May 19, 1942. R. A. COLE 2,283,792

GRINDING AND LAPPING MACHINE

Filed Aug. 24, 1940 2 Sheets-Sheet 1

Fig. 1

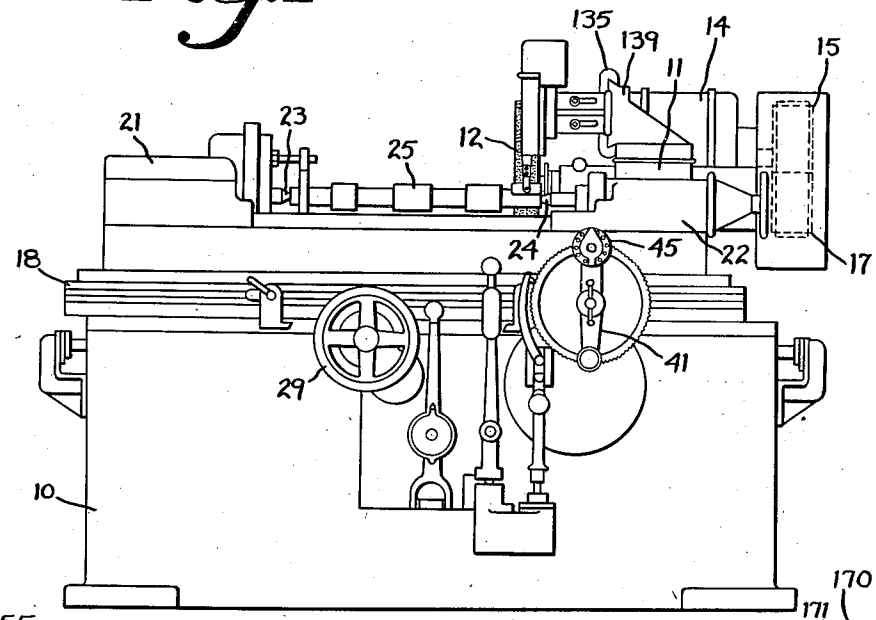


Fig. 4

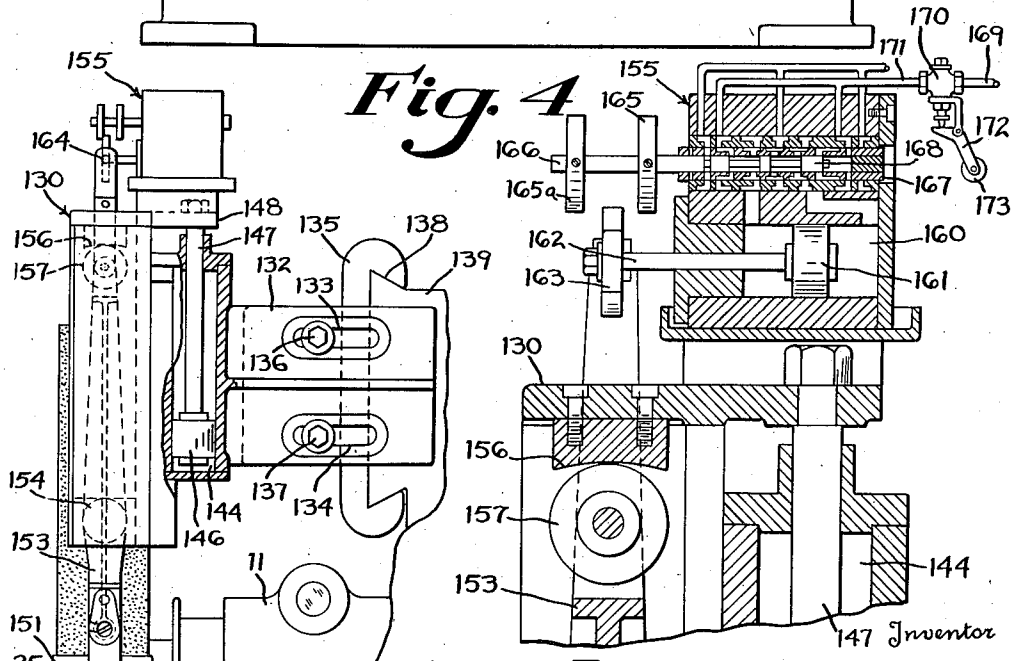


Fig. 3

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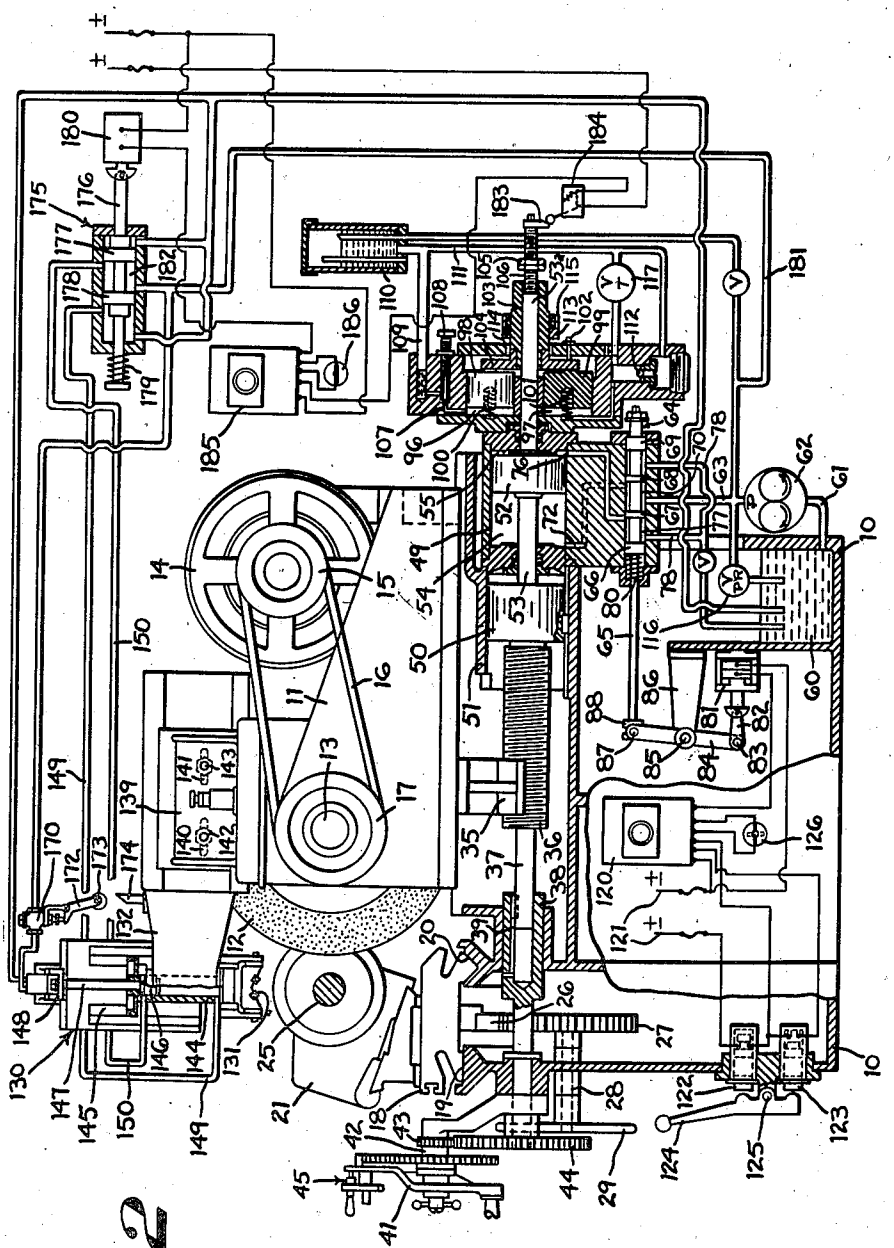


Fig. 2

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UNITED STATES PATENT OFFICE

2,283,792

GRINDING AND LAPPING MACHINE

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Application August 24, 1940, Serial No. 354,124

8 Claims. (Cl. 51—3)

This invention relates to grinding and lapping machines, and more particularly to a machine in which the work piece may be first automatically ground and then automatically lapped.

One of the objects of this invention is to provide a simple and thoroughly practical combined grinding and lapping machine for cylindrical type work pieces. Another object of the invention is to provide a combined lapping and grinding machine which is arranged to first grind a cylindrical work piece and thereafter automatically to lap the work piece. Another object of the invention is to provide a combined grinding and lapping machine in which the work piece is first automatically ground for a predetermined time interval after which the work piece is automatically lapped for a predetermined time interval. Another object of the invention is to provide a grinding and lapping machine in which the work piece is first ground to a predetermined extent after which a lapping mechanism is automatically moved into operative lapping engagement to perform a predetermined lapping operation. Other objects will be in part obvious or in part pointed out hereinafter.

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

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

Fig. 1 is a front elevation of a combined grinding and lapping machine;

Fig. 2 is a combined cross-sectional view through the grinding machine showing the wheel feeding mechanism in cross-section and showing the lapping mechanism, together with a piping and wiring diagram;

Fig. 3 is a fragmentary front elevation on an enlarged scale of the lapping head showing the piston and cylinder for positioning the same in cross-section; and

Fig. 4 is a longitudinal vertical sectional view, on an enlarged scale, through the hydraulic motor for reciprocating the lapping elements.

A grinding machine has been illustrated in the drawings comprising a base 10 which supports a transversely movable wheel slide 11, which is in turn mounted on transversely extending ways (not shown) on the base 10. The wheel slide 11 supports a rotatable grinding wheel 12, which is mounted on the end of a rotatable wheel spindle 13. The wheel spindle 13 is rotatably journaled in bearings (not shown) in the wheel slide 11. The wheel spindle 13 may be driven by any of the well known mechanisms, such as an overhead belt drive, or an electric motor 14, which is mounted on the upper surface of the wheel slide 11. As illustrated in the drawings, a driving pulley 15 is mounted on the end of the motor shaft and is connected by a driving belt 16 with a pulley 17 mounted on the end of the wheel spindle 13.

The base 10 also supports a longitudinally movable table 18 which is arranged to reciprocate longitudinally relative to the base 10 on a flat way 19 and a V-way 20. The table 18 is provided with a rotatable work support including a headstock 21 and a footstock 22 each of which is provided with a work supporting center 23 and 24 respectively rotatably to support a work piece 25 in operative relation with the grinding wheel 12. The table 18 may be traversed longitudinally by a manually operable traverse mechanism which includes a rack bar 26 depending from the underside of the table 18. The rack bar 26 meshes with a gear 27 mounted on the end of a rotatable shaft 28. A manually operable traverse wheel 29 is mounted on the outer end of shaft 28 and is arranged to be manually rotated to traverse the table 18 longitudinally relative to the base 10. If desired a power operated table traversing or reciprocating mechanism may be provided such as for example a mechanism of the type shown in the expired United States Patent Norton No. 762,838 dated June 14, 1904.

A wheel feeding mechanism is provided for manually feeding the grinding wheel toward and from the work, which comprises a half nut 35 depending from the wheel slide 11. The half nut 35 meshes with or engages a rotatable cross feed screw 36. A forwardly extending portion 37 of the cross feed screw 36 is slidably keyed to a rotatable sleeve 38. The rotatable sleeve 38 is formed as an integral part of a rotatable shaft which is mounted in bearings 39 and 40 in the base 10. A manually operable feed wheel 41 is mounted on the outer end of a stud 42. The stud 42 carries a pinion 43 which meshes with a gear 44 mounted on the outer end of a sleeve shaft 38 so that a manual rotation of the feed wheel 41 serves to rotate the feed screw 36 in either direction to cause a forward or rearward feeding movement of the grinding wheel 12 and the wheel slide 11. The wheel feed 41 may be provided with a micrometer adjusting mecha-

nism 45 which is substantially identical with that shown in the abovementioned prior United States patent to Norton. This micrometer mechanism serves precisely to adjust a stop abutment relative to the manually operable infeed wheel to compensate for wheel wear.

In the preferred construction the wheel slide 11 is arranged so that it may be moved toward and from the work piece 25 to grind the same to a predetermined size by means of a fluid pressure actuated wheel feeding mechanism. As illustrated in the drawings, the rear end of the feed screw 36 is rotatably supported in a slidably keyed bearing 50 which is supported in a casing 51 on the base of the machine. A fluid pressure cylinder 49 is attached to the casing 51 and contains a slidably mounted piston 52 which is connected by a piston rod 53 with the bearing 50 and is arranged so that when fluid under pressure is admitted to a cylinder chamber 54, the piston 52 will be moved toward the right into its rearward position, as illustrated in the drawings, transmitting a corresponding movement through the feed screw 36, the half nut 35, to move the wheel slide 11 and the grinding wheel 12 rearwardly to an inoperative position. Similarly, when fluid under pressure is admitted to the cylinder chamber 55 or the cylinder chamber 54, a rapid approaching or receding movement of the grinding wheel 12 and wheel slide 11 is provided.

A fluid pressure system is provided to supply fluid under pressure for moving the piston 52 so as to cause an infeeding or outfeeding movement of the grinding wheel 12. This system may comprise a reservoir 60 which is formed as a box-like section within the base 10 and serves to convey fluid through a pipe 61 to a fluid pressure pump 62. The pump 62 forces fluid under pressure through a pipe 63, to a control valve 64. The control valve 64 is preferably a piston type valve comprising a valve stem 65 having formed integrally therewith valve pistons 66, 67, 68 and 69. Fluid under pressure passing through the pipe 63 enters a valve chamber 70 located between the valve pistons 67 and 68 and passes through a passage 72, into the cylinder chamber 54, to move the piston 52 to its rearward position with the grinding wheel 12 separated from the work piece 25, as indicated in the drawings. During the rearward movement of the piston 52 toward the right, fluid is exhausted from the cylinder chamber 55, through a passage 76, into a valve chamber 77, between the valve pistons 66 and 67, and out through a pipe 78 which exhausts into the reservoir 60. An adjustable relief valve 71 is operatively connected to the pipe 63 and serves to exhaust excess fluid under pressure directly to the reservoir 60 so as to maintain the desired operating pressure within the fluid pressure system.

The valve stem 65 is arranged so that it may be moved endwise to shift the valve 64 into a reverse position so as to cause either a forward or rearward feeding movement of the grinding wheel 12. In the preferred construction a spring 80 is provided to maintain the valve 64 normally in its right-hand end position to cause the piston 52 and the wheel slide 11 and grinding wheel 12 to remain in their rearmost position. A solenoid 81 mounted on the base 10 is provided to shift the valve 64 toward the left to cause a forward feeding movement of the grinding wheel 12 when desired. The solenoid 81 is connected by a link 82 with a stud 83 supported at the lower end of a rock arm 84. The rock arm 84 is pivotally supported by a stud 85 which is supported by a bracket 86 fastened to the base 10 of the machine. The upper end of the rock arm 84 is provided with a stud 87 which rides within an annular groove formed in a spool-shaped member 88 supported on the left-hand end of the valve stem 65.

A suitable fluid pressure controlled or feed regulating mechanism is provided for modifying the rapid approaching movement caused by the piston 52 to obtain a controlled and predetermined infeeding movement of the grinding wheel 12. In the preferred construction a self-contained dash pot feed regulator is provided comprising a pair of dash pot cylinders 96 and 97 which contain dash pot pistons 98 and 99, respectively. The dash pot pistons 98 and 99 and their respective cylinders 96 and 97 are arranged with their axes parallel to each other and spaced on diametrically opposite sides of the piston rod 53. The dash pot pistons 98 and 99 are normally held in a rearward (right-hand) position by means of springs 100 and 101, respectively. An adjustable stop screw 102 serves to limit the rearward movement of the dash pot pistons 98 and 99, respectively. A slidable sleeve 103 is supported on the rear extension 53^a of the piston rod 53. The sleeve 103 has a flanged portion 104 which is either formed integral therewith or fixedly secured thereto. The flange 104 is arranged to engage the right-hand end faces of the dash pot pistons 98 and 99, respectively. The stop screw 102 engages the flange 104 and thereby serves to limit the rearward movement of the dash pot pistons 98 and 99 toward the right.

The rapid forward feeding movement of the grinding wheel 12 and the wheel slide 11 continues until the adjustable nuts 105 on a threaded portion 106 of the extension 53*a* of the piston rod 53 engages the righthand end of the sleeve 103. Continued movement of the piston rod 53*a* moves the sleeve 103 and the flange 104 toward the left and continued movement serves to move the dash pot pistons 98 and 99 in a direction toward the left. When the flange 104 engages the ends of the dash pot pistons 98 and 99, respectively, the rapid approaching or feeding movement of the grinding wheel 12 toward the work piece 25, as produced by the piston 52, is reduced to a slower predetermined grinding feed due to the fact that fluid confined within the dash pot cylinders 96 and 97, respectively, which are interconnected, exhausts through a passage 107, a needle valve 108, through a pipe 109, into a reservoir 110. By adjusting the aperture of the needle valve 108, a desired and predetermined infeeding movement of the grinding wheel 12 may be obtained.

When fluid under pressure is admitted to the cylinder chamber 54 to cause a rearward movement of the piston 52, the sleeve 103 together with the flange 104, is moved rearwardly by means of the released compression of the springs 100 and 101 which returns the dash pot pistons 98 and 99, respectively, to their rearward positions and moves the flange 104 and its supporting sleeve 103 toward the right until the flange 104 engages the adjustable stop screw 102. During the rearward movement of the dash pot pistons 98 and 99, a suction is created within the dash pot cylinders 96 and 97, respectively, which serves to aid in drawing fluid from the reservoir 110, through a pipe 111, and a ball check valve

112, to fill the dash pot cylinder chambers 96 and 97 for the next infeeding movement of the grinding wheel 112. During the infeeding movement of the dash pot pistons 98 and 99, fluid within the dash pot cylinders 96 and 97 serves to hold the ball check valve 112 closed so that fluid within the dash pot cylinders 96 and 97 is forced out through the passage 107 and the needle valve 108, into the reservoir 110, to control the rate of the infeeding movement, as desired. An adjustable throttle valve 117 is provided to facilitate the exhaust of fluid from the dash pot chambers 96 and 97 after the port or passage 107 is closed by the piston 98. If desired, the throttle valve 117 may be used to give a very fine final feed just prior to the stop 113 engaging its stop surface 114. In the latter case two distinct feeds of the wheel could be obtained, one feed by manipulation of the valve 108 combined with the opening of the valve 117 which would continue until the passage 107 is cut off, after which the infeed would be reduced to a very slow infeed control by the throttle valve 117.

The forward feeding movement of the grinding wheel 12, as controlled by the dash pot pistons 98 and 99, respectively, continues until an adjustable stop collar 113 carried by the sleeve 103 engages a fixed stop surface 114 on the rear face of the dash pot cylinder head. A pair of lock collars 115 serve to position the stop collar 113 and to lock the same in adjusted position.

A throttle valve 116 is located in the pipe line 78 and serves to control the exhaust of fluid from the cylinder 49 so as to regulate the speed of movement of the grinding wheel 12 and its supporting wheel slide 11 during the rapid approaching or positioning movement thereof.

In order to obtain one object of the invention it is desirable to provide a suitable control mechanism for the wheel feeding mechanism which is arranged so that when a work piece has been inserted in the machine, it is merely necessary for a control lever to be shifted to initiate an approaching movement of the grinding wheel which continues until the grinding wheel approaches the work piece, after which the approaching speed is reduced to a predetermined grinding speed. The infeeding continues until the stop 113 engages the stop surface 114 and positively limits the infeeding movement of the grinding wheel 12. The grinding wheel 12 is then allowed to remain in grinding contact with the work piece 25 for a definite predetermined time interval, after which the control valve 64 is reversed again to move the grinding wheel 12 to its rearward or inoperative position. In the preferred construction, the latter is accomplished by providing an electrical control system including an electrical time delay relay 120. Power is provided for the electrical control system from a source of power, as indicated by the power lines 121.

In the preferred construction, the time delay relay 120 is so connected as to regulate and control the shifting movement of the main control or feed control valve 64 so as to control the entire infeeding movement of the grinding wheel 12, namely to control the over-all cycle including the rapid approaching movement of the grinding wheel 12, the slower grinding infeed of the wheel, and the dwell which occurs thereafter before the grinding wheel is removed to its rearward or inoperative position. A pair of push button switches 122 and 123 are mounted on the front wall of the machine base 10. The push buttons 122 and 123 are arranged to be actuated by a control lever 124 which is pivotally supported on a stud 125 which is fixedly supported on the base 10 of the machine. The button 122, when pushed, is arranged to cause a rearward feeding movement of the grinding wheel 12 and its supporting slide 11 and the push button 123, when actuated serves to start the grinding cycle.

The time delay relay 120 is one of the standard electrically operated adjustable time delay relays such as that known as the "Microflex" instantaneous reset timer manufactured by the Eagle Signal Corporation, Moline, Illinois. The Microflex timer is a synchronous motor operated time delay relay and consists of a clutch-operating mechanism and a motor and gear train assembly, with an electromagnetically operated clutch for coupling them together. It is entirely automatic in action and requires only the closing or opening of the timer control circuit to initiate a cycle of operation. In the normal position, no current is applied to the timer; all contacts are open. The cycle is initiated by momentarily closing the switch 123 of the timer control circuit. When the control circuit is closed the timing cycle starts. When the timing interval terminates, breaking the circuit serves to de-energize the solenoid 81 which releases the compression of the spring 80 to reverse the control valve 64 and cause a rearward movement of the wheel slide 11 and the grinding wheel 12. The timer automatically resets for the next grinding cycle. If for any reason it is desired to stop grinding during a grinding cycle, the lever 124 is moved in a clockwise direction (Fig. 1) instantaneously to open the push button switch 122 which opens a circuit to interrupt the time delay relay and cause the grinding wheel to move to a rearward position.

The time delay relay may be adjusted to control the entire approaching and infeeding movement of the grinding wheel, that is, the rapid approach, grinding feed and dwell. The relay 120 allows a certain time interval to elapse after the push button 123 is actuated to initiate the forward movement of the grinding wheel 12 and to control the dwell thereafter so as to grind the work piece 25 to the desired and predetermined size. The time delay relay 120 is so connected with the push buttons 122 and 123 and also with the solenoid 81 that when the lever 124 is rocked in a counterclockwise direction to start a grinding cycle, the push button switch 123 is actuated to start the time delay relay 120 functioning and at the same time energizes the solenoid 81 which serves to shift the control valve 64 toward the left against the compression of the spring 80 to admit fluid under pressure from the pipe 63 through the passage 76, into the cylinder chamber 55, to cause the grinding wheel 12 and its supporting slide 11 rapidly to approach the work piece 21 at a rate governed by the throttle valve 116 located in the exhaust pipe line 78. The rapid approaching movement of the grinding wheel 12 and its supporting slide 11 continues until the sleeve 103 and its flange 104 engage the dash pot pistons 98 and 99, respectively, after which the rapid approaching movement caused by the fluid pressure operated piston 52 is slowed down to a slow uniform grinding speed as controlled by the exhaust of fluid from the dash pot cylinders 96 and 97, respectively, through a needle valve 108, into the reservoir 110. The

slow grinding infeed continues until the adjustable stop 113 engages the stop surface 114 which positively limits the grinding infeed and allows the grinding wheel 12 to remain in grinding contact with the work piece 25 to finish grind the work.

After a predetermined time interval has elapsed according to the adjustment of the time delay relay 120, the solenoid 81 is automatically de-energized, thereby releasing the compressed spring 80 which returns the control valve 64 into the position illustrated in the drawings so that fluid under pressure passing through the pipe 63 passes through a passage 72 into the cylinder chamber 54 to cause the wheel slide 11 and grinding wheel 12 to move rapidly to their rearward or inoperative position.

The push button 122 is provided so that if for any reason it is desirable to interrupt the grinding cycle and cause the grinding wheel 12 to move rearwardly without completing its cycle, the lever 124 may at any time during the grinding cycle be moved in a clockwise direction to operate the push button switch 122 which serves through the time delay relay 120 to deenergize the solenoid 81 and thus allow the released compression of the spring 80 to shift the valve 64 into the position shown in the drawings so that the grinding wheel 12 will move rapidly to its rearmost inoperative position.

In accordance with this invention a lapping head 130 is mounted on the wheel slide 11. The lapping head 130 includes one or more abrasive sticks 131, which are mounted so that they may be reciprocated lengthwise of the work piece 25 as the latter is rotated. The abrasive sticks 131 may be of suitable abrasive material, such as crystalline alumina or silicon carbide bonded with various types of bond, such as resinoid or vitrified ceramic material. The lapping head 130 is supported by means of a bracket 132 which is provided with elongated slots 133 and 134. The bracket 132 is adjustably fastened to a transversely movable slide 135 by means of a pair of clamping bolts 136 and 137. The clamping bolts 136 and 137 pass through the elongated slots 133 and 134 and are screw threaded into a portion of the transversely movable slide 135. The slide 135 is provided with a dovetailed slide way 138 which mates with a correspondingly shaped dovetail slide way formed on a bracket 139, which is fastened to the upper surface of the wheel slide 11. By means of the clamping bolts 136 and 137, the lapping head may be adjusted longitudinally relative to the work piece 25 to position the lapping sticks 131 in the desired position relative to the work piece 25. By means of the slide 135, the lapping head 130 may be adjusted transversely relative to the machine, so the lapping sticks 131 are in the desired relationship with the axis of the work piece 25. The slide 135 is provided with elongated slots 140 and 141 and is arranged to be clamped in adjusted position on the bracket 139 by means of clamping screws 142 and 143. The bracket 132 has a fluid pressure operated cylinder 144 formed integral therewith. The cylinder 144 is provided with a dovetailed slide way (not shown) which mates with a dovetailed slide way 145 formed on the vertically movable lapping head 130. A slidably mounted piston 146 is contained within the cylinder 144. The piston 146 is connected by a piston rod 147, the upper end of which is fixedly mounted to a bracket 148 fixedly mounted on the upper end of the head 130.

When fluid under pressure is admitted through a pipe 149 into the cylinder chamber below the piston 146, the piston 146, together with the lapping head 130 will be moved vertically to an inoperative position with the lappings sticks 131 out of operative engagement with the work piece 25. Similarly, when fluid under pressure is passed through a pipe 150 into a cylinder chamber above the piston 146, a downward movement will be imparted to the piston 146 and the lapping head 130 to move the head 130, together with the lapping sticks 131 into an operative position with the lapping sticks 131 in operative engagement with the surface of the work piece to be lapped.

The lapping sticks 131 are mounted on a holder 151 which is pivotally upported by means of a stud 152 carried at the lower end of a pivotally mounted rock arm 153. The rock arm 153 is pivotally supported to swing about the axis of a vertically movable roller 154. The roller 154 serving as a pivot point for the rock arm 153. The upper end of the rock arm 153 is arranged to be oscillated by means of a fluid motor 155 to be hereinafter described.

In order that a straight line reciprocatory movement may be imparted to the lapping stick 131 and the holder 151, a modified oscillating movement is imparted to the rock arm 153. A cam 156 which is fixedly supported relative to the vertically movable head 130 is engaged by a roller 157 which is rotatably supported on the rock arm 153. The shape of the cam 156 is such that during the oscillation of the rock arm 153 by the fluid motor 155, a slight vertical motion is imparted to the rock arm 153 so that the lapping sticks 131 are maintained in uniform operative engagement with the periphery of the work piece 25 and the lapping sticks 131 are reciprocated in a straight line path, in a direction parallel to the axis of the work piece 25.

The fluid motor 155 preferably comprises a fluid pressure cylinder 160 which contains a slidably mounted piston 161 which is connected by means of a piston rod 162 with a collar 163 which is pivotally connected by means of a stud 164 to the upper end of the rock arm 153.

The collar 163 extends upwardly and is arranged in the path of a pair of adjustably positioned spaced collars 165 and 165a which are adjustably supported on a valve stem 166 of a pilot valve 167. The pilot valve 167 is provided with a hollow cylindrically shaped aperture which contains a slidably mounted shuttle-type reversing valve 168. When fluid under presure is admitted through a pipe 169, it passes through a normally closed stop and start valve 170 and through a pipe 171 into the valve 167 so as to produce a continuous reciprocatory movement of the piston 161 which in turn imparts a oscillatory movement to the rock arm 153 to reciprocate the lapping sticks 131. The motor 155 has not been described in detail, since this motor is identical with that shown in the United States patent to Wallace H. Wood No. 2,212,871 dated August 27, 1940, to which reference may be had for details of disclosure not contained herein.

It is desirable that the motor 155 be automatically started when the lapping head 130 is moved toward an operative position and automatically stopped when the lapping head 130 is moved to an inoperative position. This is preferably accomplished by means of the start and stop valve 170 which is provided with an actuating arm 172 having a roller 173 mounted at its

lower end. The roller 173 is arranged in the path of a cam 174 which is fixedly supported on the bracket 132. It will be readily apparent from the foregoing disclosure that when the head 130 is moved downwardly the actuating roller 173 is moved into engagement with the cam 174 which serves to rock the arm 172 in a clockwise direction to open the valve 170 and thus start the reciprocatory movement of the piston 161 which in turn imparts a reciprocatory movement to the lapping sticks 131 prior to their engagement with the peripheral surface of the work piece to be lapped.

Similarly when the head 130 is moved upwardly to an inoperative position, the roller 173 rides up the surface of the cam 174 thus allowing the arm 172 to rock in a counterclockwise direction to close the valve 170 and thus stop the motor 155 to stop the reciprocatory movement of the lapping sticks 131 when the head is moved to an inoperative position after a lapping operation has been completed.

It is desirable that the movement of the lapping head 130 to and from an operative position be automatically controlled in timed relation with the grinding operation so that the lapping head 130 is maintained in an inoperative position during the grinding operation after which the head automatically is moved into an operative position and a lapping operation for a predetermined time interval is provided.

In order to accompilsh this result, a piston type control valve 175 is provided. This valve 175 comprises a valve stem 176 having formed integrally therewith a pair of valve pistons 177 and 178. The valve stem 176 is normally held in its left-hand end position by means of a compression spring 179. A pull-type solenoid 180 is provided to shift the valve stem 176 into its right-hand end position (Fig. 2). Fluid under pressure from the pump 62 passes through a pipe 181 into a valve chamber 182 located between the valve pistons 178 and 177 and in the position shown in Fig. 2 passes outwardly through a pipe 150 to the cylinder chamber above the piston 146 to initiate a downward movement of the lapping head 130. The rear end of the piston rod 53a is provided with a detent 183 which is arranged to actuate a normally open limit switch 184 when the grinding wheel 12 and the wheel slide 11 are moved to a rearward or inoperative position.

The closing of the limit switch 184 serves to set a "Microflex" electric time relay 185 in motion and at the same time serves to energize the solenoid 180 to position the valve 175 as illustrated in Fig. 2 so as to admit fluid to the cylinder chamber above the piston 146 to initiate a movement of the lapping head 130 into an operative position. The time relay 185 is adjusted so that the lapping operation will be carried on for a predetermined time interval, after which the tripping of the time relay 185 will de-energize the solenoid 180 and thus release the compression of the spring 179 to shift the valve 175 into its reverse position. This movement serves to admit fluid under pressure into the cylinder chamber below the piston 146 to raise the lapping head 130 to an inoperative position, during which movement the valve 170 is automatically closed to stop the reciprocation of the fluid motor 155 and thereby stop the reciprocation of the lapping sticks 131. It will be readily apparent from the foregoing disclosure that the lapping cycle is automatically initiated without attention on the part of the operator after the grinding operation has been completed and the lapping operation continues for a predetermined and definite time interval governed by the setting of the time relay 185.

The operation of this improved grinding and lapping machine will be readily apparent from the foregoing disclosure. Assuming all of the adjustments to have been previously made for the grinding and lapping of a work piece 25, the work piece 25 is placed in position on the headstock center 23 and footstock center 24. The control lever 124 is then rocked in a counter-clockwise direction (Fig. 2) to initiate a grinding cycle. The movement of the control lever 124, as previously described, serves to close the switch 123 which in turn sets the time relay 120 in motion and at the same time energizes the solenoid 81 to shift the grinding feed control valve 64 toward the left (Fig. 2) to start the movement of the piston 52 toward the left. The wheel slide 11 and grinding wheel 12 advance toward the left (Fig. 2) to grind the work piece piece 25 to the required and predetermined size which operation continues for a predetermined and definite time interval as governed by the time relay 120. The infeeding movement continues until the stop collar 115 engages the stop surface 114 after which the grinding wheel 12 remains in grinding contact with the periphery of the work piece 25 until the time relay operates to de-energize the solenoid 81, thereby releasing the compression of the spring 80, which shifts the valve 64 toward the right (Fig. 2) which initiates the rearward movement of the grinding wheel 12 and its supporting wheel slide 11.

When the wheel slide 11 approaches its rearward position, the detent 183 engages and actuates the roller of the normally open limit switch 184 to close the same which in turn serves to set the time relay 185 in motion and simultaneously to energize the solenoid 180 so as to admit fluid under pressure to produce a downward movement of the lapping head 130. During the downward movement of the lapping head, 130, the roller 173 engages the cam 174 which movement serves to open the stop and start valve 170. The opening of the valve 170 admits fluid under pressure to start the fluid motor 155 to impart a reciprocatory movement to the lapping sticks 131 just before the lapping sticks 131 engage the peripheral surface of the work piece to be lapped. The lapping operation continues for a predetermined time interval as governed by the time relay 185. When the time relay 185 trips, it opens a circuit to de-energize the solenoid 180 thus releasing the compression of the spring 179 to shift the valve 175 into its reverse position and thereby to move the lapping head 130 upwardly to an inoperative position. During the movement of the head 130 to an inoperative position, the valve 170 closes, thus stopping the fluid motor 125 and the reciprocatory movement of the lapping sticks 131.

A snap switch 186 is provided to render the time relay 185 inoperative in case it is desired to utilize the mechanism for a grinding operation only.

It will be readily apparent from the foregoing disclosure that the improved grinding machine is arranged automatically to grind a work piece for a predetermined grinding operation after which a predetermined lapping operation is automatically initiated so that the work piece 25 may be

ground and thereafter lapped automatically without attention on the part of the operator.

It will thus be seen that there has been provided by this invention apparatus in which the various objects here and above 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 limited sense.

I claim:

1. A grinding and lapping machine comprising means for rotating a cylindrical work piece, a grinding wheel, a wheel slide therefor, hydraulically operated means for moving the wheel toward and from the work, a lapping stick, means for oscillating the lapping stick along an element of the work, a hydraulically operated mechanism for moving the lapping stick into contact with the rotating work, means including a control valve to control the movement of the grinding wheel toward and from the work, and means including a second independent control valve which is automatically actuated when the grinding wheel moves to an inoperative position to initiate an approaching movement of the lapping stick.

2. In a grinding and lapping machine having a rotatable work support and a rotatable grinding wheel, a transversely movable slide to support said wheel, a feeding mechanism to feed the slide toward and from the work support to grind a work piece, a reciprocable lapping stick, positioning means to move said lapping stick toward and from the work support, a motor to reciprocate said lapping stick, means actuated by the movement of the stick toward an operative position to start said motor, and means automatically actuated when the wheel slide is moved into an inoperative position after a grinding operation to actuate said positioning mechanism to initiate to lappng operation.

3. A grinding and lapping machine comprising means for rotating a cylindrical work piece, a grinding wheel for grinding the same, a wheel slide, manually operated machanism for positioning the wheel relative to the work, hydraulically operated mechanism for moving the wheel slide and wheel toward and from the work, a lapping stick arranged to contact with the rotating work, hydraulically operated mechanism for moving the lapping stick toward and from the work, hydraulically operated mechanism for oscillating the lapping stick in lapping contact with the work, and means including a control valve which is actuated automatically when the grinding wheel is moved to a rearward position after a grinding operation has been completed automatically to initiate a movement of the lapping stick into operative lapping contact with the work for a lapping operation.

4. In a grinding and lapping machine having a rotatable work support and a rotatable grinding wheel, a transversely movable slide to support said wheel, means including a piston and cylinder to feed said slide toward and from the work support to grind a work piece, a lapping head including a reciprocable lapping stick, positioning means including a piston and cylinder to move said lapping stick toward and from said work support, a fluid motor to reciprocate said lapping stick, and means including a valve which is actuated by movement of the wheel slide to an inoperative position to admit fluid under pressure to said lapping stick positioning cylinder automatically to initiate a lapping operation after a grinding operation has been completed.

5. A grinding and lapping machine comprising a grinding wheel and means associated therewith for rotating a work piece and grinding a cylindrical surface thereon, a slide carrying said wheel, mechanism for moving the slide to position the wheel in contact with the work, an abrasive lapping element, a separate mechanism for moving said element into contact with the work, means automatically actuated by movement of the grinding wheel to an inoperative position after a grinding operation to initiate an approaching movement of the lapping element to move it into operative engagement with the work piece for a lapping operation, and means automatically actuated by and in timed relation with the approaching movement of the lapping element to initiate a reciprocatory movement thereof.

6. In a grinding and lapping machine having a rotatable work support and a rotatable grinding wheel, a transversely movable slide to support said wheel, a feeding mechanism to feed the slide toward and from the work support to grind a work piece, a lapping head including a reciprocable lapping stick, means including a fluid motor to move said stick toward and from the work support, a fluid motor to reciprocate said lapping stick, a valve actuated by movement of the lapping stick toward said work to start said lapping stick reciprocating motor, and means including a valve which is actuated in timed relation with movement of the wheel slide to an inoperative position to admit fluid to said first fluid motor to initiate a lapping operation.

7. In a grinding and lapping machine having a rotatable work support and a rotatable grinding wheel, a transversely movable slide to support said wheel, a feeding mechanism including a piston and cylinder to move said slide toward and from said work support to grind a work piece, a lapping head including a reciprocable lapping stick, positioning means including a piston and cylinder to move said lapping stick toward and from said work support, a solenoid actuated valve to control the flow of fluid under pressure to and from said latter cylinder, an electric time relay to control said valve, and means including a switch actuated by movement of the wheel slide to an inoperative position automatically to energize said solenoid and set said time relay in motion so as to initiate a predetermined lapping operation.

8. In a grinding and lapping machine having a rotatable work support and a rotatable grinding wheel, a transversely movable slide to support said wheel, a feeding mechanism therefor, means including a manually operable lever to start said feeding mechanism, means including an electrical time relay to control said feeding mechanism, a lapping head including a reciprocable lapping element, to reciprocate said lapping element, means including a piston and cylinder to move said lapping stick toward and from said work support, a control valve therefor, means including an electric time relay to control said valve, and a switch actuated by movement of said wheel slide to an inoperative position to set the time relay in motion and to actuate said valve so as to initiate a predetermined lapping operation.

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