April 5, 1960 O. E. HILL 2,931,145

GRINDING MACHINE

Filed Feb. 28, 1957 3 Sheets-Sheet 1

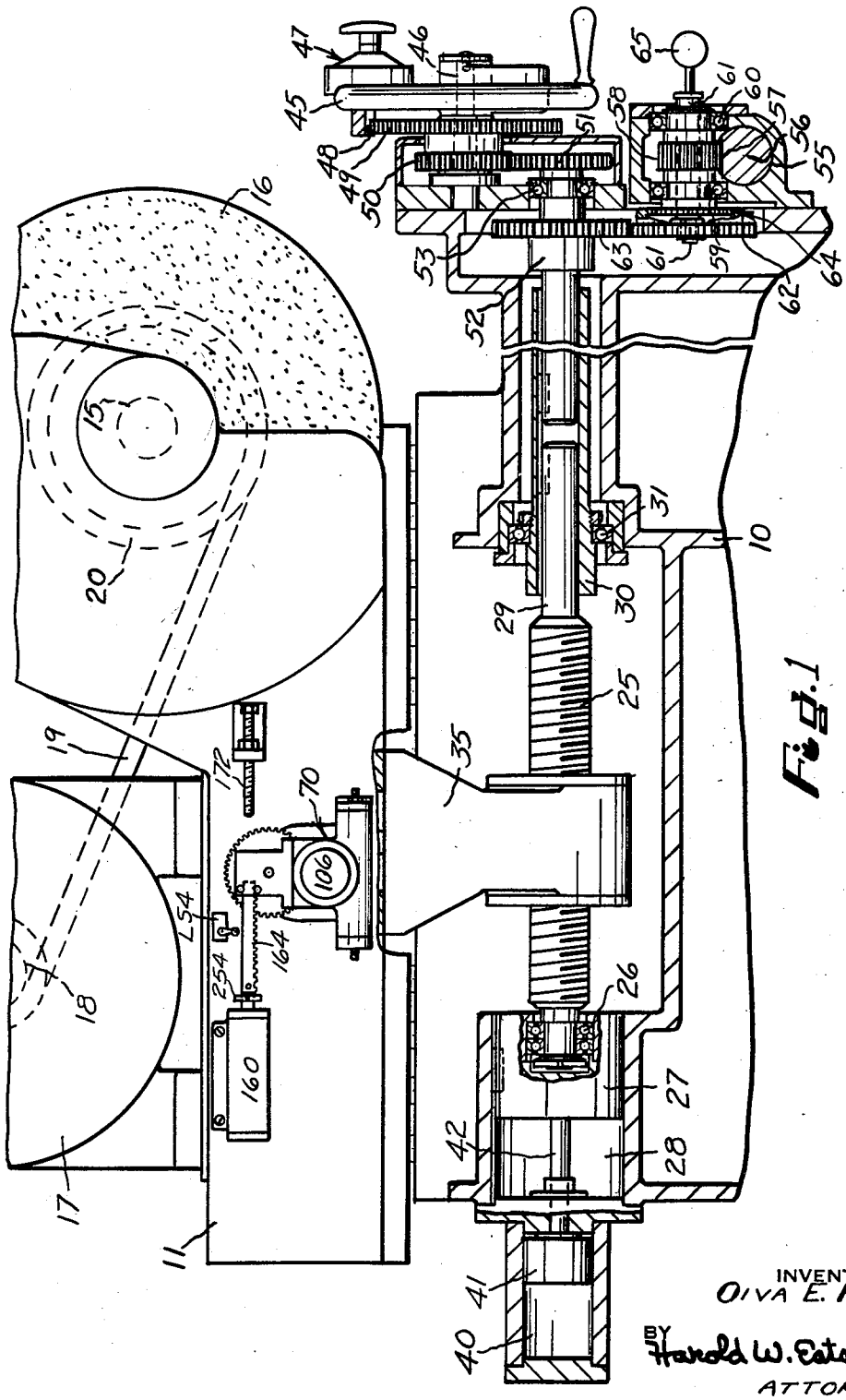



Fig. 1

INVENTOR
OIVA E. HILL

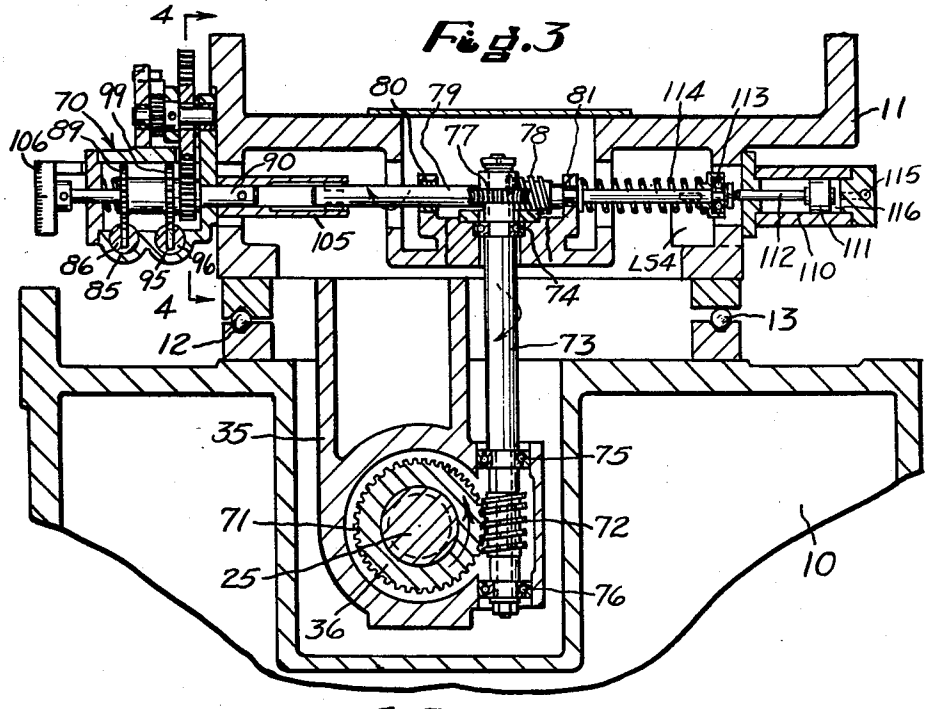
BY Harold W. Eaton
ATTORNEY

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GRINDING MACHINE

Filed Feb. 28, 1957 3 Sheets-Sheet 2

Fig. 3



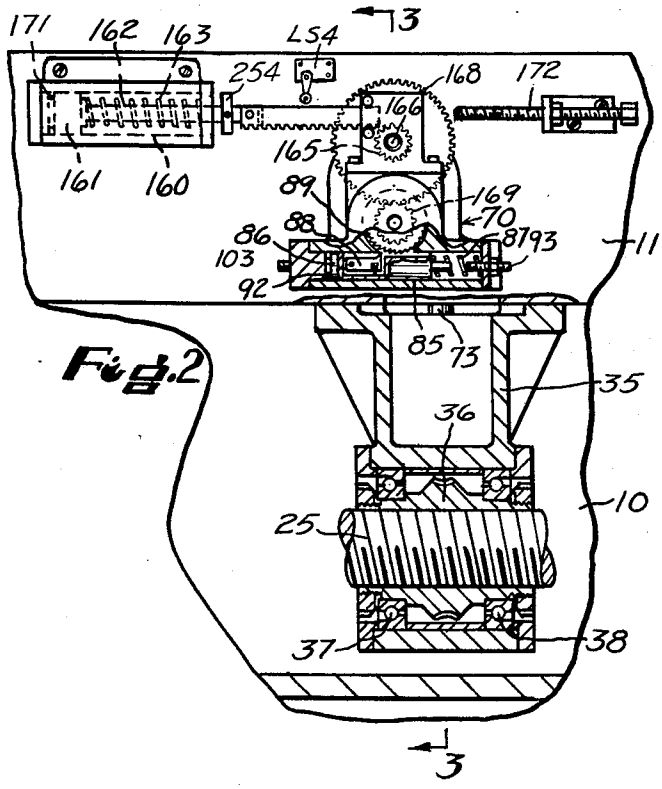
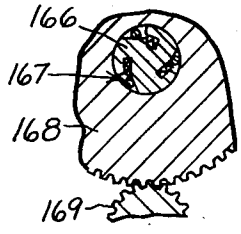




Fig. 2

Fig. 4



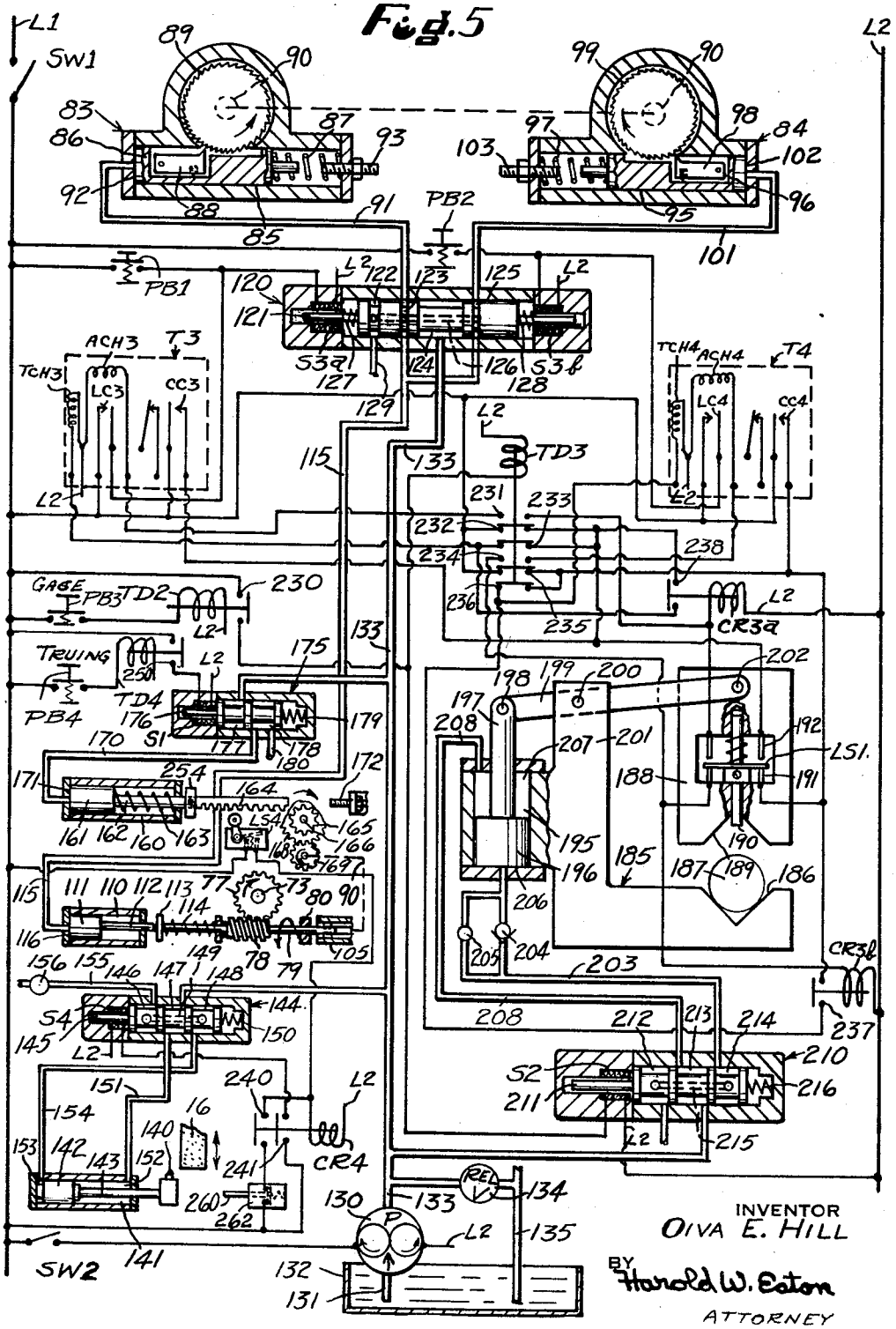

INVENTOR
OIVA E. HILL
BY Harold W Eaton
ATTORNEY

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GRINDING MACHINE

Filed Feb. 28, 1957 3 Sheets-Sheet 3

Fig. 5




INVENTOR
OIVA E. HILL
BY Harold W. Eaton
ATTORNEY

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2,931,145

# GRINDING MACHINE

Oiva E. Hill, West Boylston, Mass., assignor to Norton Company, Worcester, Mass., a corporation of Massachusetts

Application February 28, 1957, Serial No. 643,162

10 Claims. (Cl. 51—165)

The invention relates to grinding machines, and more particularly to a grinding wheel wear and work size compensating mechanism.

One object of the invention is to provide a simple and thoroughly practical grinding wheel wear and work size compensating mechanism for a grinding machine. Another object is to provide a work gauge controlled feed compensating mechanism. Another object is to provide a feed compensating mechanism automatically to compensate for oversize or undersize ground work pieces. Another object is to provide a work gauge controlled feed compensating mechanism automatically to impart a forward or rearward compensation to the grinding wheel feeding mechanism.

A further object is to provide a compensating mechanism automatically to impart a feed compensation before a grinding wheel truing operation. Another object is to provide a feed compensating mechanism which is arranged to impart either a forward or a rearward compensating adjustment for undersize or oversize work and to impart a feed compensation to the feed mechanism before each grinding wheel truing operation. 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 the invention;

Fig. 1 is a fragmentary vertical sectional view through a grinding machine, showing the grinding wheel feeding mechanism;

Fig. 2 is a fragmentary vertical section view, on an enlarged scale, through the feed compensating mechanism;

Fig. 3 is a vertical sectional view, taken approximately on the line 3—3 of Fig. 2;

Fig. 4 is a fragmentary vertical sectional view, on an enlarged scale taken approximately on the line 4—4 of Fig. 3, through the one-way clutch in the compensating mechanism; and

Fig. 5 is a combined hydraulic and electric diagram of the actuating mechanisms of the machine and the controls therefor.

A grinding machine has been illustrated in the drawings comprising a base 10 which serves as a support for a transversely movable grinding wheel slide 11. The wheel slide 11 is arranged to slide transversely on a pair of spaced anti-friction ways including a V-way 12 and a flat way 13.

The wheel slide serves as a support for a rotatable wheel spindle 15 which is journalled in spaced bearings (not shown). A grinding wheel 16 is mounted on one end of the wheel spindle 15. A driving mechanism is provided for driving the spindle 15 and the grinding wheel 16 comprising an electric motor 17 mounted on the upper surface of the wheel slide 11. The motor 17 is provided with a motor shaft (not shown) which supports a movable V-groove pulley 18. The pulley 18 is connected by multiple V-belts 19 with a multiple V-groove pulley 20 mounted on the wheel spindle 15.



The wheel slide 11 is arranged to be fed transversely relative to the base 10 by means of a rotatable feed screw 25. The left hand end of the feed screw 25 (Fig. 1) is journalled in anti-friction bearings 26 supported by a slidably mounted sleeve 27. The sleeve 27 is slidably keyed within a cylindrical aperture 28 formed in the base 10. A reduced cylindrical portion 29 formed integral with the feed screw 25 is slidably keyed within a rotatable sleeve 30 which is, in turn, rotatably journalled in an anti-friction bearing 31 supported by the base 10. A bracket 35 depending from the underside of the wheel slide 11 serves as a support for a rotatable feed nut 36 which meshes with or engages the feed screw 25. The nut 36 is journalled in a pair of spaced anti-friction bearings 37 and 38 (Fig. 2) which are supported within the bracket 35.

The wheel slide 11 is arranged thereby moving rapidly to and from an operative position by a hydraulically operated mechanism comprising a cylinder 40 arranged in axial alignment with the feed screw 25. The cylinder 40 contains a slidably mounted piston 41 which is connected to the left hand end of a piston rod 42. The right hand end of the piston rod 42 is connected to the slidably mounted sleeve 27. Movement of the piston 41 in either direction serves to cause a rapid transverse movement to the wheel slide 11.

A grinding wheel feeding mechanism is provided comprising a manually operable feed wheel 45 which is rotatably supported on a shaft 46. The feed wheel 45 is provided with the usual well known micrometer adjusting mechanism 47 including a pinion 48. The pinion 48 meshes with a gear 49 which is rotatably supported on the shaft 46. A gear 50 is formed integral with the gear 49 and meshes with a gear 51. The gear 51 is fixedly mounted on the right hand end of a rotatable shaft 52. The shaft 52 is rotatably journalled in an anti-friction bearing 53. The left hand end of the shaft 52 is slidably keyed within the central aperture formed within the sleeve 30. It will be readily apparent from the foregoing disclosure that a rotary motion of the feed wheel will be imparted through the gear mechanism above described to rotate the feed screw 25 and thereby to impart a transverse feeding movement to the wheel slide 11. The direction of rotation of the feed wheel 45 serves to determine the direction of movement of the wheel slide 11.

A hydraulically operated mechanism is provided for producing a slow precise feeding movement of the wheel slide 11 and the grinding wheel 16 during a grinding operation. This mechanism comprises a cylinder 55 which contains a slidably mounted piston 56. A plurality of rack teeth 57 are formed on the upper surface of the piston 56 and mesh with a gear 58. The gear 58 is rotatably supported by a pair of spaced anti-friction bearings 59 and 60 (Fig. 1). A shaft 61 is rotatably supported within a central aperture formed within the gear 58. A gear 62 is fixedly mounted on the left hand end of the shaft 61 and meshes with a gear 63 which is fixedly mounted on the shaft 52. A manually operable clutch 64 is provided to connect the gear 62 and the shaft 61 with the gear 58. The clutch 64 is actuated by a manually operable knob 65. When a power operated feed is desired, the clutch 64 is engaged so that movement of the piston 56 will be imparted through the mechanism above described to impart a rotary feeding movement to the feed screw 25. This mechanism above described is substantially identical with that disclosed in the prior U.S. patent to H. A. Silven, No. 2,572,529 dated October 23, 1951, to which reference may be had for details of disclosure not contained herein.

In order to attain the main object of the invention, a combined compensating unit **70** is provided on the wheel slide **11** automatically to impart either a forward or rearward compensating adjustment to the feed nut **36** for oversize or undersize ground work pieces and also to impart a feed compensating adjustment to said feed nut **36** before each grinding wheel truing operation. A worm gear **71** is formed integral with the feed nut **36** and meshes with a worm **72** mounted on the lower end of a vertically-arranged rotatable shaft **73** (Fig. 3). The shaft **73** is journalled in a plurality of spaced anti-friction bearings **74**, **75**, and **76**. The bearing **74** is fixedly supported on the wheel slide **11** and the bearings **75** and **76** are mounted within the depending bracket **35** which supports the feed nut **36**. The upper end of the shaft **73** is provided with a worm gear **77** which meshes with a worm **78** formed on a horizontally arranged rotatable shaft **79**. The shaft **79** is rotatably and slidably supported in a pair of spaced bearings **80** and **81** respectively.

The compensating unit **70** includes a forward or oversize compensator **83** and a rearward or undersize compensator **84** which are substantially idential in construction. The compensator **83** comprises a cylinder **85** which contains a slidably mounted piston **86**. A compression spring **87** serves normally to hold the piston **85** in a left hand end position (Fig. 5). The piston **86** is provided with a spring pressed pawl **88** which is arranged to engage the teeth of a ratchet wheel **89** when the piston **85** is moved toward the right. The ratchet wheel **89** is fixedly mounted on a rotatable shaft **90** (Figs. 3 and 5). When fluid under pressure is passed through a pipe **91** into a cylinder chamber **92** the piston **85** is moved toward the right so that the pawl **88** imparts a rotary motion to the ratchet wheel **89** and the shaft **90**, counterclockwise as viewed in Fig. 5. An adjustable stop screw **93** serves to determine the right hand end position of the piston **86**. By adjustment of the stop screw **93**, the number of teeth of the ratchet wheel **89** picked up at each actuation of the pawl **88** may be controlled as desired.

Similarly, the compensator **84** comprises a cylinder **95** which contains a slidably mounted piston **96**. A compression spring **97** serves normally to hold the piston **96** in a right hand end position (Fig. 5). The piston **96** is provided with a spring pressed pawl **98** which is arranged to engage the teeth of a ratchet wheel **99** when the piston **95** is moved toward the left. The ratchet wheel **99** is also fixedly mounted on the rotatable shaft **90** and is arranged to impart a rotary motion to the shaft **90** in the opposite direction clockwise as viewed in Fig. 5. When fluid under pressure is passed through a pipe **101** into a cylinder chamber **102**, the piston **95** is moved toward the left so that the pawl **98** imparts a rotary motion to the rotary wheel **99** and the shaft **90**. An adjustable stop **103** corresponding to adjustable stop **93** serves to determine the left hand end position of piston **96**.

The shaft **90** is fixedly mounted within the left hand end of a rotatable sleeve **105** (Fig. 3). The shaft **79** is slidably keyed within a central aperture formed within the right hand end of the sleeve **105**. It will be readily apparent from the foregoing disclosure that a rotary motion of the shaft **90** produced by either the oversize compensator **83** or the undersize compensator **84** will be imparted through the mechanism above described to impart a rotary compensating adjustment to the feed nut **36** in either direction so as to facilitate compensating for oversize or undersize ground work pieces.

The pawl and ratchet compensators, above described, are substantially identical with the compensators disclosed in my copending patent application Serial No. 578,412 filed April 16, 1956, now Patent No. 2,834,159, dated May 13, 1958, and in my copending patent application Serial No. 626,484 filed December 5, 1956, now Patent No. 2,895,265, dated July 21, 1959.

In order to provide a precise compensation, it is desirable to unwind and wind the feed nut **36** before and after a compensating adjustment has been made so that the thrust of the parts will be in the same direction after compensation thereby taking up backlash in the parts. This is preferably accomplished by a hydraulically operated mechanism comprising a cylinder **110** which contains a slidably mounted piston **111**. The piston **111** is fixedly mounted on the right hand end of a piston rod **112**. The left hand end of the piston rod **112** is connected by anti-friction thrust bearing **113** with the right hand end of the shaft **79**. A compression spring **114** surrounds the right hand end of the shaft **79** and is interposed between the bearing **81** and the thrust bearing **113**. The spring **114** serves normally to move the shaft **79** toward the right so that a shoulder on the right hand end of the worm **78** is maintained in engagement with the left hand end face of the bearing **81** (Fig. 3). When it is desired to impart an unwind and wind movement to the feed nut **36**, fluid under pressure is passed through a pipe **115** into a cylinder chamber **116** to move the piston **111** toward the left (Fig. 3) against the compression of the spring **114** so as to move the worm **78** axially toward the left to impart a rotary unwind movement to the feed nut **36**. When fluid is free to exhaust from the cylinder chamber **116**, the released compression of the spring **114** moves the shaft **79** together with the worm **78** toward the right to impart a rotary wind movement to the feed nut **36**. The parts are arranged so that the worm **78** remains in mesh with the worm gear **77** during the axial movement of the shaft **79**.

The compensating mechanisms are actuated automatically by a work gauging mechanism to be hereinafter described after a predetermined number of successively gauged ground work pieces are undersize or oversize. If desired, a manual compensating adjustment may be made to the feed nut **36** by manual actuation of a knob **106** which is mounted on the left hand end of the shaft **90** (Fig. 3). This latter adjustment is particularly useful in setting up and adjusting the machine.

A control valve **120** is provided for controlling the admission to and exhaust of fluid from the compensator cylinders **85** and **95** and also the unwind-wind cylinder **110**. The valve **120** is a piston type valve comprising a slidably mounted valve member **121** having a plurality of spaced valve pistons formed integrally therewith to form spaced valve chambers **122**, **123**, **124**, and **125**. The valve member **121** is also provided with a central passage **126** which interconnects the valve chambers **122**, **123**, and **125**. A pair of balanced compression springs **127**, and **128** serve normally to maintain the valve member **121** in a central or neutral position. An exhaust pipe **129** connects the valve **120** with a reservoir **132**. A pair of solenoids S3*a* and S3*b* are provided which when energized selectively serve to shift the valve member **121** either toward the right or toward the left so as to control the admission to and exhaust of fluid from the cylinders **85**, **95**, and **110**.

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 **130** which is started and stopped by manipulation of a manually operable switch SW2. The pump **130** draws fluid through a pipe **131** from a reservoir **132** and forces fluid under pressure through a pipe **133** to the various mechanisms of the machine. A relief valve **134** is connected to the pipe **133** and serves to pass excess fluid under pressure through a pipe **135** into the reservoir so as to maintain a substantially constant operating pressure within the system.

A grinding wheel truing mechanism is provided which may be located in a centerless grinding machine between the grinding wheel and regulating wheel for truing the operative face of the grinding wheel **16**. This mechanism has been illustrated diagrammatically in Fig. 5 and comprises a diamond or truing tool **140**. A traversing mechanism is provided for traversing the truing tool

140 across the operative face of the grinding wheel in either direction to true the operative face thereof. This mechanism comprises a cylinder 141 which contains a slidably mounted piston 142 fixedly mounted on the left hand end of a piston rod 143 (Fig. 5). The diamond or truing tool 140 is mounted on the other end of the piston rod 143 as shown diagrammatically in Fig. 5 of the drawings.

A control valve 144 is provided for controlling the admission to and exhaust of fluid from the cylinder 141. The valve 144 is a piston type valve comprising a slidably mounted valve member 145. The valve member 145 is provided with a plurality of spaced integral valve pistons to form a plurality of spaced valve chambers 146, 147, and 148. The valve member 145 is provided with a central passage 149 which interconnects the valve chambers 146 and 148. A compression spring 150 is provided normally to hold the valve member 145 in a left hand end position as shown in Fig. 5. A solenoid S4 is provided which when energized serves to shift the valve member 145 into a right hand end position to reverse the flow of fluid between the valve 144 and the cylinder 141.

As illustrated in Fig. 5, fluid under pressure from the pipe 133 enters the valve chamber 147 and passes through a pipe 151 into a cylinder chamber 152 to traverse the piston 142 together with a truing tool 140 toward the left into the position illustrated. During this movement fluid within a cylinder chamber 153 exhausts through a pipe 154 into the valve chamber 148, through the central passage 149 into the valve chamber 146. Fluid entering the valve chamber 146 exhausts through a pipe 155 and a throttle valve 156 into the reservoir 132. By manipulation of the valve 156, the rate of movement of the truing tool 140 may be regulated as desired.

Similarly when the solenoid S4 is energized and the valve member 145 is shifted to a right hand end position, fluid under pressure is passed from the valve chamber 147 through the pipe 154 into the cylinder chamber 153 to traverse the piston 142 and the truing tool 140 in a direction toward the right to pass the truing tool 140 across the operative face of the grinding wheel 16. During this latter movement fluid within the cylinder chamber 152 exhausts through the pipe 151 into the valve chamber 146 and through the exhaust pipe 155 and the throttle valve 156 into the reservoir 132.

It is desirable to provide an automatic feeding mechanism for the grinding wheel 16 together with the wheel slide 11 automatically to advance the grinding wheel before a truing operation is started. This mechanism comprises a cylinder 160 which contains a slidably mounted piston 161 fixedly mounted on the left hand end of a piston rod 162. A compression spring 163 serves normally to hold the piston 161 in a left hand end position as illustrated in Fig. 5. A rack bar 164 is fixedly mounted on the right hand end of the piston rod 162 and is arranged to mesh with a small gear 165 when the piston 161 is moved toward the right. The gear 165 is mounted on a rotatable shaft 166 which is connected by a one-way clucth 167 with a large gear 168. The gear 168 meshes with a gear 169 which is fixedly mounted on the shaft 90. When fluid under pressure is passed through a pipe 170 into a cylinder chamber 171 to move the piston 161 toward the right against the compression of the spring 163, the rack bar 164 imparts a rotary motion to the gear 165 to turn the shaft 166 in a clockwise direction so that the one-way clutch 167 transmits a clockwise rotary motion to the gear 168 which in turn imparts a counter-clockwise rotary motion to the gear 169 and the shaft 90. Rotary motion of the shaft 90 is transmitted through the worm 78, the worm gear 77, the shaft 73, the worm 72 the worm gear 71 to impart a rotary motion to the feed nut 36 to advance the wheel slide 11 together with the grinding wheel 16 by a predetermined amount. The extent of the advancing movement of the grinding wheel 16 is governed by an adjustable stop screw 172 which determines the stroke of the rack bar 164.

A control valve 175 is provided for controlling the admission to and exhaust of fluid from the cylinder 160. The valve 175 is a piston type valve comprising a slidably mounted valve member 176. The valve member 176 is provided with a plurality of spaced integral valve pistons to form a pair of spaced valve chambers 177 and 178. A compression spring 179 serves normally to hold the valve member 176 in a left hand end position. A solenoid S1 is provided which when energized serves to shift the valve member 176 into a right hand end position.

In the position of the valve 175 (Fig. 5) fluid under pressure from the pipe 133 is conveyed to the cylinder chamber 177. When the solenoid S1 is energized and the valve member 176 moves to a right hand end position, fluid under pressure entering the valve chamber 177 passes through the pipe 170 into the cylinder chamber 171 to move the piston 161 toward the right to impart a feeding movement to the grinding wheel 16 before the start of a truing operation.

In the position of the valve 175 (Fig. 5) fluid within the cylinder chamber 171 exhausts through the pipe 170 into the valve chamber 178 and through an exhaust pipe 180 into the reservoir 132.

A manually controlled work gauging mechanism is provided for controlling actuation of the undersize and oversize pawl and ratchet compensating mechanisms above described to compensate for underside and oversize work pieces. The mechanism is arranged so that after a predetermined number of work pieces have been gauged, if a predetermined number of work pieces are successively ground oversize, the piston 86 is actuated to impart a compensating adjustment to the feed nut 36 so that succeeding work pieces will be ground to a predetermined size. Similarly if a plurality of successive work pieces are gauged after grinding which are undersize, the piston 96 is actuated to impart a compensating adjustment in the opposite direction to the feed nut 36.

A work gauge 185 is provided having a V-shape supporting surface 186 for a ground work piece 187. A movable gauge member 188 is provided with an inverted V-shaped surface 189 which is arranged to engage the upper surface of the work piece 187 when the gauging member 188 is moved downwardly into a gauging position. The gauge member 188 is provided with a slidably mounted plunger 190 for actuating a limit switch LS1. The limit switch LS1 is normally held in the position illustrated in Fig. 5 by a compression spring so that a pair of contacts 191 are closed. A second pair of contacts 192 are normally open and are arranged to be closed when the work engaging plunger 190 is moved upwardly relative to the gauge member 188 when it is in an operative gauging position.

A hydraulically operated mechanism is provided for moving the gauging member 188 to and from an operative position comprising a cylinder 195 which contains a slidably mounted piston 196. The piston 196 is fixedly mounted on the lower end of a piston rod 197. The upper end of the piston rod 197 is connected by a stud 198 with the left hand end of a rock arm 199. The rock arm 199 is pivotally supported by a stud 200 carried by an upwardly extending bracket 201 of the gauge 185. The right hand end of the rock arm 199 is connected by a stud 202 with the movable gauging member 188. When fluid under pressure is passed through a pipe 203, through both a ball check valve 204 and a throttle valve 205 into a cylinder chamber 206, the piston 196 is moved upwardly to rock the rock arm in a clockwise direction thereby moving the gauging member 188 downwardly into an operative position. During this movement of the piston 196, fluid within a cylinder chamber 207 may exhaust through a pipe 208.

A control valve 210 is provided for controlling the admission to and exhaust of fluid from the cylinder 195. The valve 210 is a piston type valve comprising a slidably

mounted valve member 211 having a plurality of spaced integral valve pistons to form a plurality of spaced valve chambers 212, 213, and 214. The valve member 211 is provided with a central passage 215 which interconnects the valve chambers 212 and 214. A compression spring 216 normally holds the valve member 211 in a left hand end position as shown in Fig. 5. A solenoid S2 is provided which when energized serves to shift the valve member 211 into a right hand end position. When the valve member 211 is in a right hand end position fluid under pressure from the pipe 133 enters the valve chamber 213 and passes through the pipe 203 into the cylinder chamber 206 to cause an upward movement of the piston 196 thereby moving the gauging member 198 into an operative position. When the solenoid S2 is deenergized the valve 210 moves into the position illustrated in Fig. 5 so that fluid under pressure entering the valve chamber 213 passes through the pipe 208 into the cylinder chamber 207 to cause a downward movement of the piston 196 thereby rocking the rock arm 199 in a counter-clockwise direction to raise the gauging member 188 into an inoperative position.

Describing Fig. 5, a relay switch TD2 is a timed delay relay which when energized momentarily closes the normally open contacts 230 which remain closed for a predetermined time interval after deenergization. Relay switch TD3 is a timed delay relay which when energized does not actuate the contacts thereof for a predetermined time interval after energization. An electric counter T3 at count-out serves to energize the pull-type solenoid S3*a* to shift the valve member 121 toward the right to pass fluid under pressure through the pipe 101 to cause a movement of the piston 96 toward the left to impart a compensating adjustment to the feed nut 36. An electric counter T4 serves as a count-out to energize the solenoid S3*b* to shift the valve member 121 toward the left to pass fluid under pressure through the pipe 91 to cause movement of the piston 86 toward the right to impart a compensating adjustment to the feed nut 36 through the mechanism above described.

The operation of this work sizing, compensating and truing mechanism will be readily apparent from the foregoing disclosure. The switch SW1 is closed to supply electric power to the operating circuit. The switch SW2 is then closed to start the pump driving motor to supply fluid under pressure to the fluid pressure system. The closing of the switch SW1 serves to energize the clutch coils TCH3 and TCH4, respectively, of the electric counters T3 and T4 through the now closed contacts of the relay TD3. When the clutch coils TCH3 and TCH4 are energized, the contacts CC3 of the timer T3 and the contacts CC4 of the timer T4 close to pass current to the contacts 191 and 192 of the limit switch LS1.

When it is desired to gauge a ground work piece, the work piece 187 is either placed manually or automatically onto the V-shaped surface 186 of the gauge 185 after which the push button switch PB3 is momentarily closed. If desired, the push button switch PB3 may be replaced with a switch which is automatically actuated by the work piece 187 when it is moved into an operative position on the gauging surface 186. The closing of the switch PB3 serves to energize the relay switch TD2 to close the contacts 230 thereof. The closing of the contacts 230 serves to energize the solenoid S2 to shift the valve member 211 toward the right so that fluid under pressure is passed through the pipe 203, through both the throttle valve 205 and the ball check valve 204 into the cylinder chamber 206 to cause an upward movement of the piston 196 thereby moving the gauging member 188 downwardly into an operative gauging position. The closing of the contacts 230 of the relay switch TD2 serves to energize the relay switch TD3. The contacts of TD3 remain in the position illustrated in Fig. 5 for a predetermined time interval after energization of TD3. These contactors remain in the position illustrated in Fig. 5 until the gauging member 188 has moved into an operative gauging position at which time the normally open contacts 231 and 234 close and the normally closed contacts 232, 233, 235, and 236 open.

If the ground work piece 187 is oversize, the contacts 191 of the limit switch LS1 remain closed when the gauging member 188 is in a downward gauging position. Through the normally closed contacts 191 of the limit switch LS1, a relay switch CR3*b* is energized and through the now closed contacts 234 of the relay switch TD3 imparts a counting impulse to the count coil ACH4. The energizing of the relay switch CR3*b* closes the contacts 237 and through contacts 235 and 236 of relay switch TD3 serves to hold the clutch coil TCH4 of the counter T4 energized during the counting interval. If the next work piece to be gauged is either of correct size or undersize the contacts 191 of the limit switch LS1 will open and the relay CR3*b* will not be energized and there is no holding circuit established for the clutch coil TCH4 of the counter T4 and the counter T4 automatically resets. The counters T3 and T4 may be set for operation after a predetermined number of count impulses have been imparted to the count coils ACH3 and ACH4, respectively, so that the counters count out. If the counter T4 is set for actuation after gauging four work pieces, the operation will be identical with that which is described. If four consecutive ground work pieces are oversize the count coil ACH4 will be actuated four times at which time the counter T4 will count-out closing the contacts LC4 of the counter T4 so as to energize the solenoid S3*b* to shift the valve member 121 toward the left thereby passing fluid under pressure through the pipe 91 to cause a movement of the piston 86 toward the right (Fig. 5) to impart a compensating adjustment to the feed nut 36 so as to compensate for the oversize condition of the work so that further work pieces will be ground to a predetermined size.

When a work piece 187 is ground undersize, the downward movement of the gauging member 188 causes the plunger 190 to engage the surface of the ground work piece and actuate the limit switch LS1 to close the contacts 192. The closing of the contacts 192 serves to energize the relay switch CR3*a* and through the now closed contacts 231 of the relay switch TD3 imparts an impulse to the count coil ACH3 of the timer T3. The energizing of the switch CR3*a* closes the contacts 238 to set up a holding circuit to hold the clutch coil TCH3 of the counter T3 energized. Shortly after the energizing of either the count coil ACH3 of the counter T3 or the count coil ACH4 of counter T4, the relay switch TD2 times out and the contacts 230 open thereby deenergizing the solenoid S2 to shift the valve member 211 toward the left into the position illustrated in Fig. 5 so as to raise the gauging member to an inoperative position. At the same time the time delay relay TD3 is deenergized and the contacts thereof return to the position shown in Fig. 5. If the counter T3 is set for actuation after gauging four work pieces, the above operation is repeated provided that four successive work pieces are ground undersize. After the fourth undersize work piece has been gauged the counter T3 counts-out closing the contacts LC3 to energize the solenoid S3*a* which shifts the valve member 121 toward the right so that fluid under pressure within the valve chamber 124 passes through the pipe 101 to cause the piston 96 to move toward the left to impart a rotary compensating adjustment to the feed nut 36. The solenoid S3*a* remains energized until the time relay TD2 times out. More particularly, when the time relay TD2 times-out and contacts 230 open to deenergize solenoid S2, the valve 210 is shifted into the position illustrated in Fig. 5 to raise the gauge member 188 to an inoperative position. The timing out of TD2 opening contacts 230 also serves to deenergize the relay TD3 and operates to reset the counter T3. When the timer T3 resets, the contacts LC3 open to deenergize the

solenoid S3*a* thereby allowing the valve member **121** to return to a central position, as shown in Fig. 5.

If the ground work pieces are ground to a predetermined size, the contacts **191** and **192** of the limit switch LS1 both remain open when the gauging member **188** is moved downwardly into a gauging position and no counting impulse is imparted to either of the counters **T3** or T4. If the count coils ACH3 or ACH4 of the counters T3 and T4, respectively, have been previously energized due to a work piece being undersize or oversize, the opening of both sets of contacts **191** and **192** of the limit switch LS1 during gauging a correctly sized work piece serves to prevent setting up a holding circuit to the clutch coils TCH3 and TCH4 and the counters T3 or T4 automatically reset.

When it is desired to true the grinding wheel **16** the push button switch PB4 is momentarily closed to energize the time relay TD4 to close contacts **250** to energize the solenoid S1 thereby shifting the valve member **176** toward the right to pass fluid under pressure through the pipe **170** into the cylinder chamber **171** to move the piston **161** toward the right so as to impart a rotary feeding movement to the feed nut **36**, in a manner heretofore described. The extent of this feeding movement is governed by the setting of the stop screw **172**. The contacts **250** of the relay TD4 remain closed for a predetermined time interval until the feeding movement of the grinding wheel for the truing operation has been completed after which the contacts **250** open thereby deenergizing the solenoid S1 so that fluid within the cylinder chamber **171** may exhaust therefrom under the influence of the compression of the spring **163**. This infeeding movement of the grinding wheel for the truing operation takes place before the traversing movement of the truing tool **140** is started.

During the movement of the piston **161** toward the right, as the rack bar **164** moves into engagement with the stop screw **172**, an adjustable collar **254** carried by the dog bar **164** engages the actuating roller of a normally open limit switch LS4 and closes the contacts thereof. The closing of the contacts of limit switch LS4 serves to energize a relay CR4. The closing of contacts **240** of the relay CR4 sets up a holding circuit to maintain the contacts **241** of the relay CR4 closed to energize the solenoid S4 thereby shifting the valve member **145** toward the right so that fluid under pressure is passed through the valve chamber **147**, through the pipe **154** into the cylinder chamber **153** to traverse the piston **142** and the truing tool **140** across the operative face of the grinding wheel **16**. As the truing tool **140** approaches the right hand end of its stroke, it engages an actuating plunger **260** of a normally closed limit switch **261** to open the limit switch **261** thereby breaking the holding circuit to deenergize the relay CR4. The deenergizing of relay CR4 opens the contacts **241** thereby deenergizing the solenoid S4 so that the released compression of the spring **150** moves the valve member **145** toward the left into the position illustrated in Fig. 5. In this position of the valve **144** fluid under pressure within the valve chamber **147** passes through the pipe **151** into the cylinder chamber **152** to move the piston together with the truing tool toward the left to traverse the truing tool **140** across the operative face of the grinding wheel.

If more than one complete reciprocation of the truing tool **140** is desired, the push button switch PB4 may be actuated once for each complete reciprocation of the truing tool **140**. For each reciprocation the grinding wheel **16** is advanced in a manner hereinabove described by an amount equivalent to that desired to true from the operative face thereof.

It will thus be seen that there has been provided by this invention apparatus in which the various objects hereinbefore 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 above set forth, it is to be understood that all matter hereinbefore set forth as shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. In a grinding machine having a transversely movable rotatable grinding wheel, a feed nut and screw mechanism to feed said wheel transversely in either direction, means to rotate said feed screw to impart a feeding movement to said grinding wheel, a compensating mechanism including a pawl and ratchet mechanism to impart a rotary motion to said feed nut in either direction after a predetermined number of consecutive work pieces have been ground either oversize or undersize, and means independently to rotate said feed nut in opposite directions so as to impart an unwind and wind movement to said feed nut during each actuation of the compensating mechanism to facilitate picking up a feed increment.

2. In a grinding machine having a transversely movable rotable grinding wheel, a feed nut and a feed screw mechanism to feed said wheel transversely in either direction, manually operable means to rotate said screw to impart a feeding movement to said grinding wheel, a compensating mechanism including a fluid pressure actuated pawl and ratchet mechanism to impart a rotary motion to said feed nut in either direction after a predetermined number of consecutive work pieces have been ground either undersize or oversize, and fluid pressure actuated means independently to rotate said feed nut in opposite directions so as to impart an unwind and a wind movement to said feed nut during actuation of the compensating mechanism.

3. In a grinding machine, as claimed in claim 2, in combination with the parts and features therein specified of a control valve simultaneously to control admission of fluid to and exhaust of fluid from said compensating mechanism and to said cylinder simultaneously to impart a rotary motion to the feed nut in opposite directions so as to unwind and wind said feed nut to impart a compensating adjustment thereto.

4. In a grinding machine having a transversely movable rotatable grinding wheel, a feed nut and a feed screw mechanism to feed said wheel transversely in either direction, means to rotate said feed screw to impart a feeding movement to said grinding wheel, means including a gear mechanism to impart a rotary motion to said feed nut, an oversize pawl and ratchet compensating mechanism operatively connected to actuate said gear mechanism to impart a rotary adjustment to said feed nut in one direction, an undersize pawl and ratchet feed compensating mechanism operatively connected to actuate said gear mechanism to impart a rotary adjustment to said feed nut in the opposite direction, and means including a piston and cylinder mechanism operatively connected to actuate said gear mechanism independently to rotate said feed nut in opposite directions so as to impart an unwind and a wind motion to said feed nut during each actuation of either compensating mechanisms.

5. In a grinding machine having a transversely movable rotatable grinding wheel, a feed nut and screw mechanism to feed said wheel tranversely in either direction, means to rotate said feed screw to impart a feeding movement to said grinding wheel, means including a gear mechanism to impart a rotary motion to said feed nut, an oversize fluid pressure actuated pawl and ratchet compensating mechanism operatively connected to actuate said gear mechanism to impart a rotary adjustment to said feed nut in one direction, and undersize fluid pressure actuated pawl and ratchet feed compensating mechanism operatively connected to actuate said gear mechanism to impart a rotary adjustment to said feed nut in the opposite direction, means including a fluid pressure actuated piston and cylinder mechanism

operatively connected to actuate said gear mechanism independently to rotate said feed nut in opposite directions so as to impart an unwind and a wind motion to said feed nut, and a control valve simultaneously to control admission of fluid to and exhaust of fluid from one of said compensating mechanisms and to said cylinder simultaneously to unwind and wind said feed nut and to impart a compensating adjustment thereto during each actuation of either of the compensating mechanisms.

6. In a grinding machine having a transversely movable rotatable grinding wheel, a feed nut and a feed screw mechanism to feed said wheel transversely in either direction, means to rotate said screw to impart a feeding movement to said grinding wheel, means including a worm and worm gear mechanism to impart a rotary motion to said feed nut, an oversize pawl and ratchet compensating mechanism operatively connected to rotate said worm to impart a rotary compensating adjustment to said feed nut in one direction, an undersize pawl and ratchet compensating mechanism operatively connected to rotate said worm so as to impart a rotary compensating adjustment to said feed nut in the opposite direction, and means including a piston and cylinder mechanism operatively connected to impart an axial movement to said worm independently to rotate said feed nut in opposite directions so as as to impart an unwind and wind motion to said feed nut during each actuation of either compensator.

7. In a grinding machine, as claimed in claim 6, in combination with the parts and features therein specified of a longitudinally traversable truing tool, means including a piston and cylinder to traverse said truing tool longitudinally in either direction, a feeding mechanism for said grinding wheel to advance the grinding wheel for a truing operation including a piston and cylinder, and operative connections between said piston and said worm and worm gear mechanism to impart a rotary feeding movement to said feed nut to advance the grinding wheel a predetermined distance before a truing operation.

8. In a grinding machine, as claimed in claim 6, in combination with the parts and features therein specified of a longitudinally traversable truing tool, means including a piston and cylinder to traverse said tool longitudinally in either direction, a feeding mechanism for said grinding wheel to advance the grinding wheel for a truing operation including a piston and cylinder, a rack and gear mechanism operatively to connect said gear mechanism with said worm and worm gear mechanism to impart a rotary feeding movement to said feed nut to advance the grinding wheel a predetermined distance before a truing operation, and means including an adjustable stop to facilitate varying the extent of feed before each truing operation.

9. In a grinding machine, as claimed in claim 6, in combination with the parts and features therein specified of a longitudinally traversable truing tool, means including a piston and cylinder to traverse said truing tool longitudinally in either direction a feeding mechanism for advancing said grinding wheel for a truing operation including a piston and cylinder, a rack and gear mechanism actuated by said latter piston to actuate said worm and worm gear mechanism to impart a rotary feeding movement to said feed nut, means including an adjustable stop to vary the extent of feed before a truing operation, a control valve operatively connected to control the admission of fluid under pressure to said latter cylinder to initiate a truing feed of the grinding wheel, a control valve to control the admission to and exhaust of fluid from the truing tool traverse cylinder and means including a limit switch actuated by and in timed relation with the movement of the truing tool feeding mechanism to initiate a longitudinal traversing movement of the truing tool.

10. In a grinding machine having a transversely movable rotatable grinding wheel, a feed nut and a feed screw mechanism to feed said wheel transversely in either direction, means to rotate said feed screw to impart a feeding movement to said grinding wheel, means including a worm and worm gear mechanism to impart a rotary motion to said feed nut, an oversize fluid pressure actuated pawl and ratchet mechanism operatively connected to rotate said worm so as to impart a rotary compensating adjustment to said feed nut in one direction, an undersize fluid pressure actuated pawl and ratchet feed compensating mechanism operatively connected to rotate said worm to impart a rotary compensating adjustment to said feed nut in the opposite direction, means including a piston and cylinder mechanism operatively connected to impart an axial movement to said worm to rotate said feed nut in opposite directions so as to impart an unwind and a wind motion to said feed nut during each actuation of either compensator, and a control valve simultaneously to control admission of fluid to and exhaust of fluid from one of said compensating mechanisms and to said cylinder simultaneously to unwind and wind said feed nut and to impart a compensating adjustment thereto.

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