

Oct. 16, 1945.

H. A. SILVEN

2,387,044

SURFACE GRINDING MACHINE

Filed Nov. 1, 1944

7 Sheets-Sheet 1

Fig. 3

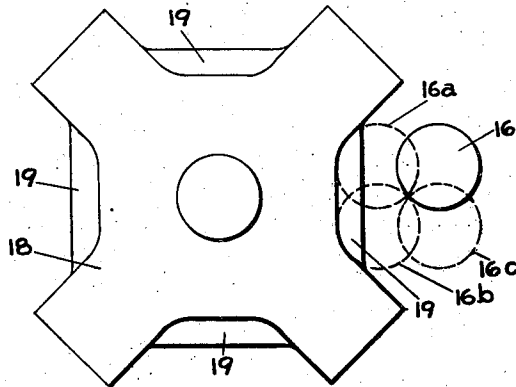
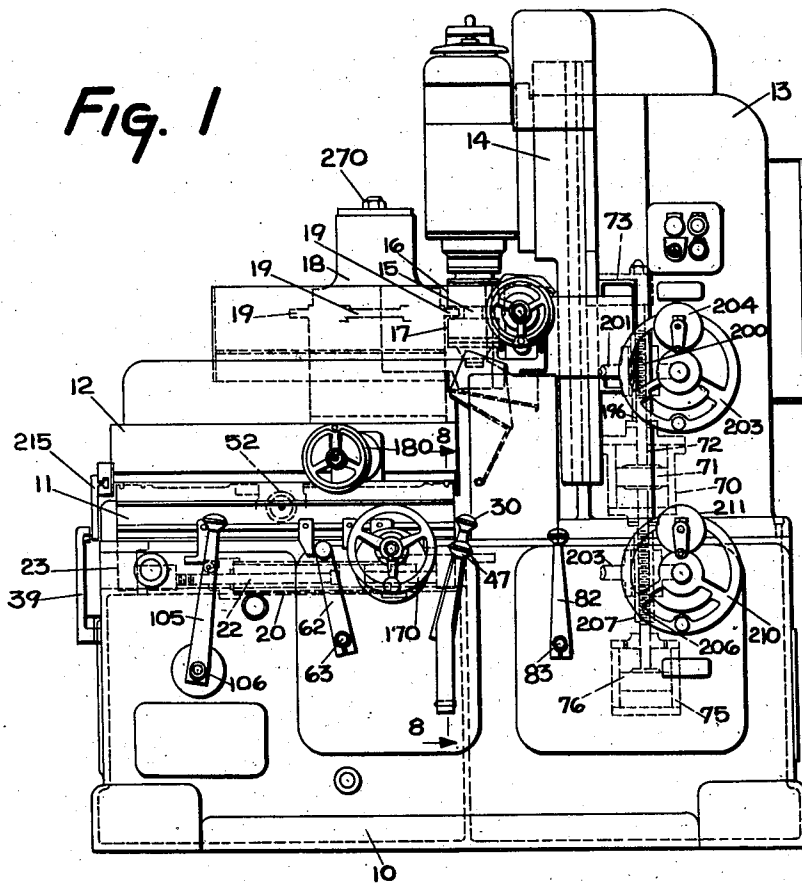


Fig. 1



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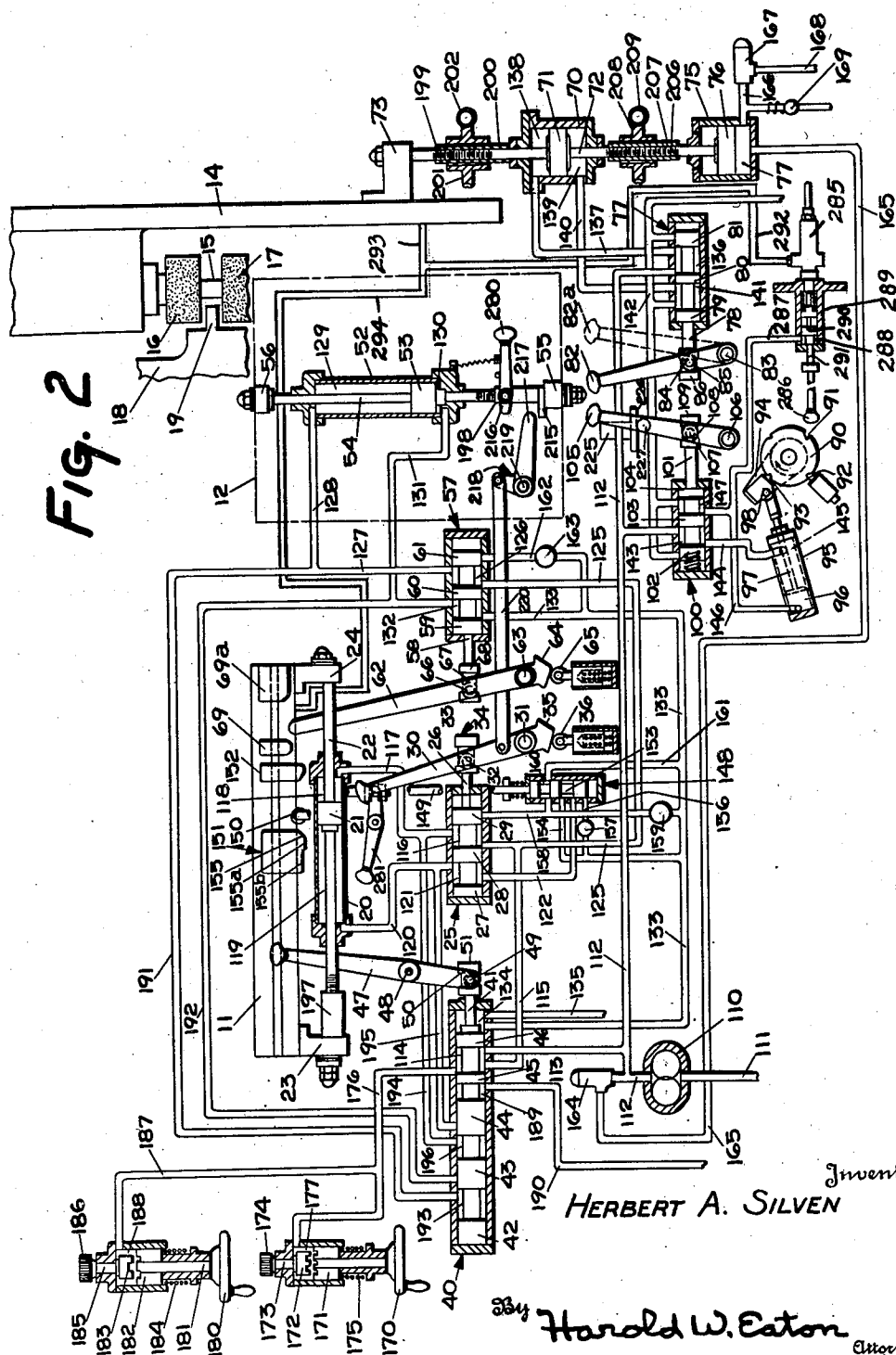
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Fig. 2



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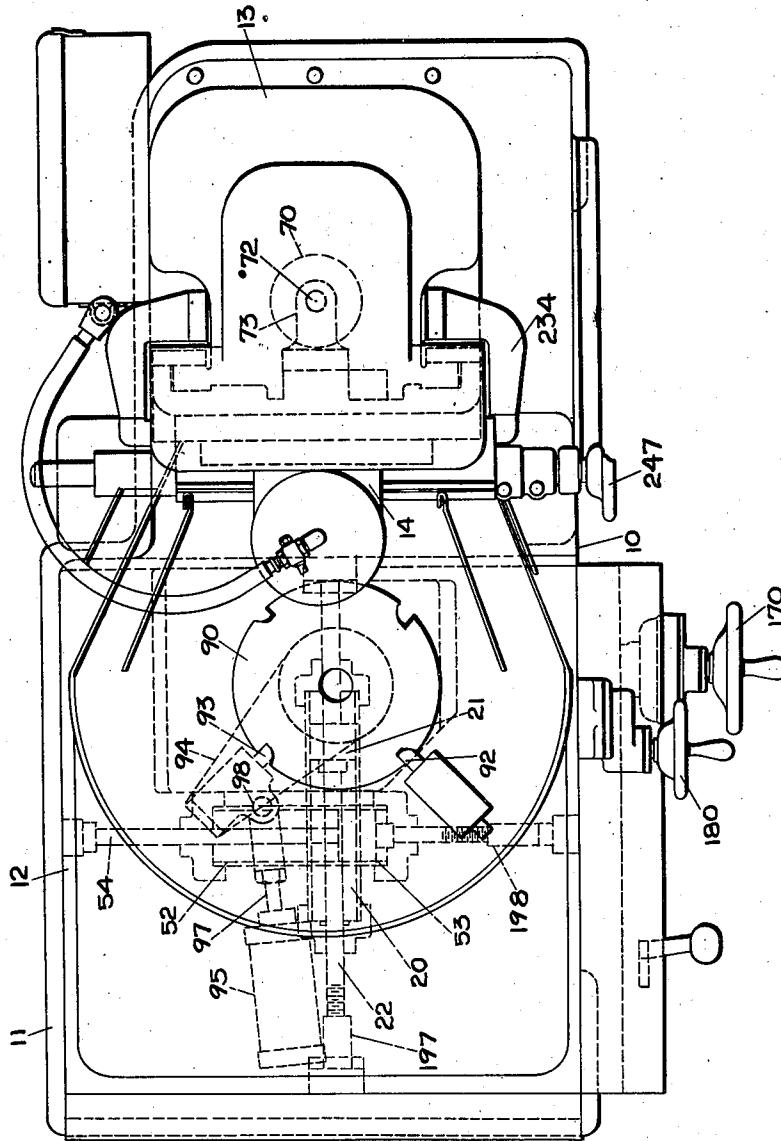
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Fig. 4



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Fig. 7

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Fig. 8

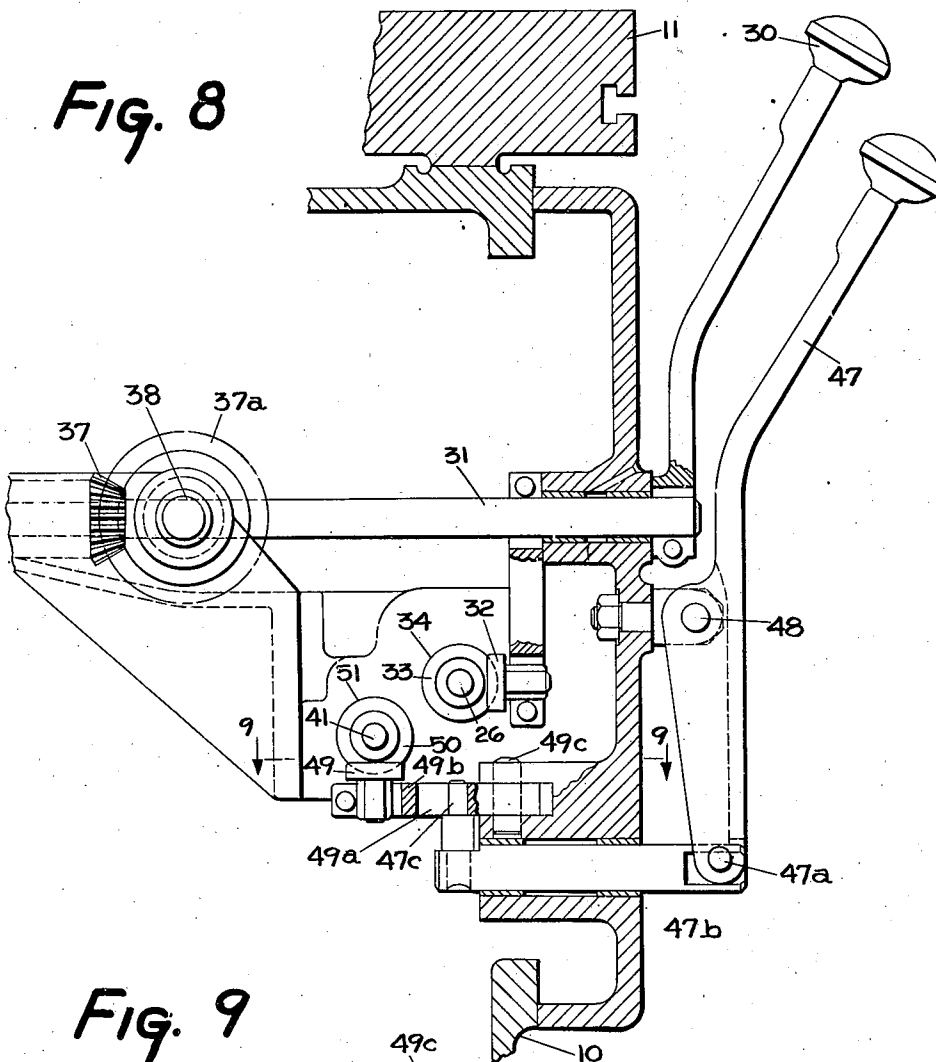
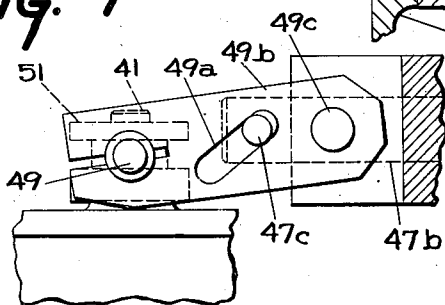


Fig. 9



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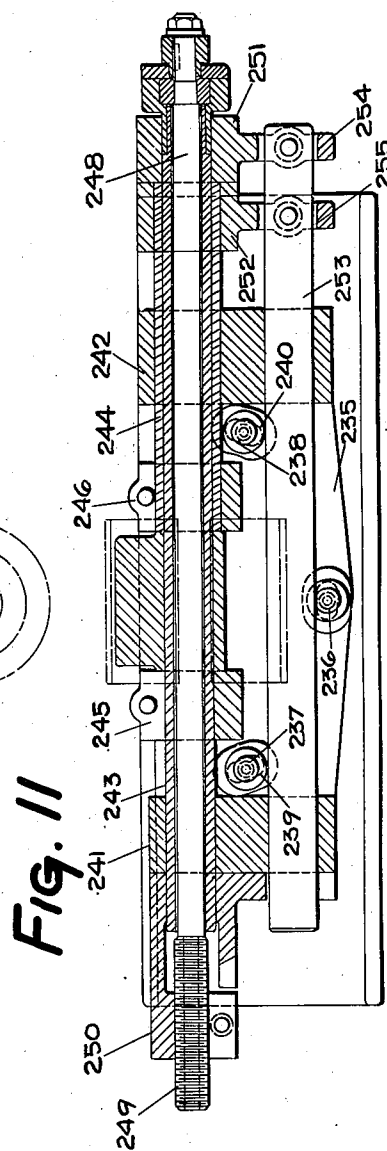
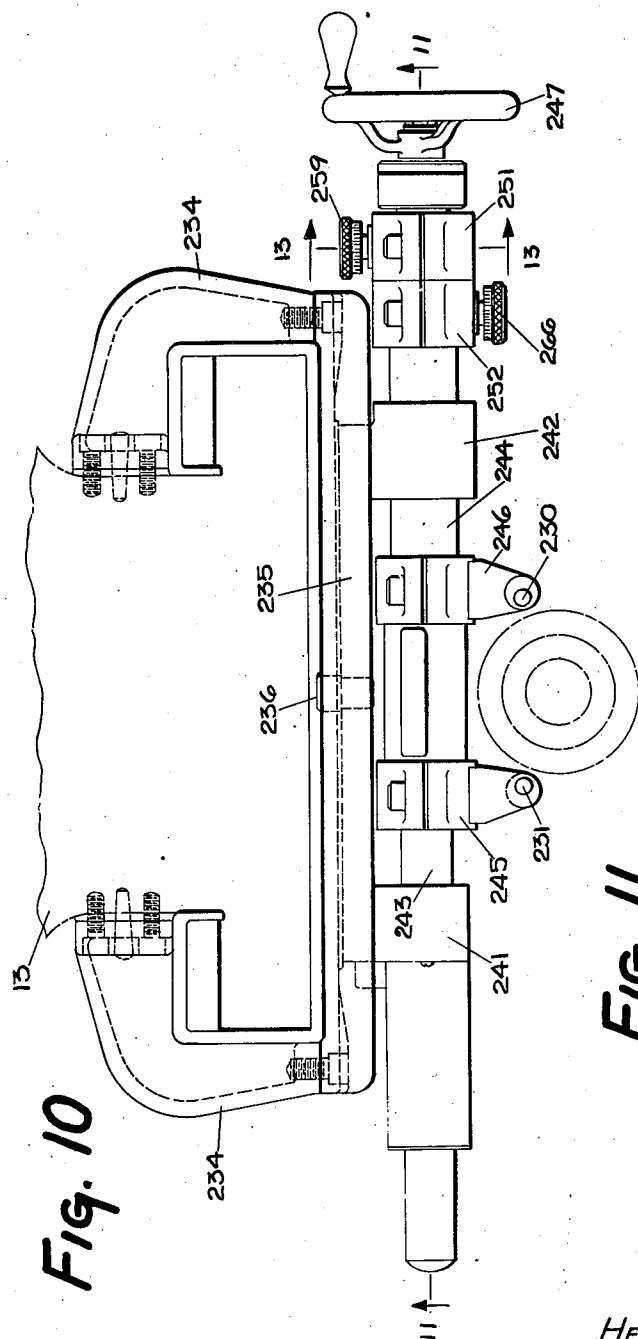
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Fig. 12

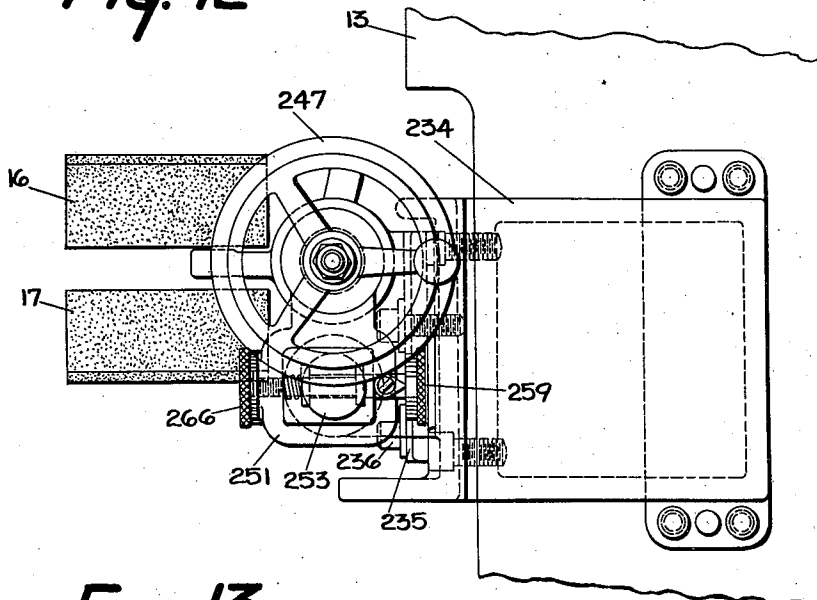


Fig. 13

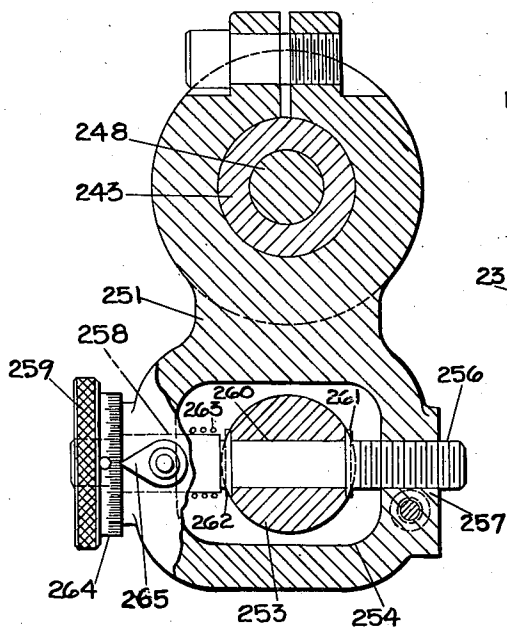
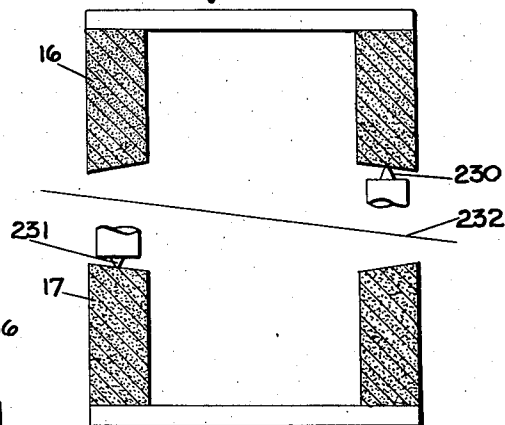


Fig. 14



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UNITED STATES PATENT OFFICE

2,387,044

SURFACE GRINDING MACHINE

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Application November 1, 1944, Serial No. 561,401

16 Claims. (Cl. 51—114)

This invention relates to grinding machines, and more particularly to a surface grinding machine for grinding plane surfaces on a work piece.

One object of the invention is to provide a simple and thoroughly practical surface grinding machine for grinding predetermined plane surfaces on a work piece. Another object of the invention is to provide a surface grinding machine in which a predetermined grinding cycle may be obtained, that is, a predetermined relative longitudinal and transverse movement between the grinding wheel and the work piece to grind a predetermined plane face on a work piece. Another object of the invention is to provide a surface grinding machine having two opposed spaced grinding wheels which may be successively positioned in predetermined positions for grinding opposed parallel plane faces on a work piece. Another object of the invention is to provide a surface grinding machine in which the work piece to be ground is mounted on an indexable work holder which is in turn supported on transversely and longitudinally movable work supporting tables by means of which the work piece may be moved through a predetermined cycle to grind a predetermined plane surface on a portion of the work piece and the work piece may be indexed to present a plurality of predetermined portions for grinding.

A further object of the invention is to provide a truing apparatus having opposed truing tools arranged for simultaneously truing the operative faces of two opposed grinding wheels in which the truing tools are maintained in a fixed position for a truing apparatus so that it is not necessary to reset the wheel positioning mechanism after a truing operation has been performed. Other objects will be apparent from the foregoing disclosure.

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 surface grinding machine;

Fig. 2 is a diagrammatic illustration of the hydraulic control and actuating mechanisms of the machine;

Fig. 3 is a fragmentary diagrammatic view of a work piece and the grinding wheel to show the relative positions therebetween during a grinding operation;

Fig. 4 is a plan view, on an enlarged scale, of the surface grinding machine;

Fig. 5 is a fragmentary front elevation, on an enlarged scale, of the control apron, showing the relationship of the control levers;

Fig. 6 is a fragmentary end elevation of the dog mechanism associated with the transversely movable work table;

Fig. 7 is a fragmentary cross sectional view, taken approximately on the line 7—7 of Fig. 6;

Fig. 8 is a fragmentary cross sectional view, on an enlarged scale, taken approximately on the line 8—8 of Fig. 1;

Fig. 9 is a fragmentary horizontal sectional view, on an enlarged scale, taken approximately on the line 9—9 of Fig. 8;

Fig. 10 is a fragmentary plan view, on an enlarged scale, of the grinding wheel truing apparatus;

Fig. 11 is a longitudinal sectional view, taken approximately on the line 11—11 of Fig. 10, through the truing apparatus;

Fig. 12 is a fragmentary front elevation, on an enlarged scale, of the truing apparatus as shown in Fig. 1;

Fig. 13 is a fragmentary cross-sectional view, on an enlarged scale, taken approximately on the line 13—13 of Fig. 10; and

Fig. 14 is a diagrammatic illustration showing the relationship of the opposed grinding wheels and the truing tools therefor.

A grinding machine has been illustrated in the drawings comprising a base 10 which supports a longitudinally movable work table 11 on suitable slideways (not shown). A transversely movable table 12 is supported on slideways formed on the upper surface of the longitudinally movable table 11, said slideways being arranged so that a work piece supported on said transversely movable table may be moved either longitudinally or transversely for a grinding operation.

The base 10 is provided with an upwardly extending column 13 which supports a vertically movable slide 14 having suitable slideways formed between the slide 14 and the column 13. The slide 14 serves as a support for a vertically arranged grinding wheel spindle 15 which in turn supports a pair of spaced grinding wheels 16 and 17, the grinding wheels 16 and 17 being arranged successively to grind an upper and a lower surface on a work piece 18. The work piece 18 is provided with a plurality of webbed portions 19 having upper and lower parallel plane surfaces to be ground to a predetermined extent.

Longitudinal table traverse

The longitudinally movable table 11 is provided with a hydraulically operated traversing mechanism comprising a cylinder 20 which is fixed relative to the base 10. A slidably mounted piston 21 is provided in the cylinder 20 and is fixedly connected to a double end piston rod 22

which extends through opposite end caps on the cylinder 20 and is fastened at its outer ends to depending brackets 23 and 24 which are fixedly mounted on the under side of opposite ends of the longitudinally movable table 11.

A control valve 25 is provided for controlling the admission to and exhaust of fluid from the cylinder 20. The valve 25 is preferably a piston type valve comprising a valve stem 26 having formed integrally therewith valve pistons 27, 28 and 29. A manually operable cycle control lever 30 is pivotally supported on a stud 31 which is fixed relative to the base 10. The lever 30 is provided with a stud 32 which rides in a comparatively wide groove 33 in a spool-shaped member 34. The lower end of the lever 30 is provided with a V-shaped end portion 35 which engages a spring-pressed roller 36. The groove 33 formed on the spool 34 is wide enough so that when the lever 30 is moved to reverse the position of the valve 25, the lever is moved until the high point of the arrow 35 passes the axis of the spring-pressed roller 36, after which the released compression of the spring-pressed roller will shift the valve stem 26 into its reverse position. The lever 30 serves as a cycle control lever to initiate a grinding cycle, as will be hereinafter described.

The control lever 30 is fixedly mounted on the outer end of a rock shaft 31. The inner end of the rock shaft supports a bevel gear 37 which meshes with a bevel gear 37a mounted on a rotatable shaft 38. An actuating lever 39 is mounted on the left-hand end of the shaft 38 (Figs. 5 and 8). The lever 39 is actuated, in a manner to be hereinafter described, by a dog mechanism carried by the transversely movable table 12.

Stop and start valve

A manually operable stop and start valve 40 is provided for stopping the hydraulic operation of the machine or starting the same when desired. This valve is a piston type valve comprising a valve stem 41 having formed integrally therewith valve pistons 42, 43, 44, 45 and 46. A manually operable control lever 47 is pivotally supported on a stud 48 which is fixed relative to the base of the machine. The lower end of the lever 47 is provided with a stud 49 which rides in a groove 50 formed in a spool-shaped member 51 which is fixedly mounted on the end of the valve stem 41.

In actual construction, as illustrated in Figs. 8 and 9, the stop and start lever 47 is operatively connected by a stud 47a with a slidably mounted rod 47b. A stud 47c is fixedly mounted on the rod 47b. The stud 47c rides in a cam slot 49a formed in a pivotally mounted lever 49b which is pivotally mounted at one end by a stud 49c which is fixed relative to the base 10. The stud 49 is mounted on the opposite end of the lever 49b. It will be readily apparent from the foregoing disclosure that movement of the start and stop lever 47 toward or away from the machine will be transmitted through the mechanism above described to actuate the start and stop valve 40.

Transverse table traverse

The transversely movable slide 12 is preferably hydraulically operated by means of a fluid pressure cylinder 52 which is fixedly mounted relative to the longitudinally movable slide 11. A piston 53 is slidably mounted within the cylinder 52 and is fixedly connected with a double end piston rod 54 which extends through the opposite end caps of the cylinder 52. The opposite ends of the connecting rod 54 are connected by depending

brackets 55 and 56 which are fixedly supported on the under side of the opposite ends of the transversely movable table 12.

A control valve 57 is provided for controlling the admission to and exhaust of fluid from the cylinder 52. This valve is a piston type valve comprising a valve stem 58 having formed integrally therewith valve pistons 59, 60 and 61. An actuating lever 62 is pivotally mounted on a stud 63 which is fixed relative to the base of the machine. The lower end of the lever 62 is provided with a narrow-pointed projection 64 which engages a spring-pressed roller 65. The spring-pressed roller 65 is arranged to serve as a load and fire mechanism to shift the valve rapidly into a reverse position. The control lever 62 is provided with a stud 66 which engages a relatively wide groove 67 formed in a spool-shaped member 68 which is fixedly mounted on the end of the valve stem 58. The relatively wide groove 67 is provided so that the lever 62 may be moved positively until the arrow-shaped portion 64 rides over the top of the spring-pressed roller 65 without moving the valve stem 58, after which the released compression of the roller 65 rapidly shifts the valve 57 into its reverse position.

The lever 62 is automatically actuated by a pair of adjustable table dogs 69 and 69a which are adjustably mounted on the front edge of the longitudinally movable work table 11.

Grinding wheel feed

The wheel slide 14 is preferably hydraulically controlled by means of a cylinder 70 which is fixed within the column 13. A slidably mounted piston 71 is provided in the cylinder 70 which is fixedly connected to a double end piston rod 72. The piston rod 72 extends through end caps formed on the opposite ends of the cylinder 70. The upper end of the piston rod 72 is fixedly connected to a bracket 73 which is in turn fixedly mounted on the vertically movable wheel slide 14.

A hydraulically operated counterbalance mechanism is provided to counterbalance the weight of the vertically movable wheel slide 14 so as to facilitate movement of the same either by power or by hand. This mechanism comprises a counter-balance cylinder 75 which contains a slidably mounted piston 76, the slidably mounted piston 76 being fixedly connected to the lower end of the piston rod 72. Fluid under pressure is at all times maintained within a cylinder chamber 77, the pressure of such fluid being sufficient to counterbalance the weight of the wheel slide 14 and its associated parts.

A wheel feed control valve 77 is provided for controlling the admission to and exhaust of fluid from the cylinder 70. This valve is a piston type valve comprising a valve stem 78 having formed integrally therewith valve pistons 79, 80 and 81. A manually operable control lever 82 is pivotally supported by a stud 83 which is fixedly mounted relative to the base 10. The lever 82 supports a stud 84 which rides in a groove 85 formed in a spool-shaped member 86 which is fixedly mounted on the end of the valve stem 78. It will be readily apparent from the foregoing disclosure that manual movement of the lever 82 from the full line position as indicated in Fig. 2 into dotted line position 82a will shift the valve 77 into its reverse position.

Work index mechanism

In order to facilitate grinding a work piece, such as the work piece 18 having four spaced

portions or webs 19 to be ground, it is desirable to provide a work piece indexing mechanism whereby after the first portion or web 19 has been ground, the work piece 18 may be precisely indexed to present the next portion or web 19 of the work piece 18 into operative relation with the grinding wheels 16 and 17. The work piece 18 is preferably mounted on a rotary indexing mechanism comprising an index plate 90 which is provided with a plurality of spaced notches 91 which correspond with the number of portions and angular positions of the portions on the work piece 18 to be ground. A holding pawl 92 is provided for locating and holding the index plate 90 in a predetermined grinding position. An index pawl 93 is pivotally mounted on a swinging arm 94. The pawl 93 and arm 94 are preferably hydraulically actuated so as to facilitate a rotary indexing of the plate 90. This mechanism may comprise a hydraulic cylinder 95 having a slidably mounted piston 96 which is connected to the left-hand end of a piston rod 97. The right-hand end of the piston rod 97 is connected by a stud 98 which is carried by the index pawl 93.

An index control valve 100 is provided for controlling the indexing movement of the work piece. This valve is a piston type valve comprising a valve stem 101 having formed integrally therewith valve pistons 102, 103 and 104. A manually operable control lever 105 is pivotally mounted on a stud 106 which is fixed relative to the base of the machine. The control lever 105 carries a stud 107 which rides in a groove 108 formed in a spool-shaped member 109 which is fixedly mounted on the right-hand end of the valve stem 101. It will be readily apparent that manual actuation of the lever 105 serves to control the position of the valve stem 100. A compression spring is provided within the left-hand end of the valve 100 (Fig. 2) normally to maintain the valve in its right-hand end position.

Hydraulic system

A hydraulic system is provided for operatively conveying fluid under pressure to and from the several mechanisms hereinabove described. This system comprises a motor driven pump 110 which draws fluid from a suitable source of supply such as, for example, a reservoir (not shown) formed either within or outside of the base 10, through a pipe 111. The pump 110 forces fluid under pressure through a pipe 112 which is connected to pass fluid under pressure through a pipe 113 into a chamber 114 formed between the valve pistons 45 and 46 in the stop and start valve 40. A pipe 115 connects the valve chamber 114 in the stop and start valve 40 with a chamber 116 formed between the valve pistons 28 and 29 in the longitudinal table control valve 25. In the position of the valve 25 as shown in Fig. 2, fluid under pressure entering the valve chamber 116 is forced through a pipe 117 into a cylinder chamber 119 formed at the right-hand end of the cylinder 20 so as to move the piston 21 and the table 11 longitudinally toward the left. During this movement of the table 11, fluid within a cylinder chamber 119 formed at the left-hand end of the cylinder 20 exhausts through a pipe 120, into a chamber 121 formed between the pistons 27 and 28 in the valve 25, and passes outwardly through a pipe 122.

Fluid under pressure passing through the pipe 115 from the stop and start valve 40 also passes through a pipe 125 into a valve chamber 126

formed between the valve pistons 60 and 61 in the transversely movable table control valve 57. In the position of the valve (Fig. 2), fluid entering the valve chamber 126 passes outwardly through a pipe 127 and through a pipe 128 into a cylinder chamber 129 formed in the upper end of the cylinder 52 (Fig. 2) to move the piston 53 and the table 12 transversely in a downward direction, as shown diagrammatically in Fig. 2. During this movement of the transversely movable table 12, fluid within a cylinder chamber 130 formed at the lower end of the cylinder 52 exhausts through a pipe 131 which is connected with a valve chamber 132 in the control valve 57. In the position of the valve 57 (Fig. 2) exhaust fluid entering the chamber 132 passes outwardly through a pipe 133 into a valve chamber 134 formed in the stop and start valve 40 and returns to the source of supply through a pipe 135.

Fluid under pressure passing through the pipe 112 also enters a valve chamber 136 formed between the valve pistons 80 and 81 in the wheel feed control valve 77. In the position of the valve 77 (Fig. 2), fluid under pressure entering the valve chamber 136 passes outwardly through a pipe 137 into a cylinder chamber 138 formed in the upper end of the cylinder 70 so as to cause a downward movement of the piston 71 and the wheel slide 14. During the downward movement of the piston 71, fluid within a cylinder chamber 139 exhausts through a pipe 140 which is connected with a valve chamber 141 formed between the valve pistons 79 and 80 in the control valve 77 and passes outwardly through an exhaust pipe 142 into the source of supply or reservoir.

Fluid under pressure within the pipe 112 also passes into a valve chamber 143 formed between the valve pistons 102 and 103 in the work index control valve 100. Fluid entering the valve chamber 143 passes out through a pipe 144 into a cylinder chamber 145 formed at the left-hand end of the cylinder 95 to cause the piston 96 to move toward the left (Fig. 2) into an inoperative position. During movement of the piston 96 toward the left, fluid within a chamber formed at the left-hand end of the cylinder 95 may exhaust through a pipe 146 into a chamber 147 formed between the valve pistons 103 and 104. Fluid exhausting into the chamber 147 passes outwardly through the exhaust pipe 142 and returns to the reservoir or source of supply.

Slow down valve

It is desirable to provide a suitable control for fluid exhausting from the longitudinal table cylinder 20 so that the movement of the table may be readily controlled. A slow-down valve 148 is provided which is a piston type control valve having a valve stem 149. The valve stem 149 is operatively connected with a roller 150 which is arranged to be actuated by a pair of table dogs 151 and 152. The dogs 151 and 152 are adjustably supported on the front edge of the longitudinally movable table 11. In the position of the valve 148 (Fig. 2), fluid exhausting from the cylinder chamber 119 passes through the valve chamber 121 in the table control valve 25 and exhausts through the pipe 122 into a valve chamber 153 in the slow-down valve 148 and passes outwardly through a pipe 154 into the exhaust pipe 133. In this position of the valve (Fig. 2), substantially unrestricted exhaust of fluid is permitted so as to produce a comparatively rapid longitudinal movement of the table 11. As the

table moves to bring the web 19 of the work piece 18 into operative grinding relationship with the grinding wheels 16 and 17, a cam face 155 on the dog 151 depresses the roller 150 which in turn moves the valve stem 149 downwardly (Fig. 2) so as to cut off the exhaust of fluid through the pipe 154 and to permit fluid to exhaust through a pipe 156 and a throttle valve 157 so as to slow down the traversing movement of the table 11 to a grinding speed. By adjusting the throttle valve 157, the grinding feed of the work relative to the wheel may be adjusted as desired.

When the control valve 25 is shifted into its reverse position to cause the table 11 to move toward the left after the work piece has been traversed transversely relative to the grinding wheel, it is desirable that the initial movement of the table 11 toward the left be maintained at a slow grinding speed until the work piece 18 has traversed out of engagement with the grinding wheels 16 or 17. In the reverse position of the valve 25, fluid exhausting from the table cylinder chamber 118 passes through the pipe 117, the valve chamber 116, and out through a pipe 158 and through a throttle valve 159 into the exhaust pipe 133. By regulation of the throttle valve 159, the grinding traverse of the table 11 toward the left (Figs. 1 and 2) may be regulated to correspond with the movement of the table 11 in the opposite direction. When the work piece 18 moves out of operative contact with the grinding wheels 16 or 17 as the table 11 moves toward the left, the cam face 155 of the dog 151 allows the roller 150 to move upwardly under the released compression of a compression spring located adjacent to the top of the valve 148, thus allowing the valve 148 to return to the position illustrated in Fig. 2 so that substantially unrestricted exhaust of fluid may be obtained by passing the exhaust fluid through a valve chamber 160 and out through a pipe 161 which connects with exhaust pipe 133.

The dog 151 is formed with a flat lower surface 155a which is positioned to hold the valve 148 in a downward position (Fig. 2) so that fluid exhausts at a relatively slow rate through the throttle valve 157. When the table 11 approaches the end of its stroke toward the right (Fig. 2) just before the sleeve 197 engages the end cap at the left-hand end of the cylinder 20, it is desirable to cut off the exhaust of fluid from the cylinder so that the fluid serves as a cushion to prevent shocks and vibrations as the table 11 is stopped. This is preferably accomplished by providing a portion 155b on the dog 151 so that as the feeding movement is stopped, the roller 150 is permitted to rise a sufficient distance so as to cut off exhaust of fluid through the pipe 156, thus stopping the entire exhaust of fluid from the cylinder 20 at the time the sleeve 197 reaches a stopped position.

The slow down valve 148 and associated parts is shown diagrammatically in Fig. 2. In actual construction, as illustrated in Fig. 5, the roller 150 is rotatably supported at the upper end of a slidably mounted rod 271. The lower end of the rod 271 is connected by a stud 272 with an arm 273 of a bell crank lever 274. The bell crank lever 274 is pivotally supported on a rock shaft 275. A downwardly extending arm 276 of the bell crank lever 274 is connected by a stud 277 with a spool-shaped member 278 which is mounted on the valve stem 149 of the slow down valve 148. A manually operable lever 281 is fixedly mounted on the outer end of the rock shaft 275.

Relief valve

An adjustable pressure relief valve 164 is arranged in the pipe line 112 to facilitate maintaining the desired operating pressure within the hydraulic mechanisms above described. After the pressure within the system reaches the pressure set by the valve 164, the valve opens and allows excess fluid under pressure to pass through the pipe 165 into the cylinder chamber 77 to act upon the piston 76 and thus counterbalance the weight of the wheel slide 14. In order to regulate the pressure utilized for counterbalancing, fluid within the cylinder chamber 77 is connected by a pipe 166 with a second adjustable pressure relief valve 167. By regulating the valve 167, the desired counterbalance pressure may be secured within the chamber 77 so as to counterbalance the weight of the slide 14 and its associated parts. Excess fluid under pressure within the counterbalance cylinder 75 will open the valve 167 and allow the excess fluid under pressure to exhaust through a pipe 168 into the reservoir.

As shown diagrammatically in Fig. 2, the counterbalance cylinder 75 appears to be the same diameter as the feed cylinder 70 but in actual practice the counterbalance cylinder 75 is considerably larger in diameter so as to provide a large piston area for the counterbalancing operation. In order to compensate for quick vertical motion of the feed piston 71 so that the chamber 77 will always be maintained full of oil on the up stroke, a check valve 169 is connected in the pipe line 166. A pipe leads from the check valve 169 into the reservoir. If there is any tendency to create a vacuum within the cylinder chamber 77, due to rapid movement of the wheel slide 14, fluid is sucked up through the pipe and the check valve 169 into the cylinder chamber 77 to maintain the chamber 77 filled at all times.

Hand traverse-longitudinal table

It is desirable to provide a suitable manually operable traverse mechanism for traversing and positioning the longitudinally movable table 11 manually in setting up the machine. As illustrated in the drawings, a manually operable traverse mechanism is provided comprising a hand wheel 170 which is rotatably supported on the front of the machine base. The hand wheel 170 is connected through a clutch mechanism comprising a slidably mounted clutch member 171 (shown diagrammatically in Fig. 2) and a clutch member 172 which is mounted on one end of a rotatable shaft 173. The shaft 173 also supports a gear or pinion 174 which meshes with a rack bar (not shown) which is fixedly supported on the under side of the table 11. A compression spring 175 serves normally to hold the clutch member 171 in engagement with the clutch member 172.

During hydraulic operation of the table, it is desirable that the clutch be disconnected so that the hand wheel 170 will not turn during the power traversing movement of the table 11. This is preferably accomplished by a hydraulically operated mechanism. Fluid pressure entering the valve chamber 114 of the stop and start valve 140, in the position of the valve shown in Fig. 2, passes out through a pipe 176 into a cylinder chamber 177 to move the clutch member 171 downwardly (Fig. 2) against the compression of the spring 175 to maintain the hand wheel 170 disengaged while the hydraulic operating mechanisms are operative.

Hand traverse-transverse table

A similar manually operable traverse mechanism is provided to facilitate manual adjustment of the transversely movable table 12. This mechanism may comprise a manually operable rotatably mounted hand wheel 180 which is rotatably supported in fixed relation with the longitudinally movable table 11. The hand wheel 180 is mounted on the outer end of a rotatable shaft 181. The inner end of the shaft 181 supports a clutch member 182 which is normally maintained in engagement with a clutch member 183 by means of a compression spring 184. The clutch member 183 is fixedly mounted on the lower end of a rotatable shaft 185. The other end of the shaft 185 is provided with a gear or pinion 186 which meshes with a rack bar (not shown) to move the transversely movable table 12 relative to the longitudinally movable table 11. In actual construction a gear mechanism is interposed between the hand wheel 80 and the clutch part 82. Since this mechanism is not considered to be a part of the present invention, the diagrammatic illustration is believed to be sufficient.

Similarly, it is desirable to provide a hydraulic mechanism for disengaging the hand wheel 180 during the hydraulic operation of the machine. The pipe 176 is connected with a pipe 187 which passes fluid under pressure into a cylinder chamber 188 so as to move the clutch member 182 downwardly against the compression of the spring 184 so that the hand wheel 180 is disengaged during the hydraulic operation of the machine.

When the machine is stopped, the stop and start lever 47 is moved in a counterclockwise direction to shift the valve stem 41 toward the right (Fig. 2), which movement shifts the valve piston 45 so that fluid within the cylinder chambers 177 and 188 may exhaust through pipes 176 and 187 through a valve chamber 189 located between the valve pistons 44 and 45 and exhaust through a pipe 190 into the reservoir. As soon as the stop and start valve is moved into this position, the released compression of the springs 175 and 184 engages the clutch parts 171—172 and 182—183 so as to render the manually operable traverse wheels 170 and 180 operative.

During the manual traverse of the longitudinally movable table 11 and the transversely movable table 12, it is desirable to provide a suitable fluid pressure by-pass so that the manual traverse may be accomplished without overcoming resistance of the fluid within the hydraulic system. As shown in Fig. 2, a pipe 191 connects the pipe 128 with a valve chamber 193 in the stop and start valve 40. A pipe 192 connects the pipe 131 with the valve chamber 193. When the stop and start lever 47 is moved in a counterclockwise direction to shift the valve stem 41 toward the right, both of the pipes 191 and 192 will be connected through the valve chamber 193 so that when the hand wheel 180 is rotated to impart a manual traversing movement of the table 12, fluid may readily by-pass from the cylinder chamber 129 in the cylinder 52 through the pipes above described into the chamber 130 and vice versa.

Similarly, a by-pass is provided for the cylinder 20. A pipe 194 is connected between the pipe 117 and a valve chamber 196 in the stop and start valve 40. A pipe 195 is connected between the pipe 120 and the valve chamber 196. When the valve 40 is shifted into its right-hand end position to stop the hydraulic operation of the

machine and render the manual traverse mechanisms operative, the pipes 194 and 195 will be connected through the valve chamber 196 so that fluid may readily by-pass between the opposite end chambers 118 and 119 of the cylinder 20. In this position of the parts, the table 11 may be readily traversed manually by rotation of the hand wheel 170.

Work table-stop mechanism

It is desirable to provide suitable stops for precisely limiting the longitudinal movement of the table 11 in one direction and the transverse movement of the slide 12 in one direction. This is preferably accomplished by providing an adjustably mounted sleeve 197 on the piston rod 22. When the table 11 is moved toward the right (Fig. 2), this movement continues to feed the work piece 18 relative to the grinding wheels 16 and 17 until the sleeve engages the cylinder head on the left-hand end of the cylinder 20 which serves as a positive stop to limit the infeeding movement of the table 11.

Similarly, a stop sleeve 198 is adjustably mounted on the piston rod 54 and serves to limit the movement of the transversely movable slide 12 toward the rear of the machine, that is, in an up direction in Fig. 2. When the slide 12 moves toward the rear to traverse the work piece relative to the grinding wheels, this movement continues at a grinding speed until the sleeve 198 engages the cylinder head on the lower end of the cylinder 52 which serves as a positive stop to limit the transverse grinding stroke of the work piece and table 12.

Wheel slide-stop mechanism

As above stated, the machine is arranged for grinding an upper and a lower plane surface on webs 19 projecting from a work piece 18. Opposed spaced grinding wheels 16 and 17 are provided. The wheel slide 14 is first moved downwardly to grind the upper surface of the web 19. After all of the upper surfaces of the webs 19 have been ground to the desired and predetermined extent, the wheel slide 14 may be moved upwardly to position the lower wheel 17 in proper position for grinding the lower surfaces of the webs 19. It is desirable to provide suitable stop mechanisms for precisely determining the up and down position of the wheel slide 14 so that the wheels 16 and 17 may be precisely positioned for the grinding operation. As illustrated in Fig. 2, the piston rod 72 is provided with a threaded portion 199 which serves as a feed screw. A sleeve 200 is screw threaded onto the feed screw 199. A worm gear 201 is slidably keyed to the outer periphery of the sleeve 200. The worm gear 201 is held against axial movement so that the piston rod 72 and the sleeve 200 are free to move in an endwise direction during the hydraulic feeding movement of the wheel slide. A worm 202 meshes with the worm gear 201. A manually operable hand wheel 203 is mounted on the outer end of the shaft supporting the worm 202. The feed wheel 203 is the standard micrometer feeding wheel which is common and well known in the grinding machine field, such as for example that shown in the expired patent to Norton, No. 762,838 dated June 14, 1904. The feed wheel is provided with a micrometer adjusting mechanism 204 and a stop (not shown) by means of which the feed wheel 203 may be turned to a predetermined position precisely to adjust the position of the upper grinding wheel 16. The lower end of the sleeve

200, when moved downwardly, engages the end cap of the cylinder 70 and serves as a positive stop to limit the downward feeding movement of the wheel slide 14 and the grinding wheel 16. To compensate for wear on the grinding wheel 16, it is merely necessary to adjust the hand wheel 203 to reposition the stop sleeve 200 so as to allow the wheel slide 14 and the grinding wheel 16 to move to a slightly lower position.

A similar feeding mechanism is provided to control the upward feeding movement of the slide 14 and the grinding wheel 17 to position the grinding wheel 17 in a predetermined position relative to the under surface of the web 19 on the work piece 18 to be ground. The piston rod 72 is provided with a second feed screw 206. A stop sleeve 207 is screw threaded onto the feed screw 206. A worm gear 208 surrounds the sleeve 207 and is slidably keyed to the outer periphery thereof. A worm 209 meshes with the worm gear 208. A manually operable feed wheel 210 is mounted on the outer end of the shaft supporting the worm 209. This feed wheel 210 is provided with the usual micrometer adjusting mechanism 211 and a stop (not shown) for limiting the rotary movement of the feed wheel 210. When the wheel slide 14 and grinding wheel 17 are moved in an upward direction, the feeding movement continues until the upper end of the sleeve 207 engages the end face of the cap enclosing the lower end of the cylinder 70 which serves as a positive stop to limit the upward feeding movement of the grinding wheel assembly precisely to position the operative face of the grinding wheel 17 relative to the lower face of the web 19 to be ground. It will be readily apparent that by adjustment of the hand wheel 210, the position of the stop sleeve 207 may be readily adjusted so as to compensate for wear of the grinding wheel 17.

In order to automatically shift the lever 30 in timed relation with the movement of the transversely movable table 12, a pair of dogs 215 and 216 are carried by the transversely movable slide 12. As shown diagrammatically in Fig. 2, the dogs 215 and 216 are mounted on the stop sleeve 198. These dogs are arranged to engage an arm 217 of a bell crank lever 218. The bell crank lever 218 is pivotally supported on a shaft 219. The short arm of the bell crank 218 is connected by a link 220 with the lever 30. It will be readily apparent from the foregoing disclosure that when the transversely movable slide 12 moves transversely to a predetermined position in either direction, the bell crank lever 218 will be rocked by one of the dogs 215 or 216 to shift the cycle control lever 30 into a reverse position, thus shifting the control valve 25 so as to start the movement of the work table 11.

In actual construction, as illustrated in Figs. 5, 6, 7 and 8, the dogs 215 and 216 carried by the transversely movable table 12 serve to rock the lever 39 to rock the shaft 38. Rotary motion of the shaft 38 is transmitted through bevel gears 37a-37 to rotate the shaft 31 and thereby to shift the control lever 30 and the control valve 25 in timed relationship with the transverse movement of the table 12. The dog 215 is preferably adjustably mounted on the end of the transversely movable table 12. The dog 216 is adjustably mounted on a pivotally mounted control lever 216a which is pivotally supported by a stud 216b on the dog 215. The control lever 216a is normally held in an operative position (Fig. 6) by means of a spring 216c. If it is desired to

traverse the table 12 toward the right (Fig. 6) beyond the normal stroke, the lever 216a may be moved in a clockwise direction to raise the dog 216 to an inoperative position out of the path of the stud 217 on the lever 39.

Interlock—work index

It is desirable to provide a suitable interlock to prevent indexing of the work piece 18 when the work piece is in an operative position relative to the grinding wheels 16 and 17. This interlock preferably comprises an adjustable dog 225 which is adjustably mounted on the front edge of the longitudinally movable table 11. The dog 225 is provided with a lower plane surface 226. The lever 105 is provided with a roller 227 which is positioned so that when the lever 105 is in an inoperative position, the roller 127 will ride beneath the surface 226 of the dog 225. When the roller 227 is positioned beneath the surface 226, it serves as a stop to prevent shifting of the index control lever 105 in a counterclockwise direction so as to prevent initiating an indexing movement of the work piece 18 except when the table 11 is in an extreme left-hand end or loading position. When the table 11 is moved to its left-hand end or loading position, the dog 225 moves out of the path of the roller 227 so that the lever 105 may be readily shifted in a counterclockwise direction to index the work piece in the manner above described.

Truing apparatus

It is desirable that a suitable truing apparatus be provided so that the opposed faces of the grinding wheels 16 and 17 may be simultaneously trued to the desired and predetermined extent. It is desirable to provide a truing mechanism in which the truing diamonds are fixed during the normal operation of the machine so that after the wheels have been trued, it is not necessary to reset the feeding mechanism before resuming the grinding operation. The diamonds are adjustable only to compensate for wear of the diamond itself. In the grinding operation illustrated in the present case, it is desirable to have the operative faces of the grinding wheels back tapered toward the center in a manner such as that diagrammatically shown in Fig. 14. A pair of truing tools or diamonds 230 and 231 are provided to true the operative faces of the grinding wheels 16 and 17, respectively. These diamonds are mounted in a manner to be hereinafter described and are arranged to traverse in a direction such as illustrated by the line 232 in the diagrammatic illustration in Fig. 14. This line 232 is parallel to the face of the wheel 16 to be trued by the diamond 230 and is also parallel to the face of the grinding wheel 17 to be trued by the diamond 231.

This truing mechanism has been illustrated in Figs. 11, 12, 13 and 14. A frame 234 is fastened to the column 13 of the machine. This frame 234 serves as a support for a plate 235. The plate 235 is arranged to pivot on a stud 236 and may be clamped in adjusted position on the frame 234 by means of clamping screws 237 and 238. The clamping screws 237 and 238 pass through elongated slots 239 and 240 formed in the plate 235. It will be readily apparent from the foregoing disclosure that the plate 235 which serves as a support for the truing apparatus may be angularly adjusted to determine the path of movement of the truing tools 230 and 231.

The plate 235 is provided with a pair of spaced

bearing brackets 241 and 242. The bearing bracket 241 rotatably supports a longitudinally extending sleeve 243 (Fig. 12). The sleeve 243 is rotatably supported within a sleeve 244 which is journaled in a bearing surface formed in the bracket 242. The sleeve 243 is provided with an adjustably mounted truing tool arm 245 which serves as a support for the truing tool 231. The sleeve 244 is provided with a truing tool arm 246 which serves as a support for the truing tool 230.

In order to traverse the truing tools 230 and 231 across the operative faces of the grinding wheels 16 and 17 respectively, a suitable traverse mechanism is provided comprising a hand wheel 247 which is mounted on the outer end of a feed screw shaft 248 having a feed screw 249 formed at its left-hand end (Fig. 11). The feed screw 249 is screw threaded into a nut 250 which is fixedly mounted relative to the plate 235 and the bracket 241. It will be readily apparent from the foregoing disclosure that rotary motion of the hand wheel 247 will be imparted through the feed screw 249 and the nut 250 to traverse the sleeves 243 and 244 longitudinally relative to the plate 235 so as to impart a traversing movement to the truing tools 230 and 231 to traverse the same across the operative faces of the grinding wheels 16 and 17, respectively.

In order to facilitate adjustment of the truing tools 230 and 231 to compensate for diamond wear, an arm 251 is fixedly mounted on the right-hand end of the sleeve 243. An arm 252 is fixedly mounted on the right-hand end of the sleeve 244. The arms 251 and 252 are substantially identical in shape and are arranged to facilitate angular adjustment of the sleeves 243 and 244, respectively. Since these arms are identical, only one of them has been illustrated in detail. The bearing brackets 241 and 242 serve as a support for a rod 253. The rod 253 extends through elongated rectangularly shaped openings 254 and 255 formed in the arms 251 and 252. An adjusting screw 256 is screw threaded into a portion 257 of the arm 251. The other end of the screw 256 is rotatably supported in a bearing 258 formed in the arm 251. An adjusting knob 259 is mounted on the outer end of the adjusting screw 256 to facilitate manual adjustment thereof. The screw 256 passes through an aperture 260 formed in the rod 253. A fixed thrust collar 261 is mounted on the screw 256 and bears against a plane surface milled on the side of the rod 253. A thrust collar 262 is slidably mounted on the outer end of the adjusting screw 256 to facilitate manual adjustment thereof. A compression spring 263 is interposed between the thrust collar 262 and the left-hand inner face of the aperture 254 of the arm 251. It will be readily apparent from the foregoing disclosure that a rotary adjustment of the knob 259 will be transmitted, angularly to adjust the arm 251 relative to the fixed rod 253 to adjust the position of the diamond 231 which trues the lower wheel 17. The knob 259 is provided with graduations 264 and an index mark 265 is fixedly mounted on the arm 251 to facilitate precise adjustment of the diamond 231 in setting up the machine and also to compensate for wear of the diamond 231.

A similar adjusting screw (not shown) is provided for adjusting the arm 252 relative to the fixed rod 253. The details of this adjustment have not been illustrated since this mechanism is identical with that shown in connection with the arm 251 above described. A graduated ad-

justing knob 266 is provided for adjusting the arm 252.

When it is desired to true the grinding wheels, the operator adjusts the position of the feed stop control wheels 203 and 210, respectively, by an amount equal to the amount it is desired to true off the faces of the grinding wheels. After this adjustment has been made, the hand wheel 247 is rotated to traverse the truing tools 230 and 231 across the operative faces of the grinding wheels 16 and 17, respectively, to true the operative faces thereof. The diamonds 230 and 231 are not adjusted during use of the machine except to compensate for wear on the diamonds themselves.

A one-shot lubricant pump 285 (Fig. 2) is provided to convey lubricant to the wheel slide way and to the work table ways. A manually operable knob 286 is provided for manually actuating the one-shot pump 285 when desired. If desired, the one-shot pump 285 may be actuated in timed relation with the operating mechanisms of the machine. As illustrated in the drawings, the pump 285 is actuated in timed relationship with the work indexing mechanism so as automatically to convey a shot of lubricant through a pipe 292 and through pipes 293 and 294 to the wheel slide and work table ways respectively (as illustrated diagrammatically in Fig. 2) each time the work index mechanism is actuated. A pipe 287 is connected at one end with the pipe 146. The other end of the pipe 287 is connected to convey fluid under pressure to a cylinder chamber 288 in a cylinder 289. A piston 290 is slidably mounted in the cylinder 289 and is formed integral with a stem 291 which connects the knob 286 with the one-shot pump 285. It will be readily apparent from the foregoing description that when the lever 105 is shifted to actuate the control valve 100 so as to admit fluid under pressure through the pipe 146 to cause an indexing movement of the work holder, fluid under pressure is also admitted through the pipe 287 into the cylinder chamber 288 to cause the piston 290 to move toward the right (Fig. 2) to actuate the one-shot pump 285 and thereby automatically pass one shot of lubricant to the wheel slide and the work table ways.

The operation of the improved surface grinding machine will be readily apparent from the foregoing disclosure. Assuming all of the parts have been previously adjusted for grinding a plurality of webs 19 on a work piece 18, the work piece 18 is placed in position on the work holder which is carried by the transversely movable table 12 and is clamped in position thereon by means of a clamping nut 270. The stop and start lever 47 is then shifted into the position illustrated in Fig. 2 to render the manual traverse wheels 170 and 180 inoperative and to render the hydraulic system operative. The cycle control lever 30 may then be shifted in a clockwise direction to initiate a grinding cycle. This movement of the cycle control lever 30 shifts the valve 25 toward the right (Fig. 2) to pass fluid under pressure into the cylinder chamber 119 to cause the table 11 to move longitudinally toward the right so as to feed the work piece into grinding relation with the grinding wheel 16. This movement of the work table 11 continues until the work piece moves so that the grinding wheel 16 is positioned as shown diagrammatically in Fig. 7 in position 16a. When the work piece approaches this position, the table dog 151, through the roller 150, closes the slow-down valve 148 to slow down the feeding movement of the table 11. At the

same time, the table dog 69 engages and shifts the control lever 62 in a clockwise direction to shift the valve 57 toward the right. The table movement serves to shift the lever 62 until the arrow point 64 passes the high point on the roller 65, after which the released compression of the spring-pressed roller 65 quickly throws the valve 57 into the reverse position. By this time the stop sleeve 197 has engaged the fixed stop, that is, the end cap on the left-hand end of the cylinder 20 which limits the longitudinal movement of the table 11 toward the right.

When the valve 57 assumes its right-hand end position, fluid under pressure is passed through pipe 131 into cylinder chamber 130 to start the movement of the transversely movable table 12 toward the rear of the machine so as to traverse the web 19 transversely relative to the grinding wheel 16 to grind the upper plane surface of the web 19 to the desired and predetermined extent. This grinding stroke continues until the stop sleeve 198 engages the cylinder cap at the lower end of the cylinder 52 (Fig. 2) which positively limits the transverse grinding feed. As the table 12 reaches the rearward end of its stroke, the dog 215 carried by the table 12 engages the arm 217 and rocks the bell crank lever 218 in a counterclockwise direction, which movement serves through the link 220 to shift the cycle control lever 30 in a counterclockwise direction into the position shown in Fig. 2 so that fluid under pressure will pass through the pipe 117 into the cylinder chamber 118 of the cylinder 20 to start the table 11 moving in a direction toward the left (Fig. 2). The transverse movement of the slide 12 toward the rear is a relatively slow movement due to the fact that fluid exhausts from the cylinder chamber 129 through the needle valve 163 which controls the rate of movement thereof.

As the table 11 starts its movement toward the left, it is desirable that the initial movement thereof, until the work has moved clear of the grinding wheel 16, be at a slow grinding speed. This is preferably accomplished by allowing the fluid exhausting through the pipe 120 to pass through the throttle valve 157, as previously described, to produce a slow grinding feed of the table 11 toward the left. After the roller 151 rides off the lower flat face 155a of the dog 151, the released compression of the spring will shift the slow-down valve 148 upwardly into the position shown in Fig. 2, after which fluid may exhaust at a substantially unrestricted rate through pipe 154 instead of through the throttle valve 157 so that the table 11 moves at a rapid rate during the remainder of its longitudinal movement toward the left. The table moves toward the left until the dog 152 again depresses the roller 150 which serves again to close the slow-down valve 148, thus cutting off exhaust of fluid from the cylinder to stop the table at its left-hand end position. At the same time, the dog 69a engages the lever 62 and rocks it into the position illustrated in Fig. 2 to shift the valve 57 into its extreme left-hand end position so that fluid under pressure will pass through pipes 127 and 128 into cylinder chamber 129 to move the table 12 transversely toward the front of the machine at a rapid rate so that the work piece returns to its initial or starting position, thus completing a grinding cycle. After the completion of a cycle, the position of the grinding wheel may be adjusted if desired. The grinding cycle may continue to be repeated automatically until inter-

rupted manually in a manner to be hereinafter described.

When it is desired to interrupt the grinding cycle, after the work piece has repeated the desired number of cycles as above described, a trip lever 280 (Fig. 2) is provided which serves to swing the dog 216 out of the path of the arm 217 of the bell crank lever 218 so that the table 11 may move to its extreme forward position. The lever 281 may then be actuated to open the slow down valve 148 to allow unrestricted exhaust of fluid from the cylinder 20 so that the table 11 will traverse rapidly toward the left to a loading position. In this position, the index control lever 105 may be shifted in a counterclockwise direction to index the work piece 18 through ninety degrees to present the next web 19 in operative relation for a grinding operation. The grinding cycle may then be continued on successive webs until the upper plane surfaces have all been ground to the desired and predetermined extent. After the lever 280 has been tripped to render the dog 216 inoperative, a lever 281 is also moved in a clockwise direction to raise the valve stem 149 so that fluid may pass through to the cylinder 20 to cause a rapid movement of the table 11 into its loading position.

When it is desired to adjust the position of the wheels 16 and 17, that is, the stop position thereof, to compensate for wheel wear or for a truing operation, it is merely necessary for the operator manually to adjust the hand wheels 203, and 210, respectively. If these adjustments are made for a truing operation, the truing tools may be traversed longitudinally by a rotary motion of the hand wheel 247 to transmit a traversing movement of the diamonds 230 and 231 so as to traverse them across the operative faces of the grinding wheels 16 and 17, respectively.

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 having a base, a wheel slide thereon, a rotatable spindle on said slide, a pair of spaced grinding wheels on said spindle having opposed operative faces which are arranged successively to grind opposed plane faces on a work piece, means including a piston and cylinder to move said slide successively to position the grinding wheel faces in operative positions, and a pair of independent micrometer adjusting mechanisms to limit the movement of said slide in either direction precisely to locate the wheel faces relative to the work piece.

2. In a grinding machine having a base, a wheel slide thereon, a rotatable spindle on said slide, a pair of spaced grinding wheels on said spindle having opposed operative faces which are arranged to grind opposed plane faces on a work piece, means including a piston and cylinder to move said slide, a double end piston rod connected with said piston, connections between said rod and said slide, a pair of stop sleeves which are screw threaded on the piston rod at opposite ends of said cylinder which are arranged to engage the ends of said cylinder so as to limit

the movement of said piston and wheel slide in either direction, and an independent micrometer adjusting mechanism precisely to adjust each of said sleeves relative to said piston rod to facilitate positioning the operative faces of the grinding wheels successively to grind opposed plane faces on a work piece.

3. In a grinding machine having a vertically movable grinding wheel slide, a rotatable grinding wheel thereon, a piston and cylinder to move said slide, a piston rod connecting said piston with said slide, an adjustable stop for limiting the movement of said piston in one direction, a micrometer feed mechanism for adjusting said stop, a control valve therefor, a longitudinally movable table, a transversely movable table on said longitudinally movable table, a piston and cylinder for said transversely movable table, a control valve therefor, and an automatic cycle control mechanism to cause a transverse movement of said table to a predetermined position and a return thereof to its initial position so as to grind a predetermined plane face on a work piece.

4. In a grinding machine having a vertically movable grinding wheel slide, a rotatable wheel thereon, a piston and cylinder to move said slide, a piston rod connecting said piston with said slide, an adjustable stop for limiting the movement of the piston in one direction, a micrometer feed mechanism for adjusting said stop, a control valve therefor, a longitudinally movable table, a piston and cylinder to move said table, a control valve therefor, a transversely movable table on said longitudinally movable table, a piston and cylinder to move said transversely movable table, a control valve therefor, a rotatable indexable work support on said transversely movable table, and an automatic cycle control mechanism for said valves for causing a movement of said longitudinally movable table to a predetermined position, then a movement of said transversely movable table to a predetermined position so as to grind a predetermined plane face on a work piece.

5. In a grinding machine as claimed in claim 4, the combination with the parts and features therein specified, of a counterbalance piston and cylinder, said counterbalance piston being connected to the wheel slide piston rod, a fluid pressure system including a fluid pump, an adjustable relief valve in said system to maintain a predetermined operating pressure in said system, a pipe to convey fluid exhausting from said relief valve into said counterbalance cylinder, and a relief valve associated with the counterbalance cylinder to facilitate controlling the pressure in said latter cylinder so as to counterbalance the weight of the wheel slide and associated parts.

6. In a grinding machine having a vertically movable grinding wheel slide, a pair of spaced rotatable grinding wheels on said slide having opposed operative faces which are arranged to grind opposed plane faces on a work piece, a piston and cylinder to move said slide, a piston rod connecting said piston with said slide, a pair of adjustable stop sleeves on said piston rod successively to position the operative faces of said grinding wheels, a control valve therefor, a longitudinally movable table, a piston and cylinder to move said table, a control valve therefor, a transversely movable table on said longitudinally movable table, a piston and cylinder to move said transversely movable table, a control valve therefor, a rotatable indexable work

support on said transversely movable table which is arranged successively to present predetermined portions on a work piece for a grinding operation, and an automatic cycle control mechanism for said valves to cause a movement of said longitudinally movable table to a predetermined position, then a movement of said transversely movable table to a predetermined position so as to grind a predetermined plane face on a work piece, after which said tables are moved to their initial positions.

7. In a grinding machine having a vertically movable grinding wheel slide, a pair of spaced rotatable grinding wheels on said slide having opposed operative faces which are arranged to grind opposed plane faces on a work piece, a piston and cylinder to move said slide, a piston rod connecting said piston with said slide, a pair of adjustable stop sleeves on said piston rod successively to position the operative faces of said grinding wheels, a control valve therefor, a longitudinally movable table, a piston and cylinder to move said table, a control valve therefor, a transversely movable table on said longitudinally movable table, a piston and cylinder to move said transversely movable table, a control valve therefor, a rotatable indexable work support on said transversely movable table which is arranged successively to present predetermined portions on a work piece for a grinding operation, and an automatic cycle control mechanism for said valves to cause a movement of said longitudinally movable table to a predetermined position, then a movement of said transversely movable table to a predetermined position so as to grind a predetermined plane face on a work piece, after which said tables are moved to their initial positions, said control mechanism being arranged so that the cycle of operation repeats itself until the surface of the work piece has been ground to the desired and predetermined extent.

8. In a grinding machine having a vertically movable grinding wheel slide, a pair of spaced grinding wheels thereon, a piston and cylinder to move said slide, a control valve therefor, a longitudinally movable table, a piston and cylinder to move said table, a control valve therefor, a manually operable control lever therefor, a transversely movable table on said longitudinally movable table, a piston and cylinder to move said transversely movable table, a control valve therefor, a control lever for said latter valve, adjustable dogs on said transversely movable table to actuate the manually operable control lever for controlling the extent of movement of said longitudinally movable table in either direction, and adjustable dogs on said longitudinally movable table to actuate the second control lever for controlling the extent of movement of said transversely movable table, said dogs and control lever mechanisms being arranged to cause a movement of the longitudinally movable table to a predetermined position, after which the transversely movable table moves transversely to a predetermined position to grind a plane face on the work piece and thereafter successively to return said longitudinally movable table and said transversely movable table to their initial positions.

9. In a grinding machine as claimed in claim 8, the combination with the parts and features therein specified, of a manually operable lever, and connections between said lever and one of the dogs on said transversely movable table to

render said dog inoperative and thereby to interrupt the continuous cycle.

10. In a grinding machine as claimed in claim 8, the combination with the parts and features therein specified, of a manually operable lever which is operatively connected to render one of the transversely movable table dogs inoperative so as to interrupt the continuous grinding cycle, and a second manually operable lever which is operatively connected to shift said tables to a loading position after a predetermined grinding operation has been completed.

11. In a grinding machine having a vertically movable grinding wheel slide, a pair of spaced grinding wheels thereon, a piston and cylinder to move said slide, a control valve therefor, a longitudinally movable table, a piston and cylinder to move said table, a control valve therefor, a manually operable control lever therefor, a transversely movable table on said longitudinally movable table, a piston and cylinder to move said transversely movable table, a control valve therefor, a control lever for said latter valve, adjustable dogs on said transversely movable table to actuate the control lever for said longitudinally movable table, and adjustable dogs on said longitudinally movable table to actuate the control lever for said transversely movable table, said dogs and levers being arranged automatically to traverse the longitudinally movable table to feed the work toward the grinding wheel to grind a plane surface on a work piece to a predetermined extent, after which the transversely movable table is automatically traversed transversely relative to the grinding wheel to traverse the grinding wheel across a predetermined face on the work piece, thereafter automatically to traverse the longitudinally movable table to move the work piece to an inoperative position first at a grinding rate until the work is out of grinding contact with the grinding wheel, after which the longitudinally movable table moves rapidly to a predetermined position and thereafter automatically to traverse the transversely movable table rapidly to return the work piece to its initial position.

12. In a grinding machine having a vertically movable grinding wheel slide, a pair of spaced grinding wheels thereon, a piston and cylinder to move said slide, a control valve therefor, a longitudinally movable table, a piston and cylinder to move said table, a control valve therefor, a manually operable control lever therefor, a transversely movable table on said longitudinally movable table, a piston and cylinder to move said transversely movable table, a control valve therefor, a control lever for said latter valve, adjustable dogs on said transversely movable table to actuate the control lever for said longitudinally movable table, and adjustable dogs on said longitudinally movable table to actuate the control lever for said transversely movable table, said dogs and levers being arranged automatically to traverse the longitudinally movable table to feed the work toward the grinding wheel at a grinding rate to grind a plane surface on a work piece to a predetermined extent, after which the transversely movable table is automatically traversed transversely relative to the grinding wheel at a grinding rate to allow the grinding wheel to grind a predetermined face on the work piece, thereafter automatically to traverse the longitudinally movable table to move the work

piece to an inoperative position first at a grinding rate until the work is out of grinding contact with the grinding wheel, after which the longitudinally movable table moves rapidly to a predetermined position and thereafter automatically to traverse the transversely movable table rapidly to return the work piece to its initial position.

13. In a grinding machine as claimed in claim 4, the combination with the parts and features therein specified, of a work index mechanism including an index plate, a holding pawl to locate said plate and work piece in a predetermined position for a grinding operation, a pivotally mounted actuating pawl associated with said indexing plate, a piston and cylinder to actuate said latter pawl to index said work piece successively to present predetermined portions of the work piece into grinding positions, a control valve therefor, a manually operable control lever to actuate said valve, and an interlock to prevent movement of said control lever except when the work table is in an inoperative or loading position.

14. In a grinding machine as claimed in claim 4, the combination with the parts and features therein specified, of a work indexing mechanism including an index plate, a holding pawl to locate said plate and work piece in a predetermined position for grinding, a pivotally mounted actuating pawl associated with said index plate, a piston and cylinder to actuate said latter pawl to index said work piece successively to present predetermined portions of the work piece into grinding positions, a control valve therefor, a manually operable control lever to actuate said valve, and an interlock including an adjustable dog on said longitudinally movable table to prevent movement of said control lever to initiate an indexing movement of the work piece except when the longitudinally movable table is in an inoperative or loading position.

15. In a grinding machine as claimed in claim 4, the combination with the parts and features therein specified, of a lubricating system for the wheel slide and work table ways, including a one-shot lubricant pump, manual means to actuate said pump, a piston and cylinder to actuate said pump, operative connections between said work index control valve and said cylinder whereby fluid under pressure is admitted simultaneously to the work index cylinder and to the lubricant pump cylinder to actuate said lubricant pump each time the work indexing mechanism is actuated to convey lubricant to the wheel slide and table ways.

16. In a grinding machine as claimed in claim 4, the combination with the parts and features therein specified, of a slow-down valve in the exhaust side of said longitudinally movable table cylinder, said valve normally being positioned to allow substantially unrestricted exhaust of fluid from either end of said table cylinder, said valve in a second position being arranged to reduce the exhaust of fluid from one end of the cylinder so as to change the rate of movement of said table from a rapid approaching to a grinding feed, and means including an adjustable dog on said longitudinally movable table to actuate said valve as the work piece approaches operative engagement with the grinding wheel to change the rate of movement of the table to a grinding speed.

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