July 6, 1937. H. A. SILVEN 2,086,052

GRINDING MACHINE

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FIG. 1

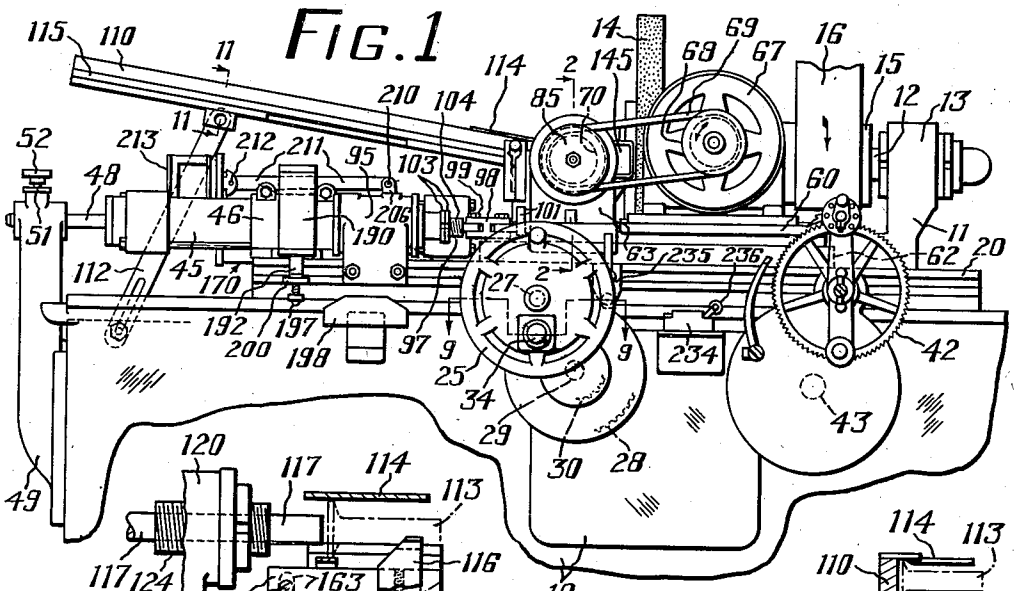

FIG. 10

FIG. 11

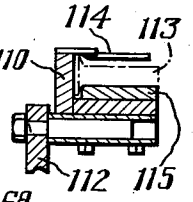

FIG. 3

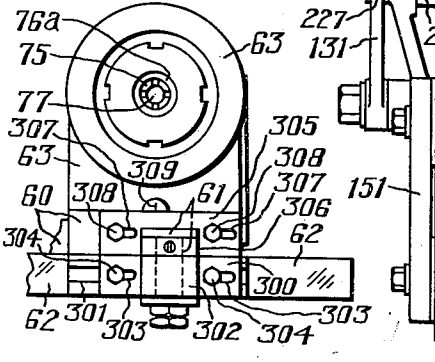

FIG. 2

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GRINDING MACHINE

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FIG. 4

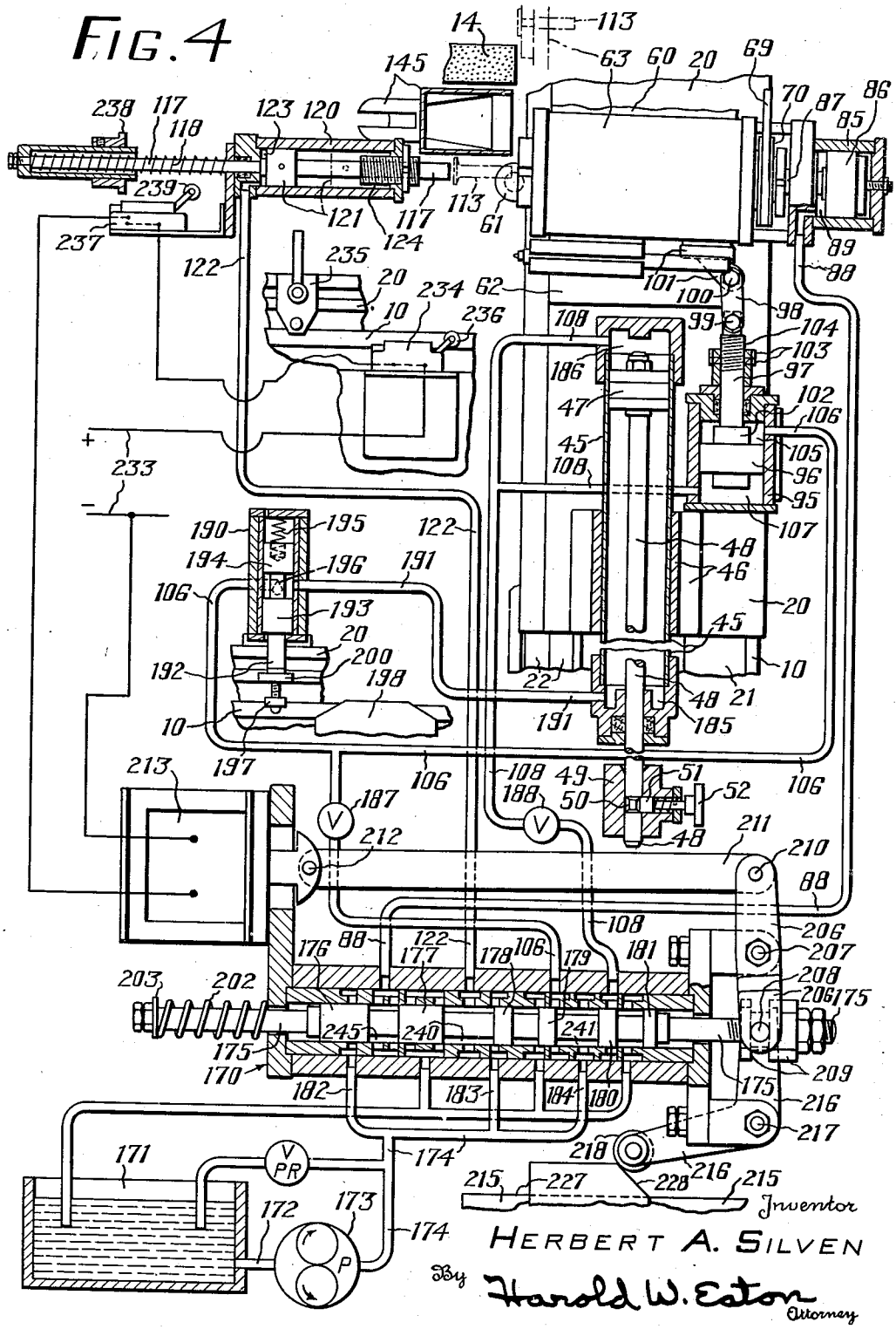

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FIG. 5

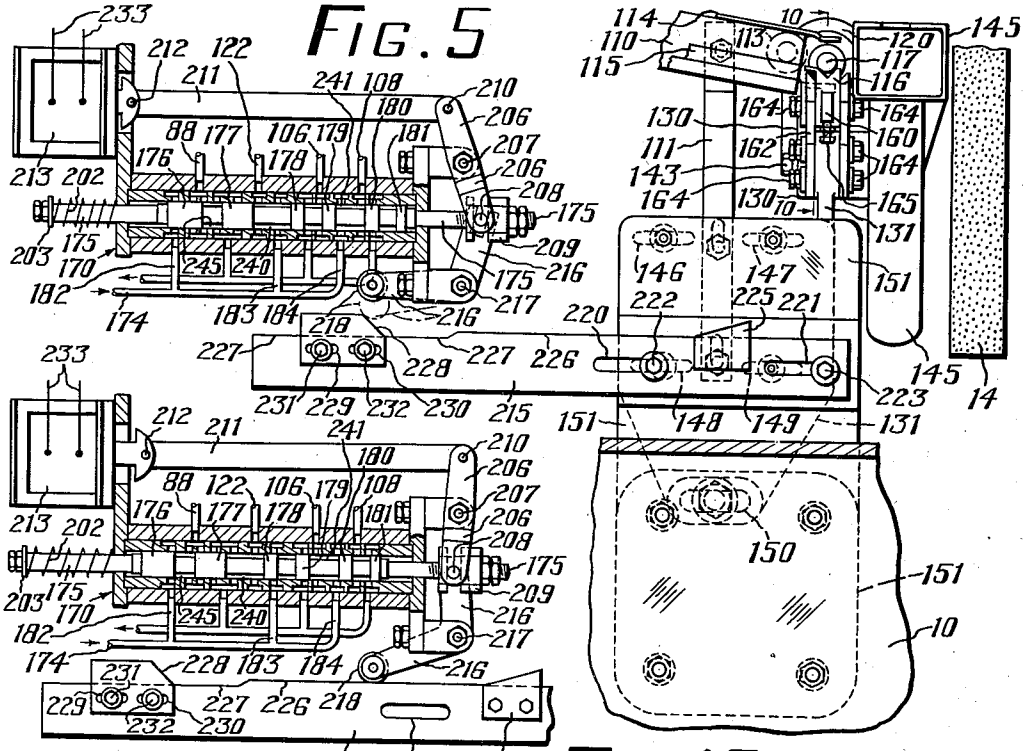

FIG. 6

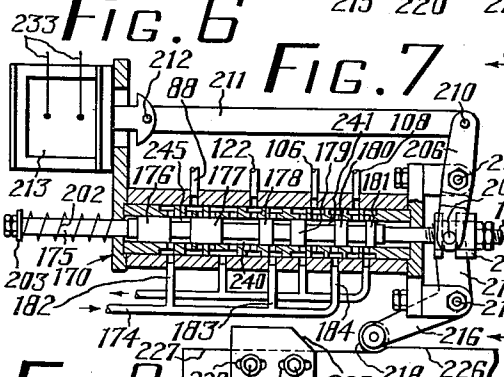

FIG. 12

FIG. 13

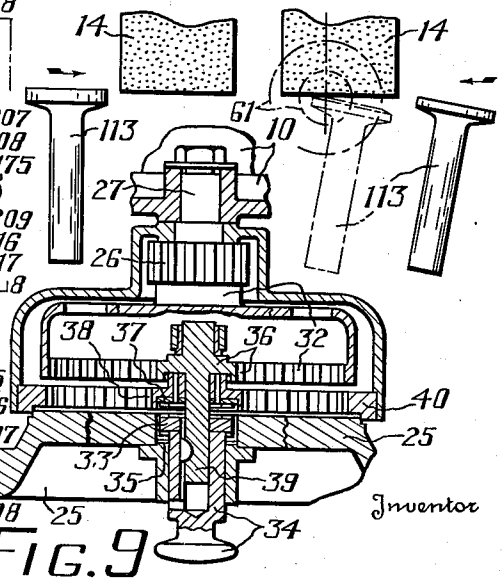

FIG. 7

FIG. 8

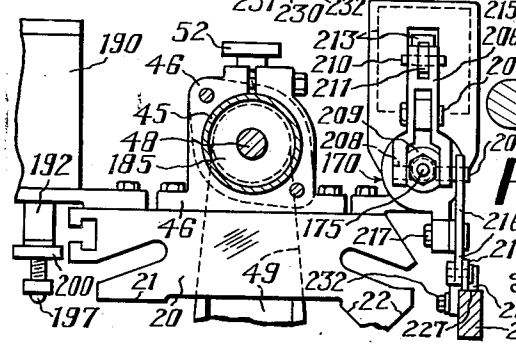

FIG. 9

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UNITED STATES PATENT OFFICE

2,086,052

GRINDING MACHINE

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Application June 26, 1936, Serial No. 87,512

16 Claims. (Cl. 51—95)

This invention relates to grinding machines, and more particularly to a machine for grinding a flat and frusto-conical surface on the end of a cylindrically shaped work piece.

One object of this invention is to provide a simple and thoroughly practical grinding machine for grinding the end face of a work piece. Another object of the invention is to provide a grinding machine which serves to produce a flat end face combined with a frusto-conical edge portion on a work piece. Another object of this invention is to provide a grinding machine in which a flat face is produced on the end of a work piece when the work piece is traversed in one direction past the grinding wheel and in which a frusto-conical edge portion is ground on the return stroke of the work piece across the wheel face. Another object of the invention is to provide a grinding machine for automatically grinding an end face on a work piece having a flat portion together with a frusto-conical edge portion. 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,

Figure 1 is a front elevation of a grinding machine embodying this invention;

Figure 2 is a fragmentary plan view of a grinding machine, showing the parts in a loading position;

Figure 3 is a fragmentary plan view of the grinding machine shown in Figure 2, having parts broken away and shown in section to more clearly show the operating construction;

Figure 4 is a fragmentary diagrammatic view, showing the fluid pressure control system as well as the electrical diagram;

Figure 5 is a longitudinal sectional view through the control valve, showing a section through the valve and its actuating parts and also showing a portion of the work hopper and work loading and discharge mechanism;

Figure 6 is a similar sectional view through the valve, showing the parts in position for traversing the work table at a slow speed;

Figure 7 is a similar sectional view through the control valve, showing the parts in a position for rapidly traversing the work table to and from an operating position;

Figure 8 is a cross sectional view, taken approximately on the line 8—8 of Figure 7, showing the control valve in end elevation and a section through the table traverse cylinder;

Figure 9 is a cross sectional view, on an enlarged scale, taken approximately on the line 9—9 of Figure 1, showing the multi-speed table traverse mechanism;

Figure 10 is a fragmentary sectional view, taken approximately on the line 10—10 of Figure 5, showing the work loading plunger and associated parts on an enlarged scale;

Figure 11 is a fragmentary cross sectional view, on an enlarged scale, taken approximately on the line 11—11 of Figure 1;

Figure 12 is a diagrammatic view, on an enlarged scale, showing the relation of the grinding wheel and work piece when the table is moved toward the right; and

Figure 13 is a similar diagrammatic view, showing the relation of the work axis to the grinding wheel when the table is moved toward the left on the return stroke.

A grinding machine has been illustrated comprising a base 10 which is arranged to support a transversely movable wheel slide 11. The wheel slide 11 rotatably supports a wheel spindle 12 in bearings 13 (only one of which has been illustrated). The outer end of the wheel spindle 12 supports a rotatable grinding wheel 14. The wheel spindle 12 may be rotated in the usual manner either by means of a belt drive or a motor drive from an electric motor mounted on the wheel slide. As illustrated in the drawings, however, a driving pulley 15 is mounted on the wheel spindle 12 and is connected by means of a driving belt 16 with any suitable source of power.

The base 10 also supports a longitudinally movable work supporting table 20 which is arranged to slide longitudinally on the base 10 on a flat way 21 and a V-way 22 which mate with correspondingly shaped ways on the base 10 of the machine.

The table 20 may be traversed longitudinally either manually or by power. A manually operable feed mechanism has been illustrated comprising a manually operable hand wheel 25 which is connected through a gear reduction unit to rotate the gear 26 which is rotatably carried on the shaft 27. The gear 26 is arranged to mesh with a gear 28. The shaft 29 carries on its inner end a rack gear 30 arranged to mesh with the

rack 31 depending from the under side of the table 20. In the preferred construction, the hand traverse mechanism may be of a multi-speed type, such as for example that shown in the prior patent to Norton No. 1,299,765 dated April 8, 1919, to which reference may be had for a detailed disclosure. A large internal gear 32 is formed integral with the gear 26 and both are rotatably supported on a stud or shaft 27. A slidable clutch member 33 is carried by a movable plunger 34 carried by the hand wheel 25. When the plunger 34 is moved outwardly, as shown in Figure 9, so that the clutch member 33 engages a fixed clutch member 35 carried by the hand wheel 25, it serves to lock a gear 36 in fixed relation with the hand wheel 25. When the hand wheel 25 is rotated, the gear 36 which is fixed thereto meshes with the internal gear 32 and causes a rotation thereof which is transmitted through the gears 26, 28, 30, and rack 31 to traverse the table 20 longitudinally.

If a slow speed traversing movement of the table is required, such as for truing, the clutch member 33 is moved upwardly, as shown in Figure 9, so that it engages a clutch member 37 which is formed integral with a gear 38 rotatably mounted on a stud 39 which is formed integral with the gear 36. The gear 38 meshes with an internal gear 40 which is of slightly larger diameter than the internal gear 32. In this position of the parts, with the clutch member 33 engaging the clutch 37, the hand wheel 25 is rotated, causing the gear 38 to revolve. The gear 38 is connected to the hand wheel 25 so that when the hand wheel 25 is rotated, the gear 38 rolls around the internal gear 40. The gear 38 is locked through the stud 39 with the gear 36 so that the gear 36 rotates and revolves with the gear 38 and due to the differential between the internal gears 40 and 32, causes a slow rotation of the gear 32 which transmits a corresponding movement through the gear 26 to the rack 31 and the table 20. For a more detailed disclosure of this multi-speed manual traversing mechanism, reference may be had to the above-mentioned prior patent to Norton. Referring to Figure 9, the slidable clutch member 33 is in a central position, that is, disengaged from the clutch members 35 and 37. It is placed in this position during grinding so that the table 20 will be free to reciprocate without rotating the parts of the manually operable table traversing mechanism.

The grinding wheel slide 11 may be fed transversely either toward or from the work support by means of a manually operable feed wheel 42 which is operatively connected to gears (not shown) to rotate a feed screw shaft 43 to cause a transverse movement of the slide. This mechanism is not considered to be a part of the present invention and consequently has not been illustrated in detail. This mechanism is substantially the same as that shown in the expired U. S. Patent to Norton No. 762,838 dated June 14, 1904.

The table 20 is also arranged so that it may be traversed or reciprocated longitudinally by a power operated mechanism. In the preferred construction, a fluid pressure operated mechanism is utilized to reciprocate or traverse the table 20. As illustrated, this mechanism comprises a fluid pressure cylinder 45 which is supported in a bracket 46 on the table 20. The cylinder 45 contains a piston 47 which is connected to one end of a piston rod 48. The other end of the piston rod is connected to a bracket 49 which is fixed to the end of the base 10.

The piston rod 48 is preferably detachably connected to the bracket 49 so that the fluid pressure mechanism may be readily disconnected to facilitate manual traverse of the table for truing the wheel and setting up the machine. The piston rod 48 is provided with an annular groove 50 which is adapted to be engaged by a spring pressed plunger 51 carried by the bracket 49. When it is desired to detach the piston rod 48 from the bracket 49, the plunger 51 may be withdrawn, by means of the knob 52, from the groove 50 so that the table may be traversed without overcoming the fluid pressure within the cylinder 45.

This machine is particularly adapted for automatically grinding the end face of a work piece, and more particularly an end face requiring a flat end surface together with a beveled or chamfered edge portion. A rotatable work support is provided on the table 20 which is arranged with its axis of rotation at substantially right angles to the axis of rotation of the grinding wheel. The work supporting member is preferably arranged so that when the table travels in one direction the axis of the work is at right angles to the operative face of the grinding wheel and when the table is traveled in the opposite direction the work axis is shifted so that its axis of rotation is at an angle to a plane perpendicular to the wheel axis so that a frusto-conical or chamfered edge portion is produced on the face of the work piece.

As illustrated in the drawings, a swivel base 60 is mounted on the upper surface of the table 20 and is pivotally connected by a stud 61 to a sub-base member 62 which is fixedly mounted on the table 20. The stud 61, which pivotally connects the work support 63 with the plate 62, is preferably arranged so that it may be adjusted longitudinally so that a line passing through the axis of the stud 61 is tangent to the line of intersection between the two surfaces to be ground, that is so that the work pivots about an axis in line with the junction between the flat surface and the frusto-conical surface. By adjusting the position of the pivot, the diameter of the flat surface as well as the extent of the frusto-conical surface may be varied as desired. In the construction illustrated, the stud is supported in a bracket 300 which is provided with a slideway 301 mating with a corresponding slideway on the plate 62. The bracket 300 is provided with a boss 302 which supports the lower end of the stud 61. The bracket 300 is provided with elongated slots 303 through which pass clamping screws 304. The screws 304 are screw threaded into the plate 62 and serve to clamp the bracket 100 in adjusted position. Similarly a bracket 305 is provided with a boss 306. The bracket 305 is provided with elongated slots 307 and clamping screws 308 which serve to facilitate adjustment of the pivot relative to the work head 63. If desired, the upper surfaces of the bracket 305 may be provided with a graduated scale, and an index or zero point 309 may be provided on the head 63 to aid in adjusting the pivot to the desired extent.

The swivel member 60 is provided with an enlarged portion 63 which rotatably supports a spindle 64 in bearings 65 and 66. The spindle 64 may be rotated by means of an electric motor 67 mounted on the swivel base 60. The motor is provided with a driving pulley 68 which is connected by a belt 69 with a pulley 70 mounted on the end of the spindle 64. The spindle 64 contains a slidably mounted chuck closing member

71 which is slidably mounted within an aperture 72 within the spindle 64. The chuck closing member 71 is normally urged toward the left (Fig. 2) by means of a spring 73 which is interposed between a shoulder on the chuck closing member 71 and an internal shoulder within the spindle 64. A spring collet or chuck 75 is slidably mounted within the chuck closing member 71 and is held in place within the spindle by means of a collar 76 which engages the front end face of the collet and is supported by a portion which is threaded into the end of the spindle 64. The collar 76 serves to locate the front end of the spring collet. A slidably mounted ejector rod 77 passes through the center aperture of the collet 75 and is held in a forward position by means of a spring 78. When a work piece is inserted within the spring collet 75, it is pushed in against the end of the ejector rod 77 and compresses the spring 78 as it is moved into an operating position within the collet.

In order to release the collet 75 when fluid under pressure is admitted to cylinder chamber 89, a stop thrust collar 76a is supported adjacent to the outer end of the spindle 76. When fluid under pressure is admitted to chamber 89, it causes the chuck closing sleeve 71 together with the collet 75 to move toward the right (Fig. 11) until the head of the work piece engages the front face of the stop collar 76a. Continued admission of fluid to the chamber 89 serves to move the sleeve 71 to a further extent toward the right while holding the collet 75 against such movement, which serves to withdraw the sleeve 75 and thereby release the spring collet. The released tension of the spring 78 then moves the ejecting plunger 77 toward the left to eject the work piece into the discharge chute 145.

A suitable means is provided to withdraw the collet closing member 71 to an inoperative position to permit ejection of the work and loading of a new piece of work into place within the collet. This mechanism preferably comprises a cylinder 85 containing a slidably mounted piston 86 which is connected to the inner reduced portion 87 of the collet closing member 71. Fluid may be admitted through a pipe 88, into a cylinder chamber 89, to cause the spring closing member 71 to be withdrawn toward the right (Fig. 2) against the tension of the spring 73 to release the spring collet from its grip on the work piece. When a work piece has been inserted within the spring collet 75, the work piece must be held in this position until the fluid pressure is cut off from the pipe 88, thereby releasing the tension of the spring 73 and causing the collet closing member 71 to slide toward the left, as viewed in Figure 2, to close the chuck or collet 75 and thereby lock the work piece in a grinding position. During the insertion of the work piece, the ejector plunger has been moved toward the right, as viewed in Figure 2, compressing the spring 78. After the work piece has been ground to a predetermined extent, and the work table has moved from a grinding position, fluid under pressure is admitted through the pipe 88, into cylinder chamber 89, to withdraw the chuck or collet closing member 71 against the tension of the spring 73, thereby releasing the tension of the spring 78, which causes the ejector plunger to move toward the left, as viewed in Figure 2, into the position illustrated to eject a finished ground work piece therefrom.

In order to swivel the plate 60 so as to automatically change the relation of the work axis of rotation relative to the operative face of the grinding wheel, a suitable mechanism is provided to shift or swivel the plate 60 about its pivot 61. This mechanism preferably comprises a cylinder 95 which is fixed to the table 20. The cylinder 95 contains a slidably mounted piston 96 which is connected by a piston rod 97 to one end of a link 98. The link 98 is connected to the piston rod 97 by a stud 99. The other end of the link is connected by a stud 100 with a projecting bracket 101 mounted on the swivel plate 60. The piston 96 is provided with an enlarged portion 102 which serves to stop the movement of the piston to position the work at right angles to the operating face of the grinding wheel 14, as viewed in Figure 4. A pair of adjustable collars 103 adjustably carried on a threaded portion 104 of the piston rod 97 serve to limit the swiveling movement of the piston 96. Fluid under pressure is admitted to a cylinder chamber 105 through a pipe 106 and to a cylinder chamber 107 through a pipe 108 by means of a fluid pressure system to be hereinafter described.

The work to be ground is preferably automatically loaded into the machine and automatically ejected therefrom. A work receiving hopper or magazine 110 is supported by a bracket 111 and a bracket 112 on the base 10. A plurality of work pieces 113 are loaded in position in the hopper 110 and roll down into the position illustrated in the drawings. The portion of the hopper 110 adjacent to the loading station is provided with an upper plate 114 which holds the work pieces on a guiding track 115 carried by the hopper 110. After a work piece has been inserted in the machine and the loading plunger withdrawn to an inoperative position, the work piece 113 rolls downwardly, due to gravity and the pressure of adjacent work pieces, into position in alignment with a loading plunger and moves downwardly until supported on a V-shaped supporting member 116 in alignment with a loading plunger 117. The loading plunger 117 is normally held in a rearward position by means of a spring 118 and is arranged to operate in timed relation with the other parts of the machine so that the plunger 117 may be moved toward the right (Figs. 2 and 4) to automatically move a work piece 113 into operative position within the collet 75.

In the preferred construction a fluid pressure cylinder 120 is provided. The loading plunger 117 is preferably formed as a piston rod which is connected to move with a piston 121 slidably mounted within the cylinder 120. Fluid under pressure is admitted from a pipe 122 into a cylinder chamber 123 to cause the loading plunger 117 to move toward the right to push the work piece 113 into an operating position within the chuck or collet 75.

It is desirable to locate the work piece 113 within the collet 75 so that the surface of the work piece to be ground is located in a definite position so that the same amount of stock is ground from the surface of each work piece. A sleeve 124 which is threaded on its periphery and meshes with corresponding threads in the head of cylinder 120 serves to limit the movement of the piston 121 toward the right, as viewed in Figure 2. When the piston 121 is moved to insert a work piece into the machine, the piston contacting with the end of the threaded sleeve 124 serves to locate the surface to be ground relative to the chuck 75.

The brackets 111 and 112 which support the hopper or magazine 110 are adjustably supported on the base 10 to permit adjustment of the same

relative to the base for setting up the machine to grind various types of work pieces. The loading plunger is provided with an integral supporting bracket 130 which is adjustable longitudinally on a bracket 131 which supports the same on the base 10. By providing suitable elongated slots and clamping bolts, the loading plunger may be adjusted longitudinally relative to the base 10 so as to adjust the position of the axis of the plunger into alignment with the work supporting chuck. The bracket 130 which supports the work loading plunger is provided with elongated slots 140 and 141 through which pass clamping bolts 142 and 143 respectively. These bolts are threaded into the bracket 131 and are arranged to permit a longitudinal adjustment of the work loading plunger 117 and its associated parts. The bracket 131, which supports the work loading plunger 117, the hopper or magazine 110 and a discharge chute 145, is provided with elongated slots 146, 147, 148, 149 and 150 through which bolts pass to adjustably secure the bracket 131 to a fixed bracket 151 which is bolted to the base 10 of the machine. The elongated slots 146, 147, 148, 149 and 150 serve to permit a longitudinal adjustment of the work loading mechanism, the magazine and associated parts, to facilitate setting up the machine.

The work piece 113 sliding into the V-shaped supporting guide 116, which aligns the work piece with the opening in the chuck or collet 75, is preferably supported on a pivotally mounted member 160 which is normally held in an upward position by means of a spring 161 supported by the bracket 131. The member 160 is pivotally supported in a frame 162 which is provided with a plurality of elongated slots 163 which surround guiding bolts 164 and permit a vertical movement of the member 160. When the work piece is pushed toward the right by means of the plunger 117, the body portion of the work piece 113 is pushed into the chuck and the head of the work piece riding over the angular surface of the V-shaped member 116 depresses the member 160 pivoting on the top bolt 164 so that the head on the work piece may pass thereover in its movement into the chuck 75. The V-shaped member 116 is adjustable longitudinally of the member 160 and may be clamped in adjusted position by means of a clamping screw 165.

In order that the various fluid pressure actuated mechanisms of the machine may be operated in the desired timed relationship with each other, it is desirable to provide a fluid pressure system in which a cycle control valve 170 is provided to control the admission and exhaust of fluid from the various cylinder and piston mechanisms above described. A fluid reservoir 171 is provided in the base of the machine and serves to convey fluid through a pipe 172 to a fluid pressure pump 173. The pump 173 is connected by a pipe 174 with the control valve 170.

The main or cycle control valve 170 is preferably a piston type valve comprising a valve stem 175 having formed integrally thereon valve pistons 176, 177, 178, 179, 180 and 181. Fluid under pressure from the pipe 174 passes through a pipe or passage 182, a pipe 183 and a pipe or passage 184 into the various valve chambers.

Fluid under pressure from the cycle control valve 170 passes at the predetermined time in the cycle through the pipe 88 to the chuck release cylinder 85, through the pipe 122, to the work loading plunger cylinder 120, through a pipe 106, into chamber 105 in the cylinder 95, to swivel the work supporting head, and also into a cylinder chamber 185 in the cylinder 45 to move the table 20 toward the left, as viewed in Figure 1, and through a pipe 108, into chamber 107 of the cylinder 95, to swivel the work head in the opposite direction and also into a cylinder chamber 186 in the cylinder 45 to move the table 20 toward the right, as viewed in Figure 1. Valves 187 and 188 are interposed in the pipe lines 106 and 108 respectively, so that the fluid passing through these pipes may be regulated, as desired, to control the speed of movement of the cylinder 45.

It is desirable that the table 20 move rapidly in bringing the work piece 113 up to an operative position where it is about to contact with the operative face of the grinding wheel 14 and to then slow down the movement of the table to a predetermined grinding speed, thereby reducing the idle time by causing rapid positioning movements of the table. This is preferably accomplished by providing a control valve 190 within the pipe line 106, which serves to control the admission of an exhaust of fluid through a pipe 191 into the cylinder chamber 185. The valve 190 is preferably a piston type valve comprising a valve stem 192 and a pair of spaced valve pistons 193 and 194 formed integrally thereon. A spring 195 serves to normally hold the valve stem 192 in a downward position (Figure 4), so that fluid exhausting through the pipe 191 enters through a V-port 196 which in the position of the parts is wide open, thereby allowing the full supply of fluid to pass into cylinder chamber 186, causing the work table to move rapidly toward the right, as viewed in Figure 1. The rapid movement of the table continues until the adjustable screw 197 in the end of the valve stem 192 engages an adjustable dog 198 mounted on the base 10 of the machine. As the end of the screw 197 rides up the inclined surface of the dog 198, the valve piston 193 is raised to partially close the V-port 196, thereby restricting the flow of fluid through pipe 191 from the cylinder chamber 185, thereby reducing the rapid idle movement of the table 20 to a slow grinding speed. By adjusting the position of the screw 197 and locking the screw in adjusted position by means of a locking nut 200, the V-port 196 may be closed to a greater or lesser extent. Similarly, after the work piece passes across the face of the grinding wheel in the movement of the table toward the right, the screw 197 rides down the incline at the other end of the dog 198 and thereby increases the speed of the table during the movement of the table toward the right and the shifting of the work holder in its angular relation with the wheel ready for its return stroke.

The cycle control valve 170 is normally urged toward the left, as viewed in Figure 4, by means of a spring 202 which is interposed between the end of the valve casing and a thrust washer 203 on the end of a valve stem 175. The valve stem 175 is arranged so that it may be moved in a direction toward the right (Figure 4) by two separately actuated means. A rock arm 206 pivotally mounted on a stud 207 is connected at one end by a pair of pins 208 with a spool shaped member 209 on the valve stem 175. The other end of the rock arm 206 is connected by a stud 210 to one end of a link 211, the other end of which is connected by a stud 212 with an electric solenoid 213. The valve stem 175 may also be actuated by means of a cam bar 215 which is adjustably sup-

ported on the bracket 151 mounted on the base 10 of the machine. A bell crank lever 216 is pivotally mounted on a stud 217 and its upper end is connected by means of one of the pins 208 which are mounted in the arm 206 engaging the spool shaped member 209. The other arm of the bell crank lever 216 is provided with a follower roller 218 which is arranged to engage the various portions of the cam bar 215. The cam bar 215 is provided with elongated slots 220 and 221 through which pass the clamping bolts or screws 222 and 223. These bolts are fastened to the supporting bracket 151 which is in turn fastened to the base 10 of the machine and serves to permit a longitudinal adjustment of the cam bar 215. The cam bar 215 is provided at its right-hand end (Figure 5) with a safety or stop member 225 which serves to shift the cycle of control valve to stop the parts of the machine in case the table travels beyond a desired distance. The cam bar is provided with cam surfaces 226 and 227 as well as an adjustable cam surface 228 which is provided with elongated slots 229 and 230 and is clamped to the cam bar 215 by clamping screws 231 and 232. By means of the elongated slots 229 and 230 and the clamping screws 231 and 232, the cam surface 228 may be adjusted relative to the portions 227 and 226 of the cam bar 215 to facilitate adjustment of the operation of the mechanism.

In order to energize the solenoid 213 in timed relation with the movements of the parts of the machine, power is supplied, as indicated, by the power lines 233. A normally closed limit switch 234 is mounted on the front of the base of the machine and is arranged so that an adjustable dog 235 engages a roller 236 to actuate the limit switch 234 as the table 20 is moved toward the right and is at the end of the grinding stroke to deenergize solenoid 213 so as to reverse the movement of the table 20. A normally open limit switch 237 is supported on a bracket on the rear of the cylinder 120 and is arranged so that an adjustable collar 238 carried by the movable work loading plunger 117 engages a roller 239 on the limit switch 237 when the plunger is moved to insert a work piece within the collet 75 and closes the circuit, thereby energizing the solenoid 213 (Figure 4).

After a work piece has been ground and the table 20 moves toward the left so that when the work piece is clear of the grinding wheel and the roller 218 rides on the cam surface 226 and when roller 218 leaves surface 226 to engage cam surface 227, fluid under pressure is admitted through the hose 88 into cylinder chamber 89 to move the valve piston 86 toward the right (Figures 2 and 4) to release the collet 75, the released tension of the spring 78 moves the ejector rod 77 toward the left to eject a work piece 113 from the collet 75 and allow it to drop into the discharge chute 145 which conveys the finish ground piece of work from the machine.

The operation of this machine is readily apparent from the foregoing disclosure. Assuming the parts to have been previously adjusted for the particular work piece 113 shown, and assuming the work table 20 to be at the extreme left-hand or in its loading position, the valves and fluid pressure parts are in the position illustrated in the diagrammatic view (Figure 4). Fluid under pressure from the pump 173 passes through pipe 174 and pipe or passage 183 into a valve chamber 240 and out through a pipe 122 into the cylinder chamber 123 to move the piston 121 toward the right until it contacts sleeve 124, as viewed in Figure 4. This movement serves to move the plunger 117 to push a work piece 113 into the aperture in the collet 75. This movement serves to move the ejecting plunger 77 toward the right (Figure 2) to compress the spring 78. When the plunger 117 has moved the work piece so that the head of the work piece engages the locating collar 76 on the outer end of the spindle 64, the adjustable collar 238 engages the roller 239 of the limit switch 237 and closes the circuit, thereby energizing the solenoid 213 and shifting the valve stem into the position as shown in Figure 5 so that fluid under pressure passing through the pipe 174 and pipe 184 passes into a valve chamber 241 and out through a pipe 108, into the cylinder chamber 107, to swivel the work support 60 to shift the work axis so that it lies at right angles to the axis of rotation of the grinding wheel and at the same time passes fluid into the cylinder chamber 186 to start the table 20 moving toward the right, as viewed in Figure 1. The table is moved first at a rapid rate and as the head of the work piece approaches the operative face of the grinding wheel 14, the screw 197 riding up on the dog 198 partially closes the V-port 196 to slow down the table movement to a grinding speed by throttling the exhaust of fluid from the cylinder chamber 185. The work 113 is rotated by the motor 67 and passes across the operative face of the grinding wheel to grind a flat end face on the surface of the work piece, as shown in Figure 12.

The movement of the table toward the right continues until the dog 235 engages the roller 236 of the limit switch 234, which serves to open the circuit, thereby deenergizing the solenoid 213, and the released compression of the spring 202 moves the valve stem 175 and its associated parts toward the left, as viewed in the various figures, until the follower roller 218 engages the surface 226 of the cam bar 215. This movement shifts the valve pistons into the position illustrated in Figure 6. Moving the valve into this position passes fluid under pressure from the pipe 174 through pipe 184, valve chamber 241 and through pipe 106, into cylinder chamber 105, which serves to swivel the support 60 in a clockwise direction into the position illustrated in Figure 4 so that the stop nuts 103 engage the fixed stop surface on the end of the cylinder and so that the axis of rotation of the work piece lies at an angle to a perpendicular plane passing through the wheel axis so that on the return stroke of the table in its movement toward the left, a frusto-conical edge portion will be ground on the outer edge of the flat end face of the work piece, as shown in Figure 13. At the same time fluid under pressure is admitted through the pipe 191 into cylinder chamber 185 to start the table moving toward the left, first at a rapid rate until the screw 197 rides up on the dog 198 to throttle the inflow of fluid to the chamber 185 and thereby slow down the table to a predetermined grinding speed. As viewed in Figure 6 also fluid exhausts from the cylinder 120 to withdraw the plunger 117 so that a new work piece will roll into place.

The movement of the table continues toward the left until the roller 218 drops into contact with the surface 227 of the cam bar 215, as indicated in Figure 8, which serves to allow a further released compression of the spring 202 to shift the valve stem 175 into the position of the parts as illustrated in Figure 8. This movement serves

to allow fluid under pressure passing through the pipe 174 to pass through pipe 182, into a valve chamber 245, and out through a pipe 88, into the cylinder chamber 89 to move the piston 86 toward the right, as viewed in Figures 2 and 4. This movement of the piston 86 toward the right serves to move the chuck releasing member 71 also toward the right to release the spring collet 75, and the released compression of the spring 78 moves the ejector rod 77 toward the left to eject the work piece 113 into the discharge chute 145. The movement of the table 20 continues toward the left until the roller 218 rides up on the cam surface 228, which serves to cut off fluid under pressure to the pipe 106 and to cut off exhaust from the pipe 108 and thereby stop the table movement. The table 20 and the work holding chuck 75 are then in position to start the next cycle of operation. The next work piece having rolled into the position on the work supporting member 116, the fluid under pressure is applied through pipe 122 to again admit fluid under pressure to cylinder chamber 123 to start the work loading plunger 117 in its movement toward the right (Figure 4) to move the next piece of work 113 into operative relation with the work holding chuck or spring collet 75, whereupon the released tension of the spring 73 moves the chuck closing member 71 toward the left (Figure 2) to clamp the work piece in operative position in the chuck. The cycle of events is then completed and successive work pieces are ground first with their axis of rotation at right angles to the axis of rotation of the grinding wheel to grind a flat end face thereon, after which the work axis is shifted so that it lies at an angle to a perpendicular plane passing through the axis of the work so that on the return stroke of the work piece across the operative face of the grinding wheel, a frusto-conical edge surface is ground adjacent to the periphery of the flat end surface. This cycle of events is then continued in grinding successive pieces of work to the desired size and shape.

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.

I claim:

1. In a grinding machine, a transversely movable rotatable grinding wheel, a longitudinally movable table, means to move said wheel transversely toward and from said table to grind a work piece, means to traverse said table longitudinally in either direction relative to the grinding wheel, a rotatable work support on said table arranged to grind one surface on the work piece during a traversing movement of said table, and automatically operated mechanism actuated in timed relation with said table traversing movement at one end of its stroke to shift said work support relative to said table so that the axis of rotation of the work is shifted relative to the axis of rotation of the grinding wheel to grind a second surface on said work piece when the table is traversed in the opposite direction.

2. In a grinding machine, a transversely movable rotatable grinding wheel, means to move said grinding wheel transversely, a longitudinally movable table, means to move said table longitudinally in either direction relative to the grinding wheel, a rotatable work support on said table, pivotal connections between said support and table, said support being arranged to grind one surface on the work piece during a traversing movement of said table in one direction, automatically operated mechanism actuated in timed relation with said traversing movement of the table at one end of its stroke to shift said work support about its pivot and relative to said table so that the axis of rotation of the work is shifted relative to the axis of rotation of the grinding wheel to grind a second surface on said work piece when the table is traversed in the opposite direction, and means to adjust the position of said pivot so that the axis of the pivot is tangent to a line passing through said axis and the junction between said first and second surfaces on the work piece.

3. In a grinding machine, a transversely movable rotatable grinding wheel, a longitudinally movable table, means to move said wheel transversely toward and from said table, means to traverse said table longitudinally in either direction relative to the grinding wheel, a rotatable work support on said table arranged to grind one surface on the work piece when the table is traversed in one direction, and automatically actuated means operated by said table at one end of its stroke to shift said work support relative to said table so that the axis of rotation of the work is shifted relative to the axis of rotation of the grinding wheel to grind a second surface on said work piece when the table is traversed in the opposite direction.

4. In a grinding machine, a transversely movable rotatable grinding wheel, a longitudinally movable table, means to move said wheel transversely toward and from said table, means to traverse said table longitudinally in either direction relative to the grinding wheel, a rotatable work support on said table arranged to grind one surface on the work piece when the table is traversed in one direction, and automatically actuated means operated by and in timed relation with said table at one end of its stroke to shift said work support relative to said table so that the axis of rotation of the work is shifted relative to the axis of rotation of the grinding wheel to grind a second surface adjacent to said first surface when the table is traversed in the opposite direction.

5. In a grinding machine, a transversely movable rotatable grinding wheel, means to move said grinding wheel transversely, a longitudinally movable table, means to traverse said table in either direction, a rotatable work support on said table which is arranged so as to grind one surface on a work piece when the table is traversed in one direction, pivotal connections between said support and table, and means actuated by said table at one end of its stroke to shift said work support about its pivot and relative to said table so as to change the axis of rotation of the work piece relative to the axis of rotation of the grinding wheel so as to grind a second surface on said work piece when the support is traversed in the opposite direction.

6. In a grinding machine, a transversely movable rotatable grinding wheel, means to move said wheel transversely, a longitudinally movable table, means to traverse said table in either direction, a rotatable work support on said table,

pivotal connections between said support and table, said support being arranged to grind one surface on the work piece when the table traverses in one direction, means to shift the work support about its pivot and relative to the table so as to shift the axis of rotation of the work piece relative to the axis of the grinding wheel to grind a second surface on said work piece when the work support is traversed in the other direction, and means to adjust the position of said pivotal connection longitudinally relative to said rotatable work support so that the axis of the pivot extended is tangent to the junction between said first and second surfaces on the work piece.

7. In a grinding machine, a transversely movable rotatable grinding wheel, a longitudinally movable table, means to move said grinding wheel transversely toward and from said table to produce the desired grinding action, means to traverse said table longitudinally in either direction, a rotatable work support carried by said table and arranged to support the work piece so that its axis of rotation bears a definite relation with the axis of rotation of the grinding wheel to grind one surface on said work piece when the table is traversed in one direction, and means including a fluid pressure piston and cylinder which is actuated by and in timed relation with the table reciprocation at one end of its stroke to automatically shift the position of said work support to change the axis of rotation of the work piece relative to the axis of rotation of the grinding wheel so as to grind a second surface on said work piece when the work support is traversed in the opposite direction.

8. In a grinding machine, a transversely movable rotatable grinding wheel, a longitudinally movable rotatable work support having its axis of rotation arranged at right angles to the axis of rotation of the grinding wheel to grind a flat end face on the work piece when the work support moves in one direction, and means actuated by said work support at one end of its longitudinal movement to shift the axis of rotation of the work piece relative to the axis of the grinding wheel to grind a frusto-conical surface adjacent to said flat surface when the work support is moved in the other direction.

9. In a grinding machine, a transversely movable rotatable grinding wheel, a longitudinally movable table, a rotatable work support thereon having the axis of rotation arranged at substantially right angles to the axis of rotation of the grinding wheel to grind a flat end face on the work piece when the work support is moved in one direction, and automatically actuated means to shift the axis of rotation of the work piece relative to the axis of rotation of the grinding wheel so as to grind a frusto-conical surface adjacent to said flat surface when the work support is moved in the opposite direction.

10. In a grinding machine, a transversely movable rotatable grinding wheel, a longitudinally movable table, a rotatable work support thereon having its axis of rotation arranged at substantially right angles to the axis of the grinding wheel to grind a flat end face on the work piece when the table is traversed in one direction, fluid pressure actuated means to reciprocate said work support, and means actuated in timed relation with said reciprocation to automatically shift the axis of rotation of the work piece relative to the axis of rotation of the grinding wheel so as to grind a frusto-conical edge portion on the end of said work piece when the work support is traversed in the opposite direction.

11. In a grinding machine, a transversely movable rotatable grinding wheel, a longitudinally movable table, fluid pressure operated means including a piston and cylinder to move said table in either direction, a rotatable work support carried by said table, means including a fluid pressure cylinder to shift the position of said rotatable work support and a control valve which is arranged in one position to move the work table longitudinally while the axis of rotation of the work piece is arranged at right angles to the axis of rotation of the grinding wheel to grind a flat end surface on the work piece, and means to shift said control valve at the end of said stroke to admit fluid under pressure so as to reverse the table movement and to said second cylinder to shift the axis of rotation of the work support relative to the axis of rotation of the grinding wheel so as to grind a frusto-conical surface adjacent the edge of said flat surface when the work support moves in the opposite direction.

12. A grinding machine comprising a base, a rotatable grinding wheel, a transversely movable wheel slide to support said wheel, a longitudinally movable work supporting table, a rotatable work supporting chuck on said table having its axis of rotation arranged at right angles to the axis of the grinding wheel so as to present the end face of a work piece for grinding, means to rotate said chuck, means to traverse the table longitudinally in one direction while the axis of the work is at right angles to the axis of the grinding wheel so as to grind a flat face on the work piece, and means to move the axis of the work supporting chuck so that the work axis makes an angle less than or greater than ninety degrees with the axis of the grinding wheel before the table is traversed in the opposite direction to grind a chamfer or frusto-conical edge portion on the work piece.

13. A grinding machine comprising a base, a rotatable grinding wheel, a transversely movable grinding wheel slide, a longitudinally movable table, a rotatable work supporting chuck on said table having its axis of rotation at right angles to the axis of the grinding wheel so as to present an end face of a work piece for a grinding operation, means including an electric motor on said table to rotate said chuck and work piece, a work loading device including a fluid pressure actuated plunger to successively load work pieces into said chuck, means including a fluid pressure piston and cylinder to clamp said work piece in said chuck, means including a fluid pressure piston and cylinder to reciprocate the work table and chuck longitudinally in one direction to grind a flat end face on the work piece, means including a fluid pressure piston and cylinder arranged to swing said chuck so that its axis of rotation is at an angle greater or less than ninety degrees relative to the axis of the grinding wheel before the piston and cylinder start the table moving in the opposite direction so as to grind a chamfer or frusto-conical face on the edge portion of said work piece.

14. A grinding machine comprising a base, a rotatable grinding wheel, a transversely movable grinding wheel slide, a longitudinally movable table, a rotatable work supporting chuck on said table having its axis of rotation arranged at right angles to the axis of rotation of the grinding wheel so as to present an end face of a work

piece for a grinding operation, means including an electric motor on said table to rotate the chuck and work piece, a work loading device including a fluid pressure actuated plunger to successively load work pieces into said chuck, means including a fluid pressure piston and cylinder to clamp said work piece in the chuck, means including a fluid pressure piston and cylinder to reciprocate the table and chuck longitudinally in one direction to grind a flat end face on the work piece, means including a fluid pressure piston and cylinder to swing said chuck so that its axis of rotation is at an angle greater or less than ninety degrees relative to the axis of the grinding wheel before the table starts moving in the opposite direction so as to grind a chamfer or frusto-conical face on the edge portion of said work piece, and means including a cycle control valve which serves to control the admission of fluid to all of said cylinders.

15. In a grinding machine, a transversely movable rotatable grinding wheel, a longitudinally movable table, means including a fluid pressure piston and cylinder which are operatively connected to traverse said table in either direction, a rotatable work supporting chuck pivotally connected to said table and arranged with its axis of rotation at substantially right angles to the axis of rotation of the grinding wheel, means including a fluid pressure piston and cylinder to control said chuck, means including a piston and cylinder to shift the axis of rotation of said chuck so that when the table moves in one direction the axis of the chuck is at right angles to the axis of the grinding wheel and so that the axis of the chuck is at an angle other than ninety degrees relative to the axis of the grinding wheel when the table moves in the opposite direction, a work loading plunger arranged to insert a work piece into said chuck, means including a fluid pressure piston and cylinder operatively connected to actuate said loading plunger, and a control valve in said system which is arranged to control the admission of fluid to said plunger cylinder to insert a work piece in said chuck, to release fluid under pressure in said chuck cylinder so as to clamp the work piece within said cylinder, to admit fluid to said table traverse cylinder, to traverse the work piece with its axis at right angles to the axis of the grinding wheel across the face of the wheel to grind a flat face thereon, to admit fluid to said third cylinder, and to swivel said work chuck so that its axis of rotation is at an angle to a plane normal to said wheel when the table moves in the opposite direction to grind a frusto-conical edge portion on said work piece.

16. In a grinding machine, a transversely movable rotatable grinding wheel, a longitudinally movable table, means including a fluid pressure piston and cylinder which are operatively connected to traverse said table in either direction, a rotatable work supporting chuck pivotally connected to said table and arranged with its axis of rotation at substantially right angles to the axis of rotation of the grinding wheel, means including a fluid pressure piston and cylinder to control said chuck, means including a piston and cylinder to shift the axis of rotation of said chuck so that when the table moves in one direction the axis of the chuck is at right angles to the axis of the grinding wheel and so that the axis of the chuck is at an angle other than ninety degrees relative to the axis of the grinding wheel when the table moves in the opposite direction, a work loading plunger arranged to insert a work piece into said chuck, means including a fluid pressure piston and cylinder operatively connected to actuate said loading plunger, and a control valve in said system which is arranged to control the admission of fluid to said plunger cylinder to insert a work piece in said chuck, to release fluid under pressure in said chuck cylinder so as to clamp the work piece within said cylinder, to admit fluid to said table traverse cylinder to traverse the work piece with its axis at right angles to the axis of the grinding wheel across the face of the wheel to grind a flat face thereon, to admit fluid to said third cylinder, and to swivel said work chuck so that its axis of rotation is at an angle to a plane normal to said wheel when the table moves in the opposite direction to grind a frusto-conical edge portion on said work piece, and to admit fluid to said chuck cylinder after one complete reciprocation of the work table to release said chuck and eject a work piece thereupon.

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