July 8, 1941. H. S. INDGE ET AL 2,248,353

CYLINDRICAL GRINDING AND LAPPING MACHINE

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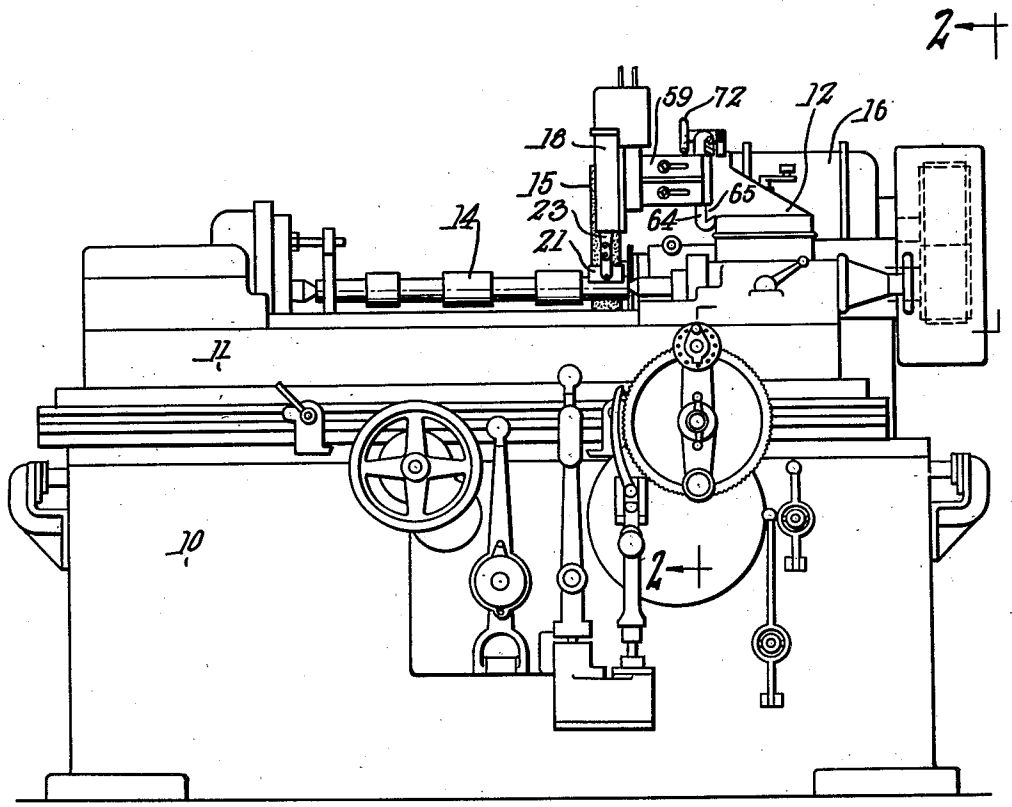


Fig. 1.

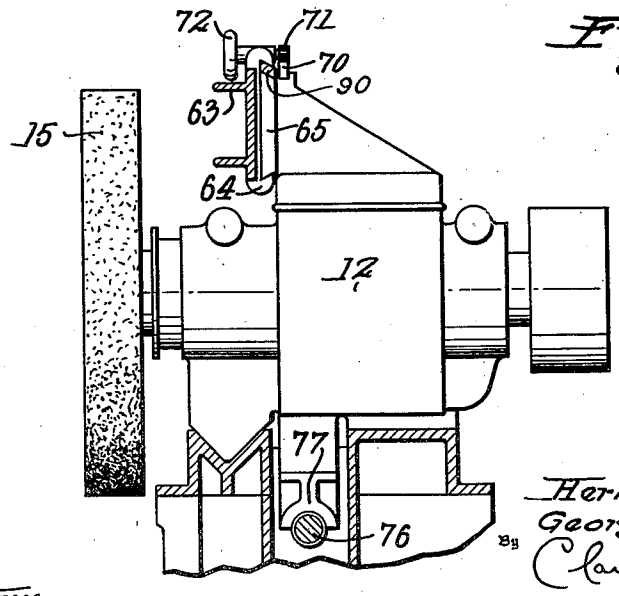


Fig. 3.

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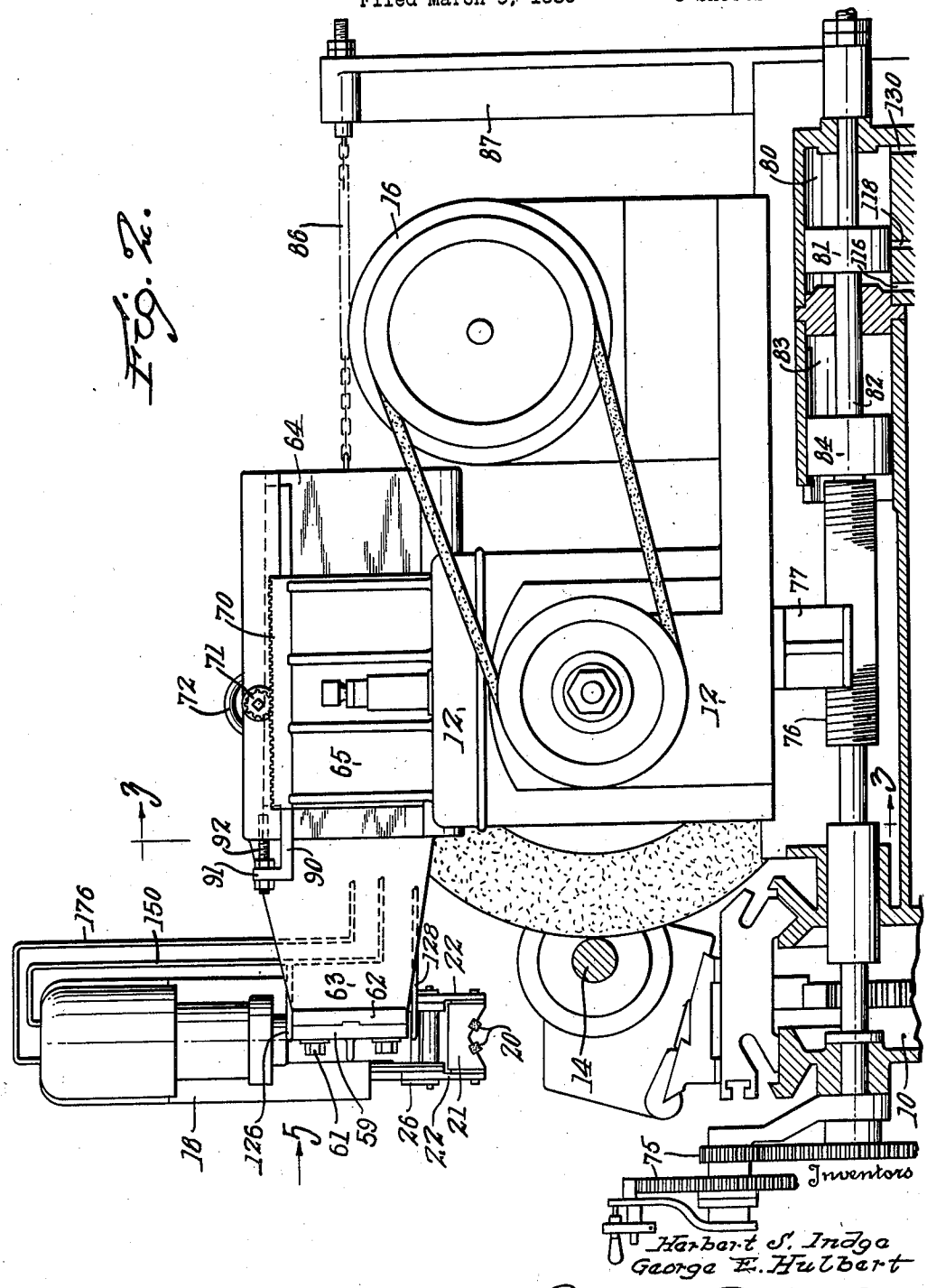
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CYLINDRICAL GRINDING AND LAPPING MACHINE

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Fig. 2.



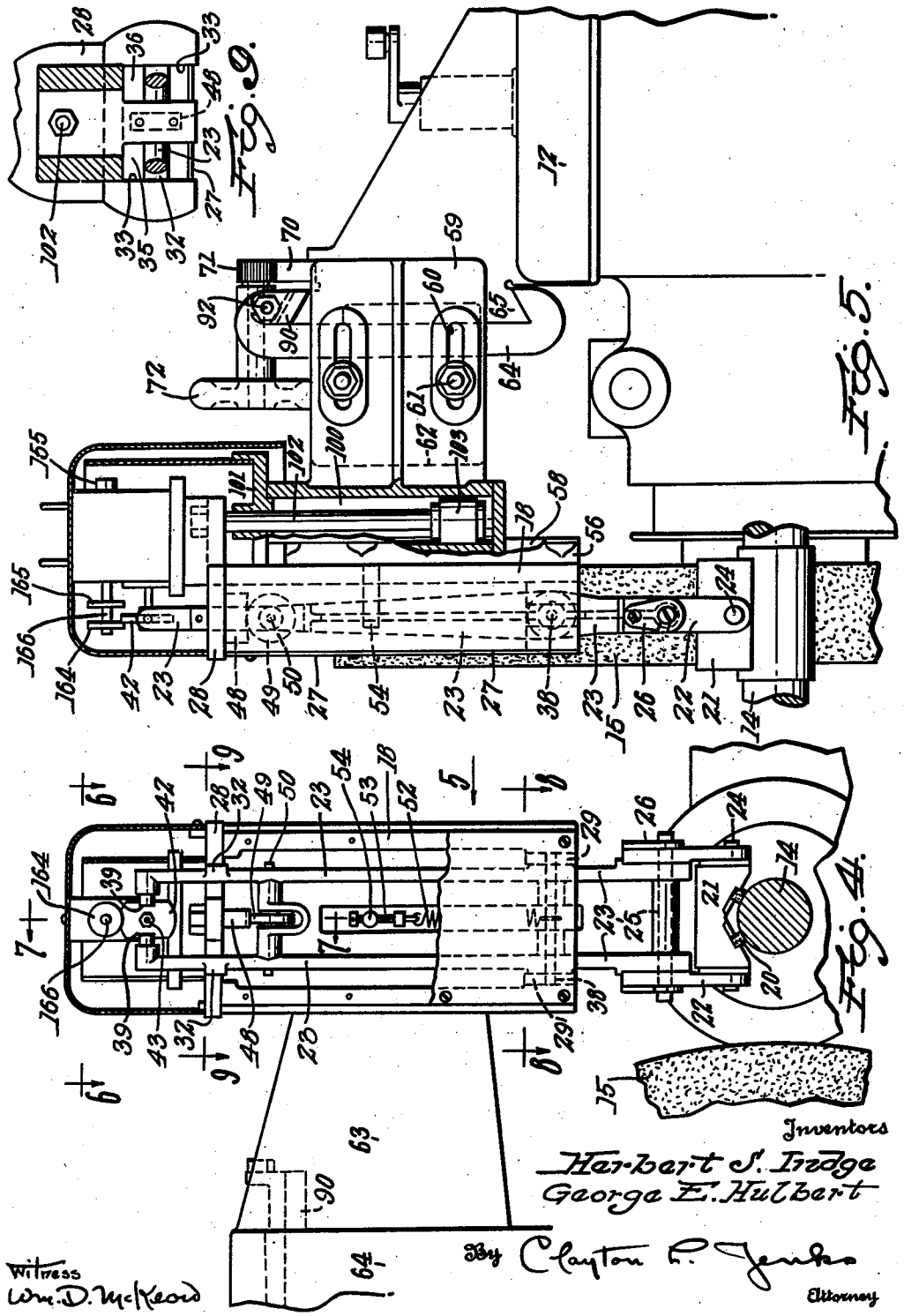
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CYLINDRICAL GRINDING AND LAPPING MACHINE

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CYLINDRICAL GRINDING AND LAPPING MACHINE

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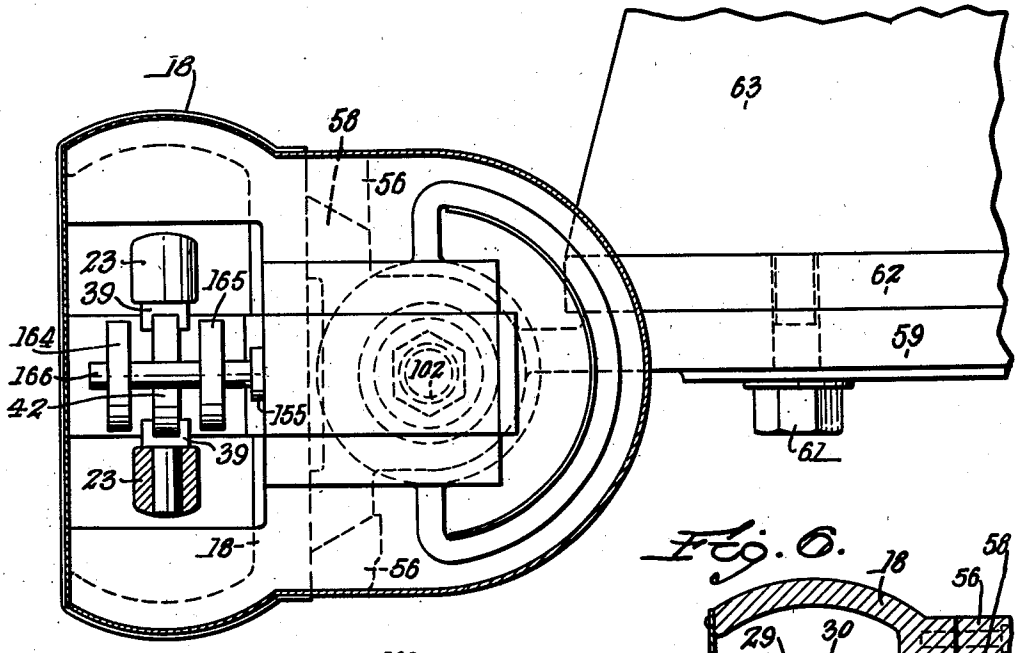


Fig. 6.

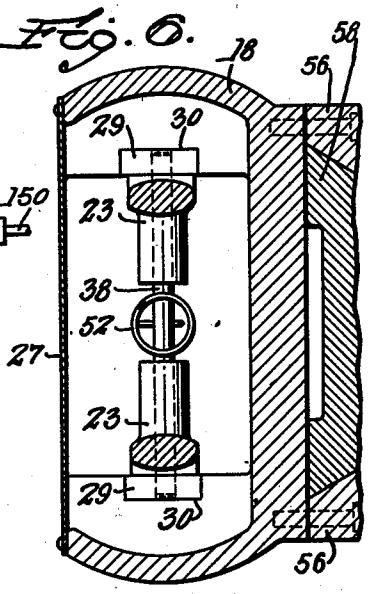


Fig. 8.

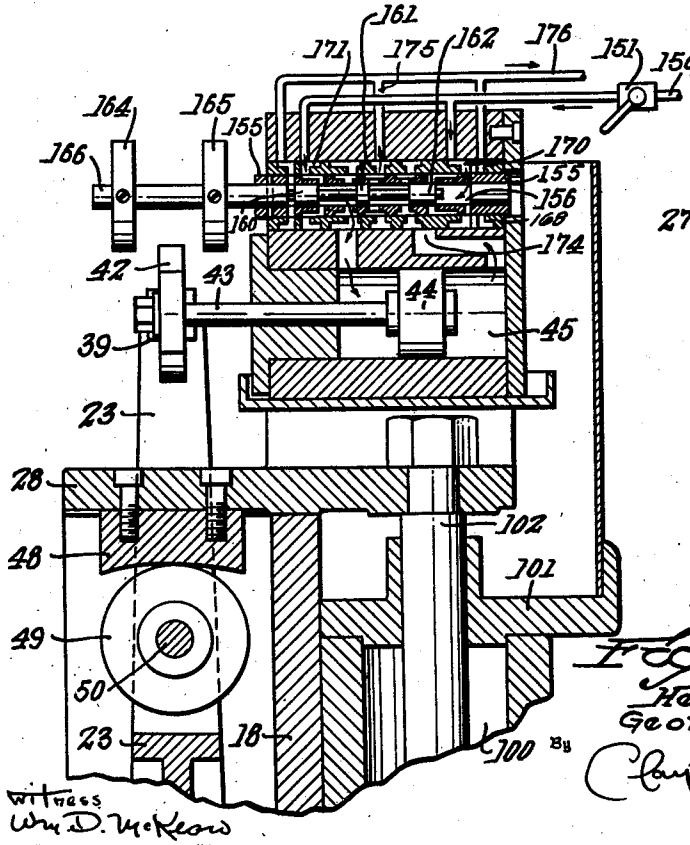


Fig. 7.

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CYLINDRICAL GRINDING AND LAPPING MACHINE

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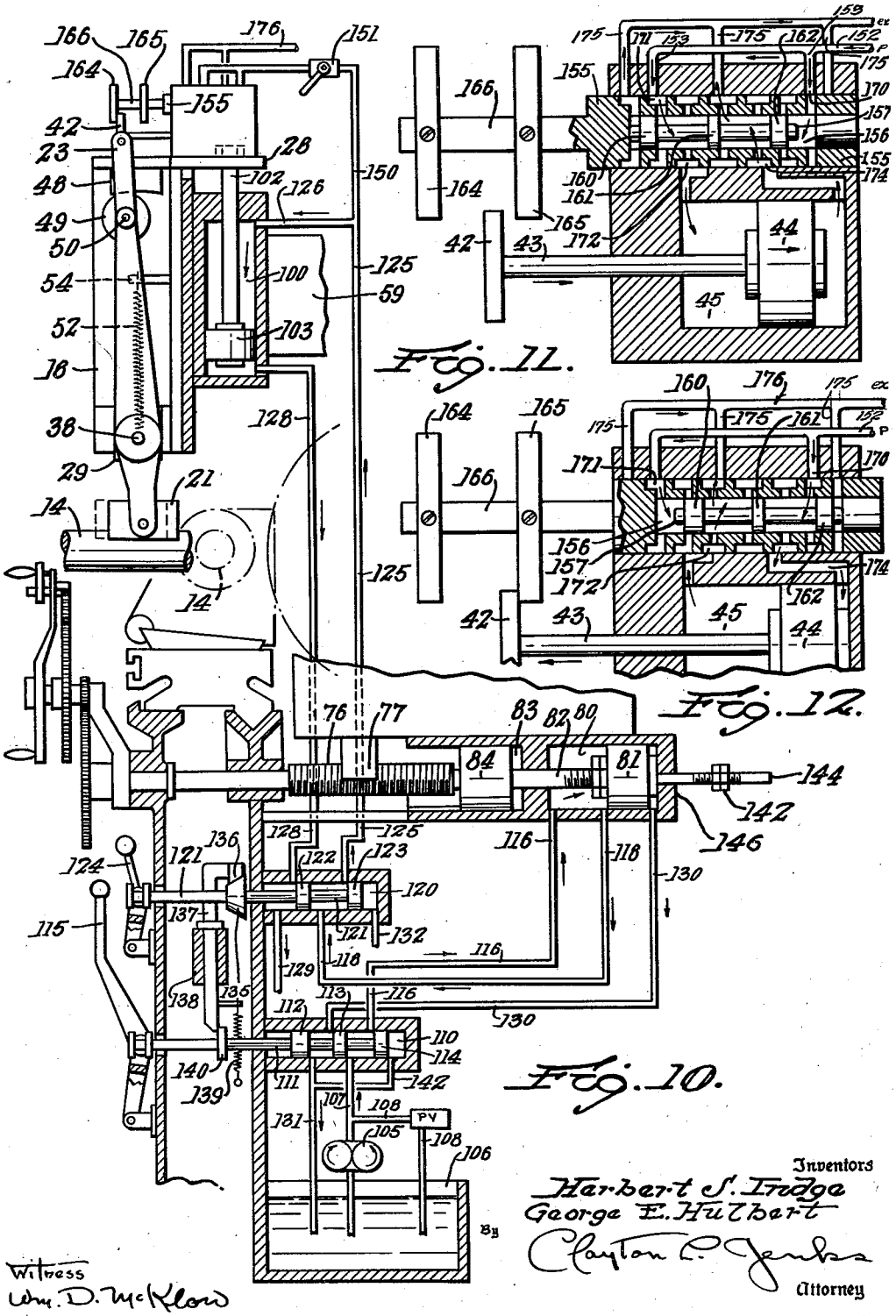


Fig. 11.

Fig. 12.

Fig. 10.

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CYLINDRICAL GRINDING AND LAPPING MACHINE

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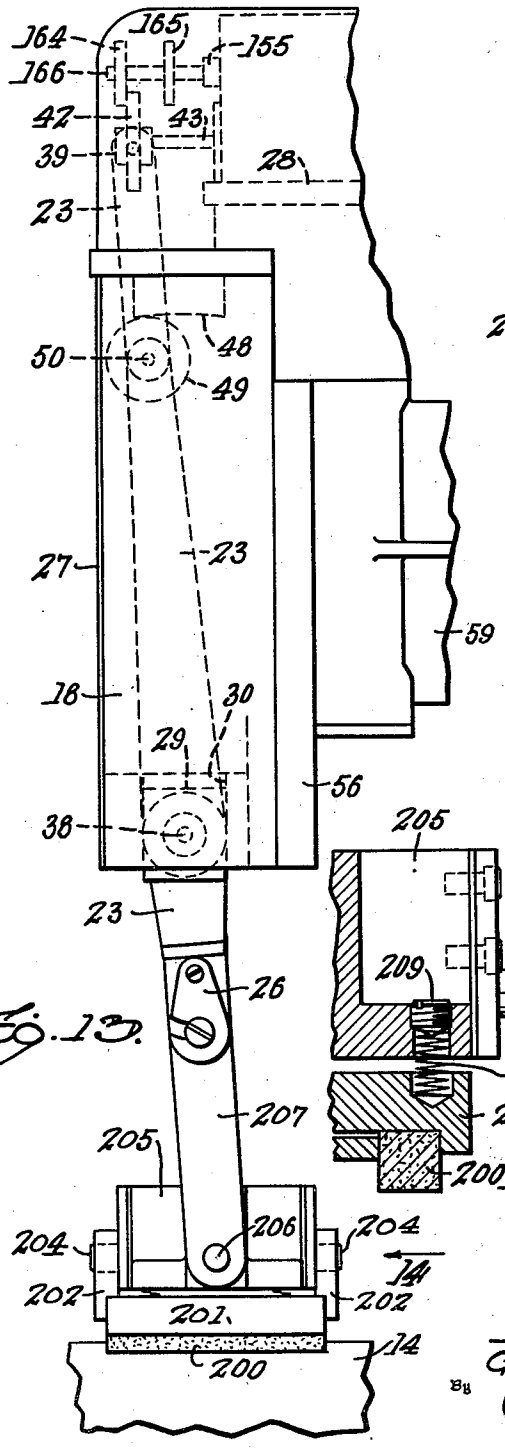


Fig. 13.

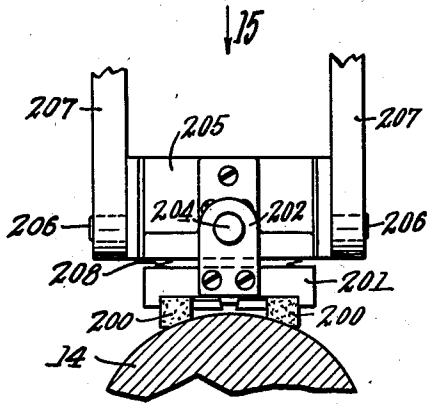


Fig. 14.

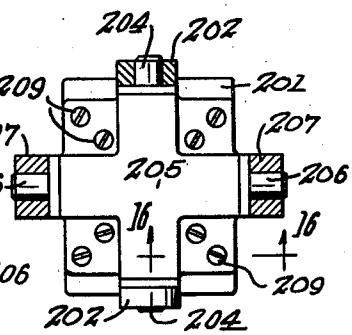


Fig. 15.

Fig. 16.

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Patented July 8, 1941 2,248,353

UNITED STATES PATENT OFFICE

2,248,353

CYLINDRICAL GRINDING AND LAPPING MACHINE

Herbert S. Indge and George E. Hulbert, Westboro, Mass., assignors to Norton Company, Worcester, Mass., a corporation of Massachusetts

Application March 9, 1939, Serial No. 260,676

9 Claims. (Cl. 51—67)

This invention relates to a cylindrical grinding and lapping machine, and more particularly to a machine arranged for grinding a cylindrical work piece by either an in-feed cut or a traversing operation and then finishing the work surface.

The machine tool industry requires today a far higher degree of accuracy and smoothness of surface or finish than in the past. For example, a bearing is required to be made with such a high degree of precision that it is not necessary to run in the bearing before it may be used normally. It, therefore, has been customary first to grind a bearing or other type of cylindrical surface to the required dimensions and thereafter to hone or lap that surface in a separate machine by means of abrasive members so arranged and operated as to form the required finish of surface and accuracy of dimensions. This not only requires the expense of having two entirely separate machines for the grinding and polishing operations, but it also involves various problems inherent in removing the work from the first machine and setting it up in the second, as well as the danger of injury to the work.

The primary object of this invention is to provide a grinding machine which will not only grind the work to required dimensions but will also insure the provision of a highly polished and accurately finished surface.

A further object of the invention is to provide a grinding machine which will both grind and lap the work without requiring removal of the work from its centers and which may be accomplished expeditiously and economically as well as efficiently.

In accordance with this invention, we have provided a grinding machine so arranged that the wheel may be operated to grind work pieces of different sizes and compensation for wheel wear made so as to perform a normal grinding operation. In addition, this machine includes a lapping device so constructed and arranged that when the grinding operation has been finished the lapping element may be brought into action to give the work a higher degree of finish. The lapping mechanism may be mounted on a head and arranged to be moved at the end of the grinding step to thrust the lap into contact with the work, and the parts are preferably so constructed and arranged that, irrespective of the size of the work or the required compensation for wheel wear, the lap will come automatically to a proper position and start the lapping operation when the grinding wheel is withdrawn.

A further object is accordingly to provide a machine of this type in which the parts are so inter-related and connected that the removal of the grinding wheel from the work automatically serves to position the lapping device and to start the lapping operation.

A further object is to provide a grinding machine with a lapping device which is so operated that work pieces of any desired size may be ground and compensation for wheel wear may be made and yet the abrasive lap will automatically come to a proper position each time that it is required for use. Other objects will be apparent in the following disclosure.

Referring to the drawings which illustrate a grinding machine embodying mechanisms for both grinding and lapping the work:

Fig. 1 is a front elevation of the grinding and lapping machine;

Fig. 2 is a section of the upper portion of the machine, taken on the line 2—2 of Fig. 1;

Fig. 3 is a fragmentary section on the line 3—3 of Fig. 2;

Fig. 4 is an elevation, partly broken away, of the lapping head;

Fig. 5 is an elevation, partly broken away, looking in the direction of the arrow 5 of Fig. 4;

Fig. 6 is a section on the line 6—6 of Fig. 4;

Fig. 7 is a fragmentary section on the line 7—7 of Fig. 4;

Fig. 8 is a section on the line 8—8 of Fig. 4;

Fig. 9 is a fragmentary section on the line 9—9 of Fig. 4;

Fig. 10 is a diagrammatic view of the hydraulic operating mechanism, with the lapping head and associated parts arranged 90° out of the plane;

Fig. 11 is a fragmentary diagrammatic enlarged view of the valve mechanism shown in Fig. 7;

Fig. 12 is a similar view with the parts in a reversed position;

Fig. 13 is a modification showing a different lapping head;

Fig. 14 is a detail of the lapping stick mount, looking in the direction of the arrow 14 of Fig. 13;

Fig. 15 is a plan view partly in section of the parts shown in Fig. 14; and

Fig. 16 is an enlarged detail on the line 16—16 of Fig. 15.

We have shown in the drawings a grinding machine of the type described in the U. S. patent to Wood No. 2,071,677; but it will be appreciated that various other grinding machine constructions may be employed with this invention. The machine illustrated comprises a base 10 having a work table 11 slidably mounted thereon and a wheel slide 12 arranged for movement toward

and from the work 14 mounted on the table. The mechanism for operating these various parts, except as herein described, may be as shown in said prior patent and others pertaining to a Norton grinding machine. The work piece, which is shown in Fig. 1 as a shaft having spaced bearings, is suitably mounted on centers and arranged to be both rotated and reciprocated past the grinding wheel 15; or the work may be a short piece no longer than the width of the wheel, in which case the wheel will be fed into the non-reciprocating work by what is known as a plunge-cut operation. The grinding wheel is suitably rotated by a motor 16 mounted on the wheel slide, and this assembly of wheel and driving motor is arranged to be moved back and forth towards and from the work by suitable mechanism, such as that illustrated and described in the patent to Belden and Cole No. 2,113,367 of April 5, 1938. The grinding wheel may be mounted if desired for reciprocation axially as shown in the patent to Flygare No. 2,101,794 wherein the wheel reciprocates parallel with its axis as it grinds the work and thus tends to make a smoother finish.

In accordance with our invention, we mount a lapping head 18 on the wheel slide 12. This lapping head 18 comprises one or more abrasive sticks 20 so mounted that they may be reciprocated lengthwise of the work when the latter is rotated. The abrasive sticks 20 may be made of suitable abrasive material, such as crystalline alumina or silicon carbide bonded with various types of bond, such as "Bakelite" resinoid or vitrified ceramic material. They are suitably mounted on a block 21 carried on the arms 22 (Figs. 4 and 5) which are removably mounted on the frame 23. The block 21 has trunnions 24 projecting laterally therefrom and fitting into two bearing holes in the spaced members 22. The latter are removably mounted on a pin 25 passing through the arms 23 and locked in position by a suitable pivoted latch 26 engaging a groove therein.

As illustrated in Fig. 8, the housing 18 is substantially U-shaped and has a cover plate 27 thereon. The housing 18 has a cross head 28 rigidly fixed thereto (Figs. 4 and 5) which is arranged to carry the motor mechanism that reciprocates the lapping sticks. The spaced parallel frame members 23 have blocks 29 (Fig. 8) secured thereto which slide in slideways 30 cut into inwardly projecting lugs at the bottom of the housing 18. The block and its slideway are short, since the vertical motion of these members is slight. Likewise, as shown in Fig. 4, the parallel frame members 23 are provided with spaced outwardly projecting bearing lugs 32 which slide against bearing surfaces 33 (Fig. 9) formed by slots 35 and 36 cut in the cross head 28, which are so arranged as to permit the frame 23 to rock laterally and to reciprocate vertically.

The frame members 23 are pivotally mounted in the slide blocks 29 by means of a pin 38 passing through the frame members and projecting into the blocks, and the latter are arranged to permit a freely swinging motion of the frame and the abrasive lap sticks carried on the bottom thereof. The two frame members 23 project above the cross head 28 and the upper ends carry blocks 39 (Fig. 4) projecting inwardly towards each other. Each block 39 is slotted (Fig. 6) and arranged to slidably engage a parallel sided disk 42 fitting within the grooves of the block 39, so that the disk may slide relative to these blocks as the frame member 23 rocks on the pivot pin 38. This disk is mounted on a piston rod 43 carrying a piston 44 located within a suitable hydraulic cylinder 45 and arranged, as hereinafter described, for reciprocation in such a way as to rock the frame 23 back and forth.

If the abrasive sticks were permitted to rock in an arcuate path, they would not contact properly with the work for lapping the same. A special feature of this construction comprises so mounting and arranging the parts that the abrasive blocks may move in a rectilinear path in full line contact with the rotating work during the lapping operation. This is accomplished by means of a cam 48 supported on the cross head 28. (Figs. 4, 5 and 7.) This cam engages a roller 49 pivotally mounted on a cross arm 50 extending between the two frame members 23. The cam face is peculiarly shaped so that as the frame rocks back and forth, the cam roller is forced by that cam to move the frame up and down and in such a manner that the abrasive sticks will themselves move in a straight line contact with the work. This vertical movement is permitted by the slides above described which locate the frame 23 within the housing 18. The frame is held upwardly, with its cam roller in contact with the cam, by means of a spring 52 connected at its lower end to the pivot pin 38 and at its upper end to an adjusting screw 53 mounted in a stud 54 projecting outwardly from the frame 18. Hence, as the frame is rocked by the piston, it will be forced to move up and down simultaneously and hold the abrasive blocks in a line contact with the work. The speed of reciprocation may be varied by suitably controlling the flow of fluid to the motor in order to suit the requirements of the lapping operation. It will therefore be seen that as the work rotates the lap is reciprocated, and thus provides a break up motion that prevents any given abrasive grain from cutting a deep gouge in the work. This lapping motion will serve whether the work is reciprocated axially or not.

In order to permit the abrasive sticks to be moved toward and from the work, the housing 18 has secured thereto two parallel slideways 56 (Figs. 5, 6 and 8) which are undercut to interfit with a dovetailed member 58 which forms a T-head on the slide member 59 (Figs. 5 and 6). The member 59 is provided with elongated slots 60 in which are mounted bolts 61 arranged for securing the same adjustably on a slide plate 62 which is connected through arm 63 with a slide 64 (Fig. 3). The slide member 64 has undercut or dovetailed bearing surfaces arranged to be mounted on a stationary support 65 which is in turn carried on the wheel slide 12. The stationary member 65 carries a rack 70 meshing with a gear wheel 71 pivotally mounted on the slide member 64 and turned by a hand wheel 72. This rack bar mechanism serves to adjust the lapping head and the lapping sticks relative to the center line of the work. The lapping head may be moved lengthwise of the work by adjusting the plate 59 relative to the plate 62.

To compensate for wheel wear, the wheel slide 12 is arranged to be operated by suitable micrometer mechanism indicated generally by the reference numeral 75, which is connected through a suitable telescoping coupling to rotate the feed screw 76 engaging the half nut 77 on the bottom of the wheel slide, and these various parts may

be as shown in the Patent No. 2,113,367 to Belden, et al. As shown diagrammatically in Figs. 2 and 10, and in said prior patent, the wheel slide may be moved toward and from the work by means of hydraulic mechanism comprising a cylinder 80 carrying a piston 81 mounted on the rod 82 passing through the cylinder head and connected to a further piston shaped member 84 riding within a second cylinder 83 which serves as a guide for the rod. This piston rod is suitably connected to the end of the worm 76 so that movement of the piston will move the wheel slide back and forth, as required.

The machine is preferably so constructed that when the wheel moves into engagement with the work, the lapping head will be out of operative position, and when the wheel moves back away from the work then the lapping head will be automatically adjusted to come exactly over and in contact with the work. In order to permit the grinding wheel to wear away and to be adjusted by the micrometer mechanism and not affect the proper position of the lapping sticks, the slide 64 is connected by a flexible chain 86 to a fixed portion 87 of the grinding machine frame. When the grinding wheel is moved forward, the lapping head can move forward with it until the chain becomes tight, and thereafter the chain holds the slide 64 from moving and the gear 71 rolls on the rack bar 70 and permits the grinding wheel slide to go ahead for the distance required. A gib 90 (Figs. 2, 3 and 5) is interfitted tightly between the dovetailed slideway 65 and the slide 64. This gib has an upturned lug 91 carrying an adjustable set screw 92 screwed into the slide 64, so that the parts are thus connected together. Hence, as the wheel is fed forward by the micrometer mechanism, the chain 86 will hold back on the lapping head and the friction gib will allow the required slippage to take place but prevent any lost motion. When the wheel housing is moved backwards by the piston 81 all of the parts will return to their rearward position with the lap properly positioned over the work and this will take place each time correctly without any movement relative to the gib, until the wheel is again adjusted by the micrometer mechanism. The rear wall of the piston chamber serves as a stop which determines the position of the lap over the work.

In order to permit movement of the abrasive sticks towards and from the work piece, the head 18 is arranged to be moved up and down by suitable fluid pressure mechanism. To this end, a piston chamber 100 (Fig. 5) is interposed between the dovetailed piece 58 and the slide member 59. The top of this cylinder is closed by a cap 101 through which slides a piston rod 102 having a piston 103 mounted on its lower end in the chamber. The piston rod 102 is attached to the cross head 28 so as to move the cross head and the housing 18.

The arrangement and operation of these various mechanisms is shown diagrammatically in Fig. 10. Oil is forced under pressure by any suitable pump, such as the oil gear pump 105, from a tank 106, through a pipe line 107, which has a pressure release valve and a pipe 108 for returning excess oil to the tank. The oil flows from the pipe line 107 to a manually controlled valve chamber 110 having a valve rod 111 carrying three pistons 112, 113 and 114 thereon. This valve is moved manually by means of a hand lever 115 suitably connected thereto.

When the valve lever 115 is thrown into the position illustrated, the oil passes from the valve chamber between the pistons 113 and 114 through a further oil pipe 116 to the piston chamber 80 where it operates to push back on the piston 81 and thus move the wheel slide rearwardly away from the work, or towards the right in Fig. 10. This rearward movement of the piston 81 ultimately opens a port into the pipe 118 and thus permits the oil to flow from chamber 80 to another manually controlled valve arranged to operate the lapping head. This valve has a chamber 120 containing a valve stem 121 and two pistons 122 and 123 mounted thereon. This valve is manually moved by a suitable hand operated lever 124 on the machine frame. The pistons in the chamber 120 are in such positions that the oil continues its passage from the space between the pistons and through pipe 125 and then through the cross pipe 126 into the piston chamber 100. This serves to push down on the piston 103 and thus move the lapping head downwardly to bring the abrasive sticks into contact with the work piece. The return flow of oil from beneath the piston 103 is through pipe 128 and thence into the lefthand end of the valve chamber 120 and out through pipe 129 to the oil reservoir 106. Similarly, any oil in the righthand end of the wheel slide operating piston chamber 80 returns through the pipe line 130 to the space between pistons 112 and 113 and thence through the pipe line 131 to the oil reservoir.

To reverse the direction of movement of the wheel slide and the lapping head, the valve control lever 124 is thrown to move the valve stem to the left and thus cause the oil flow to go up through the pipe 128 and the return oil to come down through pipe 125 and find its way to the reservoir through the righthand end of the valve casing and the outlet pipe 132.

As a safety measure to prevent moving the grinding wheel into contact with the work until the lapping sticks have been removed therefrom, we provide the interlocking arrangement shown in Fig. 10. This comprises a cone 135 so located on the stem 121 that when the valve stem is moved to the left, it cams upwardly on a cam 136 carried on the upper end of a sliding rod 137 sliding through a suitable bearing 138. The cam 136 is normally held downwardly against the cone by a spring 139 connected between the machine frame and a pin on the rod 137. Mounted on the valve stem 111 is a locking collar 140 which engages the lower end of the sliding member 137. These parts are so located that the lower valve cannot be moved to the left by means of the hand lever 115 until after the upper valve which controls the lapping head has been moved to thrust the lapping sticks out of contact with the work.

When the valve stem 121 has been moved to the left, but before valve stem 111 is moved, the oil will pass from pipe 118 to pipe 128 and move the piston 103 upwardly. The valve stem 111 may then be moved manually to the left. Then the oil travels upwardly from the pump through pipe 130 and pushes the piston 81 and the wheel slide towards the work. The oil exhausts from the lefthand end of this chamber 80 through pipe 116 back into the lower valve casing 110 and then through the pipe 142 to the oil reservoir. The piston 81 may move far enough to the left to pass beyond the port to pipe 118, so that oil coming up through the pipe 130 will again go through pipe 118 to pipe 128 and thus serve to

hold the piston 103 in its uppermost position. But, this arrangement permits moving the lap down while the wheel is grinding, by moving valve stem 121 to the right.

We may, however, adjust the nut 142 on the extending stem 144, which is fixed to and moves with piston 81, so that the nut will strike the end 146 of the piston casing and prevent piston 81 from uncovering the port to pipe 118. This holds the oil locked in the pipe 128 and keeps the lap piston 103 in its upper position. This prevents the lap from contacting with the work when the wheel is operating thereon.

The reciprocation of the lapping sticks may be accomplished by means of the mechanism shown in Figs. 7, 11 and 12, which is claimed in the application of Wood Serial No. 237,654 filed October 29, 1938. As shown, the oil passes from the pipe 125 through an extension 150 and a manually operated control valve 151 and into the pipe 152 which communicates through two passages with opposite ends of the valve casing. The reversing valve is made up of a hollow slidable cylinder or sleeve 155 having a set of ports therein through which oil passes to an inner chamber 156 within which slides the pilot valve stem 157. The pilot stem 157 has three pistons 160, 161 and 162 thereon. The pilot valve pistons and their stem are freely movable within the piston chamber 156 as determined by the direction of oil flow.

When oil is admitted through this reversing and pilot valve mechanism to the piston chamber 45, it moves the piston 44 one way or the other. The disk 42 on the end of the piston rod 43 is arranged to engage two adjustably mounted collars 164 and 165 on the reversing valve stem 166 connected to the sleeve 155 and thus serves to move that sleeve in one direction or the other. In Fig. 11, the piston is shown as moving toward the right, and thus the collar 165 will be struck when the piston has almost reached its righthand position. This serves to move the sleeve 155 into the position shown in Fig. 12, which causes a reversal of the oil flow and the piston to move in the other direction and strike the collar 164 and thus thrust the reverse valve into the position shown in Fig. 11.

The ports which lead the oil to and from the outside pipe lines are formed in a stationary sleeve 168 (Fig. 7) which is made as a separate element for the purposes of assembly. This extra sleeve is not shown in Figs. 11 and 12. The reversing valve sleeve 155 and the sleeve 168 are provided with a series of ports so located and arranged as shown in the drawings that they will accomplish this reversing motion and operate the pilot valve therefor. When the sleeve 155 has been moved to the left into the position shown in Fig. 11, the end plug in the sleeve carries the inner valve stem 157 with it, so that the valve is moved part way. This arranges the ports and valve pistons so that the oil will flow through pipe 152 to the pipe 153 and righthand port 170 (Fig. 11) in the sleeve 155 and into the pilot chamber 156 and thus serve to thrust the pilot valve piston 162 the rest of the way towards the left. When this has been accomplished, the oil will flow through the lefthand port 171 and into the lefthand portion of the chamber between the pistons 160 and 161 of the pilot valve, and this oil will then flow through a central port 172 into the lefthand end of the piston chamber 45 and thus thrust the piston 44 towards the right. The exhaust of oil in the righthand end of the piston chamber 45 will pass upwardly through the port 174 into the space in the pilot valve chamber between pistons 161 and 162 and then upwardly through a further port to the central exhaust pipe 175 and then through an exhaust pipe 176 which will bring the oil back to the reservoir.

When the piston 45 has reached the extreme righthand end of its travel and the reversing sleeve has once more been thrust toward the right, the valve stem 157 is carried part way towards the right by the end of the sliding sleeve. Then the ports will be arranged as to move the valve 157 the rest of the way towards the right as shown in Fig. 12, and again send the piston 44 back again towards the left. In this case, the oil now comes through pipe 152 and port 170 into the space between pistons 161 and 162 of the pilot valve, then through a second port into the passage 174 where the oil will now serve to push the piston 44 again towards the left. As shown in Fig. 12, the oil exhausts from the piston chamber 45 upwardly through port 172 into the space between the pistons 160 and 161 of the pilot valve and then upwardly through the exhaust valve and pipe connection 175 to the exhaust pipe 176. It will be noted by inspection of the drawings that the ports in the valve sleeve 155 are elongated and are so arranged and located that the oil will pass to and from the inlet pipes and the various piston chambers as above described. It will now be understood that the lapping head frame will be rocked and the sticks moved in a rectilinear path by the reciprocating motor and cam mechanism on the head. This goes on while the lapping head is down in its lowermost position, but when the valve lever 124 is moved towards the left, this shuts off the supply of oil to the pipes 125 and 150 and thus stops reciprocation of the lapping arm. Then the mechanism operates to move the head upwardly before the wheel slide can be moved forward.

The lapping sticks, as shown in Figs. 4 and 5, are pivotally mounted to swing only in one direction. In Figs. 13 to 16 inclusive, we have shown an arrangement in which the lapping sticks are universally mounted to swing in two directions during the lapping operation. To this end, the abrasive sticks 200 may be suitably mounted on a swivel plate 201 having two ears 202 which are pivotally mounted on pins 204 secured on a block 205. This block has opposed pins 206 mounted in bars 207 removably secured on the side plates 23 which form the sliding part of the head. These pins 206 project through holes in the lower ends of the bars 207. Sets of springs 208 are interposed between the two plates 201 and 205. These springs project into holes in the plates and are suitably secured in position by means of a cap screw 209 (Fig. 16) and thus tend to hold the abrasive sticks in a given position relative to the sliding arm 23 and so provide a certain degree of resiliency in their operation.

The operation of the device will be apparent in view of the above description. The grinding of the cylindrical piece will be accomplished in accordance with standard practice. When the surface has been reduced to size, then the grinding wheel will be retracted by throwing the lever 115. Previous to this the lapping sticks have been held out of contact with the work because of the oil remaining under pressure below the piston 103. However, as soon as the wheel has gone back from the work and the piston 81 has reached its rearward position as shown in Fig. 10, then the second valve lever 124 may be shifted to cause the lapping stick to descend and this same shifting

of the valve will start the oscillation of the lapping stick. When this operation has been finished then the reverse procedure as above explained may be carried out. Many advantages are inherent in this structure, as will be readily appreciated. In particular, it is now possible to grind a cylindrical work piece to a desired size and then finish the surface while the work remains set up in the grinding machine. This avoids the expense and delays involved in removing and mounting the work in another machine, and it especially insures that the cylindrical work surface will be finished with respect to the same axis on which that surface was ground.

It will now be appreciated that many modifications may be made in this construction and that various mechanisms may be employed for performing the desired results. Moreover, a simple type of machine may be constructed which does not embody all of the features above described. For example, the interlocking control of the valves need not be employed, so that the honing head and the wheel slide may be controlled wholly independently of each other. It, however, is to be noted that while it is entirely feasible to so arrange the parts that the lapping sticks may contact with the rotating work during the grinding operation, it is preferred that the construction be made as above described so that only one of the abrading elements, the wheel or the lapping stick, contacts with the work at a given time. This particularly insures that the grinding wheel will not interfere with the finishing operation performed by the lapping sticks. Furthermore, it will be appreciated that other types of motor may be substituted for the hydraulic mechanisms above described for operating the various parts. For example, one may employ an electric motor for reciprocating the lapping sticks, as is described in the companion application. Also, insofar as the automatic controls and operation of the machine are concerned, one may substitute other structures for the lapping head, provided these will reciprocate the lapping stick in linear contact with the work or with its operative face traveling in a plane parallel with the work axis. Owing, however, to the simplicity of construction and operation involved, it is preferred that these various mechanisms be operated hydraulically and with the inter-related controls as above described.

It will now be evident that the above description is to be considered as illustrative of the principles of the invention and of the preferred embodiment thereof and not as limitations on the claims appended hereto. The construction of the lapping device is claimed in a copending application of Indge and Wood Serial No. 258,916 filed on February 28, 1939.

We claim:

1. A grinding and lapping machine comprising a grinding wheel and means associated therewith for rotating a work piece and grinding a cylindrical surface thereon, an abrasive lapping stick, mechanism for reciprocating the stick in lapping contact with the rotating work surface while the work remains in its grinding position, mechanism for moving the lapping stick into contact with the work, means for moving the grinding wheel towards the work and means for preventing movement of the wheel towards the work until after the lapping stick has been removed therefrom.

2. A grinding and lapping machine comprising a grinding wheel and means cooperating therewith for rotating a work piece and grinding a cylindrical surface thereon, means for moving the wheel into and out of operative contact with the work, an abrasive lapping stick, means for reciprocating the same in contact with and along an element of the rotating work, separate mechanisms for moving the grinding wheel and the lap respectively into and out of contact with the work and means which prevents operation of the wheel moving mechanism to move the wheel towards the work while the lapping stick is operating thereon.

3. A grinding and lapping machine comprising means for rotatably supporting a cylindrical work piece, means including a wheel slide and grinding wheel mounted thereon for grinding a cylindrical surface on the work, manually controlled mechanism arranged to move the wheel toward and from the work and to compensate for wheel wear, a lapping stick, means for reciprocating the stick along an element of the work, a support for the lapping stick carried on the wheel slide and means rendered operative by movement of the slide which brings the lapping stick automatically into lapping position relative to the rotating work, irrespective of the adjustment of the wheel slide to compensate for wheel wear.

4. A grinding and lapping machine comprising a rotatable work support, a grinding wheel and associated mechanism for moving the wheel forward and grinding a cylindrical surface on the work, a lapping stick, means for oscillating the lapping stick along an element of the work surface and holding it with a substantially uniform pressure thereagainst, mechanism for moving the lapping stick into and out of contact with the work and mechanism for moving the wheel into contact with the work which is inoperative when the stick is in comtact with the work and is rendered operative by removal of the stick from the work.

5. A grinding and lapping machine comprising a rotatable work support, a grinding wheel and associated mechanism for grinding a cylindrical work piece, a lapping stick, means for oscillating the same in operative contact with an element of the rotating work surface, means for moving the grinding wheel towards and from the work, means for moving the lapping stick towards and from the work, and coordinated mechanism for moving the wheel and the lapping stick independently toward and from the work which prevents one from being moved while the other is moved to and from an inoperative position.

6. A grinding and lapping machine comprising means for rotating a cylindrical work piece, a grinding wheel, a wheel slide therefor, hydraulically operated mechanism for moving the wheel towards and from the work, a lapping stick, means for oscillating the same along an element of the work, an hydraulically operated mechanism for moving the lapping stick into contact with the rotating work, and means including valves and inter-related control devices for the hydraulic mechanisms which prevents the grinding wheel and the lapping stick from being moved toward operative positions simultaneously.

7. A grinding and lapping machine comprising means for rotating a cylindrical work piece, a grinding wheel for grinding the same, a wheel slide, manually operated means for positioning the wheel relative to the work, hydraulically

operated mechanism for moving the wheel slide and wheel toward and from the work, a lapping stick arranged to contact with the rotating work, hydraulically operated mechanism for moving the stick toward and from the work, hydraulically operated mechanism for oscillating the lapping stick in lapping contact with the work and means including coordinated valve mechanism which causes the grinding wheel and the lapping stick to be out of contact with the work when the other contacts therewith.

8. A grinding and lapping machine comprising a grinding wheel and means associated therewith for rotating a work piece and grinding a cylindrical surface thereon, a slide carrying said wheel, mechanism for moving the slide to position the wheel in contact with the work, an abrasive lapping element, a separate mechanism for moving said element into contact with the work, means for positively preventing operation of the wheel positioning mechanism until the lapping element has been removed therefrom and means for reciprocating the lapping element in contact with the rotating work.

9. A machine for grinding and lapping a work piece comprising mechanism including centers for rotating a work piece, means including a grinding wheel and feed mechanism for grinding the work piece, and a device for lapping the work piece while rotating on said centers including a lapping stick and means for reciprocating the stick along an element of the rotating work at a rate relative to that of the work which provides a breakup lapping action and power mechanism for moving the lapping stick towards and from contact with the work and holding it thereagainst and a manually operated device for controlling the operation of the power mechanism.

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