

Jan. 21, 1941.

D. A. WALLACE

2,229,318

LAPPING APPARATUS

Filed July 16, 1938

3 Sheets-Sheet 1

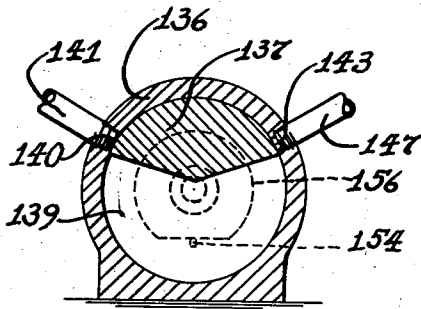


Fig. 8.

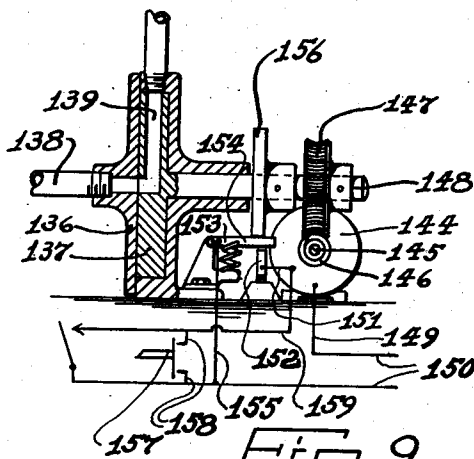


Fig. 9.

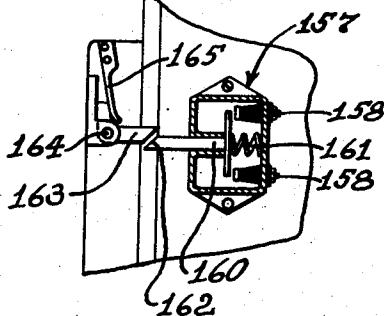


Fig. 10.

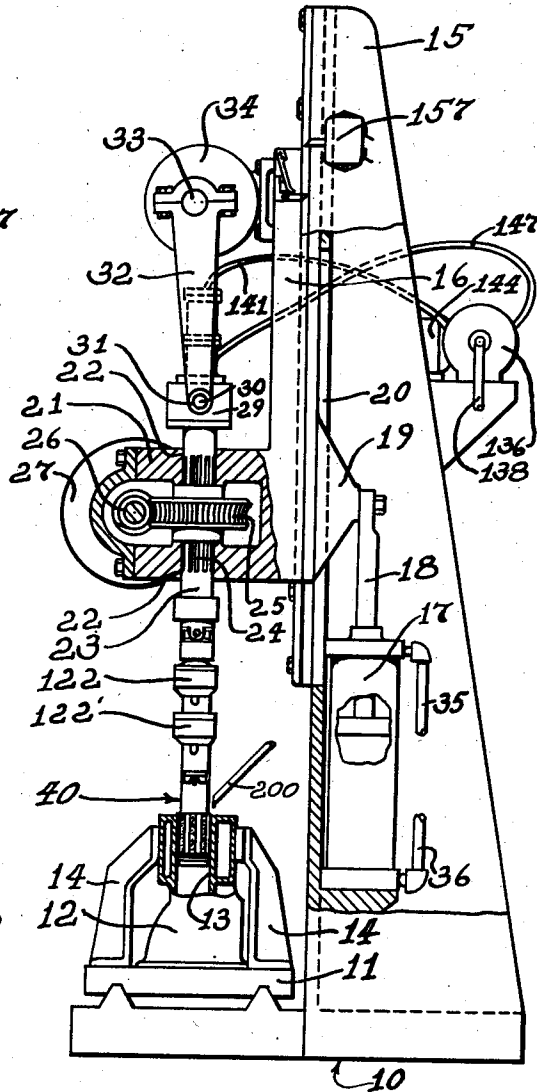


Fig. 1.

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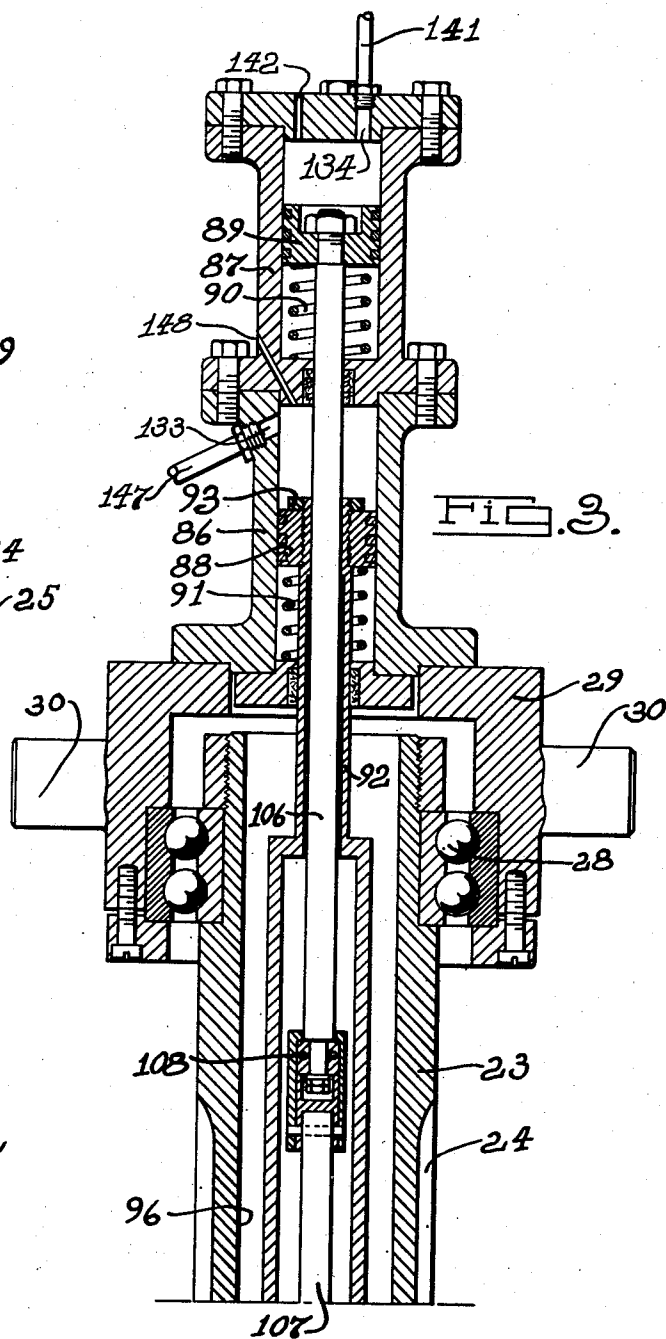
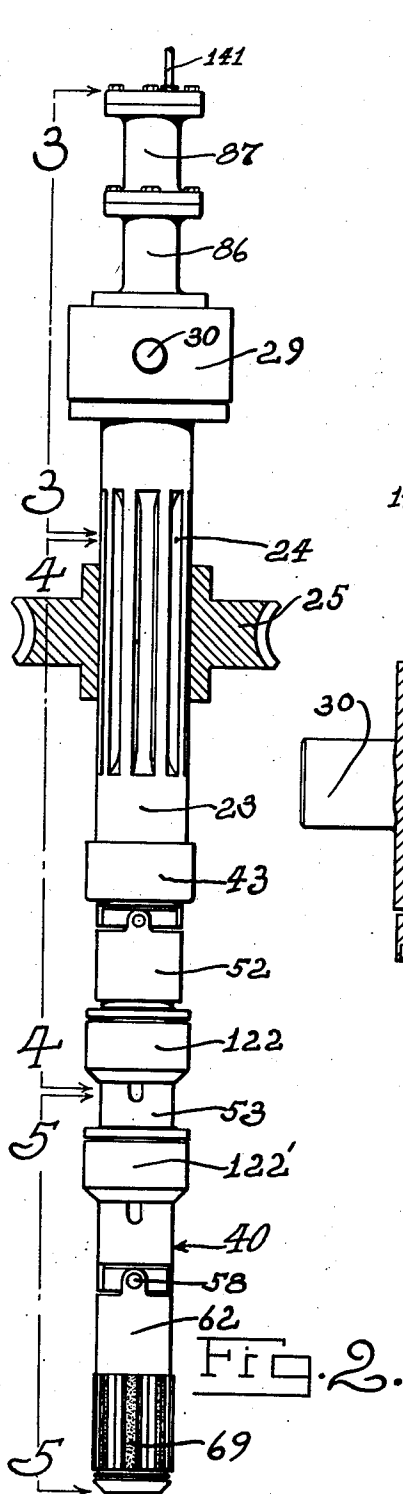
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LAPPING APPARATUS

Filed July 16, 1938

3 Sheets-Sheet 2



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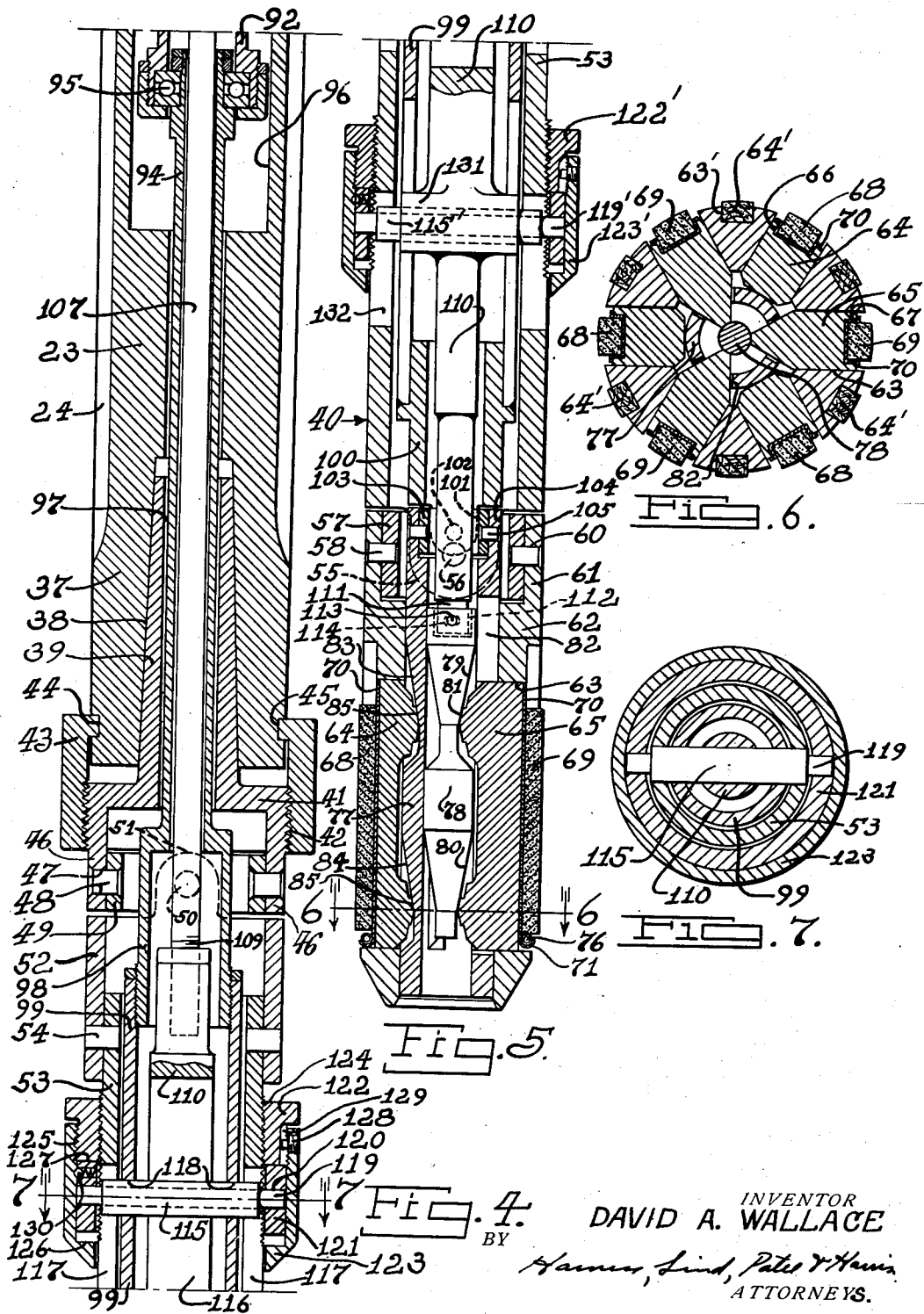
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LAPPING APPARATUS

3 Sheets-Sheet 3



UNITED STATES PATENT OFFICE

2,229,318

LAPPING APPARATUS

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Application July 16, 1938, Serial No. 219,487

10 Claims. (Cl. 51—34)

This invention relates to an improved lapping method and apparatus.

Heretofore in the lapping of surfaces of diverse shapes, it has been the practice, when abrading elements of different degrees of fineness have been employed, to partially lap or otherwise finish the surface by applying only the rougher of the abrading elements for a period of time and thereafter applying only the abrading elements of finer grain. Lapping elements may be graded in terms of the mesh of the grains or particles their lapping surfaces comprise and are available, for example, in grades or grits of 100, 200, 300 and 400 micro-inches, the finer grades of abrasive elements being more costly.

I have found that marked advantages both in lapping time requirements and in smoothness of finish are obtained by simultaneously applying rough grade and fine grade abrasive elements to the work surface operated upon in such a manner as to alternately subject substantially the same increments of area of the work surface to first one and then the other of the lapping elements of different degrees of fineness. For example, when abrading elements of 100 micro-inch size are applied to the work simultaneously in the above manner with abrading elements of 200 micro-inch size, substantially better results can be obtained in one-half the time required during finishing by individually applying to the work a rough abrading element and a much finer abrading element than the finest of the two used in the improved finishing operation.

One of the main objects of the invention is the provision of an improved lapping method during the practice of which substantially the same increments of area of a work surface are operated upon alternately by fine and comparatively rougher abrading elements respectively in a repeating cycle.

Another object of the invention is the provision of an improved lapping method of this kind by which the abrading surfaces of the abrading elements are kept clean and free from fouling by particles of material removed from the work and dislodged from the abrading element.

A still further object of the invention is the provision of relative lapping movements between a surface of a piece of work and abrading elements of diverse degrees of fineness which alternately operate upon the same increments of surface thereof, by which the time required for finishing operations is materially reduced and greater smoothness of finish is obtained while employing a combination of abrading elements,

the finest of which is coarser than that heretofore required for the output of finished surfaces of equivalent smoothness.

Additional objects of the invention are the provision of an improved lapping and abrading tool which has a plurality of abrading elements of different degrees of fineness; to provide means in a tool for selectively rendering operative only the abrading elements of one degree of fineness or simultaneously bringing into operation the abrading elements of different degrees of fineness, if desired; to provide abrading element selecting mechanism of this kind which is operable during rotative, reciprocative or combinations of rotative and reciprocative movements of a tool; to provide means for automatically bringing first the rough, then both the rough and finer lapping elements and then only the fine abrading elements into operative engagement with a surface of a piece of work during periods of predetermined lengths; to provide apparatus of this kind which automatically removes either of the abrading elements from a piece of work at the end of a predetermined lapping cycle, or, in other words, until the tool has been repositioned for operation upon another piece of work; and to provide means for automatically controlling the abrading elements which may be operated on the time cycle or as a function of a selected component of the relative lapping movement between the tool and the work.

An illustrative embodiment of the invention is shown in the accompanying drawings, in which:

Fig. 1 is an end elevational view, partly in section, of lapping apparatus embodying the invention.

Fig. 2 is a side elevational view of a lapping tool embodying the invention.

Fig. 3 is an enlarged fragmentary, vertical, sectional view of the upper end portion of the tool shown in Fig. 2 taken on the line 3—3 thereof.

Fig. 4 is an enlarged, vertical, sectional view of the intermediate portion of the tool shown in Fig. 2 taken on the line 4—4 thereof.

Fig. 5 is an enlarged, vertical, sectional view of the lower end of the tool shown in Fig. 2 taken on line 5—5 thereof.

Fig. 6 is a horizontal, transverse, sectional view taken along the line 6—6 of Fig. 5.

Fig. 7 is a horizontal, sectional view taken on the line 7—7 of Fig. 4.

Fig. 8 is a vertical, sectional view diagrammatically showing a valve mechanism for suitably controlling the supply of fluid pressure to a lapping tool embodying the invention.

Fig. 9 is a vertical, sectional view of the valve mechanism shown in Fig. 8 diagrammatically illustrating an electric driving system and wiring diagram therefor.

Fig. 10 is a vertical, sectional view of switch mechanism for an electric driving system.

In the form of the invention illustrated in the drawings, my improved lapping apparatus comprises a machine bed structure, generally designated by the numeral 10, having a horizontal table 11 for supporting a piece of work, such as an internal combustion engine crankcase 12 having cylinders 13 to be lapped. The work table 11 is provided with clamping members 14 for suitably holding the work in position for receiving a lapping, grinding, honing or other finishing operation. While only a lapping operation upon a cylinder of an internal combustion engine cylinder block is illustrated, it should be understood that diverse surfaces of various types of work may be finished in accordance with the invention. The machine bed 10 includes a vertically extending support structure 15 on which a carriage 16 is vertically reciprocally mounted. The carriage 16 may be conveniently reciprocated vertically for the purpose of applying the tool to and removing the same from the work by a fluid pressure cylinder 17 having a piston therein provided with a piston rod 18 which is attached to a post 19 carried by the carriage 16 and extending rightwardly therefrom, as viewed in Fig. 1, through a slot 20 formed in the vertical support portion 15 of the machine bed structure.

Mounted on the left side of the carriage 16, as viewed in Fig. 1, is a housing 21 having vertically aligned bearings 22 in its respectively opposite walls in which a tool spindle, generally designated by the numeral 23, is reciprocally mounted and rotatably journaled. The tool spindle 23 is provided with a splined portion 24 which is disposed within the casing 21 and on which is mounted a worm gear 25 meshed with a worm 26 carried by the shaft of an electric motor 27 which is also mounted on the carriage 16. The upper end of the spindle 23 is rotatably mounted by a bearing member, generally designated by the numeral 28, and a collar 29 having diametrically opposite trunnions 30. The trunnions 30 are pivotally received in bearings 31 of a connecting link 32 which is provided at its upper end portion with an opening in which operates an eccentric 33. The eccentric 33 is carried by a shaft of an electric motor 34 which is also mounted on the carriage 16.

During operation of the apparatus the motor 27 drivingly rotates the tool spindle 23 about its longitudinal axis and the motor 34 simultaneously drivingly reciprocates the spindle through the agency of the eccentric 33 and connecting link 32 in the direction of the longitudinal axis of the spindle and preferably throughout a relatively short stroke and at a speed of a vibratory order. If desired, a second stage of reciprocatory movement may be imparted to the spindle 23 by automatically controlling the admission and exhausting of fluid pressure medium to the relatively opposite ends of the cylinder 17 through the conduits 35 and 36 respectively.

The tool spindle 23 comprises an upper tubular section 37 having a tapered socket 38 in its lower extremity adapted to receive a tapered shank portion 39 of a lapping or similar finishing tool generally designated by the numeral 40. The finishing tool 40, illustrated in the drawings, comprises a plurality of universally pivotally

connected sections, the upper section of which carries the shank 39 and is provided with a cylindrical cup shape lower extremity 41 having an outer periphery 42 on which a split collar 43 is threaded. The split collar 43 has an inwardly extending flange 44 which is rotatably received in a groove 45 formed in the outer periphery of the tubular part 37 of the spindle. The collar 43 may be relied upon to securely hold the tool 40 against detachment from the spindle 23 and it also serves, upon rotation in respectively opposite directions, to insert the shank 39 into the socket 38 and withdraw the shank therefrom respectively. A pair of diametrically opposite ears 46 are provided on the lower extremity of the part 41 of the upper section of the tool and provided with apertures 47 in which are pivotally received pins 48 carried by a ring 49. The ring 49 is also provided with a pair of diametrically opposite ears 51 carried by a tubular sleeve 52 which together with a telescoping tubular sleeve 53 constitute the second section of the tool. The sleeves 52 and 53 may be welded or otherwise suitably secured together, as by pins 54 in the manner illustrated in Fig. 4.

Integrally formed on the lower end portion of the sleeve 53, as illustrated in Fig. 5, are a pair of ears 55 each of which is provided with an aperture for receiving the pin 56 carried by a ring 57. The ring 57 is provided with a pair of diametrically opposite pins 58 which are located in 90° relationship from the pins 56. Each pin 58 is pivotally received in an aperture 60 provided in an ear 61 which projects upwardly from a tool body 62. The pins 48 and 50 accommodate limited universal pivotal movement between the upper section and the second section of the tool and the pins 56 and 58 accommodate limited universal pivotal movement between the second section and the tool body 62. The tool body 62 comprises a relatively thick wall tubular structure having a plurality of uniformly spaced radially extending axial slots 63 therein.

In the form shown in Fig. 6 of the drawings, there are provided a series of six such radial slots, in alternate slots of which are slidably mounted blocks 64 and 65 respectively. The outer extremities of the blocks 64 and 65 are provided with channels 66 and 67 respectively in which are mounted fine and relatively rougher abrading elements 68 and 69 respectively. The abrading elements 68 and 69 are seated in sheet metal holders 70 which are press fitted, welded or otherwise suitably secured in the channels 66 and 67. The channel shape holders 70 have protruding end portions formed to bead shape, as illustrated at 71 in Fig. 5, in which is received a continuous spring band 76 by which the slidable blocks and abrading elements carried thereby are yieldably urged inwardly. The abrading elements may comprise natural or artificial compressed stones or other suitable abrasive or polishing material. Formed in the lands between the slots 63 are channels 63' in which blocks of fibrous material 64' are seated for contacting the cylindrical surface portion on which the tool operates.

Centrally located in the tool body 62 are a pair of concentric cam members 77 and 78 which operate upon the inner extremities of the blocks 64 and 65 respectively to selectively, individually or simultaneously urge the blocks 64 and 65 outwardly against the surface of a piece of work being operated upon. The cam member 78 is provided with spaced cam surfaces 79 and 80

against which inwardly extending tapered edge portions 81 of the rough abrading element carrying block 65 abut. The cam member 77 is of tubular construction and is provided with slots 82 for accommodating insertion of the tapered extremities of the blocks 65 therethrough and into engagement with the cam member 78. This tubular cam 77 comprises cam surfaces 83 and 84 against which the spaced inner edge portions 85 of the blocks 64 abut. Simultaneous downward axial movement of the cam members 77 and 78, as viewed in Fig. 5, urges all of the blocks 64 and 65 outwardly against the action of the spring 76 to variably predetermine the pressure with which both the fine and rougher lapping elements 68 and 69 are applied to the work. Either the cam member 77 or the cam member 78 may be independently axially shifted downwardly to selectively apply or variably urge the fine and rougher lapping elements 68 and 69 respectively individually against the surface of the work being operated upon.

There is provided apparatus for automatically adjusting both the cam members 77 and 78 either simultaneously or individually during operation of the apparatus and in a predetermined cycle. This apparatus includes a pair of coaxially aligned cylinders 86 and 87 mounted in superimposed relation on the collar 29 and in which are disposed pistons 88 and 89 respectively. The piston 89 is yieldably urged upwardly, as viewed in Fig. 3, by a coil spring 90 and the piston 88 is yieldably urged upwardly by a coil spring 91. The piston 88 is provided with a tubular piston rod 92 having a reduced upper end portion secured to the piston 88 by a nut 93 and an enlarged lower end portion which is rotatably connected to an intermediate tubular piston rod section 94 by a thrust bearing 95. The thrust bearing member 95 accommodates relative rotation of the upper piston rod section 92 and the intermediate piston rod section 94 but rigidly holds the sections against relative axial movement. The upper end portion of the intermediate piston rod section 94 is slidably piloted in the relatively close fitting bore 96 formed at the upper end of the tool spindle 23. This upper end portion of the intermediate piston rod section, also extends through a bore 97 formed in the tapered shank 39 of the finishing tool 40. The intermediate piston rod section 94 is provided with an enlarged externally threaded lower end portion 98 located within the sleeve 52 of the finishing tool 40 and threadedly attached to a tubular lower piston rod section 99 extending through the sleeve 53 of the finishing tool 40. The lower extremity of the lower piston rod section 99 is rigidly attached by welding, or in any other suitable manner, to a universal joint element 100 having a pair of diametrically oppositely connected ears 101 pivotally connected by pins 102 to a ring 103 which is in turn pivotally attached by pins 105 to a pair of diametrically opposite ears 104 formed integral with the upper extremity of the tubular cam member 77 and located in 90° spaced relationship with respect to the pins 102. This structure provides a universal joint between the lower piston rod section 99 and the tubular cam member 77 which accommodates limited universal movement between the lower end of the piston rod and the cam 77. Reciprocatory movement of the piston 88 is transmitted by the rod sections 92, 94 and 99 to the cam member 77.

The piston 89 is provided with an upper piston rod section 106 which is attached to an inter-

mediate piston rod section 107 by a thrust bearing member 108 which accommodates rotation of the intermediate piston rod section 107 with respect to the piston rod section 106 but which rigidly holds these piston rod sections against relative axial movement. The lower extremity of the intermediate piston rod section 107 is threadedly attached at 109 to a lower piston rod section 110 which has a reduced end portion 111 at its lower extremity received in a socket 112 formed in the upper extremity of the cam member 78. The reduced end portion 111 is attached to the cam 78 by a pin and slot connection comprising a pin 113 and a slot 114. Reciprocatory movement of the piston 89 is transmitted to the cam 78 by the piston rod comprising the sections 106, 107 and 110.

Provision is made for individually predetermining the lengths of stroke and limiting positions of the cams 77 and 78. The apparatus by which the lengths of stroke and limiting positions of the cam 77 are predetermined are illustrated at the lower end of Fig. 4. This apparatus includes the bushing 115 which extends through a slot 116 in the intermediate piston rod section 110 and through slots 117 formed in the sleeve 53 of the tool 40. The bushing 115 is received in close-fitting apertures 119 formed in the lower piston rod section 99 and is adapted to move axially therewith relative to the finishing tool. A pin 119 extends through the bushing 115 and has opposite end portions received in apertures 120 formed in a ring 121 which is concentrically mounted on the extremity of the sleeve 53 of the finishing tool 40. The ring 121 is adjustably positioned and limited in its axial movement by cooperating collars 122 and 123. The collar 122 is threaded at 124 on the outer periphery of the sleeve 53 and the collar 123 is threaded at 125 on the outer periphery of the collar 122. The collar 123 extends downwardly beyond the ring 121 and it is provided with an abutment face 126 which is adapted to engage the lower extremity of the ring 121 for limiting downward movement thereof. The collar 122 is provided with a lower extremity 127 which is adapted to engage the upper extremity of the ring 121 for limiting upward movement thereof. The collars 122 and 123 may be releasably secured in an adjusted position by a set screw 128 having a lock on its inner end which is receivable in slots 129 formed in the outer periphery of the collar 122. The ring 121 is provided with a spring pressed detent 130 which engages in a corresponding notch in the collar 123 for the purpose of yieldably holding the ring at its upper limiting position. When the set screw 128 is removed and the collar 123 turned in order to screw it upwardly on the threads 124 the position of the upper limit of the ring 121 is raised so as to correspondingly adjust the cam 77. When the collar 123 is turned relative to the collar 122 in respectively opposite directions, the abutment face 126 is raised and lowered respectively to vary the position of the lower limit of the ring 121. The gap between the abutment face 126 and the lower extremity of the ring 121 shown in Fig. 4 illustrates the extent of movement permitted by the seating of the collars shown in this figure.

This gap may be increased or decreased by the limits provided by the ends of the gap or both limiting positions may be raised or lowered if desired. By this structure the cam 77 may be adjusted to predetermine the limiting extended and retracted positions of the blocks 64 with which it coacts.

Similar adjusting collars 122' and 123' are provided on the sleeve 53 of the tool for predetermining the length of stroke and limits of movement of the lower piston rod section 110 which operates the cam 78. This apparatus is illustrated in Fig. 5 and is substantially identical to the adjusting mechanism above described, those parts of the inner cam adjusting mechanism which correspond to the parts of the outer cam adjusting mechanism shown in Fig. 4 being designated by corresponding primed numerals. The pin 119' of the inner cam adjusting mechanism and the bushing 115' thereof are received in an aperture formed in an enlargement 131 of the lower piston rod section 110 and the ends of the bushing 115', shown in Fig. 5, are slidably guided in slots 132 formed in the sleeve 53 of the finishing tool 40. The collars 122' and 123' may be threadedly adjusted relative to each other and relative to the sleeve 53 for the purpose of predetermining the length of stroke of the piston rod 110 and cam 78 attached thereto, and to predetermine the locations at which the stroke of the piston rod 110 terminates respectively.

The pistons 88 and 89 are normally urged toward their upper-most positions in their respective cylinders 86 and 87 by springs 90 and 91. There is provided mechanism, shown in Figs. 8 to 10 inclusive, for automatically supplying fluid medium to the cylinders 86 and 87 through inlets 133 and 134 respectively. This mechanism includes a valve structure generally designated by the numeral 135 having a casing 136 in which a valve body 137 is rotatably mounted. The valve body 137 is provided with a fluid medium inlet 138 which communicates with a notch 139 formed in the valve body. The casing 136 has a fluid medium outlet 140 which is connected by a flexible conduit 141 with the inlet 134 of the cylinder 87 which is provided with a bleed orifice 142. A fluid pressure medium outlet 143 is also formed in the valve casing 136 and connected by a flexible conduit 147 with the inlet 133 of the cylinder 86 which is also provided with a bleed orifice 148. The fluid pressure medium outlets 140 and 143 and the notched section 139 of the valve body 137 are so constructed and arranged that when the valve body is in the position shown in Fig. 8, the supply of fluid medium to the body outlets 140 and 143 is cut off and the pistons 88 and 89 are held in their upper-most positions by the springs 90 and 91 respectively. Under this condition both the rough and fine abrading elements are retracted and the tool is conditioned for insertion into a bore of a piece of work. During rotation of the valve body at a fixed rate, by mechanism hereinafter described, the valve casing outlet 140 is first supplied with fluid pressure medium while the outlet 143 is closed. This causes the piston 89 to be urged downwardly against the action of the spring 90 and the rough abrading elements to be urged outwardly against the work while the fine abrading elements are still in their retracted position. After operation of the tool with this setting of the abrading elements for a predetermined period of time, the outlet 143 of the valve casing is uncovered and fluid pressure medium is simultaneously supplied to the outlets 140 and 143 in order to simultaneously move both pistons 88 and 89 and cam members 77 and 78 downwardly so as to simultaneously urge both the fine and rougher abrading elements against the work. Further rotation of the valve body 137 causes the

supply of fluid pressure medium to the valve casing outlet 140 to be discontinued while the supply of medium to the outlet 143 is continued, thereby permitting the rough abrading elements to be withdrawn from engagement with the work while only the fine abrading elements are urged thereagainst. Finally the notch 139 of the valve body 137 is rotated out of registry with the outlet 143 of the casing and a supply of fluid medium to both outlets thereof is discontinued, thereby permitting the spring 76 to hold all of the abrading elements in their retracted position to facilitate removal of the tool from a cylindrical bore of a piece of work.

Operation of the foregoing valve mechanism may be automatically controlled in a predetermined time cycle by rotatively driving the valve body 137 by an automatically controlled motor 144, which, as illustrated in Fig. 9, is provided with a shaft 145 having a worm 146 thereon meshed with a worm wheel 147 carried by a shaft 148 by which the valve body 137 is rotatably supported. The motor 144 is thus adapted to rotate the valve body at a fixed rate of speed and is supplied with current by a circuit illustrated in Fig. 9 which includes a conductor 149 leading from one wire of a current supply line 150 to one terminal of the motor. The other terminal of the motor 144 is connected by a conductor 151 with a fixed contact 152 of a switch generally designated by the numeral 153. The switch 153 includes a movable contact 154 which is electrically connected by a conductor 155 with the other wire of the current supply line. The movable contact 154 is operated in timed relation with the rotative movement of the valve body 137 by a cam 156 which is so constructed and arranged as to open the circuit at the cam operated switch when the valve body 137 reaches substantially the position shown in Fig. 8. In this manner all of the abrading elements are held in their retracted position while the tool is being removed from the work and until the motor 144 is again energized in a manner hereinafter set forth, to start the rotation of the valve body and bring the cam 156 to a position such that it completes the holding circuit through the switch contacts 152 and 154.

During the beginning of each operation of the apparatus, the motor 144 is temporarily energized to accomplish the above purpose by a switch generally designated by the numeral 157 which is responsive to reciprocation of the carriage 16 on the vertically upstanding support portion 15 of the machine bed. This switch includes a pair of contacts 158 which are shunted across the conductors 151 and 155 by conductors 159. The terminals 158 are adapted to be electrically connected to shunt the switch including contacts 152 and 154 by a plunger 160 reciprocably mounted on the machine bed structure and normally yieldably held in non-contacting relationship with respect to the contacts 158 by a spring 161. The plunger 160 has a stem portion provided with an inclined extremity 162 which is disposed in the path of a bell crank lever 163 which is pivotally mounted on the carriage 16 at 164. The bell crank lever 163 is normally held in the position shown in Fig. 10 by a spring 165. Counterclockwise rotation of the lever 163 from the position shown in Fig. 10 is opposed by abutment of the lever against a surface of the carriage and thus during a slight increment of downward movement of the carriage after the tool has been inserted into the work, the plunger

160 is moved rightwardly, as viewed in Fig. 10, to close the motor circuit through the terminals 158. Further downward movement of the carriage disengages the bell crank lever 163 from the extremity 162 of the switch plunger 160 and by this time the cam 156 has closed the switch including the contacts 152 and 154 and the foregoing cycle of the valve mechanism proceeds. During upward movement of the carriage 16 to withdraw the tool from the work, the bell crank lever 163 freely pivots about its pivotal axis 164 to accommodate return of the carriage to its starting position without actuating the switch plunger 160.

The foregoing sequence of the application of the finer and rougher finishing elements may be varied substantially if desired by properly controlling the actuation of the pistons 88 and 89. This may be accomplished under manual control, if desired, by merely supplying fluid medium to the cylinders 87 and 88 under the control of a suitable manually operable valve mechanism (not shown). While there has been herein shown and described an apparatus for selectively, individually and simultaneously applying finishing or abrading elements to an internal cylindrical work surface, it should be understood that substantially all of the advantages of the apparatus and method may be procured in the finishing of surfaces of flat, external, cylindrical, diverse and other contours, to which a coolant may be supplied, for example, by a pipe 200 leading from a suitable source of coolant not shown.

The finishing or abrading elements of a tool of the foregoing type embodying the invention may be conveniently retracted to accommodate insertion of the tool into a bore of a piece of work, expanded into engagement with the surface to be operated upon and retracted to facilitate removal of the tool from the work while the tool is either drivingly rotated, drivingly reciprocated or simultaneously drivingly rotated and reciprocated in the foregoing manner. While the grade of the abrading elements may vary throughout a substantially wide range, it has been found that a tool of the type shown in the drawings provided with alternate 100 and 200 micro-inch grit stones will accomplish in substantially one-half the time better results and will produce smoother and more perfect surfaces than are obtainable with extremely fine grit stones of, for example, 400 micro-inch grit.

Although but one specific embodiment of the invention is herein shown and described, it will be understood that various changes in the size, shape and arrangement of parts may be made without departing from the spirit of the invention.

What is claimed is:

1. Lapping apparatus comprising a support for a piece of work having a surface to be lapped, a lapping tool having a fine and a comparatively rougher abrading element, each being movable into engagement with circumferentially spaced portions of said surface respectively, said tool and said work being so relatively rotatable with respect to each other as to cause the same increments of said surface to be operated upon alternately by said fine and rougher abrading elements during each relative rotation of said tool and said work, means for drivingly producing relative rotation of said tool and said work, and means including time control pressure applying mechanism for automatically urging only said rougher abrasive elements and then both of said elements

simultaneously against said surface of said work for predetermined intervals during an initial stage of the lapping operation of said apparatus and during a subsequent stage of operation thereof respectively.

2. Surface finishing apparatus comprising a support, means on said support for positioning an article having a surface to be finished for receiving a finishing operation, a tool spindle, means reciprocatively and rotatably mounting said spindle on said support, means for drivingly reciprocating and rotating said spindle, a finishing tool securable to said spindle for rotative and reciprocatory movement in unison therewith and including a pair of abrading elements shiftably mounted for movement toward and away from the rotative axis of said tool, means normally yieldably urging said elements toward said axis, means carried by said tool and spindle for selectively urging either or both of said elements outwardly, and pressure applying mechanism for actuating said means including time control apparatus for predetermining the duration and sequence of application of said respective abrading elements to said surface.

3. Surface finishing apparatus comprising a support, means on said support for positioning an article having a surface to be finished for receiving a finishing operation, a tool spindle, means reciprocatively and rotatably mounting said spindle on said support, means for drivingly reciprocating and rotating said spindle, a finishing tool securable to said spindle for rotative and reciprocatory movement in unison therewith and including a pair of abrading elements shiftably mounted for movement toward and away from the rotative axis of said tool, one of said abrading elements having a fine abrading surface and the other having a rougher abrading surface, a member normally yieldably urging said elements toward said axis, mechanism for selectively urging said elements outwardly against the action of said member and adapted to selectively apply either of said elements to a surface of a piece of work individually or simultaneously, and pressure applying mechanism for actuating said means including time control apparatus for predetermining the sequence and duration of application of said fine and said rougher abrading elements to said surface respectively.

4. A lapping device comprising a support, a hollow rotatable spindle and a hollow lapping tool body securable thereto and rotatable therewith, a plurality of members radially shiftably mounted for movement transversely of said tool body in respectively opposite directions toward and away from a surface of a piece of work respectively, means normally yieldably urging said members in one of said directions, a pair of selectively individually and simultaneously operable control members carried by said support independently of said spindle and tool body and extending through said spindle and into said tool body, one coacting with only certain of said shiftable members and the other coacting with only the others for urging said members in the other direction, and abrading elements on said members having abrading surfaces of different degrees of roughness for operating upon said work surface, said spindle and tool body being rotatable relative to said members and the latter being selectively independently operable during rotation of said spindle and tool body.

5. A lapping device comprising a hollow spindle and a hollow lapping tool body securable thereto,

a plurality of members radially shiftably mounted for movement transversely of said tool body in respectively opposite directions toward and away from a surface of a piece of work respectively, means normally yieldably urging said members in one of said directions, a pair of selectively individually and simultaneously operable control members extending through said spindle and into said tool body, one coacting only with certain of said shiftable members and the other coacting only with the others for urging said members in the other direction, fluid pressure mechanism for selectively individually and simultaneously actuating said control members to apply said abrading elements to said work surface in a predetermined cycle during operation of said tool including a fluid pressure responsive element coacting with each of said control members respectively, and abrading elements on said members having abrading surfaces of different degrees of roughness for operating upon said work surface.

6. A rotatable tool for lapping internal cylindrical surfaces including a support, a hollow tool body portion rotatably mounted on said support having a series of circumferentially spaced slots therein, an abrading member shiftably mounted in each of said slots including an external abrading surface, the abrading surfaces of alternate members being fine and rough respectively, and a pair of selectively individually and simultaneously operable control units carried by said support independently of said tool body, one coacting only with the shiftable members having fine abrading surfaces and the other coacting only with shiftable members having rough abrading surfaces for selectively individually variably urging said respective abrading surfaces against said work surface, said control units being simultaneously operable for applying all of said abrading members to said work during rotation of said tool body.

7. Lapping apparatus including a tool support, a rotatable tool journaled thereon for lapping internal cylindrical surfaces including a hollow body portion having a series of circumferentially spaced slots therein, a member shiftably mounted in each of said slots including an external abrading surface, the abrading surfaces of alternate members being fine and rough respectively, and a pair of selectively individually and simultaneously operable control units one coacting only with the shiftable members having fine abrading surfaces and the other coacting only with shiftable members having rough abrading surfaces for selectively individually and simultaneously variably urging said respective abrading surfaces against said work surface, each of said units including a cam member rotatable with said tool and engaging alternate shiftable members, an actuating member carried by said tool support and with respect to which said tool is rotatable and a coupling

between said cam and actuating members accommodating continuous relative rotation therebetween for imparting movement of said actuating member to said cam member.

8. A rotatable tool for lapping internal cylindrical surfaces including a hollow body portion having a series of circumferentially spaced slots therein, a member shiftably mounted in each of said slots including an external abrading surface, the abrading surfaces of alternate members being fine and rough respectively, and a pair of selectively individually and simultaneously operable control units one coacting with the shiftable members having fine abrading surfaces and the other coacting with shiftable members having rough abrading surfaces for selectively individually and simultaneously variably urging said respective abrading surfaces against said work surface, one of said units including an axially shiftable tubular cam member and the other including an axially shiftable cam member concentrically located within said tubular cam member and each of said units having an actuating member and a thrust bearing connecting the latter to one of said cam members respectively for accommodating relative rotation of said cam members and actuating members during rotation of said tool.

9. A rotatable tool for lapping internal cylindrical surfaces including a hollow body portion having a series of circumferentially spaced slots therein, a member shiftably mounted in each of said slots including an external abrading surface, the abrading surfaces of alternate members being fine and rough respectively, and a pair of selectively individually and simultaneously operable control units one coacting with the shiftable members having fine abrading surfaces and the other coacting with shiftable members having rough abrading surfaces for selectively individually and simultaneously variably urging said respective abrading surfaces against said work surface, each of said units including a cam member rotatable with said tool and engaging alternate shiftable members, an actuating member comprising a piston and cylinder and a coupling between said cam and actuating members for imparting movement of said actuating member to said cam member and for accommodating a non-rotative relation between said piston and cylinder during rotation of said tool.

10. In an abrading device, a pair of abrading elements, one of said abrading elements having a fine and the other having a rough abrading surface, means for initially advancing one of said abrading elements into contact with a surface to be finished, means for thereafter applying the other of said abrading elements to said surface, and means for controlling the duration of application of one of said elements to said surface.

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