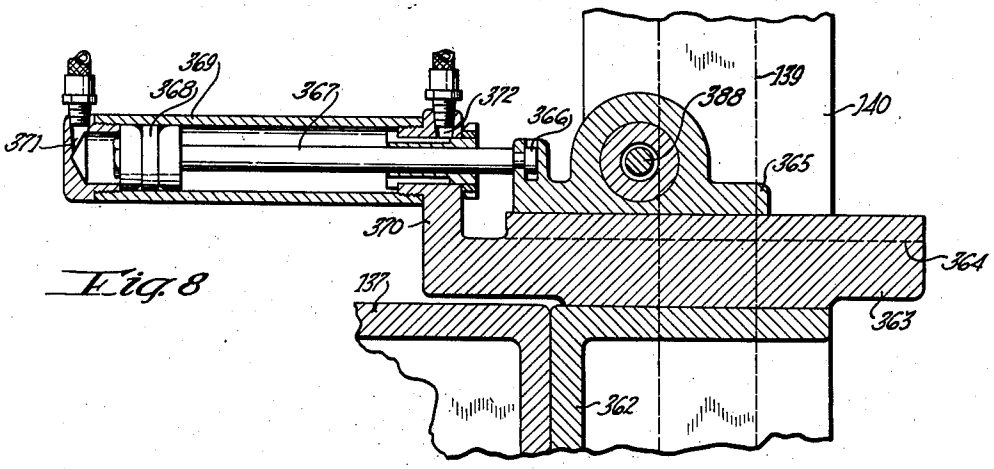

Fig. 8

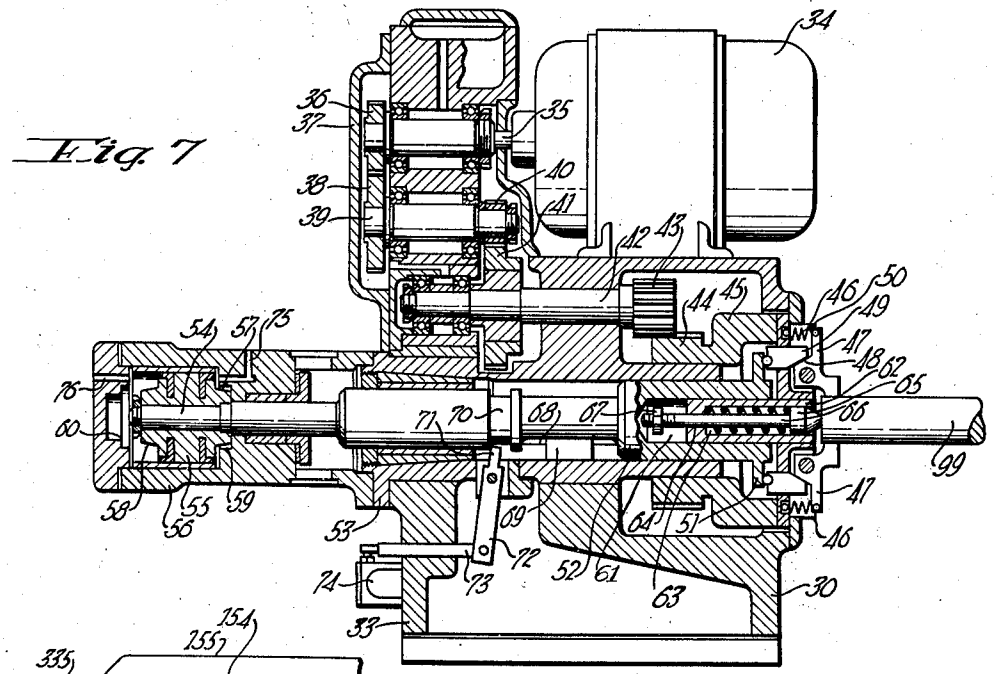

Fig. 7

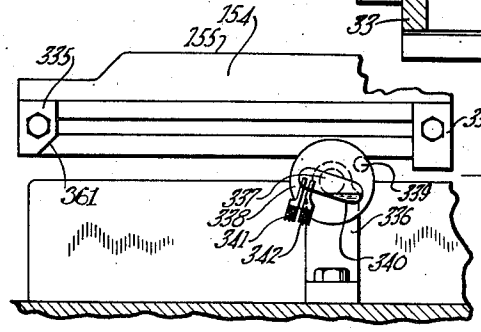

Fig. 18

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GRINDING MACHINE

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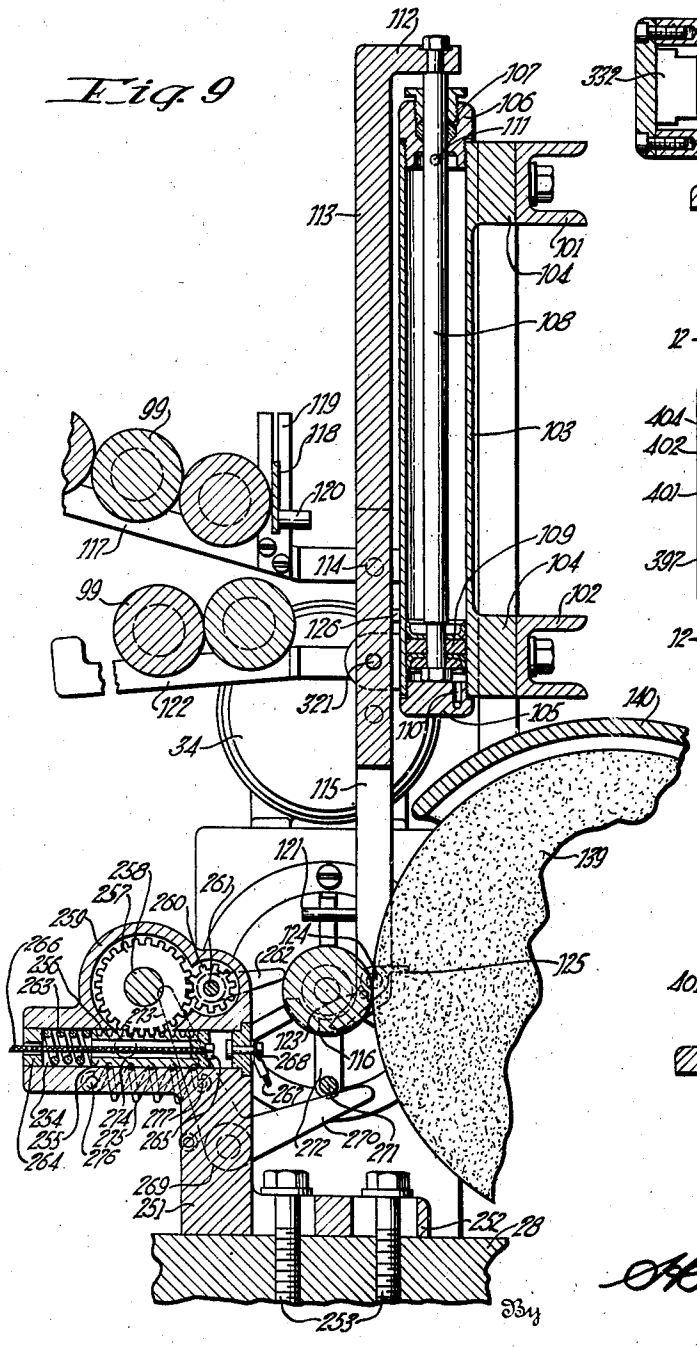
Fig. 9



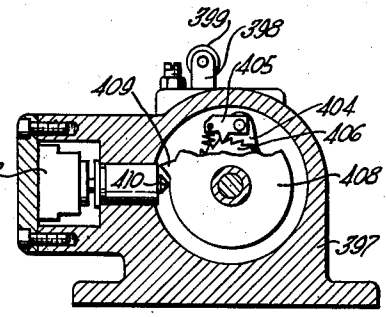


Fig. 11

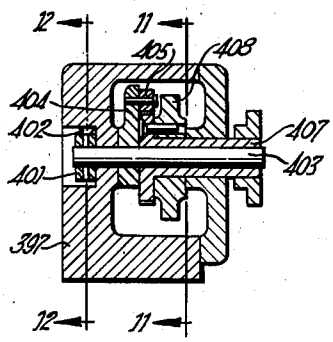


Fig. 10

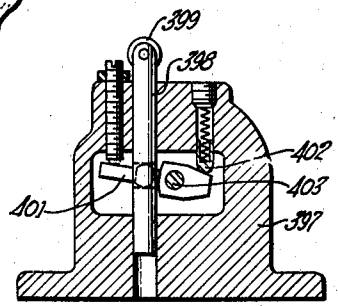


Fig. 12

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GRINDING MACHINE

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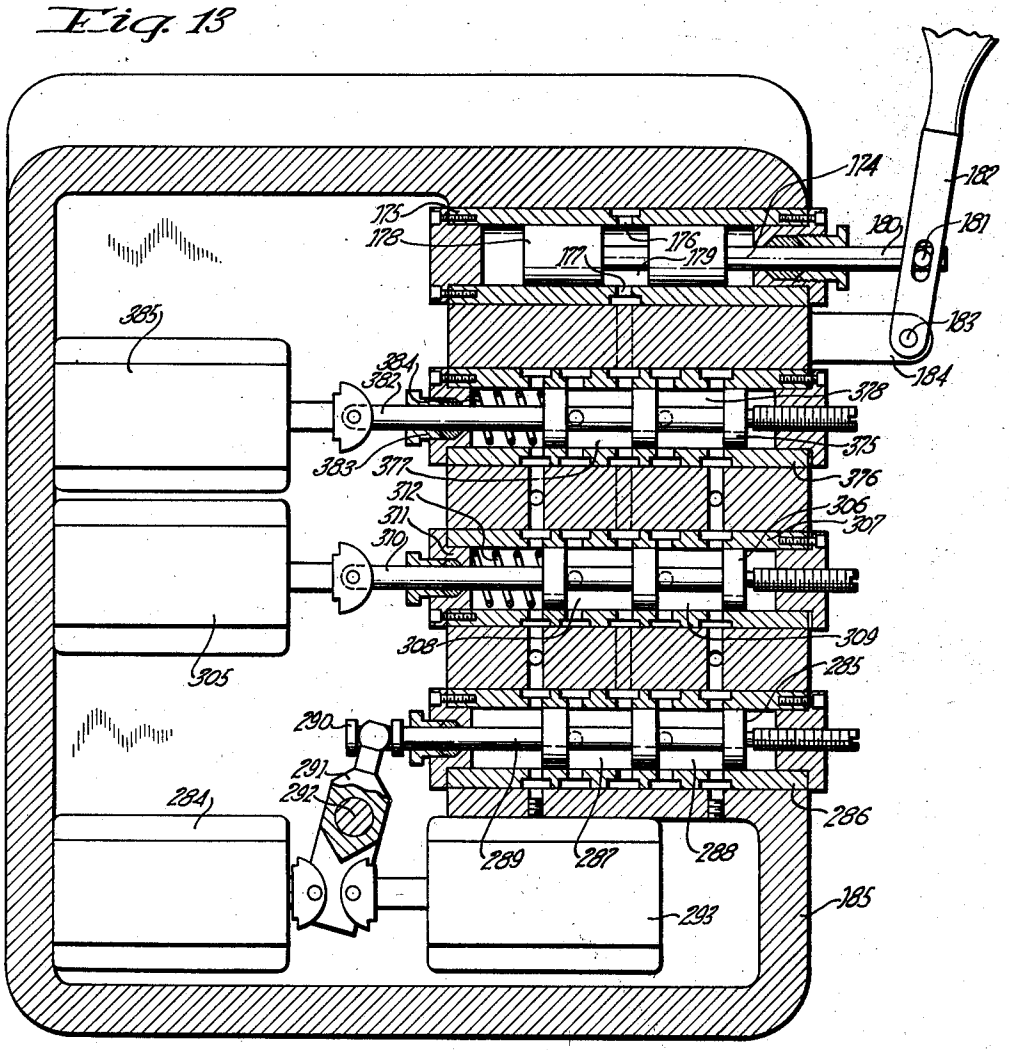
Fig. 13



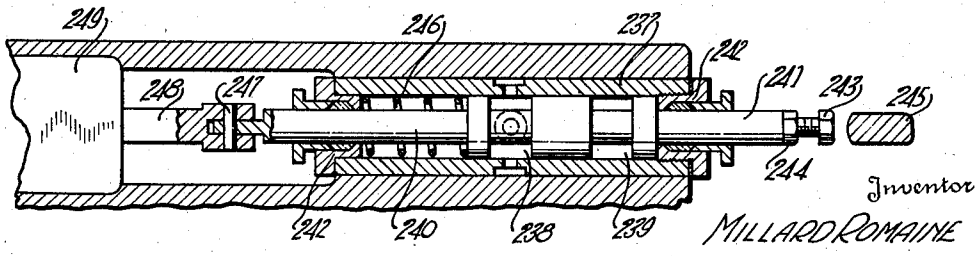


Fig. 14

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GRINDING MACHINE

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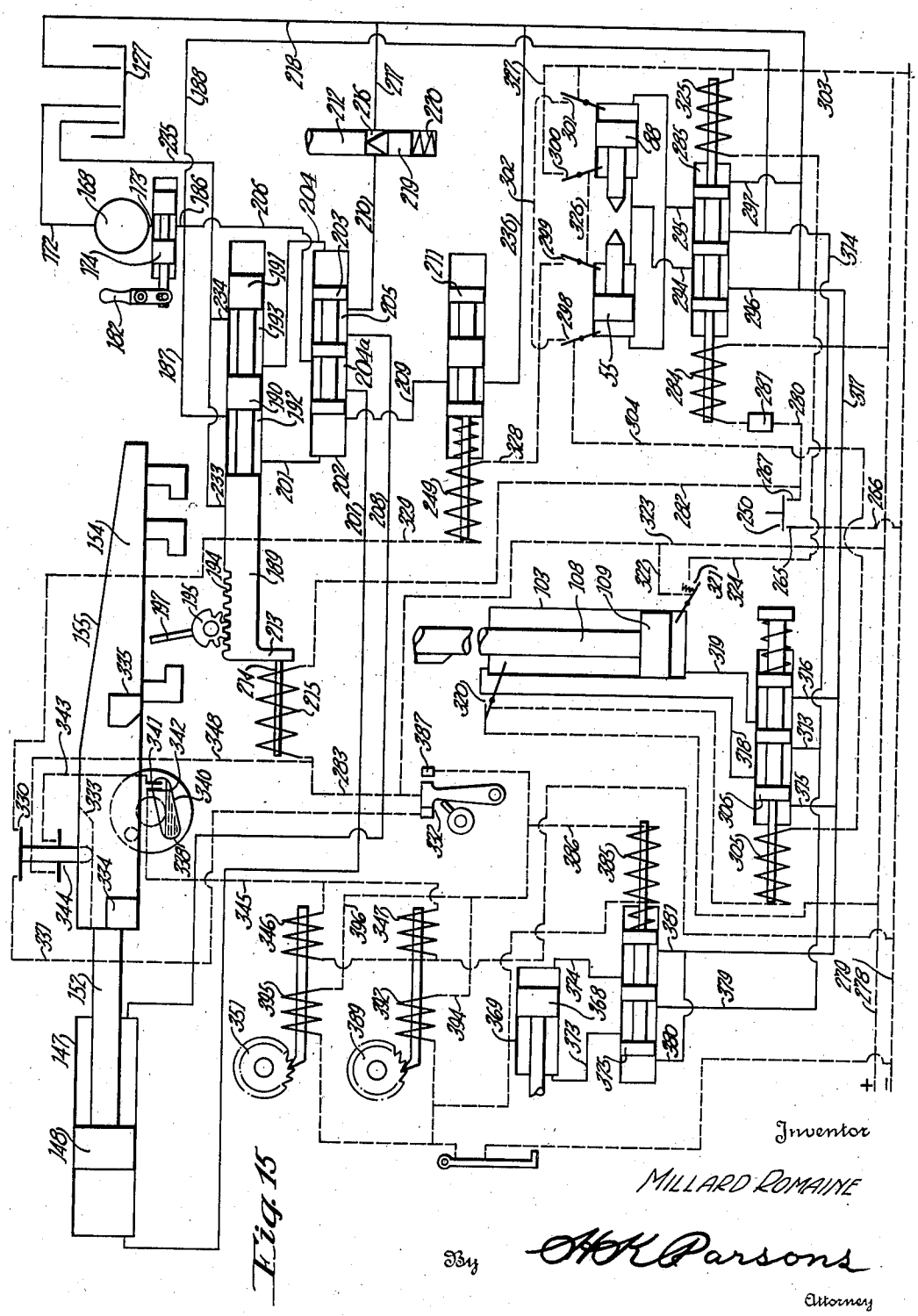

Fig. 15

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GRINDING MACHINE

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Fig. 16

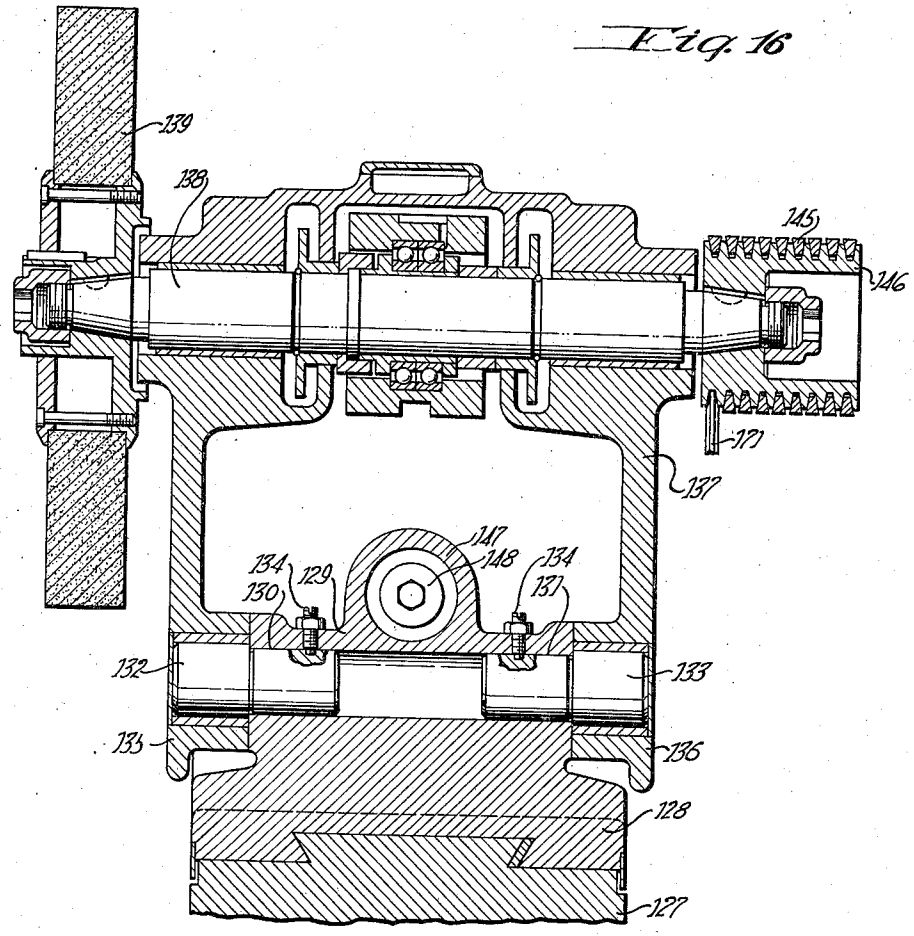
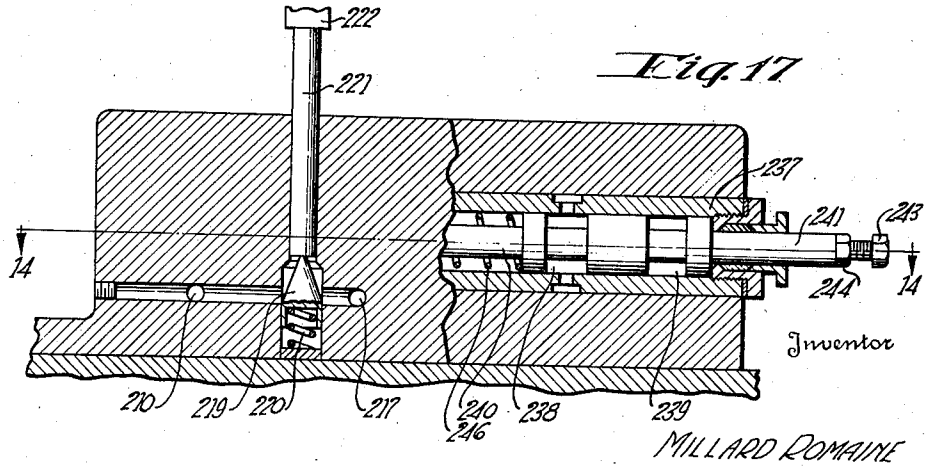


Fig. 17



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Patented Apr. 9, 1935 1,997,551

UNITED STATES PATENT OFFICE

1,997,551

GRINDING MACHINE

Millard Romaine, Cincinnati, Ohio, assignor to Cincinnati Grinders Incorporated, Cincinnati, Ohio, a corporation of Ohio

Application December 5, 1932, Serial No. 645,724

22 Claims. (Cl. 51—105)

This invention relates to improvements in machine tools and particularly to improvements in grinding machines.

An object of the invention is the provision of an improved automatic grinding machine of the center type for expeditiously and accurately producing cylindrical work pieces.

Another object of the invention is the provision of improved hydraulic and electrical control means for automatically operating and controlling machine tools, especially grinding machines.

A further object of the invention is the provision of improved means for effecting and controlling the relative feed of a tool and a work piece whereby to automatically control the size of said work piece while expeditiously producing same.

A still further object of the invention is the provision of improved hydraulic means for effecting said relative feed between the tool and work.

It is also an object of this invention to provide improved means for automatically adjusting the relative positions of the parts to automatically take care of reduction in size of the tool, such as a grinding wheel, due to wear thereon and the trimming or truing away thereof.

It is a still further object of the present invention to provide improved interlocked means between the trimming or truing devices and the normal feeding mechanism so that the relative position of the work and tool is automatically compensated for due to the truing of the wheel and to thereby maintain the proper desired relative relation between the work and tool in order to expeditiously produce successive work pieces at a minimum expense and within prescribed size limits.

Other objects and advantages of the present invention should be readily apparent by reference to the following specification considered in conjunction with the accompanying drawings, forming a part thereof, and it is to be understood that any modifications may be made in the exact structural details there shown and described, within the scope of the appended claims, without departing from or exceeding the spirit of the invention.

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 shown in Figure 1.

Figure 3 is an enlarged end elevational view as seen from the right hand side of Figures 1 and 2.

Figure 4 is a transverse fragmentary sectional view through the feeding mechanism as seen, for example, on line 4—4 of Figure 2.

Figure 5 is a view as seen from line 5—5 on Figure 4, illustrating the parts partly in elevation and partly in section.

Figure 6 is a longitudinal sectional view through the tail stock as seen from line 6—6 on Figure 2.

Figure 7 is a longitudinal sectional view through the head stock as seen from line 7—7 on Figure 2.

Figure 8 is a longitudinal sectional view through the truing tool actuating mechanism, as seen from line 8—8 on Figure 2.

Figure 9 is a vertical sectional view through the work loading and ejecting mechanism taken, for example, on line 9—9 of Figure 2.

Figure 10 is a transverse sectional view through the truing timing mechanism, as seen from line 10—10 on Figure 4, and forming a detail of the invention.

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 10.

Figure 13 is a view partly in section and partly in elevation of the control box housing the various valves and adapted to be mounted on the forward face of the bed.

Figure 14 is a sectional view through a stop valve forming a detail of the circuit control as seen from line 14—14 on Figure 17.

Figure 15 is a diagrammatic view illustrating the hydraulic and electrical circuits utilized in the performance of the invention.

Figure 16 is a vertical sectional view through the axis of pivotance of the tool carriage taken on line 16—16 of Figure 3.

Figure 17 is a sectional view taken on line 17—17 of Figure 5.

Figure 18 is a sectional view taken on line 18—18 of Figure 5.

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

Grinding machines are divided into a plurality of types and classes depending upon the way the work is presented to the wheel or tool or on the type of work produced thereby. Among these classes of grinding machines are what is known as center type machines, in which the work is supported between opposed or terminal supports or centers during the grinding operation thereon.

These machines are in turn divided into two classes, one in which the work is traversed longitudinally past the operative face of the grinding wheel during the grinding thereof and the other in which the work is held stationary as respects axial movement and the grinding wheel fed into the work. In the latter type of grinding, commonly known as plunge cut grinding, the wheel is generally given a slight axial movement for breaking up grinding lines on the work and evenly distributing the wear across the face of the wheel. The present invention has particular reference to the plunge cutting class of grinding machines and, as set forth in the objects, it is the purpose thereof to produce an improved automatically operated center type plunge cut grinding machine. It is to be understood, however, that the controls and unique mechanism disclosed in the drawings and to be subsequently defined have, with very slight modification, equal application to the operation and control of other types of grinding machines and machine tools generally.

In general the present invention contemplates the use of an oscillating type of wheel head oscillatable toward the work together with improved hydraulically operated means for effecting the said oscillation of the head. There is also utilized and disclosed an improved work loading and ejecting mechanism for automatically bringing the work into position for engagement by the work centers and automatically engaging the centers with the work. A sizing mechanism is employed for controlling the size of the work and for stopping further reduction thereof when the work reaches the said desired or final size. All of these various and several movements are interlocked in such fashion as to insure the sequential operation thereof.

Specifically, the machine comprises a bed or base **25** having formed in its upper surface V and flat guideways **26** and **27** receiving correspondingly shaped guide ribs depending from the under surface of a work supporting table **28**. The work table **28** is in turn formed on its upper surface with a dove-tailed guiding tongue **29** received in a groove formed in the under surface of the opposed head and tail stocks **30** and **31**. In order to adjust the position of the work table **28** relative to the bed **25**, there is provided usual mechanism, such as a rack and pinion, not shown, operated by a transverse shaft **411** carried by the bed **25** to which is secured a hand wheel **412** for rotating same. The bed **25** has projecting rearwardly therefrom an extension **32** which supports the grinding wheel and feeding mechanism, which will be described in detail later.

The head stock **30**, see Figure 7, is of the self-contained type and comprises a casting or casing **33** to the upper surface of which is secured a prime mover or motor **34** having keyed or otherwise secured to its shaft **35** a gear **36**. The gear **36** is enclosed within a supplemental housing **37** in which is also journaled the shaft **35** driven by the motor. Meshing with the gear **36** is a gear **38** on one end of a shaft **39** rotatably journaled in supplemental housing **37**. The other end of the shaft **39** has keyed or otherwise secured to it a pinion **40** meshing with a carrier **41** on a final driven shaft **42** journaled partially in the housing **37** and partially in the head stock casting **33**. The driven shaft **42** terminates in a pinion **43** which meshes with a gear **44** of the work chuck or driver **45**. The chuck or driver **45** terminates in a plurality of lugs or ears **46** between each pair of which is pivoted fingers **47**. The inner surface of the fingers **47** is tapered to provide cam faces **48** co-operating with the cam face on the inner surface of a ring **49**. The ring **49** is carried by the chuck-driver **45** and slidable relative thereto so that when it is retracted springs **50**, which have one end secured to the outer end of the chuck jaws **47** and their other ends to a fixed part of the chuck-driver **45**, may oscillate said jaws to release the work. The ring **49** is adapted to be axially shifted by hydraulic pressure and is directly engaged by a flange **51** formed on the end of a sleeve or shaft **52** slidable through bearings provided by a sleeve **53** secured in the head stock casting or casing **33**. The rear end of the shaft **52** is provided with a reduced portion **54** to which is secured in any desirable manner a piston **55** operable in opposite directions through a cylinder **56** carried by the rear end of the head stock casing **33** and in axial alignment with the shaft **52**. The piston **55** is provided on opposite ends with reduced portions **57** and **58** adapted to respectively enter counterbores **59** and **60** formed in opposite ends of the cylinder and co-operating with one another to form dash pots for cushioning the limits of movement of the piston **55**. The inner end of the shaft **52** is provided with a counterbore **61** into which is pressed a sleeve **62** provided with a socket **63** and an aligned reduced bore **64**. Received in the socket **63** is the head stock center **65** from which projects a stem **66** passing through the reduced bore **64**. Surrounding the stem **55** and abutting on opposite ends with the seat of the socket **63** and the center **65** is a spring normally tending to urge the center to the right, as seen in Figure 7, this movement of the center being limited by a lock nut **67** on the end of the stem **66** engaging with the outer surface of the sleeve **62**. Intermediate its ends the shaft **52** is provided with a keyway **68** receiving a suitable key **69** carried by the casing **33** which prevents relative rotative movement of the shaft **52**. Adjacent the keyway **68** the shaft **52** is provided with a circumferential groove **70** receiving the nose **71** of a lever **72** pivoted intermediate its ends to a fixed part of the head stock casting **33**. The lever **72** has pivoted to its lower end one end of a plunger **73**, the outer end of which is connected with the movable part of a double throw electrical switch **74** whereby the said switch is closed at each end of movement of the shaft **52**. The cylinder **56** is provided at opposite ends with ports **75** and **76** with which connects one terminus of a pair of hydraulic conduits as will later appear.

The tail stock **31**, see Figure 6, comprises a suitable casting or casing **77** in which is mounted against movement a sleeve member **78** providing at opposite ends thereof bearings for an axially shiftable spindle **79**. The spindle **79** is provided intermediate its ends with a key way **80** receiving the key **81** carried by the fixed sleeve **78** which prohibits any relative rotative movement of the spindle **79**. At one end, the spindle **79** is provided with a tapered socket **82** receiving therein the tapered shank of tail stock center **83**. The other end of said spindle is provided with a counterbore **84** in which is disposed a compression spring **85** abutting on one end with the seat of the counterbore and on the other end with the inner surface of a head **86** carried by a piston rod **87**. Secured to the outer end of the piston rod **87** is a piston **88** reciprocable through a cylinder **89** secured to

the tail stock casting in axial alignment with the spindle 79. The piston 88 is provided on opposite ends with bosses similar to those above described in connection with the head stock piston which co-operate with recesses formed at the end of the cylinder and form dash pots to cushion the limits of movement of the piston and parts actuated thereby. To insure retraction of the spindle 79 upon corresponding movement of the piston 88, the said spindle has secured to its end a collar 90 co-operating with the shoulder formed by the piston rod head 86 whereby movement of the piston rod to the right, as seen in Figure 6, carries with it the said spindle 79 and center 83. The spindle 79 is also provided intermediate its ends with a circumferential groove 91 to provide shoulders for engagement with the upper end or nose 92 of a lever 93 pivoted intermediate its ends as at 94 to the casting 77. The other end of the lever 93 has pivoted thereto a plunger 95 in turn having its free end connected to the movable member of a double throw electrical switch 96. The cylinder 89 is provided in opposite ends with ports 97 and 98 with which connect the termini of suitable hydraulic conduits for conveying an hydraulic medium thereto under pressure, as will be later described.

The work piece 99 is automatically brought to and aligned with the centers at which time the centers are actuated toward one another to pick up said work and upon the completion of the work it is automatically removed from between the centers. The mechanism for accomplishing this operation is best illustrated in Figures 2 and 9. As there shown, the bed extension 32 has bolted or otherwise secured to it an upstanding bracket 100 which projects upwardly above the grinding wheel. The bracket 100 has projecting outwardly from it into overlying relation with the grinding wheel, a pair of supporting bars 101 and 102, shown here as channel irons, although they may be of any desired or convenient configuration. Secured to the channel irons 101 and 102 is a cylinder 103 held by the brackets 104 against any inadvertent movement. The cylinder 103 is closed at its opposite ends by heads 105 and 106, the latter being in addition provided with a stuffing box 107 through which passes a piston rod 108. Secured to the inner end of the piston rod 108 is a piston 109 adapted to be actuated through the cylinder 103 by means of an hydraulic medium or fluid under pressure and introduced into the cylinder through the ports 110 and 111 respectively provided at the lower and upper ends thereof. The upper end of the piston rod 108 is connected in any suitable or desirable manner to an arm 112 projecting from a carrier or slide 113. The slide 113 has secured to its lower end, on opposite sides thereof, as by means of cap screws or the like 114, carrying arms 115 spaced so as to straddle the grinding wheel. The lower ends of the arms 115 are formed to provide a cradle 116 in which the work is carried during its movement into and out of grinding position.

The lower supporting arm or channel iron 102 of the bracket 100 carries a magazine 117 for unfinished work pieces which are discharged by gravity into the cradle 116. To prevent inadvertent discharge of the work pieces from the magazine 117, there is provided a shutter 118 vertically shiftable relative to the standards or guides 119 associated with the magazine. The shutter 118 has projecting from its face adjacent the carriage 113 a lug 120 adapted to be engaged by a ledge 121 extending outwardly from the arms 115 and in such a position as to engage and raise the shutter 118. Beneath the magazine 117 and supported by the arm 102 is a finished work receiving chute or platform 122 to which the work pieces are shunted during the upward movement of the carrier 113. For effecting the automatic shunting of the work, each of the arms 115 has pivoted to its lower end fingers 123 held by gravity in the position shown in Figure 9. The fingers 123 have projecting from their rear end, and in a plane above the plane of their pivots 124, a lug 125 adapted during the upward movement of the carrier 113 to be engaged by a ledge 126 secured to the outer surface of the cylinder 103. From a study of Figure 9, it will be seen that as the carrier 113 is travelling upwardly with a finished work piece disposed in the cradle 116 and as soon as the work comes even with the discharge chute or platform 122 the discharge fingers lugs 125 will engage the ledge 126 thereby oscillating said fingers in a clockwise direction and ejecting the work from the cradle onto the platform of chute 122. Continued upward movement of the carrier then causes the lug 121, of the arms 115, to engage the shutter lug 120 and elevate the said shutter thereby releasing the lowermost work piece in the magazine 117. At this time the cradle is at the end of the magazine in position to receive the work piece therefrom.

The bed extension 32 has mounted thereon a bed plate 127 which in effect constitutes a tank or sump for an hydraulic medium, preferably oil, utilized in the operation of the several units of the machine tool organization. Movable on the upper surface of the bed plate 127 is the slide 128. As seen in Figures 4 and 16, the forward end of the slide 128 has an upstanding rib-like portion 129 the lateral edges of which are faced off and provided with aligned bores 130 and 131 respectively receiving trunnions or pivots 132 and 133. The trunnions are held in place by lock screws 134 to prevent any relative movement of the trunnions with respect to their bearings. The trunnions extend beyond the lateral faces of the rib portion 129 and are respectively received in suitable bores formed in arms 135 and 136 depending from the carriage 137. The carriage 137 has journaled in its forward end a spindle 138 to one end of which is secured a grinding wheel 139, the wheel being suitably enclosed within a guard 140 secured in any desirable manner to the carriage 137. Beyond the spindle the carriage 137 has a flat surface 141 to which is secured in any desirable manner, preferably adjustably, a prime mover or motor 142. The motor shaft 143 of the motor 142 has keyed or otherwise secured to it a sheave 144 having a plurality of grooves formed therein each adapted to receive a flexible belt 145 of V-shape in cross section. The belts 145 are in turn trained about a sheave or pulley 146 keyed or otherwise secured to the outer end of the grinding wheel spindle 138.

From the foregoing it will be noted that the grinding wheel carriage 137 is mounted for oscillation relative to its supporting slide 128. The carriage 137 is adapted to be oscillated toward the work to effect a stock removal therefrom and to thereby reduce the said work to the desired size and contour, and is adapted to be fully retracted to permit replacement of the work.

For effecting the oscillation of the carriage 137 the slide rib 129 is provided with a cylinder 147 receiving in the bore thereof a piston 148. The cylinder is closed at opposite ends by means of heads 149 and 150, the latter carrying a stuffing

box 151 through which passes a piston rod 152 having its inner end secured to the piston 148. The other end of the piston rod 152 is secured to a plate or carrier 153 which carries a cam for effecting the oscillation of the carriage 137. As shown in Figures 4 and 5, the plate 153 carries the cam 154 having an inclined operative surface 155 inclining upwardly to the left, as seen in Figure 4. The upper or inclined surface 155 of the cam 154 is contacted by a roller 156 secured to a shaft 157 freely rotatably journaled in suitable bearings provided by arms 158 and 159 depending from the lower surface of the carriage 137. To reduce friction and maintain proper alignment of the plate 153 and cam 154, the under surface 160 of the cam 154, see Figure 5, rests on an anti-friction roller 161 carried by a shaft 162 rotatably journaled in arms 163 and 164 projecting upwardly from the upper surface of the slide 128. The piston 148 and piston rod 152 and parts connected therewith are adapted to be actuated by the hydraulic medium under pressure which enters the cylinder at opposite ends through suitable ports 165 and 166, which will be described in detail later.

In order to circulate the hydraulic medium, the slide 128 is provided with a lateral extension 167, see Figure 5, forming a base for the support of a suitable pump 168 which may be of any suitable or desirable rotary type. The pump 168 has its driven shaft 169 disposed co-axial with the axis of the trunnions 132 and 133 and secured to the rotary shaft 169 is a suitable sheave or pulley 170. Trained about the sheave or pulley 170 is a flexible belt 171 which in turn extends about the sheave or pulley 146 on the end of the spindle 138. From this it will be seen that the pump 168 is constantly driven during the oscillation of the carriage 137 since the oscillation takes place about the axis of the shaft 169 thereby at no time varying the separation between the axes of said shaft and the spindle.

As shown diagrammatically in Figure 15, and structurally in Figure 3, the pump 168 has extending from its suction side a pipe or conduit 172 having its other terminus in the tank or sump 127. Extending from the other side of the pump 168 is a discharge conduit 173 through which the medium passes under pressure. The pipe or conduit 173 terminates at a start and stop valve, shown diagrammatically in Figure 15 and structurally in Figure 13. As shown in the latter figure, the start and stop valve, indicated generally by the numeral 174, comprises a valve bushing 175 provided with an intake and an exhaust port 176 and 177 respectively. It is with the intake port that the pipe or conduit 173 connects. Enclosed within the bushing 175 is a spool type valve 178 having formed centrally thereof a cannelure 179 for connecting the intake and exhaust ports when the valve is in one position or in alignment with said ports, and for cutting off flow through the bushing 175 when out of registry therewith. The valve 178 has extending from its one end a valve stem 180 connected by a pin and slot connection 181 with a starting and stopping lever 182. The lever 182 has its lower end pivoted at 183 to lugs or ears 184 projecting from the side of a plate or housing member 185 secured to the forward face of the bed 25 within convenient reach of the operator. The plate or housing 185 has secured therein the starting and stopping valve bushing 175 and in addition supports several other valves for effecting and controlling the various operations of the machine, as will be later made clear.

Connected or in alignment with the discharge port 177 of the starting and stopping valve 174 is the terminus of a conduit or port 186. The other terminus of this conduit or port 186 is connected with branch conduits or ports 187 and 188, the former terminating at a pilot valve, while the latter connects with the head and tail stock centers control valve. The pilot valve is shown structurally in Figure 4 and diagrammatically in Figure 15. This valve comprises a stem portion 189 and spools 190 and 191 forming cannelure 192 between stem 189 and spool 190 and cannelure 193 between the spools 190 and 191. The stem portion 189 is provided with rack teeth 194 meshing with the teeth on rack pinion 195 which is journaled for rotation in a suitable block or casting 196, see Figure 4, secured to and carried by the slide 128. Beyond the block or casting 196 the pinion 195 has projecting from it a lever 197 adapted to be disposed in the path of movement of reversing dogs 198 and 199 adjustably secured in a T-bolt slot 200 formed in the plate 153. The pilot valve when in one position is adapted to connect the branch pressure conduit 187 through the cannelure 192 with a conduit or port 201 which terminates at one end of a reversing valve chamber 202. The reversing valve chamber 202, see Figure 4, is formed in the block or casting 196 and encloses a spool type piston valve 203. In a second position of the pilot valve it is adapted to connect by way of the cannelure 193 the branch conduit 187 with a conduit or port 204 terminating at the other end of the reversing valve chamber 202. The reversing valve 203 controls the direction of movement of the feed piston 148.

The reversing valve comprises spool portions between which is formed cannelures 204*a* and 205. Connected with the chamber 202 is one end of a conduit 206 which may be a branch pressure conduit similar to conduits or ports 187 and 188 or may be a continuation of the main pressure conduit 186. This conduit is adapted to be connected alternatively and respectively through the cannelures 204*a* and 205 with conduits 207 and 208, the former terminating in the port 165 formed in one head of the main cylinder 147 and the latter with the port 166 formed in the main cylinder at the other end thereof. In addition, the chamber 202 has extending from it exhaust ports or conduits 209 and 210 adapted respectively to be connected with the conduits 207 and 208 when said conduits are not connected with the main or branch pressure conduit 206. The said conduits 209 and 210 respectively terminate at a stop valve indicated generally by the numeral 211 and a speed control valve indicated generally by the numeral 212. The stop valve 211 determines the ultimate retracted position of the carriage 137 while the speed control valve effects and controls the rate of movement of the grinding wheel toward and relative to the work while effecting a stock removal therefrom.

The stem 189 of the pilot valve is formed on its one end with a head 213 from which projects the core 214 of a solenoid adapted to be operated upon by the coil 215. This solenoid effects the operation of the pilot valve for automatically shifting same. The pilot valve is shifted in the other direction by the dog 199 during the normal operation of the machine. In the event, and as will later appear, the parts are liable to become inoperatively disassociated from one another, the reversing dog 198 will effect a reversal thereof or shifting thereof. The shifting

of the pilot valve connects either of the lines 201 or 204 respectively with exhaust pressure lines 233 or 234 with the exhaust return line 235 which terminates in the sump or tank 127. This permits the escape of the hydraulic medium between the ends of the reversing valve 203 and the adjacent ends of the valve chamber 202 so that the pressure introduced in the other end of said chamber can effect the shifting of the valve therein without interference by the medium previously introduced into the opposite end of said valve chamber.

The speed control valve 212 diagrammatically illustrated in Figure 15 comprises a chamber 216 formed vertically in the block or casting 196. The conduit 210, as above described, terminates in the chamber 216 from which extends an exhaust conduit 217 connecting with main return conduit 218 terminating in the sump or tank 127. Disposed interiorly of the chamber 216 is a conical type of valve 219 having abutting on one end the coil spring 220, disposed within the chamber 216, and contacting on its other end with the base of said chamber. The spring 220 tends to shift the valve 219 in a direction to close off or prevent a flow of fluid from the conduit 210 through the chamber 216 into the conduit 217. The amount of movement permitted the valve 219 by the spring 220 is controlled by a valve actuator which abuts with the end of the valve opposite to that contacted by the spring and shown in Figure 4 in the nature of a vertically shiftable plunger 221. The plunger 221 is provided on its upper end with a clevice 222, see Figure 17, between the arms of which is disposed a lever 223. The lever 223 is therefore pivoted intermediate its ends to the plunger 221 and has its one end pivoted at 224 to a bracket or lug 225 extending upwardly from the casing or casting 196. The other or free end of the lever 223 rotatably carries a roller 226 contacting with a cam face 227 formed on cam plate 228 secured to and carried by the plate or carrier 153.

From this it will be seen that as the carrier 153 is moved by the piston 148 for effecting an infeed of the grinding wheel through the cam surface 155, the cam surface 227 is moving therewith and controls the position of the valve 119 for thereby controlling the exhaust through the lines 210 and 217 for controlling the rate of feed of the grinding wheel into the work. As will be noted from Figure 4, this cam is of a gradual taper extending from the point 229 at the left hand end of the cam 228, as seen in these figures, to the point 230 from which a short steep incline 231 extends to the horizontal portion 232. When the grinding wheel is completely retracted the cam face 232 is in engagement with the roller 226 for completely depressing the valve 219 and thereby completely opening the said valve whereupon a movement of the piston in a feed direction, namely right as seen in Figure 4, will at first be effected at a rapid rate until the cam portion 231 comes into play whereupon the valve will be comparatively rapidly allowed to go to a near closed position for thereby throttling the flow of the fluid and reducing the rate of feed of the grinding wheel. As the cut nears its conclusion, and since it is desired to have a high finish on the work, the rate of feed is still further reduced, thereby insuring the proper surface on the work.

The retracting movement of the carriage 137 is stopped, as noted above, by the stop valve 211. This valve during the retraction of the carriage 137 normally connects the exhaust conduit 209 with the branch exhaust return line 236 which in turn connects with the main return exhaust line 218. The valve 211 is shown diagrammatically in Figure 15 and structurally in Figures 14 and 17 and comprises a bushing 237. The bushing 237 is carried by the block or casting 196 and encloses a spool type of valve for providing cannelures 238 and 239. The valve has extending from each end thereof a stem 240 and 241 each stem passing through a stuffing box 242 provided at the ends of the valve bushing 237. The stem 241 is provided at its terminus with an adjustable abutment 243 here conveniently shown as a bolt or screw threaded into the end of the stem 241 and locked into adjusted position by the lock nut 244. Carried by the plate member 153 is a dog or arm 245 adapted when the plate has reached a position for effecting the complete retraction of the grinding wheel to engage with the abutment 243 and thereby shift the cannelure 238 out of registry with the conduits or ports 209 and 236 thereby cutting off any further exhaust flow through said conduits and stopping further movement of the main feed piston 148. The shifting of the valve through the arm 245 is against the yielding resistance of a spring 246 that surrounds the valve stem 240 and abuts on opposite ends with the valve and the stuffing box 242. The valve stem 240 is pivotally connected at 247 with the movable core 248 of a solenoid 249 which during a certain portion of the cycle of the machine further shifts the valve against the resistance of spring 246 thereby again connecting the exhaust conduits 209 and 236 with one another, this time, however, connecting same through the cannelure 239 instead of the cannelure 238.

As was noted above, the infeed of the grinding wheel is automatically reversed by the shifting of the pilot valve by electrical means including the solenoid 214—215. This mechanism is controlled by a sizing device which completes an electrical circuit and is shown diagrammatically in Figure 15 by the switch 250 and structurally in Figure 9. As shown in the latter figure, the sizing mechanism comprises a bracket member 251 having the base flange 252 which rests on the upper surface of the work table 28 being secured thereto by means of bolts 253 passing through suitable elongated perforations in the flange 252 whereby lateral adjustment of the bracket may take place. At the upper end, the bracket 251 is formed with a chamber 254 in which is disposed a rack plunger 255 having rack teeth 256 thereon meshing with the teeth of a gear 257 keyed or otherwise secured to a shaft 258 rotatably journaled in the side walls of a cover plate 259 secured to the bracket 251 and completing the chamber 254. The gear 257 also meshes with the teeth of a pinion 260 likewise keyed or otherwise secured to a shaft 261 journaled in the walls of the cover plate 259. One end of the shaft 261 extends beyond one of its bearings and has secured to said extending portion a sizing finger 262. A spring 263 is also enclosed within the chamber 254 and abuts on one end with the plunger 255 and on the other end with the plug 264 forming the rear closure for the chamber 254. The spring tends to urge the plunger 255 toward the right, as seen in Figure 9, thereby through the plunger teeth tending to rotate the gear 257 counterclockwise and the pinion 260 clockwise to bring the point or work engaging portion of the finger 262 into contact with the surface of the work being ground. When this surface of the work is reduced to the point where the work is the desired size, the spring

finger snaps past center, thereby permitting the spring to shift the plunger to its right hand limit of movement. The said right hand end of the plunger 255 carries a switch contact 265 to which is secured one end of an electrical wire or conduit 266 and this contact 265 engages with a contact 267 carried by the plug 268 closing the other end of the chamber 254. The contacts 265 and 267 constitute the switch member 250 in the hydraulic electrical diagram illustrated in Figure 15.

In order to reset the sizing device for a new work piece, there is provided a bell crank lever 269 having an arm 270 underlying the work carrying slide 113 and disposed in the path of movement of an abutment 271 projecting from a lug 272 integral with the cradle 116. The other arm 273 of the bell crank 269 flanks the side of the bracket 251 and engages with a lug 274 projecting outwardly from the plunger 255 through the wall of the chamber 254. A spring 275 has one end anchored at 276 to the bracket 251 and the other end connected at 277 with the arm 273. As the work carrying slide travels upwardly with a finished sized work piece the spring 275 contracts and oscillates the bell crank 269 about its pivot and through its arm 273 in engagement with the plunger lug 274 retracts the said plunger against the yielding resistance of the spring 263. This disposes the sizing finger 262 in an upwardlly inclined direction as respects the work having reference to the disclosure in Figure 9. This then permits the unfinished work that is being carried by the carriage 113 to be lowered into operative position without interference by the said finger 262. As the carriage descends, however, the lug 271 thereon engages with the arm 270 and oscillates the bell crank 269 in a clockwise direction against the yielding resistance of its spring 275. This movement of the bell crank, however, does not take place until after the work is below the sizing finger and as the said bell crank is oscillated in a clockwise direction, the arm 273 is removed from the plunger lug 274 so that the plunger spring 263 can again operate as above described for bringing the sizing finger into contact with the surface of the now unfinished work piece.

The other end of the wire 266 which extends from the switch contact 265 may connect with one of the wires or leads 278 or 279 of the main electrical supply. The other contact 267 of this switch has extending from it an electrical conduit or wire 280 which, as shown in Figure 15, terminates at a time relay 281. Extending from the conduit or wire 280 is a wire 282 which has its other terminus connected to one end of the solenoid coil 215. The other end of the solenoid coil is connected by a wire 283 with the other lead 278 or 279 of the main current supply. From this it will be seen that as soon as the work piece is reduced to the desired size, the solenoid 214—215 is energized for shifting the pilot valve and thereby connecting the hydraulic pressure in branch pressure line 187 with the proper end of the reversing valve chamber 202 for shifting said valve and reversing the connections to the main piston cylinder 147. As shown in Figure 15, the shifting of the pilot valve by the solenoid 214—215 will be to the left and will connect the pressure in the conduit 187 through the cannelure 193 with the right hand end of the reversing valve chamber 202 and shifting the reversing valve therein to the left. This then interrupts the connection of exhaust conduits 208 and 210 and instead connects the conduit 208 through the cannelure 205 with the branch pressure line 206 for actuating the piston 148 within the cylinder 147 to the left.

The time relay 281 connects the electrical conduit 280 with the coil of a solenoid 284 adapted for shifting the valve which controls the hydraulic connection with the head and tail stock centers pistons. The time relay 281 momentarily interrupts the flow of the current therethrough until after the solenoid 214—215 has been energized for shifting the pilot valve and initiating a retracting movement of the grinding wheel from the work. This prevents any possible interference between the work and wheel after the said work has been released by the supporting centers.

The centers control valve is shown diagrammatically in Figure 15 and structurally in Figure 13, where it is indicated in its entirety by the numeral 285. As shown in Figure 13, this valve comprises a bushing 286 pressed into and supported by the housing 185 and the bushing encloses a spool type valve for providing cannelures 287 and 288. The valve has projecting from it a stem 289 to which is secured a pair of collars 290 receiving between them the ball end of a valve shifter 291 pivoted at 292 to a fixed part of the plate or housing 85. The other end of the shifter 291 has pivoted to it a pair of solenoid cores, one of which is the solenoid 284 above described, and the other being indicated by the reference character 293. The cannelures 287 and 288 are adapted to alternately connect the branch pressure conduit 188 with the conduits 294 and 295 connecting the remaining conduit with branch return conduits 296 and 297 in turn connected with the main return conduit 218. The conduit 294 is simultaneously connected with the port 75 of the head stock cylinder 56 and the port 98 of the tail stock supporting cylinder 89 while the conduit 295 is simultaneously connected with the port 76 of the head stock cylinder 56 and the port 97 of the tail stock cylinder 89. From this it will be seen that the two centers are simultaneously either actuated toward one another to pick up the work or simultaneously actuated from one another to release the work. It will further be noted that as soon as the work piece has been completed and the grinding wheel retracted therefrom the said centers are actuated away from one another to release the work piece so that it may be removed from the machine.

Each of the head and tail stocks, as was noted above, has respectively associated with it a double switch 74 and 96 shown diagrammatically in Figure 15 by the switches 298, 299, 300 and 301. The switches 298 and 301 are electrically connected in series by means of the electrical conduit 302 while the switch 301 is further electrically connected by the wire 303 with the negative lead 279 of the main power source. The switch 298 is also further electrically connected by means of a wire or electrical conduit 304 with a solenoid 305. The solenoid 305 is associated with the control valve indicated generally by the numeral 306 which controls the operation of the loading and ejecting mechanism for alternately connecting the hydraulic medium under pressure with the upper and lower end of the cylinder 103.

This valve 306 is carried by the plate or housing 185 and comprises a valve bushing 307 enclosing a spool type valve which provides the cannelures 308 and 309. The valve has extending from it a valve stem 310 which passes through a stuffing box 311 associated with the valve bushing 307. The outer end of the stem 310 is pivotally connected with the core of the solenoid 305. En-

closed within the bushing 307 and surrounding the valve stem 310 is a spring 312 abutting on one end with the stuffing box 311 and on the other end with the adjacent spool of the valve. The spring normally tends to shift the valve toward the right or in the opposite direction of the operation of said valve when operated by the solenoid 305. Terminating at the valve bushing is one end of a pressure conduit or port 313 which connects on its other end with the pressure conduit or port 314 forming an extension of the pressure conduit 188. Also terminating at the bushing 307 are branch discharge conduits or ports 315 and 316 which connect on their other ends with the discharge conduit 317 in turn connecting with the main discharge conduit 218. The cannelures 308 and 309 alternately connect the pressure port 313 with the conduits 318 and 319 respectively terminating at the ports 111 and 110 of the cylinder 103. At this time the other of the conduits 318 and 319 is connected with either of the branch discharge conduits 315 and 316. From this it will be seen that as soon as the work centers are completely retracted the valve 306 is shifted for effecting the withdrawal of the work from the grinding position. The work piece is discharged from the carrier in the manner above described onto the chute 122, the work carrier continuing upwardly to the upper end of its movement and aligning with the magazine 117.

By reference to Figure 15, it will be noted that there is diagrammatically shown a switch 320 operable by the piston 109 or some part carried thereby preferably the carriage 113. This switch is closed when the piston reaches its lower position, that is when the work is in grinding position so that an electrical circuit is completed through the solenoid 305 and switches 298 and 301 when they are closed. As soon as the piston reaches the upper limit of its movement, however, this switch is open for thereby breaking the circuit, effecting a de-energization of the said solenoid 305 and permitting the spring 312 which was previously compressed to expand and shift the valve 306 to the position to effect the downward movement of the work carrier together with the unfinished work piece now supported thereby. Near the lower end of the movement of the work carrier and prior to the closing of the switch 320, the work carrier closes a momentary switch 321 which has its one contact connected by the electrical conductor or wire 322 with a wire 323 extending from the positive lead 278. The other contact of the switch 321 is connected by a wire or electrical conductor 324 with a solenoid 325 on the other end of the centers valve 205. The energization of this valve through the solenoid 325 connects the pressure to the centers cylinders for actuating the said centers toward one another to pick up the work piece that is now in position between said centers to be supported thereby.

As soon as the two centers are in proper work-supporting position, the switches 299 and 300 are closed thereby. As will be seen in Figure 15, these switches are electrically connected in series by the conductor or wire 326 while the switch 300 is connected by the wire 327 with the wire 303 extending from the negative lead 279. The switch 299 is in turn connected by the electrical lead 328 with one end of the coil of the solenoid 249 associated with the stop valve 211. The other end of the coil of this solenoid is connected by the wire 329 with one contact of a switch 330. The other contact of this switch 330 is connected by an electrical conduit 331 with normally closed switch 332 and by wire 323 with the positive lead 278 of the main power source. When the plate 153 is in its fully retracted position it, through a cam 333 formed thereon or carried thereby or on the cam member 154, as shown diagrammatically in Figure 15, closes the switch 330 so that the electrical circuit is completed upon the closing of the switch contacts 299 and 300. As was above described, the retraction of the plate 153, through the dog 245, secured thereto, shifts the valve 211 to a stop position for stopping the further retraction of the grinding wheel from the work. As seen for example in Figure 4, the plate 153 is actuated toward the left to effect the retraction of the said wheel, therefore the dog 245 will actuate the valve 211 likewise toward the left or in the same direction that the valve is shifted by the solenoid 249. The movement, however, of this valve by the dog merely breaks the flow from the conduit 209 into the conduit 236 by way of the cannelure 238. The further shifting of the valve when the solenoid 249 is energized aligns the cannelure 239 of said valve with its conduits thereby again permitting a flow from said conduit 209 into the conduit 236. At the time the movement of the parts was stopped, the pilot valve was in its left hand position with the lever 197 of the pilot valve shifting mechanism extending toward the right hand dog 199, as seen in Figure 4. Therefore, the shifting of the valve 211 to the position to connect these parts through the cannelure 239 effects the further movement of the stop valve 211 in a direction to continue the rearward movement of the plate 153. This movement of the parts continues until the lever 197 is engaged by the dog 199 whereupon the pilot valve is shifted for reversing the connections therethrough to the chamber 202 for effecting reverse shifting of the reversing valve 203. This then causes the actuation of the piston 148 in the opposite direction for effecting a feeding movement of the grinding wheel toward the work.

The normal cycle of the machine has now been described and it will be seen that the work pieces are automatically brought to the operative position, the centers automatically actuated toward the work to pick up same, the infeed or movement of the grinding wheel toward the work automatically effected when the work is properly supported by the centers, an automatic stopping of the infeed of the wheel when the work is to the desired size, an automatic retraction of the wheel, an automatic release of the work by the centers as soon as the wheel is retracted a sufficient distance to free the work thereof, an automatic stopping of the retraction of the grinding wheel in its inoperative position, and an automatic raising or removal of the work from the grinding position to be discharged into the work receiving trough prior to the picking up of the new unfinished work piece.

In the normal operation of the machine, the work may be brought to the desired size as determined by the sizing mechanism at successive points along the cam surface 155. Since the grinding wheel is subject to wear and must be periodically trued to maintain a sharp accurate face, this point of size of the work along the cam face 155 will gradually progress and would eventually reach the left hand end of said face, as seen in Figure 4. Therefore, the parts must be reset prior to the reaching of said left hand end of the cam face. To effect this adjustment there is provided on the cam plate a pair of dogs 334 and 335. These parts are shown diagrammati-

cally in Figure 15 and structurally in Figure 18 and from the latter figure it will be noted that the shiftable slide or carriage 129 has upstanding therefrom intermediate its ends a bracket 336. Rotatably mounted thereon as by shaft 337 is a plate 338 having projecting from its one surface a pin or lug 339. This pin or lug 339 lies in the path of movement of the dog 334 and is adapted to be engaged thereby for oscillating or rotating said plate when the piston 148 and parts actuated thereby including the plate 153, reach their right hand limit of movement, as seen in Figure 4, at which time the roller 156 on the oscillatable grinding wheel carriage 137 is near the left hand end of the cam surface 155. Secured to the plate 338 is a switch member 340 known in the trade as a "mercoid" switch. This type of switch comprises a glass tube sealed on opposite ends and containing mercury which when in the idle position has the mercury at one end of the tube and when in the operative position has said mercury at the other end of the tube for electrically bridging a pair of contacts carried by said end of the tube. These contacts are indicated in Figure 15 by the numerals 341 and 342, the former being connected by an electrical conductor or wire 343 with one contact of a switch 344 while the latter is connected by an electrical wire 345 with one end of a pair of solenoids 346 and 347. The other contact of the switch 344 is connected by an electrical conductor or wire 348 with the wire 283. From this it will be seen that the electrical circuit is not completed by the oscillation of the plate 338 unless the switch 344 is also closed. Since the switch 344 can only be closed when the parts are in the position where the carriage 137 is completely retracted and since the switch 340 is closed when the parts are in the opposite position, the switch 340 must first be closed. As will later appear in detail, this electrical interlock prevents adjustment or compensation between the parts for wheel wear when the work is in actual contact with the grinding wheel and restricting said adjustment to take place only when the parts are completely separated from one another.

The solenoid 346 is enclosed within a suitable housing mechanism 349 secured to the forward face of the bed 25. The movable core of this solenoid has pivotally connected therewith a pawl 350 adapted to engage with a ratchet 351 keyed or otherwise secured to a transverse shaft 352. This shaft projects through and beyond the bed plate of the bed extension 32 into a suitable bracket or housing 353 secured to the end of the bed plate 127. Integral with or secured to the projecting end of the shaft 352, and enclosed within the housing 353, is a pinion 354 meshing with the gear 355 of compound idler gear 356. The pinion 357 of said compound gear meshes with a gear 358 integral with or secured to the rear end of an adjusting screw 359. This screw is suitably journaled in the housing 353 against any relative axial movement with respect thereto. The screw 359 is in threaded engagement with a nut 360 secured in any desirable manner to the movable slide 128 whereby the axis of pivotance of the carriage 137 is advanced as respects the axis of rotation of the work upon the next advance of the slide 153. The dog 335, carried thereby, has a cam face 361 which engages with the pin or boss 339 for returning the oscillatable plate 338 to its normal position and breaking the electrical circuit through the switch 340 so that the next retraction of the said plate upon closing of the switch 344 will not effect a further compensation of the work and wheel.

As is well known, and as suggested above, it is necessary to periodically true the operative face of the grinding wheel. For this reason the carriage 137, see Figure 8, has secured to it a bracket 362 to which is secured a fixed slide 363 having formed therein longitudinally thereof a guideway 364 receiving a suitable guide tongue depending from the under surface of a movable carriage 365. The carriage 365 is adapted to be translated longitudinally of the slide 363 by hydraulic pressure for which reason it has swiveled thereto as at 366 one end of a piston rod 367. The piston rod 367 carries at its inner end a piston 368 enclosed within a fixed cylinder 369. The cylinder is attached to an upstanding arm 370 integral with or secured to one end of the fixed slide 363. The cylinder is provided on opposite ends with ports 371 and 372 whereby the hydraulic medium is alternately introduced into the cylinder.

By reference to Figure 15, it will be noted that the cylinder 369 has terminating respectively at its ports 371 and 372 one terminus of conduits 373 and 374 which terminate at their other ends in a reversing valve indicated generally by the numeral 375. This valve is shown structurally in Figure 13 and comprises a valve bushing 376 secured in and carried by the plate or housing 185. Enclosed within the bushing 376 is a spool type valve providing cannelures 377 and 378 alternately connecting the cylinder conduits 373 and 374 with the pressure conduit 379 extending from branch pressure conduit 314 and branch discharge conduits 380 and 381 connected with the branch conduits 317 and 218. The valve has extending from it a stem 382 passing through a stuffing box 383 carried by one end of the cylinder bushing. Surrounding the stem interiorly of the bushing is a coil spring 384 abutting on opposite ends with the stuffing box 383 and adjacent spool portion of the valve. The outer end of the stem 382 is connected with the movable core of a solenoid 385. The solenoid 385 has one end of its coil connected by the electrical conduit or wire 386 with one terminal 387 of the double throw switch 332. The switch 332 is normally broken as respects the contact 387 so that the solenoid 385 is normally de-energized permitting the spring 384 to shift the truing valve in a direction opposite to that in which it is shifted by the solenoid 385. The other end of the solenoid 385 is electrically connected with the opposite lead to that to which the switch arm of switch 332 is connected.

The truing tool carriage 375 has rotatably mounted therein a shaft or screw 388 which carries at its inner end a diamond or other truing tool for operation on the face of the grinding wheel. This screw in practice is adapted to be incrementally actuated in a direction toward the grinding wheel for which purpose it has secured to it, see Figure 5, a ratchet 389 adapted to cooperate with a pawl 390 pivotally attached to an arm 391 oscillatable about the axis of the screw shaft 388. The upper end of the arm 391 is suitably connected to the movable core of a solenoid 392. These parts are all enclosed within a suitable housing or guard 393 associated with the truing mechanism and adapted to be attached to the truing carriage 365. The diamond of the screw shaft 388 should at all times bear a definite relation to the operative surface of the grinding wheel 30 that it may be readily placed

in operation. For this reason, the arm 391 is oscillated not only by the solenoid 392, but also by the solenoid 347 above referred to. The solenoids 347 and 346 are simultaneously actuated, the latter as above described compensating for wheel wear as between the work and grinding wheel. Therefore, simultaneous with this compensation and through the solenoid 347 the diamond is adjusted with respect to the wheel thereby at all times maintaining a definite relation between the diamond and the wheel.

The solenoid 392 is electrically connected as by the wire or electric conductor 394 with the conductor 386 connecting the contact 387 of switch 332 with the truing device valve solenoid 385. From this it will be seen that simultaneous with the shifting of the valve of the truing device the diamond is actuated in a feeding direction with respect to the wheel thereby removing a predetermined amount of material from the operative surface of said wheel. This will again throw the work and grinding wheel surface out of operative relation and might result in the work not reaching its size before the roller 156 of the oscillatable carriage 137 reached the left hand end of cam face 155. To avoid this condition, the feeding pawl 350 on the movable core of the solenoid 349 is connected with the movable coil of a second solenoid, or as shown diagrammatically in Figure 15, the said core is operated upon by the coil of a second solenoid 395, which is electrically connected by the wire or conductor 396 with the conduit 386. From this it will, therefore, be seen that actuation of the switch 332 to effect a truing operation will simultaneously energize solenoids 392 and 395 for not only feeding the diamond with respect to the grinding wheel, but also for compensating or adjusting the position of the grinding wheel as respects the work in accordance with the amount of stock being removed from the operative face of the wheel.

In the automatic production of work pieces from a grinding machine, it is desirable that the truing of the wheel take place at predetermined intervals in the cycle of operation of the machine. For example, after a predetermined number of work pieces have been produced by the machine. To accomplish this result, the slide 128 has mounted thereon a housing or casing 397 enclosing a counting mechanism and the switch 332 which is automatically actuated. The details of this mechanism are shown in Figures 10, 11 and 12 and comprise a vertically shiftable plunger 398 having rotatably secured in its upper end a roller 399. This roller 399 is adapted to be engaged by cam face 400 on the adjustable dog 198 carried by the plate member 153. The plunger 398 is connected with a pivotally mounted arm 401 and oscillated in a clockwise direction by a spring pressed plunger 402 for maintaining the roller 399 in its normal upward position. The arm 401 is keyed or otherwise secured to a shaft 403 which extends transversely of the housing 397. The shaft 403 has keyed to it an arm 404 so as to partake of the oscillatory movements imparted to the shaft due to the depression of the plunger 398. The arm 404 has pivoted to its upper end a pawl 405 co-operating with the teeth of a ratchet 406 formed integral with a sleeve member 407 loosely journaled on the shaft 403. Pinned or otherwise secured to the ratchet 406 is a switch actuator plate 408 having the lug 409 projecting from its surface. The parts are so arranged that each movement of the plate 153 in a given direction causes a depression of the plunger 398 against the yielding resistance of spring plunger 402. This depression of the plunger 398 causes oscillation of the arm 404 which through the pawl 405 advances the ratchet 406. The advancement of the ratchet 406 may be one or more teeth on the ratchet depending upon the particular setting of the parts, which in turn is determined by how many pieces it is desired to finish between each truing of the grinding wheel. The cam lug 409 eventually reaches a position to engage switch plunger 410 for rearwardly shifting said plunger and effecting the closing of the switch 332 by engaging the contact 387. It is to be understood that more than one switch cam lug, such as 409, may be provided on the plate 408 for thereby closing the switch more than once for each complete revolution of the said plate and its actuating ratchet. This is determined again by the particular number of pieces it is desired to finish between successive truing operations.

In order to prevent a truing of the wheel during the grinding operation, the switch 332 is electrically connected with the switch 330 as above described, so that this truing can only take place when the parts are in a fully retracted position, which is the only time that the switch 330 is closed.

It is believed that without further explanation the complete operation of the improved automatic grinding machine will be thoroughly understood.

What is claimed is:

1. In a grinding machine of the class described the combination of a bed, a grinding wheel carriage pivotally mounted on the bed, a work support carried by the bed, an hydraulically actuated reciprocating motor operatively associated with the carriage for effecting its oscillation toward and from the work support, an hydraulic circuit for operating the motor, and means operable during the oscillation of the carriage for controlling the hydraulic circuit to thereby control the rate of oscillation of the carriage.

2. In a grinding machine of the class described the combination of a bed, a work supporting mechanism carried by the bed, a grinding wheel carriage pivotally mounted on the bed for oscillation toward and from the work supporting mechanism, hydraulically operated reciprocating means including a cam for effecting the oscillation of the carriage, an hydraulic circuit for effecting and controlling the operation of the hydraulically actuated means, and means operable by said hydraulically actuated means for controlling the rate of oscillation of the carriage.

3. In a grinding machine of the class described the combination of a bed, a work supporting mechanism carried by the bed, a grinding wheel carriage pivotally mounted on the bed for oscillation toward and from the work supporting mechanism, hydraulically operated reciprocating means including a cam for effecting the oscillation of the carriage, an hydraulic circuit for effecting and controlling the operation of the hydraulically actuated means, and means operable by said hydraulically actuated means for controlling the rate of oscillation of the carriage, said rate controlling means comprising a valve, yielding means for shifting said valve to an inoperative position, and positive means associated with the hydraulic reciprocating means for shifting said valve against the yielding resistance of said yielding means.

4. In a grinding machine of the class described

the combination of a bed, a work supporting mechanism carried by said bed, a pivotally mounted tool carriage carried by said bed, hydraulically actuated means for reversely oscillating said carriage relative to the work supporting means, an hydraulic circuit including a reversing valve for controlling the operation of said oscillating means, electro-magnetic means for shifting the reversing valve when the work is to the desired size, and means associated with the oscillating means for reversely shifting said reversing valve.

5. In a grinding machine of the class described the combination of a work supporting mechanism, a pivotally mounted tool carriage oscillatable toward the work at rapid and variable feed rates and oscillatable from the work at a rapid rate, a cam wedge axially shiftable for effecting said oscillation of the tool carriage toward and from the work, hydraulically actuated means for actuating said cam wedge, an hydraulic circuit for controlling said hydraulically actuated means, a speed control valve in the hydraulic circuit, and means associated with the axially shiftable cam wedge for actuating said speed control valve.

6. In a grinding machine of the class described the combination of a work supporting mechanism, a pivotally mounted tool carriage oscillatable toward the work at rapid and variable feed rates and oscillatable from the work at a rapid rate, a cam wedge axially shiftable for effecting said oscillation of the tool carriage toward and from the work, hydraulically actuated means for actuating said cam wedge, an hydraulic circuit for controlling said hydraulically actuated means, a speed control valve in the hydraulic circuit, means associated with the axially shiftable cam wedge for actuating said speed control valve, and means for by-passing the rate control valve during the oscillation of the carriage away from the work support.

7. In a grinding machine of the class described the combination of a work supporting mechanism, a pivotally mounted tool carriage oscillatable toward the work at rapid and variable feed rates and oscillatable from the work at a rapid rate, a cam wedge axially shiftable for effecting said oscillation of the tool carriage toward and from the work, hydraulically actuated means for actuating said cam wedge, an hydraulic circuit for controlling said hydraulically actuated means, a shiftable speed control valve in the hydraulic circuit, means associated with the axially shiftable cam wedge for actuating said speed control valve, a reversing valve in said circuit for controlling the direction of operation of the hydraulically actuated means, and a pilot valve for determining the position of the reversing valve and consequently the direction of actuation of the hydraulically actuated feeding means.

8. In a grinding machine for producing successive work pieces to a predetermined size and finish comprising a work supporting mechanism, a grinding wheel carriage rotatably supporting a grinding wheel, means pivotally mounting said carriage for oscillation toward and from the work supporting mechanism, additional means for mounting said carriage for translation toward and from the work supporting mechanism, hydraulically actuated means for effecting the oscillation of said carriage, electro-mechanical means for effecting the translation of said carriage, and means carried by the hydraulically actuated means for energizing the electro-mechanical means at a definite point in its cycle of operation.

9. In a grinding machine for producing successive work pieces to a predetermined size and finish comprising a work supporting mechanism, a grinding wheel carriage rotatably supporting a grinding wheel, means pivotally mounting said carriage for oscillation toward and from the work supporting mechanism, additional means for mounting said carriage for translation toward and from the work supporting mechanism, hydraulically actuated means for effecting the oscillation of said carriage, electro-mechanical means for effecting the translation of said carriage, means carried by the hydraulically actuated means for energizing the electro-mechanical means at a definite point in its cycle of operation, and means for controlling the rate of actuation of the hydraulic means for thereby controlling the rate of oscillation of the tool carriage and the finish on the work.

10. In a grinding machine for producing successive work pieces to a predetermined size and finish comprising a work supporting mechanism, a grinding wheel carriage rotatably supporting a grinding wheel, means pivotally mounting said carriage for oscillation toward and from the work supporting mechanism, additional means for mounting said carriage for translation toward and from the work supporting mechanism, hydraulically actuated means for effecting the oscillation of said carriage, electro-mechanical means for effecting the translation of said carriage, means carried by the hydraulically actuated means for energizing the electro-mechanical means at a definite point in its cycle of operation, means for controlling the rate of actuation of the hydraulic means for thereby controlling the rate of oscillation of the tool carriage and the finish on the work, and electro-magnetic means energizable by the work when it reaches the predetermined size for stopping further oscillation of the carriage toward the work and effecting a reverse oscillation thereof.

11. In a grinding machine of the class described for producing successive work pieces to the same size and finish the combination of a work supporting mechanism, a grinding wheel carriage pivotally mounted adjacent the work supporting mechanism for oscillation toward and from the work supporting mechanism, hydraulically actuated means for effecting the oscillation of the grinding wheel carriage, means operable by the said hydraulically actuated means for controlling the rate of oscillation of the carriage and consequently controlling the finish on the work, and means engaging the work for stopping further oscillation of the carriage toward the work supporting means when the work reaches a predetermined desired size and for effecting reverse oscillation of the carriage.

12. In a grinding machine of the class described for producing successive work pieces to the same size and finish the combination of a work supporting mechanism, a grinding wheel carriage pivotally mounted adjacent the work supporting mechanism for oscillation toward and from the work supporting mechanism, hydraulically actuated means for effecting the oscillation of the grinding wheel carriage, means operable by the said hydraulically actuated means for controlling the rate of oscillation of the carriage and consequently controlling the finish on the work, and means engaging the work for stopping further oscillation of the carriage toward the work supporting means when the work reaches

a predetermined desired size and for effecting reverse oscillation of the carriage, said hydraulically actuated means including an hydraulic circuit and a reversing valve therein, electro-magnetic means for effecting the shifting of the reversing valve in one direction and mechanically controlled means for effecting the shifting of the said valve in the opposite direction, and means interconnecting the electro-magnetic means and the means operable by the work for shifting the reversing valve and stopping further oscillation of the carriage toward the work supporting mechanism.

13. A feeding mechanism for grinding machines in which the work is rotatably supported comprising a grinding wheel, a pivotally mounted carriage for said grinding wheel, an axially shiftable wedge type cam for effecting the oscillation of said carriage, an hydraulic motor for shifting said cam, an hydraulic circuit for actuating said motor, a reversing valve in said circuit, a pilot valve for controlling the position of the reversing valve, means energizable upon reducing the work to the desired size for shifting said pilot valve in one direction, and mechanical means associated with the wedge cam for shifting said valve in the opposite direction.

14. A feeding mechanism for grinding machines in which the work is rotatably supported comprising a grinding wheel, a pivotally mounted carriage for said grinding wheel, an axially shiftable wedge type cam for effecting the oscillation of said carriage, an hydraulic motor for shifting said cam, an hydraulic circuit for actuating said motor, a reversing valve in said circuit, a pilot valve for controlling the position of the reversing valve, means energizable upon reducing the work to the desired size for shifting said pilot valve in one direction, mechanical means associated with the wedge cam for shifting said valve in the opposite direction, and means in said hydraulic circuit operable upon movement of the wedge cam for controlling said circuit and consequently the rate of movement of the wedge cam and rate of oscillation of the grinding wheel carriage.

15. A feeding mechanism for grinding machines in which the work is rotatably supported comprising a grinding wheel, a pivotally mounted carriage for said grinding wheel, an axially shiftable wedge type cam for effecting the oscillation of said carriage, an hydraulic motor for shifting said cam, an hydraulic circuit for actuating said motor, a reversing valve in said circuit, a pilot valve for controlling the position of the reversing valve, means energizable upon reducing the work to the desired size for shifting said pilot valve in one direction, mechanical means associated with the wedge cam for shifting said valve in the opposite direction, means in said hydraulic circuit operable upon movement of the wedge cam for controlling said circuit and consequently the rate of movement of the wedge cam and rate of oscillation of the grinding wheel carriage, and means associated with said wedge cam for stopping further movement thereof and consequently further oscillation of the grinding wheel carriage in a retracting direction.

16. A feeding mechanism for grinding machines in which the work is rotatably supported comprising a grinding wheel, a pivotally mounted carriage for said grinding wheel, an axially shiftable wedge type cam for effecting the oscillation of said carriage, an hydraulic motor for shifting said cam, an hydraulic circuit for actuating said motor, a reversing valve in said circuit, a pilot valve for controlling the position of the reversing valve, means energizable upon reducing the work to the desired size for shifting said pilot valve in one direction, mechanical means associated with the wedge cam for shifting said valve in the opposite direction, means in said hydraulic circuit operable upon movement of the wedge cam for controlling said circuit and consequently the rate of movement of the wedge cam and rate of oscillation of the grinding wheel carriage, means associated with said wedge cam for stopping further movement thereof and consequently further oscillation of the grinding wheel carriage in a retracting direction, and electro-magnetic means for rendering said stopping means inoperative for initiating a new feeding cycle.

17. In an automatic machine tool for automatically producing successive work pieces to the same size and with the same finish comprising a bed, a work supporting mechanism on said bed, a tool carriage pivotally mounted on said bed, means for automatically presenting an unfinished work piece to said work supporting mechanism and automatically withdrawing a finished work piece therefrom, means for automatically actuating said work supporting mechanism to cause same to terminally engage and support the work piece, means for automatically oscillating the tool carriage toward the work to effect the desired stock removal from the work, means for automatically controlling the rate of oscillation of the tool carriage for controlling the finish on the work, and means for automatically stopping the said oscillation when the work is reduced to the desired size.

18. In an automatic machine tool for automatically producing successive work pieces to the same size and with the same finish comprising a bed, a work supporting mechanism on said bed, a tool carriage pivotally mounted on said bed, means for automatically presenting an unfinished work piece to said work supporting mechanism and automatically withdrawing a finished work piece therefrom, means for automatically actuating said work supporting mechanism to cause same to terminally engage and support the work piece, means for automatically oscillating the tool carriage toward the work to effect the desired stock removal from the work, means for automatically controlling the rate of oscillation of the tool carriage for controlling the finish on the work, and means for automatically stopping the said oscillation when the work is reduced to the desired size, said automatic means including interlocked electro and hydraulic control means whereby they are sequentially actuated in timed relation.

19. In a grinding machine of the class described the combination with a bed, a work support, and a grinding wheel, of means for securing one of said parts to the bed for oscillation toward and from the other, an axially shiftable cam for effecting the said oscillation thereof, an hydraulic motor for effecting the adjustment of the cam, an hydraulic system including a valve for controlling the operation of the motor, and automatic means controlled by the size of the work for automatically actuating the valve.

20. In a grinding machine of the class described for producing successive work pieces to a predetermined size the combination with a bed, a work support, and a grinding wheel, of means for mounting one of said parts for oscil-

lation toward the other to effect a stock removable from the work, an axially shiftable cam for effecting the oscillation of said part, and means operable on the work for reversely axially shifting the cam when the work reaches said predetermined size.

21. In a grinding machine of the class described for producing successive work pieces to a predetermined size the combination with a bed, a work support, and a grinding wheel, of means for mounting one of said parts for oscillation toward the other to effect a stock removal from the work, an axially shiftable cam for effecting the oscillation of said part, means operable on the work for reversely axially shifting the cam when the work reaches said predetermined size, said cam adapted to reach size at successive points throughout its length, and means intermittently operable for varying the zone of oscillation of the part by advancing the pivot thereof toward the other part.

22. In a grinding machine of the class described for producing successive work pieces to a predetermined size the combination with a bed, a work support and a grinding wheel, of means for mounting one of said parts on the bed for oscillation toward and from the other, an axially shiftable cam having a definite path of travel and adapted to bring successive work pieces to the desired size at successive points in its travel due to the wear on the grinding wheel, and means intermittently operable for compensating for the wheel wear prior to the cam reaching one limit of its travel.

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