March 14, 1944. C. G. FLYGARE ET AL 2,344,242

EXTERNAL-INTERNAL CYLINDRICAL GRINDING MACHINE

Filed April 8, 1942 5 Sheets-Sheet 1

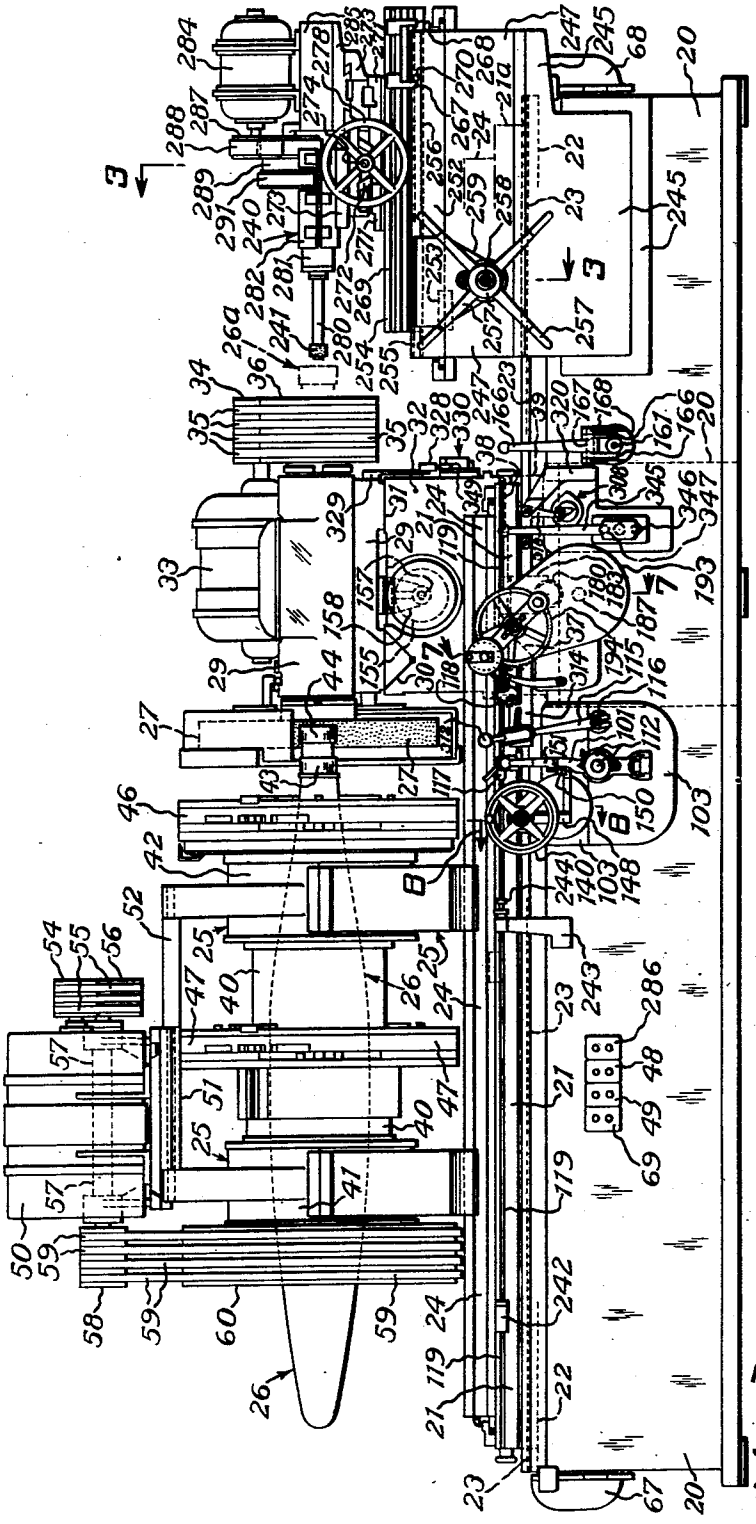


FIG. 1

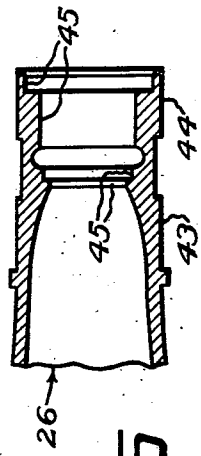


FIG. 5

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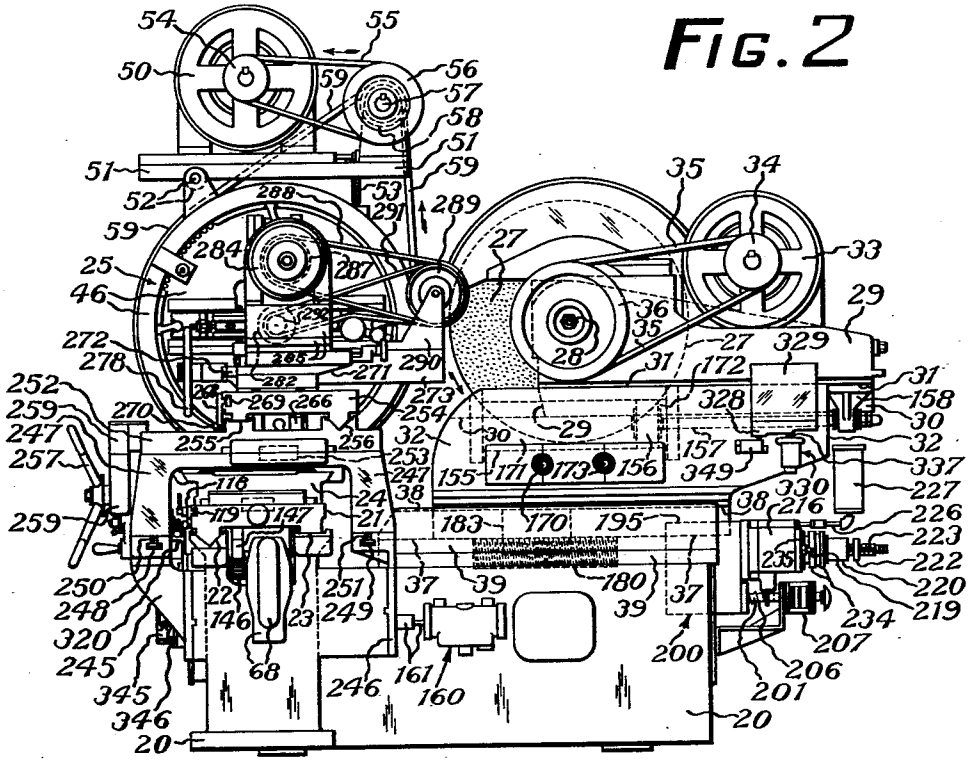
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EXTERNAL-INTERNAL CYLINDRICAL GRINDING MACHINE

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FIG. 2



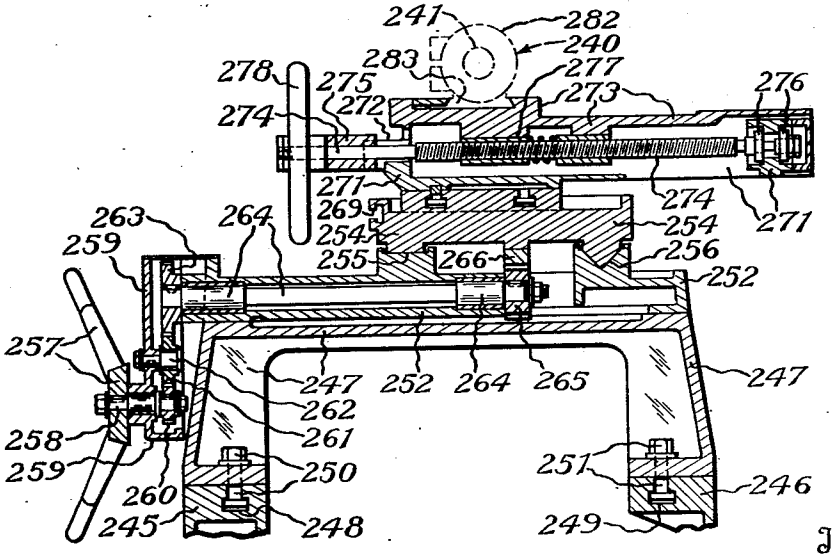


FIG. 3

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EXTERNAL-INTERNAL CYLINDRICAL GRINDING MACHINE

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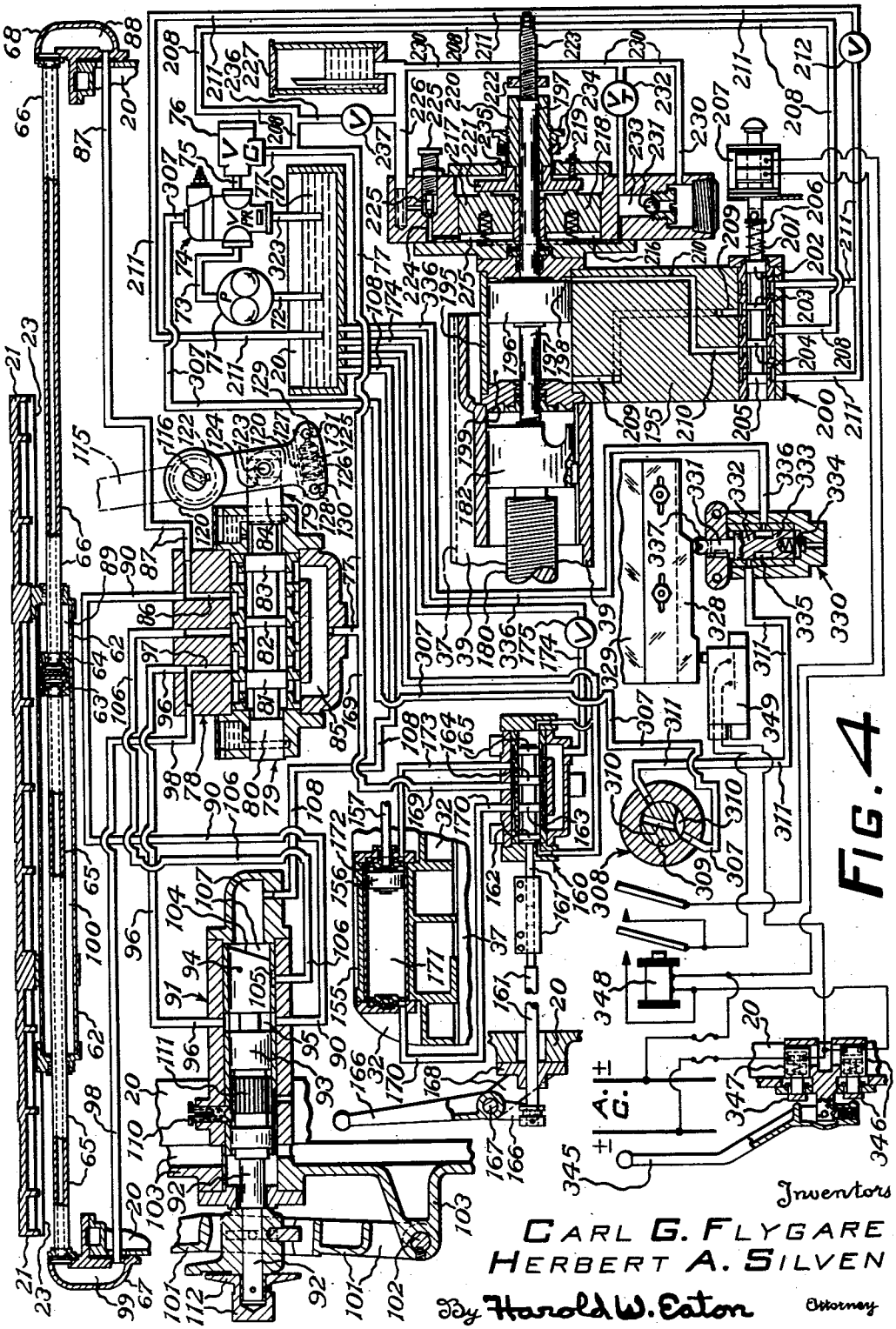


FIG. 4

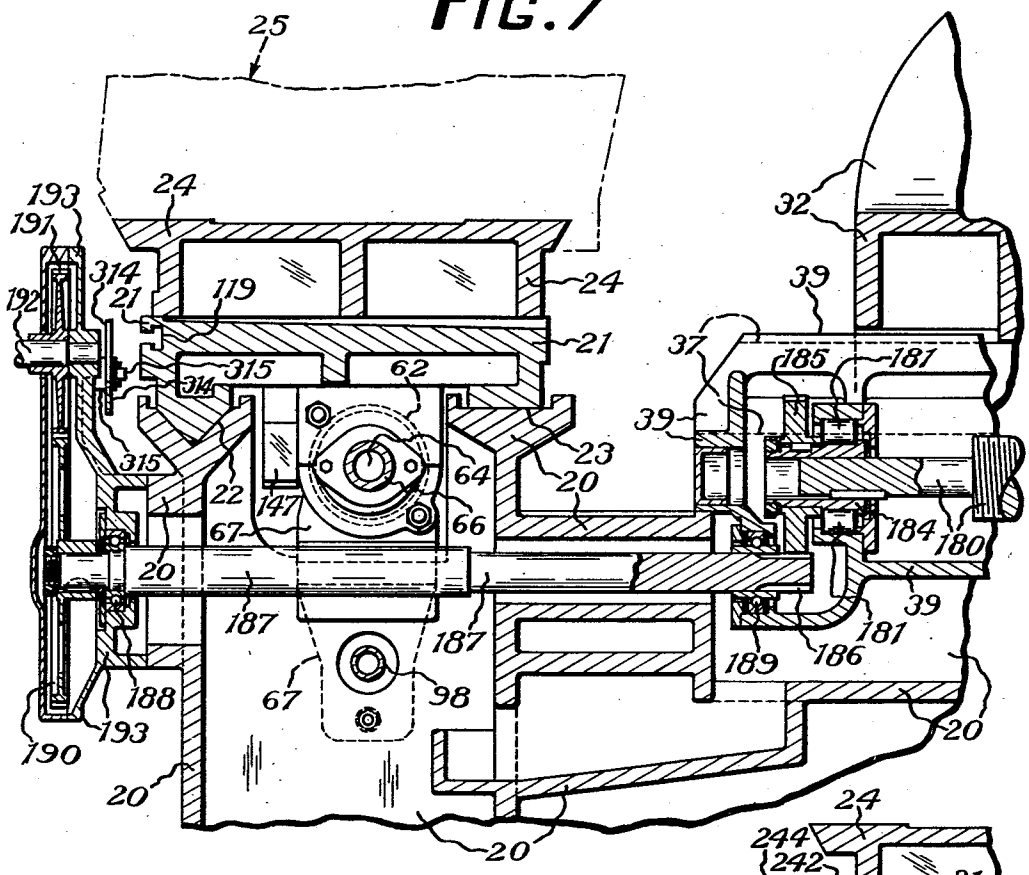
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EXTERNAL-INTERNAL CYLINDRICAL GRINDING MACHINE

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FIG. 7



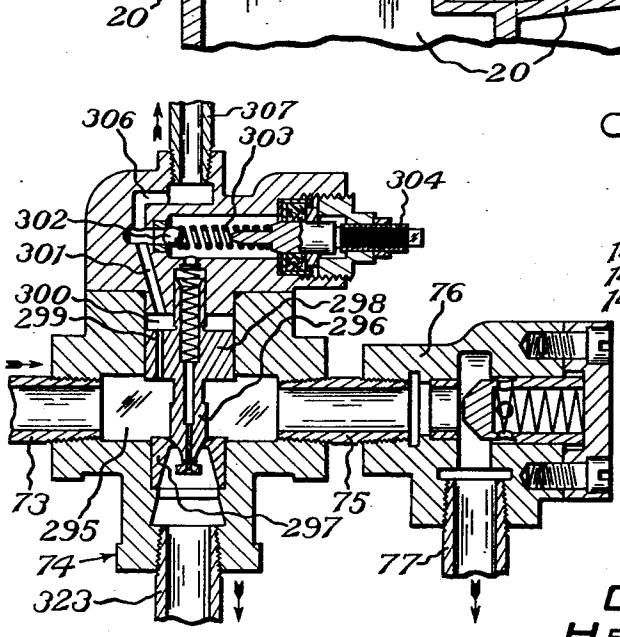


FIG. 6

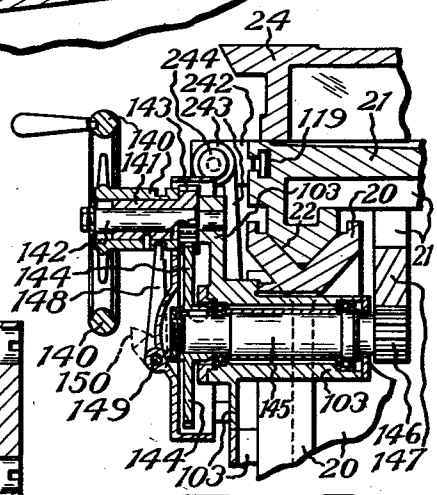


FIG. 8

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EXTERNAL-INTERNAL CYLINDRICAL GRINDING MACHINE

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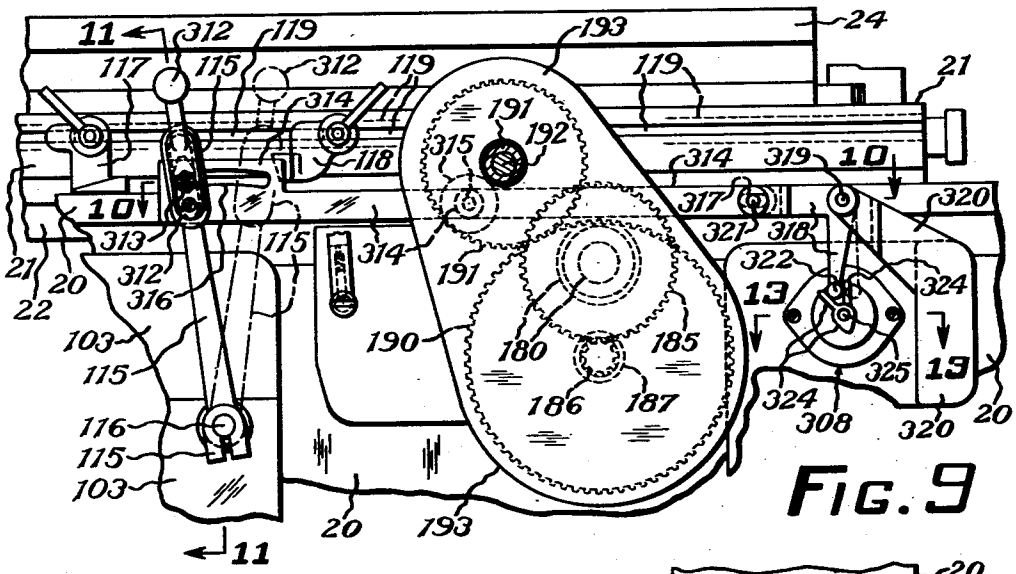


FIG. 9

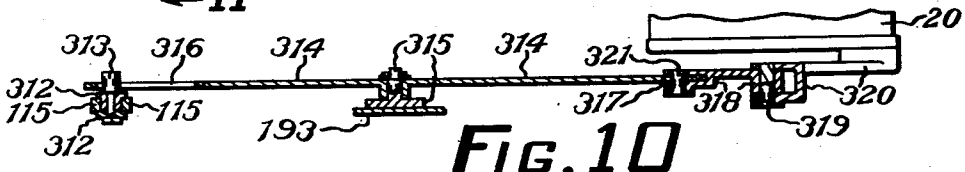


FIG. 10

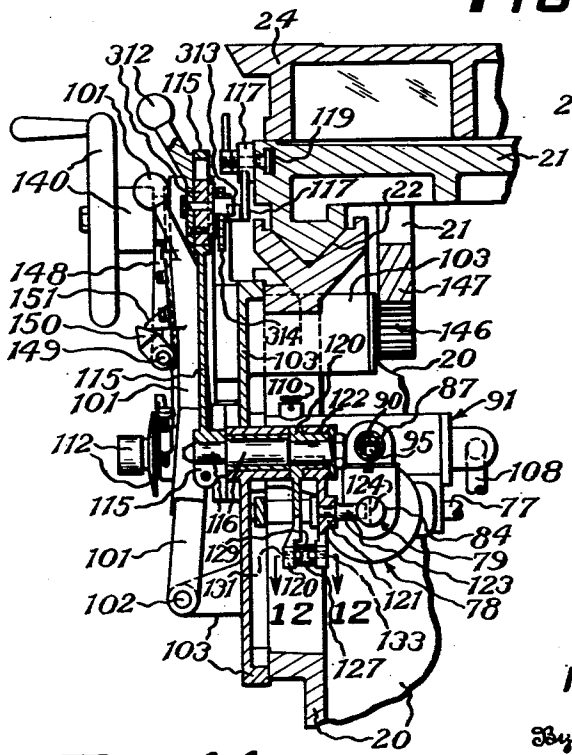


FIG. 11

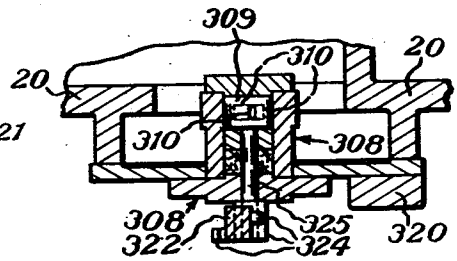


FIG. 13

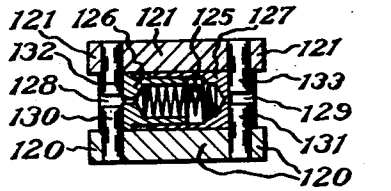


FIG. 12

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Patented Mar. 14, 1944 2,344,242

UNITED STATES PATENT OFFICE

2,344,242

EXTERNAL-INTERNAL CYLINDRICAL GRINDING MACHINE

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Application April 8, 1942, Serial No. 438,091

12 Claims. (Cl. 51—3)

The invention relates to grinding machines, and more particularly to a grinding machine for grinding both external and internal surfaces of a work piece.

One object of the invention is to provide a simple and thoroughly practical hydraulically operated grinding machine for successively grinding external and internal cylindrical surfaces on a work piece. Another object of the invention is to provide a hydraulically operated external-internal grinding machine with an interlock to prevent movement of the workpiece to an internal grinding position except when the external grinding wheel is in its rearmost or inoperative position.

Another object of the invention is to provide an electrically controlled interlock to prevent initiating an infeeding movement of the grinding wheel unless the grinding wheel slide is in a forward or operative position. Another object of the invention is to provide a hydraulic interlock to prevent movement of the work table beyond its normal reciprocatory stroke when the grinding wheel is in a forward or operative position. Other objects will be in part obvious or in part pointed out hereinafter.

The invention accordingly consists in the features of construction, combinations of elements, and arrangements of parts, as will be exemplified in the structure to be hereinafter described, and the scope of the application of which will be indicated in the following claims.

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

Fig. 1 is a front elevation of the improved external-internal cylindrical grinding machine;

Fig. 2 is a right-hand end elevation of the grinding machine, as shown in Fig. 1;

Fig. 3 is a fragmentary vertical sectional view, on an enlarged scale, taken approximately on the line 3—3 of Fig. 1, showing the transverse and longitudinal feeding or traversing mechanism for the internal grinding head;

Fig. 4 is an electric wiring and hydraulic piping diagram illustrating the actuating and control mechanisms of the grinding machine;

Fig. 5 is a fragmentary longitudinal sectional view, on an enlarged scale, through the hub portion of a propeller blade, showing the surfaces to be ground;

Fig. 6 is a vertical sectional view, on an enlarged scale, through the venting type relief valve in the hydraulic system;

Fig. 7 is a fragmentary cross sectional view, on an enlarged scale, taken approximately on the line 7—7 of Fig. 1, showing a portion of the grinding wheel feeding mechanism;

Fig. 8 is a fragmentary cross sectional view, on an enlarged scale, taken approximately on the line 8—8 of Fig. 1, showing the manually operable work table traversing mechanism;

Fig. 9 is a fragmentary front elevation, on an enlarged scale, of a portion of the control mechanism on the front of the grinding machine;

Fig. 10 is a fragmentary horizontal sectional view, taken approximately on the line 10—10 of Fig. 9;

Fig. 11 is a fragmentary vertical sectional view, taken approximately on the line 11—11 of Fig. 9, through the work table reversing mechanism;

Fig. 12 is a fragmentary cross sectional view, taken approximately on the line 12—12 of Fig. 11, through the load and fire mechanism; and

Fig. 13 is a horizontal sectional view, taken approximately on the line 13—13 of Fig. 9, through the hydraulic interlock valve.

A grinding machine has been illustrated in the drawings comprising a base 20 which supports a longitudinally reciprocable work supporting table 21 on the usual V-way 22 and flat way 23 for a longitudinal reciprocatory movement relative to the base 20. The table 21 pivotally supports a swivel table 24 clamped thereto which serves as a support for a rotatable work supporting head 25 which rotatably supports a work piece 26 in operative position relative to a grinding wheel 27. The grinding wheel 27 is mounted on one end of a rotatable wheel spindle 28. The wheel spindle 28 is journalled in suitable bearings in a transversely movable wheel slide 29 which is arranged to slide transversely on a V-way 30 and flat way 31 on an intermediate slide 32. The grinding wheel 27 may be driven by means of an electric motor 33 mounted on the upper surface of the wheel slide 29 controlled by the push button switch 48. The motor 33 is provided with a multiple V-groove pulley 34 which is drivingly connected by multiple V-belts 35 with a multiple V-groove pulley 36 mounted on the right-hand end of the wheel spindle 28 (Fig. 1). The intermediate slide 32 is supported by the usual V-way 37 and flat way 38 formed on the slide support 39 mounted on the rearwardly extending portion of the base 20 to support the intermediate slide 32 for a transverse movement relative to the base 20.

Work support and drive

The rotatable work support 25 preferably comprises a rotatable hollow spindle 40 which is journalled in bearings 41 and 42. The rotatable work support 25 illustrated is particularly adapted for supporting an irregularly shaped work piece 26 which, as illustrated, is an aeroplane propeller blade having exterior cylindrical surfaces 43 and 44 and an internal surface 45 to be ground. A chuck 46 is mounted on the right-hand end of the spindle 40 and serves to center and clamp the hub end of a propeller blade in

position for a grinding operation. A second chuck 47 is provided for supporting and centering the blade portion. The chuck 47 is longitudinally adjustable relative to the spindle 40 and is also angularly adjustable so that the clamping jaws may be positioned to engage opposite edges of the propeller blade.

The work spindle 40 may be driven by an electric motor 50 controlled by the push button switch 49 which is fixedly mounted on an adjustable slide on a pivotally mounted motor support 51. The motor support 51 is pivotally supported by a shaft 52 mounted on integral projections on the upper bearing caps of the bearings 41 and 42. An adjusting screw 53 is provided for locking the motor support 51 to tension the driving belts. The motor 50 is provided with a multiple V-groove driving pulley 54 which is connected by multiple V-belts 55 with a multiple V-groove pulley 56 mounted on the right-hand end of a rotatable shaft 57 (Figs. 1 and 2). The shaft 57 is provided at its other end with a multiple V-groove pulley 58 which is connected by multiple V-belts 59 with a pulley 60 which is mounted on the left-hand end of the work supporting spindle 40 (Fig. 1). It will thus be readily apparent that rotary power from the motor 50 will be transmitted to rotate the work spindle 40 together with the work supporting chucks 46 and 47 to rotate the work piece 26 for a grinding operation.

Work table control mechanism

The table 21 is preferably reciprocated by a hydraulically operated mechanism comprising a cylinder 62 which is supported in fixed relation with the under side of the table 21. A pair of spaced pistons 63 and 64 are slidably mounted within the cylinder 62 and are connected by hollow piston rods 65 and 66, respectively. The hollow piston rods 65 and 66 are connected to hollow brackets 67 and 68, respectively, which are mounted in fixed relation with the opposite ends of the base 20.

Fluid under pressure is supplied from a suitable source, such as a reservoir 70 formed in a box-like portion of the base 20. A motor driven fluid pump 71 which is controlled by the push button switch 69 is provided for drawing fluid through a pipe 72 from the reservoir 70 and forcing fluid under pressure through a pipe 73 to a venting type relief valve 74 to be hereinafter described. The venting type relief valve 74 is connected by a pipe 75 with a check valve 76 which is in turn connected by a pipe 77 to force fluid under pressure to a table reversing or controlling valve 78. The table reversing valve 78 is a piston type valve comprising a valve stem 79 having formed integrally therewith valve pistons 80, 81, 82, 83 and 84. In the position of the valve 78 (Fig. 4), fluid under pressure passing through the pipe 77 enters a passage or chamber 85 in the valve casing and passes into a valve chamber located between the valve pistons 82 and 83 and then out through a passage 86 and a pipe 87 which connects with a chamber 88 in the bracket 68 and passes through the hollow piston rod 66 into a cylinder chamber 89 to cause the cylinder 62 and table 21 to move toward the right (Fig. 4). A pipe 90 connects the passage 86 with a combination speed control and stop and start valve 91. This valve 91 is a piston type valve comprising a valve stem 92 having formed integrally therewith valve pistons 93 and 94.

In the position of the valve 91 (Fig. 4), fluid may by-pass from one end of the cylinder 62 to the other. Fluid within the pipe 90 is connected with a valve chamber 95 located between the valve pistons 93 and 94. A pipe 96 connects the valve chamber 95 with a passage 97 in the valve 78. The passage 97 is connected by a pipe 98 with a chamber 99 formed in the bracket 67 through which fluid passes to the hollow piston rod 65, into a cylinder chamber 100. It will be readily apparent from the foregoing disclosure that in the position of the valves 78 and 91 (Fig. 4), fluid may readily pass between opposite ends of the table reciprocating cylinder 62.

The valve 91 serves also as a stop and start valve and is arranged to be actuated by a pivotally mounted control lever 101 which is supported by a stud 102 fixedly supported by a bracket 103 which is fixed relative to the front of the machine base 20. The lever 101 is connected to move the valve stem 92 to position the valve pistons 93 and 94, respectively, as desired. When it is desired to start the reciprocatory movement of the work table 21, the control lever 101 is moved in a counterclockwise direction (Fig. 4) to move the valve stem 92 together with the valve pistons 93 and 94 toward the left so that the angularly formed end face 104 of the valve piston 94 will uncover at least a portion of a V-port 105 so that fluid exhausting from the valve 78 through a pipe 106 may pass through the V-port 105 into a valve chamber 107 and pass outwardly through a pipe 108 which exhausts into the reservoir 70.

When the stop and start valve 91 is opened to allow fluid to pass through the V-port 105, with the table reversing valve 78 in the position illustrated in Fig. 4, the cylinder 62 and the table 21 will start their reciprocatory movement toward the right (Fig. 4). During the movement of the table 21 toward the right, fluid within the cylinder chamber 100 will exhaust through the hollow pitson rod 65, through the chamber 99 in the bracket 67, and through the pipe 98. An arrow-pointed spring-pressed detent 110 is provided to engage a serrated portion 111 of the valve stem 92 normally to hold the valve stem 92 agains rotary motion. A manually operable speed adjusting knob 112 is mounted on the outer end of the valve stem 92 and serves to facilitate a rotary adjustment to vary the position of the angular end face 104 of the valve piston 94 relative to the V-port 105 so that the exhaust of fluid passing through the V-port 105 may be regulated as desired to control the reciprocatory speed of the table 21.

A manually operable or table actuated reversing lever 115 is mounted on the outer end of a rock shaft 116. The reversing lever 115 may be actuated either manually or by means of a pair of table dogs 117 and 118 which are adjustably supported in a T-slot 119 formed in the front edge of the work supporting table 21. A downwardly extending arm 120 is keyed to the inner end of the rock shaft 116. An arm 121 is rotatably supported on a hub portion 122 of the lever 120. The arm 121 carries a stud 123 which engages a notch 124 formed in the valve stem 79.

A load and fire mechanism is provided comprising a compression spring 125 (Fig. 12) which is contained within a pair of telescoping sleeves 126 and 127. The sleeves 126 and 127 are provided at their ends with transversely extending notches 128 and 129, respectively. The arm 126 carries a pair of studs 130 and 131 which ride

within the notches 128 and 129, respectively. Similarly, the arm 121 supports a pair of studs 132 and 133 which also ride in the notches 128 and 129, respectively. It will be readily apparent from the foregoing disclosure that when one of the table dogs 117 or 118 engages and swings the reversing lever 115, the movement of the arm 126 with the reversing lever 115 will compress the spring 125 before transmitting a shifting movement to the valve stem 79 to start the reversing movement of the valve 78. This mechanism is substantially identical to that shown in the prior U. S. patent to Wallace H. Wood, No. 2,071,677 dated February 23, 1937, to which reference may be had for details of disclosure not contained herein.

Manual table traversing mechanism

A manually operable table traverse mechanism is provided, comprising a manually operable hand wheel 140 which is fixedly supported on a sleeve 141 (Fig. 8). The sleeve 141 is slidably mounted on a stud 142 which is fixed relative to the base 20 of the machine. A gear 143 is formed integral with the sleeve 141 and meshes with a gear 144 which is keyed on the outer end of a shaft 145. A pinion 146 is formed integral with the inner end of the shaft 145. The pinion 146 meshes with a rack bar 147 which is fixedly mounted on and depends from the under side of the table 21. The sleeve 141 is slidably mounted on the stud 142 so that during power traverse or reciprocation of the table 21, the gear 143 may be shifted toward the left (Fig. 8) out of mesh with the gear 144 so that the manually operable hand wheel 140 will remain stationary. A lever 148 is supported by a rock shaft 149 which in turn supports a short arm 150. The short arm 150 is arranged in the path of an adjustably mounted projecting portion 151 on the lever 101. These parts are arranged so that when the lever 101 is moved in a counterclockwise direction (Fig. 11) to initiate a power reciprocating movement of the table 21, the hand wheel 140 together with the gear 143 will be moved toward the left (Fig. 8) to throw it out of mesh with the gear 144, thus rendering the manually operable traverse wheel 140 inoperative during the hydraulic traversing or reciprocating movement of the table 21.

Wheel positioning

It is necessary to withdraw the grinding wheel 27 a considerable distance from the work axis so that the work supporting swivel table 24 may be readily traversed to an internal grinding position to be hereinafter described. A grinding wheel positioning mechanism is provided, comprising a hydraulically operated mechanism interposed between the wheel slide 29 and the intermediate slide 32. This mechanism may comprise a hydraulic cylinder 155 which is formed integral with the intermediate slide 32. A piston 156 is slidably mounted within the cylinder 155. A piston rod 157 is connected at one end to the piston 156 and at the other end to a bracket 158 depending from and fixedly mounted to the under side of the wheel slide 29.

A manually operable control valve 160 is provided for controlling the admission to and exhaust of fluid from the cylinder 155. The valve 160 is a piston type valve comprising a valve stem 161 having valve pistons 162, 163, 164 and 165 formed integral therewith. A manually operable control lever 166 is provided for actuating the valve stem 161. The control lever 166 is pivotally supported by a stud 167 which is in turn supported by a bracket 168 fixedly mounted on the front of the machine base. In the position of the valve 160 (Fig. 4), fluid under pressure passing through the pipe 77 passes through a pipe 169, into a valve chamber located between the valve pistons 163 and 164 and passes out through a pipe 170, into a cylinder chamber 171, to move the piston 156 to its rearmost position so that the grinding wheel 27 is moved to its extreme rearward or inoperative position out of the path of movement of the work head 25. During the rearward movement of the piston 156, fluid within a cylinder chamber 172 is exhausted through a pipe 173, through a valve chamber located between the valve pistons 164 and 165, and passes out through an exhaust pipe 174, into the reservoir 70. A valve 175 is provided in the exhaust pipe line 174 so that the exhaust of fluid from the cylinder 155 may be readily controlled, thereby controlling the speed of movement of the grinding wheel 27 to and from an operative position.

When it is desired to move the grinding wheel 27 forward to an operative position, the control lever 166 is moved in a counterclockwise direction (Fig. 4) to shift the valve stem 161 toward the right (Fig. 4) so that fluid under pressure from the pipe 169 will pass through the valve chamber located between the valve pistons 164 and 165 and through the pipe 173, into the cylinder chamber 172 to cause the piston 156 and the wheel slide 29 to move forwardly into an operative position with the grinding wheel 27 adjacent to the surface of the work piece to be ground.

Wheel feeding mechanism

A grinding wheel feeding mechanism is provided interposed between the intermediate slide 32 and the base 20. The wheel feeding mechanism illustrated combines a manually operable wheel feed and a hydraulically operated power feeding mechanism. This feeding mechanism may comprise a rotatable cross feed screw 180 which is rotatably journalled in the base 20 in a suitable bearing 181 at its forward end and in a slidably keyed sleeve 182 at its other end. A depending half nut 183 is fixedly mounted on and depends from the under side of the intermediate slide 32 and meshes with or engages the feed screw 180.

In order to facilitate rotary adjustment of the feed screw 180, a sleeve 184 is slidably keyed to the forwardly extending portion of the feed screw 180 and is rotatably supported by the bearing 181. A gear 185 is keyed on the sleeve 184 and meshes with a pinion 186 formed on a rotatable shaft 187. The shaft 187 is journalled in bearings 188 and 189 which are supported in fixed relationship with the base 20. A gear 190 is mounted on the forward end of the shaft 187 and meshes with a gear 191. The gear 191 is rotatably supported on a stud 192 which is in turn fixedly mounted in a bracket 193. The bracket 193 is fixedly mounted on the front of the machine base 20. A manually operable feed wheel 194 is also rotatably mounted on the stud 191 and is connected so as to rotate the gear 191. The feed wheel 194 is substantially the same as that shown in the expired U. S. patent to C. H. Norton, No. 762,838 dated June 14, 1904, to which reference may be had for details of disclosure not contained herein. It will be readily apparent from the foregoing disclosure that a rotary mo-

tion of the feed wheel 194 will be transmitted through the mechanism above described to rotate the feed screw 180 to impart a transverse feeding movement to the intermediate slide 32, the wheel slide 29, and the grinding wheel 27. The direction of movement of the slides and the grinding wheel 27 is determined by the direction of rotation of the feed wheel 194.

A hydraulically operated mechanism is provided for moving the feed screw 180 bodily in an axial direction to impart a power feeding movement to the intermediate slide 32, the wheel slide 29, and the grinding wheel 27. This mechanism comprises a hydraulic cylinder 195 which is arranged in axial alignment with the feed screw 180. A slidably mounted piston 196 is contained within the cylinder 195. A double end piston rod 197 is connected to the piston 196 and at its left-hand end (Fig. 4) to the slidably mounted sleeve 182. It will be readily apparent from the foregoing disclosure that when fluid under pressure is admitted to a cylinder chamber 198 to cause the piston 196 to move toward the left (Fig. 4), it will impart a forward feeding movement through the feed screw 180 to the intermediate slide 32 so as to impart a corresponding feeding movement to the wheel slide 29 and the grinding wheel 27. Similarly, if fluid under pressure is admitted to a cylinder chamber 199 to cause the piston 196 to move toward the right into the position illustrated in Fig. 4, a rearward movement of the grinding wheel 27 will be obtained.

A reversing or feed control valve 200 (Fig. 4) is provided for controlling the admission to and exhaust of fluid from the feed cylinder 195. The valve 200 is a piston type valve comprising a valve stem 201 having formed integrally therewith valve pistons 202, 203, 204 and 205. A compression spring 206 serves normally to hold the valve stem 201 in its right-hand end position (Fig. 4). An electric solenoid 207 is operatively connected to the valve stem 201 so that when energized the solenoid 207 will move the valve stem 201 toward the left (Fig. 4) to reverse the flow of fluid to the feed cylinder 195.

Fluid under pressure from the pump 71 passing through the pipe 77 passes through a pipe 208, into a valve chamber located between the valve pistons 203 and 204, and passes through a passage 209 into the cylinder chamber 199 to move the piston 196 rearwardly, that is, toward the right (Fig. 4) into the position illustrated. During this movement, fluid within the cylinder chamber 198 exhausts through a passage 210, into a valve chamber located between the valve pistons 204 and 205, and passes outwardly through an exhaust pipe 211 into the fluid reservoir 70. A throttle valve 212 is provided in the exhaust pipe line 211 whereby the rate of exhaust of fluid from the feed cylinder 195 may be regulated as desired so as to control the transverse feeding movement of the grinding wheel 27. The mechanism above described produces a comparatively rapid forward or rearward feeding movement of the grinding wheel 27.

Dash pot feed mechanism

A suitable fluid pressure control or feed regulating mechanism is provided for modifying the rapid approaching movement caused by the piston 196 to obtain a controlled and predetermined grinding feed of the grinding wheel 27. A self-contained dash pot feed regulator is provided, comprising a pair of dash pot cylinders 215 and 216 which contain dash pot pistons 217 and 218, respectively. The dash pot pistons 217 and 218 and their respective cylinders are arranged with their axes parallel to each other and spaced on diametrically opposite sides of the axis of the piston rod 197. The dash pot pistons 217 and 218 are normally held in a rearward (right-hand) position by means of the compression springs. An adjustable stop screw 219 serves to limit the rearward movement of the dash pot pistons 217 and 218, respectively. A slidable sleeve 220 is supported on the rear extension of the piston rod 197. The sleeve 220 has a flanged portion 221 which is either formed integral therewith or fixedly secured thereto. The flange 221 is arranged to engage the right-hand end faces of the dash pot pistons 217 and 218, respectively. The stop screw 219 engages the flange 221 and thereby serves to limit the rearward movement of the dash pot pistons 217 and 218 toward the right (Fig. 4).

The rapid forward feeding movement of the grinding wheel 27, wheel slide 29 and intermediate slide 32 continues until an adjustable nut 222 on a threaded portion 223 of the rearward extension of the piston rod 197 engages the right-hand end of the sleeve 220. Continued movement of the piston rod 197 moves the sleeve 220 and the flange 221 toward the left and continued movement serves to move the dash pot pistons 217 and 218 in a direction toward the left (Fig. 4). When the flange 221 engages the ends of the dash pot pistons 217 and 218, respectively, the rapid approaching or feeding movement of the grinding wheel 27 toward the work piece 26 as produced by the piston 196 is reduced to a slower predetermined grinding feed due to the fact that fluid confined within the dash pot cylinders 215 and 216, respectively, which are interconnected, exhausts through a passage 224, a needle valve 225, through a pipe 226, into a reservoir 227. By adjusting the aperture of the needle valve 225, a desired and predetermined infeeding movement of the grinding wheel 27 may be obtained.

When fluid under pressure is admitted to the cylinder chamber 199 to cause a rearward movement of the piston 196, the sleeve 220 together with the flange 221 is moved rearwardly by means of the released compression of the spring within the dash pot cylinders 215 and 216 which returns the dash pot pistons 217 and 218, respectively, to their rearward position and moves the flange 221 into engagement with the stop screw 219. During the rearward movement of the dash pot pistons 217 and 218, a suction is created within the dash pot cylinders 215 and 216, respectively, which serves to draw fluid from the reservoir 227, through a pipe 230, and a ball check valve 231, to fill the dash pot cylinders 215 and 216 for the next infeeding movement of the grinding wheel 27. During the infeeding movement of the dash pot pistons 217 and 218, fluid within the dash pot cylinders 215 and 216 serves to hold the ball check valve 231 closed so that fluid within the dash pot cylinders 215 and 216 is forced out through the passage 224 and the needle valve 225 and a throttle valve 232 until the passage 224 is closed, into the reservoir 227 to control the rate of the infeeding movement, as desired.

The adjustable throttle valve 232 is connected between the pipe 230 and a chamber 233 to facilitate exhaust of fluid from the dash pot cylinders 215 and 216 after the passage 224 is closed by the dash pot piston 217. If desired, the throttle valve 232 may be used to give a very fine final feeding movement of the grinding wheel 27 just

prior to a positive stop 234 engaging a stop surface 235 which positively limits the forward advance of the grinding wheel 27 toward the work axis. In the latter case, two distinct speeds of the grinding wheel 27 may be obtained, one feed by manipulation of the valve 232 combined with the opening of the needle valve 225 which would continue until the passage 224 is cut off, after which the positioning movement is reduced to a very slow infeed controlled by the throttle valve 232.

In order to maintain the desired quantity of fluid in the reservoir 227, initially to fill the chamber and thereafter to replenish leakage from the feed regulator system, a pipe 236 is connected between the pipe 208 and the pipe 226. A valve 237 is provided in the pipe line 236 which may be readily opened to allow the desired amount of fluid from the fluid pump 71 to pass into the reservoir 227, after which the valve 237 may again be closed.

Internal grinding

In order to grind the internal surfaces 45 (Fig. 5), an internal grinding head 240 is mounted at the right-hand end of the machine base 20 (Fig. 1). After the external surfaces 43 and 44 of the propeller blade 26 have been ground and the grinding wheel 27 moved to a rearward or inoperative position, the work table 21 may be traversed longitudinally toward the right (Fig. 1) to position the work piece 26 in broken line position 26a (Fig. 1) in close proximity to an internal grinding wheel 241 supported by the internal grinding head 240. A stop dog 242 is carried adjustably supported by the T-slot 119 and is arranged to locate the work piece 26 in position 26a for an internal grinding operation. A bracket 243 is fixedly supported on the front of the base 20. The bracket 243 carries an adjustable stop screw 244 which is arranged in the path of the stop dog 242 precisely to locate the sliding table 21 when it is moved to an extreme right-hand end postion for an internal grinding operation.

A pair of brackets 245 and 246 are fixedly mounted at the right-hand end of the machine base 20 on the front and back surfaces thereof and serve as a support for an inverted U-shaped frame 247 which supports the internal grinding fixture. The frame 247 is adjustable longitudinally relative to the brackets 245 and 246, respectively. The upper surface of the brackets 245 and 246 are provided with longitudinally extending T-slots 248 and 249, respectively, which are arranged parallel to the slideways 22 and 23 of the machine base 20. The frame 247 is adjustably clamped in position by bolts 250 and 251, respectively. It will be noted that the inverted U-shaped frame 247 bridges over the right-hand end of the tables 21 and 24 so that when the table 24 moves to an extreme right-hand end position, it passes within the aperture formed between the U-shaped frame 247 and the base 20.

A swivel plate 252 is supported and clamped on the frame 247 and is arranged so that it may be swivelled about a stud 253 to facilitate angularly adjusting the path of travel of the internal grinding wheel 241 so that its axis will move parallel to the axis of rotation of the work piece 26 for grinding a true internal cylindrical surface or at an angle thereto if it is desired to produce a tapered internal surface. A longitudinally traversable carriage 254 is supported on a flat way 255 and a V-way 256 formed on the upper surface of the swivel platen 252. By adjusting the position of the platen 252, as previously described, the flat way 255 and V-way 256 may readily be positioned either parallel to or at an angle to the V-way 22 and flat way 23 which support the work table 21.

A manually operable traversing mechanism is provided for traversing the carriage 254 longitudinally comprising a manually operable hand wheel 257 which is keyed to a rotatable shaft 258 which is journalled in a casing 259 mounted on the swivel plate 252. A gear 260 is mounted on the inner end of the shaft 258. The gear 260 meshes with a gear 261 which is rotatably supported on a stud 262 carried by the casing 259. The gear 261 meshes with a gear 263 mounted on the outer end of a rotatable shaft 264 which is journalled in sleeve bearings in the swivel plate 252. A gear 265 is mounted on the inner end of the shaft 264 and meshes with a rack bar 266 depending from the under side of the longitudinally movable carriage 254.

Adjustable dogs 267 and 268 are supported by a T-slot 269 formed in the front edge of the carriage 254. The dogs 267 and 268 are arranged in the path of a stop abutment 270 fixedly supported on the plate 252, so that the longitudinal traversing movement of the carriage 254 may be limited as desired. A plate 271 is angularly and adjustably supported on the longitudinally movable carriage 254. A dovetailed slideway 272 is formed on the upper surface of the plate 271 which mates with a correspondingly shaped slideway formed in a transversely movable wheel slide 273.

A nut and screw feeding mechanism is provided for feeding the wheel slide 273 transversely as desired. A rotatable feed screw 274 is journalled in bearings 275 and 276 carried by the frame 271. A nut 277 meshes with the feed screw 274. A manually operable hand wheel 278 is mounted on the outer end of the feed screw 274. It will be readily apparent from the foregoing disclosure that rotation of the hand wheel 278 will be transmitted through the feed screw 274 and the nut 277 to move the wheel slide 273 transversely.

The internal grinding wheel 241 is supported adjacent to the end of a wheel spindle 280 which is rotatably supported in a housing 281 containing bearings for the spindle. This spindle housing 281 is a cartridge type cylindrically shaped member which fits within an aperture formed in a split bracket 282. The internal grinding wheel cartridge unit 281 may be readily clamped in adjusted position in the bracket 282. The bracket 282 is provided with a dovetailed shaped base 283 extending longitudinally which mates with a correspondingly shaped dovetail upon the upper surface of the wheel slide 273 so that the bracket 282 may be adjusted longitudinally relative to the wheel slide 273. The internal grinding wheel 241 and its supporting spindle 280 may be driven by means of a motor driven mechanism comprising an electric motor 284 which is supported on a transversely adjustable supporting dovetailed slide 285. The motor 284 is provided with a driving pulley 287 which is connected by a driving belt 288 with a pulley 289 which is mounted on a jackshaft mounted in a bracket 290 supported on the wheel slide 273. A belt 291 having idlers for proper tension connects the pulley 289 with a pulley 292 mounted on the end of the wheel spindle 280 to rotate it together with the grinding wheel 241 during an internal grinding operation. The electric motor 284 is controlled

by the push button switch 286 mounted on the base 20.

Hydraulic interlock

In order to prevent a traversing movement of the work table 21 to an internal grinding position before the griding wheel 27 is moved to a rearward position out of the path of movement of the work head 25, it is desirable to provide a suitable interlocking mechanism for preventing movement of the table 21 unless the wheel slide 29 and the intermediate slide 32 are in a rearward or inoperative position. This is preferably accomplished by means of the venting type relief valve 74. Fluid under pressure from the fluid pump 71 passes through the pipe 73 into a chamber 295 in the venting type relief valve 74. The relief valve 74 is of a balanced pressure type, comprising a valve member 296 and a seat 297 therefor. A piston 298 is formed integral with the valve member 296. A bleeder hole 299 passes through the piston 298 and serves to allow fluid under pressure to pass therethrough into a valve chamber 300. The valve chamber 300 is connected by means of a passage 301 with a ball check valve 302 which is normally held in a seated or closed position by means of a spring 303. An adjusting screw 304 is provided for adjusting the compression of the spring 303 as desired.

The venting valve chamber 295 is connected by the short pipe 75 with the check valve 76 which supplies fluid under pressure through the pipe 77 to the various mechanisms of the machine, as above explained. The relief valve 74 is operatively connected so that if an attempt is made to move the table 21 to an internal grinding position before the wheel slide 29 is moved rearwardly to an inoperative position, the venting type relief valve piston 298 is opened to drop the operating pressure within the hydraulic system to substantially zero so as to prevent movement of the table 21. A venting control is provided for relieving the pressure within the valve chamber 300. The passage 301 (Fig. 6) is connected with a passage 306. The passage 306 is in turn connected by a pipe 307 with a valve 308. The valve 308 is a rotary type valve having a valve rotor 309. The valve rotor 309 contains a passage 310 which connects the pipe 307 with a pipe 311, when the valve rotor is rotated in a clockwise direction so that fluid within the venting pipe 307 may pass through the valve 308 and out through pipe 311 which leads to the reservoir in a manner to be hereinafter described. The valve 308 is preferably interconnected with the reversing lever 115 so that when it is desired to allow the table 21 to traverse to its extreme right-hand end position into broken line position 21*a* (Fig. 1), the valve 308 may be actuated automatically to vent fluid within the pipe 307, thus opening the venting type relief valve 74 unless the wheel slide 29 together with the intermediate slide 32 are in their extreme rearward position.

A slidably mountd handle 312 is mounted on the upper portion of the reversing lever 115. The slidably mounted portion 312 carries a stud 313 which is positioned in the path of the table reversing dogs 117 and 118. When it is desired to allow the table 21 to travel to the internal grinding position 21*a*, the knob 312 is raised to lift the pin 313 out of the path of the table dog 117 so as to allow the table 21 to traverse to its extreme right-hand end position. A lever 314 is pivotally mounted by means of a stud 315 fixed on a bracket 193 (Figs. 9 and 10). The lever 314 is provided with an arcuate-shaped elongated slot 316 within which the stud 313 is free to move as the reversing lever 115 is actuated by the table dogs 117 and 118. The other end of the lever 314 is provided with an elongated slot 317. A bell crank lever 318 is pivotally supported by a stud 319 which is in turn supported by a bracket 320 on the front of the base 20. The bell crank lever 318 is provided with a horizontally extending yoked arm which carries a stud 321 which passes through the elongated slot 317. The bell crank lever 318 is also provided with a downwardly extending arm having a cylindrically shaped end portion 322.

It will be readily apparent from the foregoing disclosure that if the knob 312 is raised to attempt to move the table 21 to an internal grinding position when the wheel slide 29 and/or the intermediate slide 32 are in a forward or grinding position, the raising of the knob 312 will lift the stud 313 (Figs. 9, 10 and 11) to shift the valve rotor 309 (Fig. 4) so as to vent the relief valve 74, thus raising the valve member 296 of the relief valve 74 so as to allow substantially the entire capacity of the fluid pump 71 to pass directly through the pipe 323 into the reservoir 70, thus stopping the table 21 and preventing its movement to an internal grinding position.

A forked arm or actuating lever 324 is mounted on the outer end of a valve stem 325 of the valve rotor 309. It will be readily apparent from the foregoing disclosure that when the knob 312 of the reversing lever 115 is lifted to allow the table 21 to pass beyond the normal grinding stroke, the stud 313 will rock the lever 314 in a clockwise direction, which movement serves to rock the bell crank lever 318 in a counterclockwise direction to impart a clockwise rotary motion to the valve rotor 309 so that the passage 310 in the valve rotor 309 will connect the venting pipe 307 with the exhaust pipe 311.

When the wheel slide 29 is moved to a rearward or inoperative position relative to the intermediate slide 32, a cam plate 328 adjustably mounted on a plate 329 fixed to the side of the wheel slide 29 (Fig. 4) closes a valve 330 so that when the knob 312 is raised to allow the stud 313 to pass by the table dog 117, thus actuating the valve rotor 309 of the valve 308, the valve 330 being closed will prevent venting of fluid through the pipe 307 so that the table 21 will continue its movement toward the right until the dog 242 engages the stop screw 244 to position the table 21 and the work piece 26 in broken line positions 21*a* and 26*a* (Fig. 1). This construction above described provides a fluid interlock which prevents traversing of the table 21 beyond its normal stroke except when the grinding wheel 27 is in a rearward or inoperative position.

The valve 330 is mounted on the right-hand end face of the rear portion of the base 20. The valve 330 is a piston type valve, comprising a valve stem 331 having formed integrally therewith a pair of valve pistons 332 and 333. A compression spring 334 within the valve 330 normally tends to hold the valve stem 331 in an uppermost position, so that fluid within the pipe 311 will pass through a valve chamber 335 and through an exhaust pipe 336 into the reservoir 70.

The cam plate 328 is adjustably supported on the plate 329 which is mounted on the wheel slide 29 and is arranged in the path of a roller 337 mounted on the upper end of the valve stem

331. When the wheel slide 29 and/or intermediate slide 32 are in their forward or grinding positions, the valve stem 331 will be in a raised position held there by compression of the spring 334. In this raised position of the valve stem 331, if the knob 312 is raised to allow the table 21 to pass the table dog 317, the valve rotor 309 will be shifted, fluid within the venting pipe 307 will pass through the passage 310, pipe 311, through the valve chamber 335, and out through the exhaust pipe 336, thus venting the chamber 330 of the relief valve 74 to raise the relief valve piston 298 and pass substantially the entire capacity of the fluid directly from the pump 71, through the pipe 323, into the reservoir 70.

Electrical control

An electrical control circuit is provided for starting and stopping the grinding cycle, comprising a control lever 345 which is pivotally supported on a bracket in fixed relationship with the front of the base 20. The control lever 345 is arranged when moved in a counterclockwise direction to actuate a push button starter switch 346 or when rocked in a clockwise direction to actuate a push button stop switch 347 whereby the grinding cycle may be interrupted when desired. The push button switches 346 and 347 are connected through a magnetic starter or relay switch 348 to control the energizing and deenergizing of the solenoid 207 so as to actuate the feed control valve 200 as desired. A normally closed limit switch 349 is mounted on the right-hand end face of the rear portion of the intermediate slide 32 adjacent to the valve 330 and is arranged to be actuated by the cam plate 328 when the wheel slide 29 is moved to a rearward or inoperative position.

After a cylindrical grinding operation has been completed and the wheel slide 29 and intermediate slide 32 are moved to rearward or inoperative positions, the cam plate 328 engages and depresses the roller 337 into the position illustrated in Fig. 4 to close the valve 330 so that the valve piston 332 will cut off the pipe 311 from the pipe 336, thus preventing venting of fluid passing from the pipe 307 into the reservoir 70 if and when the wheel slide 29 is in its rearmost position so as to open the circuit of the limit switch 249 and prevent energization of the solenoid 207 unless the wheel slide 29 is moved forward for a grinding operation. The control lever may then be rocked to initiate a forward feeding movement of the grinding wheel 27 as the limit switch 349 has been closed.

The limit switch 349 is also arranged to deenergize the solenoid 207 when the wheel slide 29 has been moved to a rearward or inoperative position by actuation of the control lever 166 in case the operator does not wish to actuate the control lever 345 to momentarily open the push button stop switch 347 and break the circuit to the relay switch 348 and thus deenergize the solenoid 207 to move the intermediate slide 32 to its rearward position. When the wheel slide 29 is moved forward, the cam plate 328 moves toward the left (Fig. 4) so as to allow the limit switch 349 to close after the wheel slide is in its forward position, in which position the control lever 345 may be shifted in a counterclockwise direction to initiate a grinding infeed of the intermediate slide 32 and the grinding wheel 27.

The operation of this external-internal cylindrical grinding machine will be readily apparent from the foregoing disclosure. Assuming all of the parts to have been previously adjusted for a given grinding operation, a work piece such as a propeller blade 26 is positioned within the hollow work spindle 40 and is held in an adjusted centered position with its axis aligned with the axis of the work spindle by means of the work chucks 46 and 47 so that the external surfaces 43 and 44 and the internal surfaces 45 may be ground precisely to the desired and predetermined extent. After the work piece 26 has been positioned in the work head 25, the push button switches 48, 49 and 69 are actuated to start the grinding wheel driving motor 33, the headstock motor 50, and the motor for driving the fluid pump 71, respectively. The work table 21 may then be moved longitudinally either by the hydraulically operated mechanism above described or by manual rotation of the hand traverse wheel 140.

When the work has been positioned so that the portion 43 or 44 to be ground is opposite the grinding wheel, the lever 166 is moved in a counterclockwise direction (Fig. 4) to admit fluid under pressure into the cylinder chamber 172 to move the piston 156 together with the wheel slide 29 to a forward or operative position. The lever 345 may then be rocked in a clockwise direction to actuate the push button switch 346 so as to energize the solenoid 207, thereby shifting the feed control valve 200 toward the right (Fig. 4) to admit fluid under pressure through the passage 210 into the cylinder chamber 198 to cause a forward infeeding movement of the grinding wheel 27 to grind the work portion 44 to the desired and predetermined extent. After the work portion 44 has been ground to the desired and predetermined extent, the control lever 345 may be moved in a clockwise direction (Fig. 4) to deenergize the solenoid 207 and thereby cause the intermediate slide 32 to move to its rearward position, after which the table 21 may be traversed either hydraulically or manually to position the work surface 43 opposite the grinding wheel 27. The grinding wheel 27 may then be fed toward the work by actuation of the control lever 345 to grind the work portion 43 to the desired extent.

After the external surfaces have been ground to predetermined sizes, the control lever 345 may be shifted in a counterclockwise direction to deenergize the solenoid 207, thus releasing the compression of the spring 206 to return the valve 200 into the position illustrated in Fig. 4 so as to cause a rearward movement of the piston 95, thus moving the intermediate slide 32 rearwardly relative to the base 20. At the same time the control lever 166 may be moved in a clockwise direction to shift the valve 160 so as to admit fluid under pressure into the cylinder chamber 171 (Fig. 4) to cause the wheel slide 29 and the grinding wheel 27 to move rearwardly to an inoperative position so that the work table 21 may be traversed longitudinally to an external grinding position.

The knob 312 on the upper end of the reversing lever 115 may then be raised and the reversing lever 115 shifted in a clockwise direction to cause the table 21 to move toward the right (Fig. 1) so that the pin 313 on the reversing lever will be raised out of the path of the reversing dog 117. The table 21 together with the work head 25 will continue its movement toward the right until the table dog 242 engages the stop screw 244 to locate the work piece 26 in

position 26a (as shown in broken lines in Fig. 1). If desired, the table may be slowed down as the dog 242 approaches the stop screw 244 by actuation of the stop and start lever 101 to partially close the V-port 105, thus slowing down the table as it approaches a stopped position.

When the work piece has been positioned in position 20a, the internal grinding wheel motor 284 may be started by actuation of the push button switch 286. The internal grinding wheel 241 may then be traversed longitudinally by actuation of the spoked hand traverse wheel 257 to traverse the wheel 241 longitudinally. The internal grinding wheel 241 may be fed transversely in either direction by rotation of the manually operable feed wheel 278. By manipulation of the spoked traverse wheel 257 and the feed wheel 278, the internal grinding wheel may be controlled so as to grind the internal cylindrical surfaces 45 to the desired and predetermined dimensions.

After the internal grinding operation has been completed, the reversing lever 115 may be shifted manually to change the direction of flow of fluid under pressure to the table cylinder 62 and the stop and start lever 101 may be moved in a counterclockwise direction (Fig. 4) to open the V-port 105 to the desired extent, thus allowing a controlled exhaust of fluid from the table cylinder 62 so that the table 21 moves longitudinally toward the left into the full line position as indicated in Fig. 1. Due to a cam surface on the dog 117, the reversing pin or stud 313 is raised to pass over the dog 117, after which it drops under the influence of gravity into the position illustrated in Fig. 1 so that the reversing dogs 117 and 118 will be in operative position to actuate the reversing lever 115.

In the operation above described, the external surfaces 43 and 44 are ground by the so-called plunge-cut method. If desired, the table may be reciprocated by the hydraulically operated table reciprocating mechanism above described, in which case the table dogs 117 and 118 control the extent of the reciprocatory movement. The wheel may be fed manually into the work to grind the same to the desired extent by a manual actuation of the feed wheel 194.

A fluid pressure interlock which has been described above serves to prevent a longitudinal movement of the table into an internal grinding position unless the wheel slide 29 is in its rearmost position. An electrical interlock is also provided which has been described above, to prevent initiating an infeeding movement of the grinding wheel, that is, an infeeding movement of the intermediate slide 32, unless the wheel slide 29 has been moved forwardly on the intermediate slide 32 to an inoperative position.

After a work piece 26 has been ground externally and internally, the wheel 27 together with the wheel slide 29 and intermediate slide 32 are moved to their rearward or inoperative positions, the chucks 46 and 47 are actuated to release the work piece 26 which may then be readily withdrawn from the machine and replaced with a new work piece to be ground.

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

We claim:

1. In a grinding machine having a base, a transversely movable rotatable grinding wheel, a longitudinally reciprocable table thereon, a rotatable work support on said table, means including table dogs to reciprocate said table through a predetermined stroke for an external cylindrical grinding operation, means to traverse said table beyond the normal reciprocatory stroke precisely to position said table for a second grinding operation, and a hydraulic interlock to prevent movement of said table to the second grinding position except when the grinding wheel is in a rearward or inoperative position.

2. In a grinding machine having a base, a transversely movable rotatable external grinding wheel, a longitudinally and transversely movable rotatable internal grinding wheel, a longitudinally reciprocable table on said base, a rotatable work support on said table, means including table dogs and a reversing lever to reciprocate said table through a predetermined stroke for an external cylindrical grinding operation, means to traverse said table beyond the normal reciprocatory stroke precisely to position said table for an internal grinding operation, and an interlock to prevent movement of said table to an internal grinding position except when the external grinding wheel is in a rearward or inoperative position.

3. In a grinding machine having a base, a transversely movable rotatable external grinding wheel, a longitudinally and transversely movable rotatable internal grinding wheel, a longitudinally reciprocable table on said base, a rotatable work support on said table, a fluid pressure system including a piston and cylinder to move said table longitudinally in either direction, means including table dogs and a reversing lever to control the direction of flow of fluid to said cylinder, means to facilitate traversing said table beyond the normal reciprocatory stroke precisely to position said table for an internal grinding operation, and a hydraulic interlock mechanism to prevent movement of said table to an internal grinding position except when the external grinding wheel is in a rearward or inoperative position.

4. In a grinding machine having a base, a transversely movable rotatable external grinding wheel, means including a piston and cylinder to move said wheel transversely, a manually operable control valve thereon to control the direction of movement of said grinding wheel, a longitudinally and transversely movable rotatable internal grinding wheel, a longitudinally reciprocable table on said base, a rotatable work support on said table, a piston and cylinder operatively connected to move said table in either direction relative to said base, a manually operable traversing mechanism for said table to position said table for an external cylindrical grinding operation, means to facilitate traversing said table beyond the normal reciprocatory stroke precisely to position the table for an internal grinding operation, and a hydraulic interlock mechanism to prevent movement of said table to an internal grinding position except when the external grinding wheel is in a rearward or inoperative position.

5. In a grinding machine having a base, a transversely movable rotatable external grinding wheel, means including a piston and cylinder to move said wheel transversely, a manually oper-

able control valve thereon to control the direction of movement of said grinding wheel, a longitudinally and transversely movable rotatable internal grinding wheel, a longitudinally reciprocable table on said base, a rotatable work support on said table, a piston and cylinder operatively connected to move said table in either direction relative to said base, means including table dogs and a reversing lever to control the admission of fluid to and the exhaust of fluid from said table cylinder to reciprocate said table through a predetermined stroke for an external cylindrical grinding operation, means to facilitate traversing said table beyond the normal reciprocatory stroke precisely to position the table for an internal grinding operation, and a hydraulic interlock mechanism to prevent movement of said table to an internal grinding position except when the external grinding wheel is in a rearward or inoperative position.

6. In a grinding machine having a base, a transversely movable rotatable external grinding wheel, means including a piston and cylinder to move said wheel transversely, a manually operable control valve thereon to control the direction of movement of said grinding wheel, a longitudinally and transversely movable rotatable internal grinding wheel, a longitudinally reciprocable table on said base, a rotatable work support on said table, a piston and cylinder operatively connected to move said table in either direction relative to said base, means including a manually operable start and stop valve to control the traversing movement of said table, a reversing mechaism including a reversing lever and a reversing valve to change the direction of movement of said table, said start and stop valve and said reversing valve serving to facilitate positioning of the table for an external cylindrical grinding operation, means to facilitate traversing said table beyond the normal reciprocatory stroke precisely to position the table for an internal grinding operation, and a hydraulic interlock mechanism to prevent movement of said table to an internal grinding position except when the external grinding wheel is in a rearward or inoperative position.

7. In a grinding machine as claimed in claim 3, the combination with the parts and features therein specified, of a slidably mounted stud on reversing lever normally positioned in the path of said table dogs, manually operable means to move said stud out of the path of said dogs to facilitate a traversing movement of the table beyond the normal reciprocatory stroke precisely to position the table for an internal grinding operation, a venting type relief valve in said fluid pressure system normally to control the fluid pressure therein, a vent control valve associated therewith, and operative connections between said stud and said vent control valve which are arranged to open said vent control valve to vent said relief valve and thereby prevent a table traversing movement beyond the normal reciprocatory stroke unless the wheel slide is in a rearward or inoperative position.

8. In a grinding machine as claimed in claim 3, the combination with the parts and features therein specified, of a slidably mounted reversing stud on the reversing lever normally arranged in the path of said table dogs, a venting type relief valve normally to control the operating pressure within the fluid pressure system, a vent control valve associated therewith, a normally open valve on the intermediate slide which is connected in the fluid pressure system between the vent control valve and the reservoir, an adjustably mounted cam on said wheel slide to actuate and close said normally open valve when the wheel slide is moved to an inoperative position, and operative connections between said stud and said vent control valve which are arranged to open said vent control valve to vent said relief valve unless the wheel slide is in its rearmost position.

9. In a grinding machine having a base, a longitudinally reciprocable table thereon, a rotatable work support on said table, a rotatable grinding wheel, a transversely movable slide therefor, a transversely movable intermediate slide interposed between the wheel slide and base, a hydraulic piston and cylinder interposed between the wheel slide and the intermediate slide to move said wheel slide relative to said intermediate slide through a relatively long positioning stroke to move the grinding wheel to or from an operative position, and means including a piston and cylinder interposed between the intermediate slide and the base to move said intermediate slide through a relatively short controlled stroke to impart a feeding movement to the grinding wheel.

10. In a grinding machine having a base, a longitudinally reciprocable table thereon, a rotatable work support on said table, a rotatable grinding wheel, a transversely movable wheel slide therefor, a transversely movable intermediate slide interposed between the wheel slide and base, a hydraulic piston and cylinder to move said wheel slide relative to said intermediate slide through a relatively long stroke to move the grinding wheel to and from an operative position, means including a piston and cylinder to move said intermediate slide relative to the base through a relatively short controlled stroke to impart a feeding movement to the grinding wheel, a control valve to control the admission to and exhaust of fluid from said latter cylinder, a solenoid to actuate said valve to initiate an infeeding movement of the intermediate slide, and means including a limit switch which is arranged to prevent energization of said solenoid so as to prevent an infeeding movement of the intermediate slide unless the grinding wheel slide is in a forward or operative position.

11. In a grinding machine having a base, a longitudinally reciprocable table thereon, a rotatable work support on said table, a rotatable grinding wheel, a transversely movable wheel slide therefor, a transversely movable intermediate slide interposed between the wheel slide and base, a hydraulic piston and cylinder to move said wheel slide relative to the intermediate slide through a relatively long stroke to move the grinding wheel to and from an operative position, means including a piston and cylinder to move said intermediate slide relative to the base through a relatively short controlled stroke to impart a grinding feed to the grinding wheel, a control valve to control the admission to and exhaust of fluid from said latter cylinder, a solenoid to actuate said valve to initiate an infeeding movement of the intermediate slide, a normally closed limit switch on said intermediate slide which is connected in series with said solenoid, an adjustably mounted cam on said wheel slide which is arranged to actuate and open said limit switch when the wheel slide is moved to a rearward or inoperative position relative to the intermediate slide to prevent initiating an infeeding movement of the intermediate slide unless

the wheel slide is in a forward or operative position.

12. In a grinding machine having a base, a longitudinally reciprocable table thereon, a rotatable work support on said table, a rotatable grinding wheel, a transversely movable slide therefor, a transversely movable intermediate slide interposed between the wheel slide and base, a hydraulic piston and cylinder to move the wheel slide relative to the intermediate slide through a relatively long stroke to move the grinding wheel to and from an operative position, means including a piston and cylinder to move said intermediate slide relative to said base through a relatively short controlled stroke to impart a feeding movement to the grinding wheel, a control valve for said latter cylinder, a solenoid to shift said valve to cause an infeeding movement of the intermediate slide and the grinding wheel, a manually operable switch to control said solenoid, and means including a normally closed limit switch which is arranged to prevent an infeeding movement of the intermediate slide unless the wheel slide is in a forward or operative position.

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