Aug. 21, 1956 H. A. SILVEN ET AL 2,759,304

GRINDING MACHINE

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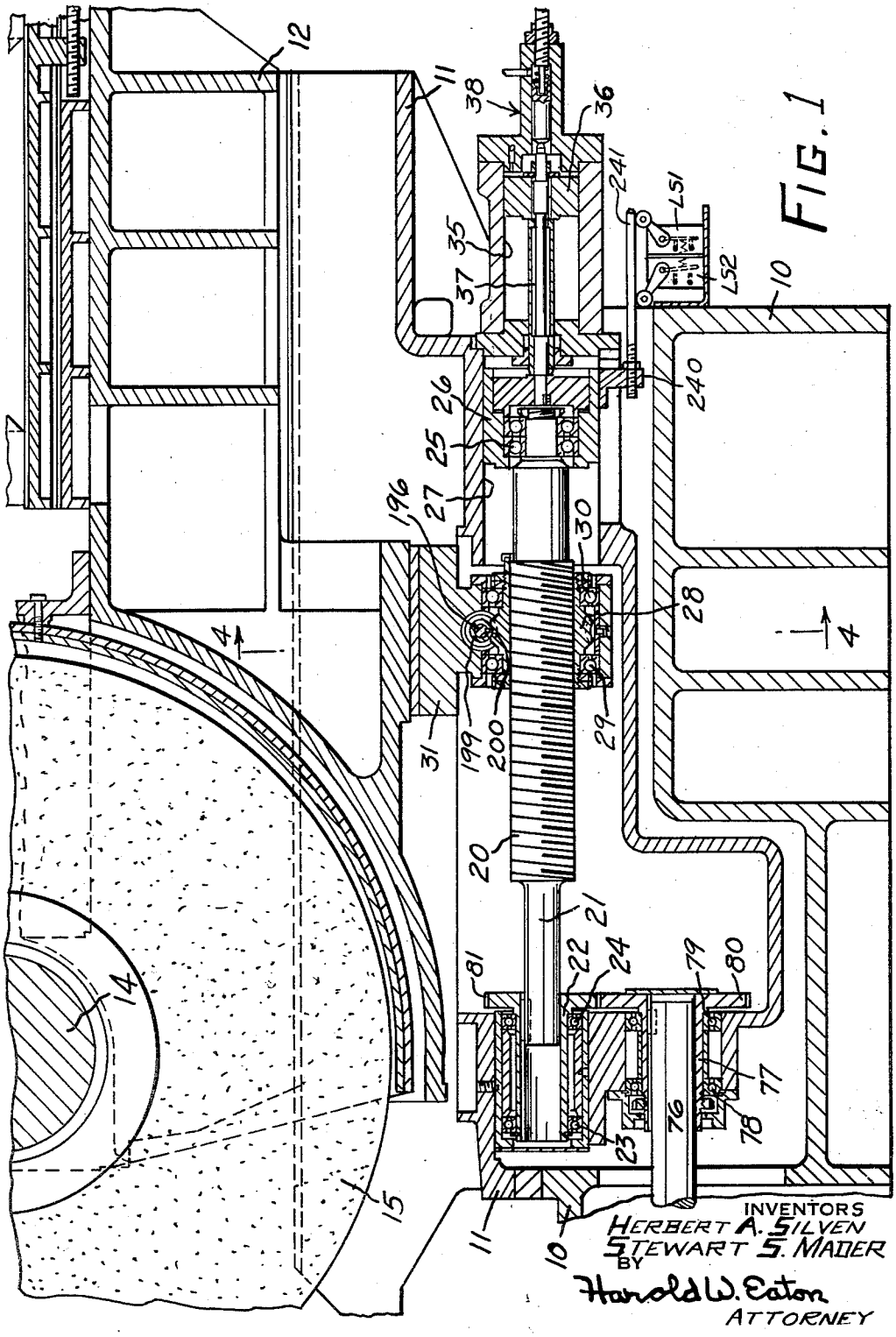


FIG. 1

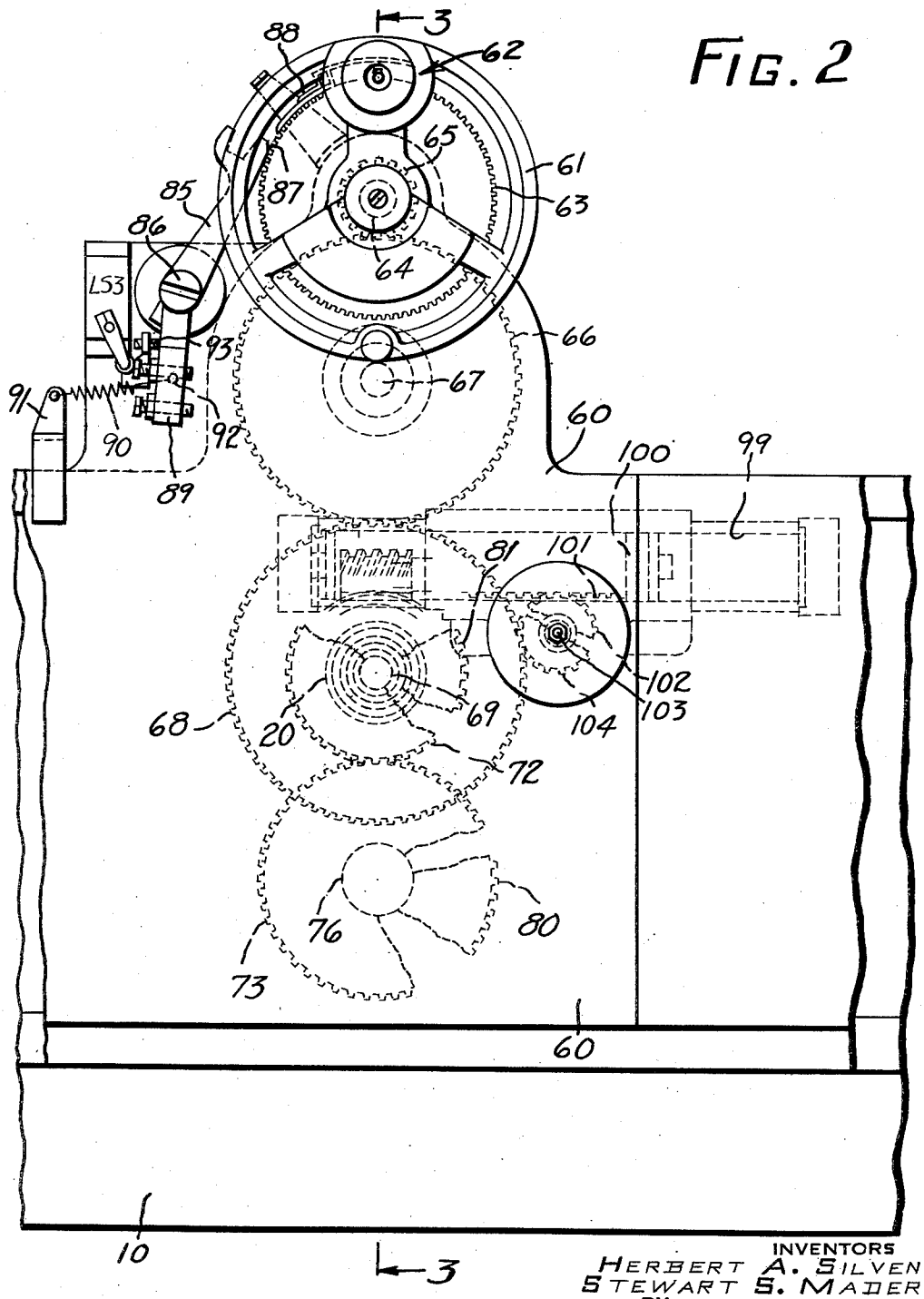
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FIG. 2



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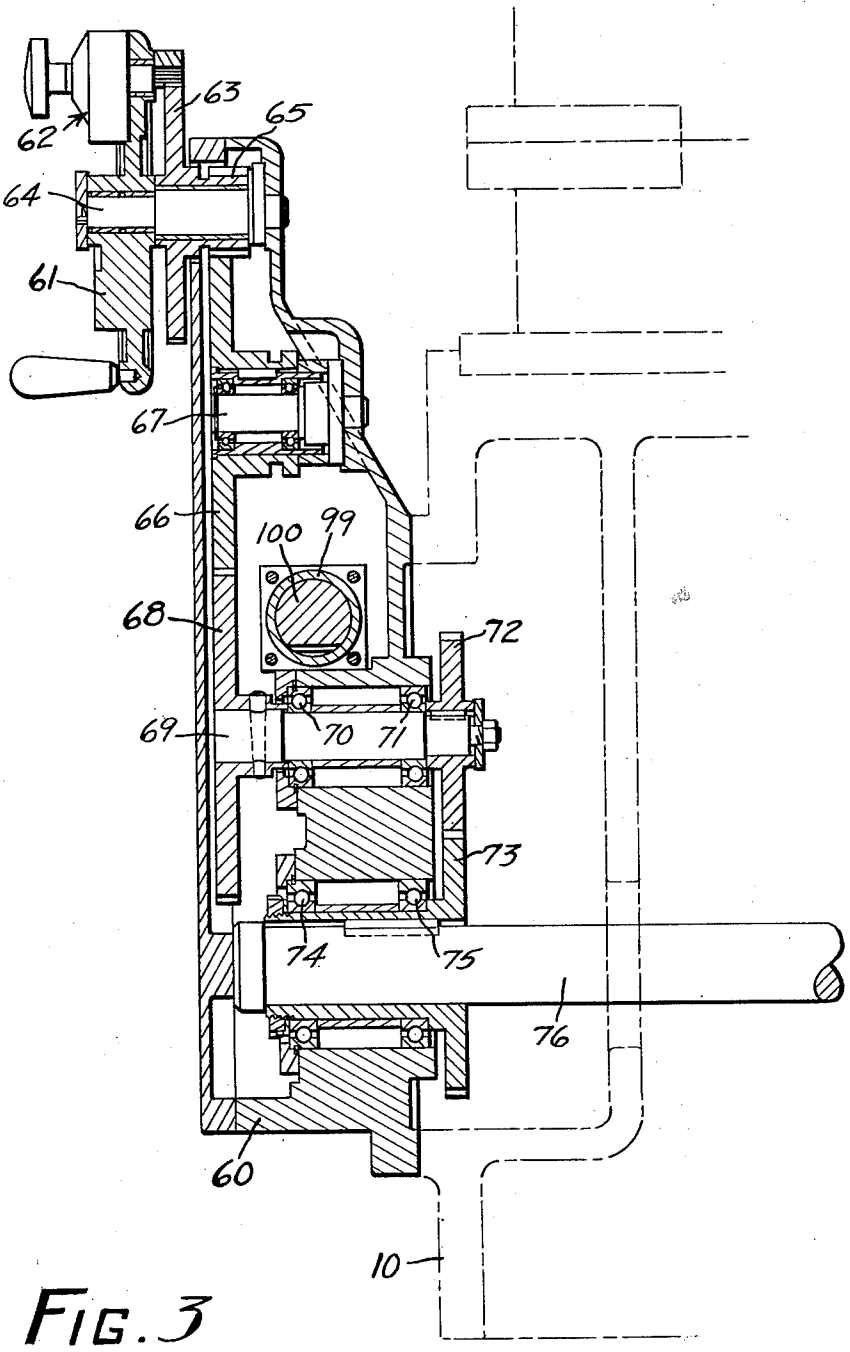


FIG. 3

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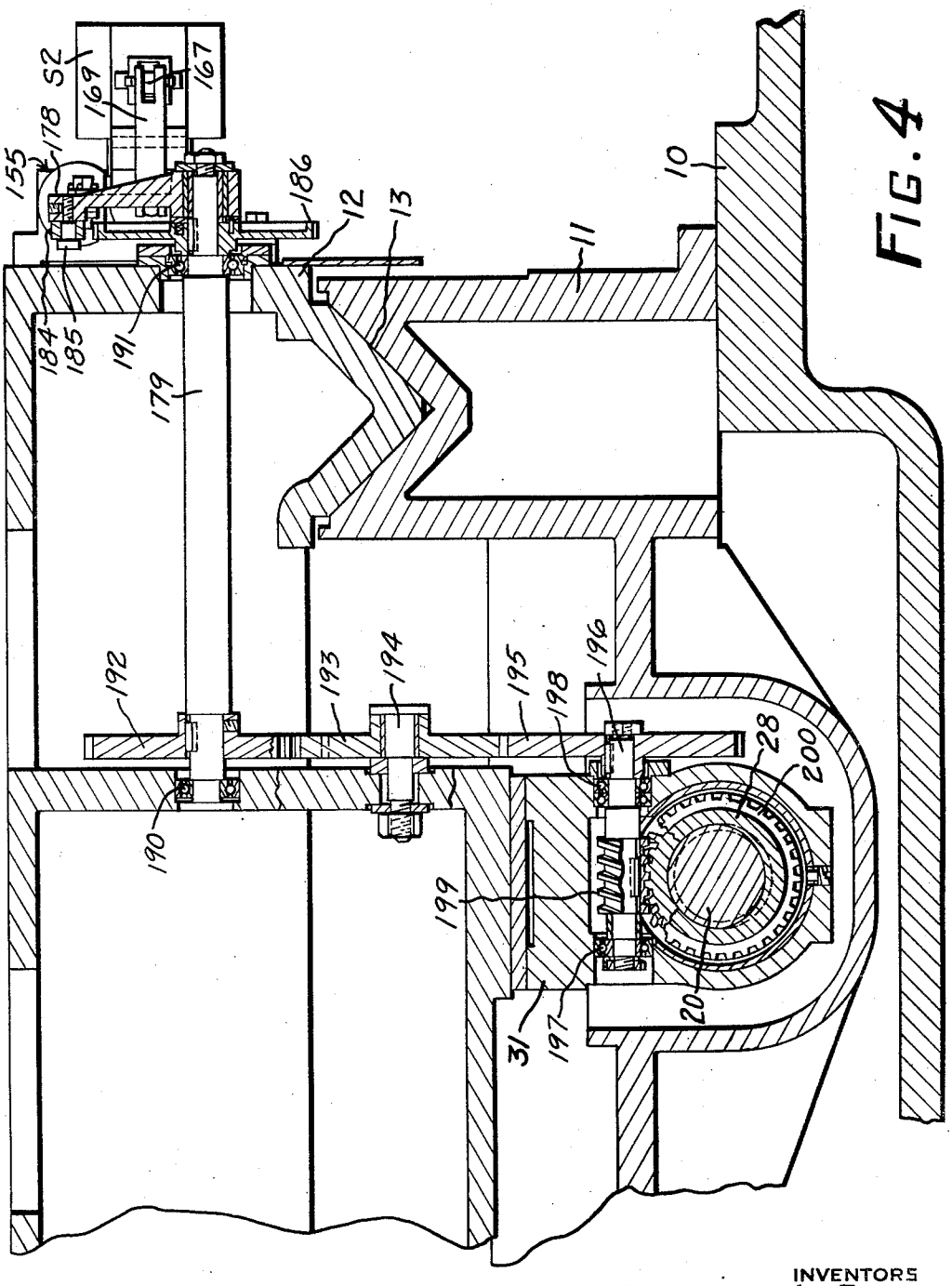


FIG. 4

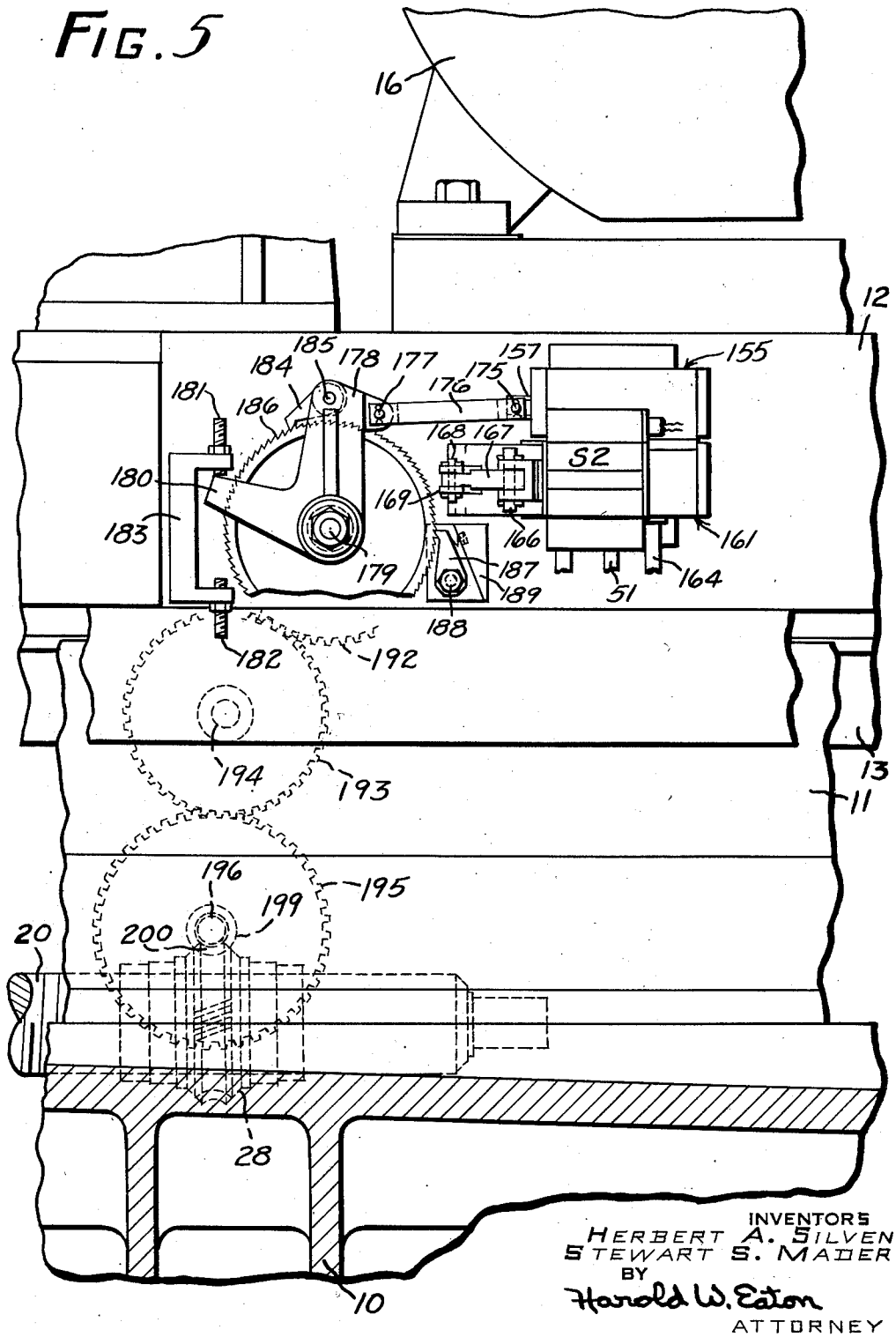
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GRINDING MACHINE

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FIG. 5



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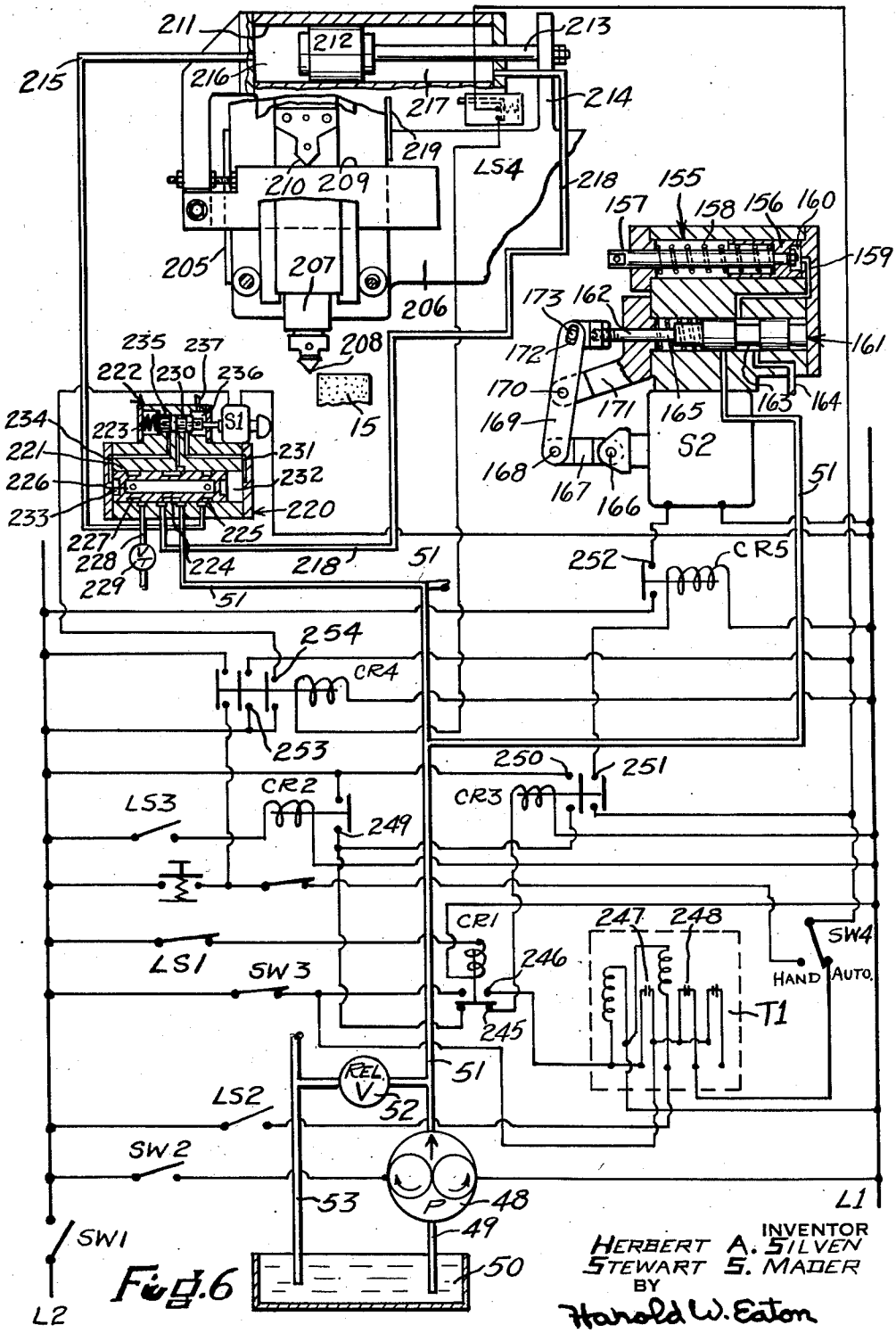


Fig. 6

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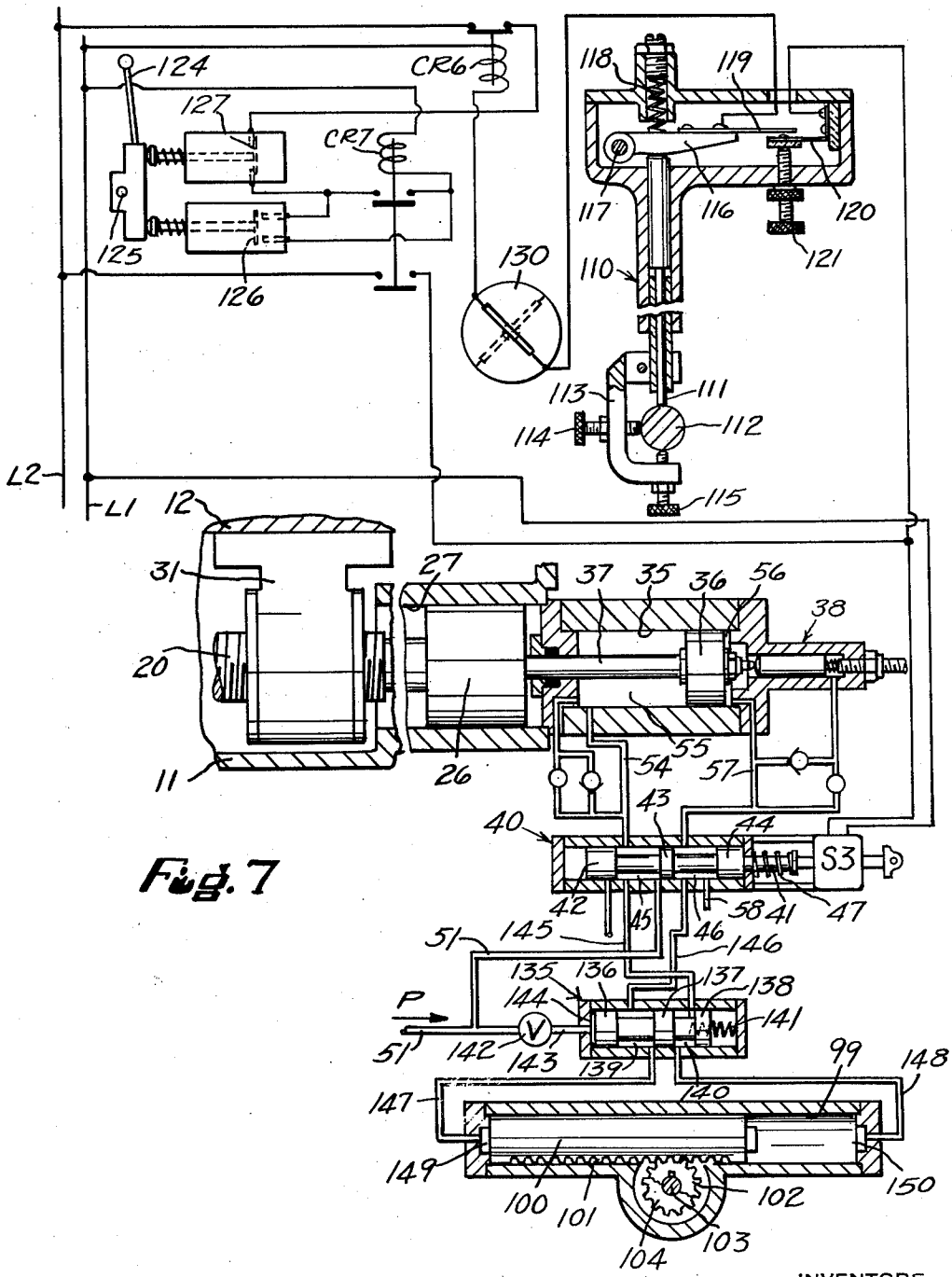


Fig. 7

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United States Patent Office 2,759,304 Patented Aug. 21, 1956

2,759,304

GRINDING MACHINE

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Application January 30, 1956, Serial No. 562,251

6 Claims. (Cl. 51—165)

The invention relates to grinding machines and more particularly to a grinding wheel feeding mechanism which is arranged to precisely and automatically control work size.

One object of the invention is to provide a simple and thoroughly practical feeding mechanism for precisely feeding a grinding wheel so as to control work size. Another object of the invention is to provide a feeding mechanism combined with an automatic wheel truing mechanism and a feed compensating mechanism automatically to compensate for wheel wear caused by grinding and truing. Another object of the invention is to provide a feed compensating mechanism which is arranged automatically to true the grinding whel and to compensate for wheel wear after a predetermined number of work pieces have been ground. Another object of the invention is to provide a feed compensating mechanism which operates automatically in timed relation with the wheel slide movement to compensate for wheel wear which is arranged automatically to omit compensation in case of wear on the truing tool. Other objects will be in part obvious or in part pointed out hereinafter.

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

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

Fig. 2 is a fragmentary front elevation of the grinding wheel feeding mechanism;

Fig. 3 is a vertical sectional view, taken approximately on the line 3—3 of Fig. 2, through a portion of the wheel feeding mechanism;

Fig. 4 is a fragmentary sectional view, on an enlarged scale, taken approximately on the line 4—4 of Fig. 1, through feed compensating mechanism;

Fig. 5 is a fragmentary side elevation of a portion of a grinding machine, showing the feed compensating mechanism;

Fig. 6 is a combined electric and hydraulic diagram of the actuating mechanisms including the wheel truing apparatus and the feed compensator and the controls therefor; and

Fig. 7 is a combined hydraulic and electrical diagram of the wheel feeding mechanism together with the work sizing gauge and the controls therefor.

A grinding machine has been illustrated in the drawings comprising a base **10** which supports a wheel slide base **11** (Fig. 4). The wheel slide base **11** in turn supports a transversely movable wheel slide **12** which is arranged to slide transversely relative to the base **10** and the wheel slide base **11** on a V-way **13** and a flatway (not shown) formed on the upper surface of the wheel slide base **11**. The wheel slide **12** serves as a support for a rotatable wheel spindle **14** which is journalled in suitable bearings (not shown). The wheel spindle **14** supports a grinding wheel **15** (Fig. 1) which may be driven in the conventional

manner by means of an electric motor **16** (Fig. 5) mounted on the upper surface of the wheel slide **12**.

A feeding mechanism is provided for the wheel slide **11** comprising a rotatable feed screw **20** having a reduced cylindrical portion **21** which is slidably keyed within a rotatable sleeve **22**. The sleeve **22** is journalled in spaced anti-friction bearings **23** and **24** (Fig. 1) which are fixedly supported by the wheel slide base **11**. The other end of the feed screw **20** is supported by anti-friction bearings **25** which are carried by a slidably mounted sleeve **26** which slides within a cylindrical bore **27** formed in the wheel slide base **11**.

A rotatable feed nut **28** is journalled in a pair of spaced anti-friction bearings **29** and **30** which are carried by a bracket **31** depending from the underside of the wheel slide **12**.

A hydraulically operated mechanism is provided for causing a rapid approaching and receding movement of the wheel slide **11** for moving the grinding wheel to and from an operative position. This mechanism may comprise a cylinder **35** which is arranged in axial alignment with the feed screw **20** and the sleeve **26**. The cylinder **35** contains a slidably mounted piston **36**. A piston rod **37** is connected at one end to the piston **36** and at the other end to the sleeve **26** so that when fluid under pressure is admitted to either one end or the other of the cylinder **35** an axially feeding movement will be imparted to the feed screw to cause a transverse movement of the wheel slide **12** and the grinding wheel **15**.

A feed control valve **40** is provided for controlling the admission to and exhaust of fluid from the cylinder **35**. The valve **40** is preferably a piston-type valve comprising a valve stem **41** having a plurality of valve pistons **42**, **43** and **44** formed integrally therewith to form a pair of spaced valve chambers **45** and **46**. A compression spring **47** serves normally to maintain the valve stem **41** in its right hand end position as illustrated in Fig. 7. A solenoid S3 is operatively connected to the right hand end of the valve stem **41** and is arranged so that when energized it shifts the valve stem **41** toward the left into a reverse position.

A fluid pressure system is provided for supplying fluid under pressure to the operating mechanisms of the machine comprising a motor driven fluid pump **48** which draws fluid through a pipe **49** from a reservoir **50** and forces fluid under pressure through a pipe **51** to the various operating mechanisms of the machine including the feed control valve **40**. A pressure relief valve **52** is connected to the pipe **51** by means of which excess fluid under pressure may be by-passed directly through a pipe **53** into the reservoir **50** to facilitate maintaining a substantially uniform operating pressure in the hydraulic system.

In the position of the valve **40** (Fig. 7) fluid under pressure passing through the pipe **51** enters the valve chamber **45** and passes through a passage **54** into a cylinder chamber **55** to cause the piston **36** to move toward the right into an inoperative position as illustrated in Fig. 7. Movement of the piston **36** toward the right also imparts a corresponding movement to the feed screw **20**, the feed nut **28**, the wheel slide **12** so as to move the grinding wheel **15** to a rearward or inoperative position. During this movement of the piston **36**, fluid within a cylinder chamber **56** may exhaust through a passage **57**, through the valve chamber **46** and passes out through an exhaust pipe **58** into the reservoir **50**.

In order to slow down the rapid rearward movement of the piston **36**, a dashpot mechanism **38** is provided which is actuated by the right hand end of the piston rod **37** in a manner substantially the same as that shown in the U. S. patent to H. L. Swainey No. 2,582,610 dated January 15, 1952, to which reference may be had for details of disclosure not contained herein.

A feed apron 60 is mounted on the front of the machine base 10. This apron supports a rotatable manually operable feed wheel 61 which is provided with the usual micrometer adjusting mechanism 62. The feed wheel 61 is connected through the micrometer adjusting mechanism with a gear 63. Both the feeding wheel 61 and the gear 63 are rotatably supported on a fixed shaft 64. A gear 65 is formed integrally with the gear 63 and meshes with a gear 66 rotatably supported on a shaft 67. The gear 66 meshes with a gear 68 which is fixedly mounted on a rotatable shaft 69. The shaft 69 is journalled in spaced anti-friction bearings 70 and 71 which are fixedly mounted within the feed apron 60. A gear 72 is fixedly mounted on the other end of the shaft 69 and meshes with a gear 73 which is supported by a pair of spaced anti-friction bearings 74 and 75 which are in turn supported by the feed apron 60. A rotatable shaft 76 is slidably keyed within a central aperture formed in the gear 73. The other end of the shaft 76 is slidably keyed within a rotatable sleeve 77 which is supported in spaced anti-friction bearings 78 and 79 carried by the wheel slide base 11. A gear 80 is formed integral with the sleeve 77 and meshes with a gear 81 formed integral with the sleeve 22. It will be readily apparent from the foregoing disclosure that a rotary motion of the feed wheel 61 will be transmitted through the gear mechanism just described to impart a rotary motion to the feed screw 20 which in turn causes a transverse feeding movement of the wheel slide 12 and the grinding wheel 15.

A feed pawl 85 is pivotally mounted on a stud 86 on the front of the machine base. The upper end of the feed pawl 85 is provided with a cam face 87 which is arranged to be engaged by a cam 88 adjustably supported on the feed wheel 61. The feed pawl 85 is provided with an integral downwardly extending arm 89. A tension spring 90 is connected at one end to a bracket 91 and at the other end to a stud 92 to exert a tension tending to rock the feed pawl 85 into engagement with an adjustable stop screw 93.

The cylinder 35 and piston 36 previously described serve to cause a rapid approaching movement of the wheel slide 12 to position the grinding wheel 15 into an operative position relative to the work piece to be ground. In order to feed the grinding wheel 15 during a grinding operation a fluid operated mechanism is provided to impart a rotary motion to the feed screw 20. This mechanism may comprise a cylinder 99 which contains a slidably mounted piston 100. The piston 100 is provided with rack teeth 101 which mesh with a gear 102 carried by a shaft 103. The shaft 103 is provided with a gear 104 which meshes with the gear 68. It will be readily apparent from the foregoing disclosure that a longitudinal movement of the feed piston 100 will be imparted through the gear mechanism above described to impart a rotary feeding movement to the feed screw 20. This feeding mechanism may be substantially identical with that shown in the U. S. patent to Homer L. Swainey No. 2,582,610 dated January 15, 1952, to which reference may be had for details of disclosure not contained herein.

An automatic control mechanism is provided for automatically controlling the duration of the grinding cycle comprising a work gauging head 110 which is provided with a slidably mounted work contact member 111 which is arranged to engage the peripheral surface of a work piece 112 being ground. The gauging head 110 is provided with a C-shaped caliper head 113 having a pair of adjustably mounted work engaging screws 114 and 115 to facilitate maintaining the gauging head 110 in a predetermined relationship with the axis of the work piece 112 during a grinding operation. The gauging head 110 is preferably supported by a bracket (not shown) on the wheel slide 12. This type of mounting is an old and well known expedient in the art and therefore has not been illustrated in the present application.

The upper end of the work contact member 111 engages a rock arm 116 which is pivotally mounted on a stud 117. A compression spring 118 is arranged to exert a downward pressure on the rock arm 116 so as to maintain the contact member 111 in operative engagement with the periphery of the work piece 112 during the grinding operation. The rock arm 116 is provided with an electrical contact member 119 which is arranged to move into engagement with the contact member 120 within the gauging head 110. An adjustment screw 121 is provided for adjusting the contact member 120 to facilitate setting up the gauge for sizing so as to grind a work piece to a predetermined size.

A pair of power lines L1 and L2 serve to supply electrical power to operate the various mechanisms of the machine. A manually operable control lever 124 is pivotally mounted on a stud 125 which is in turn supported on the front of the machine base 10. The control lever 124 is arranged to close a normally open start switch 126 when the lever 124 is rocked in a counter-clockwise direction and to open a normally closed stop switch 127 when rocked in a clockwise direction. A relay switch CR7 and a relay switch CR6 together with a selector switch 130 are provided for controlling the feeding mechanism in a manner to be hereinafter described.

When it is desired to start a grinding cycle, the control lever 124 is rocked in a counter-clockwise direction to close the start switch 126 which serves to energize the relay switch CR7 to close a circuit and thereby to energize the solenoid S3 to shift the feed control valve 40 toward the left (Fig. 7) to start a forward approaching and feeding movement of the wheel slide 12 and the grinding wheel 15. The relay switch CR7 is provided with a holding circuit so that only a momentary closing of the start switch 126 is required to start the grinding cycle. The piston 36 moves toward the left (Figs. 1 and 7) to cause a rapid approaching movement of the wheel slide 12 and the grinding wheel 15. The rapid approaching movement continues until the piston 36 engages the left hand end of the cylinder 35 after which the approaching movement of the wheel slide 12 is reduced to a grinding feed as governed by the movement of the feed piston 100 toward the right (Fig. 2).

The grinding feed continues until the work piece 112 has been ground to a predetermined size at which time the member 111 moves downwardly so that movement of the rock arm 116 in a clockwise direction moves the contact member 119 into engagement with the contact member 120 to close a circuit thereby energizing relay switch CR6 to open the contacts thereof thereby breaking a circuit to deenergize the solenoid S3 so that the released compression of the spring 47 shifts the feed control valve 40 toward the right into the position illustrated in Fig. 7. In this position of the valve 40, fluid under pressure passes through the passage 54 into the cylinder chamber 55 to move the piston 36 toward the right into an inoperative position as illustrated in Fig. 7.

A shuttle-type control valve 135 is provided for controlling the admission to and exhaust of fluid from the cylinder 99. The valve 135 comprises a slidably mounted valve member having a plurality of spaced valve pistons 136, 137 and 138 forming a pair of valve chambers 139 and 140. A compression spring 141 is provided normally to hold the valve 135 in a left hand end position, as shown in Fig. 7. In order to shift the valve 135 into a right hand end position, the pipe 51 is connected by a manually operable valve 142 with a pipe 143 which in turn is connected to a left hand end chamber 144 within the valve 135. When it is desired to shift the valve 135 into a right hand end position, the valve 142 may be opened to admit fluid under pressure from the pump 48, through the pipe 51 into the end chamber 144 to shift the valve into a right hand end position in which position fluid may by-pass from one end of the cylinder 99 to the other.

A pair of pipes 145 and 146 are connected between the

feed control valve 40 and the shuttle type valve 135. Similarly a pair of pipes 147 and 148 are connected between the shuttle valve 135 and a pair of end chambers 149 and 150 respectively formed within the cylinder 99. In the position of the feed control valve 40 and the shuttle type valve 135 (fig. 7) fluid under pressure from the pressure pipes 51 entering the valve chamber 45 passes through the pipe 145, through the valve chamber 140, through the pipe 148 into the cylinder chamber 150 to move the piston 100 toward the left into the position illustrated in Fig. 7. During this movement fluid within the cylinder chamber 149 may exhaust through the pipe 147, through the valve chamber 139, through the pipe 146 into the valve chamber 46 and exhausts through the exhaust pipe 58.

When the solenoid S3 is energized at the start of a grinding cycle to shift the valve 40 to its left hand end position fluid under pressure from the pipe 51 passes into the valve chamber 46 and through the passage 57 into the cylinder chamber 56 to start a rapid movement of the piston 36 toward the left rapidly to move the wheel slide 12 and the grinding wheel 15 into an operative position. At the same time fluid under pressure entering the valve chamber 46 passes through the pipe 146, through the valve chamber 139, through the pipe 147 into the cylinder chamber 149 to start the piston 100 moving toward the right (Fig. 7) to produce a slow rotary motion of the feed screw 20 to impart a grinding feed to the wheel slide 12 and the grinding wheel 15.

A feed compensating mechanism is provided automatically to compensate for wheel truing and wheel wear comprising a cylinder 155 (Figs. 5 and 6) which contains a slidably mounted piston 156. The piston 156 is connected to the right hand end of a piston rod 157. A compression spring 158 serves normally to hold the piston 156 in a right hand end position in the cylinder 155. When fluid under pressure is passed through a passage 159 into a cylinder chamber 160 (Fig. 6) the piston 156 will be moved toward the left.

A control valve 161 is provided for controlling the admission to and exhaust of fluid from the cylinder 155. The valve 161 is preferably a piston type valve comprising a valve stem 162 having a pair of spaced valve pistons formed integrally therewith so as to form a valve chamber 163. In the position of the valve 161 (Fig. 6) fluid may exhaust from the cylinder chamber 160, through the passage 159, through the valve chamber 163 and exhausts through a pipe 164. A compression spring 165 serves normally to hold the valve stem 162 in a right hand end position. A solenoid S2 is provided which when energized serves to shift the valve stem 162 toward the left. The solenoid armature is connected by a stud 166 with a link 167. The other end of the link 167 is connected by a stud 168 with the lower end of a rock arm 169. The rock arm 169 is pivotally supported by a stud 170 carried by a bracket 171. The upper end of the rock arm 169 is provided with an elongated slot 172. A stud 173 fixedly mounted on the left hand end of the valve stem 162 rides within the slot 172. It will be readily apparent from the foregoing disclosure that when the solenoid S2 is energized, the valve stem 162 moves toward the left so that fluid under pressure from the pressure pipe 51 passes through the valve chamber 163, through the passage 159, into the cylinder chamber 160 to move the piston 156 toward the left (Fig. 6).

The left hand end of the piston rod 157 is provided with a stud 175 which is connected to one end of a link 176. The other end of the link 176 is connected by a stud 177 with a vertically arranged arm 178 of a bell crank pawl carrying lever which is rotatably supported on a shaft 179. The bell crank lever is provided with a second arm 180 which is arranged in the path of a pair of adjustable stop screws 181 and 182 carried by a fixed bracket 183. The arm 178 is provided with a feed pawl 184 which is pivotally connected thereto by a stud 185. The pawl 184 is arranged to engage the teeth of ratchet wheel 186. A safety pawl 187 (Fig. 5) is pivotally supported by a stud 188 carried by a fixed bracket 189 to facilitate holding the ratchet wheel 186 against clockwise movement during operation of the pawl 184. The ratchet wheel 186 is keyed onto the rotatable shaft 179 which is journalled in spaced anti-friction bearings 190 and 191 supported within the wheel slide 12. A gear 192 is keyed to the left hand end of the shaft 179 (Fig. 4) and meshes with a gear 193 rotatably supported on a fixed stud 194. The gear 193 meshes with a gear 195 keyed onto a rotatable worm shaft 196. The worm shaft 196 is rotatably supported in spaced anti-friction bearings 197 and 198 carried by the downwardly projecting bracket 31 mounted on the underside of the wheel slide 12. The worm shaft 196 is provided with a worm 199 which is keyed thereon and meshes with a worm gear 200 formed integrally with the periphery of the feed nut 28. It will be readily apparent from the foregoing disclosure that actuation of the ratchet wheel 186 by the pawl 184 will be imparted through the gear mechanism above described to impart a rotary motion to the feed nut 28 so as to compensate for grinding wheel wear due to truing operations and normal wheel wear during grinding. The amount of compensation may be regulated by adjustment of the stop screws 181 and 182. These stop screws are adjusted so as to impart a compensating feed equal to the feed of the truing tool at each end of its stroke.

A wheel guard-type truing apparatus is provided comprising a frame 205 which is fixedly mounted on the wheel slide 12. The frame 205 supports a longitudinally movable slide 206 which carries a transversely movable truing tool carrier 207 having a diamond or truing tool 208 fixed at its lower end (Fig. 6). A forming bar 209 is fixedly mounted relative to the frame 205 and in the present case is provided with a plane operative face which is engaged by a follower 210 carried by the truing tool carrier 207.

A hydraulically operated mechanism is provided for traversing the truing tool 208 longitudinally so as to traverse it across the peripheral face of the grinding wheel 15. This mechanism may comprise a cylinder 211 which is fixedly mounted relative to the frame 205. The cylinder 211 contains a slidably mounted piston 212 which is connected to the left hand end of a piston rod 213 (Fig. 6). The right hand end of the piston rod 213 is connected to an upwardly extending bracket 214 fixedly mounted on the longitudinally movable slide 206. When fluid under pressure is passed through a pipe 215 into a cylinder chamber 216, the piston 212 together with the slide 206 is traversed toward the right (Fig. 6). During this movement, fluid within a cylinder chamber 217 may exhaust through a pipe 218. The slide 206 is provided with an upwardly extending lug 219 which is arranged in the path of a normally closed limit switch LS4, the function of which will be described hereinafter.

A control valve 220 is provided for controlling the admission to and exhaust of fluid from the cylinder 211. The control valve 220 comprises a slidably mounted valve member 221 which is controlled by a pilot valve 222. The pilot valve 222 is normally held in a right hand end position by means of a compression spring 223. A solenoid S1 is provided which when energized serves to shift the pilot valve 222 into a left hand end position.

In the position of the valves 220 and 222 (Fig. 6), fluid under pressure from the pipe 51 enters a valve chamber 224 in the valve 220 and passes out through the pipe 218 into the cylinder chamber 217 to move the piston 212 and the longitudinally movable slide 206 toward the left. During this movement fluid may exhaust from the cylinder chamber 216, through the pipe 215 into the valve chamber 225, through a central passage 226 in the slidably mounted valve member 221, into a valve chamber 227 and exhausts through a pipe 228 and a throttle valve 229. By manipulation of the throttle valve 229, the rate of movement of the piston 212 and the slide 206 may be

readily controlled as desired. Fluid under pressure entering the valve chamber 224 in the valve 220 also passes through a passage into a valve chamber 230 in the pilot valve 222, through a passage 231 into an end chamber 232 to move the slidably mounted valve member 221 toward the left into a left hand end position, as illustrated in Fig. 6, and to hold it in this position. During this movement of the valve member 221 fluid within an end chamber 233 may exhaust through a passage 234 into a valve chamber 235 in the pilot valve 222, through a central passage in the pilot valve 222 into a valve chamber 236 and passes out through an exhaust pipe 237.

When the solenoid S1 is energized, the pilot valve 222 is shifted to its left hand end position so that fluid under pressure from the valve chamber 224 in the valve 220 passes into the valve chamber 233 to shift the slidably mounted valve member 221 toward the right thereby reversing the flow of fluid to the cylinder 211 so as to cause the piston 212 together with the slide 206 to move toward the right thereby traversing the truing tool 208 in the reverse direction across the operative face of the grinding wheel 15. Before each pass of the truing tool across the operative face of the grinding wheel 15, a predetermined down feeding movement is imparted to the truing tool 208. This truing tool feeding mechanism has not been illustrated in the present case, since this truing apparatus is identical with that shown in the prior U. S. patent to Oiva E. Hill No. 2,659,359 dated November 17, 1953, to which reference may be had for details of disclosure not contained herein.

The slidably mounted sleeve 26 supports a bracket 240. A rod 241 is fixedly mounted to the bracket 240 and serves to actuate a pair of limit switches LS1 and LS2 (Fig. 1) during the transverse movement of the wheel slide 11. As shown in Fig. 1 the wheel slide 12 is in a rearward position. When the wheel slide moves forward, that is, toward the left (Fig. 1), the rod 41 rides off the actuating roller of the limit switch LS1 to allow the limit switch to open. After further forward movement of the wheel slide 12, the rod 241 rides off the limit switch LS2 and allows the switch LS2 to close.

Referring now to Fig. 6, the closing of switch SW1 serves through the now held close limit switch LS1 to energize a relay switch CR1 to open the normally closed contacts 245 and to close the normally open contacts 246. The closing of the contacts 246 serves to energize an electric counter T1. The energizing of the timer T1 closes the contacts 247 which establishes a holding circuit to maintain the counter T1 energized. The energizing of the counter T1 also opens contacts 248 which remain open until count-out.

During an infeeding movement of the wheel slide 12 the rod 241 (Fig. 1) rides off the limit switch LS1 to allow the limit switch LS1 to open breaking a circuit to deenergize the relay switch CR1 so that the normally closed contacts 245 are again closed. As the wheel slide continues its forward movement, rotation of the feed wheel 61 moves the cam 88 into engagement with the cam 87 to rock the pawl 85 and the arm 89 in a counterclockwise direction thereby allowing the limit switch LS3 to close. The closing of the limit switch LS3 energizes relay switch CR2 to close contacts 249 which make a circuit through the now closed contacts 245 of the relay switch CR1 to energize relay switch CR3. The energizing of relay switch CR3 serves to close contacts 250 and 251. The closing of contacts 250 serves to set up a holding circuit to hold the relay CR3 energized until the wheel slide moves rearwardly. The closing of contacts 251 serves at count-out to operate the feed compensator mechanism and to initiate a truing operation as will be hereinafter described. The relay switch CR3 is normally energized during each forward movement of the wheel slide providing there has been no wear on the truing tool. In case of wear on the truing tool, as will be hereinafter described, the cam 88 will not move a sufficient distance to engage the cam 87 and to actuate the limit switch LS3.

During each forward movement of the wheel slide the limit switch LS2 is closed to impart a counting impulse to the counter T1. After a predetermined number of work pieces have been ground according to the setting of the counter T1, the rearward movement of the wheel slide opens the limit switch LS2 which serves to break the holding circuit to the counter T1 which serves to deenergize the counter and allow it to reset for the next cycle. The closing of the contacts 248 completes a circuit through the selector switch SW4 and through the contacts 251 of the relay switch CR3 to energize the relay switch CR5. Unless there has been truing tool wear, the limit switch LS3 is closed on the last ground work piece which completes the circuit through the contacts 251. When the relay switch CR5 is energized, the contacts 252 are closed to energize the solenoid S2 to start a compensating feed to compensate for wheel wear and truing. At the same time the contacts 248 close, at count-out, a circuit is closed through the normally closed limit switch LS4 to energize a relay switch CR4. Energizing relay switch CR4 closes a pair of contacts 253 to set up a holding circuit to maintain the relay switch CR4 energized. The energizing of relay switch CR4 serves to close a second pair of contacts 254 to complete a circuit to energize the solenoid S1 to start a truing cycle, that is, one complete reciprocation of the truing tool 208 across the operative face of the grinding wheel 15. The energizing of solenoid S1 starts movement of the truing tool 208 toward the right to make the first pass of the truing tool across the face of the wheel 15. When the bracket 219 engages the actuating plunger of limit switch LS4 to open a circuit to break the holding circuit to deenergize the relay switch CR4 thereby opening the contacts 254 to deenergize the solenoid S1 thereby reversing the flow of fluid to the cylinder 211 to start a traversing movement of the truing tool 208 toward the left. As previously explained the truing tool 208 is fed downwardly at each end of the stroke as disclosed in the prior U. S. patent to O. E. Hill No. 2,659,359, above referred to.

Now referring to Fig. 7, when it is desired to start a grinding cycle, the work gauge 110 is moved into engagement with the work piece to be ground after which the control lever 124 is rocked in a counter-clockwise direction to close the start switch 126 which serves in a manner previously described to energize the solenoid S3 to shift the feed control valve 40 toward the left thereby passing fluid under pressure into the cylinder chamber 56 to start a rapid forward approaching movement of the wheel slide 12 and grinding wheel 15. At the same time fluid under pressure is passed through the shuttle-type valve 137 into the cylinder chambr 149 to move the feed piston 100 toward the right to start a rotary motion of the feed screw 20 which controls the forward grinding feed of the wheel slide 12. When the work piece has been ground to a predetermined size, the contact 119 engages the contact 120 to close a circuit to energize the relay switch CR6 thereby breaking the circuit to deenergize the solenoid S3 which reverses the direction of flow of fluid to the cylinders 35 and 99 respectively to cause a rearward movement of the wheel slide 12 and a rotary motion of the feed screw 20 in the reverse direction to reset the feed mechanism for the next grinding cycle. Unless the truing tool has worn, the cam 88 on the feed wheel 61 will actuate the pawl arm 85 to close the limit switch LS3 after each work piece has been ground. If the truing tool 208 has worn away, the grinding wheel 15 will be slightly larger in diameter and therefore the work sizing gauge 110 will reverse the direction of movement of the wheel slide before the cam 88 moves into engagement with the cam 87 so that the switch LS3 will not be closed so that at count-out the compensator will not operate but the truing apparatus is rendered operative to true the peripheral face of the grinding wheel.

The operation of the improved grinding machine will be readily apparent from the foregoing disclosure. As-

suming all of the adjustments have been previously made, a work piece **112** is positioned in the machine, the gauge head **110** is moved into operative engagement with the work piece **112**. The main switch SW1 (Fig. 6) is then closed to render the electric circuits operative. The start lever **124** is then rocked in a counter-clockwise direction to close the start switch **126** thereby energizing the solenoid S3 to start a forward feeding movement of the wheel slide **12** and grinding wheel **15**. The infeeding movement continues until the work piece has been ground to a predetermined size at which time the contacts **119—120** close to deenergize the solenoid S3 thereby causing a rapid rearward movement of the wheel slide **12** and grinding wheel **15** to an inoperative position. Movement of the wheel slide serves in a manner previously described to energize the count coils of the electric counter T1 so that after a predetermined number of work pieces have been ground, the solenoid S2 is energized to impart a compensating feed adjustment, that is, a rotary motion of the feed nut **28** to compensate for the amount of truing and wheel wear. At the same time solenoid S1 is energized to initiate a truing cycle. The truing tool **208** is passed through one complete reciprocation across the peripheral face of the grinding wheel **15** to true the wheel to the desired and predetermined extent.

The compensating feed occurs after count-out, unless the truing tool **208** has worn. In case the truing tool has worn, the diameter of the grinding wheel **15** will be oversized so that when the work piece has been ground to a pretermined size, the gauge head **110** will cause a rapid separating movement of the wheel to an inoperative position before the cam **88** engages the cam **87** to actuate the limit switch LS3. In this latter case no compensating feed adjustment is made and the truing cycle serves to reduce the diameter of the wheel. Unless the cam **88** rotates in a counter-clockwise direction a sufficient distance to engage the cam **87** and to rock the pawl arm **85** so as to actuate the limit switch LS3, no compensating feed adjustment will be made.

It will thus be seen that there has been provided by this invention a grinding machine in which the various objects hereinabove set forth together with many thoroughly practical advantages are successfully achieved. As many possible embodiments may be made of the above invention and as many changes might be made in the embodiment above set forth, it is to be understood that all matter hereinabove set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

We claim:

1. In a grinding machine having a base, a transversely movable wheel slide thereon, a rotatable grinding wheel thereon, means including a nut and screw mechanism to feed slide transversely in either direction, means including a motor to rotate said screw so as to impart a grinding feed to said slide, a feed compensator operatively connected to impart a rotary motion to said feed nut to compensate for wheel wear, a solenoid to actuate said compensator, a limit switch to actuate said solenoid, and means including a cam actuated by and in timed relation with the rotary motion of said feed screw to actuate said limit switch automatically to compensate for wheel wear.

2. In a grinding machine, as claimed in claim 1, in combination with the parts and features therein specified of an electric counter actuated by and in timed relation with the transverse movement of the wheel slide, means including a limit switch actuated by and in timed relation with the transverse movement of the wheel slide to actuate said counter, and operative connections between said counter and said solenoid to actuate said compensator after a predetermined number of pieces of work have been ground to compensate for wheel wear.

3. In a grinding machine having a base, a rotatable work support, a transversely movable wheel slide, a rotatable grinding wheel thereon, means including a nut and screw mechanism to feed said slide transversely in either direction, means including a motor to rotate said screw so as to impart a grinding feed to said slide, means including a control valve therefor, means including a manually operable switch to actuate said valve to initiate an infeeding movement of said slide, a work sizing gauge automatically to shift said valve to cause a rapid separation of the grinding wheel and work when a work piece has been ground to a predetermined size, a feed compensator operatively connected to impart a rotary motion to said feed nut to compensate for wheel wear, a solenoid to actuate said compensator, a limit switch to actuate said solenoid, and means including a cam actuated by and in timed relation with the rotary motion of said feed screw to actuate said limit switch automatically to compensate for wheel wear.

4. In a grinding machine having a base, a rotatable work support thereon, a transversely movable wheel slide on said base, a rotatable grinding wheel thereon, means including a nut and screw mechanism to feed said slide transversely in either direction, means including a motor to rotate said screw so as to impart a grinding feed to said slide, means including a control valve therefor, means including a manually operable switch to actuate said valve to initiate an infeeding movement of said slide, a work sizing gauge automatically to shift said valve to cause a rapid separation of the grinding wheel and work when a work piece has been ground to a predetermined size, a grinding wheel truing apparatus including a longitudinally traversable truing tool automatically to true said grinding wheel after a predetermined number of work pieces have been ground, a feed compensator operatively connected to impart a rotary motion to said feed nut to compensate for wheel wear, a solenoid to actuate said compensator, a limit switch to actuate said solenoid, and means including a cam actuated by and in timed relation with the rotary motion of said feed screw to actuate said limit switch unless the truing tool has worn away automatically to compensate for truing tool and wheel wear.

5. In a grinding machine having a base, a rotatable work support, a transversely movable wheel slide, a rotatable grinding wheel thereon, means including a nut and screw mechanism to feed said slide transversely, means including a fluid motor to rotate said screw to impart a grinding feed to said slide, means including a control valve therefor, means including a switch to actuate said valve to initiate an infeeding movement of said slide, a work sizing gauge automatically to shift said valve to separate the grinding wheel and work when a work piece has been ground to a predetermined size, an electric counter actuated by and in timed relation with the separation of the grinding wheel and work, a grinding wheel truing apparatus actuated by and in timed relation with said counter at count-out automatically to true said grinding wheel after a predetermined number of work pieces have been ground, a feed compensator operatively connected to impart a rotary motion to the feed nut, means including a limit switch operatively connected to actuate said feed compensator, and means including a cam actuated in timed relation with a rotary motion of said feed screw normally to actuate said limit switch unless the truing tool has worn away so as to impart a compensating feeding to the grinding wheel to compensate for wheel wear.

6. In a grinding machine having a base, a rotatable work support, a transversely movable wheel slide, a rotatable grinding wheel thereon, means including a nut and screw mechanism to feed said slide transversely, means including a fluid motor to rotate said screw to impart a grinding feed to said slide, means including a control valve therefor, means including a switch to actuate said valve to initiate an infeeding movement to said slide, a work sizing gauge automatically to shift said valve to separate the grinding wheel and work when

a work piece has been ground to a predetermined size, an electric counter actuated by the separation of the wheel and work, a grinding wheel truing apparatus including a longitudinally traversable truing tool automatically to true said grinding wheel at count-out after a predetermined number of work pieces have been ground, means to move said tool longitudinally through one complete reciprocation, means automatically to feed said tool transversely before each pass of the tool across the grinding wheel, a feed compensator actuated by said counter at count-out, operative connections between said compensator and said feed nut to impart a rotary compensating adjustment to said feed nut, means including a limit switch operatively connected to actuate said feed

compensator, and means including a cam actuated in timed relation with the rotary motion of said feed screw normally to actuate said limit switch unless the truing tool has worn so as to impart a compensating feed to the grinding wheel after a predetermined number of work pieces have been ground to compensate for wheel wear.

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