March 21, 1939. W. H. WOOD ET AL 2,151,669

GRINDING MACHINE

Filed Feb. 29, 1936 5 Sheets-Sheet 1

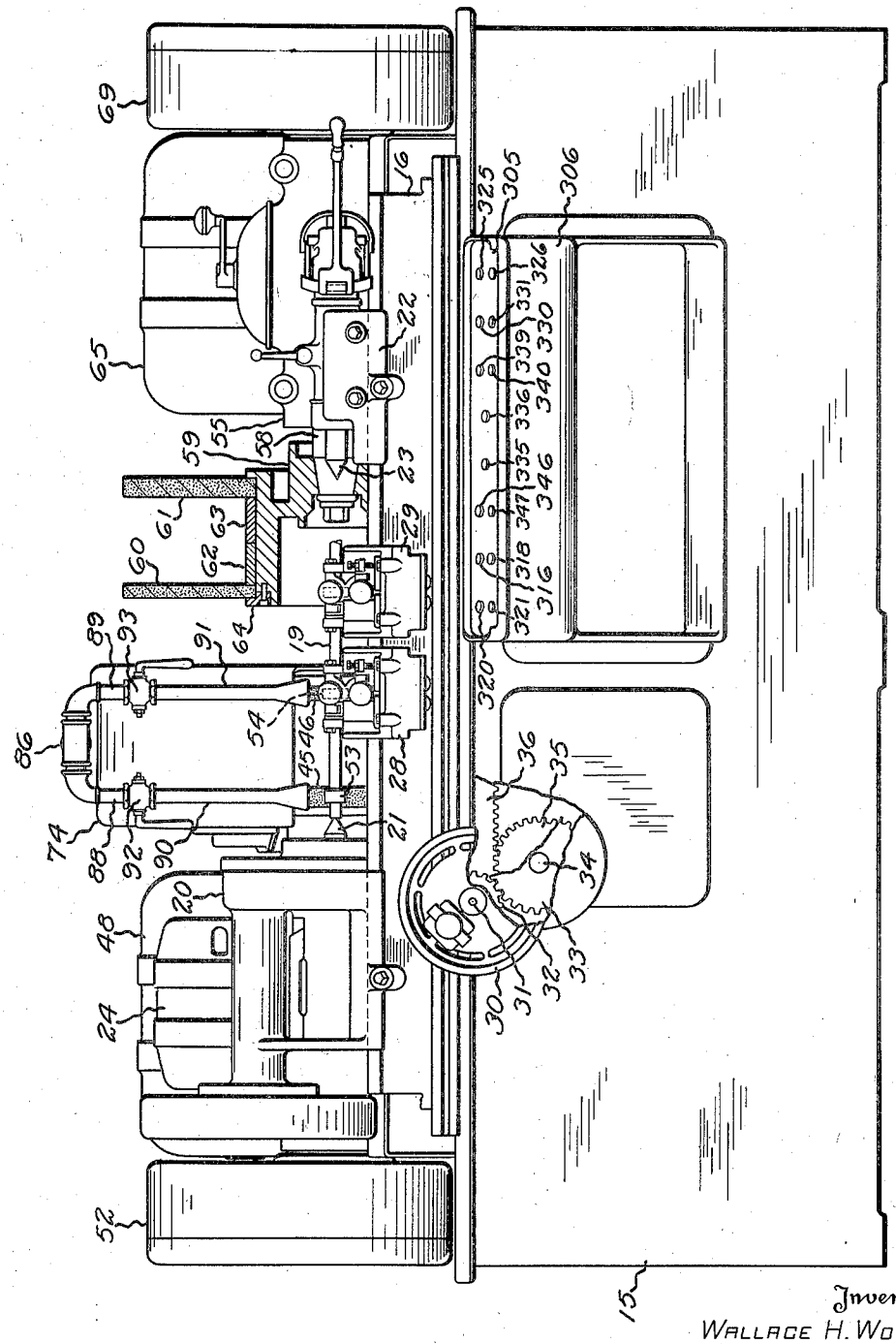


FIG. 1

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GRINDING MACHINE

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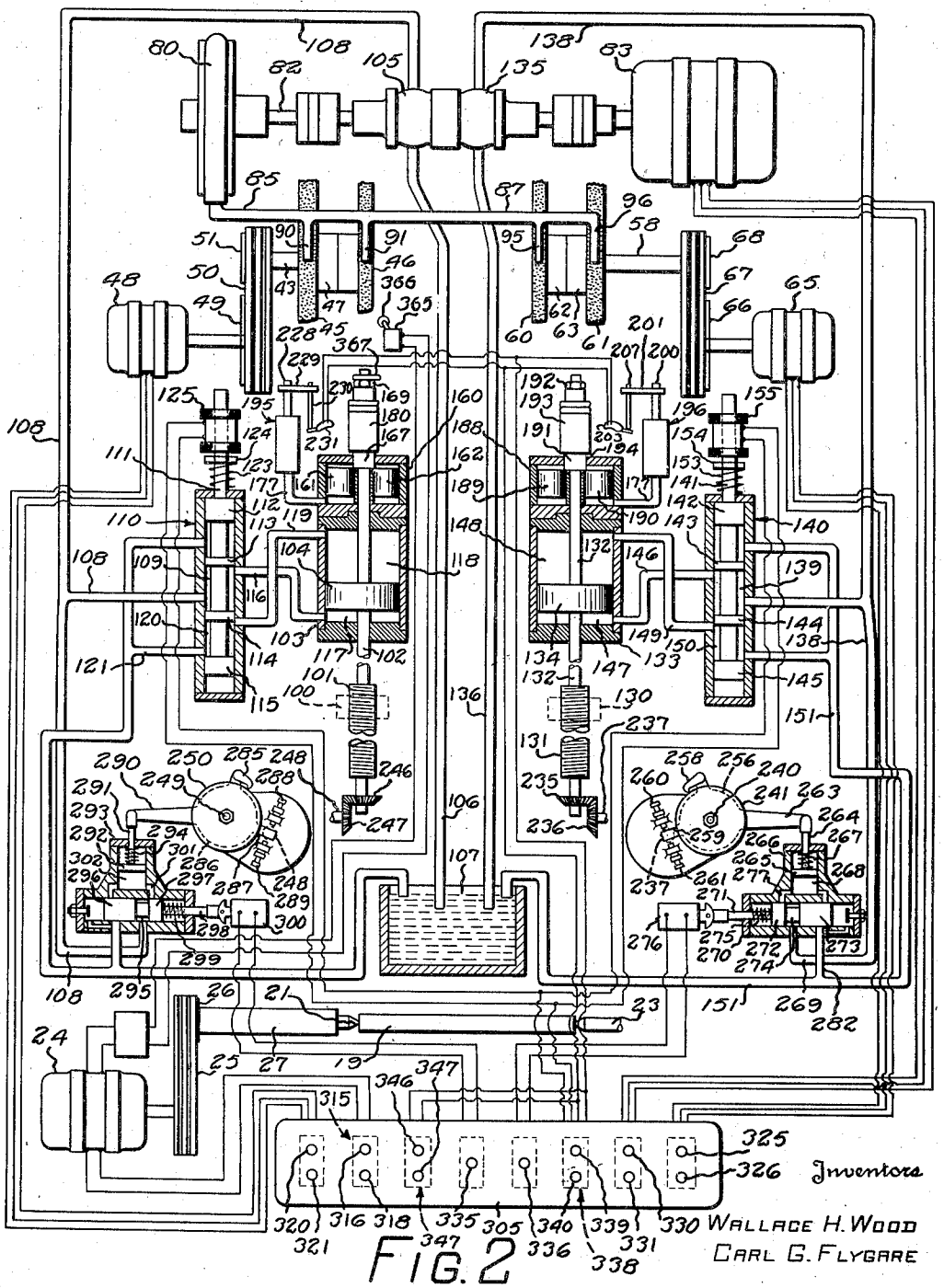


FIG. 2

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GRINDING MACHINE

Filed Feb. 29, 1936 5 Sheets-Sheet 3

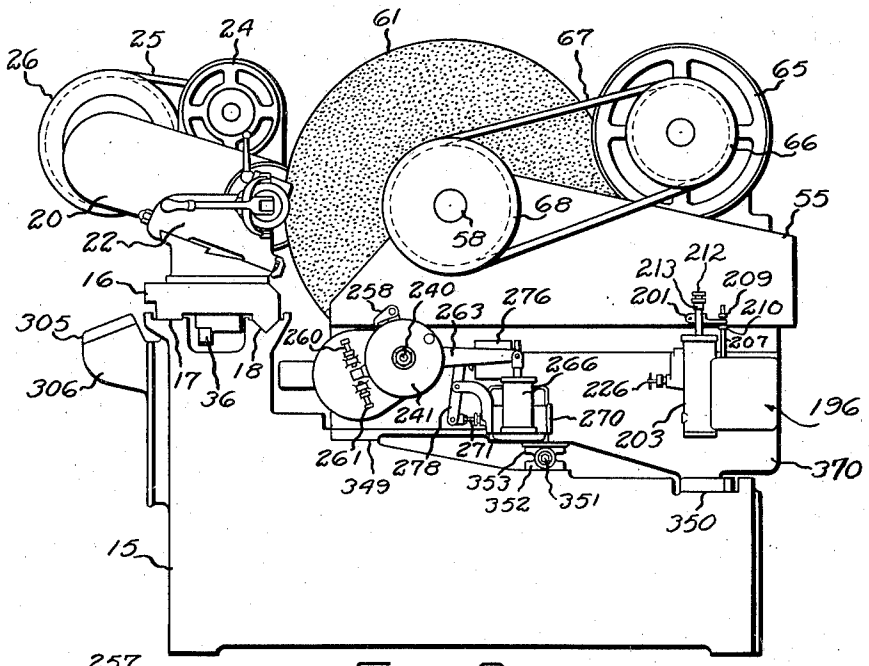


FIG. 3

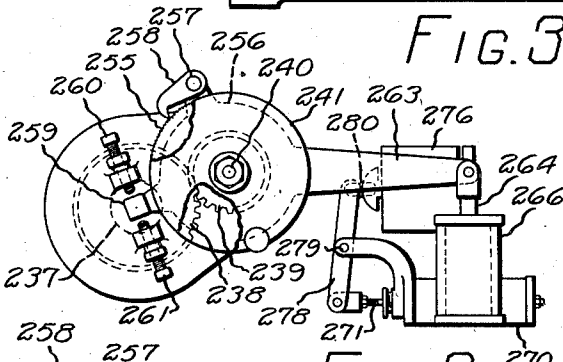


FIG. 8

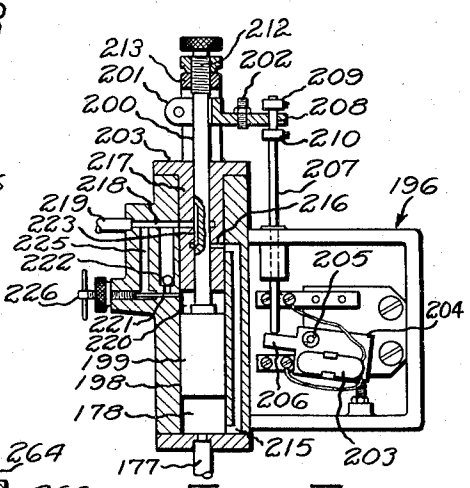


FIG. 7

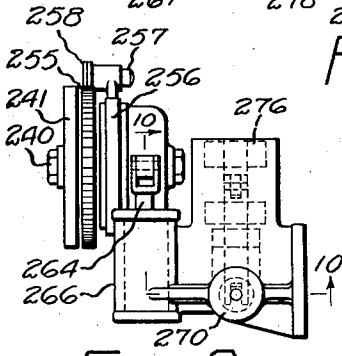


FIG. 9

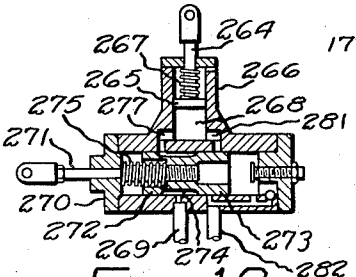


FIG. 10

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GRINDING MACHINE

Filed Feb. 29, 1936 5 Sheets-Sheet 4

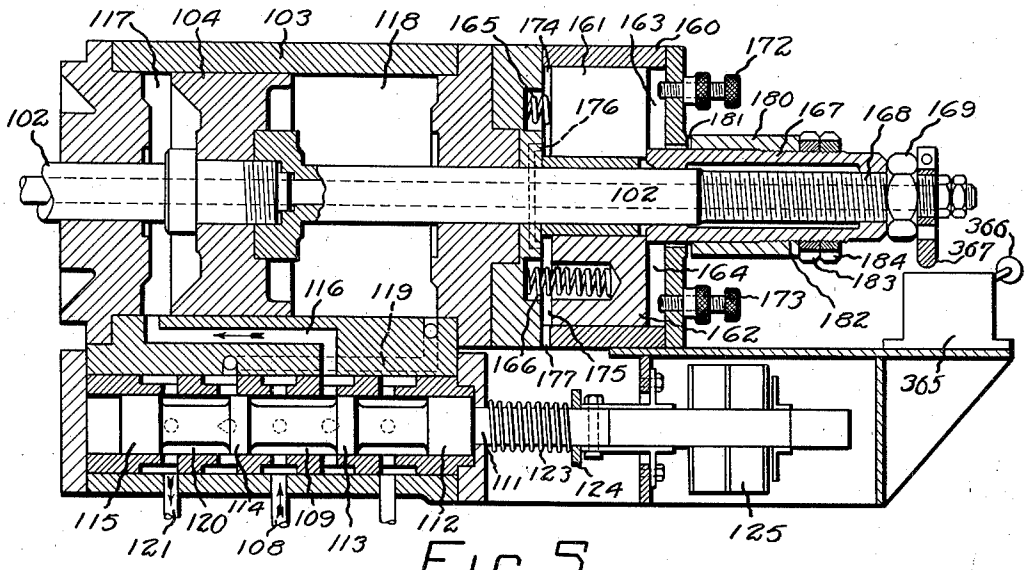


FIG. 5

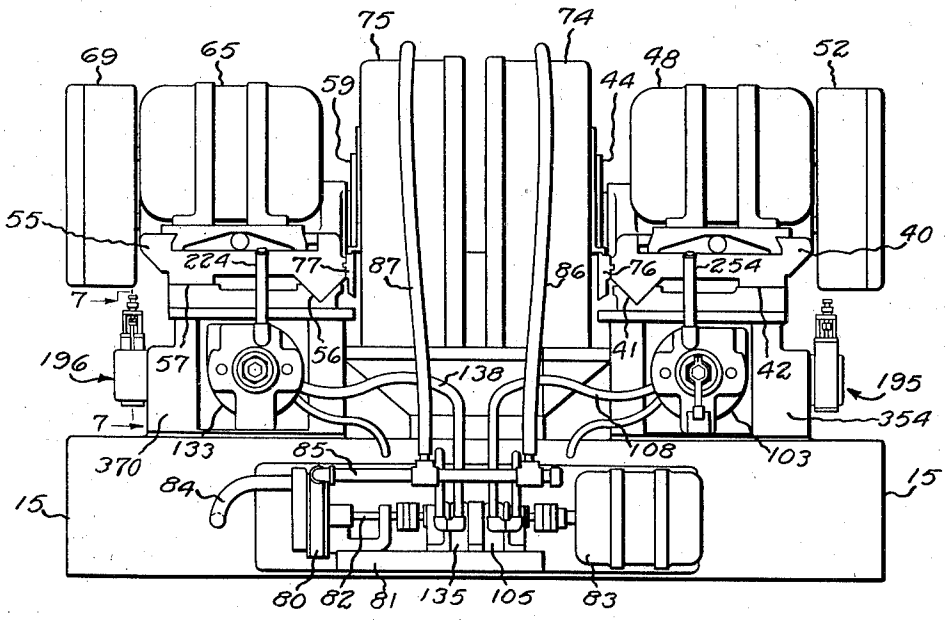


FIG. 4

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GRINDING MACHINE

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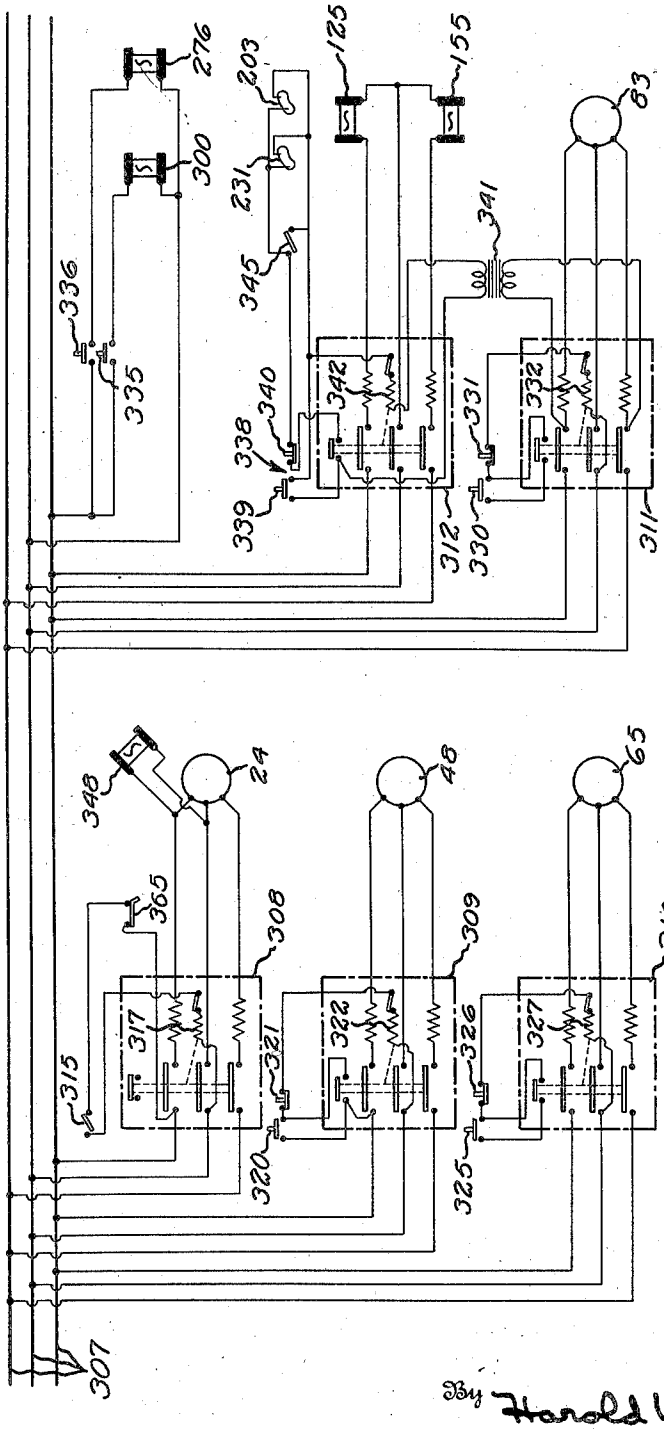


FIG. 6

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UNITED STATES PATENT OFFICE

2,151,669

GRINDING MACHINE

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Application February 29, 1936, Serial No. 66,464

10 Claims. (Cl. 51—105)

This invention relates to grinding machines, and more particularly to a multiple wheel slide cylindrical grinding machine.

One object of this invention is to provide a simple, thoroughly practical control mechanism for a multiple wheel slide cylindrical grinding machine. Another object of this invention is to provide a centralized electrical control mechanism whereby all of the mechanisms of the machine may be controlled from a station in front of the machine.

A further object is to provide a two-wheel slide machine in which the two wheel slides may be cyclically controlled to simultaneously grind and recede from a grinding position to an inoperative position. A further object of this invention is to provide an electrically controlled mechanism for advancing each of the wheel slides by predetermined increments for setting up the machine or for use in advancing the slides for a truing operation.

Another object of this invention is to provide an electrical control for the work rotation which is arranged so that the rotation of the work is automatically stopped 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 a front elevation of a grinding machine, having parts broken away and shown in section to more clearly show the construction;

Fig. 2 is a diagrammatic view showing the arrangement of the hydraulic system as well as a schematic showing of the wiring diagram;

Fig. 3 is a right-hand end view of the machine shown in Fig. 1;

Fig. 4 is a rear elevation of the improved grinding machine;

Fig. 5 is a vertical cross sectional view, on an enlarged scale, through one of the hydraulic wheel feed motors and control valves;

Fig. 6 is an electrical diagram showing the electrical wiring for the machine;

Fig. 7 is a sectional view, on an enlarged scale, taken approximately on the line 7—7 of Fig. 4;

Fig. 8 is a fragmentary side elevation, on an enlarged scale, of the wheel feed mechanism, as shown in Fig. 3;

Fig. 9 is a fragmentary right-hand end elevation of the parts shown in Fig. 8; and

Fig. 10 is a sectional view taken approximately on the line 10—10 of Fig. 9, showing the fluid pressure mechanism for actuating the wheel feed mechanism shown in Figs. 8 and 9.

A grinding machine has been illustrated comprising a base 15 which supports a longitudinally movable work table 16. The base 15 is provided with a flat way 17 and a V-way 18 which mate with correspondingly shaped ways on the table 16 to support and guide the table 16 during its longitudinal movement thereon. The table 16 is provided with a rotatable work support which comprises a headstock 20 having a headstock center 21 and a footstock 22 having a footstock center 23. The headstock center 21 and footstock center 23 are arranged to rotatably support the opposite ends of a work piece 19 during a grinding operation. The headstock 20 is preferably an electrically driven headstock in which a motor 24 is mounted on the headstock 20 which is connected by driving belts 25 with a pulley 26 on a headstock spindle 27.

The work piece 19 may be steadied by one or more steadyrests, depending upon the length of the work piece 19 being ground. As shown in the drawings, a pair of fluid operated steadyrests 28 and 29 have been illustrated as supporting and steadying the work piece 19 between its ends. These rests 28 and 29 are not considered to be a part of the present invention and consequently have not been illustrated in detail. For a detailed disclosure of the steadyrest construction, reference may be had to the copending patent application Serial No. 50,276 filed November 18, 1935.

Table traverse

The table 16 is arranged to be traversed longitudinally relative to the base 15 to position the work piece 19 in a predetermined position for a grinding operation. The table may be traversed either manually or by a power operated mechanism, if desired. As illustrated in the drawings, a manually operable traverse mechanism has been provided comprising a manually operable traverse wheel 30 which is mounted on a rotatable shaft 31. The shaft 31 carries a gear 32 which meshes with a gear 33 mounted on a shaft 34. The shaft 34 also supports a gear 35 which meshes with a rack bar 36 depending from the table 16.

Wheel slides

In the grinding of any work pieces, particularly relatively long cylindrical shafts, it is frequently necessary to grind several spaced portions on the shaft either to the same diameter or to different diameters. In the prior grinding practice, it has been customary to first grind one portion of the shaft with a single wheel and to then index the wheel or the work and grind a second portion to be ground. This procedure is continued until all of the various portions of the shaft have been ground to the desired and predetermined size.

In order to attain the main object of this invention, it is desirable to provide a grinding machine in which a plurality of grinding wheels are mounted on a wheel spindle so that the various portions of the shaft may be ground simultaneously to the desired size. In the preferred construction where grinding relatively long work pieces, such as shafts, it is desirable to provide a grinding wheel assembly comprising independently movable grinding wheel slides which may be separately controlled and adjusted and which may be moved simultaneously into operative grinding contact with the portions of the work 19 to be ground. Each of the wheel slides may support a plurality of grinding wheels in spaced relation thereon to correspond with the spacing of the portions of the work piece to be ground.

As illustrated in the drawings, the machine is provided with a grinding wheel slide 40 which is mounted for a transverse movement on the base 15 on a V-way 41 and a flat way 42. The wheel slide 40 is provided with a rotatable wheel spindle (not shown) which supports a pair of spaced grinding wheels 45 and 46 for grinding spaced portions 53 and 54 on the work piece 19. A similar grinding wheel slide 55 is mounted for a transverse movement on the base 15 on a V-way 56 and a flat way 57. The wheel slide 55 is provided with a rotatable wheel spindle 58 which supports a wheel sleeve or mounting 59. The mounting 59 is arranged to rotatably support a grinding wheel 60 and a grinding wheel 61 which are spaced from each other to correspond with the spacing of the portions of the work to be ground by spacing collars 62 and 63. The grinding wheels are held in fixed position on the wheel sleeve 59 by means of an adjustable flange 64 which holds the wheel assembly in position on the sleeve 59.

Grinding wheel drive

The grinding wheels 45, 46 and 60, 61 may be rotated by independent motor drives including an electric motor 48 mounted on the wheel slide 40. The motor 48 is provided with a pulley 49 which is connected by a belt drive 50 contained within a belt guard 52 to rotate the wheel spindle 43 so as to rotate the grinding wheels 45 and 46 at the desired speed. Similarly, an electric motor 65 is mounted on the wheel slide 55. The motor 65 is provided with a driving pulley 66 which is connected by V-belts 67 with a pulley 68 mounted on the outer end of the wheel spindle 58. The belt drive 67 is enclosed in a belt guard or casing 69, as illustrated in Fig. 1.

The grinding wheels 45, 46 and 60, 61 are protected by wheel guards 74 and 75 respectively. The wheel guards 74 and 75 are adjustably supported on slideways 76 and 77 on the wheel slides 40 and 55 respectively, so that the wheel guards may be adjusted relative to the grinding wheels as the wheels are reduced in size due to wear and truing.

Coolant fluid

In many of the production grinding operations, it is desirable to provide a coolant fluid and to apply the same to the periphery of the grinding wheel and the work during the grinding operation. A coolant fluid pump 80 is mounted on a support 81 on the rear of the base 15. A pump shaft 82 is operatively connected to be rotated by an electric motor 83. The pump 80 draws coolant fluid through a pipe 84 from a coolant fluid reservoir (not shown) within the base 15 of the machine. Coolant fluid passing through the pump 80 passes out through a pipe 85 and through pipes 86 and 87 which extend up to and over the wheel guards 74 and 75, respectively.

The pipe 86 divides the flow of coolant fluid passing therethrough to convey a stream of coolant fluid to each of the grinding wheels 45 and 46. The pipe 86 passes fluid to a pipe 88 and a pipe 89 through the spouts 90 and 91 respectively to convey coolant fluid to the grinding wheels 45 and 46 respectively. A control valve 92 is interposed between the pipe 88 and the spout 90 and a control valve 93 is interposed between the pipe 89 and the spout 91 so that the stream of coolant fluid to each wheel may be independently controlled. Similarly, the pipe 87 divides the flow of coolant fluid passing therethrough to convey a stream of coolant fluid to each of the grinding wheels 60 and 61 through spouts 95 and 96 respectively. The piping to the spouts is the same as that shown and above described in connection with spouts 90 and 91 and includes separate control valves (not shown).

Wheel feed mechanism

A fluid pressure wheel feeding mechanism is provided to control the feeding movement and adjustment of the grinding wheel toward and from the work support. Independent feed controlling mechanisms are provided for each of the wheel slides 40 and 55 respectively so that each wheel slide may be fed independent of the other wheel slide. In the preferred construction, however, the two controlling mechanisms are preferably arranged so that the grinding wheels may be fed simultaneously into grinding contact with the work piece to be ground by means of a control mechanism, to be hereinafter described. The wheel slide 40 is provided with a depending nut 100 (Fig. 2) which meshes with a rotatable feed screw 101. The feed screw 101 is rotatably supported in bearings (not shown) in the base 15. The feed screw 101 may be rotated manually for adjusting the wheel slide 40 in setting up the machine by a manually operable feed mechanism to be hereinafter described.

In order that the wheel slide 40 may be rapidly moved toward the work piece to grind the same by the plunge-cut method, the feed screw 101 is connected to a piston rod 102. A fluid pressure cylinder 103 is arranged in axial alignment with the feed screw 101 and contains a slidably mounted piston 104 which is connected to or formed integral with the piston rod 102. A fluid pressure pump 105 is mounted to be driven by the shaft 82 and pumps fluid through a pipe 106 from a reservoir 107 within the base 15. The pump 105 forces fluid under pressure through a pipe 108 to a valve chamber 109 in a feed control 110. The feed control valve 110 is preferably of a piston type comprising a valve stem 111

and pistons 112, 113, 114 and 115. In the position of the valve illustrated in Fig. 2, fluid under pressure entering the valve chamber 109 between the valve pistons 113 and 114 passes outwardly through a pipe 116 into a cylinder chamber 117 to cause the piston 104 to move rearwardly to withdraw the wheel slide 40 and the grinding wheels 45 and 46 to an inoperative position away from the work piece 19. During the passage of pressure fluid into the cylinder chamber 117, fluid is exhausted from a cylinder chamber 118 through a passage of pipe 119 into a valve chamber 120 between the valve pistons 114 and 115 and out through a pipe 121 which exhausts into the reservoir 107.

The valve stem 111 is held in the rearward position illustrated in Fig. 2 by means of a spring 123 which surrounds the valve stem 111 and is interposed between a collar 124 fixed to the valve stem 111 and the end of the valve casing 110. In order to shift the feed control valve 110 into a reverse position to cause an infeeding movement of the grinding wheels 45 and 46, an electrical control apparatus may be utilized including a solenoid 125 which serves to move the valve stem 111 into its reverse position so that fluid under pressure passing through the pipe 108 into the valve chamber 109 passes through the passage or pipe 119 into the cylinder chamber 118 to cause the piston 104, the screw 101 and the wheel slide 40 to move the grinding wheels 45 and 46 into a grinding position with relation to the work piece 19.

Similarly, a fluid pressure wheel feeding mechanism is provided to control the feeding movement and adjustment of the wheel slide 55. The wheel slide 55 is provided with a depending half nut 130 (Fig. 2) which meshes with a rotatable feed screw 131. The feed screw 131 is rotatably supported in bearings (not shown) in the base 15. The feed screw 131 may be rotated manually for adjusting the wheel slide 55 in setting up the machine by a manually operable feed mechanism to be hereinafter described.

In order that the wheel slide 55 may be rapidly moved toward the work piece to grind the same by the plunge-cut method, the feed screw 131 is connected to a piston rod 132. A fluid pressure cylinder 133 is arranged in axial alignment with the feed screw 131 and contains a slidably mounted piston 134 which is connected to or formed integral with the piston rod 132. A fluid pressure pump 135 is mounted to be driven by the shaft 82 and pumps fluid through a pipe 136 from the reservoir 107 within the base 15. The pump 135 forces fluid under pressure through a pipe 138 to a valve chamber 139 in a feed control valve 140. The valve 140 is preferably of a piston type comprising a valve stem 141 and valve pistons 142, 143, 144 and 145. In the position of the valve 140 illustrated in Fig. 2, fluid under pressure entering the valve chamber 139 between the valve pistons 143 and 144 passes outwardly through a passage or pipe 146 into a cylinder chamber 147 to cause the piston 134 to move rearwardly to withdraw the wheel slide 55 and the grinding wheels 60 and 61 to an inoperative position away from the work piece 19. During the passage of pressure fluid into the cylinder chamber 147, fluid is exhausted from a cylinder chamber 148 through a passage or pipe 149 into a valve chamber 150 between the valve pistons 144 and 145 and out through a pipe 151 which exhausts into the reservoir 107.

The valve stem 141 is held in the position illustrated in Fig. 2 by means of a spring 153 which surrounds the valve stem 141 and is interposed between a collar 154 fixed to the valve stem 141 and the end of the valve casing 140. In order to shift the feed control valve 140 into a reverse position to cause an infeeding movement of the wheel slide 55 and the grinding wheels 60 and 61, an electrical control apparatus may be utilized including a solenoid 155 which is arranged to move the valve stem 141 into its reverse position so that fluid under pressure passing through the pipe 138 into the valve chamber 139 passes through the passage or pipe 149 into the cylinder chamber 148 to cause the piston 134 to move in a forward direction and transmit a corresponding movement to the screw 131, the nut 130, to the wheel slide 55, so as to feed the grinding wheels 60 and 61 towards the work piece 19.

Dash pot

The piston and cylinder mechanisms above described serve to cause the grinding wheels 45, 46, 60 and 61 to rapidly approach the work piece 24. In order to reduce the rapid approaching movement to a predetermined grinding feed, it is desirable to provide a fluid pressure controlling mechanism, such as a dash pot mechanism, which may be rendered effective when the grinding wheels 45, 46, 60 and 61 are about to contact with the surface of the work piece to be ground. As illustrated in Fig. 5, the cylinder 103 is provided with an outwardly extending casing 160 which contains a pair of diametrically opposed dash pot pistons 161 and 162 which slide within dash pot cylinders 163 and 164. The dash pot pistons 161 and 162 are normally held in a rearward position by springs 165 and 166 respectively. During the rapid approach of the grinding wheels, the dash pot pistons 161 and 162 are ineffective. The piston rod 102 extends toward the rear of the machine and is provided at its rearward end with a sleeve 167 which may be adjusted longitudinally on the threaded portion 168 of the piston rod 102 by means of a nut 169. The parts are so arranged that the sleeve 167 moves rearwardly when the piston 104 moves into a rearward position. The dash pot pistons 161 and 162 are limited in their rearward movement by means of the adjusting screws 172 and 173 respectively. When fluid under pressure is admitted to the cylinder chamber 118 to cause the grinding wheels 45 and 46 to move toward the work piece 19, the rapid approaching movement continues until the end of the sleeve 167 engages the ends of the dash pot pistons 161 and 162. The continued movement of the piston 104 is resisted by the dash pot pistons 161 and 162 which force fluid under pressure from the dash pot chambers 174 and 175 into a dwell control mechanism to be hereinafter described. The dash pot chambers 174 and 175 are interconnected by a passage 176 and simultaneously exhaust fluid through a passage or pipe 177 into a chamber 178 of a dwell control valve shown in Fig. 7 which will be more fully described hereinafter.

Positive stop

In order to grind a work piece to a predetermined size, it is necessary to feed the grinding wheel toward the work piece 19 to grind the same and then to stop the infeed and allow the grinding wheel to grind-out or to allow the sparks to die out in order to round up the work so that it will be ground to a true cylindrical surface of a predetermined size. As illustrated in Fig. 5, the forward movement of the piston rod 102 causes

a rapid approach until the sleeve 167 picks up the dash pot pistons 161 and 162 to cause a slow grinding infeed which continues until an adjustable sleeve 180 engages a fixed surface 181 on the rear of the dash pot cylinder, thereby limiting the infeeding movement of the wheel and causing the wheel to dwell in contact with the work during a finish grinding period. The adjustable stop sleeve 180 surrounds the sleeve 167 and is threaded thereto by means of a thread 182 and is held in adjusted position thereon by means of the lock nuts 183 and 184.

An identical mechanism is provided on the rear end of the cylinder 133 (Fig. 2) for slowing down and stopping the infeeding movement of the grinding wheels 60 and 61. This mechanism has not been illustrated in detail, since it corresponds in every detail to the construction shown in Fig. 5. This mechanism has been diagrammatically illustrated in Fig. 2 and comprises a casing 188 fixed on the rear end of the cylinder 133. This casing contains a pair of diametrically opposed dash pot pistons 189 and 190 which slide within dash pot cylinders contained within said casing. A sleeve 191 surrounds the rearwardly extending portion of the piston rod 132 and is adjustably mounted thereon and held in adjusted position by means of a nut 192 threaded on the end of the piston rod 132. An adjustable stop sleeve 193 surrounds the sleeve 191 and is arranged to engage the end surface 194 of the casing 188 to stop the forward movement of the grinding wheels 60 and 61 to allow a finish grinding operation on the work piece 19.

Wheel feed—Dwell control

In order to provide a predetermined but adjustable dwell at the end of each grinding operation to allow the wheel to grind-out or finish-grind the work, a separate dwell control mechanism 195 and 196 is operatively connected with each of the dash pot mechanisms 160 and 188 respectively. These dwell control mechanisms are identical in construction and operation, consequently only one of the units has been shown in detail. The right-hand dwell control unit 196 has been shown in Fig. 7, which is an enlarged fragmentary sectional view taken approximately on the line 7—7 of Fig. 4. The dwell control unit comprises a vertical cylinder 198 having a piston 199 slidably mounted therein. Fluid under pressure exhausting from the dash pot cylinders 174 and 175 passes through a passage or pipe 177 into the cylinder chamber 178 in the lower part of the cylinder 198 to cause an upward movement of the piston 199. The piston 199 is provided with a vertically extending piston rod 200 which carries at its upper end an adjustable arm 201. The arm 201 is provided with an adjustable stop screw 202 which in the lower position engages the upper surface 203 of the cylinder 198. The screw 202 limits the downward movement of the piston 199. Associated with the dwell control unit is a normally open mercury switch 203 which is supported on a pivotally mounted plate 204. The plate 204 is pivotally supported on a stud 205 and is provided with an extending arm 206 which extends into the path of a vertically extending rod 207. The rod 207 passes through an aperture 208 in the arm 201. A pair of adjustable collars 209 and 210 is carried by the rod 207 and serve to provide a lost motion connection between the rod 207 and the arm 201.

When fluid under pressure is admitted to the dwell control cylinder chamber 178 to cause the piston 199 and the piston rod 200 to move upwardly, the arm 201 lifts the rod 207 into the position illustrated in Fig. 7, which serves to allow the plate 204 supporting the mercury switch 203 to rock under the influence of gravity in a clockwise direction and to close the mercury switch 203 and thereby close the circuit and energize the solenoid 155.

When fluid is admitted to the chamber 178 to cause an upward movement of the piston 199, fluid also passes simultaneously through a passage 215 within the wall of the cylinder 198 and passes through a passage 216 in a bushing 217 at the upper end of the cylinder. The piston rod 200 is provided with a V-shaped groove 223 which allows fluid passing through the passage 216 to pass along the V-shaped groove 223 during the upward movement of the rod 200 and out through a passage 218 in the casing through a pipe or passage 219 into a fluid reservoir 224. During the upward movement of the piston 199, fluid within a chamber 220 of the cylinder 198 may pass outwardly through a passage 221 and through a ball check valve 222 into the passage 218 and into the fluid reservoir.

The piston 199 moves rapidly in an upward direction until the piston rod 200 engages an adjustable stop screw 212 which is supported in a bracket 213 fixed to the cylinder head 203. By adjusting the position of the stop screw 212, the upward position of the V-shaped groove 223 may be adjusted and, due to the V-shaped cross sectional area of the groove 223 and the fact that this groove tapers to zero at the end of the groove, serves to control the rate of fluid exhaust from the dash pot chambers 174 and 175 and thereby control the grinding feed.

The V-groove 223 in its upward position serves to restrict the exhaust of fluid from the dash pot chambers 174 and 175 so as to control the rate of infeed of the grinding wheel during the grinding operation. When the wheels 60 and 61 are fed toward the work piece 19 by means of the fluid pressure pistons 104 or 134, the rapid approaching movement continues until the bushing 167 engages the ends of the dash pot pistons 161 and 162, after which the exhaust of fluid from the dash pot chambers through the dwell control units 195 and 196 serves to slow down the rate of movement of the grinding wheel to a predetermined grinding feed. As soon as the sleeve 167 picks up the dash pot pistons and causes them to move, the exhaust of fluid from the dash pot chambers moves the dwell control piston 199 upwardly into the position illustrated in Fig. 7, rocking the mercury switch 203 into the position illustrated in Fig. 7 to close the circuit. The mercury switch 203 is connected through an electric circuit to be hereinafter described with the solenoid 155 or 125. The piston 199 remains in its upward position during the movement of the dash pot pistons 161 and 164 which continue to move forward until the adjustable stop sleeve 180 strikes the fixed stopping surface 181, thereby preventing further advance of the dash pot piston. As soon as exhaust of fluid from the dash pot piston ceases, the forces of gravity acting upon the piston 199 and its associated parts start a downward movement of the piston 199. This downward movement serves to create a partial vacuum in the chamber 220 of the cylinder 198. Fluid entry into the chamber 220 cannot pass through the ball check valve 222 and must pass through a passage 225 and through an adjustable needle valve 226 into the chamber 220. The

needle valve may be readily adjusted to control the downward movement of the piston 199 and thereby serves to control the extent of dwell produced at the end of each grinding operation.

The period of dwell continues until the piston 199, piston rod 200 drops to a sufficient extent to lower the arm 201 and rod 207 which serves to rock the arm 206, the plate 204 so as to tip the mercury switch 203 and again open the circuit which deenergizes the solenoid on the feed control valve so as to allow the released tension of the springs to shift the reverse valve and to cause a rearward movement of the grinding wheel slide, as will be hereinafter more fully described.

The unit just described is the dwell control unit 196 which controls the dwell or finish grinding movement of the wheel slide 55 so as to control the final or finish grinding of the wheels 60 and 61. The dwell control unit 195 which is associated with the cylinder 103 is identical with the unit above described and consequently has not been described in detail. The dwell control unit 195 includes a vertically extending piston rod 228 carrying an adjustable arm 229 which serves to cause a vertical movement of a rod 230. The rod 230 serves to control a mercury switch 231 which is connected to energize or deenergize the solenoid 125 to reverse the feed control valve 110 and after a predetermined period of dwell or finish grinding to cause a rearward movement of the wheel slide 40 so as to withdraw the grinding wheels 45 and 46 from operative engagement with the work piece after it has been ground to a predetermined extent.

Manual feed adjustment

Each of the feed screws 101 and 131 are arranged so that they may be manually rotated to independently adjust the positions of the wheel slides 40 and 55 when desired. The feed screw 131 is provided at its forward end with a bevel gear 235 which meshes with a bevel gear 236 mounted on the inner end of a rotatable shaft 237 (Figs. 2 and 8). The outer end of the shaft 237 carries a gear 238 meshing with a gear 239 carried by the shaft 240 which also supports a manually operable feed wheel 241.

The feed screw 101 may be rotated manually by a similar manually operable feed mechanism, the details of which have not been completely illustrated, since they are identical in construction to that shown and above described. The feed screw 101 carries at its forward end a bevel gear 246 which meshes with a bevel gear 247 on the end of a shaft 248. The shaft 248 is connected by a pair of gears (not shown) to a shaft 249 which may be rotated by a manually operable feed wheel 250.

To facilitate truing of the grinding wheel face, it is desirable to provide a means for advancing the grinding wheel toward the work support by predetermined but adjustable increments so that the wheel may be readily advanced for a truing operation. As shown in the drawings (Fig. 8), a ratchet wheel 255 is mounted on the shaft 240. A pawl carrying disk 256 is rotatably supported on the shaft 240 and is provided with a stud 257 which supports a pawl 258 so that it rides on the teeth of the ratchet wheel 255. The pawl carrying plate 256 is provided with an outwardly extending arm 259 which is arranged in the path of a pair of opposed adjustable stop screws 260 and 261. The stop screws serve to limit the motion of the pawl carrying plate 256 so that at each actuation of the plate, the pawl 258, it will pass over and pick up the desired number of teeth on the ratchet wheel 255.

An electrically controlled fluid pressure mechanism is provided to actuate said pawl carrying member 256 and the pawl 258. The pawl carrying plate 256 is provided with an outwardly extending arm 263 which is connected to one end of a piston rod 264. The piston rod 264 is connected to a piston 265 within a fluid pressure cylinder 266. A spring 267 serves to cause a downward movement of the piston 265 when the fluid pressure is relieved in a cylinder chamber 268. Fluid under pressure from fluid pump 135 passes through the pipe 138 and a pipe 269 to a control valve 270. The control valve 270 is of a piston type comprising a valve stem 271 having valve pistons 272 and 273 thereon. Fluid under pressure entering the pipe 269 passes into a valve chamber 274 between the valve pistons 272 and 273. A spring 275 surrounding the valve piston 271 and interposed between the piston 272 and the end of the valve chamber serves to move the valve toward the right, as viewed in Figs. 2 and 10. An electrical solenoid 276 is operatively connected to move the piston rod 271 toward the left, as viewed in Figs. 2 and 10, to cause the valve piston 272 to move toward the left into the position illustrated in Fig. 2 to open a passage 277 so as to admit fluid under pressure to the cylinder chamber 268 to move the piston 265 upwardly and thereby rock the pawl carrying plate 256 so that the pawl 258 advances the ratchet wheel 255 a predetermined amount to cause a predetermined incremental infeeding of the grinding wheel slide 55. In the diagrammatic showing in Fig. 2, the valve stem 271 is connected directly to the solenoid 276. However, in the actual construction, as illustrated in Fig. 8, the valve stem 271 is connected to one end of a rock arm 278 which is pivotally mounted on a stud 279. The other end of the rock arm 278 is connected by a short link 280 with the solenoid 276.

When the solenoid 276 is deenergized, the released tension of the spring 275 moves the valve stem 271 to the right (Figs. 2 and 10) so that the valve piston 273 engages the end of the valve chamber. In this position of the valve, the released tension of the spring 267 causes a downward movement of the piston 265 which exhausts fluid from the cylinder chamber 268 through a passage 281 into the valve chamber 274 and through a pipe 282 into the pipe 151 and the reservoir 107. The downward movement of piston 265 and piston rod 264 causes the pawl carrying plate 256 to rock in a clockwise direction (Fig. 8) to carry the pawl 258 idly over the ratchet teeth to its initial position.

An identical mechanism is provided for turning the hand wheel 250 so as to provide an incremental rotation of the feed screw 101. This mechanism is identical with the mechanism for rotating the cross feed screw 131 and as shown and described in connection with Figs. 2, 8, 9 and 10. Consequently, this duplicate mechanism has not been shown in detail but has been merely indicated diagrammatically in Fig. 2. This mechanism comprises a ratchet pawl 285 carried by a plate 286 which is rotatably supported on the shaft 249. The pawl 285 is arranged to engage a ratchet wheel (not shown) which is identical to that shown in Figs. 8 and 9. The plate 286 is provided with an extending arm 287 which is arranged in the path of adjustable stop screws 288 and 289. The screws 288 and 289 serve to adjust the extent of movement of the

pawl 285 at each actuation thereof. The plate 286 is provided with an outwardly extending arm 290 which is connected to a piston rod 291. The piston rod 291 is connected to a piston 292 within a cylinder 293. A spring 294, surrounding the piston rod 291 and interposed between the piston 292 and the end of the cylinder, serves to move the piston 292 downwardly. Fluid under pressure passing through the pipe 108 passes into a valve chamber 295 between valve pistons 296 and 297. The valve pistons 296 and 297 are formed integral with a valve stem 298. A spring 299 serves to hold the valve in a position toward the left (Fig. 2) and an electric solenoid 300 connected to the valve stem 298 serves to move the valve toward the right. When the solenoid 300 is energized to shift the valve pistons 296 and 297 toward the right, fluid under pressure passing into the valve chamber 295 passes outwardly through a passage 301 into a cylinder chamber 302 to cause the piston 292 to move upwardly and thereby actuate the pawl 285 to turn the feed screw 101 through a predetermined increment, so as to advance the wheel side 40 and the grinding wheels 45 and 46 toward the work support or the truing tool for truing the operative face thereof or for making an adjustment to compensate for wheel wear.

Electric control

To attain one of the main objects of this invention, namely to provide a centralized electrical control system whereby the various movements of the machine parts may be readily controlled from an operating station in front of the machine, an electric switchboard 305 is mounted on an apron 306 projecting from the machine base 15. As shown in the wiring diagram in Fig. 6, electric power from the power lines 307 is connected through a magnetic starter switch 308 to control the headstock driving motor 24. A control switch 315 is provided to operate the magnetic starter switch 308. A pair of push buttons 316 and 318 are mounted on the control panel 305 for actuating the switch 315. The push button 316 is pushed downwardly to close the switch 315 and to energize a solenoid 317 which closes the magnetic starter switch 308 to start the motor 24 and thereby to rotate the work piece 19. When the push button 318 is pushed downwardly to open the switch 315, thereby breaking the circuit and deenergizing the solenoid 317, this movement serves to open the magnetic starter switch 308 and thereby stop the rotation of the motor 24 and the work piece 19.

Power from the power line 307 also is conveyed through a magnetic starter switch 309 to control the rotation of the motor 48 which is mounted on the wheel slide 40 for rotating the grinding wheels 45 and 46. A switch is provided for controlling the starter switch 309 which comprises a pair of push buttons 320 and 321. When it is desired to start the motor 48 to rotate the grinding wheels 45 and 46, the push button 320 is pushed downwardly, which motion serves to close a circuit and energize a solenoid 322 which closes the magnetic starter switch 309 and thereby starts the rotation of the motor 48. When it is desired to stop the motor, the push button 321 is pushed downwardly to break the circuit, deenergizing the solenoid 322 to open the magnetic starter switch 309 and thereby stop the rotation of the motor 48 and the grinding wheels 45 and 46.

Similarly, a pair of push buttons 325 and 326 are provided to control the magnetic starter switch 310 to start or stop the rotation of the motor 65 for rotating the grinding wheels 60 and 61. When the push button 325 is pushed downwardly, it serves to close the circuit and energize a solenoid 327 which serves to close the magnetic starter switch 310 to start the rotation of the electric motor 65 and thereby start the rotation of the grinding wheels 60 and 61. When it is desired to stop the motor 65, the push button 326 is pushed downwardly to open the circuit, thereby deenergizing the solenoid 327 and allowing the magnetic switch 310 to stop the rotation of the motor 65 and the grinding wheels 60 and 61.

Power from the power lines 307 is conveyed to a magnetic starter switch 311 to control the rotation of the motor 83 to drive the fluid pressure pumps 105 and 135 and also the coolant fluid pump 80. A pair of push buttons 330 and 331 serve to control the closing and opening of the magnetic starter switch 311 to start and stop the motor 83. When the push button 330 is pushed downwardly, it serves to close a circuit, energizing a solenoid 332 to close the magnetic starter switch 311 and thereby start the rotation of the electric motor 83 and thereby start in operation the fluid pressure pumps 105 and 135 and the coolant fluid pump 80. When it is desired to stop the motor 83, the push button 331 is pushed downwardly to open the circuit, thereby deenergizing the solenoid 332 to open the magnetic starter switch 311 to stop the rotation of the motor 83.

In order to advance the grinding wheels 45 and 46 for compensating for wheel wear or to advance the wheels toward a truing apparatus, power is taken from the power lines 307 through a push button switch 335 to energize the solenoid 300. When it is desired to cause an incremental infeeding movement of the grinding wheels 45 and 46, the push button 335 is pushed downwardly to close the circuit, thereby energizing the solenoid 300 which serves to actuate the valve stem 298 to admit fluid under pressure to the cylinder chamber 302 to actuate the infeed pawl 285 and thereby advance the wheel slide 40 and the grinding wheels 45 and 46 by a predetermined increment. When the push button 335 is released, it returns to an open circuit, thereby deenergizing the solenoid 300, and the released tension of the spring 299 returns the valve stem 298 to the position illustrated in Fig. 2 to allow the ratchet pawl 285 to return to its initial position so that it is ready for another incremental feeding movement.

In grinding a work piece with a plurality of grinding wheels as indicated, namely the wheels 45 and 46 mounted on the wheel slide 40 and the grinding wheels 60 and 61 mounted on the wheel slide 55, it is desirable to provide a suitable cycle control mechanism which serves to simultaneously cause an infeeding movement of both wheels, so that both wheel slides 40 and 55 simultaneously approach the work support to simultaneously grind a plurality of portions on the work piece 19. Power from the power lines is connected through a magnetic starter switch 312 to simultaneously energize the solenoids 125 and 155 to simultaneously shift the feed control valves 110 and 140 into the reverse position from that shown in Fig. 2 so as to admit fluid under pressure simultaneously into cylinder chambers 118 and 148 to cause the wheel slides 40 and 55 to move simultaneously toward the work piece 19 to bring the grinding wheels 45, 46 and 60, 61 simul-

taneously into grinding relation with the work piece 19.

In order to simultaneously control the infeeding movement of both wheel slides 40 and 55 so that they may both be moved simultaneously into operative engagement with the work, a cycle push button 339 is provided. The push button 339 is arranged to control the closing of a magnetic starter switch 312 to simultaneously energize the solenoids 125 and 155 which serve to simultaneously shift the feed control valves 110 and 140 to cause a forward movement of the wheel slides 40 and 55 and the grinding wheels 45, 46 and 60, 61 respectively. The mercury switches 203 and 231 are normally in an open position at the start of the grinding operation when the dwell control valves are in their downward position. It is, therefore, necessary to provide current to energize a solenoid 342 which serves to close the magnetic starter switch 312. In order to obtain the desired current, a transformer 341 has its primary coil connected with the magnetic starter switch 311 which is always closed during the time the machine is in running operation since this magnetic starter switch serves to rotate the fluid pumps. The secondary of the transformer 341 is connected in series with the solenoid 342 and the push button 339 so that when the push button is moved downwardly to close the circuit, it serves to energize the solenoid 342 to close the magnetic starter switch 312 so as to simultaneously energize the solenoids 125 and 155 to cause a simultaneous infeeding movement of both of the wheel slides 40 and 55.

Due to the fact that the mercury switches 203 and 231 are normally open, it is necessary to press a cycle control button 339 downwardly to energize the solenoid 342 to close the magnetic starter switch 312 and to hold the push button 339 in a downward position until the pistons 104 and 134 have advanced so that the sleeves 167 and 191 engage the dash pot pistons 161, 162 and 189, 190 which serves to force fluid through the passages or pipes 177 into the chambers 178 at the lower end of the dwell control valves in each of the dwell control units 195 and 196 which causes an upward movement of the pistons 199. The upward movement of the pistons 199 allows the mercury switches 203 and 231 to rock into a closed position, as shown in Fig. 7. The push button 339 may then be released and the infeed grinding movement of the wheel slides 40 and 55 and grinding wheels 45, 46 and 60, 61 will continue until the dwell control valve again trips the mercury switches 203 and 231 to break the circuit, thereby deenergizing the solenoids 125 and 155 so that the released tension of the springs 123 and 153 serves to reverse the valves 110 and 140 to admit fluid to the cylinder chambers 117 and 147 to cause a rearward movement of the grinding wheel slides 40 and 55.

In a precision grinding machine, the grinding operation is materially affected by rapid changes of pressure fluid in the system, such as the reversal of one of the wheel slides prior to the reversal of the other wheel slide. The sudden shift or reversal of fluid under pressure is sufficient to set up a vibration in the machine parts which detrimentally affects the grinding operation. The mercury switches for controlling the feed reversing valves are, therefore, preferably connected in parallel so that if one dwell control valve trips to open the mercury switch before the other wheels have finished grinding, the wheels first to complete their grinding remain in operative contact with the work until the second dwell control apparatus trips the second mercury switch which then opens the circuit, thereby deenergizing both of the solenoids 125 and 155 to simultaneously release the tension of the springs 123 and 153 which serves to simultaneously reverse the valves 110 and 140 and thereby remove both sets of grinding wheels simultaneously from operative engagement with the work piece.

It is desirable to provide a readily accessible control means for removing all of the grinding wheels from engagement with the work in case of trouble during a given grinding operation. A return push button 340 is provided which serves when pressed to open the circuit, thereby deenergizing the solenoid 342 and opening the magnetic starter switch 312 to deenergize the solenoids 125 and 155 to immediately return the grinding wheel slides 40 and 55 to their rearward or inoperative grinding positions.

When it is desired to true the grinding wheels, it is preferable to true the wheels when they are in their forward or finish grinding position. It is, therefore, desirable to provide means for bringing the grinding wheels forward and holding them in their forward or grinding position during the truing operation. This is preferably accomplished by a switch 345 which in the position illustrated in the wiring diagram in Fig. 6 allows the mercury switches 203 and 231 to control the reversal of the wheel slide movement. A push button 346 when pushed downwardly serves to open the switch 345, that is to place the switch in the position in accordance with Fig. 6. When it is desired to true the wheels, a switch button 347 is pressed downwardly to close the switch 345 for a truing operation. In this position of the switch 345, the cycle control button 339 may then be pushed downwardly to start a simultaneous infeeding movement of the wheel slides 40 and 55. This movement of the push button 339 serves to close the magnetic starter switch 312 so as to energize the solenoids 125 and 155 to cause an infeeding movement of both wheel slides. Due to the fact that the switch 345 is closed, the solenoid 342 holds the magnetic switch 312 closed during the desired time for truing the grinding wheels while they are in a forward position.

When it is desired to resume the grinding operation, the push button 340 is pushed to return both wheel slides to their initial or inoperative positions. The grinding push button 346 is then closed and the normal grinding cycle may then be obtained by pushing the cycle control button 339 to start simultaneous grinding movement of both wheel slides 40 and 55.

To facilitate rapid operation of the machine, it is desirable to automatically stop the work rotation after the completion of the grinding operation so that the ground work piece may be quickly removed and a new piece of work to be ground placed in the machine. To accomplish this result automatically, a limit switch 365 is connected in series with the control switch 315 in the work motor control circuit. The limit switch 365, having an actuating roller 366, is arranged in the path of an actuating arm 367 projecting from the rear end of the piston rod 102 so that when the wheel slide 40 moves to its rearward position, the arm 367 strikes a roller 366 on the limit switch 365 and opens the switch to break the circuit, thereby deenergizing the solenoid 317 which in turn opens the magnetic starter switch 308 to stop the rotation of the

work driving motor 24. In order that the rotation of the motor 24 may be stopped quickly, a solenoid brake 348 is connected in the motor circuit to stop the rotation of the motor and the work piece immediately upon the breaking of the circuit by the limit switch 365. The solenoid brake 348, as indicated by the solenoid in Fig. 6 of the drawings, is a standard electrical control unit. Consequently it is not deemed necessary to show the details of construction. One type of solenoid brake is the General Electric spring set brake in which a solenoid 348 is energized when the current is turned on to rotate the motor 24 and which is arranged so that when the current is cut off by the limit switch 345, the solenoid 348 is deenergized, thereby releasing a compression spring which contacts a pair of brake shoes engaging the motor shaft quickly to stop the rotation of the motor.

To facilitate setting up the machine for grinding various work pieces, it is desirable to provide a longitudinal adjustment for the grinding wheel slides 40 and 55. As illustrated in Fig. 3, the transversely movable wheel slide 55 together with its operating mechanism is supported on an intermediate slide 370 which is arranged for a longitudinal adjustment on ways 349 and 350 on the base 15. To facilitate longitudinal adjustment of the intermediate slide 370, a rotatable screw 351 is supported in a bearing bracket 352 on the base 15. A nut 353 depending from the intermediate slide 370 meshes with the threads on the screw 351 so that when the screw 351 is rotated, the intermediate slide 370 together with the wheel slide 55 and the grinding wheels 60 and 61 will be adjusted longitudinally relative to the base 15. An identical intermediate slide 354 is provided for adjusting the wheel slide 40 longitudinally. The ways and adjusting mechanism have not been illustrated in detail since they are identical with the adjustment for the slide 370. If the machine is to be set up for grinding a work piece having differently spaced portions to be ground, the wheel slides 40 and 55 may be readily adjusted longitudinally to locate the grinding wheels in the desired location relative to the work piece.

One or more grinding wheels may be mounted on each of the wheel sleeves 59 and the wheels may be spaced on the flanges to correspond with the spacing of the portions of the work to be ground by providing spacing collars of the desired width.

Operation

The operation of this machine will be readily apparent from the foregoing disclosure. A work piece 19 is mounted between the headstock center 21 and the footstock center 23, and the push button 320 is pressed downwardly to close the magnetic switch 309 and start the rotation of the motor 48 which starts the rotation of the grinding wheels 45 and 46. The push button 325 is then pressed downwardly to close the magnetic switch 310 to start the rotation of the motor 65 to rotate the grinding wheels 60 and 61. The push button 330 is pressed downwardly to close the magnetic starter switch 311 to start the rotation of the motor 83 to rotate the fluid pressure pumps 105 and 135 and also the coolant fluid pump 80. The push button 316 is then pushed downwardly to close the circuit to close the magnetic starter switch 308 and thereby start the rotation of the work driving motor 24 to rotate the work piece 19. The push button 346 is pressed downwardly for a grinding operation to open the switch 345 so as to render the mercury switches 203 and 231 operative. The cycle control button 339 is then pressed downwardly to start the grinding cycle. The push button 339 is held downwardly, serving to energize the solenoids 125 and 155 to shift the reverse feed control valves 110 and 140 into the reverse position from that shown in Fig. 2 to admit fluid under pressure to the cylinder chambers 118 and 148 to cause an infeeding movement of the wheel slides 40 and 55 and the grinding wheels 45, 46 and 60, 61 respectively. The push button 339 is held in a downward position until the sleeves 167 and 191 engage the ends of the dash pot pistons 161, 162, 189 and 190 which serve to raise the dwell control piston 199 in each of the dwell control units 195 and 196 to tip the mercury switches 203 and 231 to close the switches so as to hold the solenoids 125 and 155 in an infeeding position. The push button may then be released and the grinding operation proceeds until the sleeves 180 and 193 engage the ends of the dash pot cylinders to stop the infeeding movement of the grinding wheel. The dwell control valve pistons 199 in each of the units 195 and 196 then drop under the influence of gravity at a controlled rate. The downward movement of the dwell control valves serves to rock the mercury switches 203 and 231 to break the circuit. The mercury switches being connected in parallel to the circuit, after both of the mercury switches 203 and 231 have been tipped to break the circuit, the solenoids 125 and 155 are deenergized and the released tension of the springs 123 and 153 rapidly reverses the valves 110 and 140 into the position illustrated in full lines in Fig. 2 to admit fluid under pressure to the cylinder chambers 117 and 147 and thereby withdraw the grinding wheels 45, 46 and 60, 61 from operative engagement with the work piece. The rearward movement of the piston rod 102 causes the arm 367 to strike the roller 366 and actuate the limit switch 365 to open the circuit and stop the rotation of the work driving motor 24 to rapidly stop the rotation of the work and permit removal thereof and replacement with a fresh piece of work. In between grinding operations, after the machine is in operation, it is only necessary to place a work piece in the machine and to press the push button 316 to start the work rotation and to press the cycle control button 339 to start the grinding cycle. The other control buttons operate parts which run continuously during the production grinding operation of the machine.

In case it is desired to true the grinding wheels, the push button 347 is pushed downwardly to close the switch 345 so as to render the mercury switches 203 and 231 inoperative. A truing tool is then mounted, either on the work table or on centers, and the cycle control push button 339 is then pressed, which serves to move the grinding wheels 45, 46, 60 and 61 into a forward or finish grinding position. Due to the fact that the mercury switches 203 and 231 are rendered inoperative, the grinding wheels will stay in their forward or finish grinding position during the time required for truing. After the truing has been completed, the grinding wheel slides 40 and 55 may be again returned to their initial position by pressing the return button 340. During the truing operation, the wheel slides 40 and 55 may be advanced by predetermined increments by pressing the buttons 335 and 336 respectively. Each time the buttons 335 and 336 are pressed,

the feed screws are rotated through a predetermined extent by means of the feed pawls 258 and 285 so that the wheels may be advanced for truing by predetermined increments to compensate for the wear of the wheels and also to cause an infeeding movement of the wheels to a sufficient extent for the 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 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 comprising a base, a longitudinally movable table thereon, a rotatable work support on said table, means to support a work piece thereon, two spaced independently transversely movable wheel slides on said base, a rotatable grinding wheel on each of said slides which are arranged to grind spaced portions on said work piece, an independent fluid pressure operated feeding mechanism including a piston and cylinder operatively connected to independently move each of the wheel slides transversely toward and from the work support to grind a workpiece, a control valve for each of said cylinders to control the admission of fluid to and from said cylinder, electrically controlled means including a solenoid to independently actuate each of said control valves to cause a forward or rearward transverse feeding movement of said slides, an electrical cycle control mechanism including a magnetic starter switch to simultaneously energize said solenoids to shift the control valves so as to simultaneously admit fluid to said cylinders to cause a simultaneous transverse approaching movement of the wheel slides toward the work piece to grind the work piece to a predetermined size, and an electric switch associated with each of the feeding mechanisms which are connected and arranged to release said starter switch when each grinding wheel has completed a grinding operation.

2. A grinding machine comprising a base, a longitudinally movable table thereon, a rotatable work support on said table, means to support a work piece thereon, a plurality of spaced independently transversely movable wheel slides on said base, a rotatable grinding wheel on each of said slides which are arranged to grind spaced portions on said work piece, an independent fluid pressure operated feeding mechanism including a piston and cylinder operatively connected to independently move each of said grinding wheel slides toward or from the work support, a pair of control valves each connected to one of said cylinders to control the admission of fluid under pressure to said cylinders, a spring associated with each of said valves and arranged to hold the valve in position to admit fluid to cause a rearward movement of said wheel slides, electrically operated means including a solenoid associated with each of said valves which is arranged when energized to shift the control valve to cause a forward feeding movement of the grinding wheel slides, and means including an electrically actuated cycle control mechanism to simultaneously actuate said valves to cause a simultaneous approaching and receding movement between each of said slides and the work support.

3. A grinding machine comprising a base, a longitudinally movable table thereon, a rotatable work support on said table, means to support a work piece thereon, a plurality of spaced independent transversely movable wheel slides on said base, a rotatable grinding wheel on each of said slides which are arranged to grind spaced portions on a work piece, a nut and screw feeding mechanism for each of said slides, a manually operable feed wheel for independently adjusting each of said feed screws to independently adjust the position of said slides, a hydraulic piston and cylinder mechanism operatively connected to and arranged in axial alignment with each of said feed screws to cause a power operated feeding movement of the wheel slide toward and from the work support, a control valve for each of said cylinders and means including an electrically operated cycle control mechanism to simultaneously actuate each of said valves to admit fluid under pressure to each of said cylinders to cause a simultaneous movement of each of said wheel slides either toward or from the work support.

4. A grinding machine comprising a base, a longitudinally movable table thereon, a rotatable work support on said table to support a work piece thereon for a grinding operation, means including an electric motor to rotate said work piece, two spaced transversely movable wheel slides on said base, a rotatable wheel spindle on each of said slides, a rotatable grinding wheel mounted on each of said spindles which are arranged to grind spaced portions on the work piece, an independent feeding mechanism for each of said wheel slides, a cycle control mechanism to simultaneously actuate each of said feeding mechanisms to cause said slide to approach the work and grind the same to a predetermined size and to thereafter return to an inoperative position, an electric circuit including a push button to rotate the work drive motor, and electrically operated means including a limit switch actuated during its rearward movement to stop the headstock motor and thereby stop the work rotation.

5. A grinding machine comprising a base, a longitudinally movable table thereon, a rotatable work support on said table to support a work piece thereon for a grinding operation, means including an electric motor to rotate said work piece, two spaced transversely movable wheel slides on said base, a rotatable wheel spindle on each of said slides, a rotatable grinding wheel mounted on each of said spindles which are arranged to grind spaced portions on the work piece, an independent feeding mechanism for each of said wheel slides, a cycle control mechanism to simultaneously actuate each of said feeding mechanisms to cause said slide to approach the work and grind the same to a predetermined size and to thereafter return to an inoperative position, an electric circuit including a push button to rotate the work drive motor, and electrically operated means including a limit switch actuated by said slide during its rearward movement to stop the headstock motor and thereby stop the work rotation.

6. A grinding machine comprising a base, a longitudinally movable table thereon, a rotatable work support thereon, means including an electric motor to rotate said work support, a plurality of transversely movable wheel slides on said base, a rotatable grinding wheel on each of said slides,

means including an electric motor on each of said slides to rotate the wheels, means including a fluid pressure piston and cylinder for each of said slides which are operatively connected to move said slides toward and from the work support, an independent solenoid operated control valve to control the admission of fluid to each of said cylinders, a fluid system including a fluid pressure pump which is operatively connected to convey fluid under pressure to said feeding mechanism, means including an electric motor to rotate said pump, and an electrical control station on the front of the machine base including a push button control for the motor to rotate the grinding wheel, a push button control for the motor to rotate the work, a push button control for the fluid pressure pump motor, and a cycle control push button to simultaneously actuate each of said control valves to control the admission of fluid under pressure to the feeding mechanism to control the grinding cycle.

7. A grinding machine comprising a base, a longitudinally movable table thereon, a rotatable work support on said table, means to support a work piece thereon, a plurality of spaced independent transversely movable wheel slides on said base, a rotatable grinding wheel on each of said slides which are arranged to grind spaced portions on a work piece, an independent nut and screw feeding mechanism for each of said slides, an independent manually operable feed wheel for independently adjusting each of said feed screws to independently adjust the position of each of said slides, an independent electrically controlled pawl and ratchet mechanism to incrementally rotate each of said feed screws, and means including an electric push button associated with each of said pawl and ratchet mechanisms to actuate said pawl and ratchet to cause a predetermined feeding movement of the grinding wheel each time the push button is actuated.

8. A grinding machine comprising a base, a longitudinally movable table thereon, a rotatable work support on said table, means to support a work piece thereon, a plurality of spaced independent transversely movable wheel slides on said base, a rotatable grinding wheel on each of said slides which are arranged to grind spaced portions on a work piece, an independent nut and screw feeding mechanism for each of said slides, an independent manually operable feed wheel for independently adjusting each of said feed screws to independently adjust the position of each of said slides, an independent pawl and ratchet mechanism to actuate said feeding mechanism, an independent fluid pressure mechanism including a piston and cylinder to actuate each of said pawl and ratchet mechanisms, an independent electrically operated mechanism to control the admission of fluid to each of said cylinders, and an electrical control for each of said mechanisms including an independent push button which serves when actuated to admit fluid under pressure to said cylinder to actuate the pawl and ratchet and cause an incremental feeding movement of said grinding wheel.

9. A grinding machine comprising a base, a longitudinally movable table thereon, a rotatable work support on said table, means to support a work piece thereon, a plurality of spaced independent transversely movable wheel slides on said base, a rotatable grinding wheel on each of said slides which are arranged to grind spaced portions on a work piece, an independent nut and screw feeding mechanism for each of said slides, an independent manually operable feed wheel for independently adjusting each of said feed screws to independently adjust the position of each of said slides, an independent pawl and ratchet mechanism to rotate each of said feed screws, a piston and cylinder mechanism to actuate each of said pawl and ratchet, a control valve to control the admission of fluid to each of said cylinders, electrically operated means including a solenoid to actuate each of said valves, and an electrical remote control device including an independent push button for operating each of said solenoids to operate the control valve and admit fluid under pressure to said cylinder to actuate said pawl and ratchet to rotate the feed screw and thereby independently advance the grinding wheels by predetermined increments.

10. A grinding machine comprising a base, a longitudinally movable table thereon, a rotatable work support on said table, means to support a work piece thereon, a plurality of spaced independent transversely movable wheel slides on said base, a rotatable grinding wheel on each of said slides which are arranged to grind spaced portions on said work piece, an independent fluid pressure operated feeding mechanism including a piston and cylinder operatively connected to independently move each of said wheel slides rapidly toward and from the work support, a dash pot piston and cylinder associated with each of said fluid pressure feeding mechanisms which are operative when the wheel slides are moved toward the work support to slow down the rapid approaching movement of the wheel to a predetermined grinding feed, an adjustable stop to positively limit the forward advancing movement of each of said piston and cylinders, a control valve for each of said cylinders to independently control the admission of fluid to and from said cylinders, electrically controlled means including a solenoid to independently actuate each of said control valves to cause a forward or rearward feeding movement of the slide, a dwell control unit associated with each of said dash pot mechanisms including an independent electrically operated switch with each of said mechanisms, said switches being so connected that when all of the grinding wheels have ground the spaced portions of the work piece to a predetermined size, the switches will break a circuit to simultaneously deenergize the solenoids to simultaneously shift the valves to a reverse position to cause a simultaneous rearward movement of all of the wheel slides, and means including an electrical cycle control mechanism including a push button to simultaneously energize said solenoids to shift the control valves so as to simultaneously admit fluid to said cylinders to cause a simultaneous approaching movement of the wheel slides toward the work piece to grind the spaced portions of the work piece to a predetermined size.

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