

March 9, 1943.

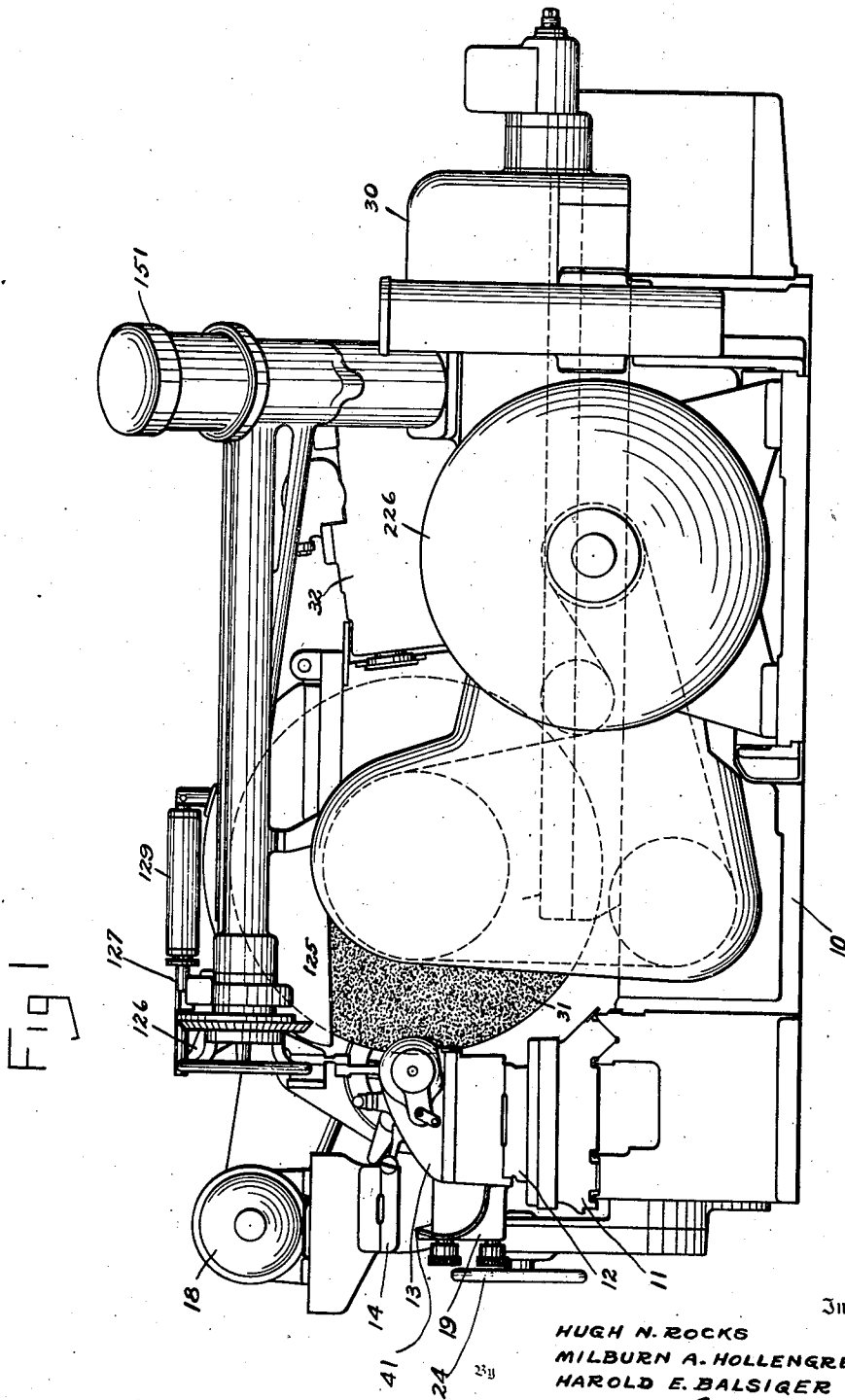
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2,313,482

MULTIPLE WHEEL GRINDING MACHINE

Filed June 6, 1940

7 Sheets-Sheet 1



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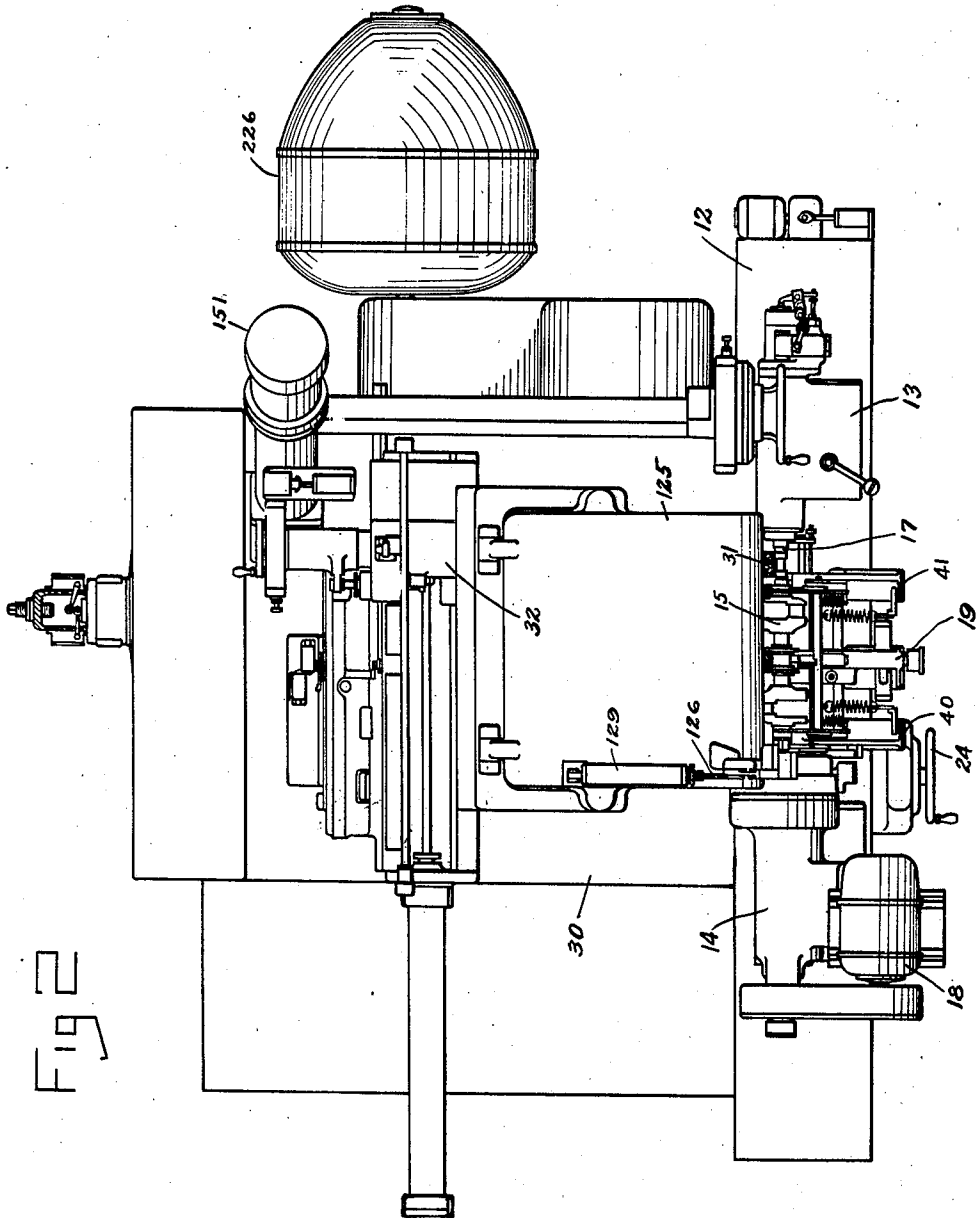


Fig 2

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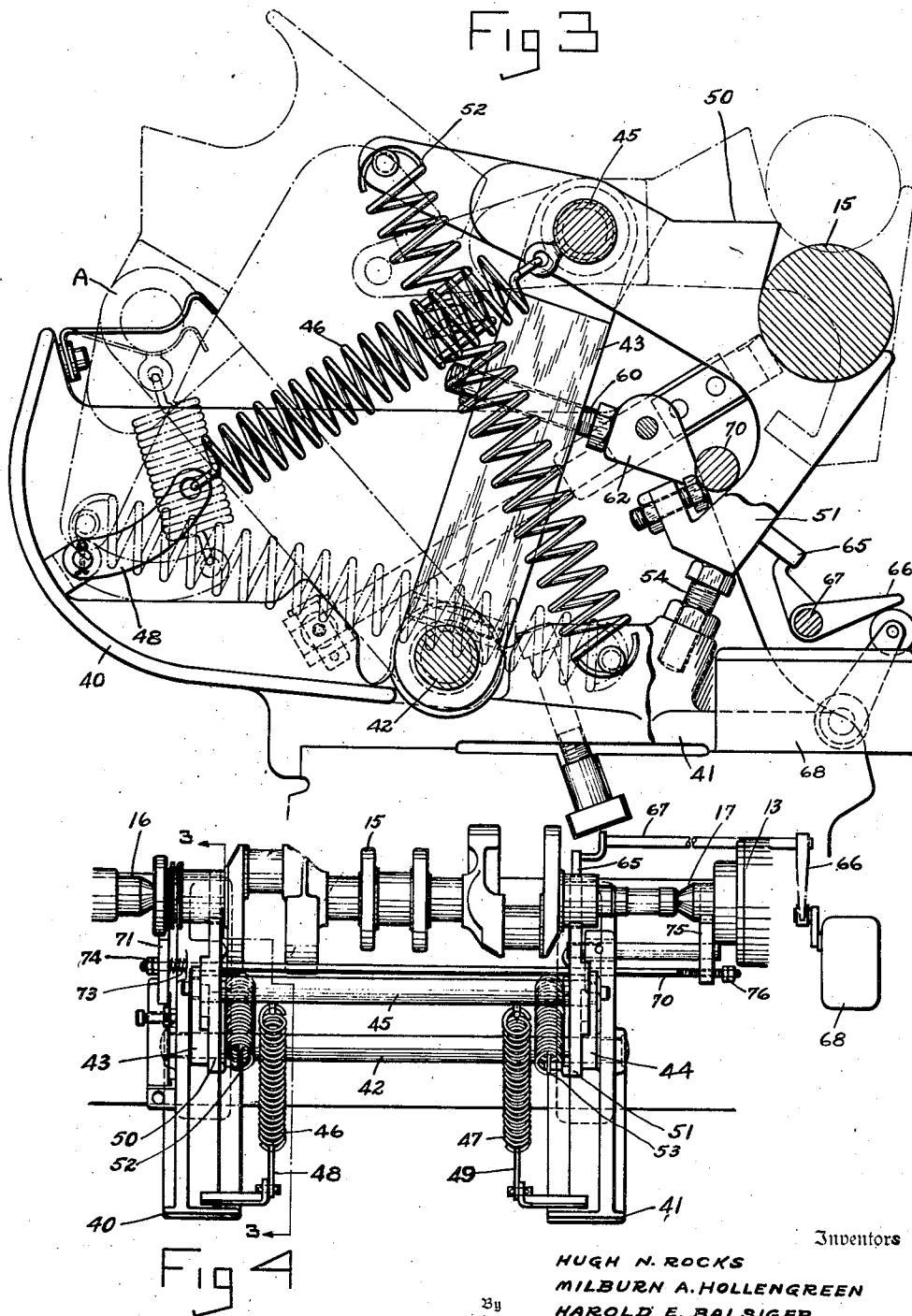
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Fig 5

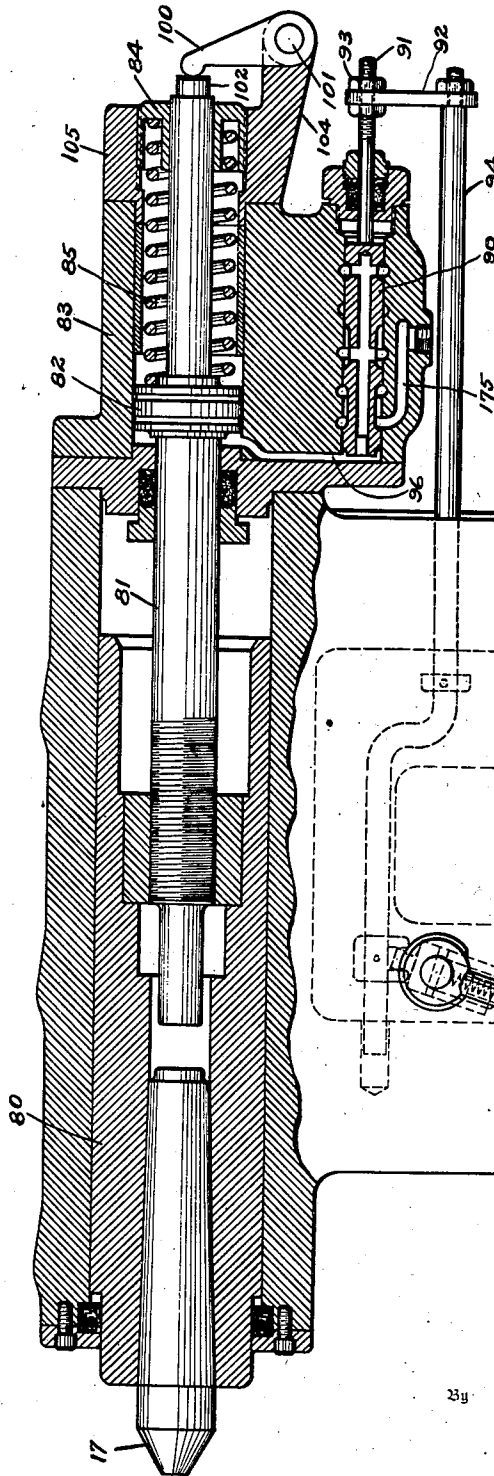
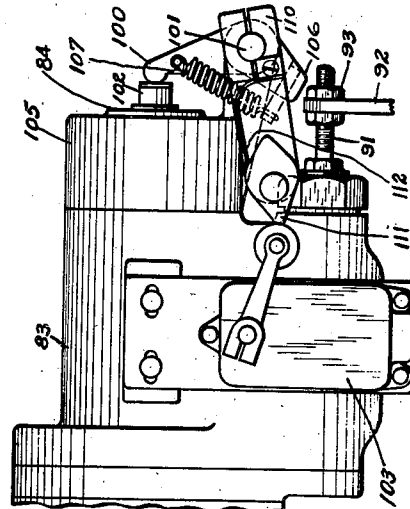


Fig 6



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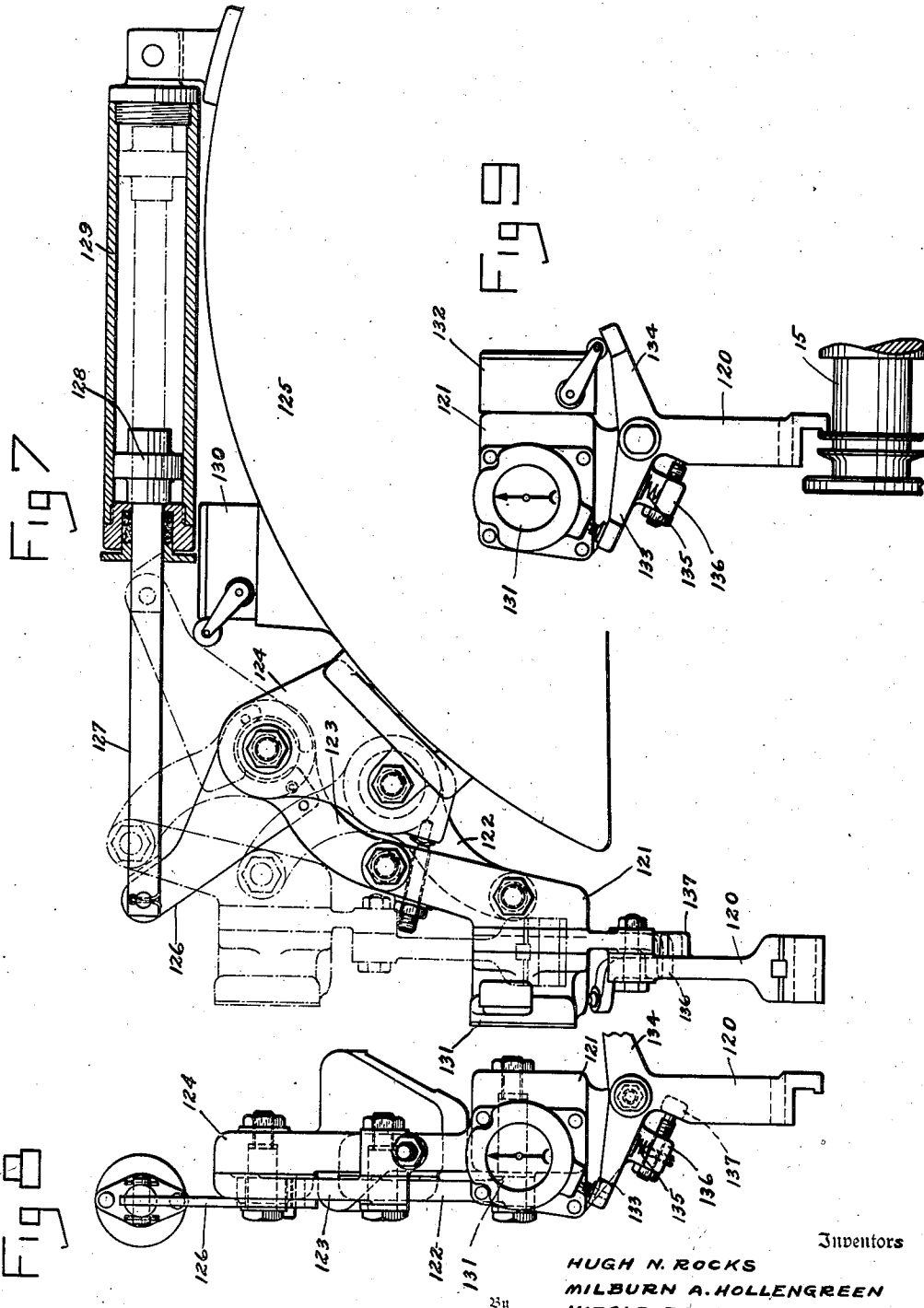
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7 Sheets-Sheet 5.



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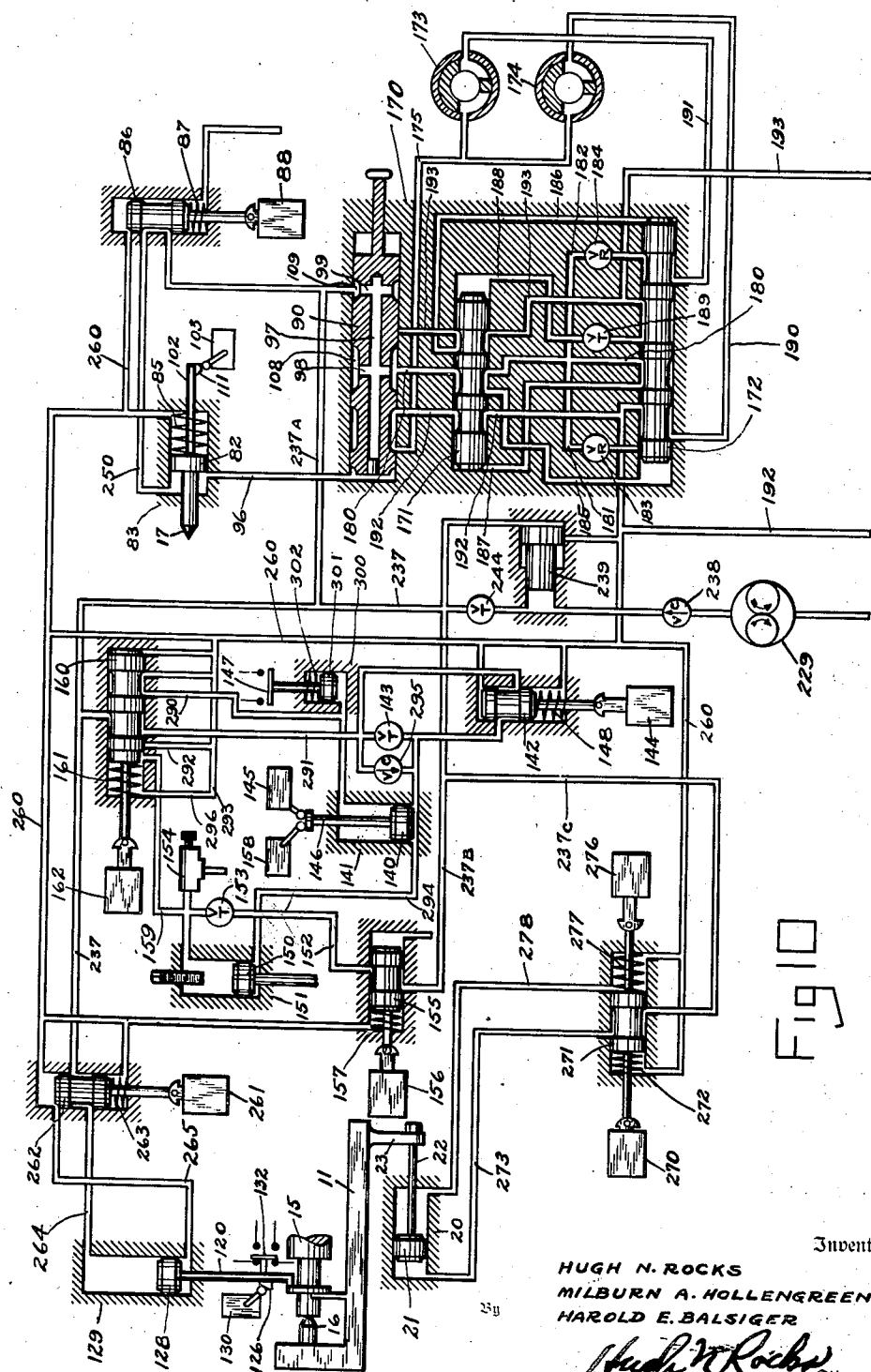
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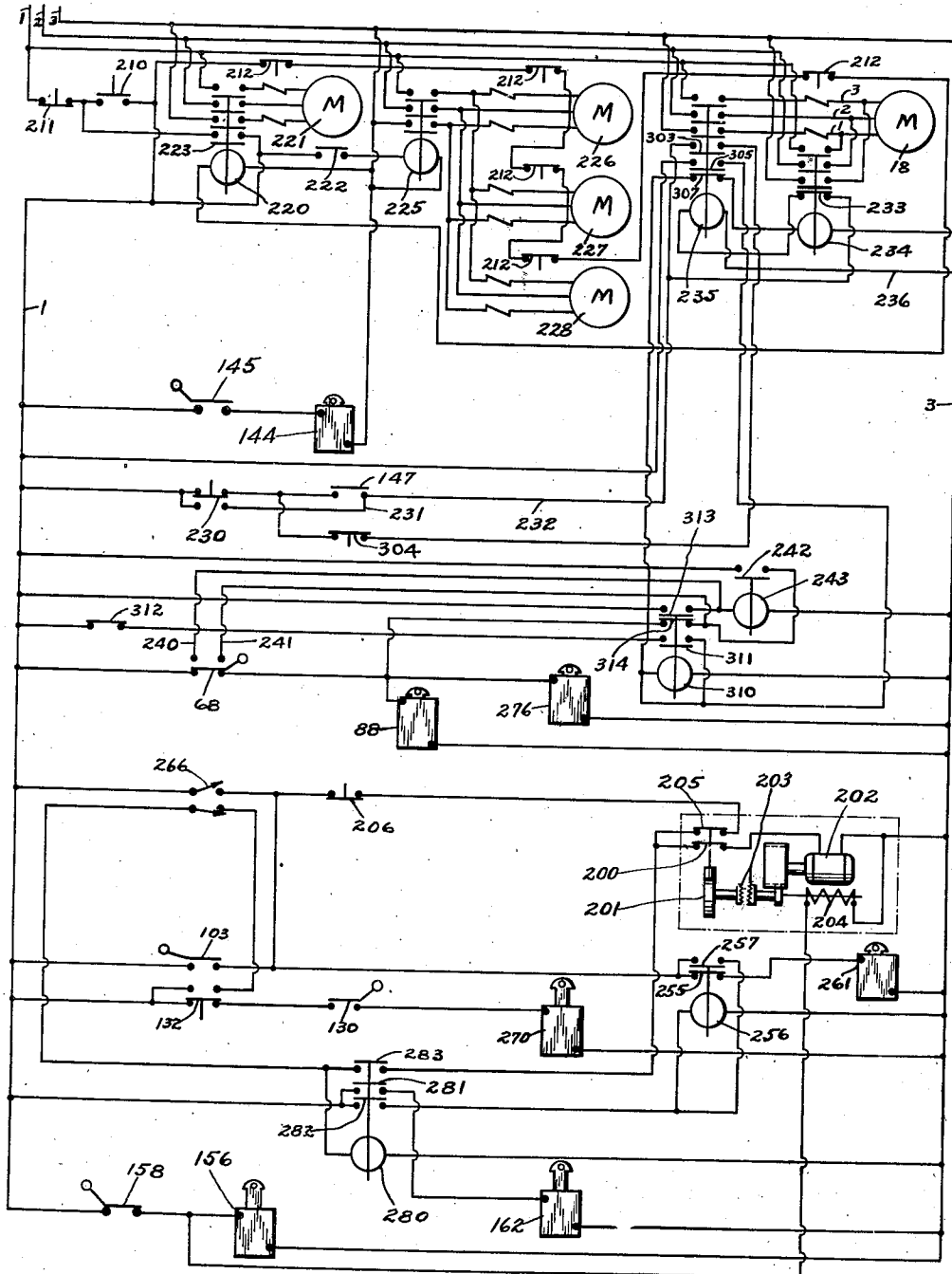


Fig 11

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UNITED STATES PATENT OFFICE

2,313,482

MULTIPLE WHEEL GRINDING MACHINE

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Application June 6, 1940, Serial No. 339,192

24 Claims. (Cl. 51—105)

Our invention relates to metal working machines, particularly grinding machines of the type having a plurality of wheels on a spindle for grinding a plurality of axially aligned bearing surfaces simultaneously.

It is an object of our invention to provide a machine wherein the cycle of operations after loading is performed automatically.

A further object is to provide a loading mechanism for a machine of this type.

A further object is to provide means responsive to movement of said loading means for initiating a predetermined cycle of operations.

A further object is to provide a machine wherein each operation in a cycle is initiated in response to a previous operation.

Our invention resides in the mechanisms for effecting sequential operation of the various elements of the machine. The work piece is placed on a loading device which in turn is shifted to place the work in alignment with the head and footstock centers. Movement of the loading device into this position operates a switch which causes the footstock center to move axially to pick up the work and to shift same into operative engagement with the headstock center. At a predetermined point in this movement of the footstock a locating member is moved into position adjacent a flange on the work piece. In response to movement of said locator the work carriage is shifted to the right to cause said flange to approach said locator. When the work has been properly positioned the carriage stops, the locator is withdrawn, the grinding wheel is advanced toward the work, and the work rest is also moved into contact with the work. Movement of the work rest may occur simultaneously with advance of the wheel, or it may be delayed until after the wheel has started to grind depending upon the characteristics of the work to be ground, or it may be initiated manually at any time. The grinding operation may be controlled by any suitable sizing device or timing mechanism. When the work has been ground to size, the wheel base is withdrawn and the withdrawal movement is utilized to effect withdrawal of the footstock center. The work piece thus released is lifted out of grinding position by the spring actuated loader. When the loader releases the normally closed switch which actuated the footstock, a solenoid valve is shifted which moves the carriage to the left, where it remains until another work piece is placed in position, when the above described cycle is repeated. Withdrawal of the footstock center and movement of

the carriage to the left may be initiated simultaneously, also.

Figure 1 is an end elevation.

Figure 2 is a plan view.

5 Figure 3 is a sectional end view on line 3—3 of Figure 4 of the loading mechanism.

Figure 4 is a plan view of the loading mechanism.

Figure 5 is a plan view of the footstock partly in section.

Figure 6 is a partial plan view of the footstock.

Figure 7 is an end view of the locating device.

Figure 8 is a front elevation of said device.

15 Figure 9 is a front elevation of the locating device showing its relation to a work piece.

Figure 10 is a diagram of the hydraulic system.

Figure 11 is a wiring diagram.

In the drawings, numeral 10 indicates the bed of a grinding machine, 11 a work carriage slidably mounted thereon, 12 a swivel table on said carriage, 13 a footstock on said swivel table, and 14 a headstock, also on said swivel table. A work piece 15, in this case a crankshaft, is rotatably supported on headstock center 16 and footstock center 17. Rotation of said crank is effected by a motor 18 driving the headstock spindle (not shown) thru suitable gearing or belt connections. A steady rest 19 supports the work 20 15 against the action of the grinding wheel. A longitudinal movement of carriage 11 is effected by a hydraulic motor consisting of a cylinder 20 secured to the bed and a piston 21 slidably mounted in said cylinder. A piston rod 22 on said piston is secured to a bracket 23 on carriage 11. Said movement may be effected manually by handwheel 24 thru any suitable transmission. A wheel base 30 is slidably mounted on bed 10 for transverse movement toward and from said work piece. A spindle (not shown) rotatably mounted in spaced bearings on said support carries one or more grinding wheels 31. A wheel dressing mechanism 32 is mounted on said support 30 behind said wheels. This mechanism is described in detail in co-pending application Serial No. 220,776 filed July 22, 1938. The mechanism for effecting said transverse movement is shown here only in diagrammatic form but is shown and described fully in co-pending application Serial No. 196,254 filed March 16, 1938, now Patent No. 2,211,530, granted August 13, 1940.

Loading mechanism

The mechanism for placing the work in grind-

ing position consists of a pair of end members 40 and 41 which form a base or support for the mechanism. A shaft 42 is rotatably mounted in said members near the bottom thereof. Said shaft forms a pivoted support for a pair of arms 43 and 44 secured at opposite ends thereof. A second shaft 45 joins said arms at another point. A pair of springs 46 and 47 are attached at one end to shaft 45 and at the other end thru links 48 and 49 to end members 40 and 41 respectively. Said springs serve to hold arms 43 and 44 in the position indicated at A.

A pair of arms 50 and 51 are secured to shaft 45. Said arms are urged in a counter-clockwise direction by springs 52 and 53 attached to one end of said arms. The other end of each of said arms is shaped to receive a work piece. A downwardly projecting portion of arm 51 engages an adjustable stop 54 in end member 41 which determines the extent of movement of the arms 50 and 51 toward the work supporting centers 16 and 17. Movement of arm 43 is limited by the adjustable stop 60 engaging lug 52 in the end member 41. Similar elements, not shown, limit the movement of arm 44.

A dog 65 on arm 51 serves upon movement of the loader to place a work piece in grinding position to depress an arm 64 on shaft 67. At the other end of said shaft is a second arm 66 adapted for operative engagement with a limit switch 68. The function of said switch is to initiate operation of the footstock to pick up the work piece and shift it against the headstock center. A rod 70 supported in said end members 40 and 41 has a disk 71 mounted at the headstock end. A spring 73 on said rod urges said disk against nuts 74 on said rod. Said disk is so positioned that if moved far enough axially it will engage a flange on the work piece and shift said piece off the headstock center. A means for so shifting said disk consists of the bracket 75 attached to said footstock center and extending into operative relation with said rod. Said bracket is movable relative to said rod but the movement is limited by adjusting nuts 76.

Footstock

The footstock 13 is of conventional construction consisting of a sliding sleeve 80 in one end of which is inserted a center 17 and in the other end of which is adjustably mounted a piston rod 81. Piston 82 is mounted in a cylinder 83. A cap 84 on said cylinder retains a spring 85 which urges said piston and footstock center to the left. Said piston is shifted to the right by fluid under pressure from a valve 86 shown diagrammatically in Figure 10. Said valve may be actuated in one direction by a spring 87 and in the opposite direction by a solenoid 88.

Attached to cylinder 83 is a start and stop valve 90. A valve stem 91 passes thru one end of a bracket 92 which may be adjusted thereon by nuts 93. The other end of said bracket is attached to rod 94 slidably mounted in the footstock base 13. Said rod may be shifted to the left by means of a lever 95. Said rod might also be shifted automatically in response to the operation of the wheel base or some other suitable mechanism. However, the function of this valve is to initiate operation of a steady rest, to be described later. As the time for starting such an operation differs considerably from piece to piece, it is preferred to leave the control to the judgment of the operator. Means for shifting said valve in the opposite direction to withdraw the

back rest consists of a fluid line 96 from the left end of cylinder 83 to the left end of said valve 90.

A switch 103 mounted on said footstock is adapted to be actuated by movement thereof. The means for actuating said switch consists of an arm 100 pivoted to one end of a shaft 101 and having one end in contact with tailrod 102 on piston 82. Said shaft is mounted in a protruding portion 104 of a member 105 forming part of cylinder 83. A lug 106 on said portion has attached thereto one end of a spring 107. The other end of said spring is attached to arm 100 and serves to hold said arm in contact with tailrod 102 as described above.

On the other end of shaft 101 is secured an arm 110. A cam 111 at one end of said arm is pivotally supported thereon. Rotation of said cam in a counter-clockwise direction is limited by a positive stop (not shown), and in a clockwise direction it is limited yieldingly by a spring 112. The function of said arm is to actuate said limit switch 103 in timed relation with the movement of the footstock. The limit switch in turn controls a work locating device.

Locator

A device for effecting longitudinal location of the work and wheel consists of a locating feeler 120 disposed in the path of travel of a flange or other portion of the work. Said locating feeler is pivotally supported on a member 121 which is in turn carried by two parallel arms 122 and 123 pivotally attached to a bracket 124 on wheel fender 125. Another arm 126 is attached to arm 122, and also to a piston rod 127. A piston 128 on said rod is slidably mounted in a cylinder 129. Said cylinder is in turn mounted on said fender 125. A two pole switch 130 is mounted on said fender in such a position as to be actuated by movement of arm 126. Said member 121 supports a dial indicator 131 and a limit switch 132. Said indicator and switch are actuated by arms 133 and 134 respectively on locating feeler 120. Said locating feeler is yieldingly held against counter-clockwise movement by a spring 135, one end of which rests against arm 133, the other against a portion of a lug 136 on member 121. Clockwise movement due to said spring is positively limited by a stop screw in lug 136 and disposed in the path of another lug 137 on locating feeler 120.

Feed mechanism

The structure of the feed mechanism used on our machine is described in co-pending application Serial No. 196,254 filed March 16, 1938, now Patent No. 2,211,530, granted August 13, 1940. Briefly it consists of a piston 140 and a cylinder 141 for shifting a feed screw and nut (not shown), aligned with the wheel support 30 toward and from working position. As the piston 140 moves the wheel support 30 toward working position the exhaust fluid from cylinder 141 may pass freely thru a normally open solenoid actuated valve 142, or if said valve is closed it must pass thru a throttle valve 143. The function of the throttle valve is to slow down the rapid feed movement sufficiently to grind surfaces such as shoulders, crankcheeks, etc. The solenoid 144 which actuates said valve is energized by a switch 145. Said switch may be held in inoperative position by some portion of the wheel support 30 or the mechanism for moving said support, in this case a tailrod 146 on the piston 140. Said switch may be adjusted in any suitable

manner to function at any desired predetermined time during the rapid feed movement. A pressure switch 147 is connected into the line thru which fluid is directed to move the support 30 toward working position. A second piston 150 is a cylinder 151 acts thru a rack and pinion or an equivalent mechanism (not shown) to rotate the feed screw or nut and thus effect a slow feed movement of said wheel support. Fluid under pressure for actuating said piston during a grinding operation is controlled by solenoid valve 155. Said valve is actuated in one direction by a solenoid 156 and in the opposite direction by spring 157. Solenoid 156 is energized by switch 158. Said switch is actuated by the tailrod 146. The relative position of said switches is such that switch 145 is released first and just as the wheel approaches the peripheral surface to be ground, switch 158 is released to start the grinding feed. Fluid under pressure for moving the piston 140 in either direction and for resetting piston 150 is controlled by a reversing valve 160. Said valve may be actuated in one direction by a spring 161 and in the opposite direction by a solenoid 162.

Steady rest operating mechanism

Steady rest 19 is similar to that shown and described in co-pending application Serial No. 274,439 filed May 18, 1939. The principal difference is in the mechanism for effecting intermittent rotation of the adjusting screws. Said mechanism, shown diagrammatically in Figure 10, consists of a valve body 170 in which are slidably mounted two hydraulically interlocked reversing valves 171 and 172, one of which directs fluid under pressure intermittently to two hydraulic motors 173 and 174. Said motors are attached to the adjusting screws of steady rest 19. For the sake of convenience, start and stop valve 90 shown and described in connection with the footstock mechanism of Figure 5, is shown in Figure 10 as being mounted in valve body 170. Valve 90 has a passage 97 formed therein joining spaced radial passages 98 and 99. Said passages open into chambers 108 and 109 respectively. Fluid under pressure enters valve 90 thru chamber 109 and is directed by passages 99 and 97 to passage 180 in valve body 170 leading to valve 171. Said passage 180 continues as thru valve 171 to supply fluid to valve 172. A pair of passages 181 and 182 lead from passage 180 to the ends of valve 172. Relief valves 183 and 184 in each of said passages determine the pressure in each passage independently. Valve 171 directs fluid from passage 180 thru one or the other of passages 185 or 186 to opposite ends of valve 172 to reciprocate said valve. Fluid supplied to valve 172 thru passage 180 is directed thru one or the other of passages 187 or 188 to opposite ends of valve 171 to reciprocate same. A throttle valve 189 in passage 188 determines the rate of movement of valve 171 and thus the frequency of reciprocation of valve 172. Fluid supplied to valve 172 thru passages 181 and 182 is directed alternately thru passages 190 and 191 to fluid motors 173 and 174. Exhaust passages 192 and 193 have connections to each of the valves 90, 171 and 172 for carrying off any exhaust fluid passing thru said valves. For resetting the steady rest, fluid under pressure is directed by valve 90 thru passage 175 which divides to carry fluid to both of the motors 173 and 174. Said motors are thus actuated in a

direction to return the work engaging members to inoperative position.

Size control mechanism

Size control may be effected either by controlling the duration of the grinding operation or by the use of a caliper to indicate a change in size of a work piece.

The caliper type of size control is shown in co-pending application Serial No. 196,254 filed March 16, 1938, now Patent No. 2,211,530, granted August 13, 1940. In this application we make use of a conventional time control mechanism, which consists of a two pole normally closed relay 200, a cam 201 for actuating said relay, a motor 202 for driving said cam, a clutch 203 for connecting and disconnecting said cam and motor, and a solenoid 204 for actuating said clutch.

The motor 202 may be connected as soon as the rapid feed starts but the actuation of the clutch 203 is preferably delayed until the grinding feed begins and is therefore connected into the circuit with solenoid 156 and switch 158.

Operation

To start our machine, the operator closes start switch 210 which connects line 1 thru stop switch 211 with a series of thermal overload relays 212, one for each of a plurality of electric motors, and with a relay 220 to start pump motor 221 for driving the pump which supplies lubricant to the spindle for rotatably supporting the grinding wheels 31.

When sufficient pressure has been built up in the spindle lubricating system, pressure switch 222 completes a circuit from contact 223 of relay 220 to energize relay 225. Said relay 225 starts wheel motor 226, oil pump motor 227, and coolant pump motor 228. Fluid under pressure for actuating the various mechanisms is supplied by a pump 229 thru a main conduit 237, and a number of branch conduits 237a, 237b, etc. A check valve 238 prevents a return of fluid thru pump 229 when said pump is stopped. A relief valve 239 described in detail in co-pending application Serial No. 321,310 filed February 28, 1940, compensates for variation in viscosity of the fluid. A throttle valve 244 in line 237 determines the pressure of fluid delivered to the hydraulic system.

Headstock motor 18 may be started manually by a jog switch 230 which completes a circuit from line 1 thru line 231 bypassing normally open pressure switch 147, thru line 232, normally closed contact 233 of relay 234 to motor control relay 235, and then thru line 236 to line 3. The only result of closing switch 230 is to start the motor.

A work piece 15 is placed on arms 50 and 51 in a portion thereof formed to receive same. Said arms are then swung into alignment with the centers 16 and 17. This movement is limited by stop 54 which locates arm 51. As arm 51 engages stop 54 a dog 65 actuates arm 66 to release normally closed switch 68. Releasing said switch closes a circuit between lines 240 and 241, but the circuit is open to line 1 at the normally open contact 242 of relay 243. Releasing switch 68 opens a circuit thru the normally open contacts thereof between line 1 and the footstock solenoid 88 thus deenergizing said solenoid. Spring 87 then shifts valve 86 to connect fluid line 250 with exhaust line 260 thus permitting the escape of fluid from footstock cylinder 83. Spring 85 then shifts piston 82 and center 17 to the left to engage work piece 15. As footstock center 17 moves to the left, tailrod 102 releases arm 100, and spring 107 causes

said arm along with shaft 101, arm 110, and cam 111 to move in a counter-clockwise position to actuate normally open limit switch 103. The time of actuation of said switch relative to the footstock movement may be adjusted by adjusting the position of arm 110 on shaft 101 or any other suitable arrangement. We prefer to actuate said switch slightly before the end of the footstock movement which shifts the crank 15 onto headstock center 16. Closing switch 103 completes a circuit thru normally closed contact 255 of relay 256 to energize locator solenoid 261. Said solenoid shifts valve 262 against spring 263 to direct fluid under pressure from line 237 thru line 264 to cylinder 129 to shift piston 128 and locating feeler 120 into operative position relative to a portion of work piece 15. Solenoid 261 may be energized also by manually operated two-pole switch 266 in parallel with switch 103. The poles of said switch are opened and closed alternately. In response to movement of piston 128, arm 126 shown as a cam in Fig. 10, actuates normally open switch 130 which completes a circuit from line 1 thru the normally closed pole of switch 132 to energize solenoid 270. Said solenoid shifts a reversing valve 271 to the left against spring 272 to direct fluid from line 237c thru line 273 to the left end of cylinder 20 to shift piston 21 and carriage 11 to the right. Another solenoid 276 when energized shifts said valve to the right against spring 277 to direct fluid under pressure thru line 278 to the right end of cylinder 20. The operation of said solenoid 276 will be described later. After the actuation of solenoid 270, carriage 11 moves to the right until a portion of work piece 15 engages locating feeler 120 and shifts it far enough to actuate switch 132. Said switch thus actuated opens the circuit from line 1 thru normally open contact of switch 130 to deenergize solenoid 270, releasing valve 271 which is shifted to central position by spring 272 to stop carriage 11 with work piece 15 in proper location relative to grinding wheels 31. Actuation of switch 132 also closes a circuit thru the normally open contacts thereof. This circuit connects line 1 thru switch 132 and switch 266, thru normally closed timer relay contact 200 to start timer motor 202. The time cycle however does not begin until later when the clutch solenoid is energized. Said circuit also energizes relay 280. One of the three normally open contacts 281 completes part of a circuit thru rapid feed solenoid 162. The rest of the circuit is completed upon withdrawal of gauge 120 when cam 126 releases switch 130 to close the normally closed contact thereof. Another contact 282 completes a circuit to energize relay 256. The circuit to locator solenoid 261 thru the normally closed contact 255 of relay 256 is opened and the relay is held thru the normally open contact 257. Deenergizing solenoid 261 permits spring 263 to shift valve 262 to direct fluid thru line 265 to shift piston 128 and locating feeler 120 to inoperative position. The third normally open contact 283 of relay 280 provides a holding circuit thru timer contact 205 and footstock switch 103 after the locating feeler has been returned to inoperative position.

Rapid feed solenoid 162, when energized, shifts valve 160 to the left directing fluid under pressure from line 237 thru line 290 to the rod end of cylinder 141 to shift piston 140 and wheel base 30 rapidly toward grinding position. Exhaust fluid from the other end of said cylinder may be directed thru a normally open bypass valve 142 from which it is directed thru line 291 to valve

160 and then thru passage 292 and exhaust manifold 293 to exhaust line 260. Fluid under pressure in line 290 enters cylinder 300 in which a piston 301 is slidably mounted and shifts said piston against spring 302 to close switch 147. Closing switch 147 has the same effect as closing the normally open contacts of switch 230 as described above. However, in addition to starting the headstock motor 18, relay 235 thru normally open contact 305 energizes relay 310. Said relay is held thru its normally open contact 311. In the line between line 11 and said contact is a plugging or brake switch 312. Energizing relay 310 closes the normally open contact 313 thereof which completes a circuit thru relay 243. Said circuit is held thru normally open contact 242 of said relay, line 240, loader switch 68 and line 241. A normally closed contact 314 of relay 310 is opened at this time. Said contact 314 is in a circuit parallel to that which includes the normally closed contact of loader switch 68.

As piston 140 and wheel base 30 move rapidly toward the work, switch 145 is released to energize solenoid 144 which shifts valve 142 to prevent the exhaust of fluid therethru from cylinder 141. Said exhaust fluid must then escape thru throttle valve 143 which is set for a feed rate suitable for grinding crank cheeks or shoulders. As the wheel approaches the peripheral surface to be ground, switch 158 is released, deenergizing solenoid 155 and permitting spring 157 to shift valve 155 to the right. In this position, said valve directs fluid under pressure from line 237b thru line 152, and throttle valve 153 to the head end of slow feed cylinder 151 to start the grinding feed. A relief valve 154 in line 152 is set for a pressure lower than the pressure in the system but sufficient for operating the slow feed mechanism. This prevents undue strain on the parts of said mechanism. Switch 158 also completes a circuit to energize clutch solenoid 204 to start the operation of the timing mechanism, the timing motor 202 having been started at the same time as the rapid feed.

The operator waits until he thinks that the portions being ground have been sufficiently rounded out and then shifts valve 90 to the left. This operation could be included in the automatic cycle but it is preferable to leave the time for initiating same to the judgment of the operator. Fluid under pressure from line 237a enters chamber 109, radial passage 99 and axial passage 97 from which it is discharged thru radial passage 98 and chamber 108 to passage 180. Fluid under pressure in passage 180 is directed by valve 171 thru either of the passages 185 or 186 to opposite ends of valve 172 to reciprocate same. Fluid in passage 180 is directed by valve 172 thru passages 187 and 188 to opposite ends of valve 171 to effect reciprocation thereof. Valve 172 receives fluid from branch passages 181 and 182 of passage 180. Fluid in said branches must pass thru pressure reducing valves 183 and 184 each of which may be adjusted for different pressures depending upon the requirements of the corresponding work engaging mechanism. Fluid from said branch passages is directed alternately by valve 172 thru passages 190 and 191 to back rest adjusting motors 173 and 174 respectively. Said motors are thus given a pulsating movement as described in the above mentioned application Serial No. 274,439. The frequency of said pulsations may be controlled by throttle valve 169 in passage 188 which alternately controls the supply of fluid to and the exhaust from one end of valve

171 thus controlling the rate of movement of said valve and the frequency of reciprocation of valve 172.

At the end of the grinding period the timing contacts are opened, timer motor 202 is stopped and rapid feed relay 280 is deenergized due to opening of timer contact 205 in the holding circuit of said relay. If it is desired to stop the grinding operation before the end of the grinding cycle, relay 280 may be deenergized by opening the cycle return switch 206 in the circuit with the timer contact 205.

Deenergizing relay 280 opens the circuit thru contacts 282 to relay 256. However, relay 256 is kept energized by the holding circuit thru normally open contact 257.

The circuit thru contact 281 of relay 280 upon opening deenergizes rapid feed solenoid 162. Spring 161 then shifts valve 160 to the right to the position shown in Figure 10. Fluid under pressure is directed from line 237 thru line 291 and check valve 295 to cylinder 141 causing piston 143 to move wheel support 30 to separate work piece 15 and wheels 31. Fluid under pressure in line 291 passes thru line 294 and enters the rod end of cylinder 151 to reset piston 150 and the slow feed mechanism. At the same time switch 158 is actuated to deenergize solenoid 156 and open the circuit to timer motor 202. Valve 155 is then shifted to the right by spring 157 to prevent further passage of fluid under pressure from line 237b to line 152. Exhaust fluid from the other end of cylinder 151 passes thru passage 159 to valve 160 from which it is discharged thru exhaust passage 296, and manifold 293 to exhaust line 260. The exhaust passage might be dispensed with and the exhaust fluid pass out thru relief valve 154 which is set for a much lower pressure than the rest of the system.

As the rearward movement of wheel base 30 continues, switch 145 is actuated to deenergize solenoid 144. Spring 148 may then reset valve 142 to its normal position, i. e. open to bypass exhaust fluid around throttle valve 143.

Pressure switch 147 remains closed under the exhaust pressure in line 290. When the rearward movement of the wheel base is completed, spring 302 will shift piston 301 to open the circuit thru said switch. Relay 235 will be held thru contact 303 thereof until tappet switch 304 is opened by rotation of the headstock spindle whereupon said relay will be deenergized. Contact 305 in the circuit to relay 310 will be opened but said relay will be held by a circuit thru its own contact 311. Normally closed contact 307 of relay 235 will complete a circuit thru said contact 311 to reverse relay 234. Said reverse relay, upon being energized, will cause motor 18 to start rotation in the opposite direction. However, such reverse rotation immediately opens plugging switch 312 in the holding circuit of relay 310 and also deenergizes reverse relay 234 thru the normally closed contact 307 of relay 235 to stop motor 18.

Deenergizing relay 310 opens the circuit thru contact 313 to relay 243 but said relay is held by the circuit thru loader switch 68 and lines 240 and 241. Line 241 is connected to line 1 thru the normally open contact 242 of relay 243. Deenergizing said relay 310 also closes the normally closed contact 314 which completes a circuit from line 1 through contact 242 to energize footstock solenoid 88. Said solenoid shifts valve 86 against spring 87 to direct fluid under pressure from line 237a thru line 250 to withdraw footstock center

17. Bracket 75 on said center is effective thru rod 70 and disk 71 to shift work piece 15 off of headstock center 16. The work being thus freed of the centers, the springs 46 and 47 and 52 and 53 of the loading device will lift it out of grinding position and carry it back to a point where the operator may remove it and replace it with an unground piece.

At the time when footstock solenoid 88 is energized, carriage control solenoid 276 is also energized. Said carriage solenoid shifts valve 217 to the right and directs fluid under pressure thru passage 278 to shift piston 21 and carriage 11 to the left to loading position.

Movement of the loading device to inoperative position permits switch 68 to return to normal position as shown in Figure 11. Thus the circuit thru lines 240 and 241 is opened and relay 243 is deenergized. With switch 68 in normal position, footstock solenoid 88 and carriage control solenoid 276 are both energized and the valves actuated thereby are so positioned as to direct fluid under pressure to hold footstock center 17 and carriage 11 in inoperative positions.

Fluid under pressure in said line 250 also passes thru line 96 to shift valve 90 to the right. This movement opens passage 175 to the fluid which shifted said valve and said fluid is thus directed to back rest motors 173 and 174 to rotate same in a counter-clockwise direction and thus reset the work engaging members of said rest.

We claim:

1. In a metal working machine, a work support having a headstock and footstock mounted thereon, work supporting centers in said headstock and footstock, a loading mechanism for placing a work piece in operative position including a pivoted work receiving member having resilient means for lifting said work away from said centers, said resilient means being just strong enough to overcome the weight of the work piece and having sufficient movement to return said work to inoperative position.

2. In a metal working machine, a support having a cutting tool mounted thereon, a work support having a headstock and a footstock mounted thereon, work supporting centers in said headstock and said footstock, mechanism for shifting one of said centers axially whereby to engage a work piece and move same into operative relation with the other center, a gauge member movable toward and from operative position for determining the relative axial positions of the work piece and the cutting tool, and means responsive to the shifting of said center for moving said gauge member into operative position.

3. In a metal working machine, a tool support movable toward and from a work piece and having a cutting tool mounted thereon, a work support, means for rotatably supporting a work piece thereon, means for moving said work support and said tool support relatively longitudinally, means for relatively locating the work and tool axially including a gauge movable toward and from work position and having means for co-acting with a locating surface on said work piece, and means responsive to movement of said gauge into working position for causing a relative longitudinal movement between said tool and said work whereby to position said tool and work for machining.

4. In a metal working machine, a tool support movable toward and from a work piece and having a cutting tool mounted thereon, a work support, means for rotatably supporting a work

piece thereon, means for relatively locating the work and tool axially including a gauge movable toward and from working position and having means for co-acting with a locating surface on said work piece, means for causing a relative longitudinal movement between said tool and said work, and mechanism actuated by said gauge when said tool and said work reach a predetermined position for stopping said longitudinal movement.

5. In a metal working machine, a tool support movable toward and from a work piece and having a cutting tool mounted thereon, a work support, means for rotatably supporting a work piece thereon, mechanisms for effecting relative transverse and longitudinal movements of said supports, means for relatively locating the work and tool axially including a gauge movable toward and from working position and having means for co-acting with a locating surface on said work piece, means for causing operation of said mechanism for effecting relative longitudinal movement between said tool and said work, and mechanisms actuated by said gauge when said tool and said work reach a predetermined position for stopping said longitudinal movement and for returning said gauge to inoperative position.

6. In a machine of the kind set forth in claim 5, means responsive to the return of said locating gauge for actuating said transverse moving mechanism for causing a feeding movement between said tool and said work piece.

7. In a machine of the kind set forth in claim 5, means responsive to the return of said locating gauge for actuating said transverse moving mechanism for causing a feeding movement between said tool and said workpiece and a size control mechanism for actuating said transverse moving mechanism to separate said work and tool at a predetermined point in the machining operation.

8. In a metal working machine, a tool support, a cutting tool mounted thereon, means for effecting a transverse movement of said support toward and from a work piece, a work support, means for rotatably supporting a work piece thereon, including a headstock and a footstock having centers for engaging the work piece, a loading mechanism for placing a work piece in and removing same from operative position, means for relatively locating the work and tool axially including a gauge movable toward and from working position and having means for co-acting with a locating surface on said work piece, means responsive to movement of said gauge into working position for causing a relative longitudinal movement between said tool and said work, mechanisms actuated by said gauge when said tool and said work reach a predetermined longitudinal position relative to one another for stopping said longitudinal movement, withdrawing said gauge to inoperative position and initiating movement of said tool toward a work piece, a size control mechanism, and means actuated thereby when a work piece has reached a predetermined size for releasing said loading mechanism to remove said work piece from operative position.

9. In a metal working machine, a tool support, a cutting tool mounted thereon, means for effecting a transverse movement of said support toward and from a work piece, a work support, means for rotatably supporting a work piece thereon, including a headstock and a footstock having centers for engaging the work piece, a

loading mechanism for placing a work piece in and removing same from operative position, means for relatively locating the work and tool axially including a gauge movable toward and from working position and having means for co-acting with a locating surface on said work piece, means responsive to movement of said gauge into working position for causing a relative longitudinal movement between said tool and said work, mechanisms actuated by said gauge when said tool and said work reach a predetermined longitudinal position relative to one another for stopping said longitudinal movement, withdrawing said gauge to inoperative position and initiating movement of said tool toward a work piece, a size control mechanism, and means actuated thereby when a work piece has reached a predetermined size for withdrawing said footstock center thereby releasing said loading mechanism to remove said work piece from operative position.

10. In a metal working machine, a tool support, a cutting tool mounted thereon, means for effecting a transverse movement of said support toward and from a work piece, a work support, means for rotatably supporting a work piece thereon, including a headstock and a footstock having centers for engaging the work piece, a loading mechanism for placing a work piece in and removing same from operative position, means for relatively locating the work and tool axially including a gauge movable toward and from working position and having means for co-acting with a locating surface on said work piece, means responsive to movement of said gauge into working position for causing a relative longitudinal movement between said tool and said work, mechanisms actuated by said gauge when said tool and said work reach a predetermined longitudinal position relative to one another for stopping said longitudinal movement, withdrawing said gauge to inoperative position and initiating movement of said tool toward a work piece, a size control mechanism, and means actuated thereby when a work piece has reached a predetermined size for releasing said loading mechanism to remove said work piece from operative position and for returning said work support to inoperative position.

11. In a metal working machine, a tool support, a cutting tool mounted thereon, means for effecting a transverse movement of said support toward and from a work piece, a work support, means for rotatably supporting a work piece thereon, means for relatively locating the work and tool axially including a gauge movable toward and from working position and having means for co-acting with a locating surface on said work piece, means for causing a relative longitudinal movement between said tool and said work to locate said parts for a cutting operation, and means responsive to withdrawal of said gauge for initiating movement of said tool toward said work piece.

12. In a metal working machine, a tool support, a cutting tool mounted thereon, means for effecting a transverse movement of said support toward and from a work piece, a work support, means for rotatably supporting a work piece thereon, means for relatively locating the work and tool axially including a gauge movable toward and from working position and having means for co-acting with a locating surface on said work piece, means for causing a relative longitudinal movement between said tool and said

work to locate said parts for a cutting operation, and interlocking means for effecting withdrawal of said gauge and for initiating movement of said tool toward said work piece.

13. In a metal working machine, a support having a cutting tool mounted thereon, a work support, means for rotating a work piece thereon including a headstock and footstock, an axially movable center in said footstock, mechanism for effecting relative feeding and longitudinal movements of said supports, a motor for moving said footstock center toward and from operative position, a loading device for placing a work piece in alignment with said footstock center, means operable when said loading device has moved a work piece into position for effecting operation of said footstock center to engage said work piece and to shift same into operative relation with said headstock, means for locating the work laterally relative to the cutting tool including a gauge member, a motor operable in response to movement of said loading mechanism for moving said gauge member into and out of operative position relative to a selected surface of the work piece, means operable after said gauge has moved into position for initiating movement of said work support to cause the locating surface on a work piece to move toward said gauge, means operable when said surface reaches a predetermined position for withdrawing said gauge and for initiating said relative feeding movement to bring the cutting tool into operative relation with a work piece and for actuating said work rotating means, a size control mechanism, means actuated thereby when the work has been ground to a predetermined size for separating said cutting tool and work, means actuated by said separating movement for stopping rotation of the work, withdrawing said footstock center, and returning said work support to starting position, and means operable in response to withdrawal of said center for causing said loading device to remove said work piece from operative position.

14. In a metal working machine, a work carriage, a tool support, a cutting tool mounted thereon, mechanisms for effecting relative transverse and longitudinal movements of said support and said carriage, mechanism for rotatably supporting a work piece on said carriage, means for actuating said work supporting mechanism to engage and support a work piece, a device for locating said work piece and said cutting tool axially of one another, means whereby operation of said transverse and longitudinal moving mechanisms, said work supporting mechanism, and said locating mechanism are actuated in a predetermined sequence, and means for initiating said sequence by placing a work piece in the machine.

15. In a metal working machine, a work carriage, a tool support, a cutting tool mounted thereon, mechanisms for effecting relative transverse and longitudinal movements of said support and said carriage, mechanism for rotatably supporting a work piece on said carriage, means for actuating said work supporting mechanism to engage and support a work piece, a device for locating said work piece and said cutting tool axially of one another and in operative relation, means whereby operation of said transverse and longitudinal moving mechanisms, said work supporting mechanism, and said locating mechanism are actuated in a predetermined sequence, means for initiating said sequence by placing a work piece in the machine, a size control mechanism and

means actuated thereby for separating said work and tool, and mechanism responsive to said separating movement for removing said work from the machine and for initiating said longitudinal movement whereby to return said carriage and said tool to inoperative relation.

16. In a metal working machine, a tool support, a cutting tool mounted thereon, a work support, means for rotatably supporting a work piece thereon, mechanism for effecting a relative transverse movement between said supports at a rapid rate to position said tool and work in operative relation, mechanism for thereafter effecting said transverse movement at a slower rate for cutting, a size control mechanism including a timing device, and means responsive to said transverse movement for starting said timing device and said slow transverse movement at substantially the same time whereby to determine the duration of a machining operation.

17. In a metal working machine, a support having a cutting tool mounted thereon, a work support having a headstock and a footstock mounted thereon, mechanism for effecting a relative transverse positioning movement between said supports, work supporting centers in said headstock and said footstock, mechanism for shifting one of said centers axially whereby to engage a work piece and move same into operative relation with the other center, a gauge member movable toward and from operative position for determining the relative axial positions of the work piece and the cutting tool, and means for effecting withdrawal of said gauge and for initiating operation of said transverse positioning movement.

18. In a metal working machine, a work support, a loading mechanism for placing work in and removing same from operative position, resilient means for holding said loading mechanism in inoperative position, means for holding the work in operative position against the action of said resilient means including a headstock and a footstock each having a center for engaging and supporting the work piece, means for retracting one of said centers, said resilient means being operable upon withdrawal of said center for returning said work and loading mechanism to inoperative position.

19. In a metal working machine, a tool support movable toward and from a work piece and having a cutting tool mounted thereon, a work support, means for rotatably supporting a work piece thereon, mechanisms for effecting relative transverse and longitudinal movements of said supports, means for relatively locating the work and tool axially including a gauge movable toward and from working position and having means for co-acting with a locating surface on said work piece, means for causing operation of said mechanism for effecting relative longitudinal movement between said tool and said work, mechanisms actuated by said gauge when said tool and said work reach a predetermined position for stopping said longitudinal movement and for returning said gauge to inoperative position, and mechanisms operable in timed relation with said gauge return movement for actuating said transverse moving mechanism.

20. In a metal working machine, a tool support movable toward and from a work piece and having a cutting tool mounted thereon, a work support, means for rotatably supporting a work piece thereon, mechanisms for effecting relative transverse and longitudinal movements of said

supports, means for relatively locating the work and tool axially including a gauge movable toward and from working position and having means for co-acting with a locating surface on said work piece, means for causing operation of said mechanism for effecting relative longitudinal movement between said tool and said work, mechanisms actuated by said gauge when said tool and said work reach a predetermined position for stopping said longitudinal movement, for returning said gauge to inoperative position, and for actuating said transverse moving mechanism to cause the tool to be moved to operative position.

21. In a metal working machine, a work support having means thereon for rotatably supporting a work piece, a loading mechanism including a member movable from a remote inoperative position to a position adjacent said rotatable work supporting means, means for normally holding said member in said inoperative position, a work carrier mounted on said member, means for holding said work carrier in position with the work piece out of alignment with said rotatable supporting means when said member is in operative position, said carrier being movable therefrom to place said work piece in alignment with said rotatable supporting means.

22. In a metal working machine, a work support having means thereon for rotatably supporting a work piece, a loading mechanism including a pivoted member movable from a remote inoperative position to a position adjacent said rotatable work supporting means, resilient means for normally holding said member in said inop-

erative position, a work carrier pivotally mounted on said pivoted member, means for yieldingly holding said work carrier in position with the work piece out of alignment with said rotatable supporting means when said pivoted member is in operative position, said carrier being movable against said yielding means to place said work piece in alignment with said rotatable supporting means.

23. In a metal working machine, a work support having a headstock and footstock mounted thereon, work supporting centers in said headstock and footstock, a loading mechanism for placing a work piece in operative position including a movable work receiving member having means capable of exerting just enough force to overcome the weight of the work piece, said work receiving member being movable from a position for receiving a work piece to a position for engagement of said work piece by said centers.

24. In a metal working machine, a tool support, a cutting tool mounted thereon, a work support, means for rotatably supporting a work piece thereon, mechanism for effecting a relative transverse movement between said supports at a rapid rate to position said tool and work in operative relation, mechanism for thereafter effecting said transverse movement at a slower rate for cutting, a size control mechanism including a timing device, and means operable substantially at the end of said transverse positioning movement for starting said timing mechanism.

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