Sept. 26, 1939. H. L. BLOOD ET AL 2,174,029

HONING MACHINE

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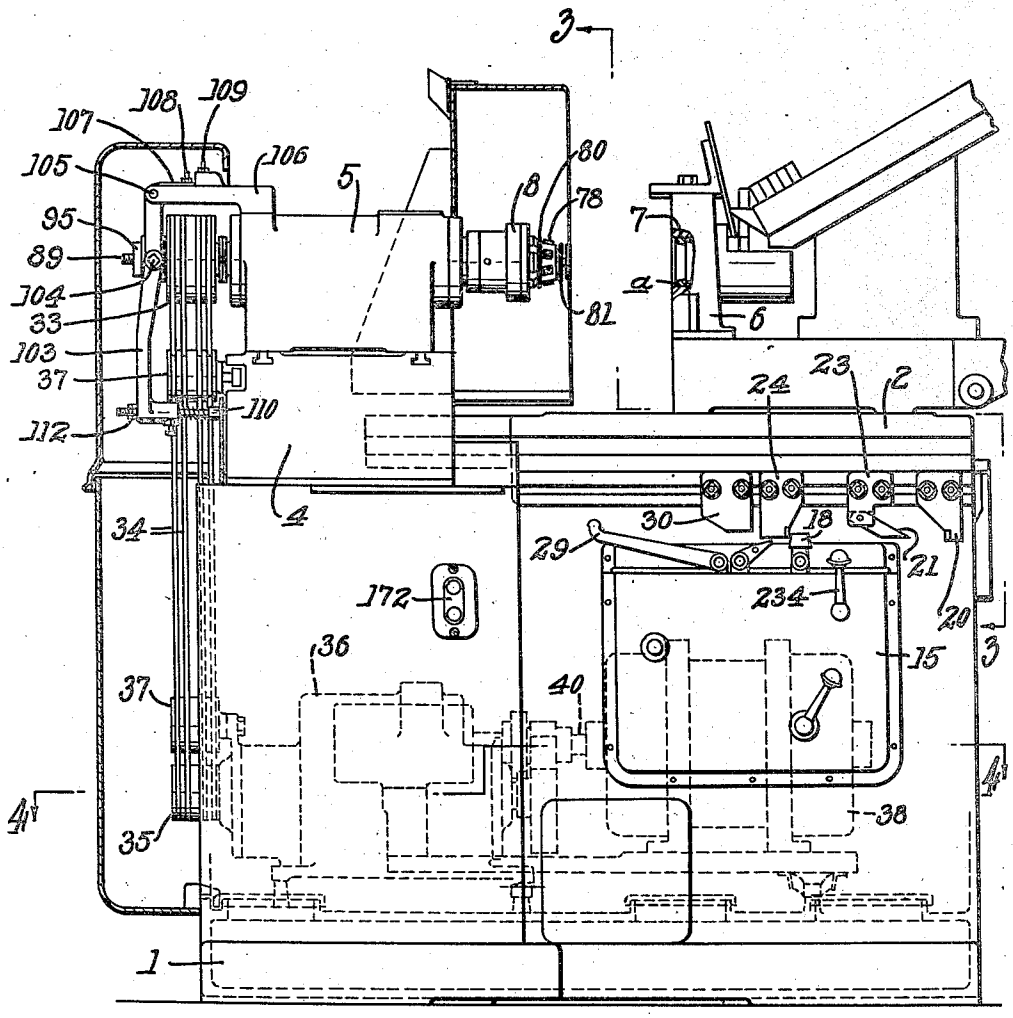


Fig. 1.

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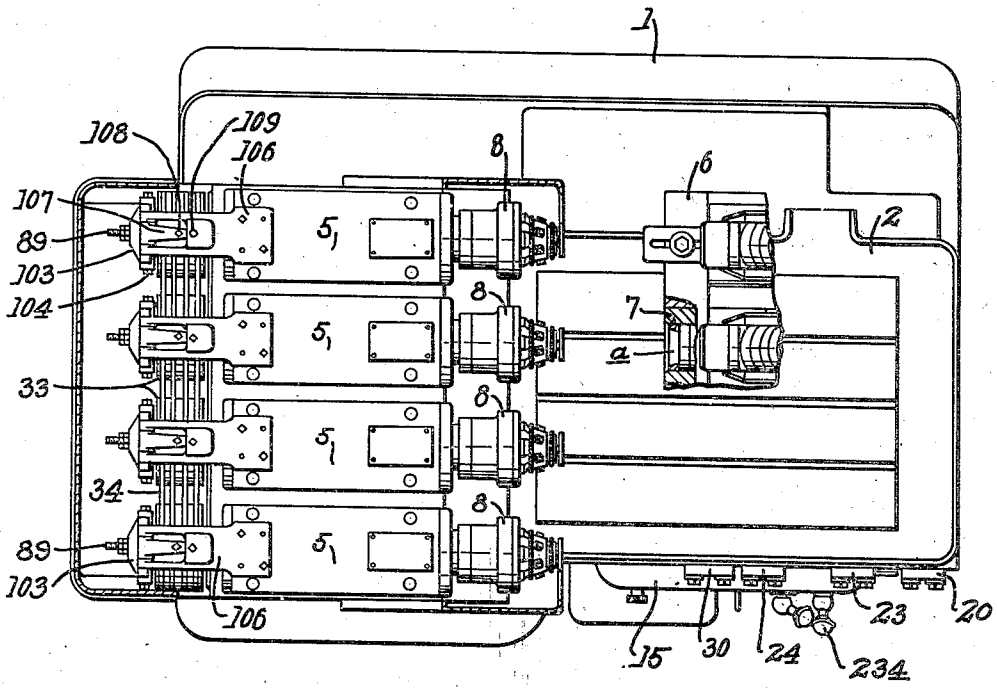


Fig. 2.

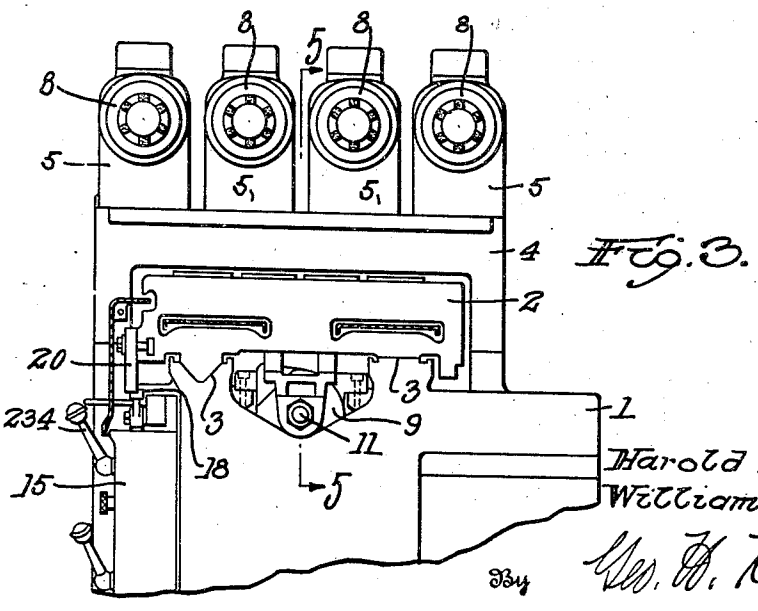


Fig. 3.

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HONING MACHINE

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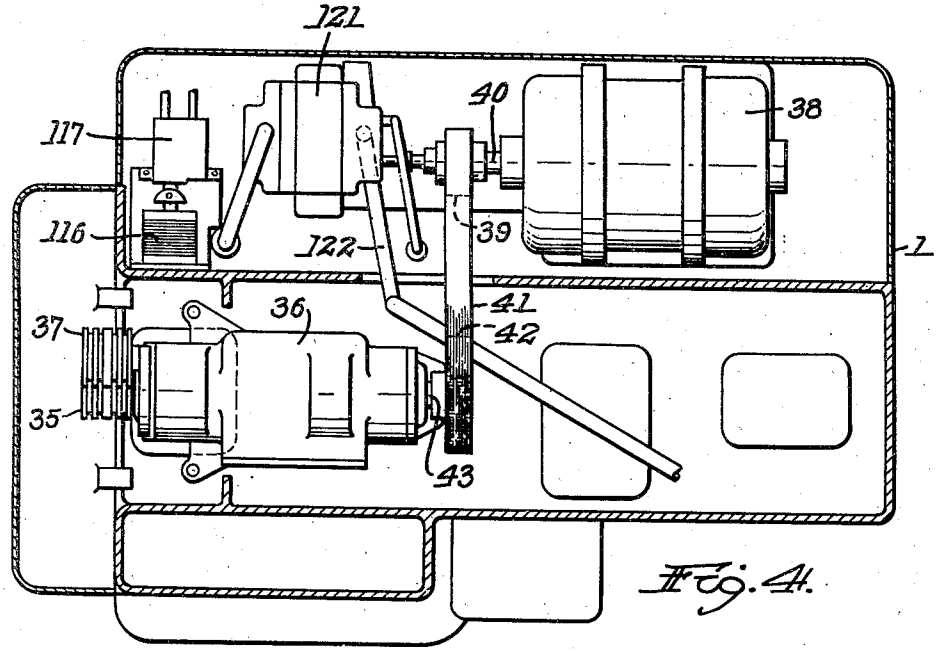


Fig. 4.

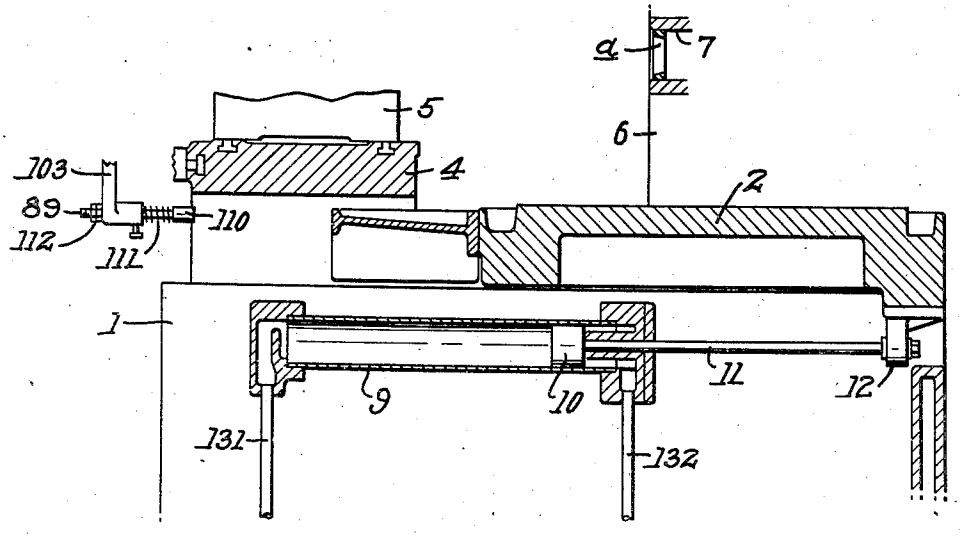


Fig. 5.

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HONING MACHINE

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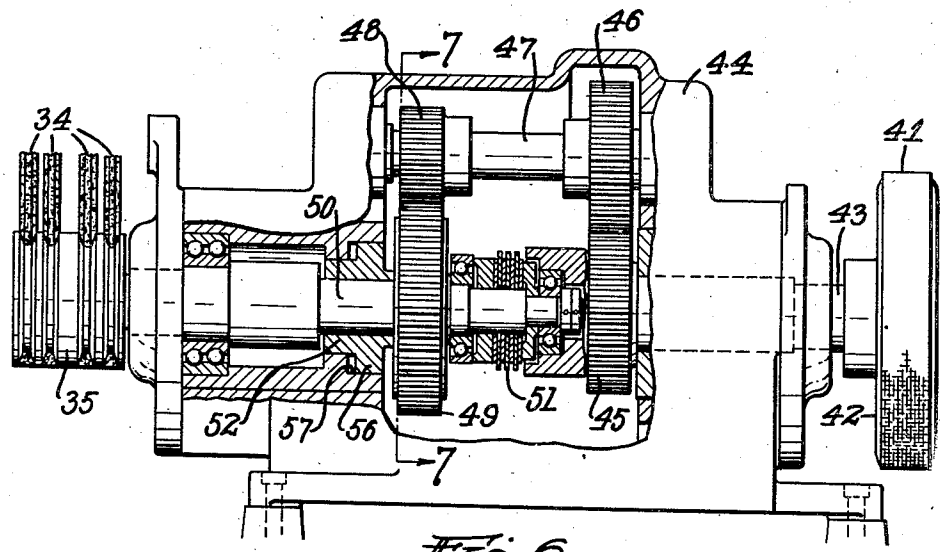


Fig. 6.

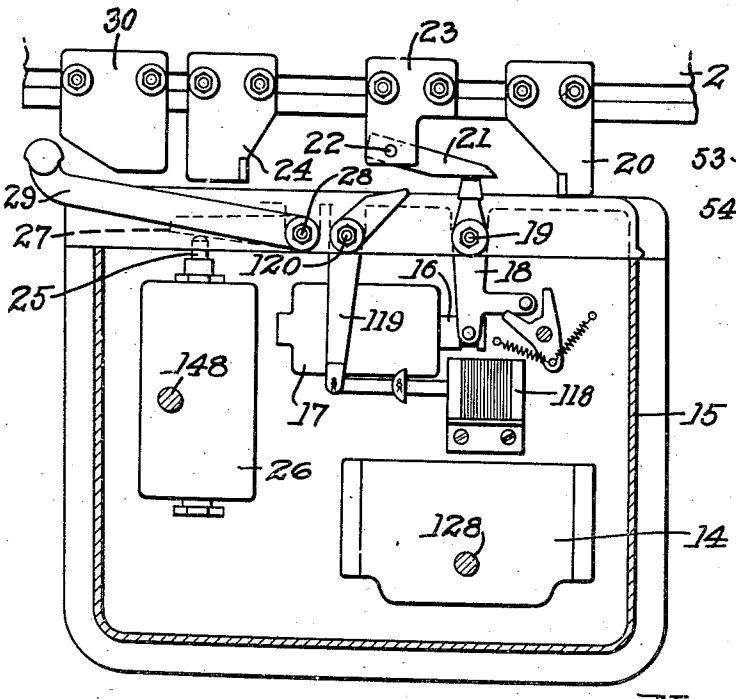


Fig. 8.

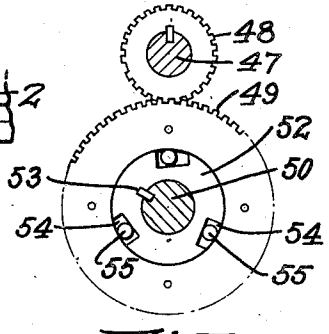


Fig. 7.

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HONING MACHINE

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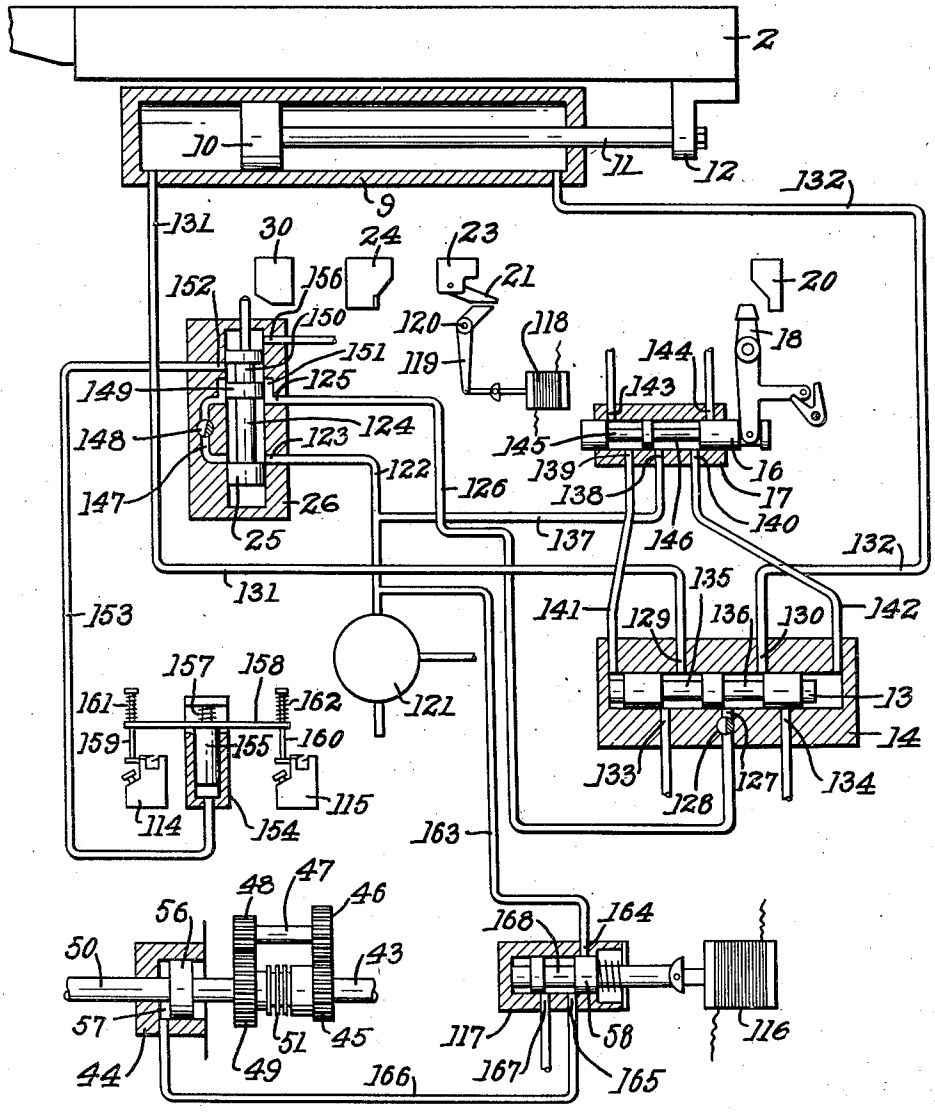


Fig. 9.

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HONING MACHINE

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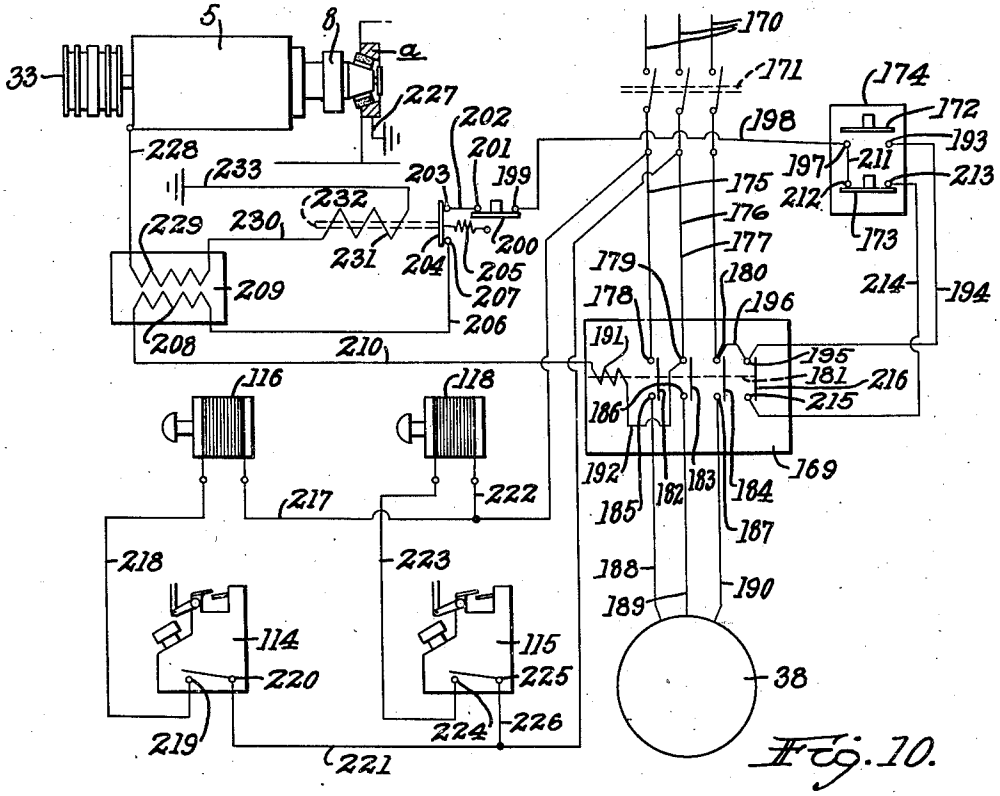


Fig. 10.

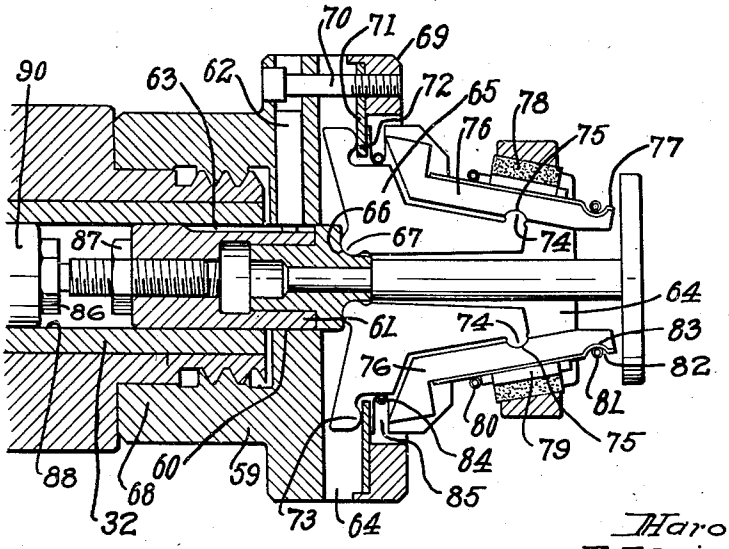


Fig. 11.

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HONING MACHINE

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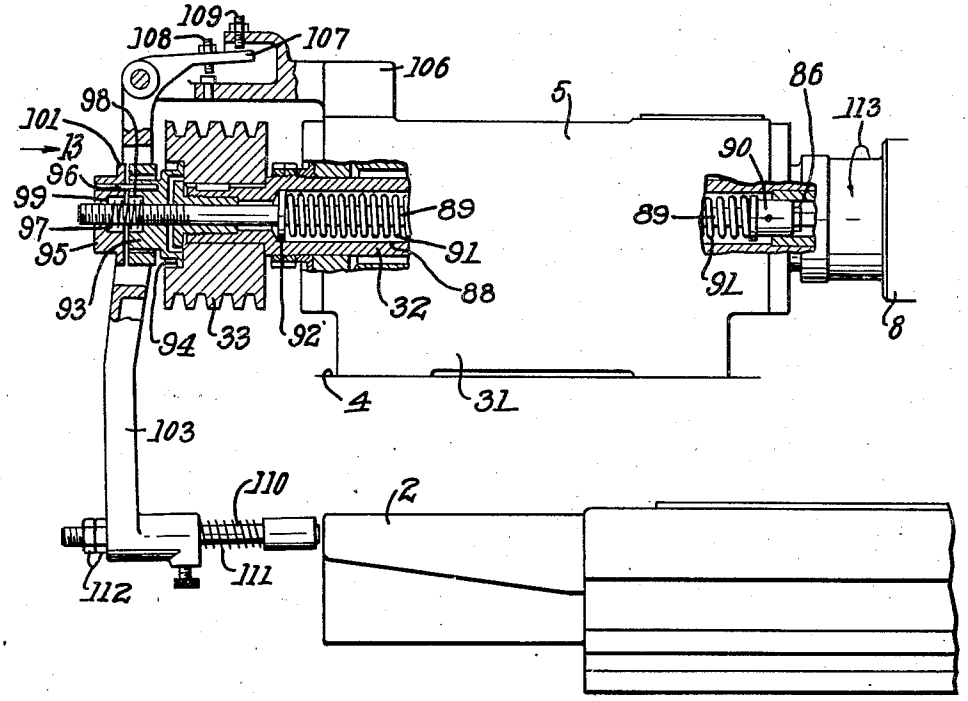


Fig. 12.

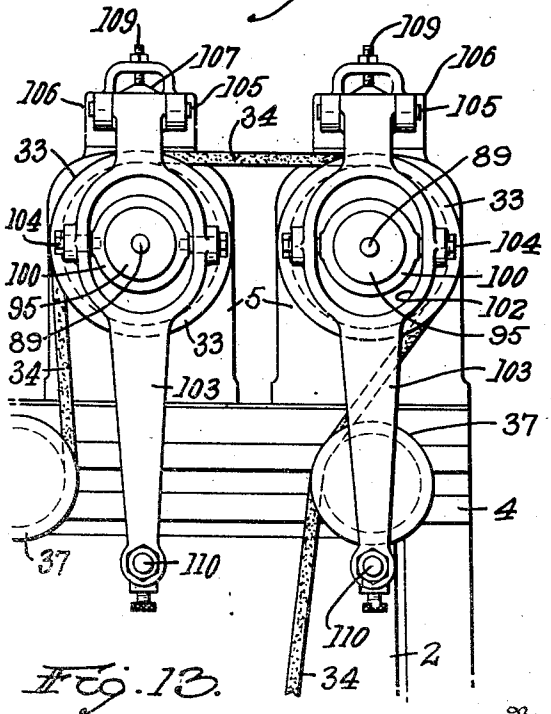


Fig. 13.

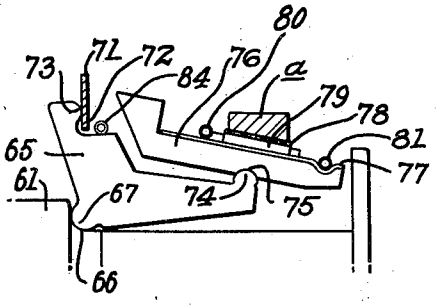


Fig. 14.

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Patented Sept. 26, 1939 2,174,029

UNITED STATES PATENT OFFICE

2,174,029

HONING MACHINE

Harold L. Blood and William D. Schmidt, Worcester, Mass., assignors to The Heald Machine Company, Worcester, Mass., a corporation of Massachusetts

Application October 2, 1936, Serial No. 103,725

8 Claims. (Cl. 51—93)

The present invention relates to a machine adapted for the honing of workpieces and is especially intended for the successive honing of a plurality of uniformly sized workpieces.

In prior devices for honing, either the workpiece or the hone has been rotated at a predetermined rate throughout the entire honing operation and, although a suitable finish is obtained, a greater length of time is required than where the honing operation can be performed with the hone and workpieces rotated at different successive relative rates of speed during a honing operation. One of the principal objects of the present invention is to provide for automatically changing the relative rate of rotation of the hone and the workpiece during the honing operation, with the change in the rate of speed preferably procured automatically in predetermined timed relation to the end of the honing operation.

In a large number of honing operations if the honing members exert the required pressure against the workpiece the desired surface finish will be obtained in a predetermined time interval and the present invention also provides for bringing the honing operation to a close after the honing members have been operating upon the workpiece for a predetermined time.

The honing members are generally in the form of small stones of abrasive material and, as the stones are used, they gradually become worn, making necessary an adjustment of the position of the honing members to compensate for the wear thereon. The present invention incorporates a structure for automatically compensating for wear on the hones so that the compensation takes place when necessary independently of the individual honing operations. By this compensation, the honing stones always exert the required pressure on the work for obtaining the desired surface finish.

As the stones become more and more worn the holders on which the stones are mounted approach and ultimately engage the surface of the workpiece. If the honing operation continues after this occurs the surface of the workpiece will be scratched or damaged by the holder, thus making the workpiece unsalable. The present invention incorporates a mechanism by which the entire machine is brought to rest after any one of the honing members becomes worn to such an extent as to be no longer usable. This mechanism is arranged to prevent the further operation of the machine, after having been brought to rest, until the worn honing member, or members, have been replaced by unworn members which will produce a satisfactory honing operation on the workpiece.

Other and further objects and advantages of the invention will more fully appear from the following detailed description taken in connection with the accompanying drawings in which—

Fig. 1 is a front elevation of a machine embodying the invention, with parts broken away to show certain features.

Fig. 2 is a plan view of the machine, also with parts broken away.

Fig. 3 is a vertical sectional view substantially on the line 3—3 of Fig. 1.

Fig. 4 is a horizontal sectional view through the machine substantially along the line 4—4 of Fig. 1.

Fig. 5 is a fragmentary vertical sectional view substantially along the line 5—5 of Fig. 3.

Fig. 6 is a view in elevation, with parts broken away, of the two-speed drive mechanism for the honing members.

Fig. 7 is a sectional view along the line 7—7 of Fig. 6.

Fig. 8 is an elevation of the mechanism within the control box on the front of the machine.

Fig. 9 is a fluid pressure diagram.

Fig. 10 is a wiring diagram.

Fig. 11 is a vertical sectional view on a larger scale, through one of the hones.

Fig. 12 is an elevation, with parts in section, of one of the honing heads, together with the mechanism which compensates for wear on the honing stones.

Fig. 13 is an end view of two of the honing heads as seen from the left in Fig. 12.

Fig. 14 is a fragmentary elevation of one of the honing stones and its supporting mechanism showing the position of the parts when the hones have been materially worn.

Like reference characters refer to like parts in the different figures.

With reference first to Fig. 1, the machine, which discloses one embodiment of the invention, has a base 1 on which is mounted for reciprocation a table 2, the base being provided with guideways 3, Fig. 3, on which the table is slidable. A bridge 4, Figs. 1 and 3, spans the guideways and extends over the table at one end of the base. Either the work or the hone may be mounted on the table for procuring a relative movement between the members. In the arrangement shown, the bridge carries a plurality of honing heads 5, only one of which will be described, and the workpieces *a* to be operated upon by the alined

honing heads are mounted in a bracket 6 secured to the table.

This bracket incorporates an automatic loading mechanism which is not a part of the present invention. It is sufficient to note that the workpiece *a* to be honed is positioned in a cylindrical bore 7 in the bracket 6 and is in axial alinement with the hone 8 on each honing head 5 for engagement by the hone as the table moves to the left to bring the hones and workpieces into engagement. The honed workpieces are discharged and unhoned workpieces automatically placed in operative position by a suitable mechanism preferably controlled by the table movements. Thus, as the table moves to the left into operative position, an unhoned workpiece is positioned in alinement with each hone and in proper position in the workholder.

The table 2 is shifted by any suitable mechanism, as by the fluid pressure actuated mechanism, best shown in Fig. 5. With reference to this figure, the base 1 has positioned therein a cylinder 9 in which is located a piston 10, the projecting piston rod 11 of which is connected to a lug 12 projecting downwardly from the table. Fluid under pressure is directed alternately to opposite ends of the table cylinder by means of a reversing valve 13, Fig. 9, located in a casing 14, which, as shown in Fig. 8, is positioned in a control box 15 on the front of the base. The position of the main reversing valve 13 is under the control of a pilot valve 16, Figs. 8 and 9, in a casing 17, also located within the control box.

A reversing lever 18 pivoted on a stud 19 on the base has one end in engagement with the projecting stem of the pilot valve and the opposite end is in a position for engagement with spaced reversing dogs 20 and 21 which are adjustably mounted on the front of the table and which provide for a reciprocation of the table in operative position. The reversing dog 21 is pivotally mounted on a pin 22 carried by a block 23 to provide for raising of said dog (to the position of Fig. 8) to render it inoperative, thereby allowing an extended movement of the table to the right (Fig. 1), for withdrawing the workpieces from operative position. An additional reversing dog 24, also adjustably mounted on the table, is in a position for engagement with the reversing lever as the table reaches the end of its movement into inoperative position (the position of Fig. 1) to return the table to operative position, unhoned workpieces being inserted in the workholder during the extended movement. The fluid pressure mechanism will be described in detail later.

Referring again to Fig. 8, the movements of the table into and out of operative position occur preferably at a maximum rate of table travel and the reciprocations of the table in operative position occur at a relatively slow rate as determined by a throttle valve 25 in a casing 26 within the control box 15. The projecting end of the valve 25 is in a position for engagement with an arm 27 mounted on a stub shaft 28 journalled in the base of the machine. An arm 29 is also mounted on the shaft 28 for turning movement therewith. The free end of the arm 29 extends upwardly into engagement with the under surface of a block 30 adjustably mounted on the table, and this block, when the table is in operative position, engages and depresses the arm 29, turning the arm 27 down and thereby shifting the throttle valve to reduce the rate of travel of the table, as will be hereinafter fully described in connection with the fluid pressure mechanism.

Each honing head 5 comprises a housing 31, Fig. 12, secured to the upper side of the bridge and within each housing is suitably journalled a spindle 32 having secured to its left hand end a pulley 33 by which the spindle is rotated. One hone 8 is mounted on the right hand end of each spindle in a position to engage a workpiece in the work-supporting structure. The pulleys 33 for the several honing heads are connected by belts 34, Fig. 1, to the driving pulley 35 of a two-speed drive mechanism 36, Fig. 4. Suitable idler pulleys 37, Figs. 1 and 13, take up the slack in the belts and are positioned to provide a suitable wrap of the belts around each of the pulleys.

A driving motor 38, Fig. 4, has a driving connection with the two-speed drive mechanism 36 and this connection in the arrangement disclosed embodies a sprocket 39 on the motor shaft 40 connected by a chain belt 41 to a sprocket 42 on the driven shaft 43, (see also Fig. 6) of the mechanism for a positive rotation of the driven shaft 43 at all times.

With reference to Fig. 6, the driven shaft 43 is journalled in the housing 44 of the two-speed drive mechanism, and has secured thereon a gear 45 which is in mesh with a gear 46 on a countershaft 47, also journalled in the housing 44. The countershaft has a second gear 48 which is in mesh with a gear 49 connected by means of a one-direction clutch, shown in Fig. 7, to the driving shaft 50 of the mechanism, the latter having secured to its outer end the pulley 35. A disk clutch 51 provides a direct connection between the shafts 43 and 50, which are in alinement with each other, and this clutch is rendered operative by axial movement of a hub 52 which is axially slidable on the shaft 50, but held against turning movement thereon by a key 53, Fig. 7. The hub 52 has a plurality of notches 54 therein, in each of which is positioned a roller 55, and the gear 49, in the form of a ring, is journalled on the periphery of the hub 52. As shown in Fig. 7, the notches 54 are of such a shape that the gear 49 is free to turn counterclockwise on the hub, but cannot turn clockwise without a corresponding movement of said hub.

The hub 52 also has a radial flange which forms a piston 56, Fig. 6, slidable in a cylinder 57 provided by the housing 44, and the axial shifting movement of the hub for rendering the clutch 51 operative is procured by directing fluid under pressure to the cylinder 57 at the left hand side of the piston 56.

When fluid under pressure is directed to the cylinder 57 the clutch 51 is operative and the pulley 35 is driven directly from the shaft 43 and at the same rate of speed, with the gear 49 turning freely on the hub 52. When the rate of rotation of the hones is to be reduced, the fluid in the cylinder 57 is allowed to exhaust by means of a valve 58, Fig. 9, hereinafter described. The clutch 51 then becomes inoperative so that the drive for the hones is through the countershaft 47, at which time the gear 49 is directly connected to the hub 52 by means of the rollers 55, and procures a rotation of the pulley 35 at a relatively slow rate of speed, as determined by the relative sizes of the gears 45, 46, 48 and 49.

The hone disclosed is similar to the hone described in a copending application filed by Blood, one of the present applicants, Serial No. 100,580, filed September 14, 1936, although any other similar type of hone can be used. It is sufficient to note for the purposes of the present application that the hone comprises a head or arbor

59, Fig. 11, having an axial bore 60, in which a spindle 61 is slidable. The head has a radial key 62 engaging with a keyway 63 in the spindle to hold the latter against rotation. The head 59 also has a plurality of radial slots 64, in each of which is positioned a hone carrying lever 65. The spindle 61 has an arcuate shoulder 66 engageable with an arcuate protuberance 67 at the corner of each of the levers. The spindle 61, as shown, is made up of separate elements which are, however, functionally integral and are so described. A cylindrical hub 68 on the head has an internal thread to provide for attachment to the end of the spindle 32 in the honing head.

Surrounding the head at the base of the slots is a ring 69 secured to the head, as by bolts 70, one of the latter holding the key 62 in position. Between the ring 69 and the head is clamped a resilient annular disk 71 in the form of a diaphragm having fingers 72 projecting inwardly into the several slots 64.

Each lever 65 has an arcuate lug 73 at one end for engagement with the inner or left hand side of the corresponding finger 72 to permit rocking movement of said lever about the lug. The opposite end of the lever has an arcuate lug 74 which engages in an arcuate recess 75 in a hone carrier 76. On the outer side of each carrier is a plate 77 to which is secured, as by suitable adhesive, a honing member in the form of a stone 78, generally of abrasive material. The honing stones are additionally held on the carrier plates 77 by flanges 79 extending outwardly from the plates.

The plates 77 are releasably held on the carriers by coil springs 80 and 81, each in the form of an annulus. The spring 80, is positioned at the inner or left hand end of the plates and engages with the flanges 79 on the plate. The other coil spring 81 is positioned in a recess 82 in the outer end of each of the plates, the inturned portion of the plate which forms the recess engaging in a correspondingly shaped recess 83 in the carrier. Not only do these coil springs hold the plates on the carrier, but they also hold the carriers in engagement with the corresponding levers 65 and hold the levers 65 against the spindle 61. The levers are also held in predetermined relation to each other by a coil spring 84 also in the form of an annulus, and positioned in a slot 85 provided in the head 59. The spindle 61 has an axially positioned bolt 86 in the end thereof by which to control the effective length of said spindle, the bolt being locked in adjusted position by a clamping nut 87.

For expanding and contracting the hone, the spindle 32 has an axial bore 88, Figs 11 and 12, in which the inner end of the spindle 61 is received. Within the spindle bore 88 is located an actuating rod 89, having at the right hand end thereof a plunger 90 engageable with the head of the bolt 86, and the rod is resiliently urged to the right by a compression spring 91 surrounding the rod and positioned between the plunger 90 and a collar 92 positioned within the bore 88. Movement of the rod 89 to the right, Fig. 12, for expanding the hone is limited by a nut 93 engaging with the threaded left hand end of the rod, said nut having a projecting flange 94 engageable with the end of the pulley 33. A second nut 95 on the rod is held against turning movement relative to the nut 93 by a pin 96 extending through both nuts, and a coil spring 97, positioned in opposed recesses 98 and 99 in the nuts 93 and 95, respectively, urges the nuts apart to place a frictional drag thereon so that the nuts are frictionally held against turning movement.

When the honing stones become worn the nuts 93 and 95 are backed away on the rod to compensate for the reduction in size of the stones, and this backing away is automatically effected by the mechanism of Figures 12 and 13. With reference to these figures, the nut 93 has a collar 100 extending therearound and in a position for engagement with a radial flange 101 on the nut 95. The collar is mounted in an open slot 102 in an arm 103 and is carried by bolts 104 extending inwardly from opposite sides of said slot and providing trunnions for said collar. The arm 103 is journalled on a pin 105 in a bracket 106 secured to the honing head. A projecting bar 107 forming part of the arm 103 has an adjustable stop 108 engageable with a part of the bracket 106, and an adjustable stop 109 in the bracket is engageable with the bar 107, the cooperating stops 108 and 109 limiting the rocking movement of the arm 103 in both directions.

The lower end of the arm 103 has a plunger 110 slidably mounted therein and normally urged into the right hand position of Fig. 12 by a coil spring 111 surrounding the plunger. The movement of the latter to the right is limited by adjusting nuts 112 on said plunger. The plunger is in a position for engagement with the end of the table 2 as the latter reaches operative position, and an oscillation of the arm 103, as controlled by the stops 108 and 109, occurs during the reciprocatory movement of the table during the honing operation.

In the normal oscillatory movement of the arm 103, the collar 100 does not come in contact with the flange on the nut 95, since the latter is also moved to the left as the result of the table movement to the left when the workpiece is in operative position, the reciprocations of the workpiece providing a corresponding reciprocation of the rod 89. As the hones become worn so that compensation for wear is necessary, the nut 95 gradually comes into contact with the collar 100 with sufficient pressure for the nut to be held against turning movement until the nuts 93 and 95 have been backed off a slight amount on the rod 89. Obviously, the spindle 32 in which the rod 89 is positioned must be rotated in the direction indicated by the arrow 113, Fig. 12, so that the nuts 93 and 95 will be turned in the proper direction.

The machine is arranged to provide for a honing operation at two separate speeds, with the hone rotated relative to the workpiece at one speed for a predetermined interval and subsequently rotated at a different speed as determined by the two-speed drive for another predetermined interval, at the end of which time the honing operation is brought to a close. To this end, the operation is under the control of two separate timers 114 and 115, Fig. 9, of any suitable character. Timers of this character are well known and it is sufficient to note for the purpose of the present invention that each timer is intended to operate a predetermined time after having been set in operation, with the time interval preferably adjustable as desired. In the arrangement shown, the timers are both set in operation together, and the timer 114 operates after the lapse of a few seconds and procures the change in the rate of rotation of the hone, or any other change in the honing operation, and the second timer 115 operates a predetermined time

thereafter to render the reversing dog 21 inoperative for a runout of the table, bringing the honing operation to a close.

When the timer 114 operates, it energizes a solenoid 116, Fig. 9, through a circuit hereinafter described, to shift the valve 58 located in a casing 117 for directing fluid under pressure to the cylinder 57, thereby changing the rate of rotation of the hones. When the timer 115 operates, it energizes a solenoid 118 which is connected to a lever 119 journalled on a stud 120 in the base of the machine. The upper end of this lever is moved into alinement with the reversing dog 21, when the solenoid 118 is energized, and elevates the latter so that it is carried over the end of the reversing lever 18 without engagement therewith, allowing the table to move to the right into the position of Fig. 1.

With reference again to Fig. 9, the fluid pressure supply for the machine is provided by a pump 121 which, as shown in Fig. 4, is directly connected to the driving motor 38 and is accordingly operated whenever the driving motor is rotating. Fluid under pressure from the pump is directed by a conduit 122 to a port 123 in the casing 26 for the slow-down valve 25. The valve 25 has a reduced portion 124 which normally provides a fluid connection between the port 123 and a second spaced port 125 which is connected by a conduit 126 to the inlet port 127 in the reversing valve casing 14. A throttle valve 128 is positioned in the port 127 and determines the maximum rate of travel of the table. Spaced ports 129 and 130 in the reversing valve casing 14 are connected to the left and right hand ends of the table cylinder 9 by conduits 131 and 132 respectively. The valve casing 14 also has spaced exhaust ports 133 and 134. The valve 13 has spaced reduced portions 135 and 136 which normally provide a fluid connection between the inlet port 127 and one of the outlet ports 129 or 130, the other outlet port being simultaneously connected to one of the exhaust ports 133 or 134.

The position of the reversing valve 13 is under the control of the pilot valve 16, and the conduit 122 has a branch conduit 137 connected to a port 138 in the casing 17 for the pilot valve. Spaced outlet ports 139 and 140 in the casing 16 are connected by conduits 141 and 142 to the opposite ends of the reversing valve casing 14. The casing 17 has spaced exhaust ports 143 and 144. The pilot valve 16 has spaced reduced portions 145 and 146 which provide fluid connection between the port 138 and either of the ports 139 or 140 selectively, the other of the latter ports being simultaneously connected to either of the exhaust ports 143 or 144. The position of the pilot valve thereby controls the position of the reversing valve by the alternate admission of fluid under pressure to opposite ends of said reversing valve so that the movements of the table are controlled by the movements of the reversing lever 18.

The slow-down valve 25 becomes operative by downward movement thereof when the table reaches operative position for procuring a slow reciprocation of the table. Referring again to Fig. 9, the casing 26 for the slow-down valve has a channel 147 in which is positioned a throttle valve 148. The opposite ends of the channel 147 are in alinement with the ports 123 and 125, respectively, and when the valve 25 is shifted downwardly by the dog 30, the full-sized portion 149 of said valve cuts off the direct connection between the ports 123 and 125 and fluid under pressure for actuating the table must accordingly pass through the channel 147 so that the table movements are under the control of the throttle valve 148.

When the slow-down valve 25 is shifted downwardly as the table reaches operative position, fluid under pressure is directed around a reduced portion 150 of the valve 26 from an annular groove 151 connecting with the port 125, to a port 152 in the casing 26. The port 152 is connected by a conduit 153 to the end of a cylinder 154 in which a plunger 155 is slidable. Fluid under pressure thus enters the cylinder 154 at the beginning of the honing operation to set the timers in operation.

As the valve 25 is released at the end of the honing operation and moves upwardly to the position of Fig. 9, the reduced portion 150 of the valve establishes fluid connection between the port 152 and an exhaust port 156 to allow the plunger 155 to move downwardly under the action of a spring 157 in readiness for the subsequent honing operation.

As shown in Fig. 9, the plunger 155 has a crossbar 158 attached thereto, in which are positioned two slidable rods 159 and 160, urged upwardly by coil springs 161 and 162, connected at their lower ends to the timers 114 and 115 respectively. The upward movement of the plunger 155 carries with it the rods 159 and 160 and thus sets the timers in operation.

After the honing operation is started the honing continues until the timer 114 operates to change the rate of rotation of the hone relation to the workpiece. Referring again to Fig. 9, the fluid pressure outlet 122 from the pump is connected by a conduit 163 to a port 164 in the casing 117. An outlet port 165 in the casing 117 is connected by a conduit 166 to the cylinder 57, and the casing also has an exhaust port 167. A reduced portion 168 of the valve 58 normally provides a connection between the ports 165 and 167 so that the piston 56 is allowed to remain at the left hand end of the cylinder 44 in order that the hone may operate at a high rate of speed. When the timer 114 becomes operative to energize the solenoid 116, the reduced portion 168 provides fluid connection between the ports 164 and 165, thereby procuring movement of the piston 56 to the right for reducing the rate of rotation of the hone.

The electrical connections for the machine are best shown in Fig. 10. With reference to this figure, the motor 38 for the machine is connected through a motor control switch 169 of conventional construction to the source of power 170 which may be a three wire system. A switch 171 is normally closed and the rotation of the motor is under the control of the motor control switch 169 which is manually controlled by starting and stopping switch 172 and 173 in a box 174 positioned on the front of the machine. The three supply leads 175, 176 and 177 from the power supply 170 are connected to contacts 178, 179 and 180 of the control switch 169, and, when the control switch is closed, the movable element 181 thereof has connectors 182, 183 and 184 which provide a connection respectively between the contacts 178, 179 and 180 and corresponding contacts 185, 186 and 187 connected by leads 188, 189 and 190 to the motor 38.

The movable element 181 is shifted by a solenoid 191, one terminal of which is connected by a lead 192 to the contact 179 of the control switch. The solenoid 191 is energized when the normally

open starting switch 172 is closed. One contact 193 of this switch is connected by a lead 194 to a contact 195 of the switch 169 and thence by a lead 196 to the contact 180. The second contact 197 of the starting switch is connected by a lead 198 to one contact 199 of a hand-operated switch 200 which is normally closed. The other contact 201 of the switch 200 is connected by a lead 202 to one contact 203 of a solenoid-operated switch 204 which is held in closed position by a spring 205. A lead 206 connects the second contact 207 of the switch 204 to the primary winding 208 of a transformer 209, this winding being also connected by a lead 210 to the solenoid 191. Thus, when the starting switch 172 is closed the solenoid 191 is energized to close the control switch 169 for starting the machine.

The terminal 197 of the starting switch is also connected by a lead 211 to one contact 212 of the stopping switch 173, which, as shown, is normally closed. The other contact 213 of this switch is connected by a lead 214 to a contact 215 of the switch 169. When the control switch 169 is closed the circuit through the solenoid 191 is closed by a connector 216 which connects the contacts 195 and 215 and is similar to the connectors 182 and 183, and the switch 169 is thus held closed. However, when the stopping switch 173 is opened, the solenoid is deenergized and the control switch 169 is allowed to open.

Again referring to the electrical diagram of Fig. 10, one terminal of the solenoid 116 is connected by a lead 217 to the lead 175 and the other terminal of this solenoid is connected by a lead 218 to one contact 219 of the time-controlled switch 114. The other contact 220 of this switch is connected by a lead 221 to the main supply lead 176. The solenoid 116 is accordingly energized when the time switch 114 operates to provide a connection between the contacts 219 and 220, thereby shifting the valve 58 for changing the rate of rotation of the honing head.

The solenoid 118 has one terminal connected by a lead 222 to the lead 217 and thence to the supply lead 223 to one contact 224 of the time-controlled switch 115. The other contact 225 of this time switch is connected by a lead 226 to the lead 221 and thence to the supply lead 176. The solenoid 118 is accordingly energized when the time-controlled switch 115 operates for terminating the honing operation.

The machine is arranged to provide for stopping the machine when the hones are worn down to a predetermined extent, which is generally when they are no longer usable. To this end, as shown in Fig. 10, the workpiece *a* is grounded, as at 227, and the hone spindle, or the bracket for the hone spindle, which is in electrical contact with the plates 77 holding the honing stones, is suitably insulated from the rest of the machine and is connected by a lead 228 to the secondary winding 229 of the transformer 209. The other terminal of this winding is connected by a lead 230 to one terminal of a solenoid 231, which upon being energized, procures movement of its armature 232 on the end of which is mounted the connector of the switch 204. The other terminal of the solenoid 231 is grounded as at 233. When the hones are worn down to such an extent that any part of the holder 77 comes in contact with the workpiece, a circuit is established through the solenoid 231 thereby breaking the electrical connection between the two contacts 203 and 207 of this switch, deenergizing the solenoid 191 and bringing the machine immediately to rest.

In the operation of the machine when an unhoned workpiece has been properly positioned within the work-suporting structure, movement of the table to the left to bring the work and hones into operative relation, is procured by shifting of the pilot valve 16, as by means of the handle 234, Fig. 1, positioned on the front of the base. As the work moves into operative position, the valve 25 is shifted by the cam 30 for setting the timers 114 and 115 in operation, so that both the solenoids 116 and 118 are de-energized. When the solenoid 116 is deenergized the valve 58 is shifted to the position of Fig. 9 to allow the piston 56 to move to the left for procuring a slow rotation of the hone within the workpiece. De-energization of the solenoid 118 allows the reversing dog 21 to move into operative position for controlling the reciprocations of the table during the honing operation.

After the honing operation has continued for a predetermined time the timer 114 becomes operative, thus energizing the solenoid 116 for shifting the valve 58 to the right, thereby increasing the rate of rotation of the hone within the workpiece. The honing operation continues at this fast rate until the timer 115 becomes operative, thus energizing the solenoid 118 for elevating the reversing dog 21, thereby procuring a run-out of the table to the position of Fig. 1. During the run-out of the table the honed workpiece or workpieces are discharged from the workholder and an unhoned workpiece is placed in operative position in the work-support. The dog 24 then engages and rocks the reversing lever 18 for returning the table to the left to bring the unhoned work-piece into operative relation to the hone.

The honing operations continue as above outlined with the compensatory mechanism of Fig. 12 operating when necessary to expand the hone in compensating for wear on the stones. The honing stones eventually become worn to such an extent that a part of the holder 77 for one or more of the hones engages with the workpiece, thereby establishing a circuit through the solenoid 231 to open the switch 204 and bring the machine immediately to rest. The machine cannot then be started for successful operation until the worn stone or stones have been replaced.

From the foregoing it will be apparent that the present invention provides an arrangement by which the rate of relative rotation of the hone and workpiece can be changed at a predetermined point during the honing operation where it is desirable to have varying rates of speed for obtaining the desired surface finish. This change in the rate of speed is procured automatically without interrupting the honing operation. The invention also incorporates a mechanism by which to compensate for wear on the hones so that in combination with a work-loading mechanism the machine can be entirely automatic for the successive honing of a plurality of work-pieces. Furthermore, the machine is arranged to provide for stopping further honing of workpieces when any of the honing stones is worn to predetermined limit of size.

We claim,

1. In a honing machine, a hone having at least one honing member, a carrier plate for the honing member, a work-support for a workpiece, and means including an electrical circuit having the workpiece as one contact thereof, said circuit being closed by engagement between the workpiece and the carrier plate for automatically

stopping the machine, said carrier forming a second contact in the circuit.

2. In a honing machine, a hone having a plurality of honing members thereon, a carrier plate for each honing member, a work-support for a workpiece, and means, including an electrical circuit having the workpiece as one contact thereof, said circuit being closed by engagement between the workpiece and any one of the carrier plates, for automatically stopping the machine, each of said carrier plates forming a contact in the circuit with any one of said carrier plates engageable with the workpiece for closing the circuit.

3. In a honing machine for the successive honing of a plurality of workpieces, a hone having a plurality of honing elements simultaneously engageable with a workpiece surface, a work-support, means for procuring honing operations on workpieces successively positioned in the work-support, including means for terminating each honing operation and means for returning the hone and work-support to operative position after an unhoned workpiece has been placed in the work-support, and means for procuring a compensation for wear on the hone when such a compensation becomes necessary.

4. In a honing machine for the successive honing of a plurality of workpieces, a hone having a plurality of honing elements simultaneously engageable with a workpiece surface, a work-support, means for procuring honing operations on workpieces successively positioned in the work-support, including means for terminating each honing operation and means for returning the hone and work-support to operative position after an unhoned workpiece has been placed in the work-support, and means for procuring a compensation for wear on the hone independently of the individual honing operations and dependent upon the amount of wear on the hone.

5. In a honing machine for the successive honing of a plurality of workpieces, a hone having a plurality of honing elements simultaneously engageable with a workpiece surface, a work-support, means for procuring honing operations on workpieces successively positioned in the work-support, including means for terminating each honing operation and means for returning the hone and work-support to operative position after an unhoned workpiece has been placed in the work-support, means for procuring a compensation for wear on the hone when such a compensation becomes necessary, and means for stopping the machine when the hone is worn away a predetermined amount.

6. In a honing machine, a hone having a plurality of honing elements simultaneously engageable with a workpiece surface, a work-support, means for procuring a movement of said work-support relative to the hone for bringing a workpiece in the work-support into honing position, timing means for procuring a change in honing operation, other timing means subsequently operative for bringing the honing operation to a close, and means responsive to said first means for setting both timing means in operation.

7. In a honing machine, a hone having a plurality of honing elements simultaneously engageable with a workpiece surface, a work-support, means for procuring a relative rotation between these parts, means for procuring a movement of said work-support relative to the hone for bringing a workpiece in the support into honing position, timing means for procuring a change in the rate of relative rotation, other timing means for terminating the honing operation, and means responsive to said second means for setting both timing means in operation.

8. In an abrading machine, an abrading member, a supporting member for the abrading member, a work-support for a workpiece, and means including a circuit having the workpiece as one contact thereof, said circuit being closed by engagement between the workpiece and the supporting member for automatically stopping the machine, said supporting member forming a contact in the circuit engageable with the workpiece.

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