

Dec. 13, 1960

R. P. HOOK
LAPPING MACHINE

2,963,830

Filed June 4, 1958

4 Sheets-Sheet 1

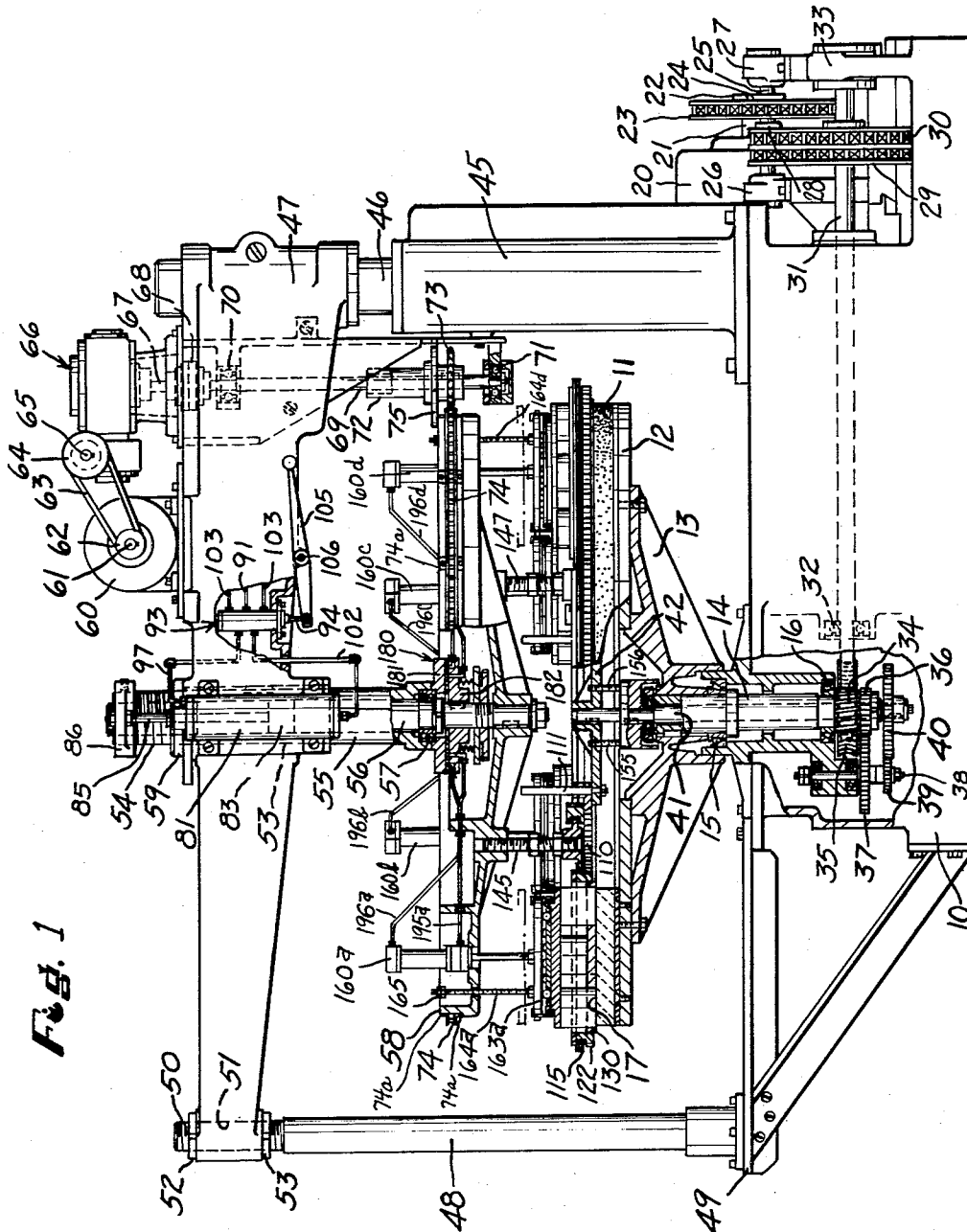


Fig. 1

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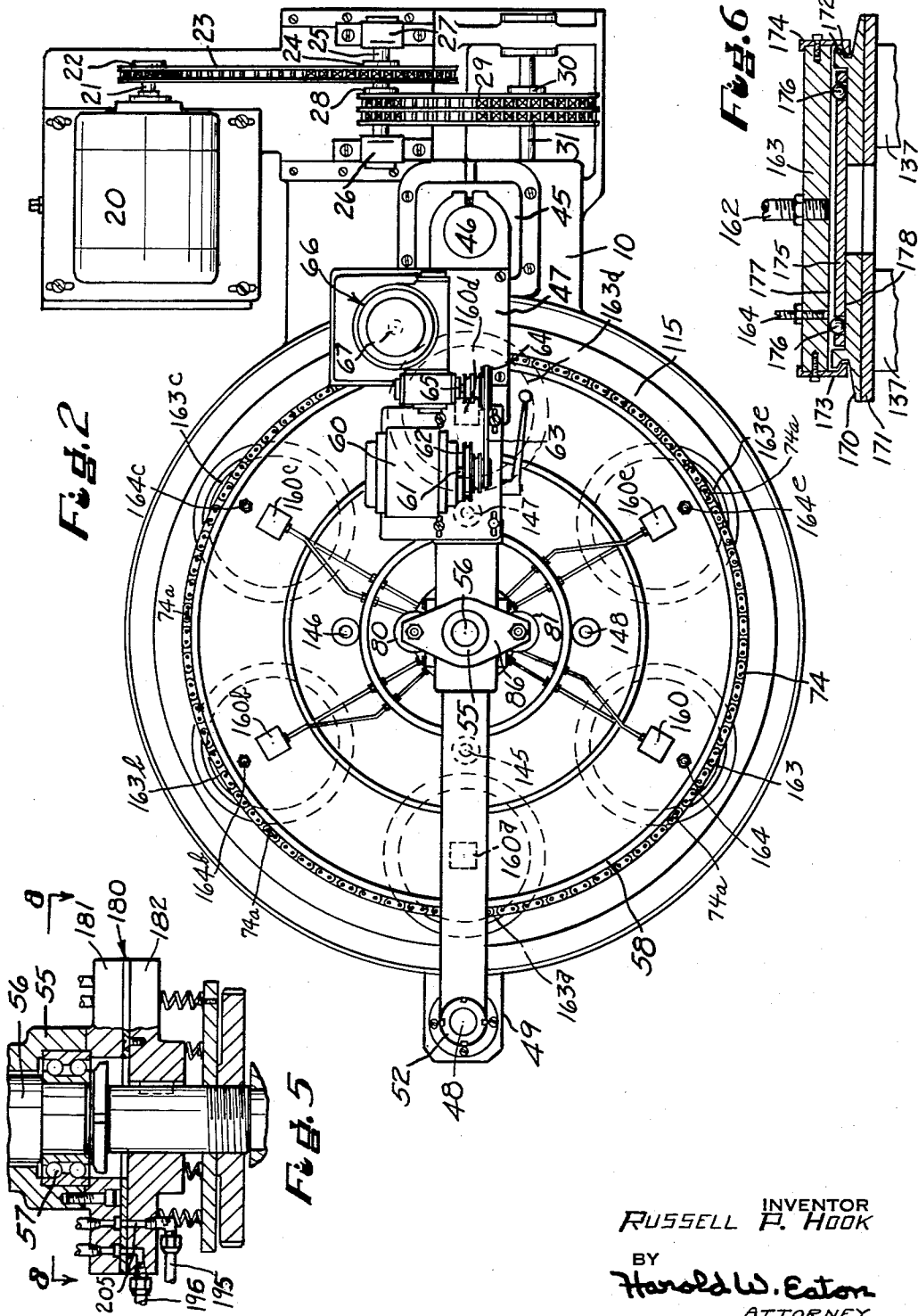
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Fig. 3

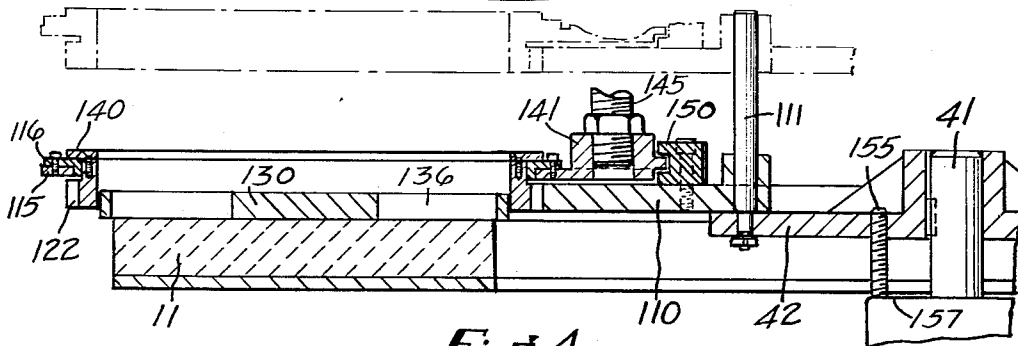
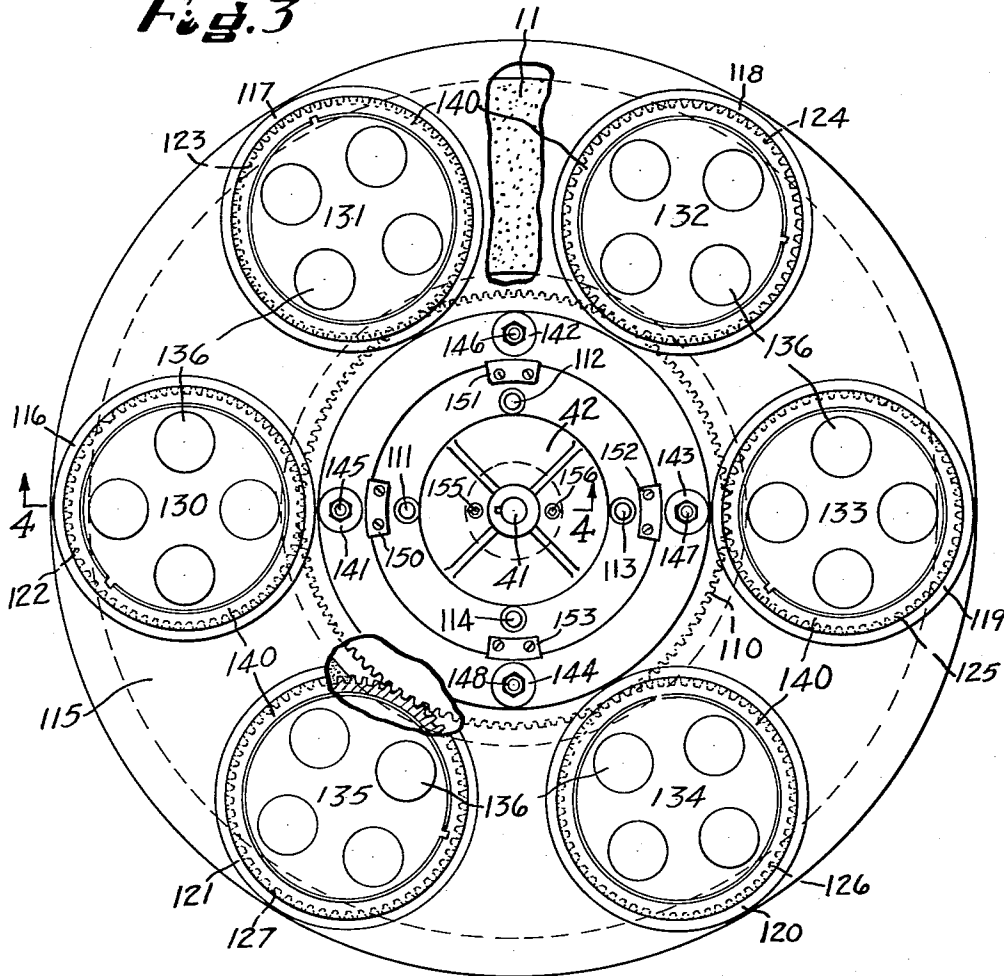


Fig. 4

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Fig. 8

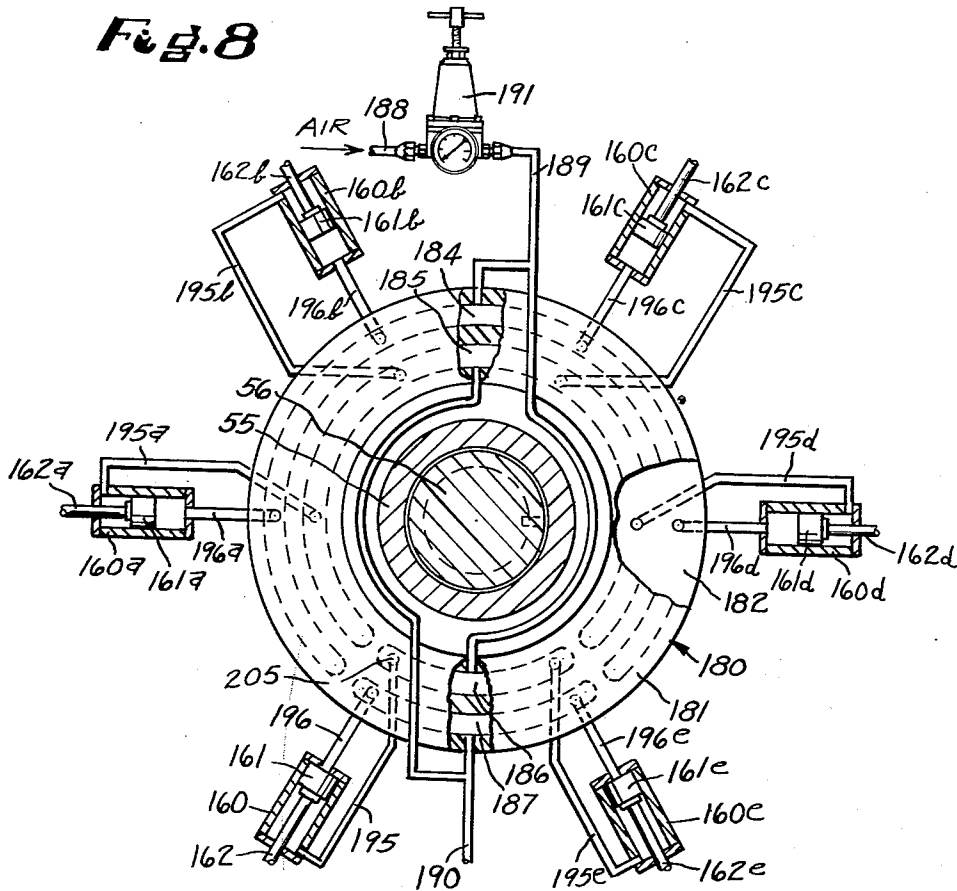
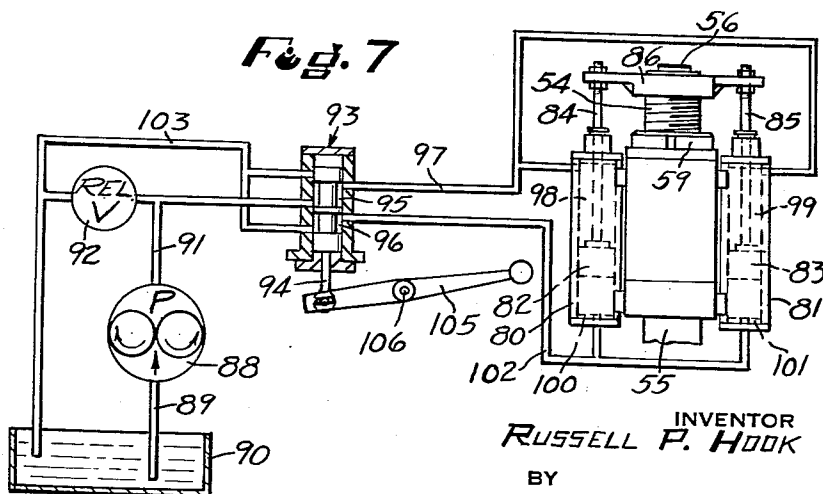


Fig. 7



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LAPPING MACHINE

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Filed June 4, 1958, Ser. No. 739,790

9 Claims. (Cl. 51—131)

The invention relates to lapping machines and more particularly to a single wheel lapping machine for simultaneously lapping a plane face on a plurality of work pieces.

One object of the invention is to provide a simple and thoroughly practical plane faced lapping machine. Another object is to provide a lapping machine for simultaneously lapping a plurality of plane-faced work pieces. Another object is to provide a lapping machine in which the work carrying cage and holders may be moved to and from an operative position without disengaging the cage and work holder driving mechanism. Another object is to provide an independent pressure actuated device for applying pressure yieldably to the work pieces carried by each of the work carrier plates. Another object is to provide a lapping machine in which both the cage and the workholders are positively driven.

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 improved lapping machine, having parts broken away and shown in section;

Fig. 2 is a plan view of a lapping machine;

Fig. 3 is a plan view, on an enlarged scale, of the work cage and driving mechanism therefor;

Fig. 4 is a fragmentary sectional view, on an enlarged scale, taken approximately on the line 4—4 of Fig. 3, through the work cage and the lapping wheel;

Fig. 5 is a fragmentary vertical sectional view, on an enlarged scale, through the rotary control valve for controlling the work pressure devices;

Fig. 6 is a vertical sectional view, on an enlarged scale, through one of the pressure plate assemblies;

Fig. 7 is a hydraulic diagram, showing the hydraulic machine for the work cage and associated parts; and

Fig. 8 is a fragmentary sectional view on an enlarged scale, taken approximately on the line 8—8 of Fig. 5, having parts of the rotary valve broken away, combined with a piping diagram showing the air pressure system for supplying a predetermined pressure to the work pieces being lapped.

A lapping machine has been illustrated in the drawings comprising a base 10 which supports a relatively large diameter plane-faced lapping wheel 11 which is in turn fixedly mounted on a plate 12. The plate 12 is fixedly mounted on a spider 13 which is keyed onto the upper end of a vertically arranged rotatable sleeve 14. The sleeve 14 is supported by anti-friction bearings 15 and 16 carried by the base 10. The lapping wheel 11 is provided with a plane operative face 17 for lapping a single plane face simultaneously on a plurality of work pieces.

A driving mechanism is provided for imparting a rotary motion to the lapping wheel 11 comprising an electric motor 20 which is adjustably mounted on a projecting portion of the base 10. The motor 20 is provided with

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a motor shaft 21 having a sprocket 22 which is connected by a link chain 23 with a sprocket 24 which is keyed onto a rotatable shaft 25. The shaft 25 is journaled in a pair of spaced bearings 26 and 27 which are fixedly mounted on the base 10. The shaft 25 is provided with a sprocket 28 which is connected by a link chain 29 with a sprocket 30 mounted on a rotatable shaft 31. The shaft 31 is journaled in suitable anti-friction bearings 32 and 33 carried by the base 10. The shaft 31 is provided with a worm 34 which meshes or engages a worm gear 35 which is fixedly mounted on the lower end of the sleeve 14.

A driving mechanism is provided for imparting a rotary motion to a plate 42 comprising a gear 36 which is fixedly mounted on the lower end of sleeve 14 (Fig. 1). The gear 36 meshes with a gear 37 which is mounted on a rotatable shaft 38. The lower end of the shaft 38 is provided with a gear 39 which meshes with a gear 40 fixedly mounted on the lower end of the rotatable shaft 41 which is rotatably supported within the sleeve 14. This latter driving mechanism is provided in case it is desired to drive the plate 42 so as to impart a rotary motion to the work holders to be hereinafter described. If desired the plate 42 together with the shaft 41 may be held stationary during the lapping operation. In case it is desired to maintain plate 42 stationary, the gears 39 and 40 may be removed from the shafts 38 and 41, respectively, so that no power is transmitted to rotate the shaft 41 and the plate 42.

The base 10 is provided with a fixedly mounted vertical column 45 which supports a vertically arranged shaft 46. The shaft 46 supports a right hand end of a cross arm 47. Due to the size of the machine, it is desirable to provide a support for the other end of the arm 47 so as to prevent deflection of the arm due to pressures applied during the lapping operation. A vertically arranged shaft or rod 48 is supported at its lower end by a bracket 49 which is fixedly mounted on the base 10 of the machine. The upper end of the shaft 48 is provided with a threaded portion 50 which passes through a clearance hole 51 formed in the left hand end of the cross arm 47. A pair of nuts 52 and 53 are threaded onto the portion 50 and serve to facilitate vertically adjusting the left hand end of the cross arm 47 and to lock the same in adjusted position.

The cross arm 47 serves as a support for a vertically movable plate 58. The plate 58 is keyed onto the lower end of a vertically arranged rotatable spindle 56 which is in turn rotatably supported within a sleeve or quill 55. The quill 55 is provided with a pair of spaced bearings 57 (only one of which has been illustrated in Fig. 1). The quill 55 is slidably keyed within a cylindrical aperture 53 formed in the cross arm 47 so that it may be moved in a vertical direction relative thereto. The plate 58 serves as a driving mechanism for a work cage to be hereinafter described and also as a support for a plurality of simultaneously arranged pressure devices for applying pressure to the work piece during a lapping operation.

A driving mechanism is provided for the plate 58 comprising a motor 60 (Figs. 1 and 2) which is mounted on the cross arm 47. The motor 60 is provided with a motor shaft 61 which is provided with a multiple step V-groove pulley 62 which is connected by a V-belt 63 with a step multiple V-groove pulley 64 mounted on a driving shaft 65 of a speed reducer unit 66. The speed reducer 66 may be any of the well known commercial speed reducer units such as for example that manufactured by the Boston Gear Works having a speed reduction ratio of 300:1. The speed reducer unit 66 is provided with a driver shaft 67 which is connected by a coupling 68 with a vertically arranged shaft 69.

The shaft 69 is supported by a pair of spaced anti-friction bearings 70 and 71 (Fig. 1). A slidably mounted sleeve 72 is supported by a flanged member 75 which is arranged to move vertically with the plate 58 as the plate is moved to and from an operative position. The sleeve 72 carries a sprocket 73 which meshes with a link chain 74. The link chain 74 surrounds and is fastened to the peripheral surface of the plate 58 by a plurality of spaced brackets 74a (Figs. 1 and 2). It will be readily apparent from the foregoing disclosure that starting of the motor 60 serves to transmit motion through the gear reducer unit 66 to rotate the shaft 69 thereby imparting a relatively slow rotary motion to the plate 58.

The upper end of the quill 55 is provided with a screw threaded portion 54 which supports a stop collar 59. The stop collar 59 serves to limit the downward movement of the quill 55 together with the shaft 56 and the plate 58.

A suitable power operated lifting mechanism is provided for raising and lowering the plate 58 together with the spindle 56 so as to separate the work cage mechanism, to be hereinafter described, from the lapping wheel 11 when it is desired to true the same. This mechanism is preferably a fluid pressure operated mechanism comprising a pair of parallelly disposed fluid pressure cylinders 80 and 81 which are arranged on diametrically opposite sides of spindle 56 and sleeve 55. The cylinders 80 and 81 are supported in fixed positions on opposite sides of the cross arm 47. The cylinders 80 and 81 contain slidably mounted pistons 82 and 83 which are connected to the lower ends of a pair of piston rods 84 and 85 respectively. The upper ends of the piston rods 84 and 85 are fixedly mounted to a flanged plate 86 carried by the threaded portion 54 of the quill or sleeve 55.

A fluid pressure system, provided for supplying fluid under pressure for the lifting mechanism, comprises a motor driven fluid pump 88 which draws fluid through a pipe 89 from a fluid reservoir 90 and forces fluid under pressure through a pipe 91. An adjustable pressure relief valve 92 is provided in the pipe line 91 (Fig. 7) to facilitate by-passing excess fluid under pressure directly to the reservoir 90 to maintain a substantially uniform operating pressure within the fluid system.

A manually operable control valve 93 is provided for controlling the admission to and exhaust of fluid from the cylinders 80 and 81. The control valve 93 is preferably a piston type valve having a valve stem 94 formed with a plurality of spaced integral valve pistons which form a pair of spaced valve chambers 95 and 96. In the position of the valve 93 (Fig. 7) fluid under pressure passing through the pipe 91 passes through the valve chamber 95 through a pipe 97 into a pair of cylinder chambers 98 and 99 formed in the upper ends of the cylinders 80 and 81 respectively. Fluid under pressure entering the cylinder chambers 98 and 99 serves to cause a downward movement of the pistons 82 and 83 respectively to move the quill 55 together with the spindle 56 and the plate 58 together with the work cage mechanism, to be hereinafter described, downwardly into an operative position. During the downward movement of the pistons 82 and 83 fluid within the cylinder chambers 100 and 101 exhausts through a pipe 102, through the valve chamber 96 and through an exhaust pipe 103 into the reservoir 90.

A manually operable mechanism is provided for actuating the control valve 93 comprising a manually operable control lever 105 which is pivotally mounted by a stud 106 on the cross arm 47. When it is desired to move the plate 58 upwardly to an inoperative position, the control lever is rocked in a clockwise direction which shifts the valve stem 94 upwardly (Fig. 7) so that fluid under pressure from the pipe 91 passes through the valve chamber 96 and through the pipe 102 into the cylinder chambers 100 and 101 to cause an upward movement of the pistons 82 and 83 so as to move the quill 55 together with the spindle 56 and the plate 58

upwardly to an inoperative position. It will be readily apparent from the foregoing disclosure that by manipulation of the control lever 105, the plate 58 may be raised or lowered as desired.

The plate 42 (Figs. 1 and 4) serves as a support for a large gear 110. The gear 110 serves in a manner to be hereinafter described to support and drive the work carriers. The gear 110 may be maintained stationary by eliminating the gears 39 and 40 in which case the rotation of the cage 115 causes the ring gear-shaped work holders to roll in mesh with the gear 110 to impart a rotary motion to the work holders during rotation of the cage 115. Or if desired the gears 39 and 40 may be utilized so as to impart a positive rotary motion to the gear 110 thereby imparting an increased rotary motion to the ring gear-shaped work holders. The plate 42 is provided with a plurality of vertically arranged studs 111, 112, 113, and 114. The studs 111, 112, 113, and 114 are fixedly mounted to the plate 42 and serve as guides during the raising and lowering of the gear 110 as will be hereinafter described. The gear 110 supports a work cage 115 which is provided with a plurality of apertures each of which is provided with a bushing 116, 117, 118, 119, 120 and 121. The bushings are fastened to the work cage 115 by screws as illustrated in Fig. 4. The bushings serve as bearing supports for a plurality of annular ring gear-shaped work holders 122, 123, 124, 125, 126 and 127 all of which mesh with the center large gear 110. A plurality of work carrier plates 130, 131, 132, 133, 134, and 135 are provided within the annular ring shaped gears 122, 123, 124, 125, 126, and 127. Each of the plates 130, 131, 132, 133, 134, and 135 are provided with a plurality of work receiving apertures 136 which in the present case have been illustrated as four in each carrier for holding work pieces 137 to be lapped in spaced relationship to each other. The work carrier plates 130, 131, 132, 133, 134 and 135 fit loosely within the central aperture of the annular ring shaped gears and are keyed thereto so that the work carrier plates are rotated with the gears during a lapping operation.

Each of the ring gears 122 is provided with an annular thrust ring 140 so as to facilitate maintaining the ring gears 122 within the bushings 116 so as to facilitate raising and lowering the ring gears 122, 123, 124, 125, 126, and 127 to and from an inoperative position when desired. Only one of these thrust rings 140 has been illustrated in Fig. 4.

The work cage 115 is provided with a plurality of upwardly extending bosses 141, 142, 143, and 144. A plurality of threaded studs 145, 146, 147 and 148 are connected at the lower ends to the bosses 141, 142, 143, and 144 respectively. The upper ends of the studs 145, 146, 147, and 148 are threaded into the driving plate 58.

A plurality of thrust blocks 150, 151, 152, and 153 are fastened to the larger center gear 110 and have grooves to receive the inner peripheral surface of the work cage 115 so that the gear 110 may be raised and lowered with the cage 115 thereby maintaining the gear 110 in mesh with the annular ring gears 122, 123, 124, 125, 126, and 127 when the cage 115 is moved vertically to and from an inoperative position.

When it is desired to raise the cage assembly for a lapping wheel truing operation, the plate 58 is raised by means of the fluid pressure operated mechanism above described. As the plate 58 moves upwardly, the studs 145, 146, 147, and 148 lift not only the work carrying cage 115 and the associated parts but also the annular ring gears 122, 123, 124, 125, 126, and 127 together with the large diameter center gear 110 without disengaging the gear connection therebetween.

The plate 42 is provided with a pair of stop screws 155 and 156 which engage a stop surface 157 formed integral with the shaft 41 to determine the operative position of the work cage 115 and the annular ring gears

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supported thereby. These stop screws 155 and 156 serve to facilitate adjusting the operative position of the work cage so that the annular ring gears 122, 123, 124, 125, 126, and 127 may be maintained in close proximity to but out of engagement with the operative face of the lapping wheel 11 as the lapping wheel wears away.

In order to obtain the desired lapping pressure of the work pieces to be lapped upon the operative face of the lapping wheel 11, a plurality of independent air or fluid pressure operated mechanisms are provided, one axially aligned with each of the annular ring gear apertures. As illustrated in the drawings these mechanisms comprise a plurality of air cylinders 160, 160a, 160b, 160c, 160d, and 160e. These cylinders are arranged with their axes aligned with the centers of the apertures in the annular ring gears 122, 123, 124, 125, 126 and 127 in the work cage 115. The cylinders 160, 160a, 160b, 160c, 160d, and 160e are each provided with a piston 161, 161a, 161b, 161c, 161d, and 161e respectively which are fastened to the upper ends of a plurality of piston rods 162, 162a, 162b, 162c, 162d, and 162e respectively. The lower ends of the piston rods are fixedly connected to a plurality of plates 163, 163a, 163b, 163c, 163d, and 163e respectively. The respective plates 163, 163a, 163b, 163c, 163d, and 163e are provided with guide rods 164, 164a, 164b, 164c, 164d, and 164e which are fastened at their lower ends to the respective plates 163, 163a, 163b, 163c, 163d, and 163e. Each of the rods 164, 164a, 164b, 164c, 164d, and 164e passes through a clearance hole formed in the plate 58. The upper ends of the rods 164, 164a, 164b, 164c, 164d, and 164e are provided with stop nuts 165 (Fig. 1). These rods 164, 164a, 164b, 164c, 164d, and 164e (Figs. 1 and 2) serve to hold the plates 163, 163a, 163b, 163c, 163d, and 163e, respectively against rotary motion as they are raised and lowered.

Each of the plates 163, 163a, 163b, 163c, 163d, and 163e serve as supports for a pressure plate 170 (Fig. 6) having a pad of resilient material 171 fixed thereto which is arranged to engage the upper surface of the work pieces 137 to maintain them in engagement with the operative face 17 of the lapping wheel 11 at the desired predetermined pressure. The plate 170 is preferably supported so that it may move in a horizontal plane relative to the plate 163 during the lapping operation. The plate 170 is provided with an annular groove 172. A plurality of spaced brackets 173 and 174 (Fig. 6) are fixedly supported on each plate 163, 163a, 163b, 163c, 163d, and 163e and have inwardly projecting lugs which ride within the groove 172. An anti-friction bearing is interposed between each of the plates 163, 163a, 163b, 163c, 163d, and 163e and the plates 170 comprising a plate 175 having a plurality of spaced balls carried thereby. The balls roll between a plane face 177 of the plates 163, 163a, 163b, 163c, 163d, and 163e and a plane face 178 of the plate 170 so as to form an anti-friction support for the plate 170 so that it is free to rotate relative to the plate 163 and also to shift laterally as the annular ring gears 122 rotate during a lapping operation. Due to the clearance between the groove 172 and the brackets 173 and 174, the plate 170 is free to float in a horizontal direction.

In order to facilitate semi-automatic operation of the machine, the plates 163, 163a, 163b, 163c, 163d, and 163e together with the associated parts are arranged so that as they approach a loading position the pistons contained within the air cylinders are raised automatically to lift the plates 163, 163a, 163b, 163c, 163d, and 163e vertically so as to facilitate removal of finish lapped work pieces and the insertion of new work pieces thereinstead.

The automatic actuation of the work engaging plates is controlled by a rotary valve 180 which is operatively connected to control the admission to and exhaust of air or fluid from the cylinders, 160, 160a, 160b, 160c, 160d, and 160e. The rotary valve 180 comprises an upper stationary valve member 181 which is fixedly mounted

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on the lower end of the quill or sleeve 53. A lower valve member 182 of the valve 180 is keyed to the spindle 56 and rotates therewith. This valve together with the associated parts of the pressure devices is substantially the same as that disclosed in the U.S. Patent No. 2,825,187 to K. L. Lindquist dated March 4, 1958, to which reference may be had for details of disclosure not contained herein.

The lower surface of the upper valve member 181 of the valve 180 is provided with a plurality of arcuate-shaped grooved valve chambers comprising a pressure chamber 184, and exhaust chamber 185, a pressure chamber 186, and an exhaust chamber 187. The pressure chamber 186 serves to control the flow of air under pressure to the cylinders as they pass through an unloading station automatically to raise the pistons 161, 161a, 161b, 161c, 161d, and 161e thereby raising the work engaging plates 163, 163a, 163b, 163c, 163d, and 163e from the work pieces 137 to facilitate removal of finish lapped pieces of work and the insertion of new pieces of work to be lapped thereinstead. The pressure chamber 184 and the exhaust chamber 185 serve to control the flow of air under pressure to the cylinders 160, 160a, 160b, 160c, 160d, and 160e so as to maintain a predetermined pressure between the work pieces 137 being lapped and the operative face of the lapping wheel 11 during the lapping cycle. Fluid under pressure, such as, air under pressure or hydraulic fluid under pressure may be utilized for actuating the pistons 161, 161a, 161b, 161c, 161d, and 161e. As illustrated in the drawings air under pressure may be supplied from any suitable source through the pipe 188 which conveys fluid under pressure through a pipe 189 to the pressure chambers 184 and 186 of the valve 180. An exhaust pipe 190 is connected to allow air or fluid to exhaust from the exhaust chambers 185 and 187. A pressure regulating valve 191 is provided to facilitate regulating air under pressure taken from the pipe 188, through the pipe 189 into the pressure chambers 184 and 186. It will be readily apparent from the foregoing disclosure that by manipulation of the pressure regulating valve 191 the pressure of work pieces 137 against the operative face 17 of the lapping wheel 11 may be readily varied if desired to obtain a predetermined lapping action.

As above described the cylinders 160, 160a, 160b, 160c, 160d, and 160e are fixedly mounted on the plate 58 which is rotated by the spindle 56. A plurality of pipes 195, 195a, 195b, 195c, 195d, and 195e are connected between the lower ends of the cylinders 160, 160a, 160b, 160c, 160d, and 160e respectively and the rotary valve 180. A plurality of pipes 196, 196a, 196b, 196c, 196d, and 196e are connected between the upper ends of the cylinders 160, 160a, 160b, 160c, 160d, and 160e respectively and the rotary valve 180. As the cylinders 160, 160a, 160b, 160c, 160d, and 160e approach the position 160 (Figs. 2 and 8), as soon as the port 205 (Fig. 5) at the end of the pipe 195 is uncovered due to rotary motion of the lower valve member 182, air or fluid is passed through the pipe 195 into the lower end of the cylinder 160 so as to raise the piston 161 thereby moving one of the plates 163, 163a, 163b, 163c, 163d, and 163e together with one of the work engaging plates 170 upwardly to an inoperative position so that the lapped work pieces 137 may be removed from the work carrier plate and replaced with new work pieces to be lapped. Fluid within the upper end of the cylinder 160 may be exhausted through the pipe 196 into the exhaust chamber 187 and out through the exhaust pipe 190.

As any one of the plates 163, 163a, 163b, 163c, 163d, or 163e approaches the position 160a (Figs. 2 and 8) during rotation of the work cage 115, the flow of fluid under pressure to the corresponding cylinder 160, 160a, 160b, 160c, 160d, or 160e is reversed so that the corresponding piston 161, 161a, 161b, 161c, 161d, or 161e moves downwardly to position one of the work engaging

plates in operative engagement with the work pieces to be lapped at the desired pressure. The work pieces remain under the desired lapping pressure until each cylinder 160, 160a, 160b, 160c, 160d, or 160e moves through the position 160e illustrated in Fig. 2 at which time the work piece has been lapped to the desired extent and the parts are raised to facilitate a loading operation. As illustrated in the drawings six cage apertures or bushings 116, 117, 118, 119, 120 and 121 are provided in the cage 115 so that while one work piece is passing between the unloading and loading stations 5 other work pieces are in the process of being lapped. The number of work pieces that may be lapped simultaneously depends upon the size and shape of the work piece which also determines the number of work apertures formed in the work carrier plates 130, 131, 132, 133, 134, and 135 and also the number of pressure devices which may be provided. In any case there is a cylinder 160 and the associated parts located directly above each of the apertures formed by each of the annular ring gears 122, 123, 124, 125, 126, and 127.

Assuming the gears 39 and 40 are removed so that the large center gear remains stationary during the lapping operation, the rotary motion of the plate 58 will be transmitted through the studs 145, 146, 147, and 148 so as to impart a rotary motion to the work cage 115. Rotation of the cage 115 will carry the annular ring gears 122, 123, 124, 125, 126, and 127 in a circular path. These annular ring gears are in mesh with the stationary gear 110 which imparts a rotary motion to the annular ring gears. During this motion, a rotary motion is imparted to the work carrier plates 130, 131, 132, 133, 134, and 135 so that the work pieces 137 move in a circular path across the operative face 17 of the lapping wheel 11 while the cage 115 carries the ring gears in a circular path thereby causing a uniform lapping action between the work pieces and the lapping wheel. This serves to cause a uniform wear of the lapping surface.

If additional motion is required, the gears 39 and 40 may be positioned as illustrated in Fig. 1 in which case a rotary motion is imparted to the large center gear 110 thereby imparting an additional controlled rotary motion of the annular ring gears 122, 123, 124, 125, 126 and 127. By regulating the speed of rotation of the plate 58, any desired lapping action may be obtained between the work pieces 137 being lapped and the operative face 17 of the lapping wheel 11.

The operation of the improved lapping machine will be readily apparent from the foregoing disclosure. Assuming all the mechanisms to have been previously adjusted, the motor 20 is started to impart a rotary motion to the lapping wheel 11. The motor 60 is started to impart a rotary motion to the plate 59 thereby imparting a corresponding rotary motion to the work cage. The fluid pump 88 is then started after which the controlled lever 105 is moved in a clockwise direction to move the valve stem 94 upwardly (Fig. 7) thereby passing fluid under pressure through the pipe 97 to cause a downward movement of the sleeve 55 and the spindle 56 together with the plate 58 and the work cage 115. The downward movement of this assembly continues until the stop surface formed on the upper portion of the cross arm 47 is reached. Air under pressure is then supplied to the pipe 183 to control actuation of the pistons 161, 161a, 161b, 161c, 161d, and 161e. Work pieces 137 are positioned in the apertures 136 formed in the work carrier plates 130, 131, 132, 133, 134, and 135 prior to the lowering of the work cage 115. As the cage 115 rotates in a counter-clockwise direction, after the ports to the cylinder 160 are cut-off from the valve chambers 186 and 187 and opened to the valve chambers 184 and 185, the passage of air under pressure to the cylinders 160, 160a, 160b, 160c, 160d, and 160e is reversed to cause a downward movement of one of the work engaging

plates into operative engagement with the work pieces 137, where it remains at a predetermined pressure during the entire lapping operation.

As successive cage apertures approach the unloading and loading positions, the same cycle of events takes place. A plurality of lapped work pieces 137 are removed from the apertures in one of the work carrying plates 130, 131, 132, 133, 134, and 135 and new pieces of work inserted thereinstead during the time the cage apertures pass from the unloading station to the loading station. The entire lapping operation of the work pieces 137 being lapped takes place while the ports for the cylinders 160 are in communication with the pressure chamber 184 and the exhaust chamber 185. The unloading operation and the loading operation take place while the ports from any of the cylinders 160, 160a, 160b, 160c, 160d, and 160e are in communication with the pressure chamber 186 and the exhaust chamber 187.

It will thus be seen that there has been provided by this invention apparatus in which the various objects hereinabove set forth together with many thoroughly practical advantages are successfully achieved. As many possible embodiments may be made of the above invention and as many changes might be made in the embodiment above set forth, it is to be understood that all matter hereinbefore set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. In a lapping machine having a base, a plane faced lapping wheel rotatably mounted upon said base, drive means operable to rotate said lapping wheel, a plate rotatably supported upon said base substantially parallel to the plane face of said lapping wheel for displacement relative to said base into and out of an operative position adjacent said lapping wheel, a work carrying cage mounted for rotation and relative displacement with said plate, a driving mechanism for rotating said plate and said cage, a plurality of spaced apertures in said cage, a plurality of ring gear-shaped work holders rotatably supported in the respective apertures in said cage for relative displacement with said cage, a central gear mounted for relative displacement with said plate and for rotation independent of said plate and operable to impart a positive rotary motion to all of said work holders during rotation of said cage, angular positioning means for said central gear rotatably mounted upon said base and arranged in continuous driving engagement with said central gear, and pressure applying means aligned with the respective work holders to maintain a predetermined lapping pressure between a plurality of work pieces and the lapping wheel, when said plate is disposed in its operative position adjacent said lapping wheel.

2. In a lapping machine, as claimed in claim 1, the combination with the parts and features therein specified of a means to move said plate and cage into and out of said operative position, means to determine the operative position of said cage and said work holders and to maintain said cage and said work holders out of engagement with the operative face of the lapping wheel, and means for maintaining the ring gear-shaped work holders in mesh with the central gear during movement of said plate and cage to and from said operative position.

3. In a lapping machine, as claimed in claim 1, the combination with the parts and features therein specified of a work carrier plate within each of said ring gear-shaped work holders, a plurality of spaced work receiving apertures in each of said plates, and driving connections between said plates and said work holders so that said plates are positively rotated and revolved relative to the operative face of the lapping wheel during rotation of said cage.

4. In a lapping machine as claimed in claim 1, the combination with the parts and features therein specified of means operable through said angular positioning

means to rotate said central gear concurrent with but independent of the rotation of said plate and said cage so as to impart a modified rotary motion to said ring gear-shaped work holders independent of said cage motion.

5 5. In a lapping machine having a base, a plane faced lapping wheel rotatably mounted upon said base, drive means operable to rotate said lapping wheel, a plate rotatably supported upon said base substantially parallel to the plane face of said lapping wheel for displacement relative to said base into and out of an operative position adjacent said lapping wheel, a work carrying cage mounted for rotation and relative displacement with said plate, a driving mechanism for rotating said plate and said cage, a plurality of spaced apertures in said cage, a plurality of ring gear-shaped work holders rotatably supported in the respective apertures in said cage for relative displacement with said cage, a central gear mounted for relative displacement with said plate and for rotation independent of rotation of said plate, said central gear being positioned in continuous meshing engagement with all of said work holders and operable to impart a positive rotary motion to all of said work holders during rotation of said cage, angular positioning means for said central gear rotatably mounted upon said base and arranged in continuous driving engagement with said central gear, and a plurality of independent pressure devices aligned with the respective work holders and slidably movable relative to said cage to maintain a predetermined lapping pressure between a plurality of work pieces and the lapping wheel, when said plate is disposed in its operative position adjacent said lapping wheel.

6. In a lapping machine, as claimed in claim 5, the combination of parts and features therein specified in which each of the slidably movable independent pressure devices is provided with a floating work engaging rotatable member having a resilient portion for engaging the work pieces, and an anti-friction support interposed between each of said pressure devices and said work engaging members so as to facilitate rotary motion of said work holders relative to said cage during a lapping operation.

7. In a lapping machine having a base, a plane faced lapping wheel mounted upon said base for rotation about a vertical axis, a first driving mechanism operable to rotate said lapping wheel, a plate supported upon said base for vertical movement relative to said base and rotatable about a vertical axis, a rotatable work carrying cage mounted for rotation and vertical movement with said plate and having its axis of rotation aligned with the axis of rotation of said lapping wheel, a second driving mechanism for rotating said plate and said cage, a plurality of spaced apertures in said cage, a plurality of ring gear-shaped work holders rotatably supported in the respective apertures in said cage for movement vertically with said cage, a central gear maintained in continuous meshing engagement with all of said work holders for vertical movement therewith and operable to impart a positive rotary motion to all of said work holders during rotation of said cage, angular positioning means for said central gear rotatably mounted upon said base and oper-

able independent of said second driving mechanism to produce modified rotation of said work holders, said positioning means being arranged in continuous driving engagement with said central gear, and a plurality of independent pressure devices aligned with the respective work holders and movable relative to said cage to maintain a predetermined lapping pressure between a plurality of work pieces and the lapping wheel.

8. In a lapping machine having a base, a plane faced lapping wheel mounted upon said base for rotation about a vertical axis, a first driving mechanism operable to rotate said lapping wheel, a plate supported upon said base for vertical movement relative to said base and rotatable about a vertical axis, a work carrying cage mounted for rotation and vertical movement with said plate and having its axis of rotation aligned with the axis of rotation of said lapping wheel, a second driving mechanism for rotating said plate and said cage, a plurality of spaced apertures in said cage, a plurality of ring gear-shaped work holders rotatably supported in the respective apertures in said cage for movement vertically with said cage, a central gear mounted for rotation independent of said cage, means for maintaining said central gear in continuous meshing engagement with all of said work holders for vertical movement therewith, and gear driving means rotatably mounted upon said base and positioned in continuous driving engagement with said central gear notwithstanding vertical movement of said central gear relative to said base, said gear driving means being operable independent of said second driving mechanism.

9. In a lapping machine having a base, a plane faced lapping wheel rotatably mounted upon said base, drive means operable to rotate said lapping wheel, a plate rotatably supported upon said base substantially parallel to the plane face of said lapping wheel for displacement relative to said base into and out of an operative position adjacent said lapping wheel, a work carrying cage mounted for rotation and relative displacement with said plate, a driving mechanism for rotating said plate and said cage, a plurality of spaced apertures in said cage, a plurality of independent pressure devices aligned with the respective apertures in said cage and slidably movable relative to said cage to maintain a predetermined lapping pressure between a plurality of work pieces and the lapping wheel, a plurality of floating work engaging members rotatably suspended from the respective pressure devices and each having a resilient portion for engaging the work pieces, and a plurality of anti-friction elements interposed between the respective pressure devices and the respective work engaging members suspended therefrom, so as to facilitate rotary motion of said work holders relative to said cage during a lapping operation.

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