April 22, 1941. C. G. FLYGARE 2,239,091

GRINDING MACHINE

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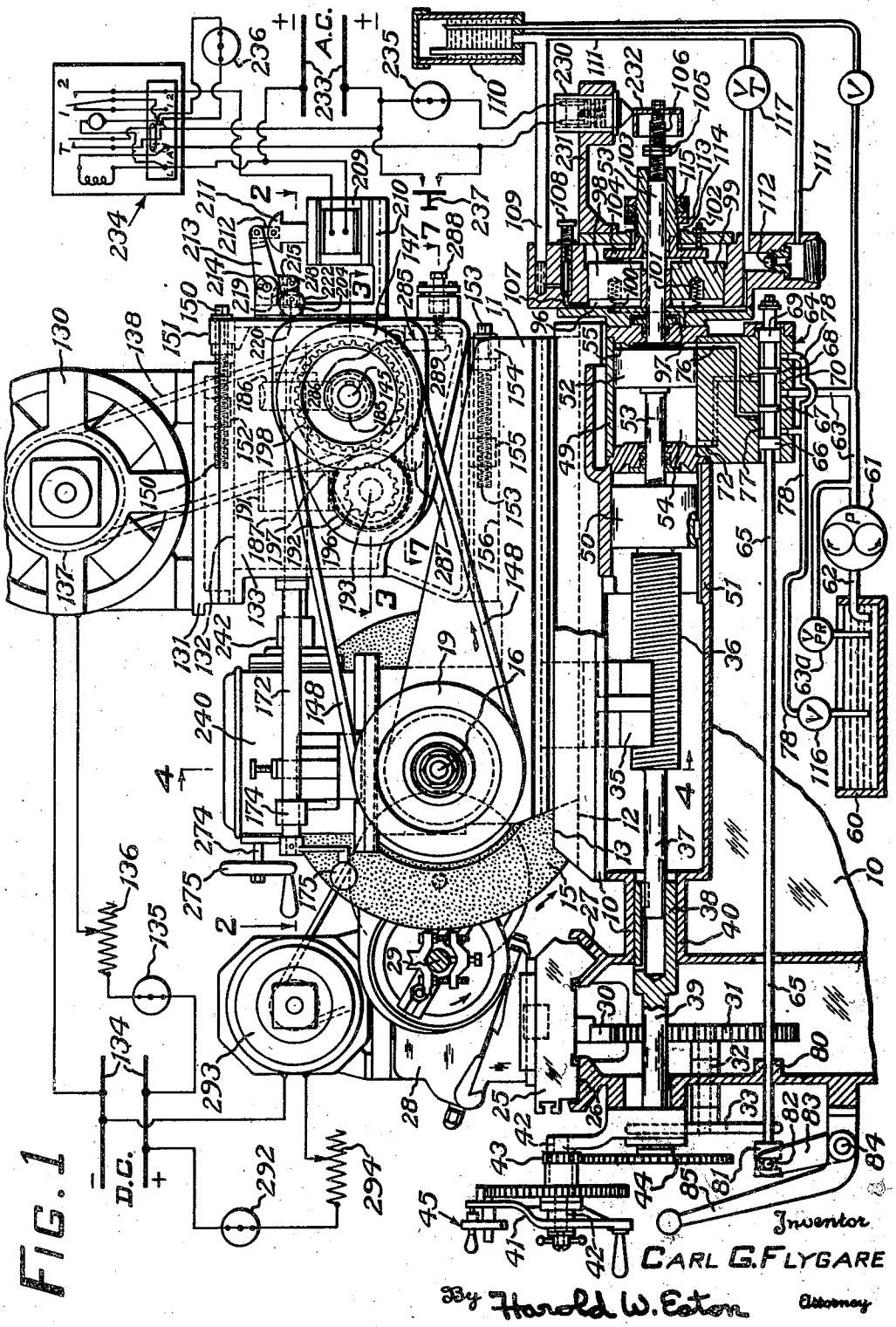


FIG. 1

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FIG. 5

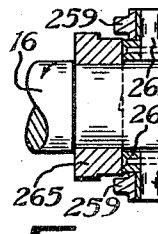


FIG. 6

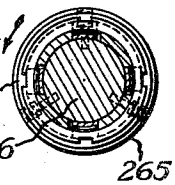


FIG. 2

FIG. 7

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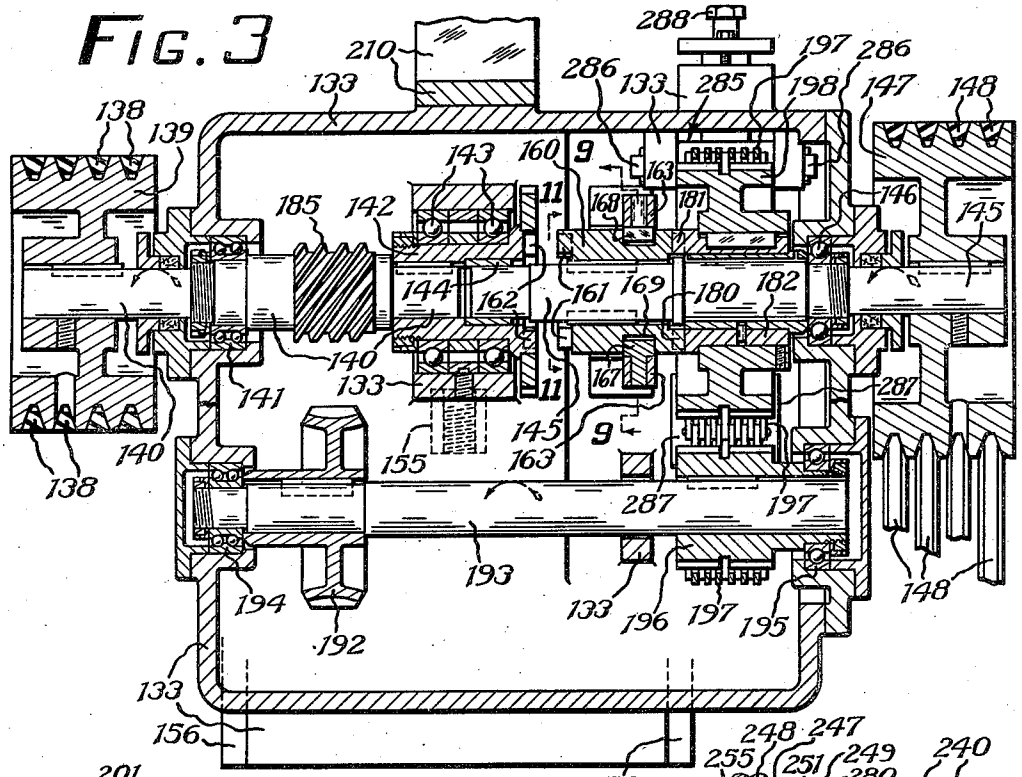
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GRINDING MACHINE

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FIG. 3



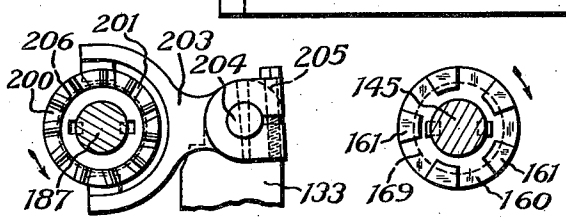


FIG. 10

FIG. 11

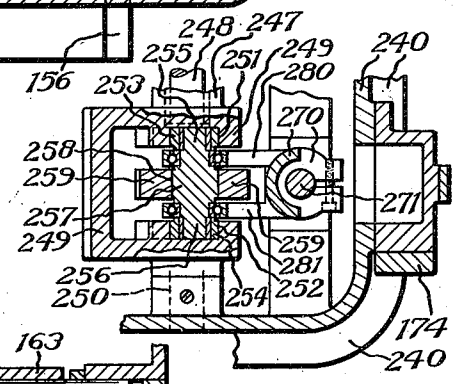


FIG. 12

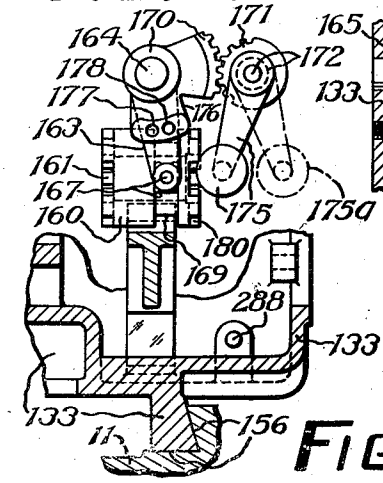


FIG. 8

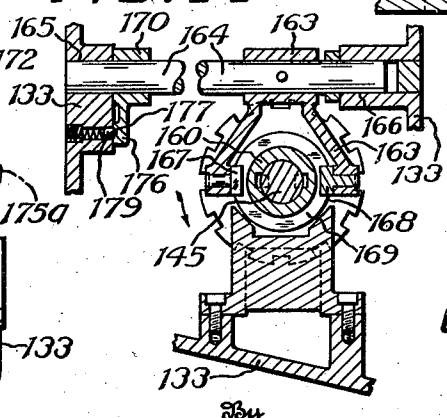


FIG. 9

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GRINDING MACHINE

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FIG. 4

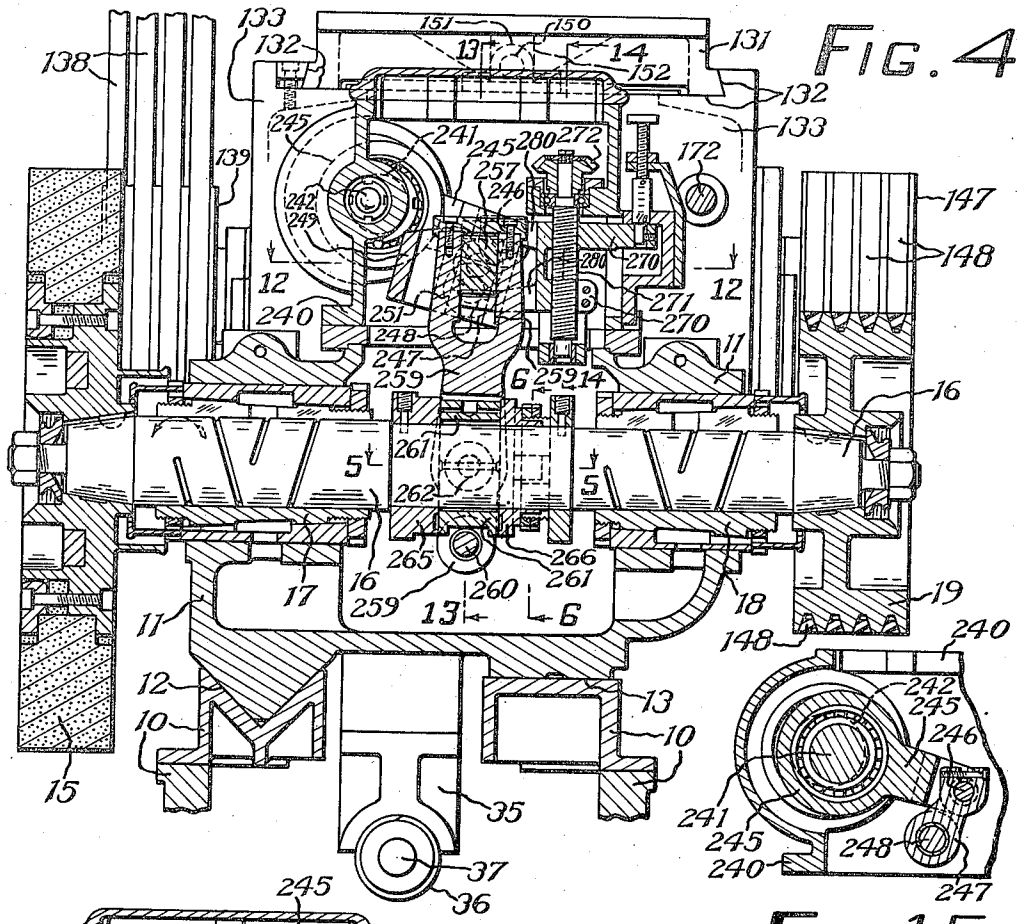
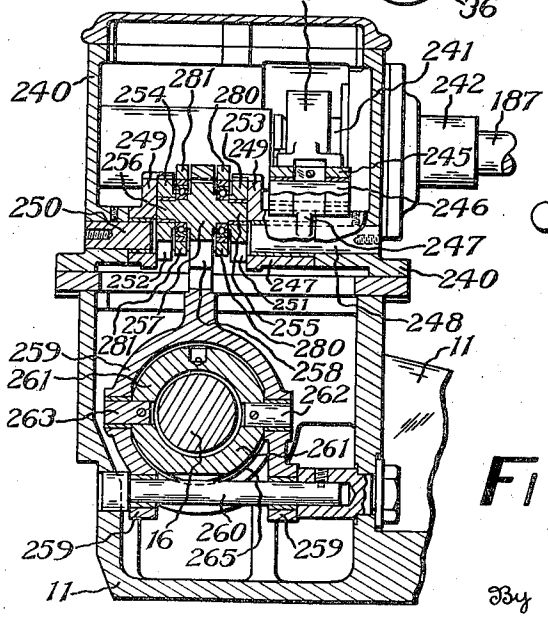


FIG. 15



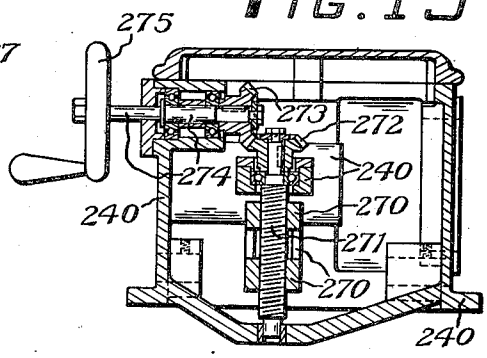


FIG. 13 FIG. 14

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Patented Apr. 22, 1941 2,239,091

UNITED STATES PATENT OFFICE

2,239,091

GRINDING MACHINE

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Application April 5, 1939, Serial No. 266,085

10 Claims. (Cl. 51—95)

The invention relates to grinding machines, and more particularly to a grinding wheel driving mechanism therefor.

One object of the invention is to provide a simple and thoroughly practical hydraulically operated electrically controlled wheel rotating and indexing mechanism for a grinding machine. Another object of the invention is to provide a grinding wheel rotating and indexing mechanism so that the grinding wheel may be rotated at a normal grinding speed, at a slow speed substantially below the normal grinding speed, or held stationary during a grinding operation and automatically indexed after each grinding operation to present a fresh grinding face. A further object of the invention is to provide a grinding wheel driving mechanism having an electrical time delay relay which serves to control the incremental indexing of the normally stationary wheel in timed relation with the wheel slide movement. 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 an end elevation of a grinding machine having parts broken away and shown in section combined with a wiring diagram more clearly to show the operating construction;

Fig. 2 is a horizontal sectional view, on an enlarged scale, taken approximately on the line 2—2 of Fig. 1;

Fig. 3 is a horizontal sectional view, on an enlarged scale, taken approximately on the line 3—3 of Fig. 1;

Fig. 4 is a vertical sectional view, on an enlarged scale, taken approximately on the line 4—4 of Fig. 1;

Fig. 5 is a fragmentary sectional view taken approximately on the line 5—5 of Fig. 4;

Fig. 6 is a fragmentary sectional view taken approximately on the line 6—6 of Fig. 4;

Fig. 7 is a fragmentary sectional view, on an enlarged scale, taken approximately on the line 7—7 of Fig. 1, showing the take-up mechanism for the chain drive;

Fig. 8 is a fragmentary view, partly in section, showing the mechanism for shifting the slow speed-high speed wheel driving clutch;

Fig. 9 is a fragmentary sectional view taken approximately on the line 9—9 of Fig. 3;

Fig. 10 is a fragmentary detail view taken approximately on the line 10—10 of Fig. 2;

Fig. 11 is a fragmentary sectional view taken approximately on the line 11—11 of Fig. 3;

Fig. 12 is a fragmentary sectional view taken approximately on the line 12—12 of Fig. 4, showing a portion of the wheel spindle reciprocating or oscillating mechanism;

Fig. 13 is a fragmentary cross sectional view taken approximately on the line 13—13 of Fig. 4;

Fig. 14 is a fragmentary sectional view taken approximately on the line 14—14 of Fig. 4, showing the mechanism for adjusting the length of the reciprocatory stroke of the grinding wheel; and

Fig. 15 is a fragmentary sectional view taken approximately on the line 15—15 of Fig. 2, showing a portion of the grinding wheel spindle reciprocating mechanism.

A grinding machine has been illustrated in the drawings comprising a base 10 which supports a transversely movable wheel slide 11 which is mounted on a V-way 12 and a flat way 13 on the base 10. The wheel slide 11 supports a rotatable grinding wheel 15 which is mounted on one end of a rotatable wheel spindle 16. The spindle 16 is journalled in suitable bearings 17 and 18 within the wheel slide 11. The right-hand end of the wheel spindle 16 (Fig. 4) is provided with a driving pulley 19 which is preferably of a multiple V-belt type. The wheel spindle 16 may be driven in a manner to be hereinafter described.

The base 10 also supports a longitudinally movable work table 25 which is arranged to reciprocate longitudinally relative to the base 10 on a flat way 26 and a V-way 27. The table 25 is provided with a rotatable work support including a headstock 28 and a footstock (not shown) each of which is provided with work supporting centers rotatably to support a work piece 29 in operative relation with the grinding wheel 15. The table 25 may be traversed longitudinally by a manually operable traversing mechanism which includes a rack bar 30 depending from the under side of the table 25. The rack bar 30 meshes with a gear 31 mounted on the inner end of a rotatable shaft 32. A manually operable traverse wheel 33 is mounted on the outer end of the shaft 32 and is arranged to be manually rotated to traverse the table 25 longitudinally relative to the base 10. If desired, a power operated table traversing or reciprocating mechanism may be provided such as, for example, a mechanism of

the type shown in the expired U. S. patent to Norton No. 762,838 dated June 14, 1904.

A wheel feeding mechanism is provided for manually feeding the grinding wheel 15 toward and from the work piece 29, which comprises a half nut 35 depending from the wheel slide 11. The half nut 35 meshes with or engages a rotatable cross feed screw 36. A forwardly extending portion 37 of the cross feed screw 36 is slidably keyed to a rotatable sleeve 38. The rotatable sleeve 38 is formed as an integral part of a rotatable shaft 39 which is journalled in bearings 40 in the base 10 of the machine. A manually operable feed wheel 41 is mounted on the outer end of a stud 42. The stud 42 carries a pinion 43 which meshes with a gear 44 mounted on the outer end of the sleeve shaft 39 so that a manual rotation of the feed wheel 41 serves to rotate the feed screw 36 in either direction to cause a forward or rearward feeding movement of the grinding wheel 15 and the wheel slide 11. The feed wheel 41 may be provided with a micrometer adjusting mechanism 45 which is substantially identical with that shown in the above-mentioned prior U. S. patent to Norton. This micrometer mechanism serves precisely to adjust a stop abutment relative to the manually operable infeed wheel 41 so as to compensate for grinding wheel wear.

In the preferred construction the wheel slide 11 is arranged so that it may be moved toward and from the work piece 29 to grind the same to a predetermined size by means of a fluid pressure actuated wheel feeding mechanism. As illustrated in the drawings, the rear end of the feed screw 36 is rotatably supported in a slidably keyed bearing 50 which is supported in a casing 51 integral with the base 10 of the machine. A fluid pressure cylinder 49 is attached to the casing 51 and contains a slidably mounted piston 52 which is connected by a piston rod 53 with the bearing 50 and is arranged so that when fluid under pressure is admitted to a cylinder chamber 54 the piston 52 will be moved toward the right (Fig. 1) into its rearward position, transmitting a corresponding movement through the feed screw 36 and the half nut 35 to move the wheel slide 11 and grinding wheel 15 rearwardly to an inoperative position.

Similarly, when fluid under pressure is admitted to a cylinder chamber 55, a rapid approaching movement of the grinding wheel 15 and the wheel slide 11 is obtained to cause the grinding wheel to be moved into operative engagement with the work piece 29. A fluid pressure system is provided to supply fluid under pressure for moving the piston 52 so as to cause an infeeding or outfeeding movement of the grinding wheel 15. This system may comprise a reservoir 60 which is formed as a box-like section within the base 10. A motor driven fluid pressure pump 61 draws fluid from the reservoir 60 through a pipe 62 and forces fluid under pressure through a pipe 63 to a control valve 64. An adjustable relief valve 63a is connected in the pipe line 63 and serves to by-pass excess fluid under pressure to the reservoir 60. The control valve 64 is a piston type valve comprising a valve stem 65 having formed integrally therewith valve pistons 66, 67, 68 and 69. Fluid under pressure passing through the pipe 63 enters a valve chamber 70 located between the valve pistons 67 and 68 and passes through a passage 72 into the cylinder chamber 54 to move the piston 52 to its rearward position with the grinding wheel 15 separated from the work piece 29 as indicated in Fig. 1. During the rearward movement of the piston 52 that is toward the right (Fig. 1), fluid is exhausted from the cylinder chamber 55, through a passage 76, into a valve chamber 77 between the valve pistons 66 and 67, and out through a pipe 78 which exhausts into the reservoir 60.

The valve stem 65 is arranged so that it may be moved endwise to shift the valve 64 into a reverse position so as to cause either a forward or rearward feeding movement of the grinding wheel 15. In the preferred construction, the valve stem 65 extends toward the front of the machine base 10 and is supported at its forward end in a bearing 80 in the base 10. The outer end of the piston rod 65 is provided with a spool-shaped member 81 which is engaged by a stud 82 carried by a lever 83. The lever 83 is similarly mounted on a stud 84. A manually operable control lever 85 is supported on the stud 84 and is operatively connected to rock the lever 83 to shift the reverse valve 64 so as to produce either a forward or rearward movement of the grinding wheel 15.

A fluid pressure controlling or feed regulating mechanism is provided for modifying the rapid approaching movement caused by the piston 52 to obtain a controlled and predetermined infeeding movement of the grinding wheel 15. In the preferred construction a self-contained dash pot feed regulator is provided comprising a pair of dash pot cylinders 96 and 97 which contain dash pot pistons 98 and 99 respectively. The dash pot pistons 98 and 99 and their respective cylinders 96 and 97 are arranged with their axes parallel to each other and spaced on diametrically opposite sides of the piston rod 53. The dash pot pistons 98 and 99 are normally held in a rearward (right-hand) position by means of springs 100 and 101, respectively. An adjustable stop screw 102 serves to limit the rearward movement of the dash pot pistons 98 and 99, respectively. A slidable sleeve 103 is supported on the rear extension of the piston rod 53. The sleeve 103 has a flanged portion 104 which is either formed integral therewith or fixedly secured thereto. The flange 104 is arranged to engage the right-hand end faces of the dash pot pistons 98 and 99, respectively. The stop screw 102 engages the flange 104 and thereby serves to limit the rearward movement of the dash pot pistons 98 and 99 toward the right.

The rapid forward feeding movement of the grinding wheel 15 and wheel slide 11 continues until the adjustable nuts 105 on a threaded portion 106 of the piston rod 53 engage the right-hand end of the sleeve 103. Continued movement of the piston rod 53 moves the sleeve 103 and flange 104 toward the left (Fig. 1) and serves to move the dash pot pistons 98 and 99 in a direction toward the left. When the flange 104 engages the ends of the dash pot pistons 98 and 99, respectively, the rapid approaching or feeding movement of the grinding wheel 15 toward the work piece 29, as produced by the piston 52, is reduced to a slower predetermined grinding feed due to the fact that fluid confined within the dash pot cylinders 96 and 97, respectively, which are interconnected, exhausts through a passage 107, a needle valve 108, through a pipe 109, into a reservoir 110. By adjusting the aperture of the needle valve 108, a desired and predetermined infeeding movement of the grinding wheel 15 may be obtained. When fluid under pressure

is admitted to the cylinder chamber 54 to cause a rearward movement of the piston 52, the sleeve 103 together with the flange 104 is moved rearwardly by means of the released compression of the springs 100 and 101 which returns the dash pot pistons 98 and 99, respectively, to their rearward positions and moves the flange 104 and its supporting sleeve 103 toward the right until the flange 104 engages the stop screw 102. During the rearward movement of the dash pot pistons 98 and 99, a suction is created within the dash pot cylinders 96 and 97, respectively, which serves to aid in drawing fluid from the reservoir 110, through a pipe 111, and a ball check valve 112, to fill the dash pot cylinder chambers 96 and 97 for the next infeeding movement of the grinding wheel 15. During the infeeding movement of the dash pot pistons 98 and 99, fluid within the dash pot cylinders 96 and 97 serves to hold the ball check valve 112 closed so that fluid within the dash pot cylinders 96 and 97 is forced out through the passage 107 and the needle valve 108, into the reservoir 110, to control the rate of infeeding movement, as desired. An adjustable throttle valve 117 is provided to facilitate the exhaust of fluid from the dash pot chambers 96 and 97 after the passage 107 is closed by the piston 98. If desired, the throttle valve 117 may be used to give a very fine final feed just prior to the stop 113 engaging its stopping surface 114. In the latter case two distinct feeds of the grinding wheel 115 can be obtained, one feed by manipulation of the valve 108 combined with the opening of the valve 117 which continues until the passage 107 is cut off, after which the infeed is reduced to a very slow infeed control by the throttle valve 117.

The forward feeding movement of the grinding wheel 15 as controlled by the dash pot pistons 98 and 99, respectively, continues until an adjustable stop collar 113 carried by the sleeve 103 engages a fixed stop surface 114 on the rear face of the dash pot cylinder head. A pair of lock collars 115 serve to position the stop collar 113 and to lock the same in adjusted position.

A throttle valve 116 is located in the pipe line 78 and serves to control the exhaust of fluid from the cylinder 49 so as to regulate the speed of movement of the grinding wheel 15 and its supporting wheel slide 11 during the rapid approaching or positioning movement thereof.

In order to obtain one of the objects of this invention, a grinding wheel driving mechanism is provided whereby the grinding wheel may be rotated at a normal grinding speed either for a grinding operation or for a truing operation, or the wheel may be rotated at a very slow speed below the normal grinding speed for a polishing operation, or the grinding wheel may be held against rotation for a honing operation and automatically indexed after each successive honing operation to present a new abrading face for the next operation.

The grinding wheel 15 is preferably driven by a motor driven mechanism comprising an electric motor 130 which is mounted on an adjustable support 131. The adjustable support 131 is provided with a dovetailed slideway 132 which mates with a correspondingly shaped way on the top of a casing 133 which supports the gear driving mechanism. The casing 133 is adjustably mounted on the upper surface of the wheel slide 11. The motor 130 is preferably a variable speed motor, such as a D. C. motor which receives its power from the power lines 134. As diagrammatically illustrated, a switch 135 serves to stop and start the motor 130, and a speed controlling device which is diagrammatically illustrated in Fig. 1 as a rheostat 136 serves to adjust and vary the speed of the motor 130. The motor 130 is provided with a driving pulley 137 which is connected by means of a multiple V-belt 138 with a multiple V-grooved pulley 139 which is mounted on the outer end of a shaft 140 which is journalled in a bearing 141 in the casing 133. The inner end of the shaft 140 is keyed within a sleeve or bushing 142 which is in turn rotatably supported by antifriction bearings 143 which are supported by the casing 133. The sleeve 142 also supports a bearing bushing 144 which serves as a bearing support for a rotatable shaft 145. The outer end of the shaft 145 is journalled in a bearing 146 carried by the casing 133. A multiple V-grooved driving pulley 147 is mounted on the outer end of the shaft 145 and is connected by multiple V-belts 148 with the multiple V-grooved pulley 19 mounted on the outer end of the wheel spindle 16.

An adjusting screw 150 is rotatably supported in a bearing 151 which is either formed integrally with or fixedly mounted on the casing 133. The screw 150 is held against endwise movement relative to the bearing 151 and the screw 150 meshes with or engages a nut 152 depending from the under side of the motor support 131. By adjusting the screw 150 the position of the motor mounting 131 may be adjusted so as to properly tension the driving belts 138. A similar screw 153 is rotatably supported against endwise movement in a bearing member 154 which is either formed integral with or fixedly mounted to the wheel slide 11. The adjusting screw 153 meshes with or engages a nut 155 depending from the under side of the casing 133. By manipulation of the adjusting screw 153, the multiple V-belts 148 may be tensioned as desired.

In order to obtain a fast speed of the grinding wheel 15 for a normal grinding operation or for truing the grinding wheel, it is desirable to provide a suitable connection whereby the shaft 140 may be connected directly with the shaft 145. The slidably mounted clutch 160 is slidably keyed onto the shaft 145. The clutch 160 is moved toward the left (Figs. 2 and 3) so that the clutch teeth 161 of the slidably mounted clutch member 160 engage clutch teeth 162 formed in the end of the rotatable sleeve 142 which is keyed to the shaft 140 so that power is transmitted directly from the shaft 140 to the shaft 145 and through the pulley 147 and multiple V-belts 148 to rotate the wheel spindle pulley 19, the wheel spindle 16, and the grinding wheel 15 at a normal relatively fast grinding speed.

The clutch member 160 is preferably arranged so that it may be readily controlled from the operator's station in front of the machine. A yoked member 163 is supported on a rock shaft 164 which is journalled in bearings 165 and 166 in the housing or casing 133. The lower end of the yoked member 163 is provided with opposed studs or shoes 167 and 168 which ride in a groove 169 formed in the periphery of the clutch member 160. The shaft 164 is provided with a gear segment 170 which meshes with a gear segment 171 carried by a shaft 172 which has one of its ends journalled in a bearing 173 formed in the casing 133 and has its outer end journalled in a bearing member 174 which is fixedly mounted on a bracket fixedly mounted on the wheel slide 11. The shaft 172 is free to slide longitudinally within the bearing 174 to facilitate transverse adjust-

ment of the driving mechanism contained within the casing 133. The outer end of the shaft 172 is provided with a manually operable actuating handle 175. Formed integral with the gear segment member 170 is a downwardly extending arm 176 which is provided with a pair of apertures 177 and 178 which are arranged to be engaged by means of a spring-pressed detent 179 to readily locate the gear segment 170 in one of two positions, namely with the clutch teeth 161 in engagement with the clutch teeth 162, or with clutch teeth 180 in engagement with clutch teeth 181 formed integral with a rotatable bushing 182 which forms a part of a slow speed driving mechanism to be hereinafter described. As shown in Figs. 2 and 3, the clutch 160 is in a slow speed position. If it is desired to rotate the grinding wheel 15 at a rapid speed, that is the normal grinding or truing speed, the manually operable control lever 175 is shifted from full line position (Fig. 8) into broken line position 175a which rocks the gear segment 171 in a counterclockwise direction. This movement in turn rocks the gear segment 170, the shaft 164, and the yoked member 163 in a clockwise direction to shift the clutch member 160 toward the left (Figs. 2, 3 and 8) so that the clutch teeth 161 engage the clutch teeth 162 to form a direct driving connection between the shaft 140 and 145.

To facilitate rotation of the grinding wheel 15 at a very slow rotative speed below the normal grinding speed, the shaft 140 is provided with a worm 185 (Fig. 3) which meshes with a worm gear 186. The worm gear 186 is keyed to a transversely arranged rotatable shaft 187 which is journalled in bearings 188 and 189 which are supported in the casing 133. The forward end of the shaft 187 is rotatably supported in a sleeve 190 which is in turn journalled in bearings 189 supported in the casing 133. A worm 191 is keyed to the rotatable bushing 190, said parts being arranged so that the worm 191 and its supporting bushing 190 may rotate independently of the shaft 187. The worm 191 meshes with a worm gear 192 which is supported on a longitudinally extending shaft 193. The shaft 193 is journalled in bearings 194 and 195 supported in the casing 133. A sprocket 196 is keyed to the shaft 193 and is arranged to transmit its rotative power through a link chain 197 to a sprocket 198 which is keyed to the periphery of the rotatable sleeve 182.

The worm 191 is arranged so that it may be readily clutched or declutched from the shaft 187. A clutch member 200 is sildably keyed onto the shaft 187 and is provided with clutch teeth 201 which are arranged to engage clutch teeth 202 formed integrally on the end of the worm 191. A yoked member 203 is supported on the end of a slidably mounted actuating rod 204. The rod 204 is journalled in a bearing 205 fixedly mounted relative to the casing 133. The yoked member 203 has integral shoes which engage a groove 206 formed in the periphery of the clutch member 200 so that endwise movement of the rod 204 serves to throw the clutch teeth 201 into engagement with the clutch teeth 202 so that rotary motion of the shaft 187 will be transmitted to rotate the worm 191 or to move the clutch memer 200 into a disengaged position (Fig. 2). The clutch member 200 is normally held in a disengaged position by means of a spring 207 which surrounds the rod 204 and is interposed between the bearing 205 and a collar 208 which is mounted on the rod 204. The clutch shifting rod 204 may be actuated manually, if desired, or in the preferred construction, as shown in the drawings, a solenoid 209 is supported on a bracket 210 fixed on the rear of the casing 133. A solenoid armature 211 is connected by means of a link 212 with an arm 213 of a bell crank lever which is pivotally mounted on a stud 214 carried by the bracket 210. A downwardly extending arm 215 of the bell crank lever is formed as a yoked member having downwardly extending arms which are connected by a stud 218 with one end of a link 219. The other end of the link 219 is connetced by a stud 220 which is in turn supported by the clutch shifting rod 204.

The spring 207 normally holds the clutch member 200 in a disengaged position. When the solenoid 209 is energized in a manner to be hereinafter described, the clutch member 200 will be thrown into an operative position with its clutch teeth 201 engaging the clutch teeth 202 formed on the end of the worm 191 to transmit a slow rotary motion through the mechanism above described to the shaft 145 and from there to the grinding wheel 15.

A stop screw 222 is supported in a threaded aperture in a boss 223 integral with the bracket 210. The screw 222 is arranged so that when the clutch shifting rod 204 is moved downwardly (Fig. 2) to throw the clutch 201 into engagement to rotate the worm 191 by means of the mechanism above described to rotate the grinding wheel 15 at a very slow rate of speed, the screw 222 may be screwed into position so that its end projects in back of the clutch shifting rod 204 so as to hold the clutch 200 in engagement and thus provide a continuous rotation of the grinding wheel 15 at a relatively slow speed below the normal grinding speed. For certain types of abrading operations, such as the honing or finishing of a cylindrical work piece 29, it is proposed to provide a stationary grinding wheel 15 during the polishing, finishing or honing operation and to provide an indexing mechanism whereby after each grinding operation, the grinding wheel may be indexed a small angular distance so as to present a fresh abrading surface for the next operation. This is preferably accomplished by providing an automatic timed controlling mechanism for energizing and deenergizing the solenoid 209.

As illustrated in the drawings (Fig. 1), a normally open limit switch 230 is supported on a bracket 231 which is fixedly mounted on the rear of the dash pot speed control mechanism. An adjustable switch actuating member 232 is adjustably mounted on the end of the piston rod 53 and is arranged when the wheel 15 and its supporting slide 11 is moved into a rearward or inoperative position to close an electric circuit receiving its source of power from power lines 233 to set in motion an electrically operated time delay relay 234 which serves to energize the solenoid 209 either the instant the switch 230 is closed or at a predetermined interval thereafter. The energizing of the solenoid 209 serves to engage the clutch teeth 201 with the clutch teeth 202 to rotate the reduction gear mechanism above described to rotate the grinding wheel 15 a fraction of a turn to present a fresh abrading surface for the next grinding or finishing operation. The extent of indexing or rotary movement of the wheel 15 is controlled and governed by adjustment of the electrically actuated time delay relay 234 so that the wheel 15 may be ro-

tated only a small angular distance or a greater angular distance as desired by adjustment of the time interval setting of the electrically operated time delay relay 234. A switch 235 is provided to facilitate opening the circuit and rendering the entire electrical control mechanism inoperative when desired. A second electrical switch 236 is provided which serves to render the electric time delay relay 234 inoperatve so that when opened, a manually operable push button 237 which is located adjacent to the operator's control station on front of the machine base 10, may be utilized to instantaneously energize the solenoid 209 to facilitate angularly indexing the grinding wheel 15 when desired by the operator.

In either a plunge-cut grinding operation or a finishing operation where the grinding wheel 15 is held stationary or rotated at a very slow speed, it is desirable to provide a grinding wheel spindle reciprocating mechanism whereby the grinding wheel spindle 16 may be reciprocated in an axial direction within its bearings 17 and 18. As illustrated in the drawings, a wheel spindle reciprocating mechanism is contained within a housing 240 which is mounted on the upper portion of the wheel slide 11. An eccentric 241 is formed integral with a rotatable sleeve 242. The sleeve 242 is rotatably journalled in bearings 243 supported in the housing 240. The sleeve 242 is preferably drivingly connected with the shaft 187 by means of a key 244, thus forming a telescopic driving connection between the shaft 187 and the sleeve 242 which facilitates adjustment of the casing 133 in tensioning the grinding wheel driving belts 148. The eccentric 241 is connected by a connecting rod 245 with a stud 246 carried by an arm 247 which is pivotally supported on a fulcrum stud 248. A frame 249 which is substantially of a C-shaped cross section is formed integral with the arm 247 and is supported at its other end by a fulcrum stud 250. When the eccentric 241 is rotated by the shaft 187, an oscillating motion will be transmitted by the connecting rod 245 to oscillate the arm 247 and the frame 249 about the fulcrum studs 248 and 250. The opposite sides of the C-shaped frame 249 are provided with substantially vertically extending grooves 251 and 252 which support slide blocks 253 and 254, respectively. The slide blocks 254 support the trunnion ends 255 and 256 of a rectangularly shaped block 257 which is slidably positioned within an elongated slot 258 in a rock arm 259. The rock arm 259 is pivotally supported on a shaft 260 which is journalled in suitable bearings within the wheel slide 11. The rock arm 259 is provided with an enlarged ring-shaped portion which surrounds the wheel spindle 16 and carries a ring-shaped member 261 which is provided with trunnions 262 and 263 which project into bearing apertures in diametrically opposite sides of the enlarged portion of the rock arm 259. The ring-shaped member 261 is supported between a fixed collar 265 and an adjustable thrust collar 266 carried by the wheel spindle 16 and serves to provide an end thrust bearing for the ring 261, said parts being arranged so that when the lever or rock arm 259 is oscillated, a reciprocating movement is transmitted to move the wheel spindle 16 axially within its supporting bearings 17 and 18 to produce a reciprocatory movement of the grinding wheel 15 during an abrading, honing or finishing operation.

It is desirable to provide means for adjusting the length of the reciprocatory stroke of the wheel spindle. For example, in the construction illustrated in the drawings, a reciprocatory stroke varying from zero up to one-eighth of an inch or more may be obtained. A vertically movable yoke-shaped member 270 is vertically adjustable by means of a rotatable screw 271. The screw 271 is journalled in bearings which are fixedly supported in the housing 240. The upper end of the screw 271 is provided with a bevel gear 272 which meshes with a bevel gear 273 supported on the inner end of a rotatable shaft 274 the outer end of which is provided with a manually operable adjusting wheel 275. The vertically adjustable member 270 is provided with yoke-shaped arms 280 and 281 which surround anti-friction ball bearings which are supported on the trunnions 255 and 256 of the slide block 257. As the screw 271 is rotated, the member 270 will be moved vertically, which serves to adjust the slide block 257 relative to the elongated aperture 258 in the rock arm 259 and at the same time adjusts the slide blocks 253 and 254 relative to the grooves 251 and 252 in the substantially C-shaped frame 249 so that the axis of the trunnions 255 and 256, respectively, may be moved toward or from the axis of the trunnions 248 and 250, respectively, to vary the length of the reciprocatory stroke of the wheel spindle 16. As illustrated in the drawings, the wheel spindle reciprocating mechanism is shown as adjusted to its maximum extent. If it is desired to change the reciprocatory stroke, the screw 271 is adjusted to lower the adjustable member 270 which serves to lower the trunnions 255 and 256 so that they approach the axes of the trunnions 248 and 250, thereby reducing the oscillatory motion transmitted to the rock arm 259 and thus reducing the reciprocatory movement of the wheel spindle 16 and the grinding wheel 15. If the adjustable member 270 is lowered until the axes of the trunnions 255 and 256 coincide with the axis of the trunnions 248 and 250, then no oscillating movement will be transmitted to the rock arm 259 and the wheel spindle 16 will be held against reciprocatory movement.

In order to pick up the slack in the link driving chain 197, a bell crank lever 285 is pivotally mounted on a stud 286 within the casing 133. A horizontally extending portion 287 of the bell crank lever 285 has an upper curved face which bears against the under side of the link chain 197 between the sprockets 196 and 198. An adjusting screw 288 is screw threaded into the casing 133 and bears against a vertically extending arm 289 of the bell crank lever 285. By manipulation of the adjusting screw 288, the tension of the link driving chain 197 may be adjusted as desired.

The operation of this improved machine will be readily apparent from the foregoing disclosure. Assuming the various mechanisms and adjustments to have been previously made, the machine as illustrated in the drawings is set up for a honing or finishing operation with a stationary grinding wheel 15 which is automatically indexed when the wheel slide 11 is moved to its rearward position automatically to present a fresh grinding face for the next operation. A work piece 29 is placed in position in the machine between centers and a starting switch 292 is closed to start the rotation of the work driving motor 293. A rheostat 294 is adjusted to vary the speed of the motor 293 so that the work 29 rotates at the desired speed. The switch 135 is then closed to start the rotation of the wheel driving motor 130.

The position of the parts illustrated does not start the rotation of the grinding wheel 15 since the wheel is normally held stationary but is rotated a small angular portion of one complete rotation to present a fresh abrading surface for the next honing or finishing operation. The lever 85 is then moved in a counterclockwise direction (Fig. 1) to admit fluid under pressure to the cylinder chamber 55 to cause the grinding wheel slide 11 and the grinding wheel 15 to approach the rotating work piece 29. The grinding wheel spindle 16 is reciprocating at a maximum stroke of approximately one-eighth of an inch or more. The stationary grinding wheel 15 is moved into operative honing or finishing relation with the work piece 29 and the operation continues until the desired finish is obtained. If desired, an automatic cycle control mechanism may be provided to allow the grinding wheel 15 to remain in operative engagement with the work piece 29 for a predetermined time interval. However, such a mechanism is not considered to be a part of the present invention and consequently has not been illustrated. For details of such a cycle control mechanism, reference may be had to the U. S. patent to Goehring No. 2,151,660 dated March 21, 1939.

After the work piece 29 has been finished to the desired extent, the lever 85 is moved in a clockwise direction to again shift the feed control valve stem 65 into the position illustrated in Fig. 1. As the wheel slide 11 approaches its rearmost position, the collar 232 carried by the threaded end portion of the piston rod 53 engages and closes the normally open limit switch 230 which operates to set the time delay relay 234 in operation. Substantially instantaneous with the starting of the time delay relay 234, the solenoid 209 is energized which serves to rock the bell crank lever 213 and thereby shift the clutch shifting rod 204 downwardly (Fig. 2) to engage the clutch teeth 201 of the clutch 200 with the clutch teeth 202 on the end of the worm 191, thus starting rotation of the grinding wheel 15. The electrical time delay relay 234 is set for a very short interval so that the grinding wheel 15 moves only a few degrees of one rotation so as to present a fresh abrading surface for the next operation. As soon as the time delay relay 234 functions, the circuit is again opened to de-energize the solenoid 209, thereby releasing the compression of the spring 207 which moves the clutch, shifting rod 204 upwardly (Fig. 2) to disengage the clutch teeth 201 from the clutch teeth 202, thus stopping the rotation of the grinding wheel 15 after it has indexed a desired number of degrees so as to present a fresh abrading surface for the next honing or finishing operation. The amount of indexing movement may be varied as desired, but due to the fact that the operation is a cylindrical grinding operation utilizing the periphery of an abrasive wheel, only a very small indexing movement is required to present a fresh abrading surface for finishing the next work piece 29. This cycle of events then continues as desired.

If it is desired to rotate the grinding wheel 15 at a normal grinding speed for a grinding operation or for truing the grinding wheel, the clutch 200 is held in a normal disengaged position and the lever 175 is rocked into the broken line position 175a (Fig. 8) which serves to slide the clutch member 160 so that the teeth 161 engage the teeth 162 formed in the end of the rotatable sleeve 142 so that the driving shaft 140 is connected directly to the driven shaft 145 to rotate the wheel spindle 16 and the grinding wheel 15 at a normal grinding speed for a grinding operation or a truing operation.

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 matters hereinabove set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. In a grinding machine having a longitudinally movable work table and a transversely movable wheel slide, a rotatable work support on said table, a rotatable grinding wheel on said slide, means to feed said wheel slide and work support relatively toward and from each other, said grinding wheel being normally held stationary during a grinding operation, an indexing mechanism operatively connected rotatably to index said grinding wheel to present a new abrasive surface for successive grinding operations, and means actuated automatically by and in timed relation with said relative feeding movement to operate said indexing mechanism.

2. In a grinding machine having a longitudinally movable table and a transversely movable wheel slide, a rotatable work support on said table, a normally-stationary rotatably-mounted grinding wheel on said slide, means to feed said slide toward and from said work support to produce an abrading operation, an electrically actuated indexing mechanism rotatably to index said grinding wheel a partial rotation to present a new abrasive surface, and means including an electrical control device which is actuated by the wheel slide when it moves to an inoperative position to actuate said indexing mechanism so as to present a new abrasive surface for the next grinding operation.

3. In a grinding machine having a longitudinally movable table and a transversely movable wheel slide, a rotatable work support on said table, a feeding mechanism to move said slide transversely toward and from said work support to produce an abrading operation, a normally-stationary rotatably-mounted grinding wheel on said slide, and an electrically controlled indexing mechanism including an electrical time delay relay which is rendered operative by and in timed relation with the rearward movement of said wheel slide automatically to index said grinding wheel a partial rotation to present a new abrading surface for successive grinding operations.

4. In a grinding machine having a longitudinally movable work table and a transversely movable wheel slide, a rotatable work support on said table, a feeding mechanism to feed said wheel slide transversely toward and from said work support, a normally-stationary rotatably-mounted abrasive wheel on said slide, a driving mechanism including an electric motor for rotating the grinding wheel, an indexing mechanism including an automatically controlled clutch to connect and disconnect said driving mechanism, electrically controlled means including a solenoid to actuate said clutch, and means including an electrical time delay relay which is set in motion by and in timed relation with said wheel slide movement to energize said solenoid

for a predetermined time interval so as to index the grinding wheel and present a new abrasive surface for successive grinding operations.

5. In a grinding machine having a longitudinally movable work table and a transversely movable wheel slide, a rotatable work support on said table, a feeding mechanism to feed said slide transversely toward and from said work support to produce an abrading operation, a normally-stationary rotatably-mounted grinding wheel on said slide, a driving mechanism including a variable speed electric motor to rotate said grinding wheel at a slow rate of speed, means including a clutch to connect and disconnect said driving mechanism with the wheel, means including a solenoid to actuate said clutch, an electrically operated time delay relay which is operatively connected to energize said solenoid for a predetermined time interval, and a switch which is actuated by the feeding mechanism when the wheel slide is moved rearwardly after an abrading operation rotatably to index the grinding wheel to present a new abrading surface for the succeeding grinding operation.

6. In a cylindrical grinding machine having a longitudinally movable table and a transversely movable wheel slide, a rotatable work support on said table, means including a variable speed electric motor to rotate a work piece supported thereon, a rotatable grinding wheel, means including a variable speed electric motor to rotate said grinding wheel, driving connections between said motor and wheel whereby the grinding wheel may be rotated either at a normal grinding speed or at a slow speed below the normal grinding speed or held stationary for a finishing or polishing operation, and means automatically actuated to rotatably index said wheel after each finishing or polishing apparatus to present a new abrading surface for the next operation.

7. In a cylindrical grinding machine having a longitudinally movable table and a transversely movable wheel slide, a rotatable work support on said table, means including an electric motor to rotate a work piece supported thereon, a rotatable grinding wheel, means including an electric motor to rotate said grinding wheel, driving connections between said motor and wheel whereby the wheel may be rotated at a normal grinding speed, driving connections between said motor and wheel whereby the wheel may be rotated at a slow speed below the normal grinding speed, said latter mechanism being arranged to hold said grinding wheel stationary for a finishing operation, and means automatically actuated rotatably to index said wheel after each finishing operation.

8. In a cylindrical grinding machine having a longitudinally movable table and a transversely movable wheel slide, a rotatable work support on said table, means including a variable speed motor to rotate a work piece supported thereon, a rotatable grinding wheel, means including a variable speed electric motor to rotate said grinding wheel, driving connections between said motor and wheel whereby the wheel may be rotated at a normal grinding speed, driving connections between said motor and wheel whereby the wheel may be rotated at a slow speed below the normal grinding speed, said latter mechanism being arranged to hold said grinding wheel stationary for a finishing operation, and means automatically actuated to rotatably index said wheel after each finishing operation.

9. In a cylindrical grinding machine having a longitudinally movable table and a transversely movable wheel slide, a rotatable work support on said table, means including a variable speed electric motor to rotate a work piece supported thereon, a feeding mechanism to feed said wheel slide transversely toward and from said table, a rotatable grinding wheel supported on said wheel slide, a driving mechanism whereby said wheel may be rotated at a slow speed below the normal grinding speed, said driving mechanism being arranged to hold said grinding wheel stationary for a polishing or finishing operation, and an indexing mechanism which is actuated by and in timed relation with said wheel slide to rotatably index said grinding wheel after a polishing operation to present a new abrading surface for the next operation.

10. In a cylindrical grinding machine having a longitudinally movable table and a transversely movable wheel slide, a rotatable work support on said table, means including an electric motor to rotate a work piece supported thereon, means to traverse said table longitudinally, a rotatable grinding wheel supported on said wheel slide, means to feed said wheel slide and grinding wheel transversely toward and from said work support, means including a variable speed electric motor to rotate said grinding wheel at a slow speed below the normal grinding speed, said latter mechanism being arranged to hold said grinding wheel stationary for a polishing or finishing operation, and an electrically controlled indexing mechanism which is actuated in timed relation with said wheel slide movement rotatably to index said grinding wheel after each grinding operation to present a new abrading surface for the next operation.

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