July 23, 1940. E. J. BULLARD 2,209,071

GRINDING AND LAPPING MACHINE

Filed July 24, 1937 4 Sheets-Sheet 1

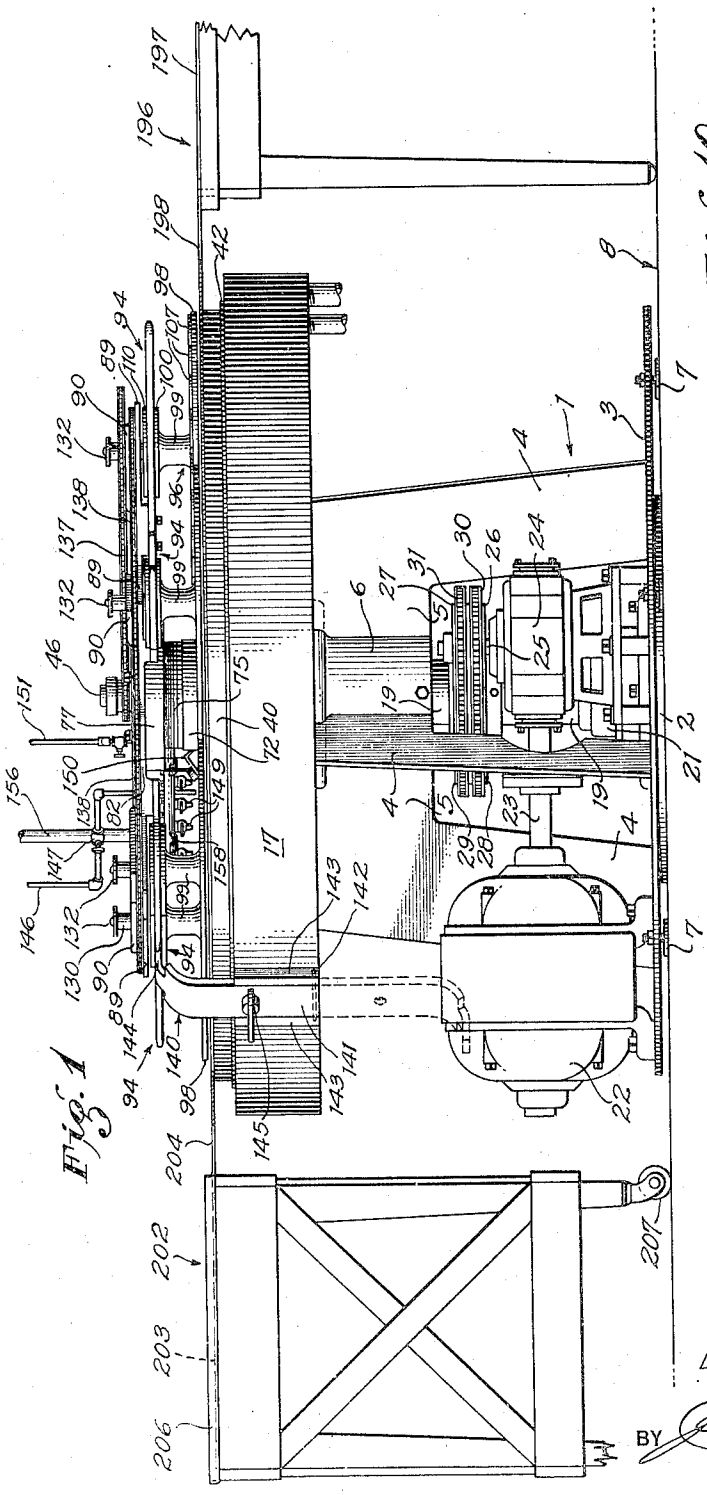

Fig. 1

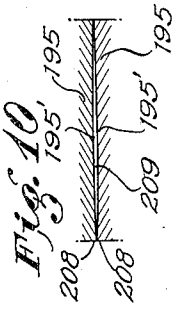

Fig. 10

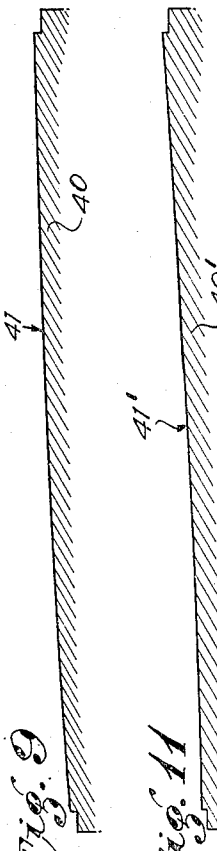

Fig. 9

Fig. 11

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GRINDING AND LAPPING MACHINE

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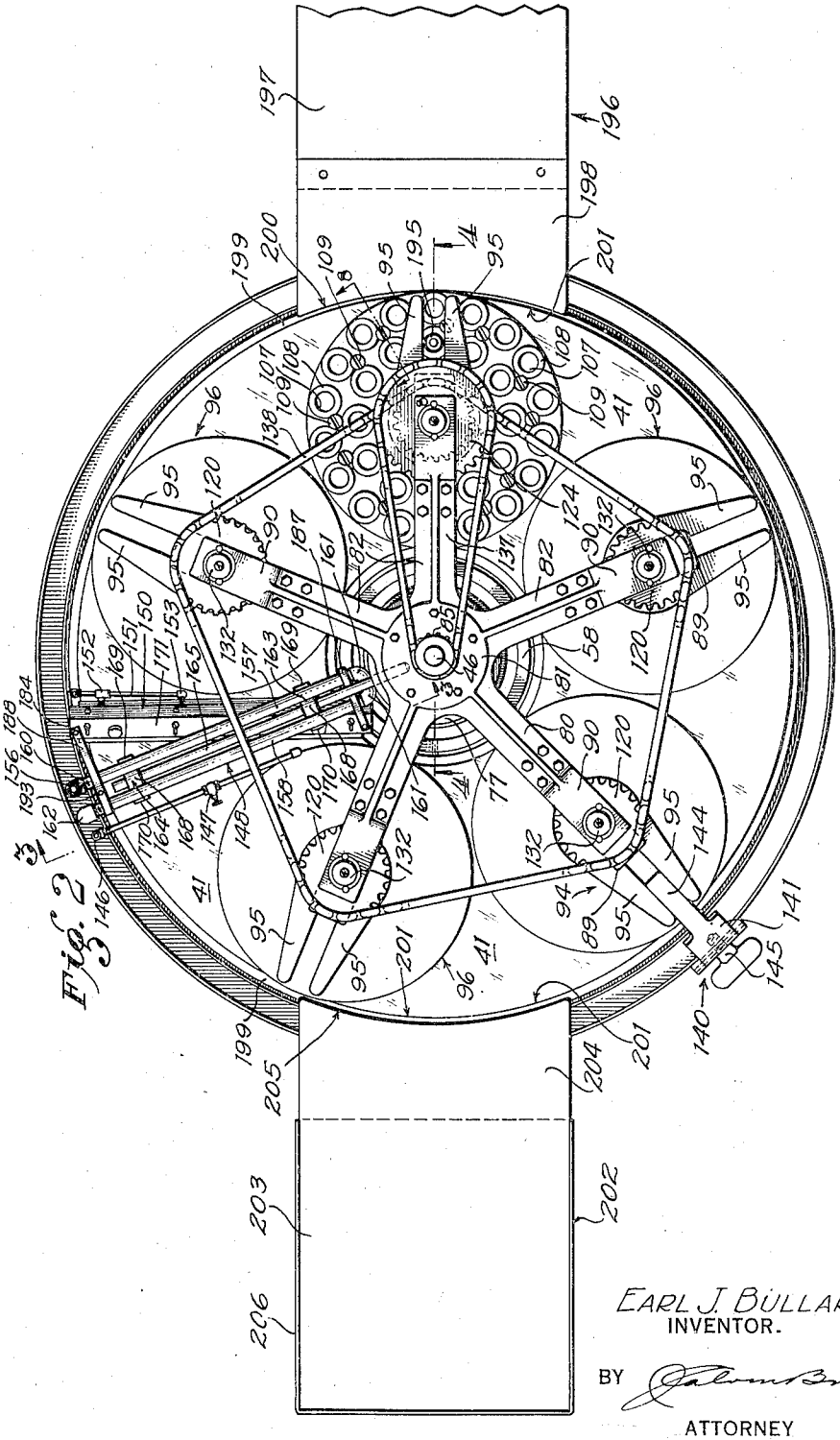

Fig. 2

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GRINDING AND LAPPING MACHINE

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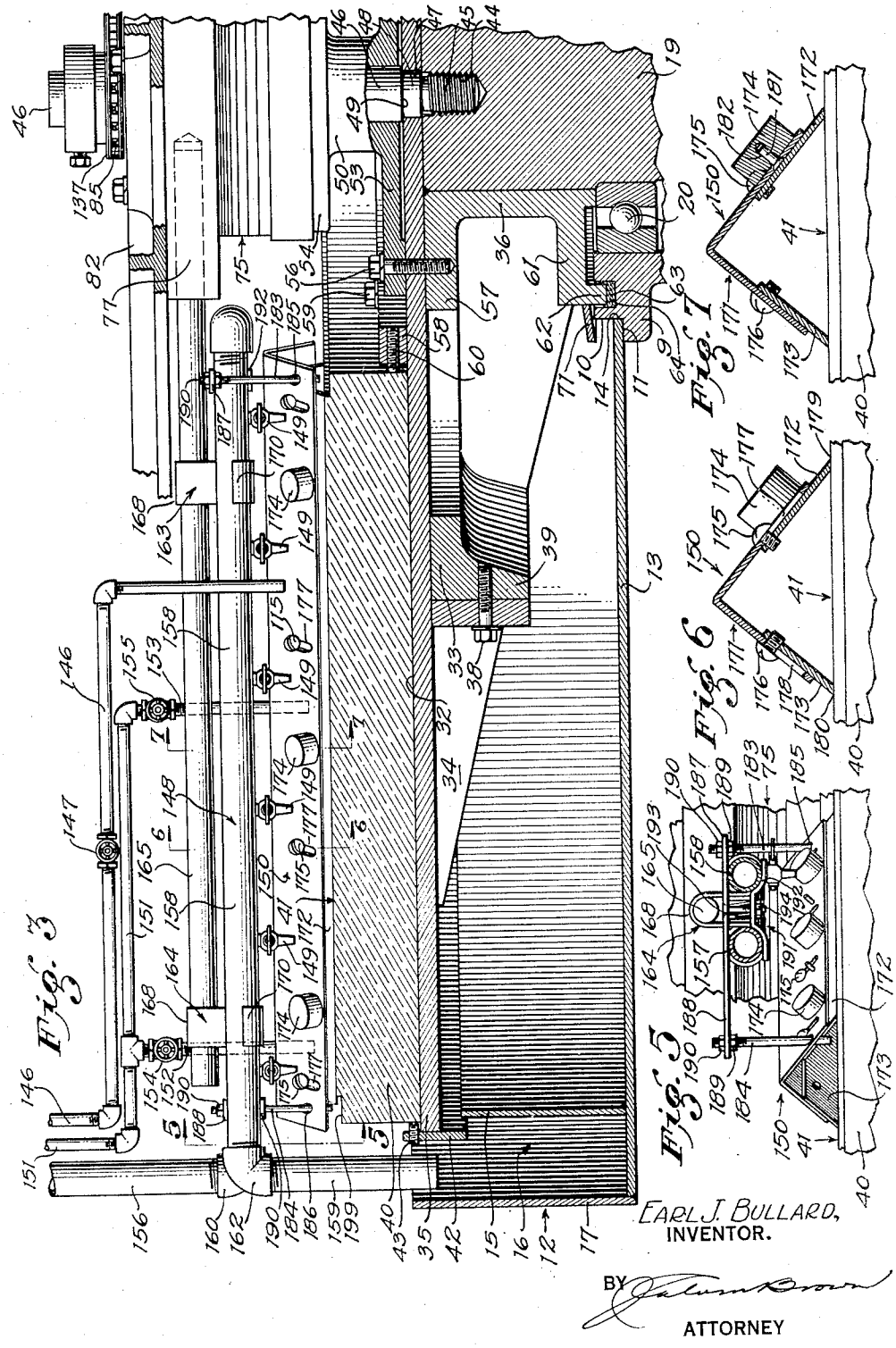

Fig. 1

Fig. 6

Fig. 3

Fig. 5

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July 23, 1940. E. J. BULLARD 2,209,071

GRINDING AND LAPPING MACHINE

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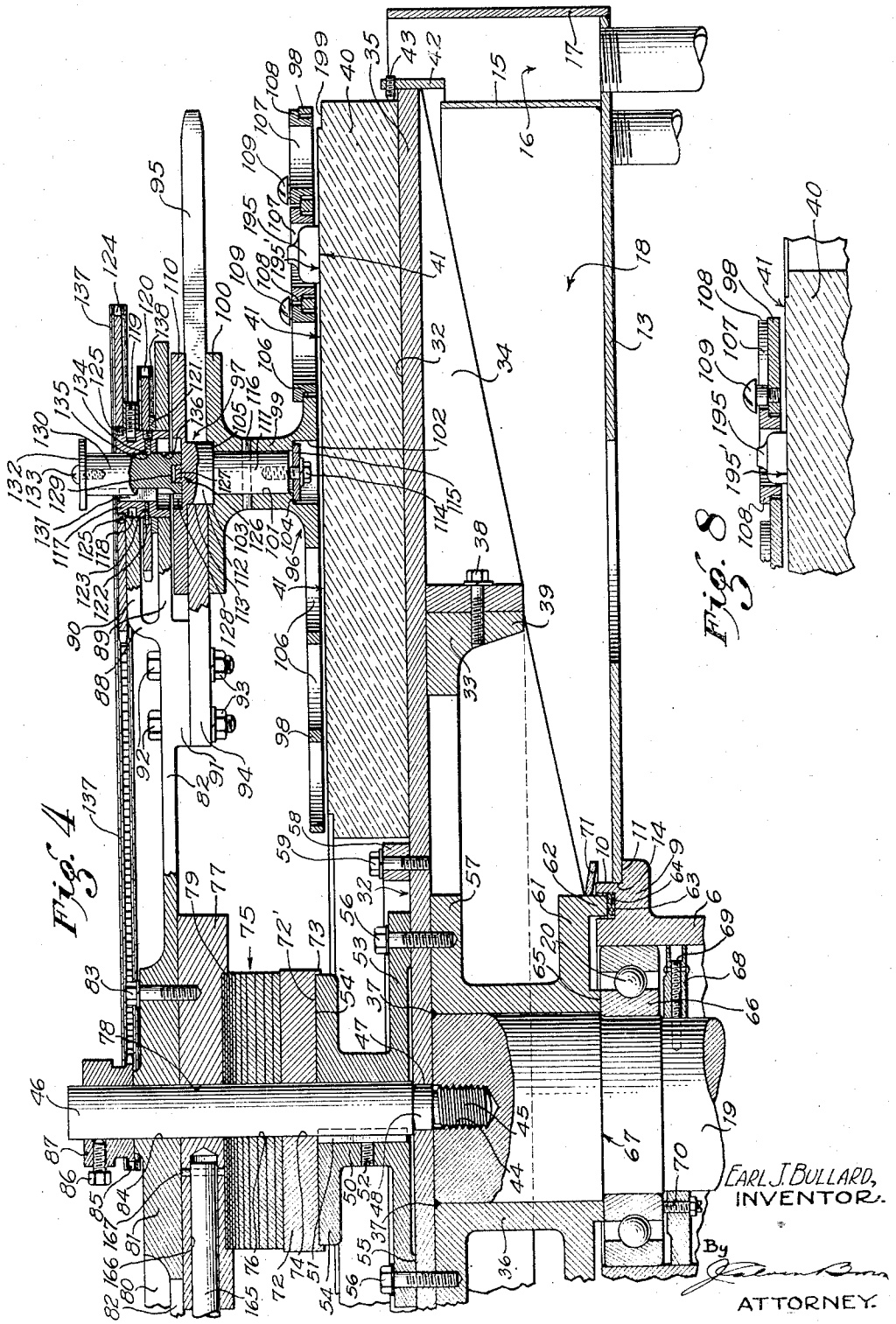

Fig. 4

Fig. 8

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Patented July 23, 1940 2,209,071

UNITED STATES PATENT OFFICE

2,209,071

GRINDING AND LAPPING MACHINE

Earl J. Bullard, Altadena, Calif.

Application July 24, 1937, Serial No. 155,490

11 Claims. (Cl. 51—131)

This invention relates to machines known in the art as lapping machines, for lapping and surfacing various products of manufacture, such as flat valves, thrust washers, piston rings, and other forms of flat work.

The general object of the invention is to provide an improved lapping machine for grinding and surfacing its work on a mass-production basis more perfectly than is otherwise possible, in order to obtain greater accuracy, a higher degree of finish, a finer surface quality, closer tolerances, and more perfect interchangeability of parts than is otherwise obtainable.

Antoher object is to provide a lapping machine in which the work is held against a rotating lap by its own or added weight and subjected to a great variety of novel motions with relation to the lap, whereby the abrading action of the lap is very evenly distributed on the work and extremely accurate grinding and surfacing of the work is accomplished.

Another object is to provide a lapping machine of the character stated with improved detachable work holders by means of which a considerable number of work pieces may be conveniently and effectively loaded onto the machine in position to be ground and surfaced, and unloaded from the machine when ground and surfaced.

A further object is to provide a lapping machine for grinding slightly concaved or convex surfaces on the work, and is particularly useful for grinding the bearing surfaces of the members of flat valves so that when the two members of each of such valves are assembled with their concaved bearing surfaces together, an oil space is provided between said surfaces, which space is closed by contact of the peripheral edges of said bearing surfaces of said members, whereby oil may be sealed in said space for lubricating said bearing surfaces indefinitely.

Other objects and advantages of my invention will appear hereinafter.

With the above and other objects in view, the invention consists in the novel and useful provision, formation, construction, association, and relative arrangement of parts, members and features, all as disclosed in a certain embodiment in the accompanying drawings, described generally, and more particularly pointed out in the claims.

In the drawings:

Figure 1 is a side elevation of my invention,

Figure 2 is a plan view of my invention,

Figure 3 is a fragmentary transverse vertical section on an enlarged scale of my invention, taken on the line 3—3 of Figure 2,

Figure 4 is a fragmentary transverse vertical section, on an enlarged scale, of my invention, taken on the line 4—4 of Figure 2,

Figure 5 is a fragmentary vertical cross section taken on the line 5—5 of Figure 3,

Figure 6 is a fragmentary vertical cross section taken on the line 6—6 of Figure 3,

Figure 7 is a fragmentary vertical cross section taken on the line 7—7 of Figure 3,

Figure 8 is a fragmentary vertical cross section taken on the line 8—8 of Figure 2,

Figure 9 is a transverse vertical section of the lap, illustrating the configuration of its upper lapping surface,

Figure 10 is a fragmentary vertical longitudinal section of a pair of flat valve members, illustrating the concaved configuration produced by my machine of the adjoining coacting flat surfaces of said members, and,

Figure 11 is a transverse vertical section of a modification of the lap for grinding convex surfaces.

Corresponding parts are designated by the same reference characters in all of the views of the annexed drawings.

Referring with particularity to the drawings, 1 designates a supporting frame comprising a base 2, a base plate 3 resting upon and extending beyond said base, a plurality of legs 4 upstanding from said base plate and joined at their upper ends respectively to a plurality of horizontal arms 5 extending radially from a tubular hub 6 disposed centrally of the machine. The base plate 3 is further supported beyond the base 2 by adjustable rests 7, which rest upon the floor or other surface 8 upon which also rests the base 2. The hub 6 is formed at its upper end with an external flange 9 (Figure 4), the upper portion of which is reduced in diameter as at 10, forming an annular, external shoulder 11 at the base of said reduced portion. A circular pan 12 is provided in its bottom wall 13 with a central opening 14 through which extends the reduced flange portion 10 of the hub 6, and said bottom wall 13 of said pan rests around the edge of its said opening upon the shoulder 11 of said hub. Said pan 12 is constructed with an annular partition 15 upstanding from the bottom wall 13, which partition forms an annular receptacle 16 between itself and the outside vertical wall 17 of the pan 12, and forms an inner auxiliary pan 18.

A vertical main shaft 19 extends through the hub 6 and is journaled in said hub in a ball bearing 20, and at its lower end in an end-thrust bearing 21 (Figure 1) mounted upon the base plate 3. On said base plate is also mounted an electric motor 22, the shaft 23 of which drives a reduction gearing 24 also mounted on said base plate 3. On the upper end of the driven shaft 25 of the reduction gearing 24 is secured a pair of sprockets 26 and 27, and on the main shaft 19 below the hub 6 is secured a pair of sprockets 28 and 29. A chain 30 extends over the sprockets

26 and 28, and a chain 31 extends over the sprockets 27 and 29, whereby the main shaft 19 is driven by the motor 22 through the reduction gearing 24.

On the upper end portion of the main shaft 19 is mounted a turntable 32 (Figures 3 and 4), which comprises a circular supporting frame 33, a plurality of supporting arms 34 and a disc 35. The frame 33 is formed with a hub 36 which is fitted on the upper end portion of the main shaft 19 and is welded to the upper edge of said shaft at 37. The supporting arms 34 are secured at their inner ends by bolts 38 to a depending rim 39 on the outer edge of the supporting frame 33. The disc 35 rests and is supported upon the supporting frame 33 and supporting arms 34, and is secured to said frame in the manner hereinafter described. On the turntable 32 is mounted a lap 40, which comprises an annular slab of marble and rests centrally upon the turntable disc 35. The upper surface 41 of said lap is slightly convex and inclines transversely slightly downwardly to its outer upper edge as shown in Figure 9 of the drawings on an exaggerated scale. A band 42 is fitted tightly on the periphery of the turntable disc 35, extending above and below said disc, and in the upper portion of said band are adjustably threaded a plurality of set-screws 43 which are spaced around said band and engage the outer side of the lap 40 for centering said lap on the turntable 32. In the upper end of the main shaft 19 is formed a threaded socket 44 in which is screw seated the lower threaded end 45 of an auxiliary upper shaft 46, which shaft extends through a central opening 47 in the turntable disc 35, the portion 48 of said upper shaft which extends through said opening being slightly reduced, forming an annular shoulder 49 at the upper end of said reduced portion, which shoulder engages the upper face of the turntable disc 35 for clamping said disc tightly against the upper end of the main shaft 19 when the lower threaded end 45 of the upper shaft 46 is screwed home in the threaded socket 44 in the upper end of said main shaft. On the upper shaft 46 immediately above the turntable disc 35 is fitted a hub 50, which is keyed to said shaft by a key 51, said key being secured in said shaft by a set screw 52 in said hub. The hub 50 is formed with an external base flange 53 and an external upper flange 54, said base flange being formed on its lower side and at its outer edge with a depending annular embossment 55, which rests upon the upper surface of the turntable disc 35 and is secured thereto by bolts 56, which extend downwardly through said disc and into the upper wall 57 of the turntable supporting frame 33, in threaded engagement therewith, said bolts clamping the disc 35 between the hub flange 53 and the supporting frame wall 57 and securing said disc firmly to said wall 57. A ring 58 surrounds the base flange 53 of the hub 50 and is secured to the upper side of the disc 35 by bolts 59, there being a plurality of set screws 60 seated in said ring in spaced relation around said ring for engaging the inner side of the lap 40, which set screws coact with the set screws 43, engaging the outer side of said lap, for centering said lap on the turntable 32. The turntable hub 36 is formed with an external flange 61 near its lower end, which flange extends over the ball bearing 20 and is formed at its outer edge with a depending annular rim flange 62 which extends into an annular dust groove 63 in the upper side of the external flange 9 on the upper end of the hub 6 of the supporting frame 1, there being a dust packing 64 in the groove 63 engaged by said rim flange 62 forming a dust seal to prevent dust entering the upper side of the ball bearing 20. The lower end 65 of the hub 36 of the turntable frame 33 rests upon the inner ring 66 of the ball bearing 20, upon which ring also rests an annular shoulder 67 formed on the main shaft 19. An adjusting ring 68 is secured on the main shaft 19, below the ball bearing 20, within the hub 6 of the supporting frame 1, by a screw 69, and in said adjusting ring is seated an adjusting screw 70, the upper end of which engages the lower side of the ring 66 of the ball bearing 20. A dust cap ring 71, surrounding the rim flange 62, is secured to said flange and extends downwardly at a slight angle over the outer portion of the dust groove 63, and the outer edge of the flange 9 of the hub 6 of the supporting frame 1, for shielding said dust groove from dust, grit and dirt.

On the upper side of the upper flange 54 of the hub 50 rests a bearing disc 72 formed with a depending peripheral rim flange 73 which fits over the peripheral edge of said hub flange 54, said disc 72 being formed with a central opening 74 through which extends the auxiliary upper shaft 46. A plurality of superimposed adjusting discs 75 are supported upon the bearing disc 72 and are provided with central openings 76 through which the auxiliary upper shaft 46 extends, certain of said discs being of different thicknesses and the thinnest of said discs being at the top of the stack of said discs. Upon the top of the stack of discs 75 is mounted a circular crown block 77 which is provided with a circular opening 78 through which extends the auxiliary upper shaft 46, and is formed with a concentric circular recess 79 in its lower side which receives the upper end of the stack of discs 75. Upon the crown block 77 is mounted a spider 80 comprising a hub 81 and a plurality of radial arms 82, preferably five, extending from said hub. The spider hub 81 rests upon the upper side of the crown block 77 and is bolted to said block by bolts 83, said hub being provided with a central opening 84 through which extends the auxiliary upper shaft 46. On the upper end of the auxiliary shaft 46 is secured a sprocket 85 by means of a set screw 86 threaded in the hub 87 of said sprocket and engaging said shaft. The outer end of each spider arm 82 is bifurcated at 88, forming a pair of extension arm members 89 and 90, the arm member 90 being spaced above the arm member 89. Each spider arm 82 is also formed at the inner end of lower arm member 89 with a depending embossment 91, to the lower side of which is secured, by bolts 92 and nuts 93, the inner end of a fork 94, formed with a pair of horizontally-spaced outwardly-extending fork arms 95, said embossment 91 offsetting and spacing said fork below the lower spider arm member 89.

On the fork 94 of each spider arm 82 a work holder 96 is rotatably suspended by means of a suspension bearing 97. The work holder 96 comprises a work-holding disc 98, formed with a central upstanding hub 99. The bore 101 of the hub 99 is enlarged at its lower end at 102, and at its upper end at 103, forming an annular shoulder 104 at the upper end of said lower bore enlargement and an annular shoulder 105 at the lower end of said upper bore enlargement. The work holding disc 98 is formed with a plurality of work-holder openings 106 to receive a plurality of work holding members 107 respectively, each of which

work holders being in the form of a ring loosely fitted in one of said openings 106 and formed at its upper edge with an external annular flange 108 which rests upon the upper surface of the work-holding disc 98, around said opening, and suspends the work holder on said disc in said opening, as illustrated in Figure 4 of the drawings. A plurality of screws 109 are threaded in the upper side of the work-holding disc 98 in such position that the heads of certain of said screws may respectively engage the flanges 108 of two work holding members 107, while the heads of the other screws may respectively engage the flanges 108 of three of said work holders, to prevent the work holders from moving upwardly out of the openings 106 of the work-holding disc 98, said screws being so adjusted as to provide a little play between their heads and the flanges 108 of the work-holding members 107 so that said work-holding members may rotate freely in the openings 106 of the work-holding discs 98. The suspension bearing 97 comprises a bearing disc 110 and a stud 111 depending centrally from said disc into the bore 101 of the hub 99 of the work holder 96, said stud being enlarged for a short length from said bearing disc as at 112 to fit in the enlarged upper end 103 of said hub bore with the lower end of said stud enlargement or hub 112 engaging the shoulder 105 in the upper end of the hub bore, whereby the bearing disc 110 is spaced a predetermined distance above the bearing disc 100 of the work holder 96, so that the fork arms 95 may be extended between said bearing discs with the upper disc 110 under the lower spider arm member 89, and the enlarged upper portion portion or hub 112 of the stud 111 inserted between said fork arms against the inner end 113 thereof, with a turning fit between the discs 100 and 110 and the lower and upper sides respectively of said fork arms, and with a turning fit of said stud enlargement 112 between said fork arms 95 and against the crotch 113 of the fork 94, as shown in Figure 4 of the drawings. A set screw 114 extends through a disc 115 in the lower enlarged portion 102 of the hub bore 101 and is threaded in the lower end of the stud 111 of the suspension bearing 97, so that upon turning said set screw, the head thereof engages the lower side of said disc 115 and holds the upper side thereof against the hub shoulder 104, while the engagement of the set screw 114 with the stud 111 draws said suspension bearing downwardly with relation to the work holder 96, the stud 111 and its enlarged upper portion 112 being drawn downwardly respectively in the hub bore 101 and its upper enlarged portion 103 until the bearing disc 110 is drawn close enough to the bearing disc 100 so that said discs will be brought against the upper and lower sides respectively of the fork arms 95 to the proper turning fit of said discs, respectively, against said sides of said fork arms. When the bearing discs 110 and 100 are adjusted to proper fitting relation to the upper and lower sides of the fork arms 95 as aforesaid, said discs are fixed in such adjusted relation by a pin 116 driven through the hub 99 of the work holder 96 and the stud 111 of the suspension bearing 97.

In the spider arm extension members 89 and 90 is journaled a sprocket hub 117 with which the work holder 96 is axially aligned when the upper enlarged portion 112 of the suspension bearing stud 111 is in engagement with the crotch 113 of the fork arms 95, said sprocket hub being formed with a peripheral groove 118 into which extends a set screw 119 threaded in the outer end of the extension member 90, whereby said hub is maintained against vertical displacement in said spider arm extension members 89 and 90. On said sprocket hub 117 between said spider arm extension members 89 and 90 is fitted a sprocket 120, which turnably rests upon a washer 121 surrounding said hub and resting upon the upper side of the spider arm extension member 89, said sprocket being formed with a slot 122 extending from its hub opening to receive the outer end of a set screw 123 seated in said hub 117, whereby the sprocket 120 is keyed on said hub. On the upper end of the hub 117, above the spider arm extension member 90, is fitted a sprocket 124 which is detachably secured on said hub by set screws 125, each of which is threaded partly in the periphery of said hub and partly in the edge of the hub opening in said sprocket, said sprocket turnably resting upon the upper side of said spider arm extension member 90. The suspension bearing 97 is clutched to the sprocket hub 117 by a clutch 126, which comprises a male member 127, upstanding from the bottom of a recess 128 in the upper side of the bearing disc 110, and a female member 129 in the lower end of a slidable stud 130 splined in the sprocket hub 117 by a spline 131, which is adjustably secured in said hub by the set screws 123. Said clutch stud 130 extends upwardly from above the upper end of the hub 117 and a disc handle 132 of larger diameter than said hub is secured on the upper end of said stud by a screw 133, by means of which handle the clutch stud 130 may be lowered or raised in the hub 117 to engage or disengage the clutch 126. The clutch 126 may be locked in engaged or disengaged position by a ball spring lock 134, mounted in the sprocket hub 117, to engage a notch 135 in the stud 130, to lock said stud in its lowered position with the clutch members 127 and 129 engaged, as shown in Figure 4, and to engage a notch 136 in said stud to lock a stud in its raised position with the clutch members 127 and 129, disengaged. A chain 137 extends over the sprockets 85 and 124, whereby the work holder 96 which is suspended on the spider arm 82 on which the sprocket 124 is journaled, is rotated from the main shaft 19 and auxiliary shaft 46 through the medium of the hub 117, clutch 126, and suspension bearing 97. A chain 138 extends over the sprockets 120 on each of the spider arms 82, whereby the work holders 96 on all of the spider arms 82, except the arm on which the sprocket 124 is journaled, are rotated by the sprocket 120, journaled on said arm. All of the sprockets 120 are of different diameters and consequently are caused by the chains 138 to rotate at different speeds and to rotate the work holders 96 at correspondingly different speeds.

The spider 80, work holders 96, crown block 77, adjusting discs 75 and bearing disc 54 are held against rotation with the auxiliary upper shaft 46, by means of a stop 140, which includes a bracket 141 pivoted at its lower end by a pivot 142 between and to a pair of vertical guides 143 secured to the outside of the vertical wall 17 of the pan 12, which bracket is bent inwardly at its upper end at right angles into an arm 144 which is extended between the arms 95 of one of the spider arm forks 94. A thumb screw 145 extends through the bracket 141 above its pivot 142 and is threaded in the side wall 17 of pan 12, so that the head of said set screw may be brought against said bracket to hold it against said wall 17 and the bracket arm 144 in engagement with the

fork 94 between its arms 95, as illustrated in Figures 1 and 2.

Grit and oil are supplied to the upper grinding surface 41 of the lap 40 at a suitable point between the outer and inner edges of said surface by a pipe 146, which pipe is controlled by a valve 147. Clear oil is supplied to the grinding surface 41 of the lap by a pipe 148 through a plurality of valve-controlled spouts or cocks 149 depending therefrom. Grit and oil are removed from the grinding surface 41 of the lap by a scraper 150 located rearwardly of the grit pipe 146. Clear oil is supplied to the grinding surface 41 of the lap by a pipe 151 through two depending branches 152 and 153 thereof at the rear of the scraper 150, said branches being controlled by valves 154 and 155, respectively.

The oil pipe 148 is formed in a plurality of sections 156, 157, 158 and 159. The section 156 extends downwardly from a source of oil supply (not shown) to the outer end of the section 157, which extends inwardly horizontally across and above the lap 40. The section 158 extends outwardly horizontally across and above the lap 40, parallel to the section 157 and is spaced forwardly of said section 157. The section 159 extends downwardly from the outer end of the section 158 into the annular pan receptacle 16. The lower end of the section 156 is connected to the outer end of the section 157 by an elbow 160. The inner end of the section 157 is connected to the inner end of the section 158 by elbows 161. The outer end of the section 158 is connected to the upper end of the section 159 by an elbow 162. The oil pipe 148 is suspended by clips 163 and 164 from a horizontal suspension rod 165, which is seated at its inner end in a bore 166 (Figure 4) in the crown block 77 and is secured in said block at its inner end by a pin 167. The clip 163 is positioned on the suspension rod 165 near the crown block 77 while the clip 164 is positioned on the said rod near the outer end thereof. Each of the clips 163 and 164 comprises a piece of strap metal bent in the form of an intermediate loop 168, which straddles the suspension rod 165 and bent at its ends, below said loop, outwardly and upwardly in the form of upturned hooks 169 and 170 in which rest the sections 157 and 158, respectively, of the oil pipe 148.

The scraper 150 comprises an angle bar 171, a pair of scraper blades 172 and 173, and a plurality of weights 174. The blades 172 and 173 are adjustably secured to the forward and rear sides, respectively, of the angle bar 171, by screws 175 and 176, respectively, which screws are threaded in said blades, respectively, and extend through lateral slots 177 and 178, respectively, in said forward and rear sides of said angle bar, with the heads, respectively, of said screws engaging said forward and rear sides, said blades being positioned and adjusted by said screws, respectively, so that their outer edges 179 and 180, respectively, extend below the edges of said forward side and said rear side of said angle bar and rest upon the upper grinding surface 41 of the lap 40. The weights 174 are detachably positioned on the forward side of the angle bar 171 by means of pins 181 upstanding from said forward side which are received in bores 182 in said weights. The pins 181 are spaced longitudinally along the forward side of the angle bar 171 and weights 174 may be positioned on all or any of said pins to hold the edges 179 and 180 of the blades 172 and 173, respectively, in perfect contact with the upper grinding surface 41 of the lap 40. The scraper 150 is maintained in operative position on the lap by means of guide pins 183 and 184, the lower ends of which extend through holes 185 and 186 in the inner and outer ends, respectively, of the forward weighted side of the scraper bar 171, said guide pins being secured at their upper ends in guide bars 187 and 188 by nuts 189 and 190, which guide bars are clamped upon the sections 157 and 158 of the oil pipe 148 by clamps 191, each of which clamps comprises a clamp member 192, a bolt 193 extending downwardly through one of said guide bars and said clamp member, and a nut 194 on the lower end of said bolt engaging the lower side of said clamp member and drawing said clamp member against the lower side of said pipe sections (see Figure 5).

The work holders 96 with the work, such as flat valve members 195, positioned in the work-holding members 107, are loaded successively on the machine from an elongated loading table 196, which is positioned at the right side of the machine, as shown in Figures 1 and 2 of the drawings, the top 197 of which table being level with the upper surface 41 of the lap 40 and formed with an extension 198 at its inner end, extending into a rabbet 199 in the upper edge of said lap, the inner end edge 200 of said extension being curved to conform to the curvature of the inner peripheral side 201 of said rabbet.

The work holders 96, with the finished work 195 in their work-holding members 107, are successively unloaded from the machine onto an unloading table 202 which is positioned at the left side of the machine, as shown in Figures 1 and 2 of the drawings, the top 203 of which table being level with the upper surface 41 of the lap 40 and formed at its inner side with an extension 204 which extends into the rabbet 199 in the upper edge of said lap, the inner edge 205 of said extension being curved to conform to the curvature of the inner peripheral side 201 of said rabbet. The top 203 is formed with upturned flanges 206 along three of its edges, leaving its inner edge open so that each work holder 96 may be slid off a spider arm fork 94 upon the top extension 204 and onto the top 203, said flanges preventing the work holder from sliding off said top.

The unloading table 202 is mounted on castors 207, so that said table may be moved away from the machine with a work holder 96 thereon to deliver said work holder, after removing the finished work 107 therefrom, onto the top 197 of the loading table 196 to receive other work and to be again loaded onto the machine for surfacing said work, as will be hereinafter more fully described.

The lap 40' shown in Figure 11 has a concaved grinding surface 41' for grinding surfaces on the work of different contour from that shown in Figure 10.

The operation, uses and advantages of my invention are as follows:

Assuming the work holders 96 to be mounted on the spider arm forks 94, as illustrated in Figures 1, 2 and 4 of the drawings, with flat valve members 195 positioned in the work holding members 107 of said work holders, and the flat bearing surfaces 195' of said valve members resting upon the upper grinding surface 41 of the lap 40, as illustrated in Figures 4 and 8 of the drawings, upon closing the motor switch and running the motor 22, the main shaft 19, turntable 32, auxiliary shaft 46, bearing hub 50, and sprocket 85 are rotated clockwise through the medium of the motor shaft 23, reduction gear

24, and its driven shaft 25, sprockets 26 and 27, chains 30 and 31 and sprockets 28 and 29, whereupon one of the work holders 96, as shown in Figure 4, is rotated clockwise from the sprocket 85 through the medium of chain 137, sprocket 124, the sprocket hub 117 on which said sprocket is secured, and the clutch 126 and suspension bearing 97 for said work holder, while the other work holders 96 are rotated clockwise from the sprocket 120 on said hub through the medium of chain 138 and the sprockets 120, hubs 117, clutches 126 and suspension bearings 97 of said other work holders, during which operation the spider 80, crown block 77, adjusting discs 75 and bearing disc 72 are held stationary or against rotation by the stop 140 with its arm 144 engaging the work arms 95 of one of the spider arm forks 94, the lower bearing surface 72' of the bearing disc 72 resting upon the rotating upper bearing surface 54' of the rotating upper hub bearing disc 54. Rotation of the lap and the work holders moves the flat surfaces 195' of the valve members 195 in the work holders over the lap grinding surface 41. While the above described movements are described as clockwise, they could be counter clockwise, or any combination of clockwise and counter-clockwise movements. Grit and oil are applied to the upper grinding surface 41 of the lap 40, at a point nearer the inner than the outer edge of the lap and forwardly of the scraper 150, by the pipe 146, upon opening the valve 147, and clear oil is applied at several points to the grinding surface 41 of the lap 40 between the inner and outer edges of the lap and forwardly of the scraper 150 by the pipe 148 through the cocks 149 upon opening said cocks. The position of the scraper 150 on the grinding surface 41 of the lap 40 is such that the grit and oil supplied by pipe 146 and the clear oil supplied by pipe 148 to said grinding surface are scraped and distributed outwardly over said surface by said scraper, and the surplus scraped into the annular pan receptacle 16. After the machine is run for a suitable period of time, the valve 147 is closed and no grit and oil are supplied by the pipe 146 to the lap grinding surface 41. The cocks 149 are allowed to remain open thereafter for a short time to apply clear oil to the lap grinding surface 41 forwardly of the scraper 150, while the valves 154 and 155 are opened so that the pipe 151 through its branches 152 and 153 will supply clear oil to the lap grinding surface 41 rearwardly of the scraper 150 to enable said scraper to remove all grit from the lap grinding surface 41 and the flat surfaces 195' of the valve members 195 in the work holders 96. The cocks 149 and valves 154 and 155 are then partly closed for a short period to reduce the supply of clear oil to the lap grinding surface 41. The cocks 149 and valves 154 and 155 are then completely closed and the clear oil shut off completely from the lap grinding surface 41, and the machine is allowed to run until all oil is removed from the lap grinding surface 41 by the scraper 150 and directed by said scraper into the annular pan receptacle 16, at which time the surfaces 195' of the valve members 195 are completely ground and surfaced by the grinding surface 41 of the lap 40, whereupon the motor switch is opened and the machine stops running.

The set screw 145 of the stop 140 is then turned to move outwardly and release the stop, and the stop is swung outwardly on its pivot 142 until its arm 144 is removed from between the fork arms 95 of one of the spider arm forks 94. The spider 80, together with crown block 77, adjusting discs 75 and bearing disc 72 are turned by hand on the auxiliary shaft 46, until one of the work holders 96 is opposite the table 202. The clutch 126 of said work holder is then disengaged by pulling up the clutch stud 130, until the ball lock 134 engages the notch 136 in said stud and locks said stud in its elevated position and the clutch in its disengaged or inoperative position. Said work holder is then removed from its supporting fork 94 of the spider 80 onto the top 203 of the table 202, the bearing disc 100 and the suspension bearing 97 of said work holder sliding outwardly off the arms 95 of said fork. The finished work or valve members 195 are then removed from the work holding members 107 of said work holder 96, and the table 202 with said unloaded work holder on the table top 203 is rolled away from the left side of the machine to the stationary table 196, into position with the extension 204 of said table 203 toward the top 197 of said stationary table. The unloaded work holder 96 is then moved off the top 203 over the extension 204 of the table 202 onto the top 197 of the stationary table 196. The table 202 is then rolled back to its receiving position at the left side of the machine. The spider 80, together with all parts mounted thereon, is again turned by hand until the next work holder 96 is opposite the table 202, and said work holder is moved off of the spider onto said table, where the finished work is removed from said work holder, and said table is moved to the loading table 196 where said unloaded work holder is transferred from the table 202 onto said loading table along-side said first work holder to be removed from the spider and transferred to said loading table. The table 202 is then rolled back to its receiving position at the left side of the machine. The spider 80 is turned successively; the work holders 96 with the finished work 195 are removed successively from the spider onto the table 202; the finished work is removed from the work holders successively on said table; the table 202 with the unloaded work holders is moved successively to the loading table 196; and said work holders are transferred successively from said table 202 onto said loading table, until all of the work holders are removed from the spider of the machine and unloaded and transferred to said loading table. Only five work holders are shown in the drawings, but ten work holders are actually used, so that while five are in operation on the machine, five others are loaded on the table 197 ready for use. Increased production is made possible by using five movable tables 202 for respectively removing the work holders from the machine and transferring the same to the table 197 where they are allowed to remain while five other previously loaded work holders are loaded on the machine, after which the finished work is unloaded from said work holders remaining on said table.

To load the machine, the work holders 96 on the loading table are loaded with the work, such as the valve members 195 which are placed in the work-holding members 107, with their working surfaces 195' resting upon the top 197 of said loading table; the loaded work holders 96 are successively moved along the loading table over the table extension 198, and onto the spider forks 94 successively, the spider 80 being rotated intermittently by hand to bring said forks successively opposite the loading table to receive said work holders, and the hubs 112 of the suspen-

sion bearings 97 of the work holders being introduced between the arms 95 of the forks 94 successively, while the arms of said forks are introduced between the bearing discs 100 and 110 of the work holders successively, until the hubs 112 engage the crotches 113 of said forks, in which position of said hubs the work holders are clutched respectively to the sprocket hubs 117, by the clutches 126, upon pushing down the clutch studs 130 until the male clutch members 127 engage the female clutch members 129 and the ball locks 134 engage the notches 135 in said clutch studs and lock said clutches in clutching position, as shown in Figure 4 of the drawings. The stop 140 is then swung inwardly on its pivot 142 until the stop arm 144 is introduced between the arms 95 of one of the forks 94 and the stop secured in such position by the thumb screws 145, as shown in Figure 2 of the drawings.

The machine now being again loaded, upon again starting the motor 22, the machine may again be run to grind and surface the work 195, as above described.

During the grinding and surfacing of the work pieces 195, the lap 40 is rotated clockwise on its own axis, and the work holders 96 are rotated clockwise on their own axes, at different speeds from that of the lap and from each other, while contact of the work pieces with the lap causes said work pieces to rotate clockwise, and said work pieces, by their contact with the inner surface of the work-holding members 107, to rotate said members clockwise, at different speeds from that of the work holders 96 and the lap 40, all of which motions being produced simultaneouly and causing the work pieces to move over the grinding surface 41 of the lap, thus greatly diversifying the line of travel of the work pieces over the lap grinding surface 41, and causing the abrading action of the lap to be very evenly distributed over the surfaces 195' of the work pieces 195 whereby extremely accurate grinding and surfacing of the work is produced. Further variation of the path of travel of the work over the lap grinding surface 41 may be produced by unscrewing the set screw 86 from the auxiliary shaft 46, and turning the sprocket 85 to a different position on the auxiliary shaft 46, and then securing said sprocket in said position on said shaft by said set screw. Such change of position of the sprocket 85 on the auxiliary shaft 46 changes every position of the work pieces upon the lap grinding surface 41, and tends to break up the regular movements between the lap and the work holders, which causes the laps to wear evenly, and produces an even finer grinding of the surfaces 195' of the work pieces 195.

As the lap grinding surface 41 is worn down from grinding the work pieces 195 and the lower surfaces 195' of the work pieces are thereby lowered too far below the lower ends of the work-holding members 107 for their effective holding and grinding of said work pieces, the work holders 96 may be lowered closer to the lap grinding surface 41 to their most effective holding and grinding position as shown in Figure 4, by removing one or more of the adjusting discs 75 from under the crown block 77 and lowering said crown block upon the remaining uppermost adjusting disc which lowers the spider 80 and the work holders 96 a distance equal to the thickness of the removed adjusting disc or discs 75, and the wear of the lap grinding surface is thus taken up for the most effective grinding and surfacing operation of the machine.

While the work pieces generally are heavy enough to rest of their own weight upon the lap for grinding, the work pieces, such as piston rings and the like, when they are too light, may be provided with weights to hold them against the lap with sufficient pressure.

Through the combination of movements, application of grit and liquids, speeds of lap and pressure of scraper, the wearing surface of the lap can be controlled, with regard to shape and depreciation.

The tool marks are removed from the parts to be finished through the application of proper speeds, liquid, grit, and material from which the lap or grinding wheel is made.

The grit and grit marks are removed by cleaning the lap by applying certain liquids, speeds and length of operation.

The final lapping and burnishing are produced by application of proper liquids in kind and amount and speed producing the desired result, without removing the parts from the machine.

The slight convexity of the lap grinding surface 41 grinds the bearing surfaces 195' of the valve members 195 with a very slight concavity, so that when the two members 195 of a valve are assembled, with their said bearing surfaces 195' together, as shown in Figure 10 of the drawings, only the outer peripheral edges 208 of said bearing surfaces touch, while said surfaces are spaced slightly apart inwardly from said edges at distances increasing progressively to the center of said valve members, at which central point the distance between the bearing surfaces 195' of the valve members is approximately .000025 of an inch. The space 209 formed between said concaved bearing surfaces of said valve members is large enough to contain sufficient oil to lubricate said bearing surfaces indefinitely, which oil is indefinitely retained in said space by the contacting peripheral edges 208 of said bearing surfaces, which close said lubricating space entirely around the same.

I claim:

1. In a lapping machine, a rotatable lap, a suspension fork, a rotatable work holder formed with a bearing disc, a suspension bearing formed with a bearing disc and a depending stud shaft secured in said work holder with the bearing disc of said suspension bearing spaced above the bearing disc of said work holder, so that said stud shaft may be inserted between the arms of said suspension fork and said fork arms inserted between said bearing discs for rotatably suspending said work holder upon said suspension fork in position for holding the work upon said lap, and means for rotating said work holder while suspended upon said suspension fork for enabling said lap to grind and surface the work held in said work holder.

2. In a lapping machine, a rotatable lap, a supporting arm, a suspension fork mounted on said supporting arm, a rotatable work holder formed with a bearing disc, a suspension bearing formed with a bearing disc, and a depending stud shaft secured in said work holder, with the bearing discs of said suspension bearing and said work holder, respectively, spaced one above the other, so that said stud shaft may be inserted between the arms of said fork and said fork arms inserted between said bearing discs, for rotatably suspending said work holder upon said suspension fork in position for holding the work upon said lap, a hub journaled in said support-

ing arm, a clutch stud splined in said hub, a clutch constructed and arranged to be engaged upon depressing said clutch stud and to be disengaged upon lifting said clutch stud, and means for rotating said hub with said clutch engaged for rotating said work holder while suspended upon said suspension fork, for enabling said lap to grind and surface the work held in said work holder.

3. In a lapping machine as claimed in claim 2: a yielding spring lock for engaging said clutch stud to lock the clutch either engaged or disengaged.

4. In a lapping machine, a rotatable lap, a spider turnably mounted above said lap, a releasable stop for preventing rotation of said spider during rotation of said lap, a plurality of work holders detachably mounted on the arms respectively of said spider, means for rotating said work holders while mounted on said spider arms, for enabling said lap to grind and surface the work held in said work holders, said spider being turnable, when said stop is released therefrom to bring the spider arms and the work holders mounted, respectively, thereon, successively into unloading position, for removing said work holders, with the ground and surfaced work therein successively from said spider arms, to unload said work from said work holders respectively, said spider arms, with the work holders removed therefrom, being also brought successively into loading position when said spider is turned as aforesaid, for positioning said work holders, upon being loaded with the work to be ground and surfaced, onto said spider arms successively.

5. In a lapping machine, a rotatable lap, a shaft mounted to rotate with said lap, a bearing disc secured on said shaft to rotate therewith, a bearing disc turnable on said shaft and turnably resting upon said bearing disc which is secured to said shaft, a plurality of adjusting discs turnable on said shaft and supported upon said turnable bearing disc, a crown block turnable on said shaft and supported upon the uppermost of said adjusting discs, a spider turnable on said shaft and resting upon and secured to said crown block, work holders rotatably mounted on the arms respectively of said spider for holding the work upon said lap for grinding and surfacing the work, hubs journaled in said spider arms, means for clutching said hubs to said work holders respectively, a sprocket on one of said hubs, a sprocket on said shaft, a chain extending over said sprockets, other sprockets on said hubs respectively, and a chain extending over said other sprockets.

6. In a lapping machine, a rotatable lap, a shaft mounted to rotate with said lap, a bearing disc secured on said shaft to rotate therewith, a bearing disc turnable on said shaft and turnably resting upon said bearing disc which is secured to said shaft, a plurality of adjusting discs turnable on said shaft and supported upon said turnable bearing disc, a crown block turnable on said shaft and supported upon the uppermost of said adjusting discs, a spider turnable on said shaft and resting upon and secured to said crown block, work holders rotatably mounted on the arms respectively of said spider for holding the work upon said lap for grinding and surfacing the work, hubs journaled in said spider arms, means for clutching said hubs to said work holders respectively, a sprocket on one of said hubs, a sprocket turnably fitted on said shaft, means for securing said latter sprocket to said shaft in different positions to which said sprocket is turned on said shaft, a chain extending over said sprockets, other sprockets on said hubs respectively, and a chain extending over said other sprockets.

7. In a lapping machine, a rotatable lap, a shaft mounted to rotate with said lap, a bearing disc secured on said shaft to rotate therewith, a bearing disc turnable on said shaft and turnably resting upon said bearing disc which is secured to said shaft, a plurality of adjusting discs turnable on said shaft and supported upon said turnable bearing disc, a crown block turnable on said shaft and supported upon the uppermost of said adjusting discs, a spider turnable on said shaft and resting upon and secured to said crown block, work holders rotatably mounted on the arms respectively of said spider for holding the work upon said lap for grinding and surfacing the work, hubs journaled in said spider arms, means for clutching said hubs to said work holders respectively, a sprocket on one of said hubs, a sprocket on said shaft, a chain extending over said sprockets, other sprockets on said hubs respectively, and a chain extending over said other sprockets, said other sprockets being of different diameters for causing said work holders to be rotated at different speeds with relation to each other.

8. In a lapping machine, a rotatable lap, an arm and a suspension rod mounted above said lap, means for holding said arm and said suspension rod against rotation while said lap is rotated, a work holder journaled on said arm for holding the work upon said lap, means for rotating said work holder when said lap is rotated, a pipe suspended from said suspension rod above said lap for supplying grit and liquid to said lap, a scraper resting upon said lap, and means secured to said pipe for guiding said scraper on said lap for scraping said grit and liquid from said lap.

9. In a lapping machine, a rotatable lap, an arm and a suspension rod mounted above said lap, means for holding said arm and said suspension rod against rotation while said lap is rotated, a work holder journaled on said arm for holding the work upon said lap, means for rotating said work holder when said lap is rotated, a pipe suspended from said suspension rod above said lap for supplying grit and liquid to said lap, a weighted scraper resting upon said lap, means for varying the weight of said scraper, and means secured to said pipe for guiding said scraper for scraping said grit and liquid from said lap.

10. In a lapping machine, a rotatable lap, an arm mounted above said lap, means for holding said arm against rotation while said lap is rotated, a work holder journaled on said arm for holding the work upon said lap, means for rotating said work holder while said lap is rotated, a weighted scraper resting upon said lap, means for varying the weight of said scraper, and means for guiding said scraper on said lap for scraping grit and oil, supplied to said lap, from said lap.

11. In a lapping machine, a rotatable lap, a plurality of work holders mounted above said lap, work-holding members rotatably mounted in said work holders for holding and guiding the work pieces upon said lap, and means for rotating said work holders at different speeds from each other while said lap is rotated.

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