March 4, 1958 K. L. LINDQUIST 2,825,187

LAPPING MACHINE

Filed July 13, 1955 3 Sheets-Sheet 1

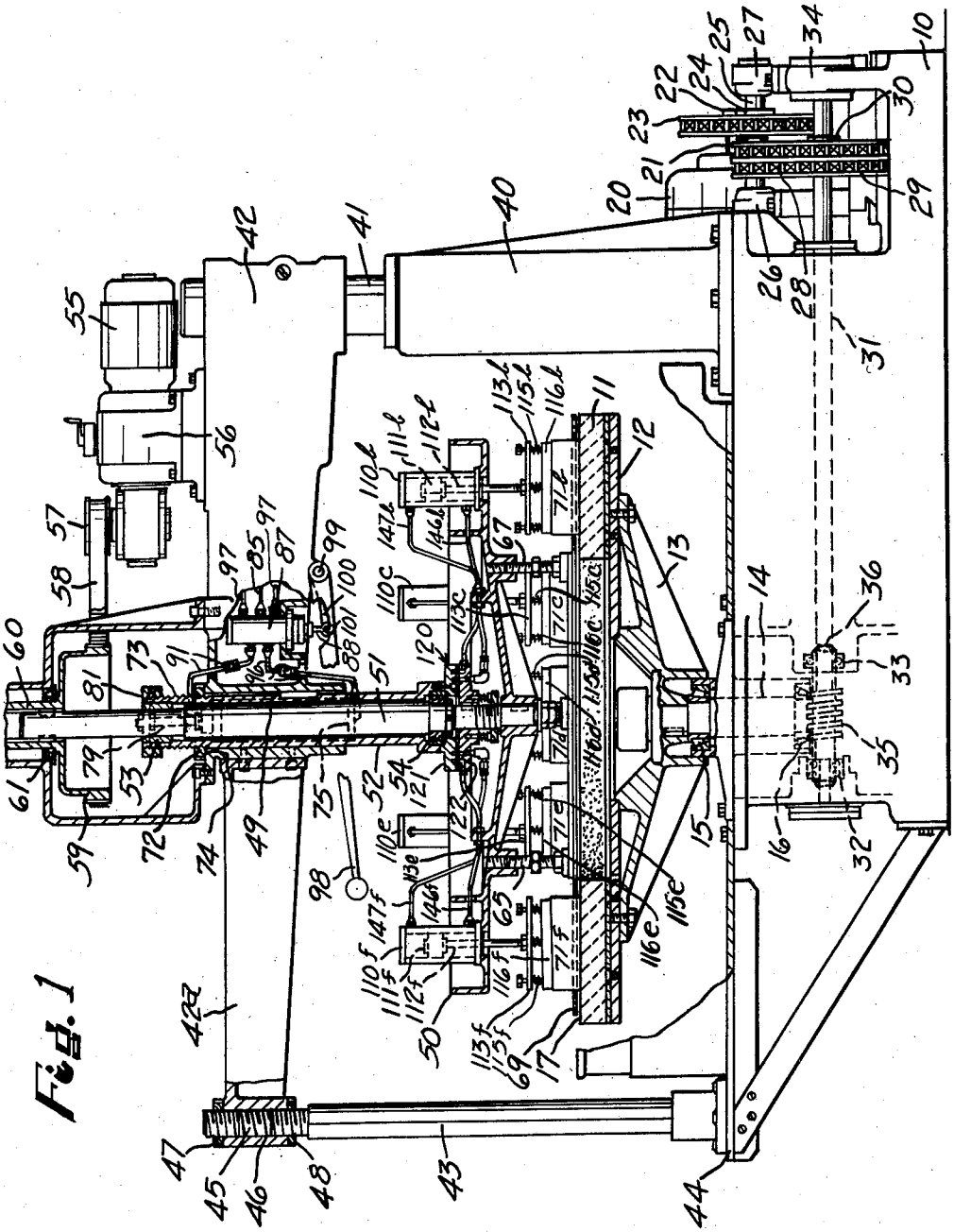


Fig. 1

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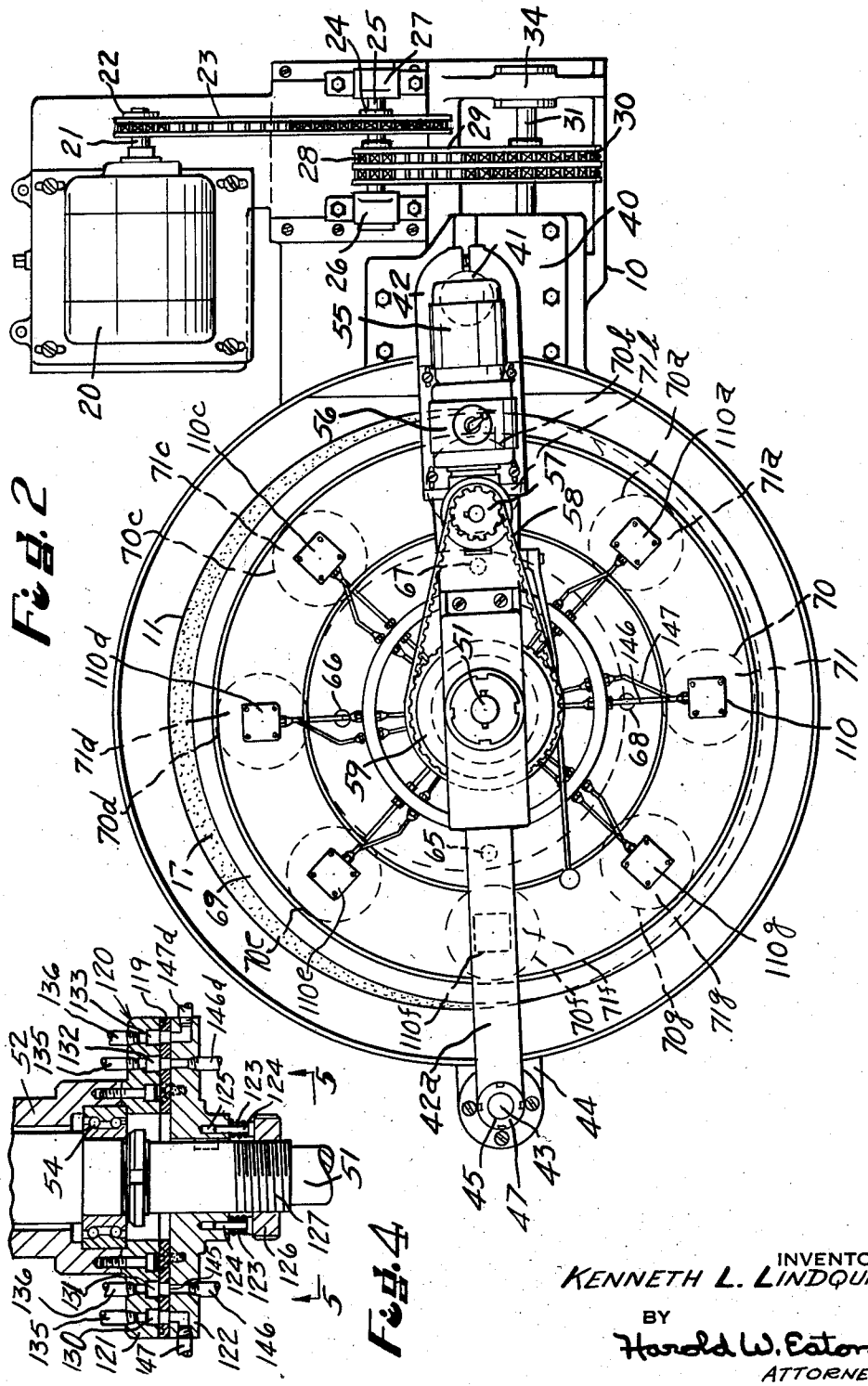


Fig. 2

Fig. 4

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Fig. 5

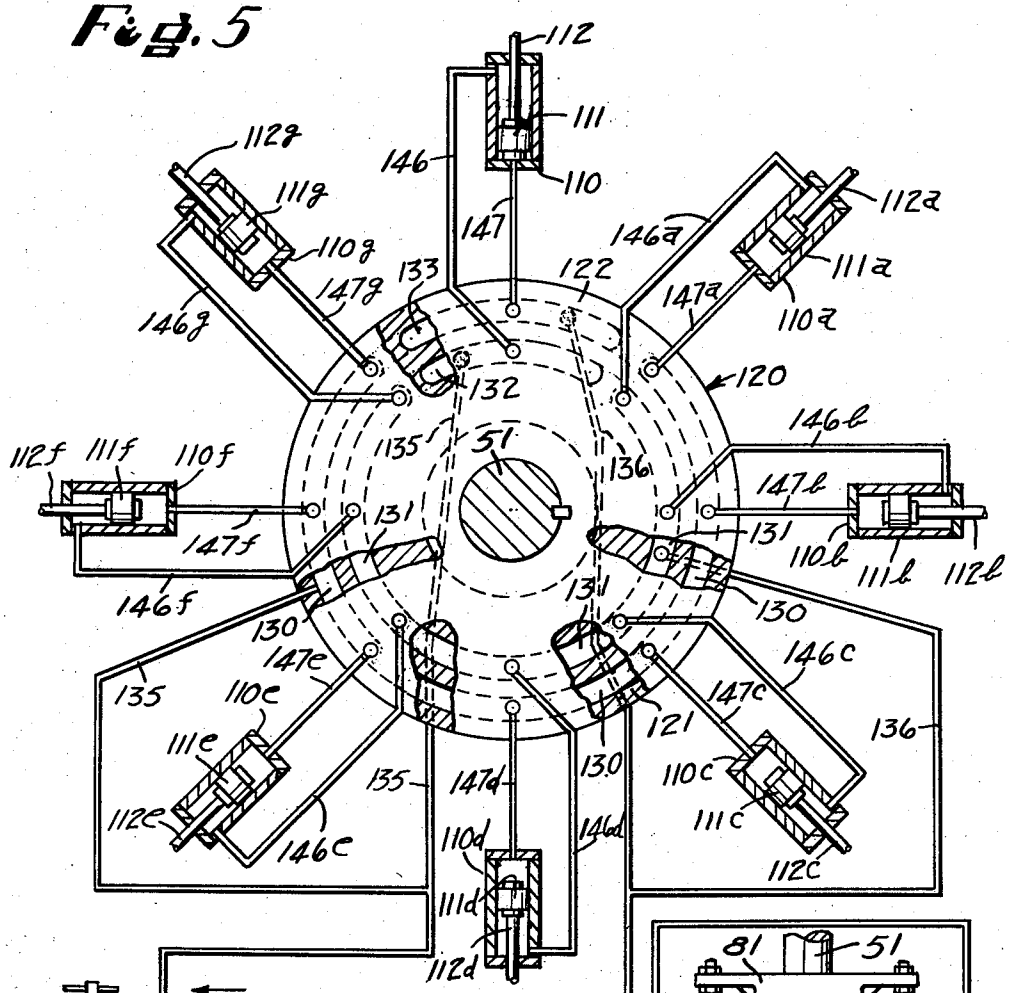
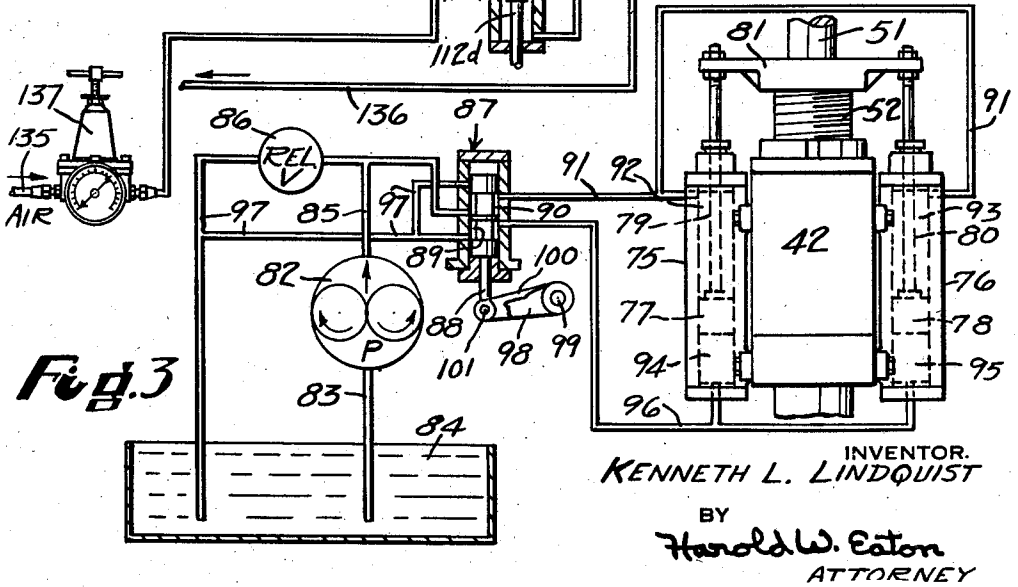


Fig. 3



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2,825,187

LAPPING MACHINE

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Application July 13, 1955, Serial No. 521,804

2 Claims. (Cl. 51—131)

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

One object of the invention is to provide a simple and thoroughly practical lapping machine. Another object is to provide a single wheel lapping machine having a plane operative faced lap for simultaneously lapping a plurality of plane-faced work pieces. Another object is to provide a lapping machine in which the work carrying cage may be separated from the lap by means of a hydraulically operated mechanism. Another object of the invention is to provide a pressure actuated mechanism for applying pressure independently to each of the work pieces to produce the desired lapping action. Another object of the invention is to provide a fluid pressure operated mechanism for supplying pressure independently to each work piece during a lapping operation which is automatically moved to an inoperative position to facilitate loading work pieces into the machine when a finish lapped work piece has moved to a loading station. 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 having parts broken away and shown in section;

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

Fig. 3 is a hydraulic diagram showing the hydraulic lift for the work cage;

Fig. 4 is a fragmentary vertical sectional view through the rotary control valve for controlling the work pressure devices; and

Fig. 5 is a fragmentary sectional view, on an enlarged scale taken approximately on the line 5—5 of Fig. 4, having parts of the rotary control valve broken away, combined with a piping diagram showing the air pressure system for supplying lapping pressure.

A lapping machine has been illustrated in the drawings comprising a base 10 which supports a relatively large diameter plane-faced lapping wheel 11. The lapping wheel 11 is mounted on a plate 12 which is in turn fixedly mounted on a spider 13. The spider 13 is keyed onto the upper end of a vertically arranged rotatable shaft 14 which is journalled in spaced bearings 15 and 16 supported by the base 10. The lapping wheel 11 is provided with a plane operative face 17 for lapping a single plane face 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 a motor shaft 21 having a sprocket 22 which is connected by a link chain 23 with a sprocket 24. The sprocket 24 is fixedly mounted on a rotatable shaft 25 which is journalled in separate bearings 26 and 27 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 journalled in a plurality of spaced bearings 32, 33 and 34 which are fixedly mounted relative to the base 10. The shaft 31 is provided with a worm 35 which meshes with a worm gear 36 which is fixedly mounted on the lower end of the vertical shaft 14. The reduction drive mechanism above described serves to impart a relatively slow rotary motion to the lapping wheel 11, such as, for example 60 to 70 R. P. M. It will be readily apparent from the foregoing disclosure that when the motor 20 is started, a rotary motion will be transmitted through the mechanism above described to impart a rotary motion to the lapping wheel 11.

The base 10 is provided with a fixedly mounted vertical column 40 which supports a vertically arranged shaft 41. The shaft 41 supports the right hand end of a cross arm 42. Due to the size of the machine, it is desirable to provide a support for the outer end of the arm 42 by means of an extension 42*a* to prevent deflection thereof during a lapping operation. The right hand end of the arm extension 42*a* is fixedly mounted on the left hand end of the arm 42. A vertically arranged shaft or rod 43 is supported at its lower end by a bracket 44 fixedly mounted on the base 10. The upper end of the shaft 41 is provided with a threaded portion 45 which passes through a clearance hole 46 at the cross arm extension 42*a*. A pair of nuts 47 and 48 are threaded onto the portion 45 and serve to vertically adjust the left hand end of the cross arm extension 42*a* and to lock the same in adjusted position.

The cross arm 42 serves as a support for a vertically movable plate 50. The plate 50 is keyed onto the lower end of a vertically arranged spindle 51 which is in turn rotatably supported within a sleeve or quill 52. The quill 52 is provided with a pair of spaced bearings 53 and 54 for rotatably supporting the spindle 51. The quill 52 is slidably keyed within a cylindrical aperture 49 formed in the cross arm 42 so that it may be moved in a vertical direction relative thereto. The plate 50 serves as a driving mechanism for a work cage to be hereinafter described and also as a support for pressure devices for applying pressure to the work piece during a lapping operation.

A driving mechanism is provided for the plate 50 comprising a motor 55 which is formed as an integral part of a variable speed driving unit 56, such as for example, a Graham integral motor variable speed transmission. The variable speed unit drives a pulley 57 which is serrated on its periphery to drive a cog belt 58, such as a Gilmer timing belt. The timing belt 58 drives a pulley 59 which is formed integral with a rotatable sleeve 60. The sleeve 60 is rotatably journalled in spaced anti-friction bearings 61, only one of which has been illustrated, which are carried by the arm 42. The upper end on spindle 51 is slidably keyed within a central aperture in the sleeve 60 so that when the motor 55 is started a rotary motion will be imparted through the mechanism above described to rotate the plate 50.

A positive stop mechanism is provided to limit the downward movement of the sleeve 52, spindle 51, and plate 50 to facilitate positioning a work carrying and driving cage 69 into the desired relationship with the operative face of the lapping wheel 11. An adjustable stop collar 72 is threaded onto a threaded portion 73 on the sleeve 52. The collar 72 is arranged to engage a stop surface 74 formed integral with the arm 42 so as to limit the downward movement of the sleeve and the parts associated therewith.

The plate 50 is provided with a plurality of adjustably positioned studs 65, 66, 67 and 68 the lower ends of which are connected to the work cage 69. When the plate 50 is in a downward or operative position, the studs 65, 66, 67

and 68 may be adjusted so as to position the work cage 69 relative to the lapping wheel 11. The studs 65, 66, 67, and 68 serve also to impart a rotary motion to the work cage 69. The work cage 69 is provided with a plurality of spaced work receiving apertures 70, 70*a*, 70*b*, 70*c*, 70*d*, 70*e*, 70*f* and 70*g* for positioning work pieces 71, 71*a*, 71*b*, 71*c*, 71*d*, 71*e*, 71*f* and 71*g* to be lapped. The motor 55 and the variable speed unit 56 serve to impart a slow rotary motion to the plate 50 and the work cage 69 at speeds ranging from zero to 3 R. P. M. depending upon the lapping operation to be performed. As illustrated in the drawings eight work receiving apertures are provided. For different types and sizes of work, the number and size of cage apertures may be varied, that is, if smaller work pieces are to be lapped smaller sized apertures are required and, therefore, more apertures may be provided in the cage 69.

The axis of the spindle 51 is offset relative to the axis of the spindle 14 (Fig. 2) so that as the work pieces are revolved on the operative face 17 of the lapping wheel 11, they travel from the outer periphery of the lapping surface to the inner surface and then again to the outer surface thereby equalizing the lapping action and producing an even wearing of the lapping wheel due to the lapping operation.

It is desirable to provide a suitable power operated lifting mechanism to raise and lower the plate 50 together with the spindle 51 and the work cage 69 to and from an operative position. This mechanism is preferably a fluid pressure operated mechanism comprising a pair of diametrically opposed fluid pressure cylinders 75 and 76 which are arranged on diametrically opposite sides of the spindle 51 so as to equalize the pressure exerted upon the plate 50. The cylinders 75 and 76 are supported in fixed position relative to the cross arm 42. The cylinders 75 and 76 contain slidably mounted pistons 77 and 78 which are connected to the lower ends of a pair of piston rods 79 and 80 respectively. The upper ends of the piston rods 79 and 80 are fixedly connected to a flange plate 81 carried by the upper end of the sleeve or quill 52.

A fluid pressure system is provided for supplying fluid under pressure for the lift mechanism comprising a motor driven fluid pump 82 which draws fluid through a pipe 83 from a fluid reservoir 84 and forces fluid under pressure through a pipe 85. An adjustable pressure relief valve 86 is provided in the pipe line 85 to facilitate passing excess fluid under pressure directly to the reservoir 84. By adjustment of the relief valve 86, the desired operating pressure may be maintained within the fluid system.

A manually operable control valve 87 is provided for controlling the admission to and exhaust of fluid from the cylinders 75 and 76. The control valve 87 is preferably a piston type valve having a valve stem 88 formed with a plurality of spaced integral valve pistons which form a pair of spaced valve chambers 89 and 90.

In the position of the valve 87 (Fig. 3) fluid under pressure passing through the pipe 85 passes through a valve chamber 90, through a pipe 91 into a pair of cylinder chambers 92 and 93 formed in the upper ends of cylinders 75 and 76 respectively. Fluid under pressure entering the valve chambers 92 and 93 serves to cause a downward movement of the pistons 77 and 78 to move the quill 52 together with the spindle 51 and the plate 50 and the work carrying cage 69 downwardly into an operative position. During the downward movement of the pistons 77 and 78, fluid within cylinder chambers 94 and 95 exhausts through a pipe 96, through the valve chamber 89 and through an exhaust pipe 97 into the reservoir 84.

A manually operable mechanism is provided for actuating the control valve 87 comprising a manually operable lever 98 which is mounted on a rock shaft 99 carried by the cross arm 42. A short arm 100 is also fixedly mounted on the rock shaft 99. The left hand end of the arm 100 is connected by a stud 101 with the valve stem 88. When it is desired to move the plate 50 and the work cage 69 upwardly to an inoperative position, the control lever 98 is rocked in a clockwise direction to shift the valve stem 88 upwardly (Fig. 3) so that fluid under pressure from the pipe 85 passes through the valve chamber 89 and through the pipe 96 into the cylinder chambers 94 and 95 to cause an upward movement of the pistons 77 and 78 so as to move the quill 52 together with the spindle 51 and the plate 50 upwardly into an inoperative position. During the upward movement of the pistons 77 and 78, fluid within the cylinder chambers 92 and 93 respectively exhausts through the pipe 91, through the valve chamber 90 and through the pipe 97 into the reservoir 84. It will be apparent from the foregoing disclosure that by manipulation of the control lever 98 the plate 50 may be raised and lowered as desired.

In order to obtain the desired lapping pressure of the work piece 71 upon the operative face of the lapping wheel 17, a plurality of independent air or fluid pressure operated mechanisms are provided, one for each work aperture in the work cage 69. As illustrated in the drawings a plurality of air cylinders 110, 110*a*, 110*b*, 110*c*, 110*d*, 110*e*, 110*f* and 110*g* are provided which are fixedly mounted on the plate 50. These cylinders are arranged with their axes aligned with the centers of the work receiving apertures 70 in the cage 69. The cylinders 110, 110*a*, 110*b*, 110*c*, 110*d*, 110*e*, 110*f* and 110*g* are each provided with a piston 111, 111*a*, 111*b*, 111*c*, 111*d*, 111*e*, 111*f* and 111*g* respectively which are fastened to the upper end of piston rods 112, 112*a*, 112*b*, 112*c*, 112*d*, 112*e*, 112*f* and 112*g* respectively. Plates 113*b*, 113*c*, 113*e*, and 113*f* are fixedly mounted at the lower end of each of the piston rods. Each of the plates 113*b*, 113*c*, 113*e*, and 113*f* are yieldably connected by a plurality of studs with work engaging plates 116*b*, 116*c*, 116*e*, and 116*f* respectively which are arranged to engage the upper surface of the work pieces 71*b*, 71*c*, 71*e* and 71*f*. Compression springs 115*b*, 115*c*, 115*e*, and 115*f* surround the studs 114 and are interposed between the plates 113*b*, 113*c*, 113*e*, and 113*f* and work engaging plates 116*b*, 116*c*, 116*e* and 116*f* so that when the pistons are moved downwardly to move the work engaging plates 116*b*, 116*c*, 116*e* and 116*f* into operative engagement with the work pieces 71*b*, 71*c*, 71*e* and 71*f*, the springs 115*b*, 115*c*, 115*e*, and 115*f* compress to yieldingly maintain the plates 116*b*, 116*c*, 116*e* and 116*f* in engagement with the work pieces during a lapping operation.

In order to facilitate semi-automatic operation of the machine, the work engaging plates 116*b*, 116*c*, 116*d*, 116*e* and 116*f* together with the associated parts are arranged so that as they approach a loading position, the pistons are raised automatically to lift the plates 116*b*, 116*c*, 116*d*, 116*e* and 116*f* vertically to facilitate removal of the finish lapped work piece and the insertion of a new work piece thereinstead.

The automatic actuation of the work engaging plates is preferably controlled by a rotary valve 120 which is operatively connected to automatically control the admission to and exhaust of air or fluid from the cylinders 110, 110*a*, 110*b*, 110*c*, 110*d*, 110*e*, 110*f* and 110*g*. The rotary valve 120 comprises an upper stationary valve member 121 which is fixedly mounted on the lower end of the quill or sleeve 52. A lower member 122 of the valve 120 is keyed to the spindle 51 and rotates therewith. A disc 119 of a resinoid material such as Formica impregnated with molysulfide is fixedly mounted on the upper surface of the member 122 of the valve 120 and serves to provide a bearing surface between the upper stationary valve member 121 and the lower rotary member 122 of the valve 120. In order to adjust the pressure between the valve members 122 and 121 of the valve 120, a plurality of compression springs 123 are provided, each of which is supported by a stud 124. The studs 124 slide within holes 125 formed in the lower member 122 of the valve 120. The heads of the studs 124 bear against the upper surface of a collar 126 which is screw threaded

onto a threaded portion 127 of the spindle 51. It will be readily apparent from the foregoing disclosure that by adjustment of the collar 125 the compression of the springs 123 may be varied as desired so as to vary the pressure between the valve members 122 and 121.

The lower surface of the upper member 121 of the valve 120 is provided with a plurality of arcuate-shaped grooves or valve chambers comprising a pressure chamber 130, an exhaust chamber 131, a pressure chamber 132 and an exhaust chamber 133. The pressure chamber 132 and exhaust chamber 133 serve to control the flow of air under pressure to the cylinders as they pass through an unloading station automatically to raise the pistons 111, 111*a*, 111*b*, 111*c*, 111*d*, 111*e*, 111*f*, and 111*g* thereby raising the work engaging plates 116*b*, 116*c*, 116*d*, 116*e*, and 116*f* from the work pieces 71 to facilitate removal of a lapped piece of work and the insertion of a new piece of work to be lapped thereinstead. The pressure chamber 130 and exhaust chamber 131 serve to control the flow of air under pressure to the cylinders 110 to maintain a predetermined pressure between the work being lapped and the lapping wheel 11 during the lapping cycle. Fluid under pressure, such as, air under pressure or fluid under pressure may be utilized for actuating the pistons 111, 111*a*, 111*b*, 111*c*, 111*d*, 111*e*, 111*f*, and 111*g*. As illustrated in the drawings air under pressure may be supplied from any suitable source through a pipe 135 which conveys pressure to the pressure chambers 130 and 132 of the valve member 121. An exhaust pipe 136 is connected to allow air to exhaust from exhaust chambers 131 and 133. A pressure regulating valve 137 is provided to facilitate regulating the air under pressure passing from the pipe 135 into the pressure chambers 130 and 132. It will be readily apparent from the foregoing that by manipulation of the pressure regulating valve 137, the pressure of the work pieces 71 against the operative face 17 of the lapping wheel 11 may be readily varied as desired to obtain a predetermined lapping action.

As above described the cylinders 110, 110*a*, 110*b*, 110*c*, 110*d*, 110*e*, 110*f* and 110*g* are fixedly mounted on the plate 50 which is rotated by the spindle 51 together with the work cage 69. A plurality of pipes 146, 146*a*, 146*b*, 146*c*, 146*d*, 146*e*, 146*f* and 146*g* are connected between the lower ends of the cylinders 110, 110*a*, 110*b*, 110*c*, 110*d*, 110*e*, 110*f* and 110*g* respectively and the rotary valve 120. A plurality of pipes 147, 147*a*, 147*b*, 147*c*, 147*d*, 147*e*, 147*f*, and 147*g* are connected between the upper ends of the cylinders 110, 110*a*, 110*b*, 110*c*, 110*d*, 110*e*, 110*f* and 110*g* respectively and the rotary valve 120. As the cylinders 110, 110*a*, 110*b*, 110*c*, and 110*d*, 110*e*, 110*f* and 110*g* approach the position 110 (Figs. 2 and 3), as soon as the port 145 at the end of the pipe 146 is uncovered due to the rotary motion of the lower valve member 122 air or fluid is passed through the pipe 146 into the lower end of cylinder 110 to raise the piston 111 thereby moving one of the plates together with one of the work engaging plates upwardly to an inoperative position so that the lapped work piece 71 may be removed from the cage 69 and replaced with a new work piece to be lapped. Fluid within the upper end of the cylinder 110 may exhaust through the pipe 147 into the exhaust chamber 133 and out through the exhaust pipe 136.

As the work cage 69 together with the plate 50 rotate in a counter-clockwise direction so that cylinder 110 approaches the position of 110*a*, the flow of fluid under pressure to the cylinder 110 is reversed so that the piston 111 moves downwardly to position one of the work engaging plates in operative engagement with the work piece to be lapped at the desired pressure. The work piece remains under the desired lapping pressure until the cylinder 110 moves through the position 110*g* illustrated in Fig. 3 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 eight cage apertures 70 are provided in the cage 69 so that while one work piece is passing through the loading and unloading stations seven 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 determines the number of cage apertures and pressure devices which may be provided. In any case there is a cylinder 110 and the associate parts located directly above each cage aperture 70.

The operation of the improved lapping machine will be readily apparent from the foregoing disclosure. Assuming all of the mechanisms to have been previously adjusted, the motor 20 is started to impart a rotary motion to the lapping wheel 11. The motor 55 is started to impart a rotary motion to the plate 50 and the work cage 69. The fluid pump 82 is then started after which the control lever 98 is moved in a counter-clockwise direction to move the valve stem 88 downwardly into the position illustrated in Fig. 5 thereby causing a downward movement of the spindle 51, the sleeve 52, the plate 50 together with the work cage 69. The downward movement continues until the stop collar 72 engages the stop surface 74 so as to position the work cage 69 in an operative position. Air under pressure is then supplied to the pipe 135 to control the actuation of the pistons 111. A work piece 71 is then positioned in the cage aperture 70. As the cage 69 rotates in a counter-clockwise direction, after the ports to the cylinder 110 are cut off from the valve chambers 132 and 133 and opened to the chambers 130 and 131, the passage of air under pressure to the cylinder 110 is reversed to cause a downward movement of one of the work engaging plates into operative engagement with the upper surface of the work piece 71 where it remains during the entire lapping operation.

As successive cage apertures approach the unloading and loading position, the same cycle of events takes place. A lapped work piece 71 is removed from the cage aperture and a new work piece inserted thereinstead during the time the cage aperture passes through the unloading station. The entire lapping operation on the work piece being lapped takes place while the ports for the cylinder 110 are in communication with the pressure chamber 130 and the exhaust chamber 131. The unloading operation and loading operation take place while the ports from any of the cylinders 110, 110*a*, 110*b*, 110*c*, 110*d*, 110*e*, 110*f* and 110*g* are in communication with the pressure chamber 132 and the exhaust chamber 133.

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 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 rotatable plane-faced lapping wheel thereon, means to rotate said lapping wheel at a predetermined speed, a rotatable platen, a rotatable work carrying cage supported by said platen which is arranged to rotate about an axis offset relative to the axis of said wheel, means including a variable speed driving mechanism for rotating said platen and cage at a predetermined speed to facilitate varying the lapping action, a plurality of spaced work receiving apertures in said cage, means to move said platen and cage vertically to and from an operative position, a positive stop to determine the operative position of said cage, means including an independent pressure cylinder and piston on said platen aligned with each cage aperture for maintaining the desired lapping pressure of the work against the said

lapping wheel, means including a valve to regulate said pressure to facilitate varying the pressure of the work against the face of the lapping wheel, and means including a rotary control valve to control the admission to and exhaust of fluid from said cylinders.

2. In a lapping machine having a base, a rotatable plane-faced lapping wheel thereon, means to rotate said lapping wheel at a predetermined speed, a vertically movable rotatable platen on said base, a work carrying cage adjustably supported by said platen with its axis offset relative to the axis of the lapping wheel, means including a variable speed driving mechanism for rotating said platen and said cage at a predetermined speed, a plurality of spaced work receiving apertures in said cage, means to move said platen and cage vertically to and from an operative position, a positive stop to determine the operative position of said platen and cage, means including

an independent pressure cylinder and piston mounted on said platen aligned with each cage aperture for maintaining a predetermined lapping pressure of the work piece against said lapping wheel, means including a pressure regulating valve to vary said lapping pressure, and means including a rotary control valve to control the admission to and exhaust of fluid from said cylinders, said rotary control valve serving to reverse the flow of pressure to said cylinders during movement through a loading station to facilitate a work loading operation.

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