

March 22, 1938.

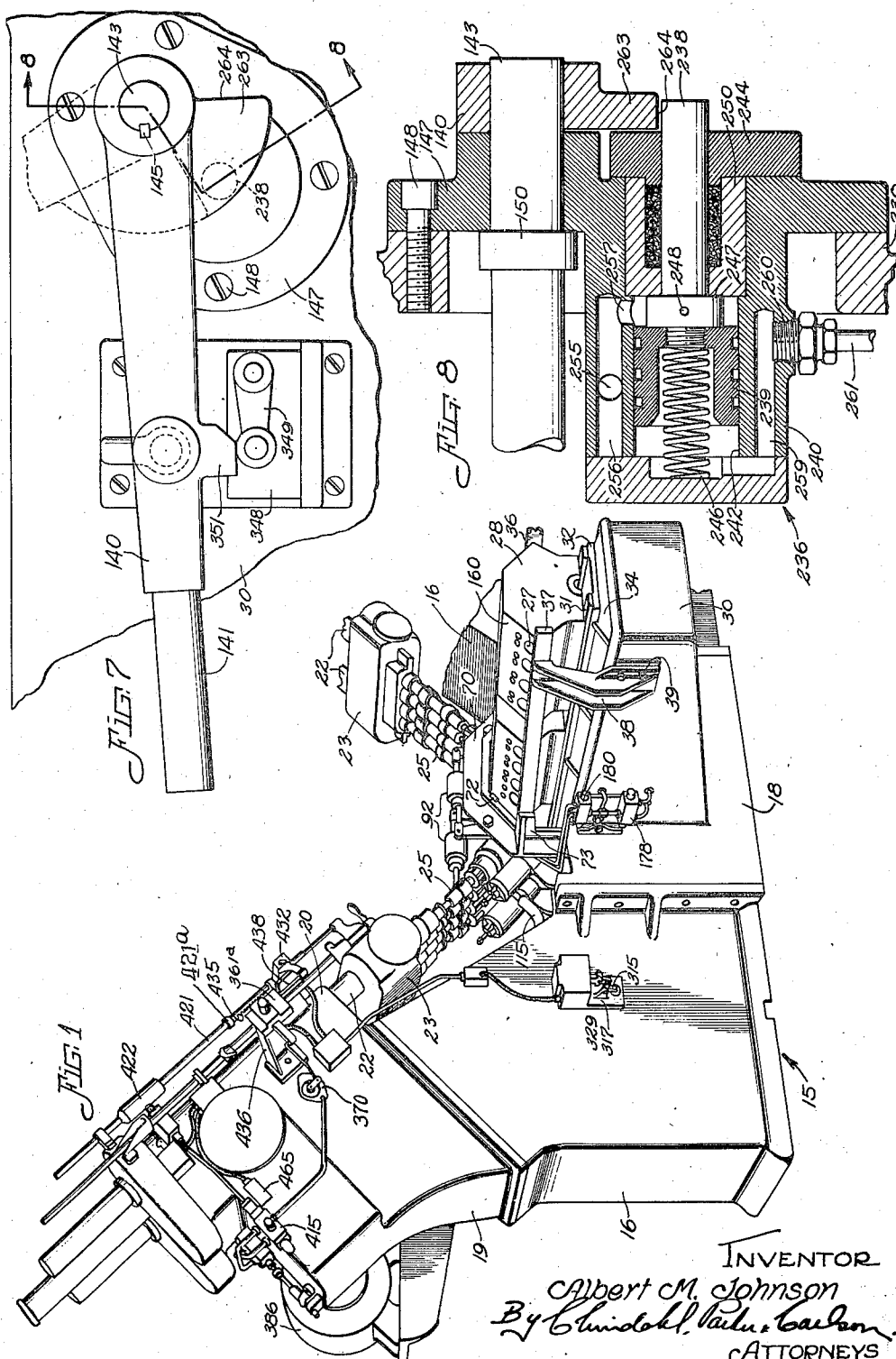
A. M. JOHNSON

2,111,784

HONING MACHINE

Filed Sept. 20, 1934

4 Sheets-Sheet 1



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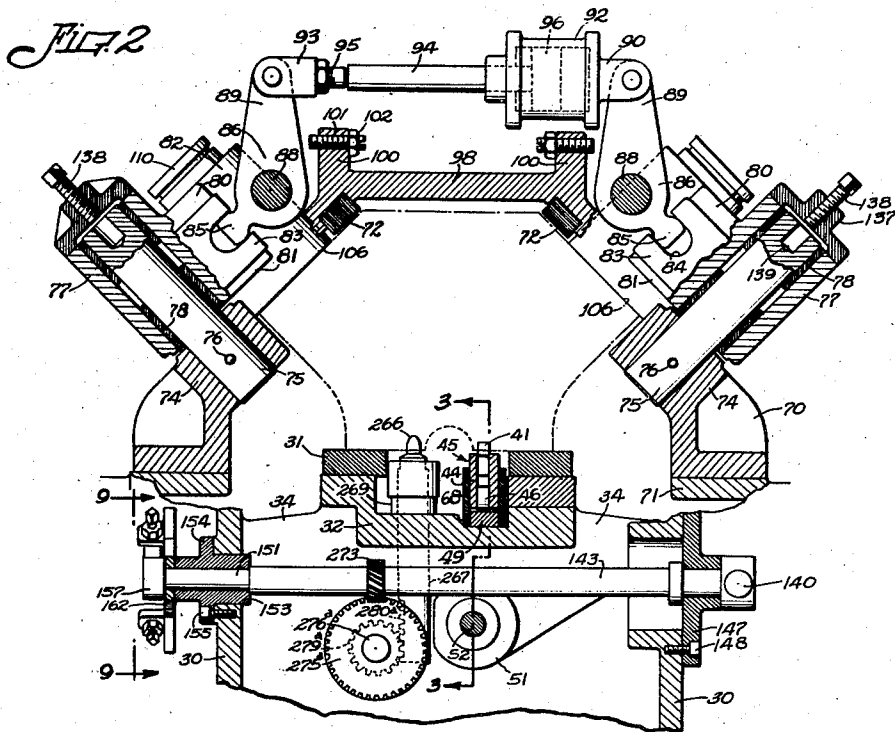
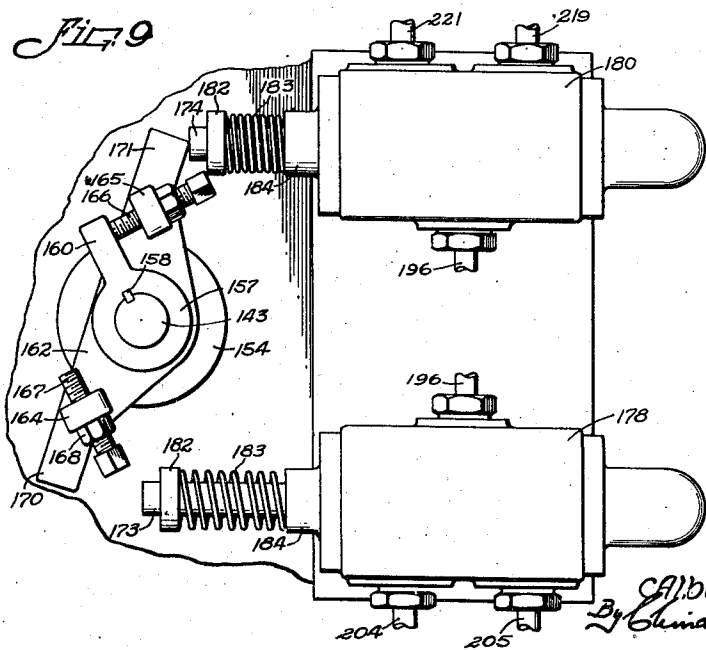
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4 Sheets-Sheet 2



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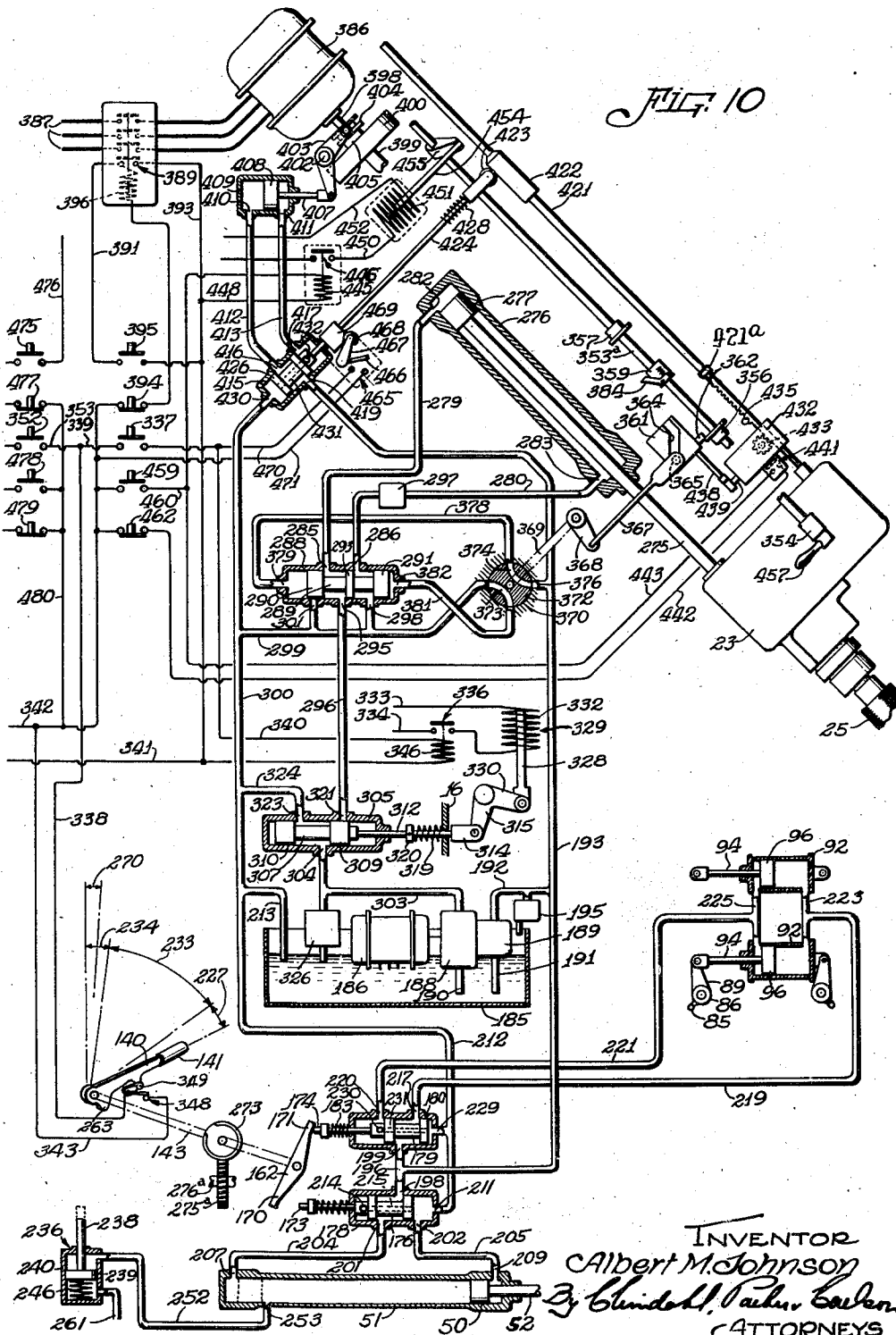
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4 Sheets-Sheet 4



UNITED STATES PATENT OFFICE

2,111,784

HONING MACHINE

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45 Claims. (Cl. 51—34)

The invention relates to improvements in honing machines of the type in which one or more rapidly rotating honing tools is reciprocated by hydraulic means for the purpose of producing a smooth, highly finished surface upon the interior of a hollow cylindrical body, and has especial reference to an improved machine of this character particularly adapted for operating upon surfaces disposed at an inclination to the horizontal.

Honing machines having flexible reciprocably and rotatably mounted spindles carrying honing tools have been extensively employed to finish internal combustion engine cylinders arranged in vertical banks of 4 to 8, more or less. These machines have generally been provided with flexible spindles for carrying the honing tools due to the inherent advantages of this construction. With these machines, however, it has been necessary to maintain an accurate vertical axial relationship between the hones and the cylinder bores in order to obviate any damaging effects of the hone grinding stones upon the cylinder walls when inserting the tools or removing the same from the bores. Thus, in the case of V-type internal combustion engines in which the cylinders are disposed convergently from opposite sides of the engine block towards a common center, it has been heretofore necessary first to hone vertically one bank of cylinders and thereafter turn the block around and hone the other bank of cylinders. This procedure has proved relatively slow and expensive, and the need has therefore been recognized for a honing machine in which the convergent cylinders can all be simultaneously honed if desired.

It is therefore a principal object of the present invention to provide a honing machine in which the diagonal cylinders of a V-type automotive engine block, or other cylindrical surfaces disposed diagonally to the horizontal, can be honed on a diagonal axis.

Another object of the invention resides in the provision of a machine of the foregoing character in which both the banks of convergent cylinders of a V-type internal combustion engine block may be simultaneously or independently honed with the base of the engine block supported in a horizontal plane.

Another object is to provide in combination with a honing machine, means for supporting a work piece in position to receive the honing tool, and including improved means for accurately defining the position of the work piece relative to the honing tool as well as means for retaining

the work piece in such position until completion of the honing operation, together with control mechanism to synchronize operation of the positioning and retaining means.

Another object resides in the provision of a conveniently arranged work support adapted to receive a plurality of work pieces to be successively guided into position to be operated upon by the tool means of the machine, and including a hydraulically operated device adapted to be clamped against the work and serving to guide the tool means into the work piece.

Another object is to provide an improved guiding device for the tools, in which is incorporated means for delivering coolant positively and without splash to the tools when in working engagement.

Another object of the invention is to provide a novel arrangement of electrically controlled hydraulic means for operating the honing machine.

Another object of the invention is to provide a honing machine of the foregoing character having power driven means for rotating the honing tools, wherein a hydraulically operated clutch is provided for connecting or disconnecting the power from said means in synchronized relationship with the operation of the reciprocatory parts of the machine.

Other objects include the provision of a single manual control member for operating the positioning, retaining and tool guiding means together with an electric master switch closable by said control member only after the completion of a predetermined sequence of operations; and an interlock for preventing operation of said control member during a certain period of operation of the means controlled thereby.

Other objects and advantages will become apparent in the following description and from the accompanying drawings, in which:

Fig. 1 is a fragmentary perspective view of a machine embodying the features of the invention.

Fig. 2 is a sectional elevation showing details of the work support and associated mechanism.

Fig. 3 is a sectional elevation taken substantially on line 3—3 of Fig. 2.

Fig. 4 is a fragmentary sectional elevation showing details of the improved tool guiding and coolant delivery means.

Fig. 5 is an enlarged sectional plan view of a honing tool of a preferred type.

Fig. 6 is a fragmentary sectional elevation through the honing tool taken substantially on line 6—6 of Fig. 5.

Fig. 7 is an enlarged elevation of the control

handle for controlling operation of the work positioning and tool guiding means and showing the relationship of the switch for electrical control of the honing machine.

Fig. 8 is a sectional elevation through the interlock taken substantially on line 8—8 of Fig. 7.

Fig. 9 is an enlarged elevation taken on line 9—9 of Fig. 2 and showing the arrangement for controlling the hydraulic operators for the work positioning and clamping and tool guiding mechanisms.

Fig. 10 is a schematic representation of the hydraulic, electrical and mechanical operating and control means and their relationship in the operation of the honing machine.

While the invention is susceptible of various modifications and alternative constructions, I have shown in the drawings and will herein describe in detail the preferred embodiment, but it is to be understood that I do not thereby intend to limit the invention to the specific form disclosed, but intend to cover all modifications and alternative constructions falling within the spirit and scope of the invention as expressed in the appended claims.

Generally stated, the machine as illustrated herein comprises a substantially V-shaped supporting structure carrying reciprocatory heads from which depend convergent spindles carrying honing tools, and having a work standard between the said heads for supporting a work piece in the form of a V-type cylinder block of an internal combustion engine having diagonally disposed cylinder bores to be operated upon by the honing tools. Suitable hydraulic means are provided for reciprocating the heads, and rotation of the spindles and tools is effected by suitable means hydraulically controlled to operate in synchronism with operation of the heads. Hydraulically operated means are provided in association with the work support for horizontally moving a cylinder block into operative position relative to means adapted to be clamped against the block for guiding the honing tools to the diagonal cylinder bores therein. Sufficient clearance is allowed between the latter means and the block during the positioning operation to permit free movement of the block. Suitable coolant is supplied to the tools while engaged with the cylinder walls, but due to the clearance necessary during movement of the block together with the inclined disposition of the cylinder bores it is necessary to provide for positively conducting the coolant to the bores to avoid spilling-over or splash. Provision is therefore made to supply the coolant to the cylinder bores through the honing tool guide means which is preferably arranged for substantially liquid-tight contact with the block. Operation of the entire machine is simplified and coordinated by means of manual and automatic mechanical as well as electrically actuated controls governed through conveniently located electric switches.

While the machine is shown and herein particularly described as provided with a pair of reciprocatory heads each having a bank of four hone spindles and adapted to operate upon internal combustion engine motor blocks, it will be apparent that any number of spindles may be provided and that the machine may be utilized for operating upon types of work other than engine motor blocks.

More specifically described, the machine comprises a base 15 having a pair of upwardly and outwardly extending columns 16 and an inter-

mediate work support 18, providing a substantially V-shaped structure. Each of the columns 16 preferably carries a similar arrangement of parts, so that a description of one will suffice for the other.

As a matter of practical expediency and for purposes of illustration, the honing machine is shown as embodying hone operating mechanism of substantially the same character as disclosed in Patent No. 1,783,019, issued November 25, 1930, to Albert M. Johnson.

At the upper end of the column 16 is mounted a main housing 19 having one or more auxiliary housings 20 extending therefrom toward the inside of the machine and with the lower end located above and facing toward the work support 18. Guide sleeves 22 extend through the auxiliary housings 20 and provide means for reciprocably guiding a head structure 23. The head structure supports a plurality of tool carrying spindles 25, herein shown as four in number. These spindles 25 are directed diagonally to the horizontal so as to extend axially of the bores of cylinders 27 in a work piece, such as a V-type internal combustion engine motor block, to be herein referred to as a block 28.

The work support 18 is preferably constructed to receive a plurality of blocks 28 and to this end may be provided at one side with a receiving extension or knee 30 to increase substantially the working length of the support so that the blocks may be positioned for honing in rapid succession and without substantial interruption. A similar extension or knee (not shown) may be provided on the opposite side of the support 18 for receiving the blocks after they have been honed. A pair of parallel tracks 31 is carried by a longitudinal bridge member 32 supported by trusses 34 extending to each side and attached to the walls of the knee 30 or the body of base 18. The blocks 28 are slidably received on the tracks 31 and guide bars 36 and 37 prevent lateral displacement of the blocks as the same are moved along the tracks 31. The guides 36 and 37 are supported adjacent their outer ends by suitable means such as standards 38 secured as by bolts 39 to the walls of the knee 30.

In order to move one of the blocks 28 along the tracks 31 and into position to be honed, mechanism, controlled to be operated in synchronism with other parts of the machine, is preferably provided for automatically actuating said one block into honing relation with the spindles 25, and simultaneously ejecting the preceding block which has already been honed. The mechanism for this purpose may comprise an hydraulically operated indexing mechanism including a pawl 41 pivotally mounted by means of a pin 42 between the parallel sides 44 of a reciprocating carriage 45 (Figs. 2 and 3). The carriage 45 is supported for longitudinal movement on the bridge 32 by means of a roller 46 adjacent one or both of its ends, which roller is rotatably mounted in the carriage by means of a shaft 48 and rides on a track 49. Reciprocating movement is imparted to the carriage 45 by an hydraulically operated piston 50 (Fig. 10) reciprocable in a cylinder 51 and connected to a stem 52 which has removably attached at its outer end a connecting member 54 extending upwardly therefrom and connected to the carriage 45 by means of a pin 55. The member 54 is carried by a block 57 connected to the end of the stem 52 by means of retaining disks 58 and 59 each of which has a

collar 60 through which a set screw 61 passes to form a removable connection with the stem.

The pin 42 passes through the pawl 41 in off center position so that what will be termed the rearward end of the lever will be pulled downwardly by the force of gravity to raise the forward end, which has an abutment face 63 adapted to engage with the end of a block 28 to urge the same to the right, as viewed in Fig. 3, when the indexing mechanism is operated to move the carriage 45. The pawl 41 is freely rotatable so that when the carriage is moved to the left, it will slide under the base of the following block 28 until it has reached the opposite end thereof, whereupon the abutment face 63 will be brought into position by gravity to bear against the said opposite end. A limit pin 65 extends through the pawl 41 and is slidable in a slot 66 in the wall 44 of the carriage and limits rotation of the pawl 41 so as to prevent the upper and lower edges of the rear end thereof from passing beyond the edge of the sides 44 of the carriage. Guide plates 68 are attached at each side of the track 49 and prevent lateral displacement of the carriage 45 from the track. After one of the blocks 28 has been positioned by the indexing mechanism, other mechanism will be brought into play to further prepare the machine for operating thereon.

The machine of the present invention, as has already been pointed out, is particularly adapted for operating upon work which has internal cylindrical surfaces disposed at approximately a 45° angle to the horizontal, such as are found in the motor blocks of V-type automotive engines. The spindles 25 are preferably of a relatively flexible construction and consequently tools carried upon the outer ends thereof will, through the force of gravity, normally tend to find a position vertically relative to the point of suspension. It is therefore an aim of the present invention to provide means for maintaining the spindles in diagonal position and for guiding the tools carried thereby into the work. Moreover, it is necessary to supply a coolant fluid to the work while a tool is operating thereon, and with the cylinders diagonally disposed it is necessary, after a block has been moved into position, to make adequate provision for conducting the coolant to the interior of the cylinder bores. The present invention, therefore, contemplates means not only for guiding a tool to the cylinder bore but also means operative after the movement of the block into position to conduct the coolant to the cylinder bore positively, without splash and in an efficient manner to produce the desired results.

One form of mechanism that has been found desirable for the purposes outlined comprises a pair of arch-like frame members 70 which are secured in any suitable manner adjacent the opposite ends of the work support 18 on flanges 71 formed at the upper edges of the work support. The spacing between the frame members 70 is preferably substantially equal to the length of the work piece to be operated upon, and a pair of guide strips 72 is secured to the inner edges of the frames not only to connect the same rigidly but also to serve as guides for the block passing thereunder. Brackets 73 on the frame members support the adjacent ends of the guides 37 and 36.

Each frame member 70 has formed on its inwardly facing side a pair of bracket members 74 (Figs. 2 and 4). These members are internally bored and adapted to receive stationary rods 75 which are secured therein by means of pins

76. The rods 75 are of substantial diameter and are slidably engaged by guide casings 77 on their outer ends. To form a substantially frictionless sliding contact with the rods, the casings 77 have highly finished bearing bushings 78 therein. Each of the casings 77 has formed on its inner side a pair of spaced parallel flanges 80 and 81 adapted to engage securely the end of a jig member 82. An extension 83 having a lateral slot 84 is formed at each end of the jig members 82 to receive a knuckle arm 85 of a bell crank lever 86 which is rigidly mounted on the end of a stub shaft 88 suitably journaled in the frame member 70.

An upstanding arm 89 of each bell crank is pivotally connected at its upper end with the opposite crank on the same frame member 70. Thus, a bifurcated lug 90 is provided on one end of each of a pair of cylinders 92 and is pivotally connected to one of the crank arms 89. A yoke 93 is pivotally connected to the opposite crank arm 89 and is secured to one end of a piston rod 94 by means of an adjustable screw connection 95. The other end of the rod 94 extends into the cylinder 92 and has a piston 96 thereon. When the arms 89 are pivoted away from one another, the bell cranks will pivot on shafts 88 to carry knuckle arms 85 downwardly and thereby force the jigs 82 and the guide casings 77 to move downwardly on the rods 75. Conversely, when the arms 89 are retracted and moved toward each other the jigs and casings 77 will be moved upwardly on the rods 75. At their inner edges each of the frames 70 is provided with a transverse flange 98, and upstanding lugs 100 are formed on said flange. These lugs are tapped to receive stop screws 101 which are adjustable and extend therethrough and are adapted to limit the approaching movement of arms 89. Suitable lock nuts 102 are secured to the inner ends of stops 101 to fasten the same in adjusted position.

Each of the jig members 82 is of substantially rectangular cross section and is adapted to abut squarely against a diagonal face 106 of the block 28 (Fig. 4). Bores 107 are formed in the jigs coaxial with the cylinder bores 27 in the block 28, and each of the bores 107 has a bushing 110 therein extending substantially above the outer surface of the jig member 82. The bushings 110 serve as means to guide honing tools 112 which are carried by the spindles 25 to the cylinders 27.

A conduit 115 is suitably connected to an inlet pipe 116 which is threadedly secured in the wall of the jig member and connects with a longitudinal passage 118 communicating with ports 119 in the bushings 110. Coolant fluid is delivered through the conduit 115 from any suitable source (not shown) and passes to the interior of bushings 110 through the ports 119 and is thus delivered to the cylinders 27 and tools 112 in the block 28. Any suitable means may be provided for controlling the flow of coolant incident to the operation of the jigs 82 or of the honing tools 112. The jigs 82 are tightly clamped against the faces 106 of the block 28 so as to form a substantially sealing contact therewith whereby the coolant is positively conducted to the work without splash. Any suitable means such as a sump (not shown) may be provided within the work support 18 for receiving the coolant to return the same for reuse.

The honing tools 112 carried at the ends of the spindles 25 are preferably annular in form and

are provided with a plurality of radially extending grinding stones 121 (Figs. 5 and 6) for engaging the cylinder walls to hone the same to a uniform mirror finish. Due to the force of gravity it is necessary to provide protective means for preventing abrasive damage to the bushings 110 and the cylinder walls during the period of insertion and retraction of the hones. For this purpose hones having a plurality of radially extending rigidly secured fiber guide members 123 intermediate the hone stones 121 have been found desirable.

As an example of the operative arrangement of this form of hone, the stones 121 may be mounted on retractable backing members 124 which are provided with inwardly facing cam surfaces 125 and 126 engaging with a plunger 128 having complementary cam surfaces 130 and 131. The ends of the backing members are engaged by encircling retaining springs 132 which tend at all times to force the cam surfaces 125 and 126 into engagement with the plunger 128. In many instances it is desirable to permit equalizing of the stones and in such case the cam surfaces 125 and 131 may be omitted to permit relative lateral rocking movement of the stones. In order to operate the plunger 128 to force the stones 121 into engagement with the bores 27, outstanding pivotal levers 134, which are adapted to engage with the inner wall of the bushing members 110, are mounted on a member 135 forming part of the spindle 25 intermediate the hone 112 and the head 23. A stem 136 on the plunger is operatively connected with the levers 134 so that when the levers are forced inwardly by engagement with the bushing 110 the stem 136 will be moved to urge the plunger downwardly as viewed in Fig. 6. Thus the cam surfaces 130 and 131 will bear against the cam surfaces 125 and 126 on the backing members 124 and force the stones 121 radially outwardly beyond the periphery of the wipers 123 and into contact with the face of the cylinder 27. When the levers 134 are removed from the bushing 110, the springs 132 will cause the backing members 124 to force the plunger 128 upwardly and thereby retract the stones 121.

The upper ends of the casings 77 are provided with caps 137 tapped to receive square headed bolts 138 which provide safety stops for limiting the downward movement of the reciprocatory heads 23 whereby insertion of the hones 112 within the cylinders 27 beyond a given point is prevented should a failure occur in the control mechanism to be hereinafter described. The upper ends of the rods 75 are provided with apertures 139 to permit a free range of adjustment of the stops 138.

The sequence of operations in a normal cycle of operation of the present machine comprises indexing or positioning the work piece, clamping the jig members in place on the face of the work, moving the reciprocatory head to bring the honing tools into operative relationship within the cylinder bores, operating the tools through a given number of strokes, returning the head to starting position to remove the tools, unclamping the work, and finally replacing the work. These operations are preferably carried on in sequence, and controls are provided to correlate the operations.

The indexing and clamping mechanisms are hydraulically operated, and a manually operable control lever 140 having a handle portion 141 and which is rigidly secured to the end of a shaft 143

by means of a key 145 provides a convenient single control for operating both of these mechanisms. The lever 140 is preferably mounted at one side of the knee 30, and the end of the shaft 143 is journaled in a closure plate 147 secured by means of screws 148 to the wall of the knee. A retaining collar 150 (Fig. 8) is secured to the shaft 143 at the inside of the plate 147, and the opposite end of the shaft is provided with a reduced end 151 (Fig. 2) which is journaled in a bearing 153 having a rim portion 154 secured by screws 155 to the wall of the knee 30.

A collar 157 is rigidly secured to the outer end of the shaft 143 by means of a key 158 (Fig. 9) and is provided with a substantial integral radial lug 160. A plate 162 is freely rotatable between the collar 157 and the outer end of the bushing 153 and has outstanding eye lugs 164 and 165 on its outer face. The lugs 164 and 165 are internally threaded to receive similar stop bolts 166 and 167 which are held in adjusted position in the eyes by means of lock nuts 168. The ends of the stops 166 and 167 are positioned to be engaged by the lug 160 when the collar 157 is rotated one way or the other by the shaft 143.

The plate 162 has oppositely extending arms 170 and 171 which are respectively adapted to engage the ends of valve stems 173 and 174. The stem 173 is secured to a plunger 176 of a valve 178 for controlling the hydraulic operation of the indexing mechanism, and the stem 174 is similarly connected to a plunger 179 of a valve 180 for controlling the hydraulic operation of the clamping mechanism.

A retaining collar 182 is attached adjacent the outer end of each of the stems 173 and 174 and a compression spring 183 is placed between each of the collars 182 and a projecting bearing portion 184 on the end of each of the valves 178 and 180. The compression springs 183 normally force each of the collars 182 and thereby the stems 173 and 174 to the left as viewed in Figs. 9 and 10, to carry the plungers 176 and 179 into one operative position, the other operative position of the plungers being attained when the springs are compressed.

A source of pressure fluid such as a sump 185 (Fig. 10) is conveniently provided in any desired part of the machine and a motor 186 drives a high pressure pump 188 and a low pressure pump 189 which withdraw fluid from the sump through intakes 190 and 191, respectively. As pressure fluid is withdrawn from the sump 185 by the pump 189, it is forced through a branch line 192 into a main distributing line 193. A relief valve 195 is connected in the line 192 so that the pressure in the pressure fluid circuit supplied by the pump 189 will not rise above a predetermined point. The line 193 connects at one end with a cross line 196 which is connected at opposite ends to the valves 178 and 180 to deliver pressure fluid through ports 198 and 199, respectively.

When the plunger 176 is moved to the left or right as viewed in Fig. 10, it will alternately cause the pressure fluid delivered through the port 198 to escape through either a port 201 or a port 202, providing openings from the valve 178 to lines 204 or 205, respectively. The line 204 connects with a port 207 at one end of the indexing cylinder 51 to receive pressure fluid to force the piston 50 to what will be termed the "return" position of the indexing mechanism, and the line 205 will deliver pressure fluid to the opposite end of the indexing cylinder through a port 209 to force the piston 50 in the opposite direction or

into the "indexing" position. The end of the valve 178 adjacent port 202 is provided with an exhaust port 211 and pressure fluid will escape therethrough into a return line 212 connected with an exhaust 213 when the piston 50 is being forced to the return position. Adjacent the stem end of the plunger 176 there is formed a port 214 connecting with a longitudinal passage 215 through which exhaust fluid from the cylinder 51 is adapted to be returned to the return line 212 during the indexing stroke of the piston 50.

The pressure fluid delivered to the valve 180 through the port 199 will be directed either through a port 217 into a line 219 or through a port 220 and into a line 221, depending on the positions of plunger 179 in the valve. The line 219 connects with a branch line 223 which is connected to deliver pressure fluid through suitable ports at one end of the clamping cylinders 92, and the line 221 is connected to a branch line 225 adapted to deliver pressure fluid through suitable ports at the opposite ends of the cylinders 92. When pressure fluid is delivered through the line 219 and the branch line 223, the pistons 96 will be carried to the opposite ends of the cylinders whereby to extend the stems 94 toward their outer limits. Thus the arms 89 of the bell crank levers 86 are moved apart to cause downward movement of the knuckle arms 85 to carry the bosses 83 and the jigs 82 downwardly to cause the jigs to clamp against the faces of the block 28.

As has already been observed, the springs 183 normally tend to urge the stems 173 and 174 and thereby the plungers 176 and 179 into one position. Thus, when the plunger 176 is in the left hand position as seen in Fig. 10, pressure fluid will be transmitted through line 204 and through the port 207 into the cylinder 51 to force the piston 50 to the return position of the indexing mechanism. When the plunger 179 is similarly in the left hand position, pressure fluid will be transmitted through the line 221 and the branch line 225 to deliver the fluid to the left end of the cylinders 92 and force the pistons 96 to the right to draw the arms 89 toward one another and thereby cause the jig members 82 to be retracted from clamping position to permit removal of the work piece.

The jig members 82 must be clamped against the work during the entire honing operation and the cylinders 92 must therefore be maintained under constant substantial fluid pressure during this period to maintain the clamping mechanism under compression. This is accomplished in the present instance by arranging the collar 157 on the control shaft 143 so that the lug 160 will bear against the stop 166 adjacent the arm 171 to force the latter into engagement with the end of the plunger 174 during the full at-rest or, in the present instance, the horizontal position of the control lever 140. Thus the plunger 179 will be forced to the right as seen in Fig. 10 during the honing period and a constant supply of pressure fluid through the line 219 will cause the pistons 96 to maintain the clamping mechanism under compression.

The control lever 140 will be moved through a substantial arc in operating the controls, and when it is moved through the segment of the arc indicated by 227 (Fig. 10) the lug 160 will be correspondingly moved to release pressure against the stop 166, thereby permitting the compression spring 183 to force stem 174 and plunger 179 to the left so that pressure fluid will be directed through the lines 221 and 225 to force the pistons

96 into unclamping position. During the unclamping operation pressure fluid from the right ends of the cylinders 92 will escape through lines 223 and 219 through an exhaust port and outlet 229 to the return line 212. A port 230 in the plunger 179 opens into a passage 231 and provides for exhaustion of pressure fluid to the return line 212 during the clamping operation.

In order to secure a relatively smooth transition from the clamping to the indexing operation, a substantial lost motion is provided between the lug 160 and the stops 166 and 167 so that the clamping mechanism will be entirely open before the indexing mechanism is operated to position another work piece thereunder. Thus, while the operating lever 140 is moved through a segment of its arc of movement as indicated by 233, neither of the arms 170 and 171 will be operative to bear against either of the stems 173 or 174. However, when the lever 140 is moved through a segment of the arc of movement indicated by 234, the arm 170 of the plate 162 will be forced against the plunger 173 upon engagement of the stop 167 by the lug 160, whereby to force the plunger 176 to the right as viewed in Fig. 10. Pressure fluid will then be delivered to the indexing cylinder to actuate the piston 50 and the piston rod 52 to carry the indexing carriage 45 through its indexing movement.

It is desirable to provide means for preventing retraction of the operating lever 140 until the indexing operation is complete. That is, the operating lever should not be removed from that position in which the lug 160 is effective to force the arm 170 of the plate 162 into engagement with the stem 173 until indexing of a work piece is completed. A form of means suitable for locking the operating lever may comprise an hydraulically operated interlock 236 (Figs. 8 and 10). The interlock comprises a plunger 238 suitably secured at its inner end to a piston 239. A cylinder 240 is attached to or may form a part of the cover plate 147 and is provided with an internal cylindrical bearing surface 242 with which the piston 239 is in engagement. The plunger 238 is adapted to be slidably projected through a suitable aperture in an auxiliary closure plate 244, and a compression spring 246 normally forces the plunger into projected position. A stop collar 247 is secured adjacent the inner end of the plunger 238 by means of a pin 248 to limit outward movement of the plunger under the influence of the compression spring 246 and to provide a spaced relationship between the piston 239 and the inner face of a packing gland 250 which provides a fluid tight seal about the plunger 238.

A pressure fluid line 252 is connected with a port 253 at the end of the indexing cylinder 51 adjacent the port 207. During the period when the piston 50 is being forced to return position, the line 252 is adapted to convey pressure fluid to the cylinder 240 through an inlet port 255 which connects with a passage 256 in the wall of the cylinder. A port 257 opens to the space between the piston 239 and the gland 250 adjacent the collar 247, and the pressure fluid will force the piston to the left as viewed in Fig. 8, to compress the spring 246 and to draw the outer face of the plunger 238 flush with the surface of the plate 244. Thus, the plunger 238 will only extend beyond the face of plate 244 during the indexing operation when pressure fluid is being exhausted from the indexing end of the indexing cylinder, and will be retracted during all the remainder of the time. An angular passage 259 in the wall of

the cylinder 240 connects with the space at the rear of the piston 239 and is adapted to receive any pressure fluid that may escape between the piston and the bearing surface 242 and convey the fluid to a port 260 for removal through a drain 261.

The operating lever 140 is provided with a detent 263 having an abutment face 264 which will engage with the protruding end of plunger 238 when the operating lever has been moved to the farthest limits of its arc of movement, namely, within a segment 270 of the arc. The port 263 is located in the indexing cylinder wall at a position such that when the piston 50 has reached the end of its indexing stroke and has assumed the dotted line position indicated in Fig. 10, the pressure fluid on the indexing side of the piston will be delivered through the line 252 to the interlock 236 and thereby cause the plunger 238 to be retracted and allow the operating lever 140 to be returned toward starting position.

While the interlock 236 provides an effective control to prevent retraction of the operating lever 140 until the indexing stroke of the indexing mechanism is completed, it is desirable to provide additional means to further control movement of the operating lever in order to insure against operating the clamping mechanism until a work piece is properly positioned to receive the jigs 82 in a manner such that there will be an accurate coaxial alignment of the cylinders 27 and the bushings 110. To this end suitable means are provided for automatically controlling the movement of the shaft 143 after the interlock 236 has been actuated to retract the plunger 238 to release the operating lever 140. This means may comprise one or more centering pins 266 (Figs. 2 and 3) having substantially rounded tapering upper ends and being secured to a reciprocable element herein shown as a bar 267 which is slidably mounted in a bearing 269 attached to the bridge member 32. The block 28 is provided with one or more centering apertures 271 into which the pins 266 are adapted to enter after the work piece has been placed in position under the clamping mechanism by means of the indexing mechanism.

A helical driving gear 273 is keyed to the shaft 143 and meshes with a driven helical gear 275^a attached to the end of a shaft 276^a which is journaled in one or more support bearings 278 suspended from the bridge 32. A spur gear 279^a is keyed to the shaft 276^a and meshes with a rack 280^a milled on a face of the bar 267. Thus, when the operating lever 140 is raised toward a vertical position, the gear 275^a will be driven clockwise as viewed in Fig. 2, to rotate the shaft 276^a and the spur gear 279^a, whereby the bar 267 will be moved downwardly to withdraw the centering pin 266 from the work piece. The gear relationship is predetermined to effect insertion and removal of the centering pin 266 during the movement of the operating lever through the segment 233 of the arc of movement, which corresponds to the lost motion movement of the lug 160. Hence the centering pin 266 will be completely removed from the aperture 271 before the indexing mechanism is rendered operative to position another work piece in place. On the other hand, the centering pin 266 must be completely inserted within the aperture 271 of a work piece before the operating lever 140 can be moved through the segment 227 of its arc of movement to carry the lug 160 into engagement with the stop 166 whereby to move the arm 171 of

the plate 162 into engagement with the end of the stem 174 of the valve 180 to shift the plunger 179 to the position shown in Fig. 10 so that pressure fluid will be delivered to the cylinders 92 to operate the clamping mechanism.

The indexing and clamping operations are closely followed by the honing operation and it is therefore preferred to correlate the operation of the reciprocatory heads 23 supporting the spindles 25 and hones 112 with the operation of the indexing and clamping means. The heads 23 are preferably hydraulically operated and it is desirable to control operation of the same electrically by means of conveniently centrally located switches so arranged that either head 23 may be operated independently or both heads may be operated simultaneously. Each of the heads 23 is preferably similarly operated and a description of the electrical and hydraulic circuits used in the operation of one will therefore suffice for both.

In order to reciprocate the head 23, a piston rod 275 is attached to the upper end thereof and extends into a stroking cylinder 276 suitably mounted on the main housing 19. A piston 277 is attached to the inner end of the piston rod 275 and is adapted to be reciprocably moved within the cylinder 276 by the force of pressure fluid alternately delivered to opposite ends of the cylinder through pressure lines 279 and 280 communicating through ports 282 and 283, respectively. The opposite ends of lines 279 and 280 lead to ports 285 and 286, respectively, in a main control valve 288. A plunger 289 having piston enlargements 290 and 291 at opposite ends and a spaced relatively narrow intermediate piston disk 293, which divides the space between the piston enlargements into a pair of chambers, is reciprocable in the valve 288. The piston disk 293 is alternately moved to opposite sides of an intermediate port 295 through which the pressure fluid is delivered to the valve 288 by a high pressure fluid line 296. Pressure fluid will thus be directed alternately through ports 285 and 286 into the fluid lines 279 and 280 leading to opposite ends of the cylinder 276.

A check valve 297 is interposed in the line 280 so that when the piston 277 is at the top of its stroke as shown in Fig. 10, the pressure fluid supporting the same will not return through the line until a predetermined pressure is built up by the flow of pressure fluid to the upper side of the piston through the line 279. Thereupon the pressure fluid will exhaust through the valve 288 and into an exhaust outlet 298 leading to an exhaust line 299 connected to an exhaust return line 300, which will return the fluid through the exhaust 213 to the sump 185. An exhaust outlet 301 is also connected to the exhaust line 299 for the return of pressure fluid from the cylinder 276 through the line 279 at the up stroke of the piston 277.

The head 23 must be rapidly reciprocated and for this reason it is necessary to supply fluid under relatively high pressure to the stroking cylinder 276. The high pressure pump 188 forces the pressure fluid through a line 303 which communicates through a port 304 with an auxiliary control valve 305. This valve has a reciprocable plunger 307 provided with a pair of spaced piston enlargements 309 and 310. A stem 312 is attached to one end of the plunger 307 and extends through the wall of the column 16 for pivotal attachment by means of a yoke 314 to an arm of a bell crank lever 315 which is pivotally sup-

ported by a bracket 317 attached to the outside of the column 16. A compression spring 319 bears at one end against a collar 320 secured to the stem 312 and at its other end against the wall of the column 16 whereby to normally force the plunger 307 to the left as viewed in Fig. 10. In this normal position, the piston 309 will cover a port 321 through which the line 296 communicates with the valve 305. A port 323 which leads to an outlet line 324 connected to the return line 300 will then be open and the high pressure fluid will return directly to the sump 185. A relief valve 326 is connected into the line 303 to prevent the building up of excessive pressure within the hydraulic circuit supplied by the pump 188.

The valve 305 is preferably electrically controlled, and to this end an armature arm 328 of a solenoid 329 is pivotally connected to an arm 330 of the bell crank lever 315. An electro-magnetic coil 332 surrounding the armature arm 328 is adapted to be energized by electrical energy received from any suitable source through leads 333 and 334. A normally open electro-magnetic switch 336 is connected in series in the lead 334 and is adapted to be closed by the closing of a normally open starting switch 337 which is connected in series in an electrical circuit comprising leads 342, 343, 338, 339, 340 and 341. The circuit is connected to a suitable source of electrical energy through the leads 341 and 342 and when the circuit is closed by the switch 337 a coil 346 of the switch 336 will be energized to close the latter switch. The solenoid coil 332 is then energized, and the armature arm 328 will be drawn inwardly to rotate the bell crank 315 and thus draw the stem 312 outwardly. The plunger 307 will thereby move to the right in the valve 305, as seen in Fig. 10, to open the port 321 and close the port 323 so that high pressure fluid will pass through the line 296 and then through the valve 288 and into the line 279 to be delivered into the upper end of stroking cylinder 276 to cause a down stroke of the piston 277.

The electric leads 338 and 343 are connected in series with a normally open master switch 348 having an actuating arm 349 (Figs. 7 and 10) which is mounted on the outer wall of the knee 30 adjacent to the operating lever 140. The actuating arm 349 is adapted to be engaged by a lug 351 on the lever 140 when the lever is in the at-rest position to thereby close the switch 348. A normally open starting switch 352 is connected in series in a lead 353 of an electrical control circuit for the opposite side of the machine, and this lead is connected to the lead 338 in parallel with the lead 339. It will thus be evident that until the operating lever 140 is in the position in which the clamping mechanism is operated to secure the jigs 82 against a work piece, the switch 348 will remain open and the control circuits for neither side of the machine can be closed by the switches 337 and 352. The control lever 140, therefore, serves as a master control over all operations of the machine.

The means for controlling the reciprocations of the head 23 may be of a similar character as that disclosed in Patent No. 1,945,045 issued to A. M. Johnson on Jan. 30, 1934, and is diagrammatically illustrated in Fig. 10 only in so far as it is necessary to an understanding of the operation of the present machine. Thus, there is provided a stop bar 353^a which is rotatably associated with the head 23 and connected for reciprocation therewith by a bracket 354. Stops 356 and 357 are adjustably secured in spaced relationship on the

bar 353^a, and a skip stop 359 is secured intermediate stops 356 and 357. A plate 361 is slidably mounted in suitable guide means 361^a (Fig. 1) supported by the housing 20 adjacent to the bar 353^a and has a laterally extending operating arm 362 thereon adapted to be engaged by the stops. An eccentric cam slot 364 is formed in the plate 361 and is engaged by a roller 365 carried by the end of a link 367 which is pivotally connected to a crank arm 368.

The other end of the crank arm 368 is rigidly secured to the outer end of a shaft 369. A pilot valve 370 having a rotor 372 provided with arcuate passages 373 and 374 is suitably mounted for controlling operation of the valve 288, and the inner end of the shaft 369 is firmly secured to or forms a part of the rotor. When the rotor 372 is rotated, the passages 373 and 374 will alternately register with a branch 376 on the low pressure line 193. A line 378 leads to a port 379 in one end of the valve 288 and a line 381 leads to a port 382 in the opposite end of the valve. Upon rotation of the rotor 372 the passages 373 and 374 will alternately form a direct passage between the branch 376 and the lines 378 and 381 so that pressure fluid from the line 193 will enter first one end and then the other end of valve 288 to reciprocate the plunger 289 and move the piston disk 293 first to one and then to the other side of the port 295.

The rotor 372 of the pilot valve is caused to rotate synchronously with the reciprocations of head 23 and thereby controls the stroke of the head. Thus, when pressure fluid is delivered to the upper end of cylinder 276 whereby a downward stroke is imparted to the piston 277 and the head 23, the bar 353^a will likewise be moved downwardly until the stop 357 engages operating arm 362 on the plate 361 and carries the same downwardly. Upon downward movement of the plate 361, the roller 365 will be moved in the cam slot 364 to carry the lever 367 to the right as seen in Fig. 10, and the crank arm 368 will be pivoted and cause the rotor 372 to rotate. While one of the passages 373 or 374 in the rotor forms a direct connection between the branch 376 and one of the lines 378 or 381, the other passage forms a connection between either of lines 378 or 381 and exhaust return line 299 so that as pressure fluid is delivered to one end of the valve 288 the fluid in the opposite end will be simultaneously exhausted.

When the head 23 is forced downwardly by piston 277 until the stop 357 engages the operating arm 362 and therethrough causes the rotor 372 to reverse the pressure fluid to the valve 288, the hones 112 will be positioned at the lowermost reach to which it is desired to insert the same within the cylinders to be honed. At this point, of course, the stroke of the head 23 will be reversed to withdraw the hones. However, the honing operation normally contemplates a substantial number of reciprocations of the hones within the cylinders, and a pawl 384 is therefore arranged on the skip stop 359 to engage the arm 362 before the head 23 has returned sufficiently to remove the hones from the cylinder bores. The pawl is yieldably extended into the path of the operating arm 362 so that the skip stop 359 may move freely past the arm on the initial down stroke. Upon upward movement of the bar 353^a, however, the pawl will engage the arm 362 to move the plate 361 as heretofore described. Thus, reciprocation of the head 23 will be limited to a distance equal to that between the stops

357 and 359, which distance is predetermined for the stroke desired for the hones within the cylinder bores being operated upon.

After the honing tools have been inserted in operative position within the cylinder bores, the tools must be rotated as well as reciprocated in order to produce the desired grinding effect on the cylindrical surfaces. To this end suitable means are provided in the housing 19 and the columns 20 for imparting rotary motion through the spindles 25 and thereby to the hones 112. A desirable form of such means is disclosed in the aforementioned Patent No. 1,783,019, and may be employed in all its essential detail in the present machine. Thus, there is provided a drive motor 386 connected with a suitable source of electrical energy through power lines 387 and adapted to drive the gear mechanism (not shown) for rotating the spindles 25. The present invention, however, contemplates certain improvements in the control of the said means.

Operation of the drive motor 386 is controlled by a magnetic power line switch 389 which is connected to the lead 342 and leads 391 and 393, the latter lead being connected with the lead 341. A normally closed switch 394 is interposed in the lead 342, and a normally open switch 395 is connected in series in the lead 391. In order to close the magnetic switch 389 and start the motor 386, the switch 395 is closed to close a preliminary electric circuit through the leads 341, 393, 391 and 342 which energizes an electro-magnet 396 of the switch 389 to close the switch contacts and complete a continuing circuit through the leads 341, 393 and 342. The latter circuit will then remain closed and keep the power line switch closed until the switch 394 is opened to interrupt the circuit, which will then allow the electro-magnet 396 to become inoperative and open the power line switch to stop the motor 386.

Power from the drive motor 386 is transmitted through a shaft 398 to a shaft 399 by means of a suitable clutch 400. Rotary motion should only be imparted to the honing tools during the honing operation, and the same are preferably maintained nonrotatable at all other times. Improved hydraulic control means are therefore contemplated by the present invention for synchronizing the rotation of the hones with the other operations of the machine. In a preferred form of this control means, a bell crank 402 has a shifter arm 403 engaging a conventional annular, channeled shifter collar 404 connected to a clutch element 405 adapted to engage the clutch upon clockwise movement of the bell crank 402 as viewed in Fig. 10. The opposite arm of the crank 402 is pivotally connected to a piston rod 407 which is attached at its opposite end to a piston 408 reciprocable in a cylinder 409. The cylinder 409 is provided at its opposite ends with ports 410 and 411 which provide inlets for pressure lines 412 and 413, respectively. The lines 412 and 413 connect with a control valve 415 through ports 416 and 417 therein, and pressure fluid is delivered to the valve from the pressure line 193 through a port 419.

A bar 421 is slidably mounted parallel with the auxiliary housing 20 and is adapted at its lower end to freely contact the head 23. Downward movement of the bar 421 is limited by a stop 421^a calculated to permit the bar to follow the descent of the head to a position short of the upper limit of its honing stroke. Near its upper end the bar 421 is provided with a weight 75 in the form of a cam member 422 for gravita-

tionally moving the bar downwardly and for engaging with a roller 423 mounted at the end of a stem 424 which is connected at its opposite end to a plunger 426 within the valve 415. A compression spring 428 is adapted to normally urge the stem 424 to the right as viewed in Fig. 10 so as to maintain the roller 423 in the path of the cam 422. The position of the cam 422 on the bar 421 is such that when the head 23 moves in a down stroke the bar 421 will follow until halted by the stop 421^a, and the roller 423 will ride out of engagement with the cam and allow the stem 424 and the plunger 426 to move to the right, whereupon the port 417 will be placed in communication with the port 419 and pressure fluid will pass through the line 413 to the back of the piston 408. The piston rod is thus moved outwardly to rotate the bell crank 402 clockwise and cause engagement of clutch 400 to cause rotation of the shaft 399 and thereby actuate the mechanism for rotating the spindles 25. The cam 422 is preferably of a length such that the roller 423 will ride thereon until the head 23 has moved downwardly sufficiently to carry the honing tools within the bores to be honed. A port 430 in the end of the valve 415 allows fluid to exhaust to the return line 300 when the port 416 is uncovered by the plunger 426, and a passage 431 through the plunger 426 communicates through a port 432 through which fluid may exhaust from the line 413.

The hones 112 need only be reciprocated and rotated for a predetermined length of time in order to effect the desired results, and it is therefore advantageous to provide means whereby operation of the honing machine may be easily and conveniently automatically controlled to withdraw the hones from the work and stop the machine at the end of a given period of operation. A desirable form of control for this purpose is disclosed in the aforementioned Patent No. 1,945,045 and includes a stroke counting mechanism operated by the reciprocations of the head 23.

Without entering upon an elaborate description of the details of the counting mechanism, it is sufficient for the present purpose to point out that the same comprises a counter 432 including a pinion 433 adapted to engage with a rack 435 on the bar 421. The counter 432 is fixedly mounted upon a suitable bracket 436 rigidly secured to the auxiliary housing 20. A lever arm 438 is associated with the plate 361 and as said plate is reciprocated by engagement of the arm 362 with the stops on the bar 353, the arm 438 will actuate a shaft 439 associated with the mechanism within the counter 432.

The counter may be adjusted so that after a predetermined number of reciprocations of the plate 361 a trip mechanism will close a switch 441, thereby closing a circuit through leads 442 and 443. The lead 442 is connected to the lead 342 and the lead 443 is connected to one end of an electro-magnet 445 of a switch 446. The other end of the electro-magnet 445 is connected by a lead 448 directly or through the lead 393 to the lead 341, so that upon closing of the switch 441 a circuit will be completed through the leads 442, 443, and 448 to energize the electro-magnet 445 and close the switch 446. The switch 446 is connected in series in a power lead 450, one end of which is connected to a solenoid 451. A lead 452 is connected to the opposite end of the electro-magnet of solenoid 451 and leads to a suitable source of electrical energy. When

bers 70. Pressure against the new block 28 will force the honed block to the other end of the work support where the same may be removed.

When the pressure on the left of the piston 50, as viewed in Fig. 10, is released and the pressure fluid is allowed to exhaust through the port 207, the compression spring 246 of the interlock 236 will become effective to force the plunger 238 outwardly into the path of the lug 263 on the operating lever 140 so that when the lever is moved through the final segment 270 of its arc of movement the plunger 238 will prevent return movement of the lever. When the indexing stroke of the piston 50 is completed and the work piece 28 has been fully positioned by the indexing mechanism, the port 253 will be opened to the pressure fluid and the plunger 238 will be retracted to allow the operating lever 140 to be returned toward initial position.

As the operator returns the lever 140, the plate 162 will be pivoted so that the arm 170 releases the stem 173 and allows the plunger 176 to return to the left and open the port 201 to the pressure fluid which is delivered through the line 204 to the indexing end of the cylinder 51. The piston 50 and the indexing carriage 45 are thus returned to starting position so that the pawl 41 will engage behind another succeeding work piece to be operated upon in the next cycle of operation. The centering pins 266 will then be raised into engagement with the apertures 271 in the block, and the valve 186 will be actuated to open port 217 and allow pressure fluid to enter through the line 219 to the cylinders 92 to actuate the pistons 96 and clamp the jigs 82 in place. When the operating lever is returned to its at-rest position, the arm 349 will be engaged to close the master control switch 348 between the leads 343 and 338 of the electric control circuit.

Thereupon everything is in readiness for the honing operation and the operator will close one or both of the normally open starting switches 337 and 352 to close the circuit for energizing the electro-magnet 346 which closes the switch 336 whereby the circuit for energizing solenoid 329 is completed. Thereupon, the plunger 307 of the valve 305 will uncover the port 321 and allow high pressure fluid from the pump 188 to be delivered through the line 296 to the valve 288. Thence the pressure fluid will travel through the line 279 to the upper end of the stroking cylinder 276. Downward movement of the piston 277 will carry the piston rod 275 and the reciprocating head 23 downwardly to carry the honing tools 112 from the guide bushings 110 into the cylinder bores 27. The operating levers 134 will engage the inner surfaces of the bushings 110 approximately coincident with the complete entry of the honing tools into the cylinder bores and operate to force the plunger 128 within the honing tools into engagement with the cam faces on the backing members 124 which will then carry the grinding stones 121 beyond the peripheral limits defined by the fiber guides 123 whereby the grinding stones will engage the walls of the cylinder bores 27.

Downward movement of the reciprocating head 23 carries with it the bar 421 and the associated cam member 422 so that the roller 423 on the end of operating stem 424 will ride off of the said cam and the stem will be moved to the right under the influence of spring 428. Movement of the stem 424 carries with it the cam block 469 and the plunger 426. The switch 465 is closed by the cam block 469. Thus, the oper-

ator must maintain the switch 337 closed until the initial downward stroke of the head is substantially under way and the switch 465 is closed, whereafter the energizing circuit for the switch 336 will remain closed until the cam 422 is returned to its upper position to engage the roller 423 and move the stem 424 back into starting position.

When the plunger 426 is moved to the right the port 417 in the valve 415 will be uncovered to permit pressure fluid to be delivered through the line 413 into the cylinder 409 in back of the piston 408 to force the same to the left whereby to operate the bell crank 402 and engage the clutch 400 to transmit power to the shaft 399 from the continuously running drive motor 386, which is independently controlled, to rotate the spindles 25 and the honing tools 112.

The stops on the bar 353^a serve to define the reciprocations of the head by engaging the arms 362 to move the plate 361 and operate the pilot valve 370 which controls the valve 288. After the head 23 has reciprocated a number of times through a stroke amplitude defined by the distance between the stop 357 and the pawl 384 of the stop 359, the counter 432 will operate to close the switch 441. Thereupon the circuit for closing the electro-magnetic switch 446 will be closed and the energizing circuit connected with the solenoid 451 will be closed to operate the solenoid and rotate the bar 353 to remove the stop 359 from operative engagement with the operating arm 362 and allow the reciprocating head 23 to return to starting position. Then the switch 465 will be opened, the hydraulically operated clutch 400 will be disengaged, the solenoid 329 will be deenergized, and operation of the head 23 and the associated hones will be stopped.

From the foregoing it will be apparent that the present invention provides an ingenious arrangement of hydraulically and electrically controlled mechanisms constituting an improved honing machine which is closely correlated in operation, is easily controlled, provides for quick adjustment of the work and is durable and efficient in use.

I claim as my invention:

1. A machine for truing the bores of the cylinders of a V-type internal combustion engine or the like comprising, in combination, a pair of oppositely disposed reciprocatory members supporting rotatably mounted spindles carrying honing tools operable upon converging axes, a support between said members and adapted to receive a work piece to be operated upon by said tools, guide members for receiving said tools to maintain the same in accurately defined axial relationship to said work and for guiding the same into position, said guide members being movable into substantially sealing engagement with said work, and means within said guide members for delivering coolant to said tools when in operation upon said work.

2. In a machine for truing the bores of the cylinders of a V-type internal combustion engine or the like, in combination, a pair of oppositely disposed reciprocatory members carrying rotatably mounted spindles terminating in honing tools, a support between said members and adapted to receive a work piece to be operated upon by said honing tools, a frame rigidly secured to said support and including movable elements adapted to be engaged with said work to clamp the same on said support in position to receive said honing tools, means for delivering 75

the switch 446 is closed the circuit through the leads 450 and 452 will be closed to energize the solenoid 451 which has an armature arm 454 pivotally connected at its outer end to a crank arm 455 secured to the bar 353^a adjacent its upper end. When the solenoid is energized the arm 454 will be drawn to the left as seen in Fig. 10, to turn the crank arm 455 and rotate the bar 353^a, whereby the stop 359 will also be rotated so that the pawl 384 will be moved out of the path of the operating arm 362. The head 23 will then move up through an abnormal stroke until the arm 362 engages the stop 356, and the honing tools will be disassociated from the work.

The rack 435 is only of such length as to engage the pinion 433 during the upward movement of the head 23 to withdraw the tools from the work, that is, while the bar 353^a is in movement with the arm 362 in position between the stops 359 and 356. The bar 421 is cut away below the rack, so that the pinion is operatively associated with the mechanism for resetting the counter only during the abnormal stroke of the head 23. When the switch 441 is opened, the circuit through the leads 442 and 443 is broken and the electromagnet 445 will be deenergized to open the switch 446 and break the circuit through the leads 450 and 452 whereby the solenoid 451 will be deenergized and allow the bar 353^a to assume its initial position.

At times it may be desirable to decrease the period of operative contact of the tools with the work and stop the reciprocatory movements of the head 23 before the counter 432 closes the switch 441. Auxiliary manual as well as electrical control means are in the present instance provided for the purpose. Thus, an operating lever 457 is secured to the lower end of the bar 353^a so that the bar may be manually rotated to shift the pawl 384 of the stop 359 out of operative position relative to the operating arm 362 to permit a premature abnormal stroke of the head 23 to return it to its uppermost position. In addition, a normally open switch 459 is connected in series in a shunt lead 460 and may be closed at the will of the operator to cut out the switch 441 and directly complete the circuit through the leads 443 and 448 to energize the electromagnet 445 and close the switch 446 to operate the solenoid 451 and thereby cause rotation of the bar 353^a.

It may also become desirable at times to increase the time of the honing operation, and for this purpose a normally closed switch 462 is connected in series in the lead 442 so that the circuit may be kept open even after the switch 441 will normally be closed by the counter 432. This may be done at the will of the operator, who may keep the switch open as long as desired and upon releasing the same will close the circuit to operate the switch 446 and thereby the solenoid 451.

An auxiliary circuit maintaining switch for controlling the stroking operation of the machine is provided to be operated by actuation of the stem 424, the movements of which are directly responsive to the stroke of the reciprocatory head 23. Thus, a normally open switch 465 has a contact member 466 attached to one end of a pivotal lever 467 which carries a roller 468 at its opposite end and is adapted to engage a cam block 469 supported by the stem 424. The switch 465 is connected to leads 470 and 471, and will be closed while the stem 424 is in the right hand position into which it will be urged by the spring

428 when the head 23 starts downward and during the time it is in the lower reaches of its reciprocatory movements. The cam block 469 then engages the roller 468 to move the lever 467 clockwise to carry the switch contact 466 across the contact points of the switch. When the head 23 is allowed to move to its uppermost position so that the cam 422 engages the roller 423 which forces the stem 424 to the left, the circuit through the leads 342, 471, 470 and 340 will be opened and the electromagnet 346 will be deenergized to allow the switch 336 to open to interrupt the energizing circuit for the solenoid 329. Thereupon, the valve 305 will cut off the supply of high pressure fluid to the stroking cylinder 276 and the reciprocating head will be stopped.

In addition to the starting switch 352 for initiating the reciprocations of the twin heads 23 of the opposite sides of the machine and which is identical in function to the switch 337, there is provided a switch 475 in series in a lead 476 and similar in function to the switch 395. Likewise, a plurality of control switches 477, 478 and 479, corresponding in function to the switches 394, 459 and 462, respectively, are connected in series with a lead 480, which is connected in parallel with the lead 342. In practice the switches of similar function are placed close together so that an operator may open or close any individual switch, or with one hand may simultaneously actuate the similarly functioning switches for both sides of the machine. Preferably the switches are of the push button type and are all arranged together in a limited area, such as on a suitable panel at a conveniently located part of the machine.

Briefly summarized, the operation of the machine is as follows:

Assuming that the position of the apparatus and controls as shown in Fig. 10, represents the completion of the honing operation upon one of the cylinder blocks 28, the operator will raise the operating lever 140 through the segment 227 of its arc of movement, whereupon the arm 171 of the plate 162 will release the stem 174 so that the compression spring 183 surrounding the same will force the stem and the associated plunger 179 to the left and thereby open the port 220 to the pressure fluid delivered through the lines 193 and 196. The pressure fluid will be delivered through the line 221 to the pistons 92 to force the same to the right and thereby unclamp the jigs 82 from each of the bevelled faces of the block 28.

Then the operator further moves the lever 140 through the arc segment 233 and the rotation of the shaft 143 will drive the spiral gear 273 and cause the gear 275^a and the associated shaft 276^a to rotate clockwise as viewed in Fig. 2 so that the pinion 279^a which is in mesh with the rack 283^a will carry the one or more shafts 267 downwardly to remove the centering pins 266 from the apertures 271 in the work piece 28.

The operating arm 140 will then be moved through the arc segment 234, whereupon the arm 170 of the plate 162 will engage the stem 173 and force the same to the right to uncover the port 202 so that pressure fluid will be delivered to the line 285 through which it is delivered to the return end of the cylinder 51. The piston 50 carries the operating stem 52 with it to actuate the indexing carriage 45 so that the engagement face 63 of the pawl lever 41 will bear against the succeeding block 28 to force the same along the tracks 31 into position under the frame mem-

coolant to said work, and means carried by said elements for guiding said honing tools to said work.

3. In combination in a honing machine, a pair of tool carrying reciprocatory heads in substantial spaced relationship, rotatable honing tools carried by each of said heads, a work support between said heads and adapted operatively to support a work piece relative to said tools, means for reciprocating said heads, hydraulically controlled means for rotating said tools, electrically operated means for controlling the operation of said first mentioned means, and independent electric switches for controlling said electrically operated means for each of said heads, said switches being located in adjacent relationship on one part of the machine whereby said switches may be jointly or separately operated to initiate the reciprocation of said heads simultaneously or independently.

4. In a machine for simultaneously honing the angularly disposed cylinders of a V-type cylinder block, a pair of oppositely inclined reciprocatory members mounted to move axially of said cylinders, spindle means operatively associated with said members and terminating in hones having stones for operating upon the walls of said cylinders, means for clamping a cylinder block in position to receive the hones, means for guiding the hones into the cylinders, means associated with said hones for maintaining the hone stones inoperative until said hones have been positioned within the cylinders, and means for actuating said members independently or simultaneously to reciprocate the hones.

5. In a machine for honing a diagonal cylindrical surface, in combination, a diagonally mounted reciprocable tool carrying member, a honing tool carried by said member and including abrasive means engageable with a diagonal cylindrical surface during operation of the tool as well as non-abrasive contact means to prevent damage by said abrasive means while the tool is being moved to or from engagement with said surface, an element for maintaining said tool in a given axial relationship and adapted to be placed into contact with a work piece having a cylindrical surface whereby to guide the tool into operative relation with said surface, said non-abrasive contact means serving to protect said element from damage by said abrasive means, and means operable incident to the movement of the tool into operative relation for rendering said abrasive means operative upon said surface.

6. In a honing machine, in combination, a stationary work support, a pair of twin reciprocatory heads one at each side of said support, rotatable members carried by said heads and adapted to reciprocate on converging axes, honing tools carried by said members and arranged to be driven thereby, hydraulically controlled means for rotatably driving said members, hydraulically actuated means for reciprocating said heads, means actuated as an incident to the reciprocatory movements of said heads for governing the reciprocatory movements thereof, solenoid operated valve means for controlling the flow of pressure fluid to said hydraulically actuated means, and manually actuatable electric control means for selectively effecting the operation of said heads simultaneously or independently.

7. A honing machine having, in combination, a stationary work support, rotatable reciprocatory members mounted at opposite sides of said support and adapted to reciprocate on converging

axes, honing tools carried by said members and arranged to be driven thereby, hydraulically controlled means for rotatably driving said members, hydraulically actuated means for reciprocating said members, solenoid operated valve means for controlling the flow of pressure fluid to said last mentioned means, and manually actuatable electric control means for selectively effecting the operation of said members simultaneously or independently.

8. A honing machine having, in combination, a stationary work support, rotatable reciprocatory members mounted at opposite sides of said support and adapted to reciprocate on converging axes, honing tools carried by said members and arranged to be driven thereby, means for rotatably driving said members, means for reciprocating said members, and electrical control means for selectively effecting the operation of said members simultaneously or independently.

9. A honing machine having, in combination, a stationary work support, rotatable reciprocatory members mounted at opposite sides of said support and adapted to reciprocate on converging axes, honing tools carried by said members and arranged to be driven thereby, means for rotatably driving said members, means for reciprocating said members, and means for selectively effecting the operation of said members simultaneously or independently.

10. In a honing machine of the class described, the combination of a reciprocatory head having rotatable spindle means operatively associated therewith, honing means carried by said spindle means, a support adjacent said head for supporting work to be operated on by said honing means, means for indexing the work, means for clamping the work in place on said support, electrically controlled means for reciprocating said head, lever controlled means for operating said indexing and clamping means, an electric control switch closable by contact with said lever only when said lever is in position to operate said clamping means, and means for retaining said lever out of position to operate said clamping means until the work has been indexed.

11. A machine for truing the bore of an internal combustion engine cylinder or the like, having, in combination, a spindle carrying a honing tool, a support upon which the work is positioned with the axis of the bore to be honed aligned with the axis of the spindle, means including a power source for rotating the spindle, pressure fluid actuated means for effecting relative movement between the work and the spindle longitudinally of the latter, said pressure fluid actuated means having a main control valve and an auxiliary control valve, automatic means for operating said main control valve whereby to effect continuous relative reciprocation with a normal stroke of a length determined by the length of the bore, means for controlling said automatic means to produce an abnormal stroke of a predetermined length such as to disassociate the tool and the work, independent means for operating said auxiliary control valve so as to stop relative longitudinal movement at the end of said abnormal stroke, and a hydraulically operated clutch operable incident to said abnormal stroke to disengage said means for rotating the spindle from said power source coincident with the stopping of the reciprocating means.

12. In a machine of the class described, a reciprocatory tool carrying member, said member being reciprocable through a defined tool op-

erative stroke as well as through an abnormal longer stroke, electrically controlled means for reciprocating said member, a normally open switch manually closable to initiate the operation of said electrically controlled means, an auxiliary switch closable as an incident to the reciprocations of said member and adapted to remain closed to maintain said electrically controlled means in operation during said operative stroke of said member, and means coacting with said tool carrying member to open said auxiliary switch as an incident to said abnormal stroke of said member to stop the operation of said electrically controlled means.

13. In a machine of the class described, a reciprocatory tool actuating member reciprocable through a defined tool operative stroke and through an abnormal longer stroke, means for reciprocating said member, a bar mounted to reciprocate with said member, automatic stroke counting mechanism actuated by the reciprocatory movements of said member, means controlled by said mechanism for moving said member through said abnormal stroke after a predetermined number of tool operative strokes, and means actuated by said bar for automatically halting operation of said first mentioned means to stop the reciprocations of said member incident to said abnormal stroke.

14. In a machine of the character described, a reciprocatory member operatively carrying a rotatable tool, a work support arranged to receive a work piece to be operated upon by said tool, means for automatically positioning the work piece correctly on said support, a device movable toward said work piece for guiding said tool thereto and including means for delivering coolant to the work, coordinately controlled means for operating said device and said means for positioning the work, means for reciprocating said member, power driven means for rotating said tool, and means operable incident to the reciprocatory strokes of said member for controlling the operation of said power driven means.

15. In a machine of the character described, a reciprocatory member operatively carrying a rotatable tool for acting upon the cylindrical bore of a work piece, a support arranged to receive the work piece, means for automatically positioning said work piece on said support, a device movable toward said work piece for guiding said tool to said work and including means for delivering coolant to the work, common control means for synchronously operating said device and said means for positioning the work, means also operated by said control means for centering said work on said support, means for reciprocating said member and including operating means governed by said control means, power driven means for rotating said tool, and means operable incident to the reciprocatory strokes of said member for controlling the operation of said power driven means.

16. In a machine of the class described, a reciprocatory tool carrying member, tools carried by said member, means for rotating said tools, a hydraulically operated clutch for controlling the operation of said means, electrically actuated means for controlling the reciprocation of said tool carrying member, and means operable incident to the reciprocatory movements of said member for controlling the operation of said clutch and said electrically actuated means.

17. In apparatus of the character described, a work support adapted to receive a work piece

having a pair of diagonal faces in converging planes and bored perpendicularly to said planes, a pair of members having openings therethrough and movable on axes defined to bring said members into engagement with the diagonal faces of said work piece with said openings in registration with the bores in said faces, and means operable to move said members simultaneously toward said faces.

18. In a machine of the character described adapted to operate upon a work piece having a face disposed diagonally to the horizontal, the combination of a tool carrying member adapted to direct a tool perpendicularly to the diagonal face of the work piece, a tool carried by said member, stationary means for supporting the work piece in position for operation thereon by said tool, and a guide member positioned adjacent said tool carrying member and adapted to guide said tool to the work, said guide member being movably mounted relative to said supporting means and including means for delivering coolant fluid to the work and tool, and power actuated means for clamping the guide member into substantially sealing contact with the work to prevent escape of said fluid due to the diagonal position of said work face.

19. In a honing machine of the character described, in combination, a reciprocatory head having a rotatable spindle member terminating in a honing tool, a support adjacent said head and adapted to receive a piece of work to be operated on by said honing tool, a rigid frame on said support, a reciprocable member associated with said frame and adapted to be moved into engagement with said work to clamp the same in position on said support, and means for guiding said honing tool relative to said work including a bushing carried by said reciprocable member.

20. In a honing machine of the class described, the combination of a reciprocatory head, rotatable spindle means operatively supported by said head, honing means carried by said spindle means, a support adjacent said head for supporting work to be operated on by said honing means, indexing means for accurately positioning a piece of work relative to said spindle means, and means for clamping the work in place on said support including means for guiding said honing means to the work.

21. In a honing machine of the class described, the combination of a hydraulically operated reciprocatory head carrying rotatable spindle means, honing means carried by said spindle means, a support adjacent said head for supporting work to be operated upon by said honing means, hydraulic means for indexing a piece of work relative to said spindle means, and hydraulic means for clamping the work in place on said support.

22. In a machine of the character described, a support for a piece of work, means movable in a substantially horizontal plane in engagement with the piece of work for moving said piece of work horizontally into position upon the support, means rigid with said support and carrying reciprocable clamping means for securing said work against movement on said support, and common means for operating said indexing means and said clamping means one after the other in the order named.

23. In apparatus of the character described, in combination, a support for a piece of work, indexing means for moving said work into position on said support, means for clamping the

work in place after said indexing means has positioned the work, and common control means for successively actuating said indexing means and said clamping means.

24. In a honing machine of the class described, the combination of a reciprocatory member having rotatable spindle means operatively associated therewith, honing means carried by said spindle means, a support adjacent said member for supporting work to be operated on by said honing means and including means for moving the work into position to be honed, a clamp for holding the work in place on said support during operation of the honing means, and manually operable means for controlling both said moving and clamping means.

25. In a machine of the class described, the combination of a tool carrying member, tools carried by said member, a support for carrying a work piece in operative relationship to said tools, means for automatically indexing a work piece on said support, means for clamping said work piece on the support in operative relationship to said tools, electrically controlled means for operating said member and tools, a manually operable control lever for controlling the operation of said indexing and clamping means, and an electric master control switch operable by said lever as an incident to the operation of said clamping means for controlling the operation of said electrically controlled means.

26. In a machine of the character described, a work support, hydraulically operated means for automatically positioning a work piece on said support, a control lever for operating said hydraulically operated means, and an hydraulically operated interlock engageable by said control lever and operable incident to the operation of said hydraulically operated means to control the movement of said lever.

27. In a machine of the character described, means for operating a tool, a support for receiving a work piece to be operated upon by said tool, means for automatically positioning a work piece on said support, an operating lever for controlling the operation of said means, and an interlock operable incident to the operation of said means and engageable by said lever for controlling its movement.

28. In a honing machine of the class described, the combination of a reciprocatory member having rotatable spindle means operatively associated therewith, honing means carried by said spindle means, a support adjacent said member for supporting work to be operated on by said honing means and including a device for indexing the work, clamping means adapted to bear against the work during operation of the honing means, control means for the device and clamp, and an interlock for preventing the operation of said clamp until said device has operated to index the work on said support.

29. A machine of the character set forth, comprising, in combination, a tool carrier, a tool supported by the carrier, a support adjacent said tool carrier for supporting work to be operated upon by said tool, means for indexing the work by moving the same into tool operating position, means for engagement with said work to hold the same in indexed position, means for clamping the work against said support, and a single control for successively operating each of said means.

30. In a machine of the character described, a tool carrier operatively supporting a tool, a sup-

port adjacent said carrier and adapted to receive a work piece to be operated upon by said tool, means for positioning a work piece upon said support, an operating lever for controlling the operation of said means, and a centering pin actuated by movement of said operating lever to engage with said work piece after said means has operated thereon to position the same on said support.

31. A machine of the character set forth comprising, in combination, a tool carrier, a tool supported by the carrier, a support adjacent said tool carrier adapted to receive work to be operated upon by said tool, hydraulically operated means for positioning the work on said support, hydraulically operated means adapted to be clamped against said work when in position relative to said tool, separate valves for controlling the hydraulic operation of both of said hydraulically operated means, control mechanism for operating said valves including a shaft having a valve actuating member and an operating lever thereon, a centering pin element for engagement with a work piece after the latter has been positioned on said support, and means actuable by the movement of said shaft by said lever for operating said element.

32. A honing machine comprising, in combination, means for supporting a V-type engine block in upright position with the cylinders inclined upwardly and outwardly and with upwardly and inwardly inclined upper end faces, a pair of tool supporting heads mounted above said block on opposite sides thereof for reciprocation parallel to the axis of the cylinders and having rotary honing tools for the respective cylinders, clamping means coacting with the inclined upper end faces of the block to hold it in position during the honing operation, and means for reciprocating said heads simultaneously.

33. A honing machine comprising, in combination, means for supporting a V-type engine block in upright position with the cylinders inclined upwardly and outwardly and with upwardly and inwardly inclined upper end faces, a pair of tool supporting heads mounted above said block for reciprocation parallel to the axis of the cylinders and having rotary honing tools for the respective cylinders, means for reciprocating said heads in timed relation to effect the simultaneous honing of all of said cylinders, and coolant supply means engageable with said inclined faces of the block in liquid conducting relation to the cylinders thereof.

34. A honing machine comprising, in combination, means for supporting a V-type engine block in upright position with the cylinders inclined upwardly and outwardly and with upwardly and inwardly inclined upper end faces, a pair of tool supporting heads mounted above said block on opposite sides thereof for reciprocation parallel to the axis of the cylinders and having rotary honing tools for the respective cylinders, clamping means coacting with said upper end faces of the block to hold it in position during the honing operation, means for reciprocating said heads, and means operative as an incident to the engagement of said clamping means with the block to provide a plurality of coolant supply passages in liquid-conducting relation to the respective cylinders of the block.

35. A honing machine for operating upon a V-type engine block comprising in combination a pair of oppositely disposed heads reciprocable in oppositely inclined planes and having rotary tool spindles with honing tools flexibly suspended

thereon, means for supporting an engine block in upright position between said heads with its cylinders coaxial with the respective spindles, means for guiding the honing tools into and out of their respective cylinders, and means for supplying coolant through the guide means to the cylinders, said supporting means for the block and said guide means being relatively movable to effect a substantially tight liquid seal between the block and the guide means.

36. In a machine of the character set forth, in combination, a tool carrier, a tool supported by the carrier, a support adjacent said tool carrier for supporting work to be operated upon by said tool, and means for indexing a work piece on said support including a reciprocable carriage carrying a pawl adapted to engage said work piece to move the same into position upon actuation of the carriage, said pawl being mounted on an eccentric pivot with the heavier end extending rearwardly to maintain the forward end in a normal work engaging position, and a stop coacting with said pawl to maintain the rear end of the pawl positively below a plane wherein the same might catch upon a work piece.

37. In a honing machine or the like, a reciprocatory tool carrying member operable through a reciprocal cycle including in one part an operative stroke and in another part a longer approach and return stroke overlapping said operative stroke, electrically controlled means for reciprocating said member, a normally open starting switch for initiating said reciprocal cycle, an auxiliary control switch for governing operation of said electrically controlled means following initiation of said cycle, and a controller coacting with said member for operating said auxiliary switch as an incident to said reciprocal cycle and serving to maintain said auxiliary switch closed throughout said operative stroke and during part of said approach and return stroke beyond said operative stroke but effective to open said auxiliary switch in the extreme return position of said member.

38. A honing machine for V-type engine blocks comprising, in combination, a substantially V-shaped supporting structure including an elongated horizontal base and upright supports at opposite sides of the base, tool heads mounted on the respective upright supports for reciprocation in paths disposed approximately 45 degrees from a median plane extending longitudinally of the base, each of said heads having a plurality of rotatively driven tool spindles with honing tools flexibly suspended therefrom, means for supporting an engine block for movement longitudinally above the base into an upright position in operative relation to said honing tools, means carried by the supporting structure closely adjacent opposite sides of the block and adapted to support and guide the honing tools during the insertion thereof into and withdrawal from the block, and power driven mechanism for driving said spindles and imparting a reciprocatory motion to said heads.

39. A honing machine for V-type engine blocks comprising, in combination, a substantially V-shaped supporting structure including an elongated horizontal base and upright supports at opposite sides of the base, tool heads mounted on the respective upright supports for reciprocation in paths disposed approximately 45 degrees from a median plane extending longitudinally of the base, each of said heads having a plurality of rotatably driven tool spindles with honing tools

flexibly suspended therefrom, means for supporting an engine block for movement longitudinally above the base into an upright position in operative relation to said honing tools, means carried by the supporting structure closely adjacent opposite sides of the block and adapted to support and guide the honing tools during the insertion thereof and withdrawal from the block, and power driven mechanism for driving said spindles and imparting a reciprocatory motion to said heads, said power driven mechanism including a separate driving means for the respective heads arranged for manual control from a common point and operative independently to impart reciprocatory motion to the heads and rotate the spindles thereof.

40. An apparatus of the character described comprising, in combination, means for supporting work pieces for movement in a predetermined path, a pair of machine units disposed on opposite sides of said path and each having a reciprocable tool carrying member, means for reciprocating each of said members including a separate operation controlling mechanism for each of said members, means for rotating said members, means coacting with each of said members and responsive to the reciprocable movements of the latter for controlling the operation of said rotating means, and independent manually operable elements for controlling each controlling mechanism, said manually operable elements being located adjacent one of said units and adapted for separate or joint operation to initiate reciprocation of said members independently or simultaneously.

41. An apparatus of the character described comprising, in combination, supporting means for carrying work pieces for movement in a predetermined path, a pair of machine units disposed on opposite sides of said path and each having a reciprocable tool carrying member, means for reciprocating said members including a separate electrically controlled operating mechanism for each of said members, and independent electric switches for controlling said operating mechanisms, said switches being located in adjacent relationship on one part of the apparatus for joint or separate operation to initiate reciprocation of said members independently or simultaneously.

42. An apparatus of the character described comprising, in combination, means for supporting work pieces for movement in a predetermined path, a pair of machine units disposed on opposite sides of said path and each having a reciprocable tool carrying member, separate hydraulically operated means for reciprocating each of said members and including separate electrically actuated control mechanisms; and separate electric switches for operating said control mechanisms, said switches having a common location on the apparatus for joint or separate operation to initiate reciprocation of said members simultaneously or independently.

43. In a honing machine for finishing internal cylindrical surfaces, a reciprocable tool carrier having a rotary honing tool thereon, a stationary work support, a jig member having a passage coaxial with the cylindrical surface to be honed, guide means for said member mounted on said work support and reciprocably supporting said member for movement toward and from the work support, said member being operative to clamp the work against said work support and to support and guide said tool in its movement into the work, means for moving the jig member into

clamping engagement with the work, and means for moving said tool carrier to carry the tool through said passage into the work.

44. In a machine of the character described, 5
a reciprocable tool, supporting means for carrying a work piece in position within the operative range of said tool, power actuated means for moving the work piece into position on said supporting means, power actuated means for engaging said 10
work piece to retain the same in fixed position on said supporting means, common control mechanism for operating both of said power actuated means in the order set forth, and means operable by said control mechanism to initiate the reciprocation of said tool, said means being effective 15
until the work piece is in said fixed position to maintain said tool inoperative.

45. In a honing machine of the class described,

reciprocatory honing tool carrying means reciprocable through a defined tool operative stroke and through an abnormal longer stroke, mechanism for reciprocating said tool carrying means, means including a member mounted to reciprocate with said tool carrying means, stroke determining means actuated by the reciprocatory movements of said member, means controlled by said stroke determining means for moving said member through said abnormal stroke after a 10
predetermined number of tool operative strokes, means for halting operation of said mechanism to stop the reciprocations of said tool carrying means after it has moved to one limit of said abnormal stroke, and means carried by said member and coacting with said last-mentioned means 15
for operating the latter.

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