Dec. 7, 1937. R. A. COLE ET AL 2,101,790

GRINDING MACHINE

Filed Oct. 14, 1936 2 Sheets-Sheet 1

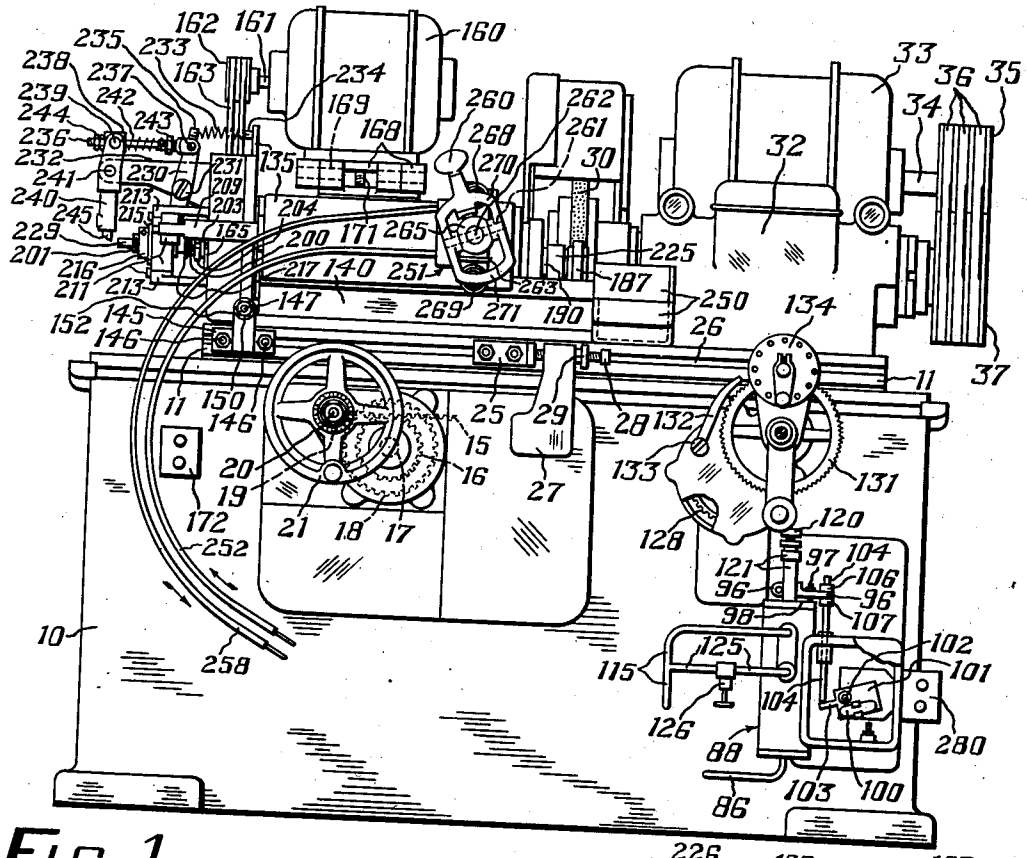


FIG. 1

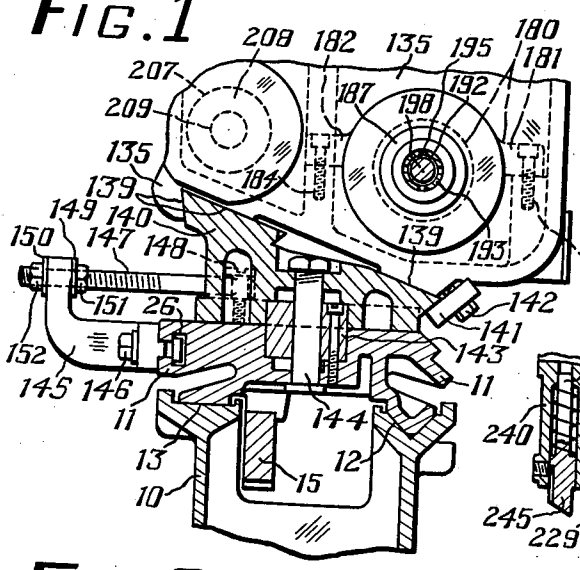


FIG. 3

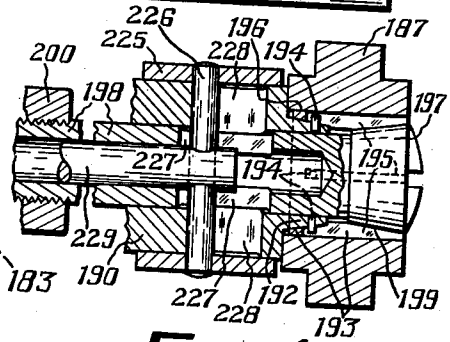


FIG. 4

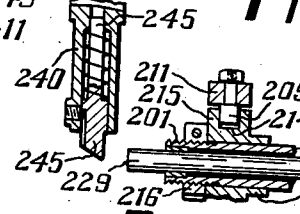


FIG. 5

Inventors

RAYMOND A. COLE

CHARLES H. AMIDON

By Harold W. Eaton Attorney

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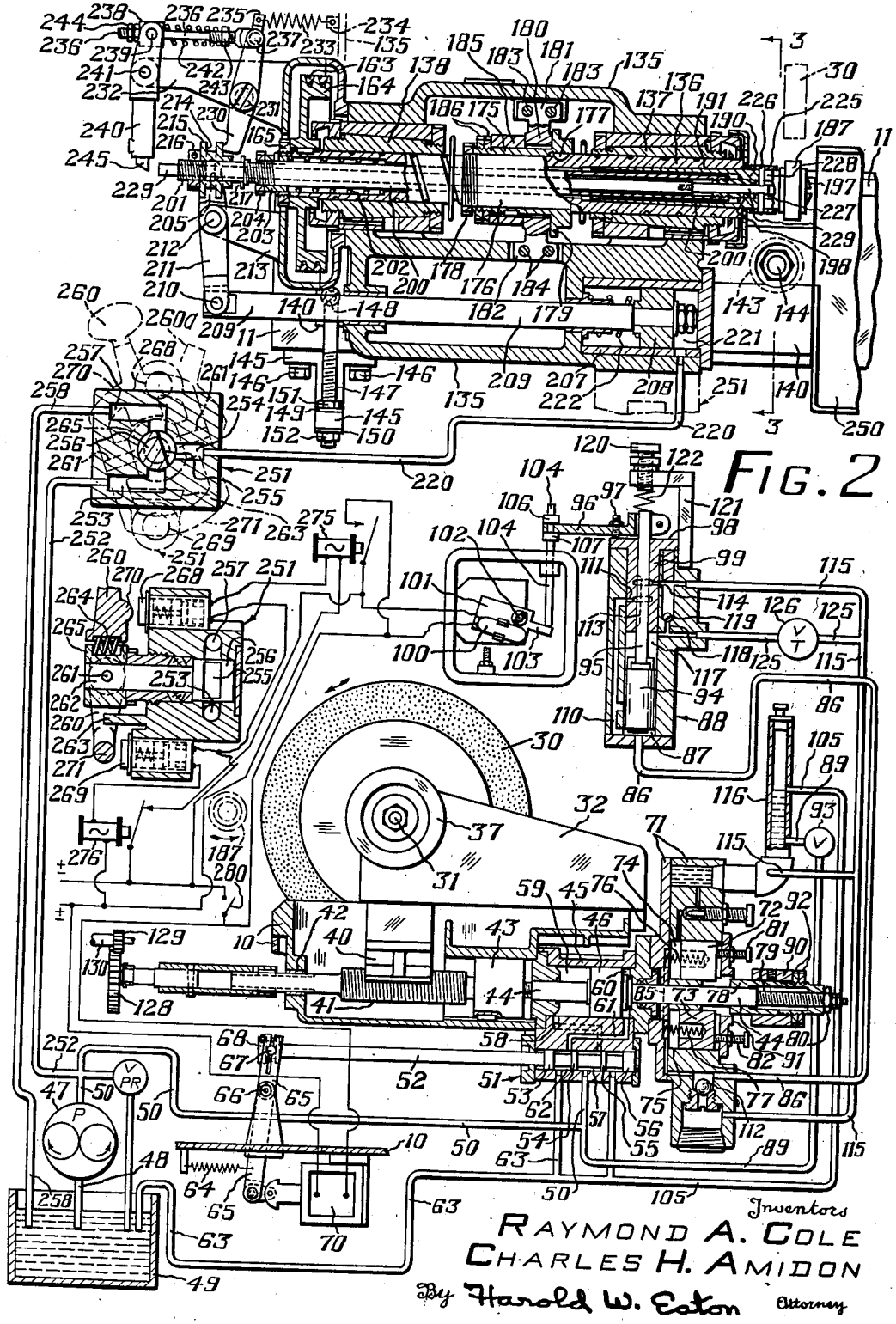


FIG. 2

Inventors
RAYMOND A. COLE
CHARLES H. AMIDON
By Harold W. Eaton Attorney

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GRINDING MACHINE

Raymond A. Cole and Charles H. Amidon, Worcester, Mass., assignors to Norton Company, Worcester, Mass., a corporation of Massachusetts

Application October 14, 1936, Serial No. 105,566

7 Claims. (Cl. 51—105)

This invention relates to a grinding machine, and more particularly to an electrical and hydraulic control mechanism therefor.

One object of the invention is to provide an improved hydraulically operated grinding machine with an improved cycle control mechanism. A further object of the invention is to provide an improved live spindle headstock which is controlled by a manually operable cycle control lever. It is a further object of the invention to provide a hydraulic control mechanism for the grinding wheel and the live spindle headstock which are controlled by a single control lever. A further object of the invention is to provide a hydraulically operated feeding mechanism with an improved electrical control therefor which is controlled or actuated by movement of a single control lever. A further object of the invention is to provide a cyclic wheel feeding mechanism which is electrically controlled. Other objects will be in part obvious or in part pointed out hereinafter.

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

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

Fig. 1 is a front elevation of the improved grinding machine;

Fig. 2 is a sectional view through the live spindle headstock and through the hydraulic wheel feeding mechanism combined with an electrical and hydraulic diagram to illustrate the operation of the machine;

Fig. 3 is a fragmentary sectional view, on an enlarged scale, taken approximately on the line 3—3 of Fig. 2, showing the pivot for the swivel table;

Fig. 4 is a fragmentary sectional view, on an enlarged scale, through the expansion work supporting arbor; and

Fig. 5 is a fragmentary sectional view, on an enlarged scale, through the work ejector actuating mechanism.

A grinding machine has been illustrated in the drawings comprising a base 10 which supports a longitudinally movable work table 11 on a V-way 12 and a flat way 13. The work table 11 may be traversed longitudinally either manually or by power by any of the well-known manual or power operated mechanisms. For simplicity of illustration, a manually operable traverse mechanism has been illustrated. A rack bar 15 depending from the table 11 meshes with a gear 16 which is supported on a shaft 17. The shaft 17 also supports a gear 18 which is either formed integral with the gear 16 or is rigidly connected thereto and arranged to rotate therewith. The gear 18 meshes with a gear 19 carried on the inner end of a rotatable shaft 20. The outer end of the shaft 20 supports a manually operable traverse wheel 21. By rotating the hand wheel 21 in either direction, the work supporting table 11 may be moved longitudinally in the desired direction.

This machine is particularly adapted for grinding a work piece by means of the plunge-cut method, that is by feeding the grinding wheel directly into the work. It is in such an operation that it is desirable to provide a locating mechanism for the work supporting table, whereby the table may be readily positioned in the desired position for grinding. An adjustable dog 25 is carried by a T-slot 26 in the front of the table 11. A fixed bracket 27 is mounted on the machine base and carries an adjustable stop screw 28 and a lock nut 29 which are arranged in the path of the dog 25 and serve to limit the longitudinal movement of the table 11 when the table is moved in a direction toward the right (Fig. 1).

A rotatable grinding wheel 30 is supported on one end of a rotatable grinding wheel spindle 31 which is journaled in bearings (not shown) in a transversely movable wheel slide 32. The wheel slide 32 is arranged to be moved transversely on ways (not shown) on the base 10. The grinding wheel spindle 31 may be rotated in any of the well known manners, such as by means of an overhead drive shaft or countershaft or by means of an electric motor 33 which is mounted on the wheel slide 32. The motor 33 is provided with a motor shaft 34 which carries on its outer end a driving pulley 35. The pulley 35 is connected by driving belts 36 with a pulley 37 mounted on the outer end of the wheel spindle 31. The belt drive above described is preferably of a multiple V-belt type in which a plurality of belts 36 of V-shaped cross sectional area are connected between a multiple V-grooved pulley 35 and a multiple V-grooved pulley 37.

The wheel slide 32 is arranged to be fed transversely toward or from the work supporting table 11 by means of a wheel feeding mechanism to be hereinafter described.

Wheel feeding mechanism

A wheel feeding mechanism is provided to control the feeding movement and adjustment of the grinding wheel 30 toward and from the work support. The wheel slide 32 is provided with a depending nut 40 which meshes with a rotatable feed screw 41. The feed screw 41 is rotatably supported in bearings 42 and 43 in the base 10. The feed screw 41 may be rotated manually for adjusting the position of the wheel slide 32 in setting up the machine by a manually operable feed mechanism, to be hereinafter described.

In order that the wheel slide may be rapidly

moved toward the work piece to grind the same by the plunge-cut method, the feed screw 41 is connected to a piston rod 44. A fluid pressure cylinder 45 is arranged in axial alignment with the feed screw 41 and contains a slidably mounted piston 46 which is connected with the piston rod 44. A fluid pressure pump 47 is mounted to be driven by a shaft (not shown) or by an individual motor drive (not shown) to pump fluid through a pipe 48 from a reservoir 49 within the base 10. The pump 47 forces fluid under pressure through a pipe 50 to a feed control valve 51. The feed control valve 51 preferably is of a piston type comprising a valve stem 52 and pistons 53, 54, 55, and 56. In the position of the valve 51 (Fig. 2), fluid under pressure enters the valve chamber 57 between the valve pistons 54 and 55 and passes out through passage 58 into a cylinder chamber 59 to cause the piston 46 to move rearwardly to withdraw the wheel slide 32 and grinding wheel 30 to an inoperative or rearward position away from the work piece. During the passage of fluid under pressure into the cylinder chamber 59, fluid is exhausted from a cylinder chamber 60, through a passage 61, into a valve chamber 62 between the pistons 53 and 54, and out through a pipe 63 which exhausts into the reservoir 49.

The valve stem 52 is held in a rearward position (Fig. 2) by means of a spring 64 which is connected to a rock arm 65 pivotally mounted on a stud 66 on a bracket mounted on the base 10. The other end of the rock arm 65 is connected by a pin 67 with a spool-shaped member 68 which is mounted on the end of the valve stem 52. In order to shift the feed control valve to a reverse position to cause an infeeding movement of the grinding wheel 30, an electrical control apparatus may be utilized including a solenoid 70 which is connected to the outer end of the rock arm 65. The solenoid 70, when energized, serves to move the valve stem 52 into its reverse position so that fluid under pressure passing through the pipe 50 into the valve chamber 57 passes through the passage 61 into the cylinder chamber 60 to cause the piston 46, to feed screw 41 and the wheel slide 32 to move the grinding wheel 30 into a grinding position with relation to the work piece.

Dash pot

The piston and cylinder mechanism, above described, serves to cause the grinding wheel 30 rapidly to approach or recede from the work piece. In order to reduce the rapid approaching movement to a predetermined grinding feed, it is desirable to provide a wheel feed controlling mechanism, such as a dash pot mechanism, which may be rendered effective when the grinding wheel 30 is about to contact with the surface of the work piece being ground. As illustrated in Fig. 2, an outwardly extending casing 71 is fixed to the end of the cylinder 45 and contains a pair of diametrically spaced dash pot pistons 72 and 73 which slide within dash pot cylinders 74 and 75. The dash pot pistons 72 and 73 normally are held in a rearward position by springs 76 and 77, respectively. During the rapid approach of the grinding wheel 30, the dash pot pistons are inoperative.

The piston rod 44 extends toward the rear of the machine and is provided at its rearward end with a sleeve 78 which may be adjusted longitudinally on a threaded portion 79 of the piston rod 44 by means of a nut 80. The parts are so arranged that the sleeve 78 moves rearwardly when the piston rod 44 moves into a rearward position. The dash pot pistons 72 and 73 are limited in their rearward movement by means of adjusting screws 81 and 82, respectively. When fluid under pressure is admitted to the cylinder chamber 60 to cause the grinding wheel 30 to move toward the work piece, the rapid approaching movement continues until the end of the sleeve 78 engages the ends of the dash pot pistons 72 and 73. The continued movement of the piston 44 is resisted by the dash pot pistons 72 and 73 which forces fluid under pressure from the dash pot cylinders 74 and 75 into a dwell control mechanism to be hereinafter described. The dash pot cylinders 74 and 75 are interconnected by a passage 85 and exhaust fluid through a pipe 86 into a chamber 87 of a dwell control valve 88, as shown in Fig. 2, 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 30 toward the work piece to grind the same and then to stop the infeed and allow the grinding wheel 30 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 cylindrical surface of a predetermined size. As illustrated in Fig. 2, the forward movement of the piston rod 44 causes a rapid approach until the sleeve 78 picks up the dash pot pistons 72 and 73 to cause a slow infeed which continues until an adjustable sleeve 90 engages a fixed surface 91 on the rear end of the casing 71, thereby positively limiting the infeeding movement of the wheel 30 and causing the wheel to dwell in contact with the work during a finish grinding period. The adjustable stop sleeve 90 surrounds the sleeve 78 and is held in adjusted position thereon by means of lock nuts 92.

Wheel feed—dwell control

In order to provide a predetermined but adjustable dwell at the end of the grinding operation to allow the wheel 30 to grind out or finish grind the work, a dwell control mechanism is operatively connected with the dash pot mechanism. The dwell control unit comprises the vertical valve 88 having a piston 94 slidably mounted therein. Fluid under pressure exhausting from the dash pot cylinders 74 and 75 passes through the pipe 86 into the valve chamber 87 in the lower end of the valve 88 to cause an upward movement of the piston 94. The piston 94 is provided with a vertically extending piston rod 95 which carries at its upper end an adjustable arm 96. The arm 96 is provided with an adjustable stop screw 97 which in the lower position engages the upper surface 98 of the bushing 99 of the valve 88. The screw 97 limits the downward movement of the piston 94. Associated with the dwell control unit is a normally open mercury switch 100 which is supported on a pivotally mounted plate 101. The plate 101 is pivotally supported on a stud 102 and is provided with an extending arm 103 which extends into the path of a vertically extending rod 104. The rod 104 passes through an aperture in the arm 96 and carries a pair of adjustable collars 106 and 107 which serve to provide adjustable connections between the rod 104 and the arm 96 to rock the mercury switch 100.

When fluid under pressure is admitted to the

dwell control valve chamber 87 to cause the piston 94 and the piston rod 95 to move upwardly, the arm 96 lifts the rod 104 and allows the plate 101 supporting the mercury switch 100 to rock under the influence of gravity in a counterclockwise direction and to close the mercury switch 100 and thereby close the circuit and energize the solenoid 70.

When fluid is admitted to the dwell control chamber 87 to cause an upward movement of the piston 94, fluid also passes simultaneously through a passage 110 within the wall of the valve 88 and passes through a passage 111 in the bushing 99. The piston rod 95 is provided with a V-shaped groove 113 which allows fluid passing through the passages 110 and 111 to pass along the V-shaped groove 113 during the upward movement of the piston rod 95 and out through a passage 114 in the casing 88, through a pipe 115, into a fluid reservoir 116 mounted on the casing 71 located above the dash pot cylinders 74 and 75. During the upward movement of the piston 94, fluid within a valve chamber 117 of the valve 88 may pass outwardly through a passage 118 and through a ball check valve 119 in the passage 118, through pipe 115 and into the fluid reservoir 116.

The piston 94 moves rapidly in an upward direction until the piston rod 95 engages an adjustable stop screw 120 which is supported in a bracket 121 fixed to the valve head 98. By adjusting the position of the stop screw 120, the upper position of the V-shaped groove 113 may be adjusted and, due to the V-shaped cross sectional area of the groove and the fact that this groove 113 tapers to zero at the end of the groove, serves to control the rate of fluid exhaust from the dash pot chambers 74 and 75 and thereby control the grinding feed.

The V-shaped groove 113 in its upward position serves to restrict the exhaust of fluid from the dash pot chambers 74 and 75 so as to control the rate of infeed of the grinding wheel 30 during the grinding operation. When the grinding wheel 30 is fed toward the work piece by means of the fluid pressure piston 46, the rapid approaching movement continues until the bushing 78 engages the ends of the dash pot pistons 72 and 73, after which the exhaust of fluid from the dash pot chambers 74 and 75 from the dwell control unit serves to slow down the rate of movement of the grinding wheel 30 to a predetermined grinding feed. As soon as the sleeve 78 picks up the dash pot pistons 72 and 73 and causes them to move, the exhaust of fluid from the dash pot chambers 74 and 75 moves the dwell control valve piston 94 upwardly, compressing the spring 122, and rocking the mercury switch 100 so as to close the circuit. The mercury switch 100 is connected through an electric circuit to be hereinafter described with the solenoid 70. The piston 94 remains in its upward position during the movement of the dash pot pistons 72 and 73, which continue to move forward until the adjustable stop sleeve 90 strikes the fixed stop surface 91, thereby preventing further advance of the dash pot pistons 72 and 73. As soon as the exhaust of fluid from the dash pot cylinders 74 and 75 ceases, the released tension of the spring 122 and the force of gravity acting upon the piston 94 and its associated parts starts a downward movement of the piston 94. This downward movement serves to create a partial vacuum in the chamber 117 of the valve 88. Fluid entering into the chamber 117 cannot pass through the ball check valve 119 and passes through a passage or pipe 125 and an adjustable needle valve 126 into the chamber 117. The pipe 125 is connected to the pipe 115 to pass fluid into reservoir 116. The needle valve 126 may be readily adjusted to control the downward movement of the piston 94 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 94 and piston rod 95 drop to a sufficient extent to lower the arm 96 and rod 104 which serves to rock the arm 103 of the plate 101 so as to tip the mercury switch 100 and again open the circuit, which deenergizes the solenoid 70 so as to allow the released tension of the spring 64 to shift the reverse feed control valve 51 and to cause a rearward movement of the grinding wheel slide 32, as will be hereinafter more fully described.

On the return stroke of the grinding wheel, the springs 76 and 77 return the dash pistons 72 and 73 to a rearward position in engagement with the adjustable stop screws 81 and 82, respectively. During this movement the dash pot cylinder chambers 74 and 75 are refilled by fluid under pressure from the reservoir 116 passing through the pipe 115 and a ball check valve 112 so that on the next forward feeding movement of the grinding wheel, the dash pot cylinders are filled and ready to control the infeed of the grinding wheel.

In order to fill the reservoir 116, a pipe 89 is connected with pipe 50 so that fluid from the pump 47 may pass through a control valve 93 and a pipe 89 into the reservoir to fill the same. An overflow pipe 105 serves to prevent the fluid rising beyond a predetermined level in the reservoir 116. The overflow pipe 105 is connected to pipe 63 which exhausts into the reservoir 49. The valve 93 may be opened when desired by the operator to refill the reservoir 116 to take care of any leakage or, if desired, the valve 93 may be partially opened to allow a continuous flow of fluid into the reservoir to maintain the oil level within the reservoir 116 at all times.

Manual feed adjustment

The feed screw 41 is arranged so that it may be rotated manually to adjust the position of the wheel slide 32 when desired. The feed screw 41 is slidably connected at its forward end with a gear 128 which meshes with a gear 129 rotatably mounted on the inner end of a shaft 130. The other end of the shaft 130, which projects from the front of the base 10, supports a manually operable feed wheel 131.

The feed screw 41 may be rotated manually by rotation of the manually operable feed wheel 131 in either direction to adjust the position of the wheel slide 32 and the grinding wheel 30. A stop pawl 132 is pivotally mounted by a stud 133 on the base 10. The pawl 132 is arranged to engage an abutment (not shown) carried by the manually operable feed wheel 131. The feed wheel is provided with a manually operable micrometer adjusting mechanism 134 to facilitate adjustment of the abutment relative to the feed wheel 131, as desired. This mechanism has not been illustrated in detail, since it is not considered part of the present invention. Reference may be had to the prior United States patent to Norton No. 762,838 dated June 14, 1904 for a detailed disclosure.

Rotatable work support

A rotatable work support is provided on the table 11 to support a work piece in operative relation with the grinding wheel 30 for a grinding

operation. In the preferred construction, a live spindle work rotating and supporting mechanism is provided comprising a headstock 135 which is arranged rotatably to support a spindle 136 in bearings 137 and 138. The headstock 135 is provided with surfaces 139 which mate with correspondingly shaped surfaces on a swivel table 140 which is supported on the table 11. The headstock 135 is arranged to be clamped in position on the swivel table 140 by means of a clamping member 141 and a clamping screw 142.

The swivel table 140 is provided so that the axis of rotation of the work rotating spindle 136 may be adjusted relative to the path of movement of the table 11 so that either a true cylinder may be ground or a tapered surface, as desired. The swivel table 140 is pivotally supported on a pivot pin 143 which is secured within the upper surface of the table 11 and which engages an aperture within the swivel table 140. A bolt or stud 144 passes through the table 11, the pivot 143, and the swivel table 140 to hold the swivel table in adjusted position thereon and prevent lifting of the swivel table 140 relative to the table 11. A swivel adjustment is provided at the other end of the swivel table. A bracket 145 is adustably supported by bolts 146 which slide in the T-slot 26 in the front of the table 11. An adjusting screw 147 is connected at its inner end by a stud 148 which is secured to the swivel table 140. The outer end of the screw 147 passes through an aperture within the bracket 145. Thrust washers 149 and 150 are mounted on the screw 147 on either side of the bracket 145. A pair of nuts 151 and 152 carried by the screw thread 147 serve to adjust and to lock the screw 147 in adjusted position. By manipulation of the nuts 151 and 152, the left-hand end of the swivel table 140 (Figs. 1 and 2) may be adjusted transversely so that the axis of rotation of the spindle 136 may be adjusted so that it is parallel to or at an angle with the path of movement of the table to grind either a true cylinder or a tapered work piece thereon. After the swivel table has been adjusted into the desired position, the nuts 151 and 152 are locked in adjusted position and the bolt 144 tightened to lock the swivel table 140 in rigid adjusted position with the table 11.

The work supporting spindle 135 may be rotated by an electric motor 160 which is mounted on top of the headstock 135. A motor shaft 161 is provided with a V-grooved pulley 162 which is connected by multiple V-belts 163 with a pulley 164 which is keyed to the end of the work spindle 136 and is held in adjusted position thereon by a collar 165.

In order to tension the driving belt, the motor 160 is preferably mounted on a pivotally mounted support 168 which is connected by pivot pins 169 with the headstock 135. The rear end of the pivotal support 168 is provided with an adjusting screw 171 by means of which the pivotal support 168 may be adjusted so as to tension the driving belts 163, as desired.

In order that the motor 160 may be readily controlled from the operator's station in front of the machine base, a two-button snap switch 172 is mounted on the front of the machine base.

A suitable end thrust bearing is provided to pick up the end thrust of the rotatable work supporting spindle 136. A sleeve 175 fits on a reduced portion 176 of the spindle 136 and is keyed thereto by means of a key 177. The sleeve 175 is held in position on the spindle by means of the collar 178 which is screw threaded onto the reduced portion 176 of the spindle 136. The sleeve 175 is provided with an integral flange 179 which engages one side of a fixed thrust member 180. The thrust member 180 has diametrically opposed projections 181 and 182 which are secured to the headstock frame 135 by screws 183 and 184. An adjustable thrust collar 185 surrounds the sleeve 175. One end of the sleeve 175 bears against the fixed thrust member 180. A pair of adjustable thrust collars 186 are screw threaded onto the end of the sleeve 175. By adjusting the collars 186, the end thrust of the spindle may be adjusted, as desired, to take up the thrust of the spindle during the grinding operation.

In grinding of certain types of work, it is desirable to provide a live spindle work supporting member which is arranged so that work pieces may be inserted, ground and ejected therefrom without stopping the rotation of the spindle. Such a mechanism has been illustrated in the drawings. A collet supporting member 190 fits within a tapered aperture 191 in the end of the work spindle 136. The outer end of the collet supporting member 190 is provided with a tapered portion 192 which is arranged to support a split expansion arbor or collet 193. The collet 193 is held on the tapered portion 192 by means of a plurality of pins 194 which pass through the slots 195 in the collet member 193 and are fixed in the tapered portion 192 of the collet supporting member 190. The outer surface 196 of the collet 193 is of a size to fit the aperture within the work piece 187. In order to expand the arbor or collet 193, a frusto-conical expanding member 197 is provided on the outer end of a slidable sleeve 198. When the sleeve 198 is drawn or moved toward the left (Figs. 2 and 4), the frusto-conical expansion member 197 engaging an internal frusto-conical surface 199 within the collet 193 expands the same securely to lock the work piece 187 in operative relation to rotate with the spindle 136. The sleeve 198 of the collet expanding member 197 is screw threaded into the end of a sleeve 200 which is arranged to slide longitudinally within the work rotating spindle 136. The sleeve 200 is provided with a reduced threaded portion 201 which projects from the end of the spindle 136. In order automatically to expand or contract the collet 193, the sleeve 200 is moved either toward the right or toward the left (Figs. 2 and 4). It is desirable to provide means for automatically clamping or releasing a work piece on said collet. This is preferably accomplished by means of a power actuated mechanism. A spring 202 is contained within an enlarged aperture in the spindle 136 and is interposed between a shoulder in said aperture and a collar 203 carried by the sleeve 200. The tension of the spring 202 may be adjusted by means of a collar 204 screw threaded onto the sleeve 200. The spring 202 is provided having sufficient compression to move the sleeve 200 toward the left (Figs. 2 and 4) so as to move the expansion member 197 also toward the left (Fig. 4) to expand the collet 193 to hold the work piece 187 in operative position for a grinding operation.

It is desirable to provide a means to move the collet closing member 197 toward the right against the tension of the spring 202 quickly to contract the collet 193 to release the work piece 187 after a grinding operation has been completed. This is preferably accomplished by means of a fluid pressure operated mechanism comprising a fluid pressure cylinder 207 having a slidably mounted piston 208 contained therein.

The piston 208 is connected by a piston rod 209 and a pin or stud 210 with the lower end of a rock arm 211. The rock arm 211 is pivotally supported on a stud 212 carried by a bracket 213 which is fixed to the headstock 135. The other end of the rock arm 211 is yoke shaped and is connected by pivotally supported shoes 205 with a groove 214 in a spool shaped member 215 which is slidably mounted on a reduced portion of the sleeve 200. An adjustable collar 216 and a thrust washer 217 on the reduced portion 201 serve to allow a lost motion connection between the rock arm 211 and the sleeve 200. By adjusting the collar 216 relative to the sleeve 200, the amount of lost motion in said connection may be adjusted as desired.

When it is desired to release the work piece from the expansion arbor or collet 193, fluid under pressure is admitted through a pipe or passage 220 into a cylinder chamber 221 to move the piston 208 and the piston rod 209 toward the left (Fig. 2) so as to rock the arm 211 in a clockwise direction on its supporting pivot 212. During this movement of the rock arm 211, the spool shaped member 215 slides on the sleeve 200 until it engages the thrust washer 217. Continued movement of the rock arm 211 in a clockwise direction slides the sleeve 200 toward the right (Figs. 2 and 4) which in turn moves the member 198 and the tapered collet closing member 197 also toward the right to allow the expansion collet 193 to contract to release the work piece 187. In case the collet 193 moves toward the right with the collet closing member 197, this movement can continue only a short distance until the pins 194 carried by the conical member 192 of the collet supporting member 170 engage the ends of the slots 195 which holds the collet 193 against further endwise movement and allows the collet closing member 197 to withdraw a sufficient distance to allow the collet 193 to contract and release the work piece 187.

After the work piece 187 has been removed and a new piece of work inserted on the rotating collet 193, the fluid pressure within the pipe 220 is cut off and connected with the exhaust by a mechanism to be hereinafter described, which serves to release the compression of the spring 202 which moves the sleeve 200 toward the right to expand the collet 193 again to lock the next piece of work 187 in an operative position to rotate with the spindle 136. A spring 222 which surrounds the piston rod 209 and is interposed between the piston 208 and the left-hand end of the cylinder 207 (Fig. 2) serves to return the piston 208 to its initial position, as illustrated in Fig. 2. A spring 222 cooperates with the spring 202 in closing the collet 193.

Ejecting mechanism

It is desirable to provide an ejector mechanism which will automatically remove the work piece 187 endwise from engagement with the collet 193 when the collet is released. This is preferably accomplished by means of a short sleeve 225 which is slidably mounted on the member 190. A transversely extending pin 226 is fixed at opposite ends to the sleeve 225 and slides within elongated slots 227 and 228 within the members 198 and 190, respectively. The pin 226 passes through an ejector rod 229, of two-piece construction, which is slidably mounted within the sleeve 198 threaded to the sleeve 200 and a bushing at the other end of the sleeve 200, as shown in Fig. 5. When the rod 229 is moved toward the right (Fig. 4), the rod carries the pin 226 and sleeve 225 which engages the end of the work piece 187 and slides the same off the collet 193. It is desirable to provide a suitable mechanism to snap the rod 229 quickly to remove the work piece 187 rapidly from position on the collet 193. This is preferably accomplished by means of a load and fire mechanism comprising a rock arm 230 which is pivotally mounted on a stud 231 supported on a bracket 232. A spring 233 interposed between a stud 234 on the headstock 135 and a stud 235 on the rock arm 230 serves to hold the rock arm 230 in the position illustrated in Fig. 2. A connecting rod 236 is pivotally connected to the rock arm 230 by means of a stud 237. The rod 236 slides within a sleeve 238 which is pivotally mounted on a stud 239 at one end of a rock arm 240. The rock arm 240 is pivotally mounted on a stud 241 on the bracket 232 projecting from the headstock 135. A spring 242 surrounds the rod 236 and is interposed between a nut 243 carried by the rod 236 and the sleeve 238. The tension of the spring 242 may be adjusted by means of the nut 243 and the position of the rock arm 240 may be varied by adjustment of nuts 244 on the end of the rod 236. The lower end of the rock arm 240 is provided with a spring pressed detent 245, as shown in Fig. 5, which is arranged to engage the end of the ejector rod 229 to move the sleeve 225 to eject a work piece 187 from grinding position on the expansion collet 193.

When fluid under pressure is admitted to cylinder chamber 221 to contract the collet 193 to release a work piece 187 after a grinding operation has been completed, the initial movement of the spool-shaped member 215 serves to rock the rock arm 230 and, through the connecting rod 236, serves to rock the rock arm 240 in a counterclockwise direction so that the detent 245 engages the end of the ejector rod 229. Continued movement of the spool-shaped member 215 toward the left (Fig. 2) serves to compress the spring 242 until the sleeve 200 moves a sufficient distance to move the collet expanding member 197 toward the right to contract the expansion collet 193, whereupon the released tension of the spring 242 quickly rocks the rock arm 240 and moves the ejector rod 229 toward the right (Figs. 2 and 4). This movement in turn moves the pin 226 and sleeve 225 rapidly to eject the work piece 187 from the collet 193 into a discharge chute 250 which is supported on the table 11 of the machine.

A fluid pressure control valve 251 is provided manually to control the admission of fluid under pressure through the pipe or passage 220 into the cylinder chamber 221 and to exhaust fluid therefrom when desired. A pipe 252 is connected with the pipe 50 and the pump 47 and passes fluid into a valve chamber 253. In the position of the valve 251 (Fig. 2), fluid is exhausted from the chamber 221, through the pipe or passage 220, into valve chamber 254, through passage 255 in the rotary valve member 256, into valve chamber 257, and out through a pipe 258 which exhausts into the reservoir 49. When it is desired to release a work piece after a grinding operation, the rotary valve 256 is turned so that fluid passing through the pipe 252 into the valve chamber 253 passes through the valve passage 255, into the valve chamber 254, and through the pipe 220, into the cylinder chamber 221, to actuate the piston 208 and its associated parts to release the expansion collet 193 and eject a work piece 187 therefrom.

Control mechanism

It is desirable to provide a simplified control for the machine so that the live spindle headstock **135** and the cyclic control of the wheel feed mechanism may be readily controlled by means of a single manually operable lever. A manually operable control lever **260** is pivotally supported by a stud **261** which passes through a collar **265** and a valve stem **262** which is formed integral with the rotary valve member **256**. By rocking the lever **260** in a plane parallel to the wheel axes, the rotary valve member **256** may be shifted so as either to admit fluid to or exhaust fluid from the cylinder chamber **221** so as either to expand or contract the expansion arbor **193** and clamp or release a work piece **187** thereon. The control lever **260** is held in a vertical position by means of a spring **264** which is supported in an aperture, part of which is formed within the pivotally mounted control lever **260**, and the other part of which is formed in a bushing or collar **265** mounted on the end of the valve stem **262**. In order to limit the swing of the lever **260** to rotate the rotary valve member **256**, a projection **263** is provided to position the valve passage **255** to allow exhaust or intake to the cylinder chamber **221**.

In order that the wheel feed mechanism may be controlled by means of the main control lever **260**, it straddles the collar **265** so that a pair of normally open push buttons **268** and **269** mounted in the control valve **251** are arranged in the path of portions **270** and **271** of the control lever **260**. The portions **270** and **271** of the control lever **260** are formed as arcuate members which are arranged so that in any position of the control lever, the portions **270** and **271** are in a position to actuate the push buttons **268** and **269**, respectively.

To start the cyclic wheel feeding movement, the control lever **260** is rocked in a clockwise direction (as shown in full lines in Fig. 2) to push the button **268** which serves to operate a relay **275** which serves to close a circuit to energize the solenoid **70**. The energizing of solenoid **70** serves to shift the feed control valve **51** to initiate a forward movement of the grinding wheel **30**, the cycle of movement of which continues under the control of the hydraulic piston **46**, the dash pot pistons **72** and **73**, and the dwell control valve **88** which controls the extent of dwell and then returns the grinding wheel **30** and its supporting slide **32** to a rearward or inoperative position.

It is desirable to provide means for interrupting the cycle of operation of the machine and rapidly returning the wheel **30** and wheel slide **32** to their initial or rearward position when desired by the operator in case of trouble with the machine. In order to accomplish this result, the push button **269** is arranged so that when the lever **260** is rocked in a counterclockwise direction (Fig. 2), it serves to close a circuit, thereby energizing a relay **276**. The energizing of relay **276** serves to break the electrical circuit which holds the solenoid **70** energized for an infeeding movement, thereby deenergizing the solenoid **70** and releasing the tension of the spring **64** which serves rapidly to move the valve stem **52** toward the right (Fig. 2) to reverse the flow of fluid under pressure and thereby admit fluid under pressure to the cylinder chamber **59** to cause a rapid rearward movement of the slide **32** and the grinding wheel **30**. The lever **260** may be operated at any time during the grinding cycle in case of difficulty in the operation of the machine quickly to return the parts to a starting or inoperative position.

The cyclic wheel feeding mechanism above described serves to bring the grinding wheel **30** forward to a predetermined position and then automatically to withdraw the grinding wheel **30** to an inoperative position. In case it is desired to true the grinding wheel **30**, it is desirable to provide means whereby the grinding wheel slide **32** may be moved into its forward position and retained there during the wheel truing operation. A two-button snap switch **280** (Figs. 1 and 2) serves when closed to close a circuit independent of the cyclic wheel feed mechanism above described so as to energize the solenoid **70** which causes a forward feeding movement of the grinding wheel **30**. The wheel slide **32** moves forward until the stop sleeve **78** engages the stop surface **91** on the end of the dash pot cylinder casing **71**. The solenoid **70** remains energized, holding the control valve **51** in a position to retain the wheel slide **32** in its forward position until the desired truing operation has been completed. The snap switch **280** may then be operated to open the circuit which serves to deenergize solenoid **70** and allows the released tension of the spring **64** again to shift the control valve **51** into the position illustrated in Fig. 2, thus providing an independent means to move the grinding wheel **32** forward into its finish grinding position for a wheel truing operation.

Operation

The operation of this grinding machine is readily apparent from the foregoing disclosure.

Assuming the parts to have been previously adjusted so that the desired grinding cycle is obtained and the live spindle work headstock **135** has been adjusted and set up for grinding a work piece **187** of a predetermined size, a snap switch is operated to start the rotation of the motor **33** to rotate the grinding wheel **30**, a second snap switch is operated to start the fluid pressure pump **47**, and a snap switch **172** is operated to start the rotation of the work rotating motor **160**. The work piece **187** is then manually placed in position on the expansion arbor **193** which is continuously rotated, the control lever **260** (dotted lines, Fig. 2) is then moved from position **260a** to allow fluid within the chamber **221** to exhaust through the pipe or passage **220** and valve **251** and pipe **258** into the reservoir **49**. This movement releases the spring **222** and the spring **202** which serves to return the piston **208** to the position shown in Fig. 2 and to move the sleeve **200** toward the left (Figs. 2 and 4) so that the collet expanding member **197** expands the collet **193** to hold the work piece **187** in an operative grinding position to rotate with the spindle **136**.

The lever **260** (full lines, Fig. 2) is then moved in a clockwise direction to operate the push button **268** which serves to actuate the relay **275** so as to energize solenoid **70** which in turn shifts the control valve **51** to admit fluid so as to cause a forward feeding movement of the wheel slide **32** and the grinding wheel **30**. The control lever **260** is held in a position to hold push button **268** in a closed position during the initial forward feeding movement of the grinding wheel **30** and until the sleeve **78** picks up the dash pot pistons **72** and **73** which exhausts fluid through pipe **86** to cause an upward movement of the dwell control valve piston **94**. The upward movement of the dwell control piston **94** allows the mercury switch **100** to rock in a counterclockwise direction to close

the circuit, which holds the solenoid 70 in an energized position, after which the control lever 260 may be released and the spring 264 returns it to the position illustrated in Fig. 2.

The infeeding movement of the grinding wheel 30 continues at a slow rate until the stop sleeve 90 engages the stop surface 91 at the rear of the dash pot cylinder casing 71. The grinding wheel 30 remains in grinding contact with the work piece 187 until the piston 94, under the influence of the released tension of the spring 122, pushes down piston 94 at a controlled rate to rock the mercury switch 100 again in a clockwise direction into the position illustrated in Fig. 2, which movement serves to break the circuit, thereby deenergizing the solenoid 70. The deenergizing of the solonoid 70 releases the tension of the spring 64 which returns the valve 51 into the position illustrated in Fig. 2 to admit fluid into cylinder chamber 59 to cause the grinding wheel 30 and the wheel slide 32 to move to an inoperative rearward position.

When the wheel slide has withdrawn, the lever 260 may be rocked from position 260 (broken lines, Fig. 2) into position 260*a* which serves to shift the valve 251 so as to admit fluid under pressure through the pipe or passage 220 into cylinder chamber 221 which operates through the associated parts above described to contract the collet 193 and eject the work piece 187 therefrom into the discharge chute 250. A new piece of work 187 may then be inserted on the continuously rotating collet 193 and the cycle of operation may be continued.

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, a base, a rotatable grinding wheel, a transversely movable slide therefor, a rotatable work supporting spindle, a motor which is arranged continuously to rotate said spindle, a chuck on said spindle, means including a fluid pressure piston and cylinder to control said chuck to clamp or release a work piece thereon, means including a fluid pressure operated piston and cylinder operatively connected to move the wheel slide transversely in either direction, an electrical control mechanism for said fluid pressure wheel feeding mechanism, a control valve to admit fluid to said chuck operating cylinder, and a manually operable control lever which is arranged when moved in one direction to operate said valve and when moved in a second direction to actuate said electrical mechanism to control the wheel feeding movement.

2. A grinding machine comprising a base, a rotatable grinding wheel, a transversely movable slide therefor, a feeding mechanism including a fluid pressure piston and cylinder operatively connected to move said slide transversely in either direction, a control valve to control the admission of fluid to said cylinder, electrically operated means including a solenoid to actuate said valve, an electric switch which is operatively connected to control said solenoid, a continuously rotated expansible work supporting member, means including a fluid pressure piston and cylinder to expand or contract said work support to clamp a work piece thereon for a grinding operation or to release it therefrom after a grinding operation has been completed, a control valve which is arranged to control the admission of fluid under pressure to said second cylinder, and a control lever which is arranged when moved in one direction to actuate the valve and control the admission and exhaust of fluid to and from said second cylinder and when moved in a second direction serves to actuate said electric switch to control the transverse feeding movement of the grinding wheel.

3. A grinding machine comprising a base, a rotatable grinding wheel, a transversely movable slide therefor, a feeding mechanism including a fluid pressure piston and cylinder to move said slide transversely in either direction, a control valve to control the admission of fluid under pressure to said cylinder, an electrical solenoid to shift said valve to cause an infeeding movement of the grinding wheel, a spring to return said valve to position said valve to cause a rearward movement of the grinding wheel, a longitudinally movable work supporting table, manually operable means to traverse said table longitudinally, means including a continuously rotated work supporting arbor, yieldable means to expand said arbor to support and drive a work piece thereon for a grinding operation, fluid pressure actuated means including a piston and cylinder which are operatively connected to contract said arbor and eject a work piece therefrom, a control valve which is arranged to admit fluid under pressure to the latter cylinder, and a control lever which is arranged when moved in one direction to actuate said control valve to control the admission of fluid to said second cylinder and when moved in a second direction to actuate an electric switch to control the feeding movement of the grinding wheel.

4. A grinding machine comprising a base, a rotatable grinding wheel, a transversely movable slide therefor, a rotatable work supporting spindle, means including a motor which is arranged continuously to rotate said spindle, yieldable means to clamp a work piece on said spindle, fluid pressure mechanism including a piston and cylinder to release said work piece, an ejector actuated thereby to eject a finish ground work piece therefrom, a rotary control valve operatively connected to control the admission of fluid to said cylinder, a feeding mechanism including a fluid pressure piston and cylinder operatively connected to move said slide transversely in either direction, a control valve to control the admission of fluid under pressure to said feed cylinder, electrically controlled means including a solenoid to actuate said valve, a switch located adjacent to said first control valve and arranged to control said solenoid, and a single control lever which is pivotally connected to said valve stem and arranged when moved in one direction to rotate said valve to control the admission and exhaust of fluid from said first cylinder and when moved in a second direction to actuate said switch and thereby control the transverse feeding movement of the wheel slide.

5. A grinding machine wheel feeding mechanism comprising a rotatable grinding wheel, a transversely movable slide therefor, a fluid pressure piston and cylinder operatively conected to move said slide rapidly in either direction, a dash pot mechanism associated therewith and effective on the

infeeding movement of the wheel slide to slow down the infeed to a predetermined feed, an adjustable positive stop positively to limit the infeed of the wheel, a control valve arranged to control the admission of fluid under pressure to said cylinder, a spring normally to hold said valve in a position to cause the wheel slide to move rearwardly, a solenoid to shift said valve to initiate an infeeding movement of the grinding wheel, an electrical switch operatively connected to energize said solenoid to initiate an infeeding movement of the grinding wheel, a second electric switch operatively connected and arranged to deenergize said solenoid to cause a rearward movement of the grinding wheel, and a pivotally mounted lever which is arranged to actuate both of said switches.

6. In a grinding machine, a rotatable work spindle, means including a motor which is arranged continuously to rotate said spindle, a work chuck carried by said spindle, a slidable sleeve within said spindle to actuate said chuck to grip a work piece thereon, yieldable means acting on said sleeve normally to hold said chuck in a gripping position, a fluid pressure mechanism including a piston and cylinder to actuate said sleeve and chuck to release the work piece, an ejector rod slidably mounted within said sleeve and arranged to eject a work piece from the chuck, a load and fire mechanism including a spring, and means actuated by movement of said sleeve to operate said load and fire mechanism to cause a rapid movement of said ejector when the chuck has been released.

7. In a grinding machine, a rotatable work supporting spindle, means including a motor arranged continuously to rotate said spindle, a work chuck carried by said spindle, a slidable sleeve within said spindle to actuate said chuck to grip a work piece, yieldable means acting on said sleeve normally to hold said chuck in a gripping position, a fluid pressure mechanism including a piston and cylinder to actuate said sleeve and chuck to release the work piece, an ejector rod slidably mounted within said sleeve to eject a work piece from the chuck, a load and fire mechanism including a spring, and a pivotally mounted lever actuated by movement of said sleeve to operate said load and fire mechanism and said ejector rod rapidly to eject a work piece from said chuck.

RAYMOND A. COLE.
CHARLES H. AMIDON.