This invention relates to automatic grinding machines and more particularly to improved automatic means for truing the grinding wheels thereof.

One of the objects of this invention is to provide an improved automatic truing mechanism especially adapted for use in automatic grinding machines.

Another object of this invention is to provide an improved mechanism of the class described for automatically truing two intersecting faces on the periphery of a grinding wheel.

A further object of this invention is to provide an improved automatic control circuit for controlling the successive movement of two power operable truing devices operating in different planes on the periphery of the same grinding wheel.

A still further object of this invention is to provide an improved control mechanism including work counting means for automatically determining the frequency of truing operations in an automatic machine by controlling the number of work pieces ground for each truing operation.

An additional object of this invention is to provide an improved automatic control mechanism for effecting truing operations at some predetermined frequency and each time automatically affecting compensation in the position of parts resulting from the truing operation.

Another object of this invention is to provide a truing mechanism with relative control means such that the truing operation may be performed with the grinding cycle progressing or alternatively with the cycle interrupted and in either case at some regular frequency predetermined, for instance, by the number of work pieces ground.

Other objects and advantages of the present invention should be readily apparent by reference to the following specification, considered in conjunction with the accompanying drawings forming a part thereof, and it is to be understood that any modifications may be made in the exact structural details there shown and described, within the scope of the appended claims, without departing from or exceeding the spirit of the invention.

Referring to the drawings in which like reference numerals indicate like or similar parts:

Figure 1 is a plan view of a grinding machine to which this invention has been applied.

Figure 2 is a vertical section through the grinding wheel support and actuating mechanism therefor as viewed on the line 2—2 of Figure 1.

Figure 3 is a sectional view in elevation as viewed on the line 3—3 of Figure 1.

Figure 4 is a detail section on the line 4—4 of Figure 3.

Figure 5 is a fragmentary view as viewed on the line 5—5 of Figure 3.

Figure 6 is a sectional view as viewed on the line 6—6 of Figure 3.

Figure 7 is a view of one truing slide as viewed on the line 7—7 of Figure 3.

Figure 8 is a vertical section through the main truing slide adjusting mechanism as viewed on the line 8—8 of Figure 3.

Figure 9 is a sectional view on the line 9—9 of Figure 8.

Figure 10 is a sectional view through the work support adjusting mechanism as viewed on the line 10—10 of Figure 1.

Figure 11 is an end view partly in section of the work support compensating mechanism as viewed on the line 11—11 of Figure 10.

Figure 12 is a detail sectional view as viewed on the line 12—12 of Figure 11.

Figure 13 is a diagram of the solenoid control circuit.

Figure 14 is a chart to accompany the circuit shown in Figure 13.

Figure 15 is a diagram of the electrical control circuit.

Figure 16 is a chart to accompany the control circuit shown in Figure 15.

Figure 17 is a diagrammatic view of the hydraulic control circuit.

Automatic grinding machines have a continuously repeating grinding cycle and in order to obtain maximum production are usually provided with automatic work loading means. Due to the high productive rate of such machines it will be obvious that the wear of the grinding wheel will be at a corresponding high rate. It nevertheless is necessary to maintain the grinding wheel in good grinding condition, that is, its cutting quality, its shape, and its position with respect to the work, if precision or accuracy of work size is to be maintained.

In the more highly developed machines, the grinding wheel face is altered to grind some other shape on the surface of the work, than a plain cylindrical surface. For example, in the roller bearing industry the raceways have a dished angular surface and the demand of the industry requires that these surfaces be ground in one operation. This obviously requires a corresponding shape on the periphery of the grinding wheel, which in this case constitutes two intersecting...
surfaces which must be dressed or trued with accuracy.

The truing mechanism of this invention is particularly adaptable for use in this type of automatic machine and is adapted to automatically true two angularly intersecting surfaces on the periphery of the grinding wheel in coordinated relation to the continuously repeating automatic grinding cycle. This invention is so contrived that it will perfectly interlat the cycle action after a predetermined number of work pieces have been ground, and true the two angular surfaces on the wheel automatically in succession and then reinstate the grinding cycle. In addition, the control mechanism of this invention may be adjusted at will to cause the truing operation to be performed simultaneously with the grinding operation, in those cases where the amount of stock to be removed is sufficient to permit the truing operation to be completed before the grinding operation is completed.

A counter mechanism has also been provided that may be manually set to select the number of work pieces to be ground between truing operations and thus determine the frequency of the truing operations.

It will be obvious that after each truing operation that the grinding wheel has been reduced in diameter, and this requires readjustment between the wheel and the work as well as readjustment of the truing elements with respect to the wheel, and mechanism has been provided by means of this invention for automatically effecting these readjustments.

A grinding machine shown in the application, Serial No. 734,080, filed March 12, 1947, now Patent 2,478,562, issued August 9, 1949, has been selected as an example of an automatic grinding machine to which this invention is particularly adaptable.

In this machine, the general structure of which is shown in Figures 1 and 2 of the drawings, the reference numeral 13 indicates the bed of the machine upon which is slidably mounted a work supporting structure indicated generally by the reference numeral 14 and which may be moved or adjusted along the top of the bed by means of a head screw 12, which, as shown in Figure 10, is threaded in a nut member 13 fixed with the bed 12 of the machine.

The work piece is indicated by the reference numeral 14 in Figure 1 and is held against the driving member 15 by means more fully disclosed in the co-pending application, and further description thereof is not believed to be necessary since it forms no part of this invention.

The grinding wheel is indicated by the reference numeral 16, and it will be noted that it has two angular faces 17 and 18 formed on its periphery for grinding an angular surface on the workpiece. The grinding wheel 16 is secured to the end of a rotatable spindle 19 which is journaled in suitable bearings 20 mounted in an oscillatable support 21 as shown in Figure 2. The support 21 constitutes, in effect, a grinding wheel head, which is supported for oscillation about a trunnion 22 to give the center of the grinding wheel through an arcuate path, indicated by the dotted line 23 in Figure 2, to cause engagement of the periphery of the grinding wheel with the work.

The grinding head 21 is oscillated in the automatic grinding cycle consisting of a rapid traverse movement to take up the work loading clearance between the work and the wheel, a feeding movement during which the grinding operation is performed, followed by a rapid traverse movement back to starting position.

Strictly, the mechanism for oscillating these movements consists of a hydraulic jack, indicated generally by the reference numeral 24, which effects the rapid traverse movement, and a feed piston indicated by the reference numeral 25, which effects the feed movement. The grinding wheel 16, which is rigidly mounted a sleeve 26 and a piston member 27 which has a reduced piston rod portion 28 that passes through the cylinder end 29 and is in constant engagement with a bell crank 30 pivoted in the bed 31. The other arm 32 of the bell crank engages the end of the piston rod 33 formed integral with the end of the piston 25.

In Figure 2 it will be noted that most of the weight of the grinding head 21 is to the right of the trunnion 22 whereby gravity causes the head 21 to rotate from the clockwise direction. The parts are shown in Figure 2 after they have completed the rapid traverse movement and are ready to start the feed movement. The chamber 34 above the piston 27 is filled with fluid under pressure, and it should be obvious that if there were no fluid under pressure, the chamber 34 that the head 21 would rotate in a clockwise direction and collapse the chamber 34 due to the fact that the piston 27 would be held in the position shown. The protuberance 35 on the cylinder head 36 which closes the end of the sleeve 26 would thus enter the depression 37 formed in the end of the piston 27. This would limit the extent of counterclockwise movement of the head 21 and would correspond to the extreme return position of the grinding wheel.

Thus, at the beginning of a cycle, fluid pressure is admitted to the chamber 34 which would rotate the head 21 in a counterclockwise direction until the shoulder 38 formed on the piston rod 27 engaged the bottom 39 of a dashpot depression 40 formed on the inner end of the cylinder head 29. When this occurs, it is probable that the balance and further movement would stop due to the fact that the pressure in the chamber 34 is attempting to push the grinding head up, while its engagement with the shoulder 38 is preventing such movement. In other words, the pressure in the chamber 34 at this moment is only holding the cylinder head 36 in a separated relation with respect to the end of the piston rod 27. This upward movement to this extent is the rapid traverse movement.

The feed movement is started by admitting pressure fluid through the port 41 behind the piston 25, causing the same to advance toward the right, as viewed in Figure 2, and thereby effect counterclockwise rotation of the bell crank. This will cause upward movement of the piston 27, and the piston rod 33 will transmit this movement to the head 21, thereby causing the head 21 to move in unison with the piston and bell crank. This feed movement will continue until the feed regulating cam 42 carried by the head 21 engages the positive stop 43. When this occurs, it is probable that the bell crank 30 will dwell to interlock to insure sparking out of the grinding wheel, and in order to insure that the parts are held in a tight relation, the piston 25 and the bell crank 30 continue their movement to a limited degree. In so doing, the piston 27 will now advance in the chamber 34 and force oil out of the chamber, thereby insuring a suffi-
clent pressure therein to hold the cam 42 solidly against the positive stop 43. During this advancing movement the bell crank arm 32 is at all times held against the piston face of the spring pressed plunger 44, which is continuously acted upon by a spring 45 interposed between a shoulder 46 integral with the plunger 44 and a positive abutment or shoulder 47 formed on the member 48 which is secured to the bed 10. A second positive stop 49 is the end of the hollow member 45 to act as a final limit to the movement of the rod 44. It has been found that usually it is not necessary to use this stop because the tarry time has usually elapsed before the plunger 44 engages the stop 49.

At the end of the grinding cycle the port 41 of the feed piston and the chamber 34 are connected to exhaust so that the parts are free to rotate in a clockwise direction by the action of gravity back to the starting position.

The control circuit whereby this cycle of operation may be effected automatically is shown in Figure 17. This machine is usually provided with an automatic loading fixture, the details of which form no part of the present invention, but it is necessary to know when a new work piece is placed in the machine and to have some means for detecting this fact in order to start the grinding cycle. For this reason the piston 50 and cylinder 51 which causes actuation of the work loading mechanism, indicated generally by the reference numeral 52, is shown in Figure 17. In other words, the work pieces are loaded in a chute 53 and the member 54 in moving up receives a work piece and upon downward movement carries it down to the grinding position indicated by the dotted circle 55. The cylinder 51 is connected by channels 56 and 57 to ports 58 and 59 of a work loading reversing valve indicated generally by the reference numeral 60.

This valve has a pressure port 51 connected to the main pressure supply line 62 which receives fluid under pressure from a pump 63 having an intake 64 through which fluid is withdrawn from a reservoir 65. A suitable relief valve 66 is connected to the line 62 to control the pressure therein. It will be noted that the valve 66 is in position to connect the pressure port 61 to port 58 whereby the work loading fixture has returned to position a new work piece in the machine. The port 53 is connected at this time to exhaust port 67, the returning fluid flowing through the exhaust line 68 and the low pressure relief valve 69 back to the reservoir 65.

When the work loading control valve is shifted to the right it will be obvious that the pressure port 61 will be connected to the port 58, and that port 53 will be connected to a second exhaust port 70 which is also connected to line 66, and that the work fixture will be elevated to receive a new work piece. The valve 61 is shifted by a solenoid 71, whose sequence of automatic operation will be explained later in connection with the electrical circuit.

A second valve, indicated generally by the reference numeral 72, and which may be defined as the rapid traverse control valve has a pressure port 73 which it will be noted, is connected by the valve plunger 74 to port 75. Fluid pressure will thus flow through line 76 to port 77 in the rapid traverse jack, the port communicating with a wide annular groove 78 formed in the periphery thereof.

A port 79 is drilled in the sleeve to establish communication with the chamber 34. As previously stated, the parts are in the position at the completion of the rapid traverse movement and therefore the chamber is under pressure. The shifting of the valve 72 is controlled automatically by a solenoid 80.

A third valve 81, which may be termed the feed control valve, has a pressure port 82 and an exhaust port 83. This valve, it will be noted, has not yet been shifted to establish the feed movement and is held in its right hand position by a spring 84. A solenoid 85 when energized will shift the valve plunger 86 to the left and thereby connect the pressure port 82 to channel 87, and the fluid pressure will then flow through a reducing valve 88 and throttle valve 89 to channel 90.

It will be noted that the channel 90 has a branch line 91 leading back to the port 82 of valve 81. When the valve 86 is shifted to the left it will close the port 83, thereby isolating the channel 91 so that the fluid pressure in line 86 will not be lost. The fluid pressure in channel 90 will flow to the feed cylinder, thereby actuating the feed piston to effect the feed rate.

When the grinding operation is completed all of the solenoids will be deenergized whereby the feed valve 81 will return to the position in which it is shown in Figure 17, and the fluid in the feed cylinder will pass directly to reservoir through interconnected ports 82 and 83 without passing through the rate valve. This allows the flow of fluid from the feed cylinder so that the piston 29 will return freely under the action of spring 45. The return of the rapid traverse valve will effect connection of port 75 with the reservoir port 83, thereby permitting the fluid in chamber 34 to return to reservoir whereby the port 36 will eventually flow through a reducing valve 37 formed in the end of cylinder 27 which will act as a dashpot to prevent shock to the mechanism.

The solenoid 71 is the last one to be released to insure that the grinding wheel is out of engagement with the work before the work is lifted out of its grinding position. When this occurs, port 61 will be connected to port 58 which will thereby lift the work loading mechanism, which will immediately return to load a new work piece and start a new automatic cycle.

The truing mechanism which will be described in detail later is illustrated diagrammatically in Figure 17 and comprises a first reciprocable member 94 which is attached to the reciprocating rod 95 that is slidable mounted in the guide block 96 for movement parallel to the face 97 of the grinding wheel. The member 98, in turn, has guided in it a second slidable member 99 that is guided for movement parallel to the other face 98 of the grinding wheel. The member 99 has a diamond holder 100 integrally secured to the end thereof in which is mounted a diamond 101 for truing the face 98, and a second diamond 102 for truing the face 97 of the grinding wheel. The rod 98 has an operating piston 103 slidable mounted in a cylinder 104 which has ports 105 and 106 in opposite ends thereof. These ports are connected by channels 107 and 108 to 109 and 110 of a reversing valve 111. This valve has a pressure port 112 and a valve plunger 113 which is normally held in the position shown by a spring 114.

In this position the port 112 is connected to port 109 which holds the piston 103 in the position shown during the grinding operation. Upon actuation of the solenoid 115, which is operatively connected to the valve plunger 113, the
port 112 will be connected to the port 110 whereby the diamond 101 will be caused to traverse across the face 99 of the grinding wheel.

In actual operation, the face 97 of the grinding wheel is trued first, and this is accomplished by providing two piston members 116 and 117, which are slidable in bores formed in the guides 98 the piston 110 being integrally connected by the member 110 to the rod 99 and the piston 117 being integrally connected to the member 94. It will thus be seen that the parts 116, 118, 95, 94, and 111 are all connected together to form a unit which is capable of reciprocation relative to the support 99 and, in addition, the member 94 supports the member 98 and therefore the member and its actuating piston and cylinder also move with the member 94. By admitting pressure behind the piston 117 the entire assembly is moved relative to the support 99 to cause the diamond 102 to reciprocate across the face 99 of the grinding wheel.

Fluid pressure is admitted to the piston 117 through channel 119 which is connected to port 120 of a reversing valve, indicated generally by the reference numeral 121. This valve also has a port 122 which is connected by channel 123 to the piston 116. This valve has a pressure port 124 which is shown connected by the valve plunger 125, when in its normal position, to port 122, while port 120 is connected to an exhaust port 126. In this position of the parts it will be noted that fluid pressure is continuously acting on the piston 116 to hold the diamond support in retracted position with respect to the grinding wheel and during the grinding operations.

When the time comes to true the face 97 of the grinding wheel a solenoid 127, which is operatively connected to the valve piston 125, is energized, thereby shifting the valve plunger to the right against the resistance of a spring 128, and the port 124 is connected to the port 120, and the port 122 is connected to exhaust port 129. The two exhaust ports 126 and 129 are connected by channel 130 to a throttle valve 131 which regulates the rate of traverse of the diamond across the face of the grinding wheel.

After the face 97 of the grinding wheel is true, the other solenoid 115 is energized to cause traverse of the diamond 101 by interconnecting pressure port 115 to port 110, and port 109 to port 132. When the solenoid 115 is deenergized the valve returns to the position shown, and port 112 is connected to port 109 and port 110 is connected to exhaust port 133. Both of the exhaust ports 132 and 133 are connected to a throttle valve 134 which regulates the rate of traverse of the diamond 101. The sequence of operation of solenoids 115 and 127 will be explained in connection with the electrical circuit.

The actual construction of the traversing slides is shown in Figures 3 to 9 inclusive.

Referring to Figure 8, it will be noted that the support 99 which contains the pistons 116 and 117, and the slidable member 95, is secured by clamping bolts 135, as shown in Figure 6, to another slidable member 136 which is movable in a radial plane of the grinding wheel. The slidable member 95 has an angular bracket 137 formed on the end thereof as shown in Figure 7, and the support 94 is secured to this bracket by stud bolts 138. Referring to Figure 3 the member 98 has an enlargement 139 to which is bolted the cylinder casting 140 containing the piston 103 and piston rod 141 which is connected at one end by a T slot connection 142 to the end of the sliding member 98. The other end of the piston rod is threaded at 143 to receive an adjustable stop member 144 which may be rotatably adjusted on the end of the piston rod to cause the diamond to traverse across the face 99 of the grinding wheel. A lock screw 147 is also threaded in the member 144 to clamp the stop member 144 against rotation. The bushing 146 is fixed in the end of a housing 148 which is bolted to the end of the cylinder casting 140 and within this housing are certain reversing limit switches, one of which is operated by a collar 149 which may be adjustably positioned on the piston rod, and another of which is actuated by the stop member 144. The relationship of these parts is more particularly shown in Figure 6.

Since the position of the diamond with respect to the grinding wheel may need some adjustment the support 99 is made adjustable with respect to the slide 136 by providing a pair of adjusting screws 150 and 151, which, as shown in Figure 7, are threaded in bosses 152 and 153 formed integrally on the side of the member 98, and the slide 136 is provided with a fixed stop member 154 against which the adjusting screws may be operated to shift the position of the member 99 with respect to its supporting slide 136 and also used for locking in position in conjunction with the T bolts 155.

The member 96 has a housing 155 formed on the top thereof in which are mounted a pair of limit switches which are adapted to be operated by plungers 156 and 157 which are alternately engageable by a projection 158 formed on the bracket 137, and the adjustable screw 159 carried by the connecting member 112. The operation of these limit switches will be explained in connection with the operation of the electrical circuit.

It will be obvious that after the true diamond 101 have reciprocated across the face of the grinding wheel that it is necessary to feed the diamonds toward the wheel in preparation for the next operation. This is accomplished automatically in the following manner. As previously described, it will be noted that the entire diamond supporting structure shown in Figure 3 is pivotally supported on the slide 136 and, as shown in Figure 4, the slide 136 is provided with a dovetailed guideway and adjustable gib 160 for movement relative to the wheel housing support, indicated generally by the reference numeral 21. As shown in Figure 8, the slide 136 has a ratchet mechanism housing 161 formed on the top thereof. A feed screw 162, which is threaded in a nut 163 secured in the wheel head 21, passes through the housing and is anchored therein by the shoulder 164 integral with the screw 162 and an indicating dial 165 which is secured to the screw by a clamping screw 166. A hand wheel 161 is secured to the upper end of the screw 162 for effecting manual rotation thereof.

Within the housing and mounted on the unthreaded portion 168 of the screw is an adjustable stop member 169, a ratchet wheel 170 and a pawl carrier 171. Referring to Figure 9, the pawl carrier 171 is connected by the pawl 175 to the armature 174 of an operating solenoid 175. On the opposite side of the shaft 168, the pawl carrier 171 has a spring 176 connected to it for effecting counterclockwise rotation of the pawl carrier upon deenergization of the solenoid. The pawl 175 is generally connected to the pawl carrier by a pin 178, and the heel 179 of the pawl, upon its return by the spring engages the stop.
the member 69 which is upstanding from the member 169 as shown in Figure 8.

The opposite sides of the member 169 are adapted to be engaged by stop screws 161 and 162 for determining the rotatable position of the stop 166, thereby determining the amount of rotation that will be effected by the ratchet mechanism upon actuation of the solenoid. To assist the operator in determining this amount, the stop member 169 has an upstanding lip 163 upon which appears certain indices as indicated by the reference numeral 164 in Figure 3 of the drawings. The housing has an opening 165 adjacent the periphery of the lip 163 whereby the index may be observed by the operator. It should now be obvious that each time the solenoid is energized that the feed screw 162 will be rotated some predetermined amount and the diamonds fed toward the grinding wheel.

It will be obvious that, after a trueing operation, the grinding wheel has become smaller in diameter, and since the wheel head always stops in the same final position at the end of a feeding movement, the work would be ground large, and, therefore, it is necessary to effect a readjustment between the work and the grinding wheel. This is accomplished by adjusting the work support toward the grinding wheel a sufficient amount to compensate for the trueing operation.

As previously described, the work support slide 11, as shown in Figure 10, carries a feed screw 12 which meshes with a nut 13 fixed with the bed 10. A backlash eliminating nut 165 is threaded on the screw and held against rotation by a bolt 167 which is threaded in the bed and interferes with a slot 160 formed in the periphery of the nut 165. A spring 169 is interposed between the head of the nut 166 and a sleeve 190, which is pushed against the end of the nut 13 whereby the spring tends to separate the nuts and thereby take out the backlash.

The slide 11 has an end plate 181 which depends from the end of the slide, and this plate has a bore 192 which forms a bearing for the shaft portion 183 of the screw. A flanged sleeve 194 is keyed at 195 to the screw and held in position by a nut 196 threaded on the end of the screw. The flange portion 197 of the sleeve has a cotter key plate 186 secured thereto which has formed integrally thereon an internal gear 199. This gear intermeshes with a pinion 200, as shown in Figures 1 and 11, the pinion being keyed to the end of a long shaft 201 which extends to the other end of the machine where it is provided with a hand wheel 202 having micrometer graduations 203 formed on the hub thereof. The cover plate 198 has a handle 204 secured thereto, and it should now be obvious that by means of the handle 204 the screw 12 may be rotated directly, or by means of the hand wheel 202, the screw may be rotated through a reduction means so as to effect fine adjustments of the work support.

Mechanism has been provided on the end plate 191, Figure 10, to also effect fine adjustments automatically to compensate for the trueing operation. This consists of a flange sleeve 205 which is supported for free rotation on the periphery of the sleeve 194, and an electro-magnetic 206 which is secured to the sleeve 205, the magnet forming part of an electro-mechanical clutch. The clutch plate assembly 207 is attached to the flange 197 of the sleeve 184 and held in position by a series of studs 208 on which are slidably mounted a series of headed buttons 209 which are contiguously urged by spring 210 to hold the clutch plate against the flange 197. It will be obvious that there should be a slight clearance between the plate and the magnet when the magnet is deenergized and that better operating conditions can be obtained during energization of the magnet if the plate 207 would move into contact with the magnet. By means of this construction it is possible because the springs 210 will yield sufficiently to make it so.

The member 205 has an operating lever 210' formed integral therewith, and this lever is operatively connected by a link to the operator member of the solenoid 207, Figure 11. A spring pressed plunger 212 located in the bottom of the housing 213 normally urges the lever 210 in a clockwise direction against a stop screw 214. In operation the clutch is first energized, and then the operating solenoid is energized to rotate the lever 210' in a counterclockwise direction, and while so held the clutch is deenergized whereby upon release of the solenoid the lever 210' may move back without causing counterrotation of the screw. This performs the same function as an index mechanism with the added advantage that the operator may make slight manual adjustments at any time without disturbing the length of the next indexing because there is no ratchet mechanism.

In order to prevent shocks to the mechanism by the sudden operation of the solenoid, a dashpot has been arranged in conjunction with the plunger 212 in the form of a chamber 215 which is connected by a throttle valve 216 to a reservoir space 217, which is maintained full of oil. A check valve 218 is also connected between the space 215 and the reservoir whereby upon movement of the plunger 212 to the left, oil will be admitted to the space 215 by automatic opening of the check valve 218; and upon return of the plunger 212 to the right, the check valve will close, and the oil will be throttled through the valve 216. This will prevent hammering of the parts and insure smooth operation.

The electrical control circuit which governs the complete automatic operation of the machine will now be explained in connection with Figures 13, 14, 15, and 16.

In general, one part of the electrical control circuit controls the automatic operation of the grinding cycle. Most of the remaining part of the circuit controls the automatic operation of the trueing mechanism, and this portion of the circuit is interconnected with the first part of the circuit by a counting mechanism which may be preset to determine the number of work pieces that are to be ground between each trueing operation. In addition, a selector switch is provided whereby the trueing operation may be effected while the grinding cycle is interrupted, that is, with the wheel head static, or by being performed simultaneously during a grinding cycle.

The automatic grinding cycle is initiated by closing the start button 218, Figure 15, which establishes a circuit from the power line 220 through a stop button 221, line 222, and relay CR1 to line 223. Relay CR1 will close its contacts CR1A and CR1B, thereby activating the holding circuit around the start button 218 as well as connecting line 228 to main line 220 which can only be broken by the stop button 221. In addition, the operation of the push button will establish a circuit through line 224 to relay CR12 which will close its contacts CR12A in line 225 and thus complete the following circuit from line 229 through stop button 221, line 226, closed contacts
CRA and CRB, line 225, normally closed switch 226', line 227, normally closed contacts CRA to relay CR2. CR2 establishes its own holding circuit by closing contact CRA, thereby completing a circuit from line 228 through normally closed contacts LS3 to line 227. In addition, relay CR2 closes a second contact CR2B completing a circuit from line 228, through line 230 to relay CR3. As shown in Figures 13 and 14, energization of relay CR3 closes contact CRA, energizing solenoid 71, thereby lowering the work fixture.

Attention is invited to the fact that while the work fixture is up in a loading position, it holds a limit switch LS1 closed as shown in Figure 13 of Patent 2,478,662, supra. This switch is in line 231, which interconnects line 228 with line 225 and also contains the normally closed reset switch 232. It will be noted that the line 231 is connected in parallel with the contact CRA and, this contact is only momentarily closed while the start button 219 is held depressed. In other words, as soon as the start button is released, the circuit through line 225 is broken, and as soon as the work fixture moves down to a grinding position the limit switch LS1 is opened. The object of the limit switch LS1 is to automatically close the circuit to line 221 after each grinding operation to start the next cycle, thus avoiding the necessity of operating the push button to close contact CRA.

Relay CR3 also closes contact CR3B in line 233 which is connected by branch line 234 to line 236. When the work fixture has completed its downward movement it closes a limit switch LS2 as shown in said patent supra by a suitable operator such as lug 54', thereby establishing a circuit from line 228 through lines 235, normally closed contact TR1A and line 236 to rapid relay CR4. This relay latches itself in by closing contact CR4A, thus completing a circuit from line 228 through closed contact CR2B, line 234, line 233, closed contacts CR3B and CR4A, normally closed contact TR1A and line 236 to line 223.

Referring to Figures 13 and 14, rapid traverse relay CR4 closes contact CR4B, thus energizing the rapid traverse solenoid 80. In addition, relay CR4 closes contact CR4C which, it will be noted, is located in line 237, paralleling the limit switch LS2 so that when the limit switch is opened by the rising of the work fixture, the circuit may still be maintained to relay CR4.

It will now be seen that the automatic operation of the machine timed the rapid traverse movement of the wheel head and upon completion of this movement the wheel head automatically operates limit switch LS3 as shown in said patent supra and indicated diagrammatically in Figure 2 as actuated by lug 24' which has a pair of normally closed contacts LS3A and a pair of normally open contacts LS3B. As previously explained, the normally closed contact LS3A was in line 225 which constituted the holding circuit for relay CR2 so that upon opening of contact LS3A the holding circuit to relay CR2 is now broken and the relay is deenergized, which thus opens contact CR2B. The circuit to CR4 is, however, maintained, it now extending from line 228 through line 237, closed contact CR4C, line 235, line 233, closed contact CR4A, closed contact CR3B, lines 234 and 230 to CR3. Switch LS3B is simultaneously closed in time with the opening of LS3A to establish a circuit in line 225 to feed control relay CR5 which closes contact CR5A in line 239.

Referring to Figures 13 and 14, feed control relay CR5 closes contact CR5B, thus energizing the feed solenoid 85, thereby causing the grinding wheel to advance at a feed rate to effect grinding of the work.

Line 238 leading to relay CR5 has a branch connection 239' in which is a normally closed selector switch 240 which leads to timer relay TR1. This relay is set to time the grinding operation including the time to execute the feed movement and the tarry of the grinding wheel after the wheel head has engaged the positive stop 43. When the time has run out, the relay opens its normally closed contact TR1A, thereby releasing the rapid traverse control relay CR4. This opens the contact CR4B in Figure 13, deenergizing the rapid traverse solenoid 80, so that valve 14 immediately shifts to effect rapid retraction of the grinding wheel. This also breaks contacts CR4A and CR4C in lines 233 and 237 respectively, but the circuit to line 228 through contact CR5A is maintained to prevent disengagement of the work fixture until the grinding wheel has disengaged the work. When the grinding wheel head has retracted to the point where it started the feeding movement, it will again operate limit switch LS3, thereby opening contact LS3B and closing contact LS3A. The opening of contact LS3B will release the relay CR5, reversing the feed control valve to effect feed return and opening the contact CR5A which will deenergize the work loading control relay CR3 and through the opening of contact CR3A in Figure 13 will cause the control valve 80 to be closed and cause elevation of the work fixture. Thus, the rapid traverse return separates the wheel from the work and then the feed return and elevation of work fixture follows.

The closing of contact LS3A in line 229 establishes the circuit in line 225 to contact CR2A which is open at this time. Elevation of the work fixture closes limit switch LS1 to energize relay CR2 and initiate a new grinding cycle and close contact CR2A to establish again a holding circuit through line 225 to the relay CR2. It will thus be seen that this part of the electrical circuit controls the continuously repeating automatic grinding cycle of the machine.

The automatic counter which determines how many work pieces shall be ground before the grinding wheel is trued is indicated generally by the reference numeral 241. In Figure 10, this device is mounted on the bed 10 of the machine, and since this is a commercial device its particular construction forms no part of the present invention. However, this device is known as a No. HX1G counter manufactured by the Eagle Signal Corporation and is more particularly described in Patents Nos. 2,175,864 and 2,175,865.

As shown in Figure 10, it has an operating knob 242 which may be rotated to any selected position, the knob having a first pointer 243 which is movable over an inner scale 244, and an outer pointer 245, one graduation mark of an outer scale 246. For illustrative purposes, the device has been set for 22. This means that 22 work pieces will be ground between trueing operations. This is an electrical device and referring to Figure 15 it has a clutch operating coil 247 and a counting coil 248. In general, the device is a ratchet mechanism and the clutch connects the ratchet mechanism to a control cam, and each time the counting coil is energized and released the index-
The indexing mechanism is operated, and after a selected number of indexing operations, the cam closes contact CR4D and normally closed contact CR11A. The selector switch CR50 determines whether the truing operation shall be performed during the grinding cycle or the grinding cycle shall be interrupted during the truing operation so that the wheel head is stationary. Switch CR50 is shown in the drawing as set for the latter type of operation. It should now be obvious that upon the first of a series of grinding cycles that the operation of the rapid traverse control relay CR4 will close contact CR4D and thus energize the clutch coil CR41. In so doing, the clutch coil will close contact CR50 and thus latch itself in through line 253 leading from the main 220, line 254, line 256, and parallel lines 256 and 257, the former containing the normally closed contact CR11A and the latter containing the normally closed limit switch LS4. It will now be seen that on the first cycle of a series of grinding cycles that the clutch in the counting device is engaged and will be maintained engaged throughout the required number of cycles regardless of the subsequent opening and closing of contact CR4D.

The operation of rapid traverse control relay CR4 also closes a contact CR4E and this completes a circuit from line 254 through line 255 to the counting coil CR45. Thus, each time that the rapid traverse control relay is energized to cause advancement of the grinding wheel, the counting coil is energized, and upon release of the rapid traverse control relay to cause return of the grinding wheel, the counting coil is released and effects a count on the counting mechanism.

When the necessary number of counts have been made, the counting coil upon its release at the start of a rapid traverse return, closes contact CR50 and completes a circuit through closed switch 251 to the truing cycle start relay CR4. The actuation of relay CR4 closes contact CR50 and thereby latches itself in through line 254. The relay CR4 is the one that interrupts or halts the grinding cycle and initiates the truing operation.

This is accomplished as follows. The relay CR50 opens the normally closed contact CR50A in line 271, thereby opening the circuit to relay CR52, so that upon closing of limit switch LS4 at the end of a cycle, a new grinding cycle will not be started.

Relay CR50 starts the truing cycle by closing contact CR50C. This interconnects main line 228 of the machine control circuit to the main line 264 of the truing control circuit.

It also completes a circuit from line 223 through limit switch LS5 and normally closed contacts CR50A to control relays CR1 and CR5. Referring to Figure 14 control relay CR7 has two contacts CR7A and CR7B which energize solenoids 127 and 175, the first of which is shown in Figure 17 and the other in Figure 5. The closing of 127 actuates the valve 121 to start the first truing operation by the diamond 102 while the solenoid 175 indexes the diamond supporting slide 136. Relay CR50 also closes a contact CR50D to energize work support feed clutch 200 shown in Figure 10.

The relay CR50 closes contact CR50A shown in Figures 13 and 14 and energizes solenoid 257 shown in Figure 11 which indexes the work support through the electric clutch 200.

At the end of the first truing operation, limit switch LS8 shown in Figures 7 and 15 is actuated, which opens its contact 258 and closes its contact 258, thereby energizing relay CR8. This relay will open its normally closed contact CR8A, de-energizing relays CR1 and CR5 to effect return of truing diamond and close the latching contact CR8D in line 270. In addition, relay CR8 will close contact CR8C in line 271 so that upon return of the truing diamond caused by deenergization of solenoid 127 due to the release of contact CR7A, limit switch LS6 will be closed and a circuit established to the timer relay TR2.

This relay will eventually close contact TR2A, establishing a circuit from line 272 through normally closed contact CR1B and closed contact TR2A to relay CR10. This relay will close contact CR10B shown in Figures 13 and 14 and energizes solenoid 118 which will result in valve to start the movement of the second truing diamond. Relay CR10 will also close contact CR10B in line 273 so that upon the finish of the truing operation and the closing of limit switch LS7 a circuit will be established from line 223 through closed limit switch LS7, line 273 and closed contact CR10B to timer relay TR3. This relay will time close, thereby allowing dwell for the diamond at the end of its truing stroke, eventually closing contact TR3A, thereby completing a circuit to relay CR41 which will latch itself in by closing contact CR41C.

Relay CR41 will open its normally closed contact CR41B to release relay CR10 and solenoid 118 whereby the hydraulic control valve 111 will shift and return the second diamond to its starting position.

Relay CR41 will also open its normally closed contact CR41A in line 256 to clutch coil 247 so that upon completion of return of the second truing diamond and operation of LS4 the circuit to the clutch will be broken. This will result in the counter mechanism automatically returning to its starting position and simultaneously open contact 252. This will break the circuit to relay CR5 and open contact CR5C, which will break circuit to the entire truing circuit releasing relays CR8 and CR41.

The work support clutch 206 has to be operated by direct current and, therefore, is connected by a rectifier 274 across lines 264 and 222.

As previously mentioned, the truing operation may be performed during the grinding operation and the circuit is set for this purpose by selector switch 250. In other words, switch 250 is opened and switch 275 is closed. Thus, upon completion of a count by counter coil 248 upon release of contact CR4E at the start of a rapid traverse return of the grinding wheel, contact 250 will be closed as previously explained. Since switch 261 is open the circuit to relay CR6 must be completed through contact CR5C and CR4F, but CR4F opened simultaneously with CR4E. The return movement of the grinding wheel will, therefore, continue, feed relay CR3 dropping out to open contact CR3C to complete the feed return movement.

Upon reversal of the grinding wheel, and start of the next cycle, the rapid traverse relay CR4 will close CR4F, and then the feed relay CR5
will close CR5C, thus completing the circuit through 259 to relay CR6 just at the beginning of the feed movement. Thus, the truing cycle will progress simultaneously with the feedings movement of the grinding wheel, superimposed sliding wheel, cutting tool supports, and the grinding wheel support including an indexable slide mounted on said wheel support, power operable indexing means connected to the indexable slide, a second slide mounted on the first slide, power operable means carried by the indexable slide and comprising the cutting tool slides and second slide for moving the same in a direction parallel to one face of the wheel, a third slide mounted on the second slide, and supporting the truing tools, power operable means connected for moving the third slide parallel to the other face of the wheel, a source of power, a grinding cycle counting mechanism having means connected for counting the source of power to the first two power operable means simultaneously, and trip operable means effective upon actuation by the second slide upon completion of its cycle of movement to connect the source of power to the third named power operable means.

4. In a grinding machine having a grinding wheel support carrying a grinding wheel, said support being movable toward and from a work support in the grinding machine which may be done with the grinding cycle stopped or during a grinding cycle and the necessary compensations in the relative position of wheel and work resulting from the truing operation are effected automatically as well as infeeding of the diamonds in preparation for the next truing operation.

What is claimed is:

1. In a grinding machine having a bed, a grinding wheel support and a work support mounted thereon, the combination of a feed screw supported by the bed and operatively connected to one of said supports, manually operable means connected to the feed screw for imparting rotation thereto including a plate fixed with said screw, a power oscillatable member supported for free rotation on the screw and having a definite stroke for imparting an indexing movement to said screw, and electro-magnetic means carried by said member and energizable for coupling the member to the plate in any rotatable position thereof upon connection of power to said oscillatable member.

2. In an automatic grinding machine having an automatic work loader movable between a loading position and a grinding position, and an oscillatable grinding wheel support carrying a grinding wheel, the combination of a power operable cycle actuating mechanism connected to said grinding wheel support for effecting a cycle movement thereof to and from said grinding position, and having a starting control circuit energized by a limit switch connected to a source of power trip operable by the work loader during movement to a grinding position to start a grinding cycle, a counting mechanism operatively connected with said grinding wheel support for counting the grinding cycles including a switching means operable by the mechanism to deenergize said starting circuit, and a power operable truing mechanism mounted on the grinding wheel support for truing the grinding wheel including starting switch means operable by said counting mechanism to start a truing operation whereby the grinding cycle will be interrupted during the truing operation.

3. In an automatic cycle grinding machine wherein the grinding wheel has a pair of angularly arranged grinding faces for simultaneously grinding two surfaces on a work piece and is automatically movable through recurring cycles, the combination with a support for said grinding wheel, of individual dressing tools for the respective grinding wheel faces, independently operable means for actuating the dressing tools on the grinding wheel support including an indexable slide mounted on said wheel support, power operable indexing means connected to the indexable slide, a second indexable slide mounted on the first slide, power operable means carried by the indexable slide and comprising the cutting tool slides and second indexable slide for moving the same in a direction parallel to one face of the wheel, a third indexable slide mounted on the second indexable slide, and supporting the truing tools, power operable means connected for moving the third indexable slide parallel to the other face of the wheel, a source of power, a grinding cycle counting mechanism having means connected for counting the source of power to the first two power operable means simultaneously, and trip operable means effective upon actuation by the second slide upon completion of its cycle of movement to connect the source of power to the third named power operable means.

5. In an automatic grinding machine having an indexable work support including an automatic work loader movable to and from a grinding position and an oscillatable grinding wheel support having a grinding wheel, the combination with a power operable cycle actuating mechanism connected to said grinding wheel support including a starting control circuit energizable by a starting switch operable by the work loader upon movement to a grinding position, of a cycle counting mechanism operatively connected to said grinding wheel support having said control means responsive to a predetermined count to deenergize said starting control circuit, and stop the grinding cycle, a truing mechanism comprising an indexable slide mounted on the grinding wheel support and carrying two truing slides each having a power operable cycle actuating mechanism connected thereto including a starting control circuit having a starting solenoid connected thereto, switch means in one truing starting circuit operable by the counting mechanism to energize one solenoid and effect actuation of one truing slide, switch means in the other truing starting circuit operable by the actuated truing slide to energize the other solenoid, means operable by the second truing slide to actuate the switch control means of the counting mechanism to reenergize the starting con-
trol circuit of the grinding wheel support and other switch means operable by the counting mechanism to effect indexing of the indexible supports at the beginning of the truing operation.

FREDERICK S. HAAS.

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