

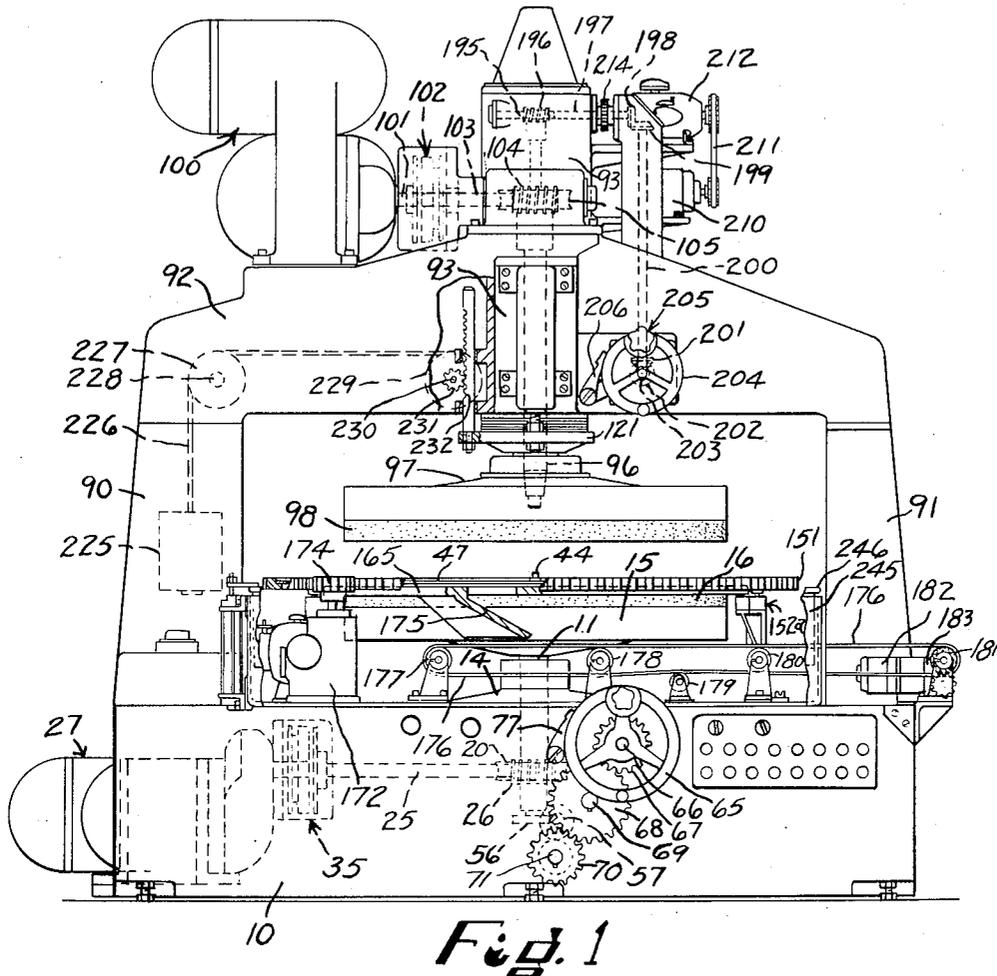
June 7, 1955

H. S. INDGE
LAPPING MACHINE

2,709,876

Filed April 20, 1954

5 Sheets-Sheet 1



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5 Sheets-Sheet 2

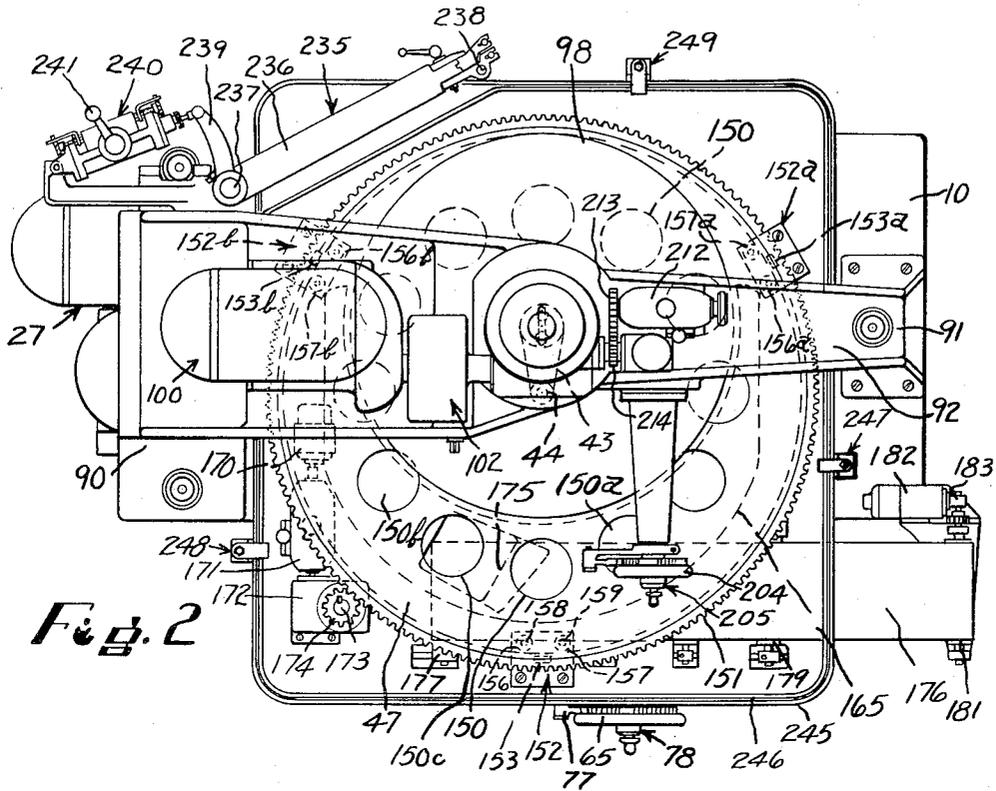


Fig. 2

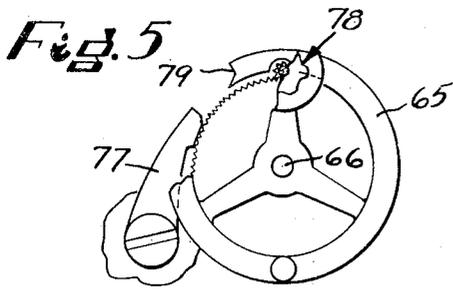


Fig. 5

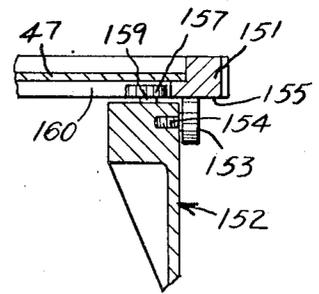


Fig. 6

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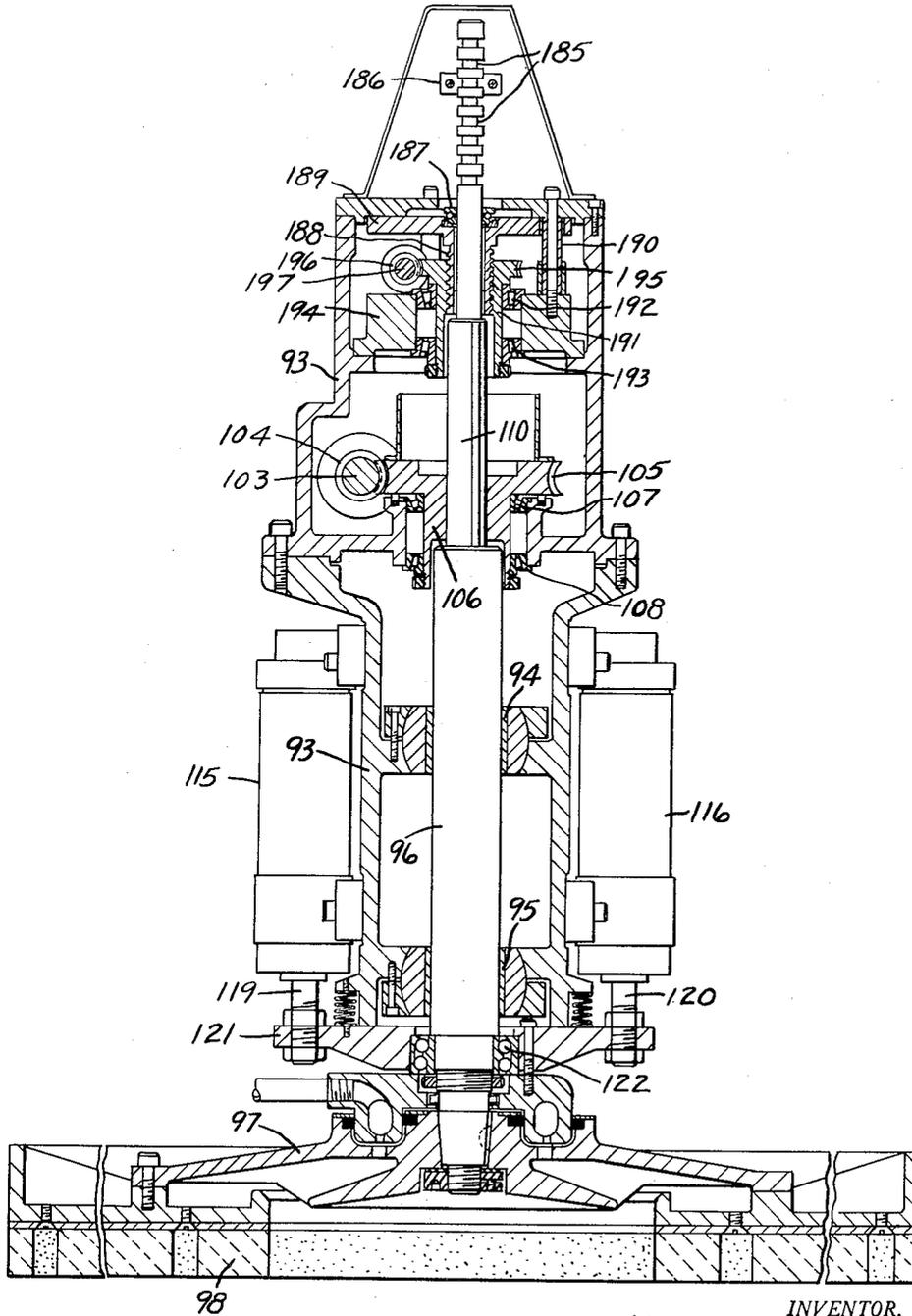


Fig. 3

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5 Sheets-Sheet 5

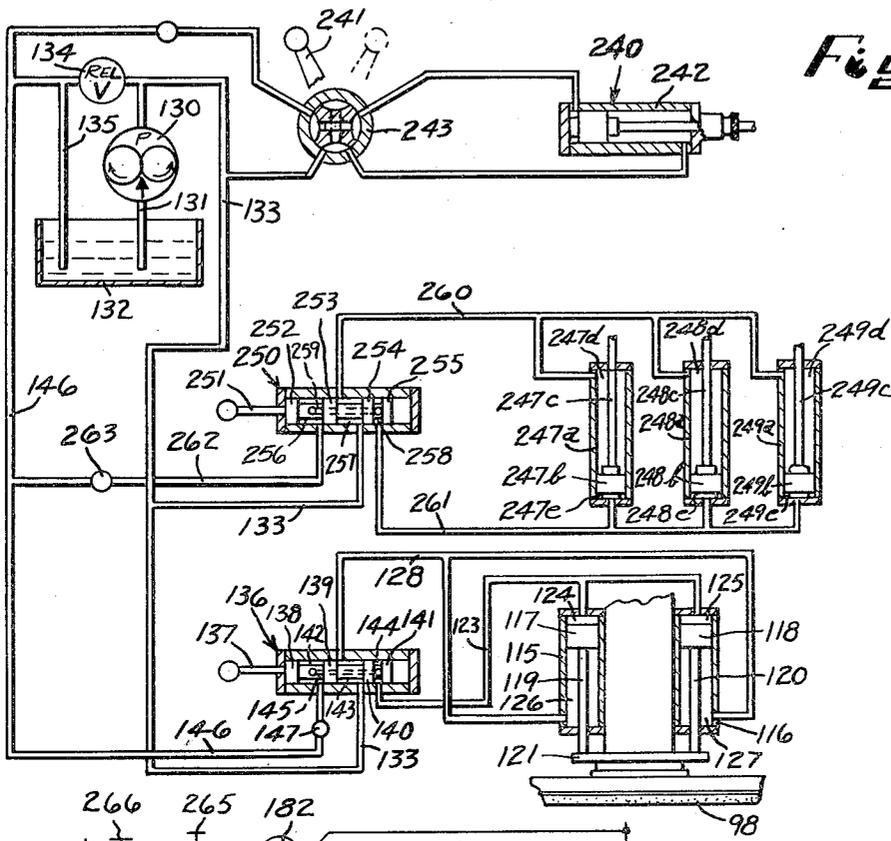


Fig. 8

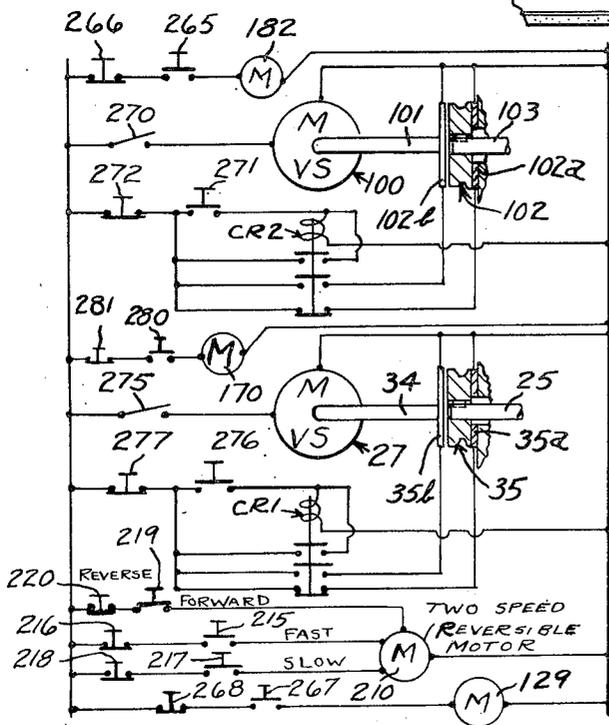


Fig. 9

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2,709,876

LAPPING MACHINE

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Application April 20, 1954, Serial No. 424,325

6 Claims. (Cl. 51—118)

The invention relates to lapping machines, and more particularly to a motor driven hydraulically operated lapping machine.

One of the objects of the invention is to provide a simple and thoroughly practical hydraulically operated lapping machine. Another object is to provide an independent motor driven variable speed mechanism for driving the lapping wheels, work cage and discharge conveyor. Another object is to provide a hydraulically operated mechanism for producing a rapid approaching and receding movement of one of the lapping wheels. Another object is to provide a manually operable and an independent fluid motor driven nut and screw mechanism for imparting a feeding adjustment to the upper lapping wheel. Another object is to provide a reversible electric motor driven fluid motor actuated nut and screw mechanism to feed the upper lapping wheel either toward or from engagement with the work pieces to be lapped.

Another object is to provide a manually operable nut and screw supporting mechanism having a micrometer stop for precisely adjusting the position of the lower lapping wheel to compensate for wheel wear so as to maintain the operative face in a predetermined position relative to the work cage. Another object is to provide a motor driven work discharge mechanism to convey lapped work pieces from the work cage to the side of the machine. Other objects will be in part obvious or in part pointed out hereinafter.

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 lapping machine;

Fig. 2 is a plan view of the lapping machine as shown in Fig. 1;

Fig. 3 is a vertical sectional view, on an enlarged scale, through the upper lapping wheel assembly;

Fig. 4 is a vertical sectional view, on an enlarged scale, through the lower lapping wheel assembly;

Fig. 5 is a fragmentary detailed view, on an enlarged scale, of one of the manually operable hand wheels for adjusting the position of the lapping wheels;

Fig. 6 is a fragmentary sectional view, on an enlarged scale, of one of the roller supports for the work cage;

Fig. 7 is a fragmentary detailed view of the variable speed driving unit for the lapping wheels;

Fig. 8 is a hydraulic diagram of the actuating mechanisms of the machine; and

Fig. 9 is an electrical diagram of the electrical controls of the machine.

A lapping machine has been illustrated in the drawings having a base 10 which supports a vertically arranged hollow spindle 11. A spindle 11 is supported in spaced bearings 12 and 13 carried by a housing 14 which is fixedly mounted on the base 10. A platen 15 is keyed on the upper end of the spindle 11 and serves as a support for a lower lapping wheel 16 having a plane operative face.

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A driving mechanism is provided for driving the spindle 11 and the lower lapping wheel 16 comprising a worm gear 20 (Fig. 4) which is provided with an integral hub 21. A hub 21 is supported by a pair of spaced bearings 22 and 23 carried by a housing 24 which is fixedly mounted on the base 10. A horizontally arranged rotatable shaft 25 (Fig. 1) is provided with a worm 26 which meshes with the worm gear 20.

It is desirable to provide a variable speed drive for the lower lapping wheel 16. Any one of the various commercial variable speed driving units may be utilized, such as, for example, the Special Speed-Trol unit which is manufactured by the Sterling Electric Motors Inc., of New York city. The Speed-Trol unit has been illustrated in Fig. 7 and comprises an electric motor 27 having a motor shaft 28 for driving a variable speed cone pulley arrangement comprising a fixed frusto-conical member 29 mounted on the shaft 28 and an opposed frusto-conical pulley member 30 which is slidable axially on the shaft 28. The pulley 29—30 is connected by a V-belt 31 with an adjustable cone pulley 32—33 mounted on a driven shaft 34. The pulley 32—33 comprises a frusto-conical pulley member 32 which is fixedly mounted on the shaft 34 and a frusto-conical pulley member 33 which is axially movable on the shaft 34. A lever mechanism 36 is provided for simultaneously actuating the cone pulleys 29—30 and 32—33 so as to vary the speed of the driven shaft 34. When the lever mechanism 36 is moved to cause the pulley members 29—30 to approach each other a corresponding movement is imparted to separate the pulley members 32—33 to facilitate varying the speed of the driven shaft 34. The driven shaft 34 is connected through a clutch 35 to rotate the shaft 25. The clutch 35 may be a standard commercial clutch such as, for example, a motor brake-clutch such as manufactured by the Warner Electric Brake Manufacturing Company of Beloit, Wisconsin. It will be readily apparent from the foregoing disclosure that when the motor 27 is started, a rotary motion will be imparted to the lower lapping wheel 11 at a speed governed by the variable cone pulley drive mechanism above described.

The hollow spindle 11 contains a vertically arranged shaft 40, the upper end of which is supported in a bearing 41 carried by the spindle 11. The lower end of the shaft 40 is fixedly mounted in a cup-shaped member 42 which is fixedly mounted on the lower portion of the housing 24 and the upper end of the shaft 40 is fixedly mounted within the cup-shaped member 42 and is thereby held against rotation. The upper end of the shaft 40 is provided with an arm 43 which supports a vertically arranged stud 44 having a flanged bushing 45 mounted thereon. The flanged bushing is arranged to engage a central aperture 46 of a work supporting cage 47. The stud 44 is offset relative to the axis of the shaft 40 and the spindle 11 so as to locate the work cage 47 eccentric relative to the lapping wheel 16.

It is desirable to provide a feed adjusting mechanism to facilitate a vertical adjustment of the spindle 11 and the lapping wheel 16 so that the plane operative face of the lapping wheel 16 may be maintained in a predetermined plane relative to the work cage 47. When the lapping wheel wears away due to lapping operations and truing, the lapping wheel may be adjusted vertically to maintain the operative face thereof in the desired relation with the work cage 47. A sleeve 50 is provided with a central aperture which mates with a tri-lobe portion 51 of the shaft 40 so that the sleeve 50 is held against rotation. The outer surface of the sleeve 50 is provided with a screw thread 52 which mates with or meshes with an internal thread formed in a rotatable nut 53 which surrounds the sleeve 50. The nut 53 is rotatably supported by spaced anti-friction bearings 54 and 55 carried

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by the housing 24. A worm gear 56 is formed integral with the nut 53. The worm gear 56 meshes with a worm 57 fixedly mounted on a shaft 58 which is journaled in spaced bearings 59 and 60 carried by the housing 24. An anti-friction end thrust bearing 61 is supported on the upper end of the sleeve 50 and serves as an end thrust bearing for the spindle 11. A suitable manually operable mechanism is provided for actuating the worm and worm gear feeding mechanism which may comprise a hand wheel 65 (Fig. 1) which is supported on the outer end of a shaft 66 on the front of the machine base 10. The shaft 66 carries a gear 67 which meshes with a gear 68 mounted on a rotatable shaft 69. The gear 68 meshes with a gear 70 mounted on the outer end of a rotatable shaft 71. The inner end of the shaft 71 is provided with a gear 72 which meshes with a gear 73 mounted on the right hand end of the shaft 58 (Fig. 4). It will be readily apparent from the foregoing disclosure that a rotary motion of the feed wheel 65 will be imparted to cause a rotary motion of the nut 53 which in turn imparts a vertical adjustment to the threaded sleeve 50 thereby vertically adjusting the position of the spindle 11 within its bearings 12 and 13 and imparting a corresponding vertical adjustment to the lower lapping wheel 16.

An alternative driving mechanism is provided between the hand wheel 65 and the shaft 71, as shown in Fig. 4, a sprocket 74 is fixedly mounted to rotate with the hand wheel 65. The sprocket 74 is connected by a link chain 75 with a sprocket 76 mounted on the outer end of the shaft 71. A pivotally mounted stop pawl 77 is provided on the front of the machine base to facilitate positively stopping rotary motion of the feed wheel 65 to maintain the operative surface of the lapping wheel in the desired relationship. The feed wheel 65 may be provided with a micrometer adjusting mechanism so that a stop abutment 79 carried by the wheel 65 may be varied to compensate for wear on the lapping wheel.

Due to the size of this improved lapping machine, it may be desirable to provide a feed adjustment which may be operated from the rear of the machine adjacent to the truing apparatus to be hereinafter described. This mechanism may comprise a rotatable shaft 80 which is supported in bearings 81 and 82. The inner end of the shaft 80 is provided with a gear 83 which meshes with a gear 84 mounted on the left hand end of the shaft 58. A manually operable feed wheel may be provided for imparting a rotary motion to the nut 50. This feed wheel and its connection with the shaft 80 is identical with that just described and consequently has not been illustrated or described herein.

The base 10 supports a pair of spaced vertically extending columns 90 and 91. A cross head 92 is fixedly mounted on the upper ends of the columns 90 and 91. The cross head 92 serves as a support for a vertically arranged housing 93 having a pair of spaced spindle bearings 94 and 95 (Fig. 3). A rotatable spindle 96 is journaled in the bearings 94 and 95 and is provided at its lower end with a face plate 97 which supports an upper lapping wheel 98 having a plane operative face which is parallel to the operative face of the lower lapping wheel 16.

A driving mechanism is provided for driving the spindle 96 and the lapping wheel 98 at a predetermined lapping speed. A Speed-Trol unit 100 is provided having a driven shaft 101. The Speed-Trol unit is identical with that previously described for driving the lower lapping wheel. The driven shaft 101 is connected by a brake-clutch 102 to the left hand end of a rotatable shaft 103. The shaft 103 is provided with a worm 104 which meshes with a worm gear 105. The worm gear 105 is provided with a downwardly extending integral hub 106 which is journaled in a pair of spaced anti-friction bearings 107 and 108. The worm gear 105 and the hub 106 are provided with a central aperture which is shaped to mate with a tri-lobe portion 110 formed on the upper

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end of the spindle 96. This tri-lobe shaft connection with the worm gear 105 forms a splined driving connection which allows rotation of the spindle 96 and at the same time permits a vertical axial movement of the spindle for positioning the upper lapping wheel.

A hydraulically operated mechanism is provided for raising and lowering the spindle 96 and the lapping wheel 98 to move the same to and from an operative position. This mechanism preferably comprises a pair of spaced diametrically arranged cylinders 115 and 116 arranged on diametrically opposite sides of the spindle 96. The cylinders 115 and 116 contain slidably mounted pistons 117 and 118 respectively. The pistons 117 and 118 are connected to the upper ends of a pair of piston rods 119 and 120 respectively. The lower end of the piston rods 119 and 120 are fixedly connected to opposite ends of an arm 121. The arm 121 is supported by an anti-friction bearing 122 which is fixedly mounted on the lower portion of the spindle 96. It will be readily apparent from the foregoing disclosure that when fluid under pressure is passed through a pipe 123 into cylinder chambers 124 and 125 respectively, the pistons 117 and 118 will be moved downwardly to cause a downward movement of the spindle 96 and the lapping wheel 98. By arranging the hydraulic pistons and cylinders on diametrically opposite sides of the spindle, the pressure exerted upon the spindle adjacent to the upper lapping wheel 98 is equalized. During a downward movement of the spindle 96, fluid within a pair of spaced cylinder chambers 126 and 127 may exhaust through a pipe 128.

A fluid pressure system is provided for supplying fluid under pressure to the operating parts of the machine. This mechanism comprises motor driven fluid pump 130, driven by a motor 129, which draws fluid through a pipe 131 from a fluid reservoir 132 and forces fluid under pressure through a pipe 133 to the various actuating mechanisms of the machine. An adjustable relief valve 134 is provided in the pipe line 133 to facilitate exhausting excess fluid under pressure through a pipe 135 into the reservoir 132 thereby maintaining the desired operating pressure within the system.

A manually operable control valve 136 is provided for controlling the admission to and exhaust of fluid from the cylinders 115 and 116. The valve 136 is preferably a piston-type valve comprising a valve stem 137 having a plurality of valve pistons 138, 139, 140 and 141 formed integrally therewith so as to form a plurality of valve chambers 142, 143 and 144.

In the position of the valve (Fig. 8) fluid under pressure passing through the pipe 133 enters the valve chamber 143 through the pipe 128 into the cylinder chambers 126 and 127 to move the pistons 117 and 118 together with the spindle 96 and upper lapping wheel 98 upwardly to an inoperative position. During this movement of the pistons 117 and 118 fluid is exhausted from the cylinder chambers 124 and 125 through the pipe 123 into the valve chamber 144, through a central passage 145 into the valve chamber 142 and passes out through an exhaust pipe 146 into the reservoir 132. A throttle valve 147 is provided in the pipe 146 to facilitate regulating the return of exhaust of fluid from the valve 136 and thereby regulating the rate of movement of the spindle 96 and the upper lapping wheel 98.

When it is desired to move the lapping wheel 98 downwardly into an operative position in lapping engagement with the work pieces to be lapped, the valve stem 136 is moved toward the right (Fig. 8) to reverse the flow of fluid to the cylinders 115 and 116. In this position of the valve 136, fluid under pressure in the pipe 133 passes through the valve chamber 143, through the pipe 123 into the cylinder chambers 124 and 125 to cause a downward movement of the pistons 117 and 118 respectively to cause a corresponding movement of the spindle 96 and the upper lapping wheel 98.

The work cage 47 is provided with a plurality of work

receiving apertures 150 to carry work pieces between the operative faces of the lapping wheels 16 and 98. The periphery of the work cage 47 is supported and driven by a ring gear 151 which is supported by three roller supports 152, 152a and 152b. Each of the roller supports is provided with a plurality of rollers including a roller 153 which is arranged to rotate about a horizontal stud 154. The roller 153 is arranged to engage the lower plane face 155 of the ring gear 151 (Fig. 6). Each of the roller supports 152, 152a and 152b are also provided with a pair of spaced rollers 156 and 157 which are arranged to rotate about vertically arranged studs 158 and 159 respectively. The rollers 156 and 157 are arranged to engage an internal cylindrical surface 160 formed on the ring gear 151. The rollers for the units 152a and 152b are identical with those just described in connection with unit 152. The rollers 153, 153a and 153b determine the plane of rotation of the ring gear 151. The rollers 156—157, 156a—157a and 156b—157b are positioned to guide the ring gear as it rotates about the axis of the stud 44.

As previously explained, the axis of the stud 44 and also the axis of rotation of the work cage 47 are eccentric to the axes of the lapping wheels 16 and 98 respectively so that the work pieces are carried in an eccentric path across the operative faces of the opposed lapping wheels 16 and 98. As shown in Fig. 2, a platen 165 is fixedly mounted relative to the base of the machine and is provided with an upper plane face which lies in the same plane with the upper operative face of the lower lapping wheel 16. The platen 165 serves to support work pieces when they are loaded into the cage in aperture 150a. The cage then carries the work pieces into lapping engagement with the operative faces of the lapping wheels in an eccentric path until they reach the position aperture 150b (Fig. 2).

The ring gear 151 is driven by an electric motor 170 which drives a variable speed hydraulic transmission unit 171. This unit may be any of the well known commercial units such as, for example, that manufactured by Vickers Inc. of Detroit, Michigan. The transmission unit 171 drives a gear reduction unit 172 which may be of a standard commercial variety. The gear reduction unit is provided with a vertically arranged driven shaft 173 which is provided with a gear 174 meshing with the ring gear 151. When the motor 170 is started, a rotary motion will be imparted through the mechanism above described to rotate the ring gear 151 and the work cage 47 at a predetermined but adjustable speed.

The work pieces carried by the cage 47 make one pass between the operative faces of the lapping wheels and then are carried onto the platen 165 by the cage apertures. When the work pieces reach the position indicated by aperture 150c, the work pieces drop out onto a discharge chute 175 (Fig. 1) onto an endless conveyor belt 176 which carries the lapped work pieces to the right hand side of the machine.

The conveyor belt 176 is supported by a plurality of rollers 177, 178, 179, 180 and 181. The conveyor belt 176 is driven by an electric motor 182 through a gear reducer unit 183 at the desired and predetermined speed. It will be readily apparent from the foregoing disclosure that work pieces are loaded manually into the work cage into aperture 150a (Fig. 2) and are moved in a counter-clockwise direction in an eccentric path between the operative face of the lapping wheels 16 and 98 after which they are automatically discharged when apertures reach position 150c onto the conveyor belt 176 which conveys the finished lapped work piece to the right hand side of the machine where it may be removed manually or dropped into a container (not shown).

It is desirable to provide a positive stop for limiting the rapid downward movement of the spindle 96 and the upper lapping wheel 98. The upper end of the wheel spindle 96 is provided with a plurality of spaced grooves

185 to which a stop 186 may be clamped. The stop 186 may be adjusted and positioned in any one of the grooves 185 as desired. The rapid downward movement of the spindle 96 continues until the stop 186 engages the upper face of an anti-friction thrust bearing 187 which serves to position the lapping wheel 98 as desired.

The hydraulic mechanism previously described serves to cause a rapid positioning movement of the upper lapping wheel 98 to and from an operative position. It is desirable to provide a suitable feeding mechanism to facilitate adjusting the upper lapping wheel 98 so as to apply the desired lapping pressure of the wheel upon the work being lapped and to also facilitate compensating for wear or truing of the operative face of the upper lapping wheel 98. This mechanism may comprise a hollow screw 188 (Fig. 3) which surrounds the upper portion of the spindle 96 and is provided with an integral flange 189. The flange 189 serves as a support for the thrust bearing 187. A vertically arranged guide sleeve 190 is provided to hold the flange 189 and the screw 188 against rotation but permitting it to move in an axial direction as will be hereinafter described. A nut 191 engages or meshes with the screw 188. The nut 191 is rotatably supported in a pair of spaced bearings 192 and 193 which are fixedly mounted within a collar 194. The collar 194 is fixedly mounted within the upper portion of the housing 93. A worm gear 195 is formed integral with the upper portion of the nut 191. The worm gear 195 meshes with a worm 196 mounted on the end of a rotatable shaft 197. A suitable mechanism is provided for actuating the nut 191 either manually or by power.

A manual feeding mechanism is provided comprising a bevel gear 198 mounted on the right hand end of the shaft 197 (Fig. 1). The bevel gear 198 meshes with a bevel gear 199 mounted on the upper end of a vertical shaft 200. The lower end of the shaft 200 is provided with a bevel gear 201 which meshes with a bevel gear 202 mounted on the rear end of a horizontal shaft 203 which supports a manually operable feed wheel 204. The feed wheel 204 is provided with a micrometer feed adjusting mechanism 205 to facilitate adjusting the position of a stop abutment (not shown) which moves in the path of a pivotally mounted stop pawl 206. The feed wheel and associated parts are identical with that shown in Fig. 5 for controlling the vertical feeding movement of the lower lapping wheel 16.

A power operated mechanism is provided for actuating the nut 191 which comprises a motor driven mechanism including a two speed reversible motor 210 which is connected by a V-belt 211 with a hydraulic variable speed transmission unit 212 such as, for example, the well known hydraulic variable speed transmission unit manufactured by Vickers Inc. of Detroit, Michigan. The driven shaft of the transmission unit 212 is provided with a gear 213 which meshes with a gear 214 mounted on the shaft 197. It will be readily apparent from the foregoing disclosure that when the motor 210 is started in either direction, a rotary motion will be imparted through the shaft 197, the worm 196, and the worm gear 195 to rotate the nut 191 and thereby impart a vertical feeding movement to the spindle 96 and the upper lapping wheel 98. As shown diagrammatically in Fig. 9, a push button start switch 215 is provided to start the motor 210 at its fast speed and a push button stop switch 216 is provided to stop the motor when desired. Similarly a push button start switch 217 is provided to start the motor 210 at a slow speed and a push button stop switch 218 is provided to stop the motor 210 when desired. Similarly a push button start switch 219 is provided for starting the motor 210 in a reverse direction and a push button stop switch 220 is provided for stopping the motor 210 when operating in a reverse direction.

A counterbalance mechanism is provided for counterbalancing the weight of the upper lapping wheel and its

supporting assembly. This mechanism may comprise a weight 225 (Fig. 1) which is attached to the end of a flexible chain or cable 226. The chain or cable 226 passes over an idler pulley 227 mounted on a shaft 228. The other end of the cable 226 is attached to the peripheral portion of a pulley 229 which is supported on a shaft 230. A gear 231 fixedly mounted to rotate with the pulley 229 meshes with a vertically arranged rack bar 232, the lower end of which is attached to the arm 121.

A truing apparatus is provided to facilitate truing both the upper lapping wheel 98 and the lower lapping wheel 16 either one at a time or simultaneously, as desired. This mechanism comprises a truing apparatus 235 (Fig. 2) having an arm 236 fixedly mounted on a rock shaft 237. The right hand end of the arm 236 is provided with a pair of adjustably mounted diamonds or truing tools 238, only one of which has been illustrated in Fig. 2. These truing tools are arranged so that one is arranged to true the upper lapping wheel and the other the lower lapping wheel and both are adjustably positioned relative to the arm 236. An arm 239 is also fixedly mounted on the rock shaft 237 so that the arms 236—239 serve as a bell crank lever. A hydraulically operated mechanism is provided for oscillating the bell crank lever 236—239 comprising a fluid pressure unit 240 controlled by a manually operable lever 241. By actuation of the lever 241, the bell crank lever 236—239 may be caused to swing in an arcuate path to pass the truing tools across the operative faces of the lapping wheels 16 and 98. This hydraulic actuating mechanism and the adjustable mounts for the truing tools are identical with that shown in my prior U. S. Patent No. 2,285,717 dated June 9, 1942, to which reference may be had for details of disclosure not contained herein. The hydraulic mechanism for actuating the truing apparatus has been shown diagrammatically in Fig. 8 and comprises a piston and cylinder mechanism 242 which is controlled by a control valve 243 actuated by the control lever 241.

A suitable rectangularly shaped pan 245 is fixedly mounted on the base 10 and is provided with an upwardly extending side wall. A vertically slidable extension 246 is provided for the pan 245 which is arranged so that it may be raised and lowered before and after a lapping operation to confine fluid used in the lapping operation. A fluid pressure actuated mechanism is provided to facilitate raising and lowering the pan comprising a plurality of fluid pressure actuated units 247, 248 and 249. These units each comprise a cylinder 247a, 248a and 249a which contain slidably mounted pistons 247b, 248b and 249b respectively. The pistons are connected to the lower ends of piston rods 247c, 248c and 249c, the upper ends of which are connected to the rim of the pan extension 246.

A control valve 250 is provided for controlling the admission to and exhaust of fluid from the units 247, 248 and 249. The valve 250 is a piston type valve comprising a valve stem 251 having a plurality of valve pistons 252, 253, 254 and 255 formed integrally therewith to form spaced valve chambers 256, 257 and 258. The valve member is provided with a central aperture 259. In the position of the valve 250 (Fig. 8) fluid under pressure in the pipe 133 passes through the valve chamber 257, through a pipe 260 into cylinder chambers 247d, 248d and 249d to move the pistons 247b, 248b and 249b downwardly to move the pan extension 246 downwardly to an inoperative position. During this movement fluid within cylinder chambers 247e, 248e and 249e is exhausted through a pipe 261 into the valve chamber 258, passes through the central passage 259 into the valve chamber 256 and passes out through a pipe 262, through a throttle valve 263 into the exhaust pipe 146 and the reservoir 132. By manipulation of the throttle valve 263, the rate of movement of the pan extension 246 to and from an operative position may be readily controlled.

When it is desired to raise the pan extension 246 to an

operative position, the valve stem 251 is moved toward the right (Fig. 8) so that the flow of fluid is reversed and fluid under pressure passes through the pipe 261 to the cylinders 247a, 248a and 249a to raise the pistons 247b, 248b and 249b to raise the pan extension 246 vertically to an operative position.

As shown in Fig. 9, a push button switch 265 is provided for starting the conveyor belt driving motor 182. A push button stop switch 266 is provided to stop the motor 182. A push button start switch 267 is provided for starting the fluid pump driving motor 129. A push button stop switch 268 is provided to stop the motor 129. A push button start switch 280 is provided to start the cage driving motor 170. A push button stop switch 281 is provided to facilitate stopping the cage driving motor 170 when desired.

A switch 270 is provided to start the motor in the Speed-Trol unit 100. In the position of the brake clutch 102 (Fig. 9) the brake portion 102a is engaged to hold the driven shaft 103 against rotation. When it is desired to start rotation of the upper lapping wheel 98, a push button start switch 271 is actuated to energize a relay switch CR2 which serves to set up a holding circuit to hold the relay switch CR2 energized and at the same time breaks the circuit to deenergize the magnetic brake 102a and makes a circuit to engage the clutch portion 102b to start rotation of the driven shaft 103 and thereby start rotation of the lapping wheel 98.

Similarly a switch 275 is provided for starting the electric motor of the Speed-Trol unit 27. As shown diagrammatically in Fig. 9 the magnetic brake 35a of the brake clutch unit 35 is engaged to hold the driven shaft 25 stationary. When it is desired to start the rotation of the lower lapping wheel 16, a push button start switch 276 is actuated to energize a relay switch CR1 which sets up a holding circuit to hold CR1 energized, breaks a circuit to deenergize the magnetic brake 35a, and makes a circuit to engage the clutch 35b to start rotation of the driven shaft 25 and thereby to start rotation of the lower lapping wheel 16. A push button stop switch 277 is provided to facilitate deenergizing the relay CR1 so as to disengage the clutch 35b and to energize the brake 35a when it is desired to stop the rotation of the driven shaft 25 to stop rotation of the lower lapping wheel 16.

The operation of the improved lapping machine will be readily apparent from the foregoing disclosure. Work pieces are loaded in the apertures 150 and 150a. The switches 270 and 275 are closed to start the Speed-Trol motors 100 and 27 respectively. The push button switches 271 and 276 are then closed to start the rotation of the lapping wheels 98 and 16 respectively. The switch 280 is then closed to start the cage driving motor 170. The switch 265 is then closed to start the motor 182 so as to start the conveyor belt 176. The valve 250 is then actuated to raise the pan extension vertically to an operative position. The valve 136 is then actuated to cause a downward movement of the lapping wheel which continues at a rapid rate until the stop 186 engages the upper face of the thrust bearing 187 to position the upper lapping wheel 98. The hand wheel may then be rotated to feed the upper lapping wheel downwardly to establish the desired lapping pressure between the lapping wheels 98 and 16 and the work pieces carried within the cage apertures. The rotation of the cage 47 carries work pieces within the aperture 150 in an eccentric path relative to the lapping wheels to lap the opposite faces of the work piece in a single path between the wheels. When the work pieces reach the position indicated by aperture 150c, they drop by gravity onto the discharge chute 175 and onto the conveyor belt 176 which carries the lapped work pieces to the right hand side of the machine.

If desired the motor 210 may be started to cause the downward feeding movement of the lapping wheel to apply the desired pressure by actuating either the switch 215 to give a fast downward movement of the upper lapping

wheel 98 or by closing the switch 217 to impart a slow downward feeding movement to the upper lapping wheel 98.

When a truing operation is desired, the bell crank arm 239—236 is oscillated by movement of the control lever 241. The micrometer adjusting mechanism 78 is reset and the hand wheel 65 rotated in a clockwise direction until the stop abutment 79 engages the stop pawl 77 to raise the lower lapping wheel 16 by an amount equal to that desired to be trued therefrom during the truing operation. The upper lapping wheel may then be positioned by manual actuation of the feed wheel 204 to position the operative face of the upper lapping wheel 98 for a truing operation. The operative face of the lower lapping wheel 16 is maintained in a predetermined relationship with the plane of the work cage so that there is no necessity for adjusting or repositioning the work cage as the lower lapping wheel wears away.

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 hereinabove 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 lapping machine having a base, an upper and a lower opposed axially-aligned plane-faced rotatable lapping wheel supported thereby, means including an independent motor driven variable speed driving mechanism to rotate each of said wheels, a work cage between said wheels having a plurality of work receiving apertures, means including a plurality of symmetrically arranged rollers to support said cage for rotation about an axis eccentric to the axes of said wheels, means including a piston and cylinder mechanism rapidly to move one of said wheels toward and from the other to position said wheel in an operative position, a positive stop to limit the rapid approaching movement of said upper lapping wheel, a manually operable feeding mechanism to impart a feeding movement to said upper lapping wheel to obtain the desired lapping action, and means including an independent manually operable feeding mechanism to adjust the position of the lower lapping wheel to compensate for wheel wear so as to maintain the operative face of the latter wheel in a predetermined position relative to the work cage.

2. In a lapping machine, as claimed in claim 1, in combination with the parts and features therein specified of an independent motor driven variable speed driving mechanism operatively connected to rotate said cage at a predetermined speed, a work discharge chute to receive lapped work pieces from said cage after a single pass between said lapping wheels, and a motor driven variable speed discharge conveyor to convey work pieces from the discharge chute to the side of the machine.

3. In a lapping machine as claimed in claim 1, in combination with the parts and features therein specified of a nut and screw feeding mechanism for the upper lapping wheel including a non-rotatable screw, a rotatable nut on said screw, anti-friction bearings rotatably to support said nut and to hold it against axial movement, an adjustably mounted positive stop which is engageable with the end of said screw positively to limit the move-

ment of said upper lapping wheel in one direction, means including a manually operable feed wheel operatively connected to rotate said nut so as to impart a feeding movement to said upper lapping wheel, a micrometer adjusted stop mechanism for said feed wheel precisely to position said upper lapping wheel, and an independent reversible motor operatively connected to rotate said nut so as to cause a feeding movement of the upper lapping wheel in either direction.

4. In a lapping machine, as claimed in claim 1, in combination with the parts and features therein specified of a nut and screw mechanism operatively connected to feed the upper lapping wheel, a manually operable feed wheel to actuate said mechanism, means including a micrometer adjusted stop mechanism to limit rotation of said feed wheel in one direction to facilitate precisely positioning the upper lapping wheel, and an independent nut and screw mechanism operatively connected to feed the lower lapping wheel vertically to compensate for wheel wear.

5. In a lapping machine, as claimed in claim 1, in combination with the parts and features therein specified of a nut and screw mechanism operatively connected to feed the upper lapping wheel, a manually operable feed wheel to actuate said mechanism, means including a micrometer adjusted stop mechanism to limit rotation of said feed wheel in one direction to facilitate precisely positioning the upper lapping wheel, an independent nut and screw mechanism operatively connected to feed the lower lapping wheel vertically, and a manually operable feed wheel including a micrometer adjusted stop to actuate said latter nut and screw mechanism to facilitate imparting a feeding movement to the lower lapping wheel to compensate for wheel wear.

6. In a lapping machine having a base, an upper and a lower opposed axially-aligned plane-faced lapping wheel, a pair of vertically axially-aligned rotatable spindles supported by said base to support said lapping wheels, means including an independent motor driven variable-speed driving mechanism to rotate each of said wheels, a work cage between the operative faces of said lapping wheels having a plurality of work receiving apertures therein, means rotatably to support said cage for rotation about an axis eccentric to the axes of said wheels, a motor driven variable speed driving mechanism operatively connected to rotate said cage, means including a piston and cylinder rapidly to move the upper lapping wheel toward and from the lower wheel, a positive stop adjustably mounted on the upper lapping wheel spindle positively to limit the rapid approaching movement of said upper lapping wheel, a manually operable feeding mechanism including hollow non-rotatable screw surrounding the upper lapping wheel spindle which is arranged in the path of said stop, a rotatable nut meshing with and surrounding said screw, and a manually operable feed wheel operatively connected to actuate said nut to feed the upper lapping wheel to obtain the desired lapping action on the opposite faces of the work pieces being lapped.

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