Feb. 9, 1943. M. H. ARMS 2,310,338

METALWORKING MACHINE

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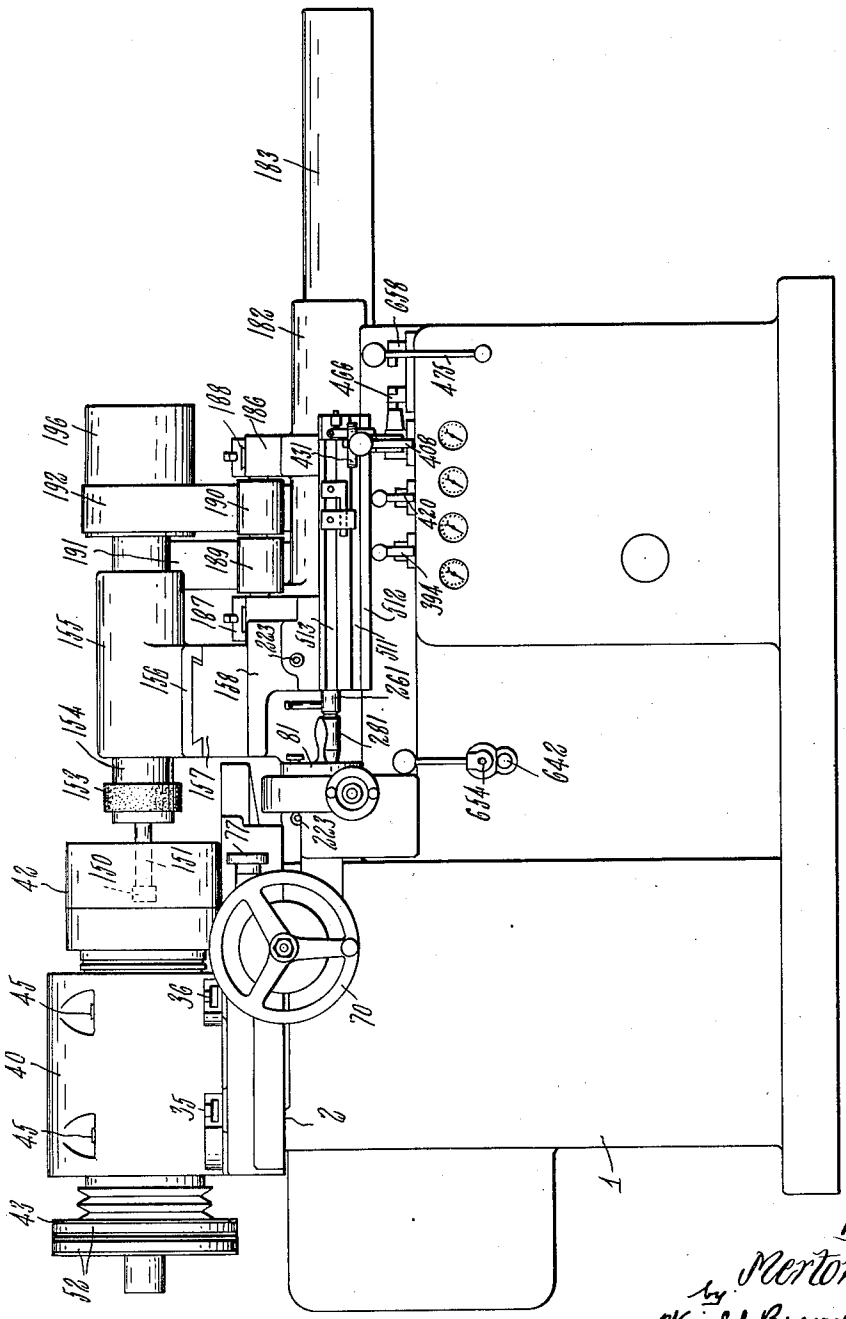


Fig. 1.

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METALWORKING MACHINE

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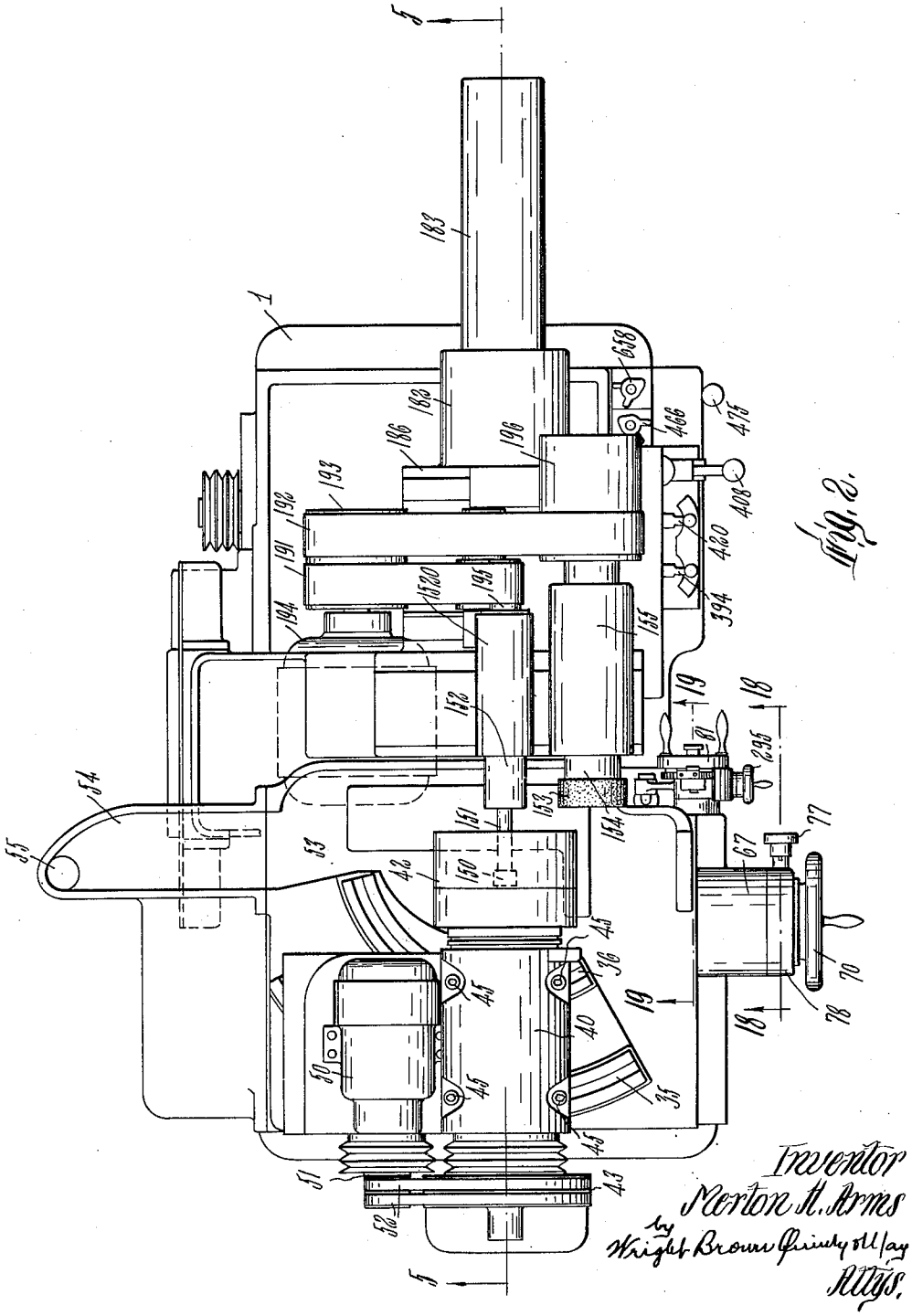


Fig. 2.

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METALWORKING MACHINE

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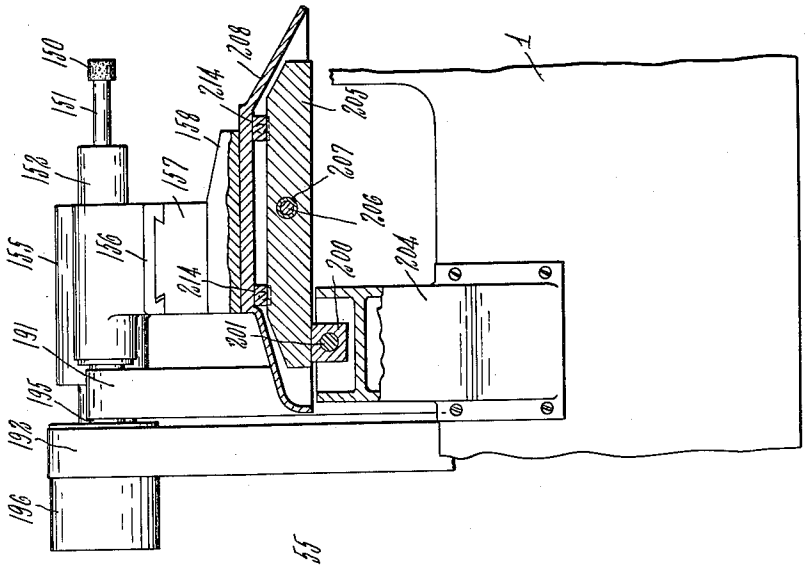


Fig. 4.

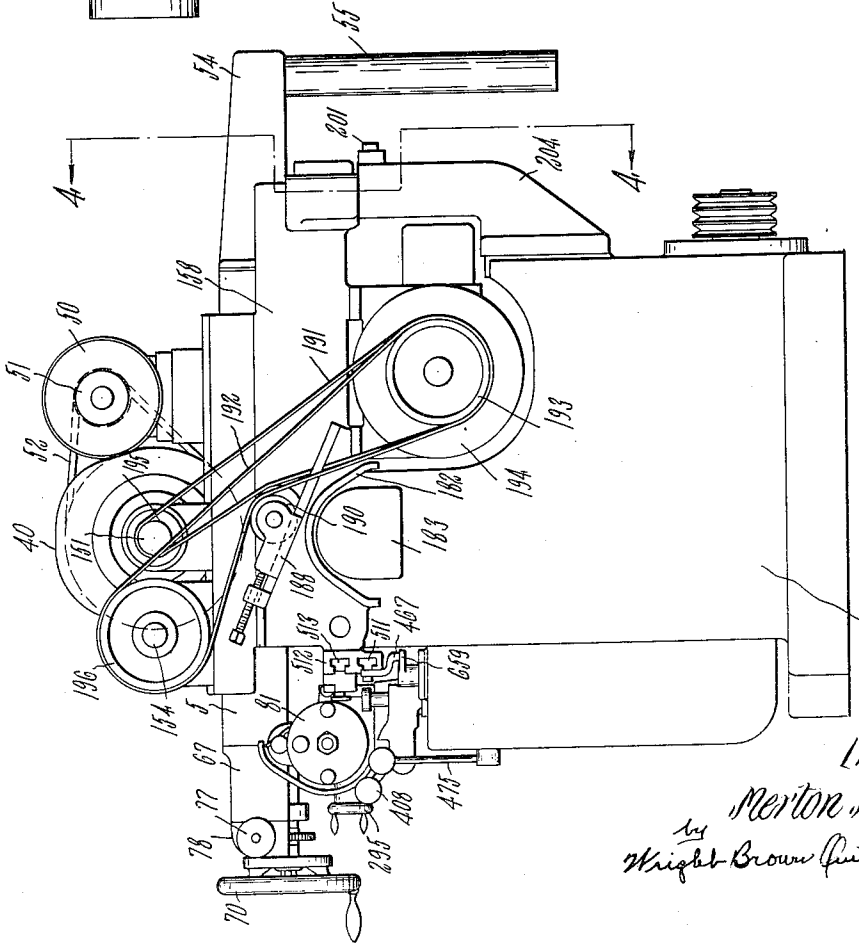


Fig. 3.

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METALWORKING MACHINE

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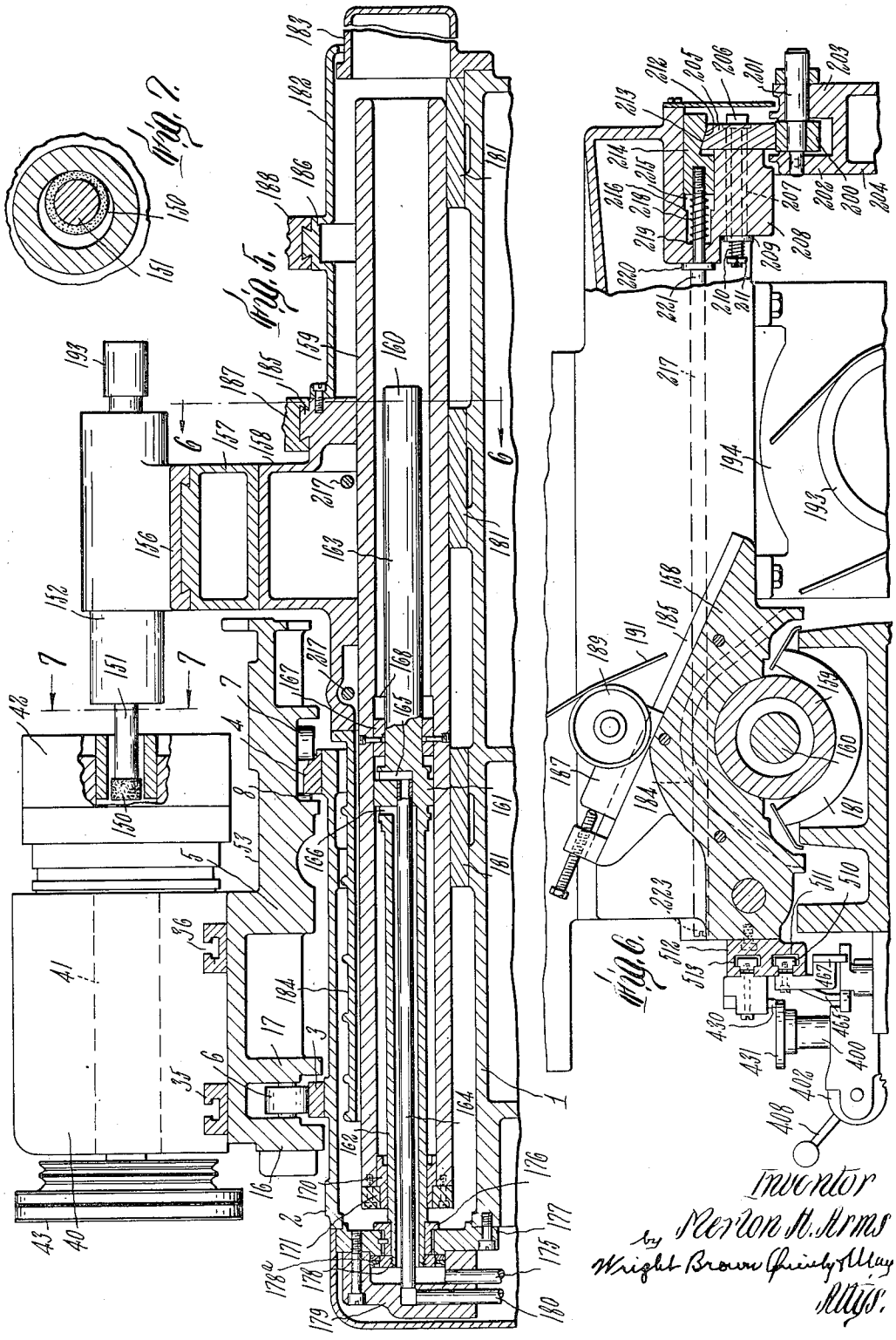


Fig. 2.

Fig. 5.

Fig. 6.

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METALWORKING MACHINE

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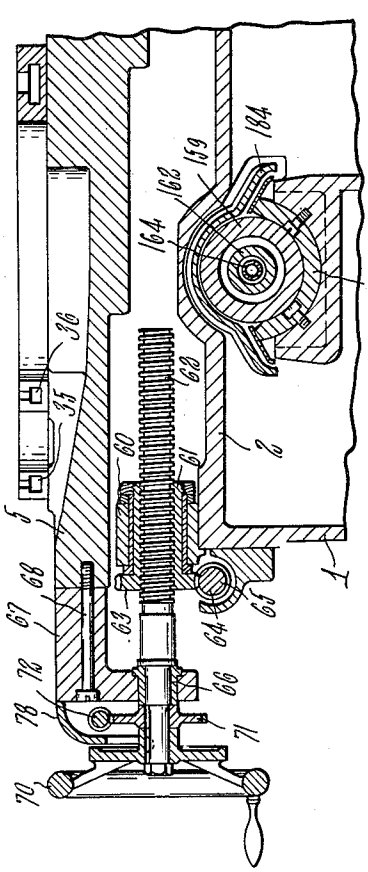


Fig. 9.

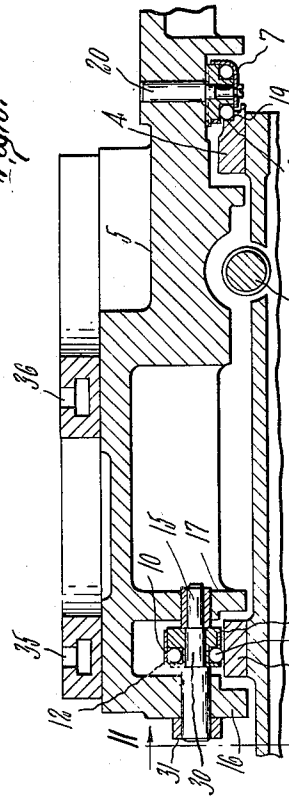


Fig. 10.

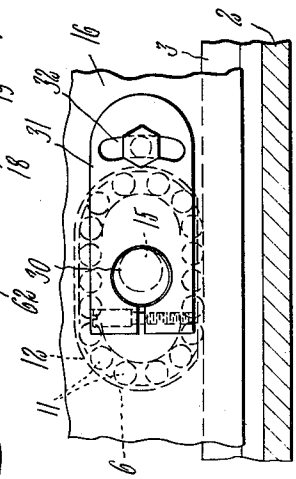


Fig. 11.

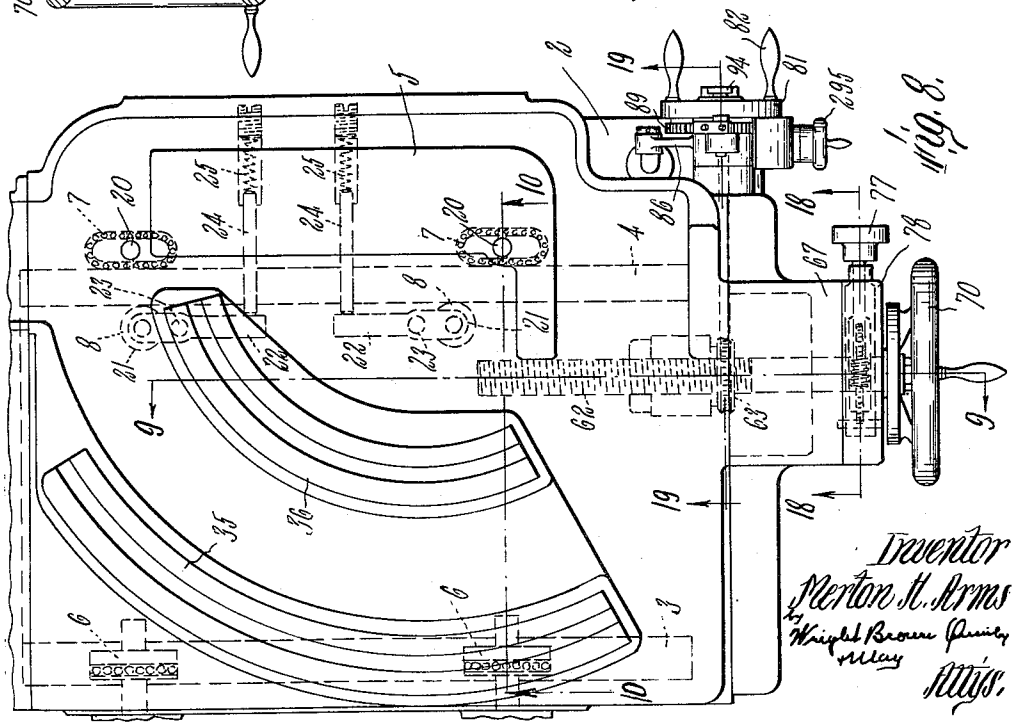


Fig. 8.

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METALWORKING MACHINE

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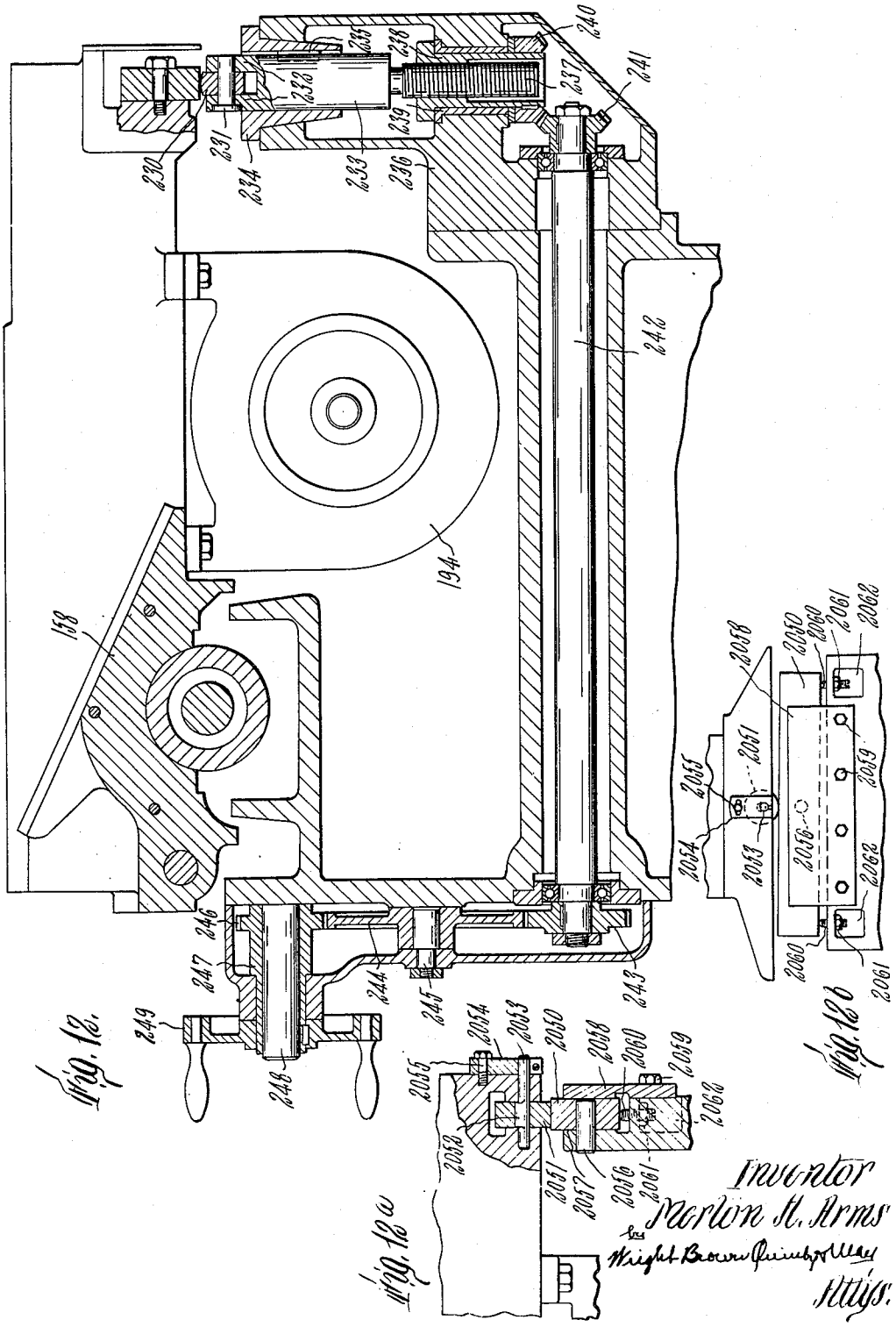


Fig. 12.

Fig. 12a

Fig. 12b

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METALWORKING MACHINE

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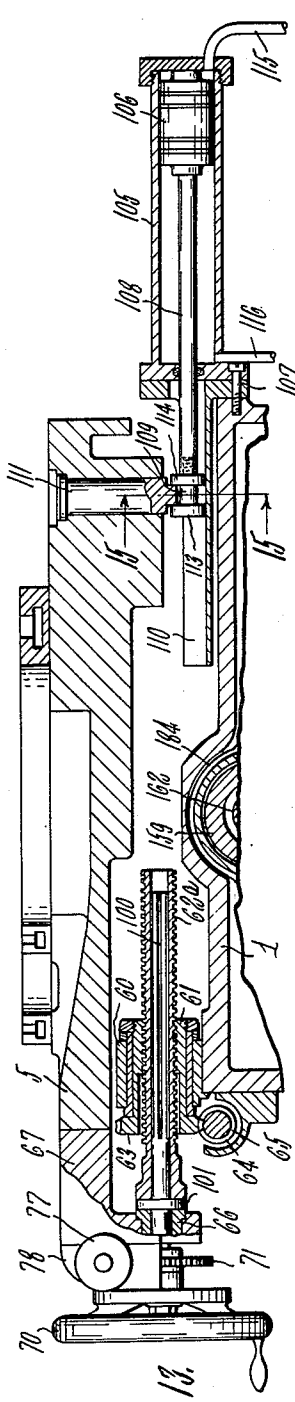


Fig. 13.

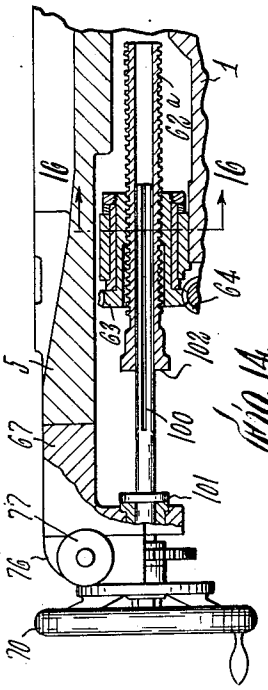


Fig. 14.

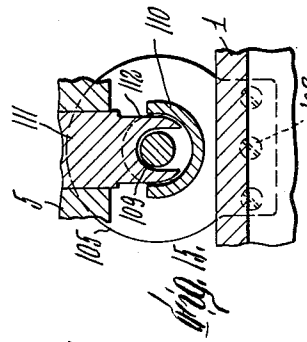


Fig. 15.

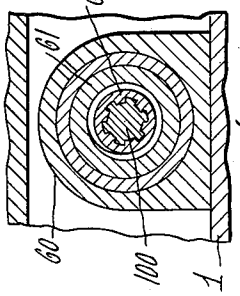


Fig. 16.

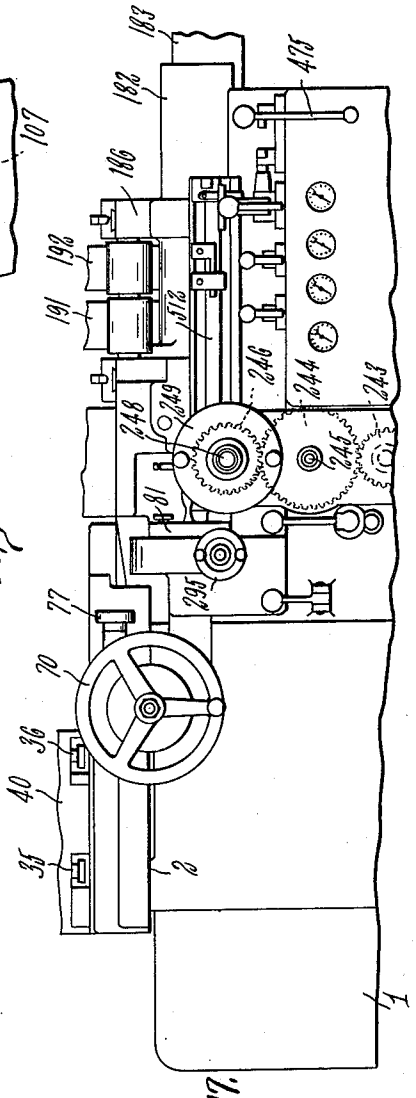


Fig. 17.

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METALWORKING MACHINE

Filed Nov. 9, 1940 13 Sheets-Sheet 8

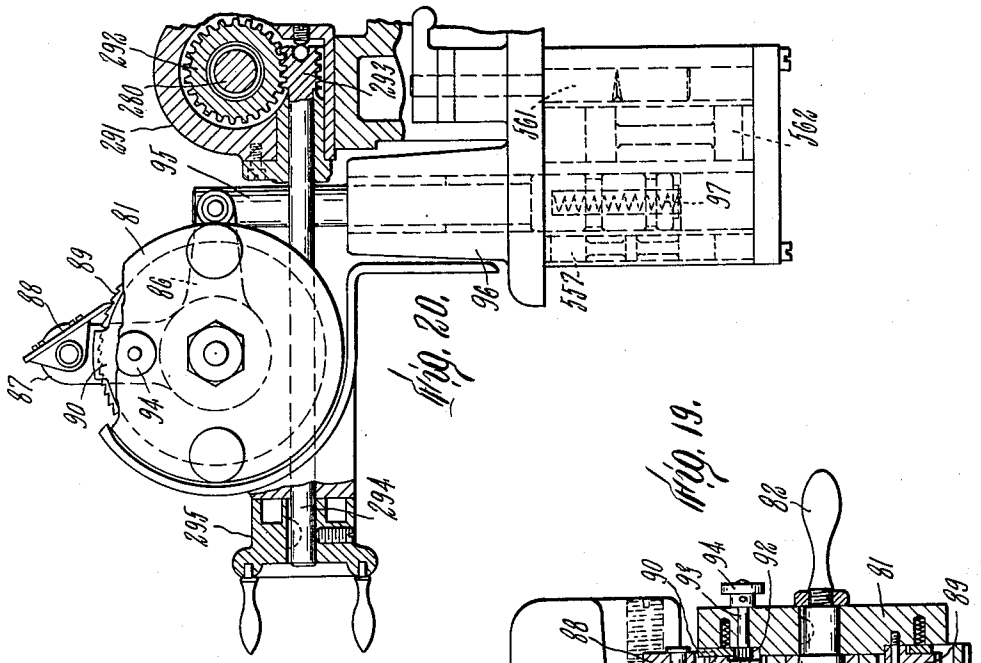


Fig. 20.

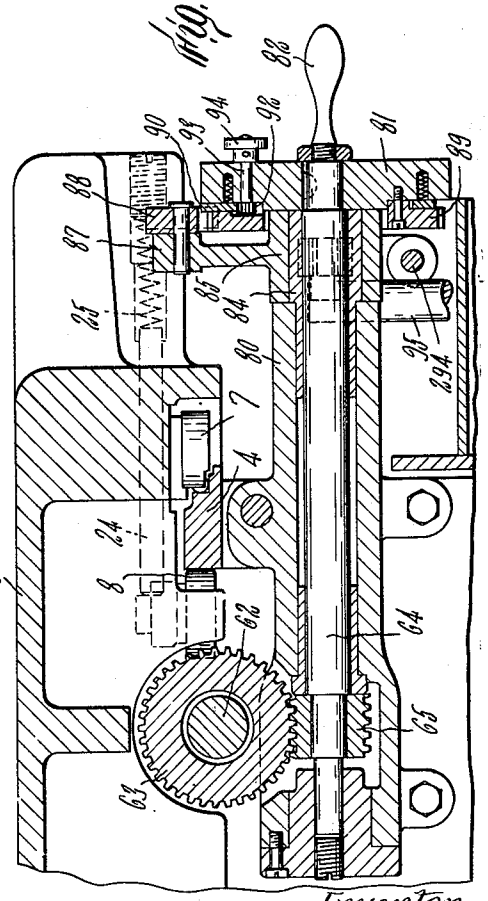


Fig. 19.

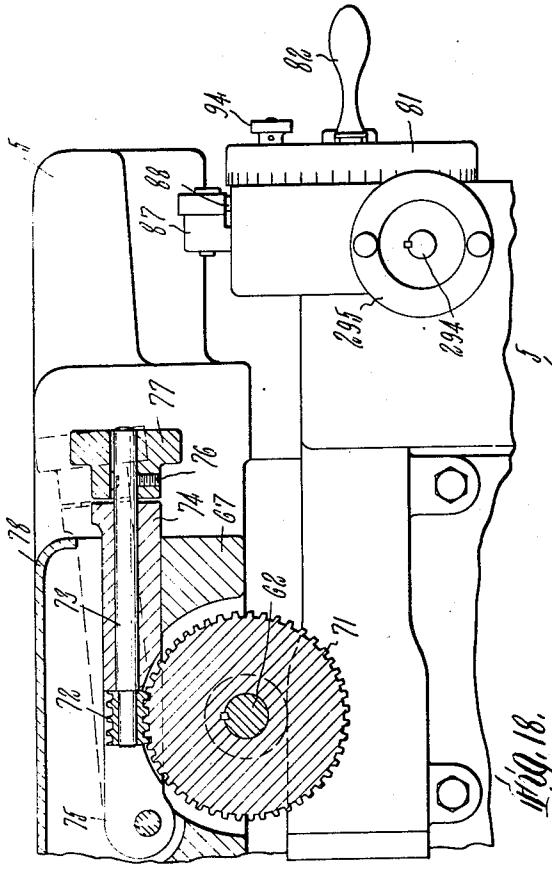


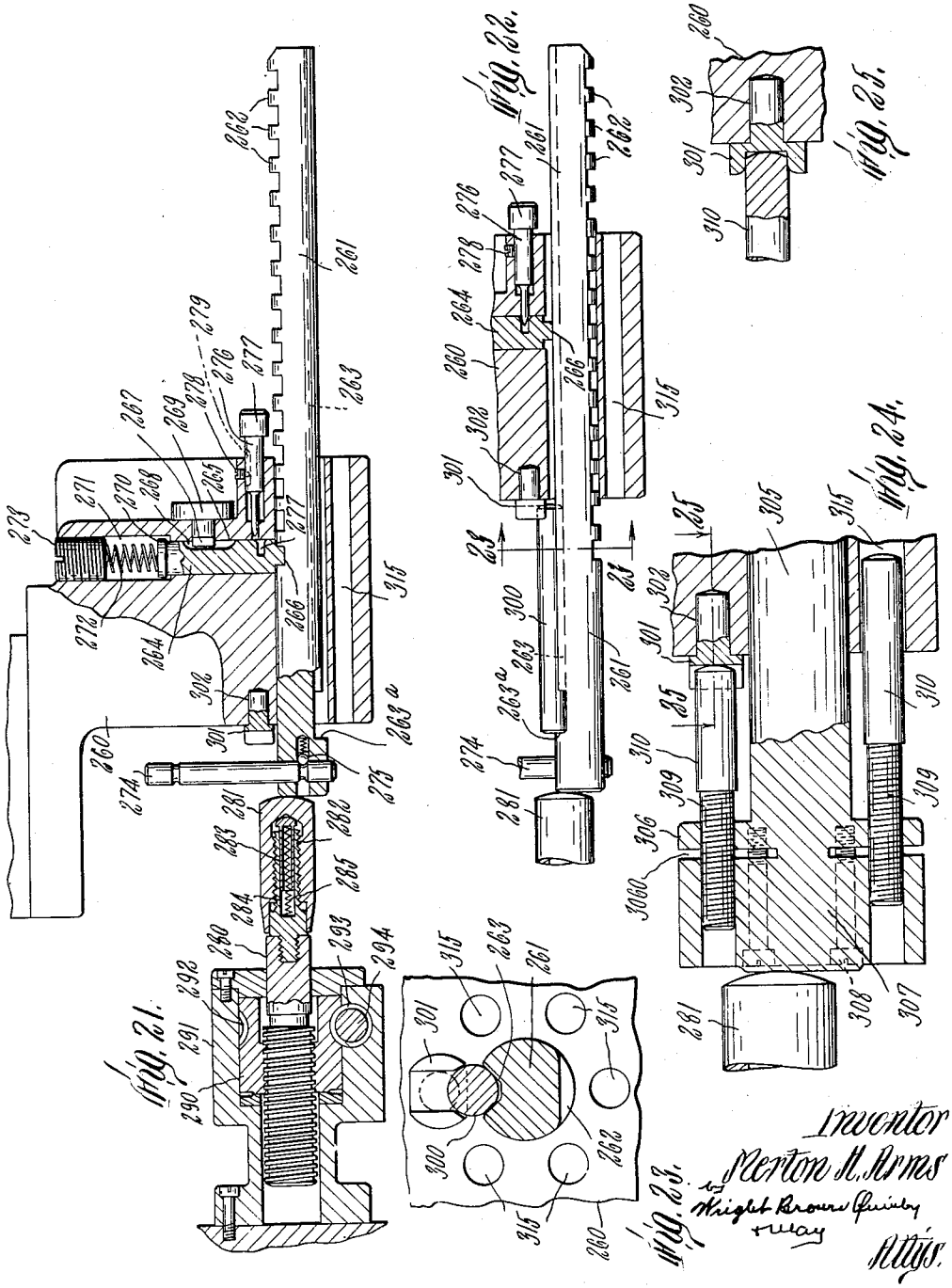
Fig. 18.

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METALWORKING MACHINE

Filed Nov. 9, 1940 13 Sheets-Sheet 9



Feb. 9, 1943. M. H. ARMS 2,310,338

METALWORKING MACHINE

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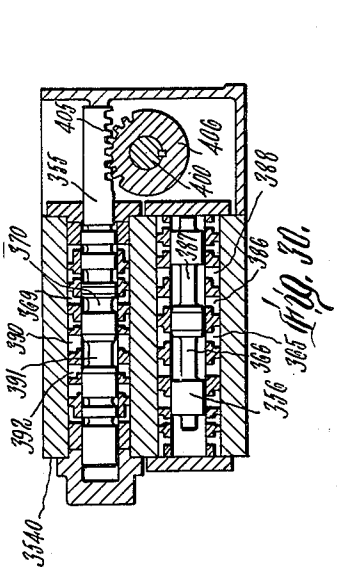


Fig. 30.

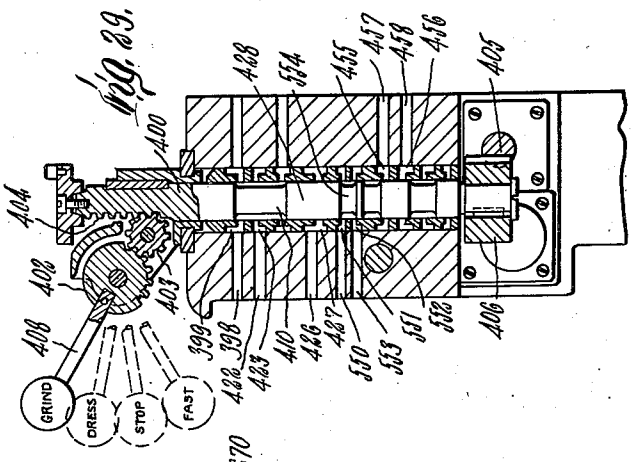


Fig. 29.

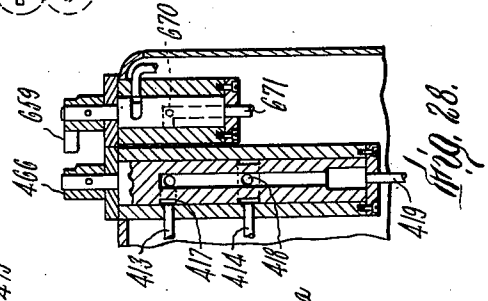


Fig. 28.

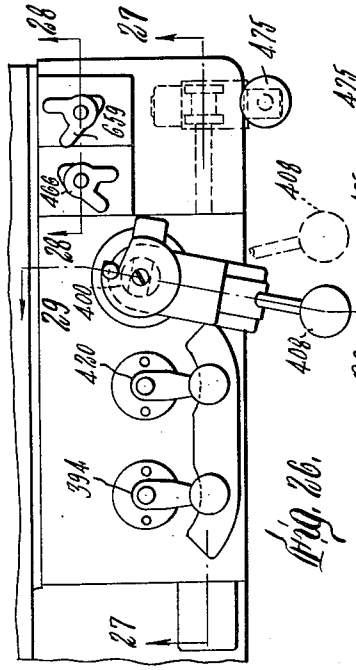


Fig. 26.

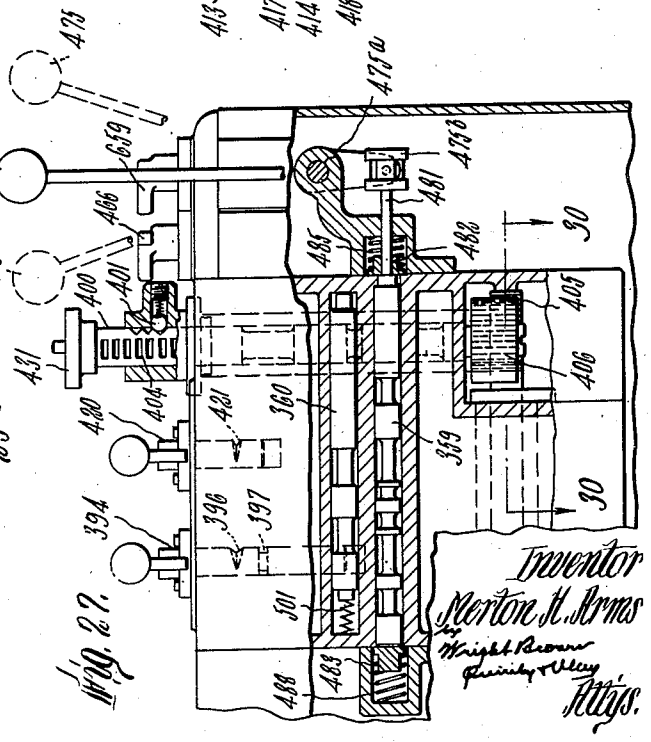


Fig. 27.

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METALWORKING MACHINE

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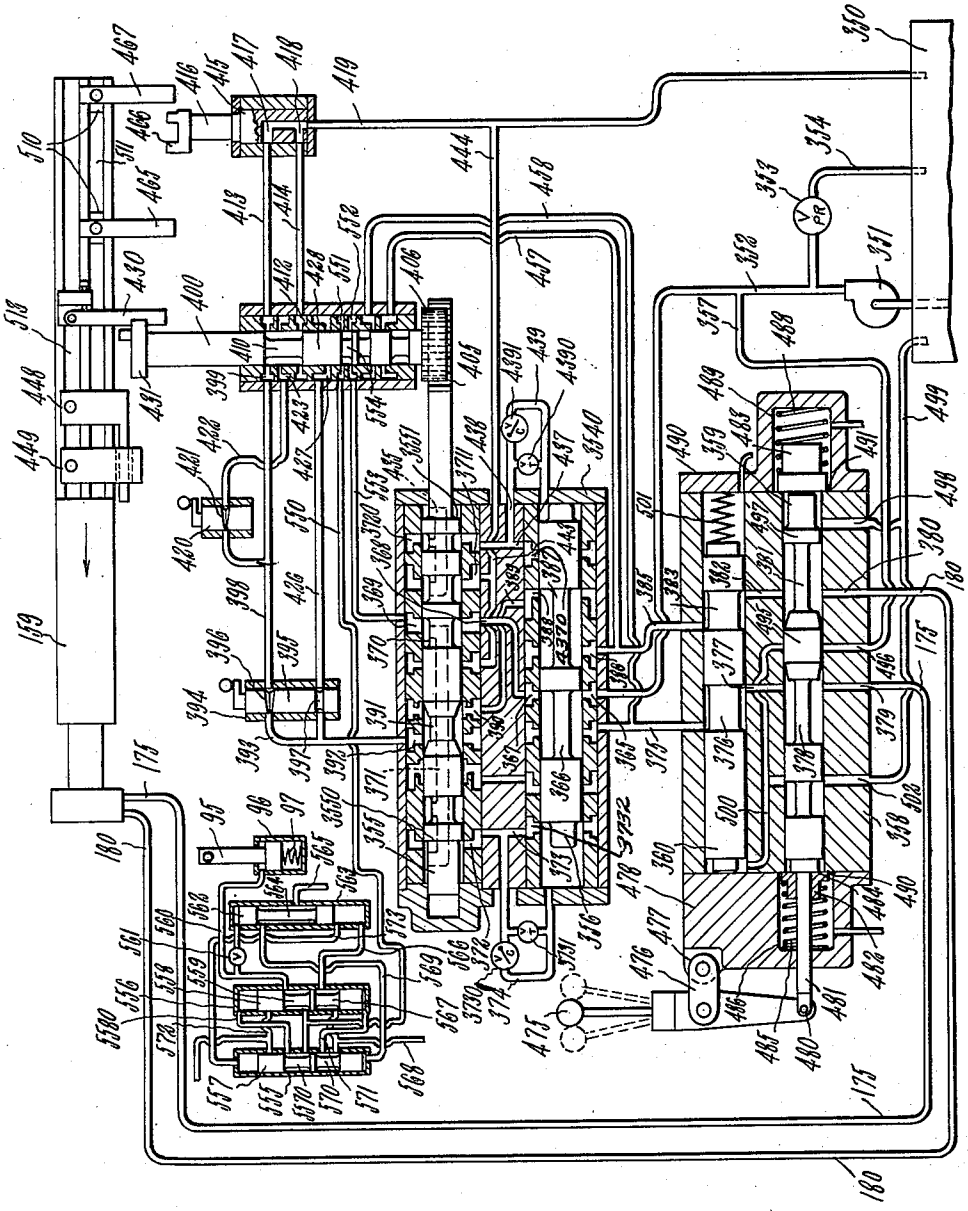


Fig. 31.

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METALWORKING MACHINE

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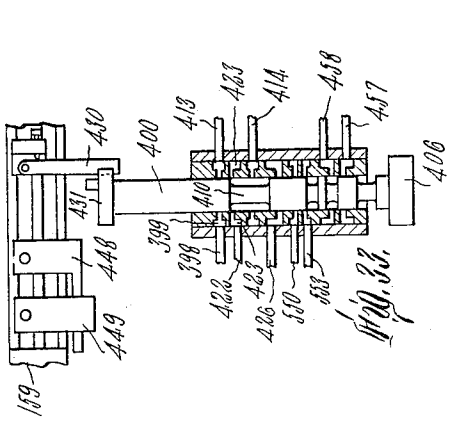


Fig. 33.

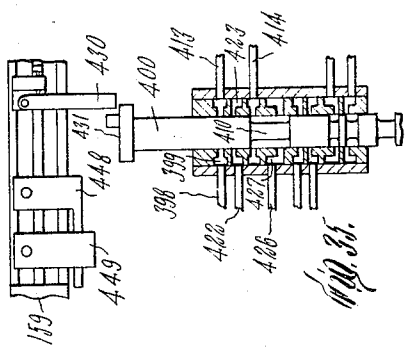


Fig. 35.

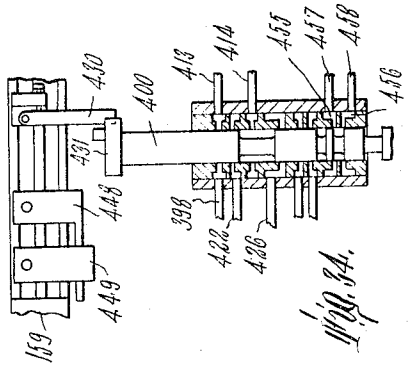


Fig. 34.

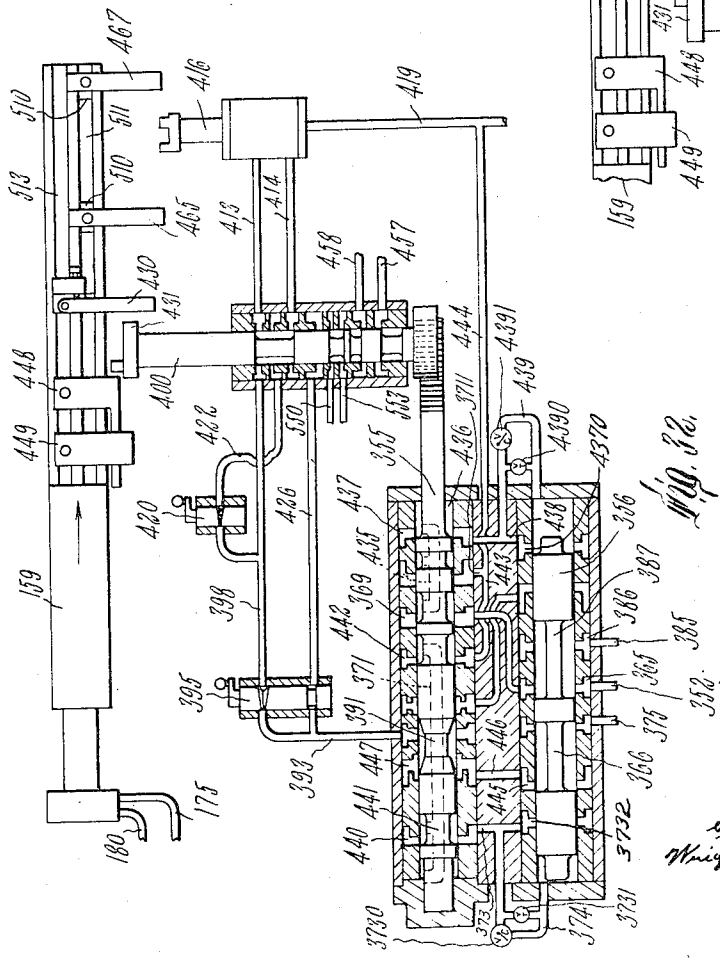


Fig. 32.

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METALWORKING MACHINE

Filed Nov. 9, 1940 13 Sheets-Sheet 13

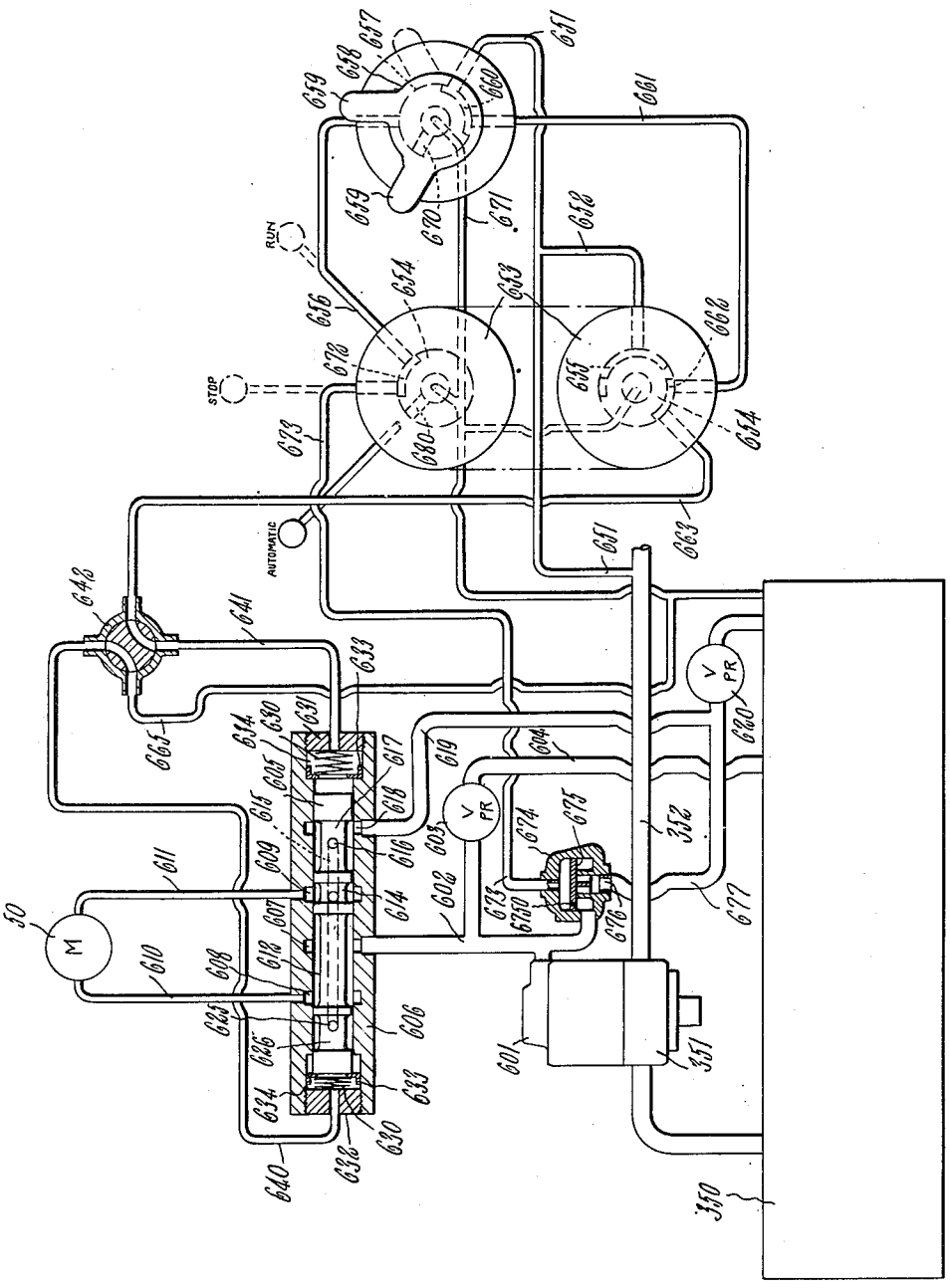


Fig. 16.

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Patented Feb. 9, 1943 2,310,338

UNITED STATES PATENT OFFICE

2,310,338

METALWORKING MACHINE

Merton H. Arms, Springfield, Vt., assignor to Bryant Chucking Grinder Company, Springfield, Vt., a corporation of Vermont

Application November 9, 1940, Serial No. 365,071

17 Claims. (Cl. 51—50)

This invention relates to metal working machines and while not restricted thereto, the machine herein shown has been designed more particularly for internal grinding.

One of the objects of this invention is to avoid the use of overhead structure thus facilitating the placing and removal of work and access to the work and to the tool or tools as this may be desired.

A further object is to provide for accurate support and control of the tool with respect to the work.

Another object is to provide for wide angular adjustment of the work with respect to the tool.

A further object is to provide advantages of pivotal and slidable mounting of the tool carriage but with the feed axis below rather than above the wheel.

Still another object is to provide improved traverse limit stop mechanism.

Another object is to provide hydraulic controlling and actuating mechanism.

A further object is to provide rigid support for the wheel when the stroke is relatively long.

Still another object is to provide for reception of work heads of a great variety of types.

For a more complete understanding of this invention, reference may be had to the accompanying drawings in which

Figure 1 is a front elevation of a grinding machine embodying the invention.

Figure 2 is a top plan of the same.

Figure 3 is a right end elevation of the machine.

Figure 4 is a detail section on line 4—4 of Figure 3.

Figure 5 is a fragmentary longitudinal section on line 5—5 of Figure 2.

Figures 6 and 7 are detail sections on lines 6—6 and 7—7, respectively, of Figure 5.

Figure 8 is a view similar to a portion of Figure 2, but to a larger scale and showing parts in dotted lines.

Figures 9 and 10 are detail sections on lines 9—9 and 10—10, respectively, of Figure 8.

Figure 11 is a detail section on line 11—11 of Figure 10.

Figure 12 is a view similar to Figure 6, but showing a modification.

Figure 12*a* is a view similar to a portion of Figure 4, but showing a further modification.

Figure 12*b* is a view similar to a portion of Figure 6, but showing the same construction as Figure 12*a*.

Figure 13 is a view similar to Figure 9, but showing a modification.

Figure 14 is a view similar to a portion of Figure 13, but showing the parts in different positions.

Figures 15 and 16 are detail sections on lines 15—15 of Figure 13 and 16—16 of Figure 14, respectively.

Figure 17 is a view similar to a portion of Figure 1, but showing the modification of Figures 12 to 16, inclusive.

Figures 18 and 19 are detail sections on lines 18—18 and 19—19, respectively, of Figures 2 and 8.

Figure 20 is a fragmentary view partly in elevation and partly broken away and in section of the wheel feed mechanism.

Figure 21 is a view partly in side elevation and partly in vertical section of a traverse limit stop.

Figure 22 is a view similar to a portion of Figure 21, but with parts in different positions and with a different action.

Figure 23 is a detail section on line 23—23 of Figure 22.

Figure 24 is a view similar to a portion of Figures 21 and 22 but showing a modification.

Figure 25 is a detail section on line 25—25 of Figure 24.

Figure 26 is a top plan view of a portion of the hydraulic control box.

Figures 27, 28 and 29 are detail sections on the correspondingly numbered section lines of Figure 26.

Figure 30 is a detail section on line 30—30 of Figure 27.

Figure 31 is a diagram of the wheel slide hydraulic drive the reversing valve being in grinding position.

Figure 32 is a view similar to a portion of Figure 31, but with the parts in position for reverse direction traverse.

Figures 33, 34 and 35 are views similar to a portion of Figure 31, but showing the automatic reversing valve in dress, stop and fast positions, respectively.

Figures 36 is a diagram of the hydraulic control of the work driving motor.

Work Carriage Mounting and Control

Referring first to Figures 1 and 2, the machine as shown comprises a base 1 having a bed 2 at one end portion provided with a pair of transverse ways 3 and 4 (see Figures 5 and 10) on its upper face. On these ways is mounted a work supporting carriage 5. The means for mounting this carriage 5 comprise antifriction bearings 6, 7 and 8 (see Figures 5 and 8).

The bearings 6 which ride on the way 3 comprise cartridges having ways 10 (see Figures 8, 10 and 11) for supporting a series of balls 11 in continuous array, the balls on the lower stretch engaging the upper face of the way 3 and the balls on the upper stretch on the return being held in place by a cover plate 12. Each of these cartridges, two being shown, are pivotally supported on a pivot pin 15 between a pair of

walls 16 and 17 depending from the lower face of the carriage 5. These bearings 6 are arranged to take vertical thrust only.

The bearings 7 are arranged with ball ways for supporting a series of balls in horizontal array and engage a vertical wall 18 on the way 4 and also a horizontal wall 19, these bearings being thus arranged to take both vertical and horizontal load. These bearings are mounted on vertical pivots 20.

To take the side thrust from the bearings 7 are cylindrical bearing members 21 (see Figure 8) carried by levers 22 fulcrumed at 23, the opposite end of these levers being engaged by the ends of bars 24 pressed thereagainst by the springs 25 in the carriage 5.

As shown in Figure 11, the pivots 15 for the bearings 6 have eccentric middle portions 30 carrying the cartridge. The outer end of each pin is mounted in a plate 31 adjustably secured to the outer face of the wall member 16 as by the arcuate slot and bolt construction shown at 32. Angular adjustment of the plate rocks the portion 30 and thus raises or lowers the carriage 5 about the row of balls engaging the wall 18 as a center. Angular adjustment of the carriage 5 about this row of balls may be employed to bring the substantially horizontal planes of the work and wheel axes into exact parallelism to permit, with proper angular adjustment of the work holder, a facing wheel such as 153 to contact the end face of the work both above and below its rotational axis. This anti-friction mounting of the slide per se is not claimed herein but forms subject matter of a co-pending application, Serial No. 220,294, filed July 20, 1938, for Antifriction slides, now Patent No. 2,230,442 granted February 4, 1941. The top face of the carriage 5 is provided with a pair of arcuate under-cut guide tracks 35 and 36 to which may be adjustably secured a support 40 within which is journaled a work-carrying spindle 41 which carries a suitable work-supporting chuck 42 at its inner end and is shown with belt pulleys 43 at its outer end. By this mounting the axis of the work spindle may be adjusted angularly throughout a wide range with respect to the lengthwise axis of the machine and with respect to a traversing tool carriage which will later be described. Bolts 45 (see Figure 2) engaging in the under cut guide members 35 and 36 may be employed to secure the spindle in the desired angularly adjusted position. For driving the spindle 41 there is shown a reversible hydraulic motor 50 carried by the support 40 and having belt pulleys 51 which may be connected with the belt pulleys 43 by suitable belts 52.

The top face of the carriage 5 may be provided with a coolant-receiving depression 53 which leads the coolant backwardly through a trough 54 where it may pass from the back of the machine as through a pipe 55.

The work carriage may be moved transversely of the machine as for positioning and feed. For this purpose the top portion of the machine bed, as shown best in Figure 9, may have secured thereto a bearing 60 within which a nut member 61 is rotatably mounted, but held against axial motion. The nut member 61 has threaded engagement with a lead screw 62. This nut member 61 is shown as provided with a worm wheel portion 63 with which meshes a worm 64 on a shaft 65. When the shaft 65 is stationary, the nut member 61 is held against rotation, but rotation of the screw 62 may then be employed to move the work-holding carriage. To this end the lead screw 62 extends through a bearing sleeve 66 secured in a bracket member 67 attached by means such as screws 68 to the forward face of the work carriage 5 and to the forward end of this lead screw 62 is keyed a hand feed wheel 70 by which it may be rotated.

Means may be provided for locking the lead screw 62 against rotation and also for producing when desired a slow feed rotation thereto. To this end, the lead screw 62 has secured thereto between the bearing bushing 66 and the wheel 70 a worm wheel 71, and as shown best in Figure 18 this worm wheel may be engaged by a worm 72. The worm 72 is carried by a shaft 73 which is journaled longitudinally of a lever 74. This lever is fulcrumed at 75 and by upward rocking of this lever, the worm 72 may be lifted out of contact with the worm wheel 71 as shown in the dotted line position of Figure 18. When so lifted the hand wheel 70 is free to be turned, thus rotating the lead screw 62 for relatively fast motion.

When the lever 74 is in the full line position shown in Figure 18 with the worm 72 in engagement with the worm wheel 71, the lead screw 62 is locked against rotation by means of the wheel 70, but it may be given a slow rotation by rotation of the shaft 73 carrying the worm 72. For this purpose the outer end of the shaft 72 has secured thereto as by a set screw 76 a small hand wheel 77. The lever 74 is mounted in a portion of the bracket 67 and is normally substantially covered by a cover plate 78.

As before noted, motion of the work carriage 5 may be produced by rotation of the nut member 61 by rotation of the shaft 64. As shown best in Figure 19, this shaft 64 is journaled within a sleeve 80 and has keyed to its outer end a hand wheel 81 provided with actuating handles 82. Inwardly of the hand wheel 81 there is rockably mounted on a bushing 84 within which the shaft 64 is journaled the hub 85 of a bell crank lever having an arm 86 and an arm 87. (See Figures 19 and 20.) The arm 87 has pivoted thereto a feed dog 88 adapted to engage the teeth of a ratchet wheel or ring 89 secured to the inner face of the hand wheel 81, so that by rocking of the bell crank lever a relatively slow intermittent turning of the hand wheel 81 may be produced thus to effect a slow power feed of the work carriage through the slow intermittent rotation of the shaft 64. This feed through rotation of the shaft 64, is, of course, unaffected by the locking of the screw 62 against rotation.

A ring member 90 having a suitable pawl knock-off may be rotatably supported between the ratchet 89 and the back face of the hand wheel 81 and it may be provided with internal teeth meshing with a pinion 92 of a shaft 93 projecting through the hand wheel 81 and carrying a knob 94 on its outer end by which it may be turned, thereby to adjust the angular position of the knock off ring 90 and thus to determine the extent of feed by rocking of the bell crank lever arm 86. For the purpose of rocking this bell crank, its arm 86 is operatively connected to the upper end of a feed actuating hydraulic plunger 95 working in a cylinder 96 and normally held elevated as by a spring 97. The operation of this feed mechanism will be more fully described in connection with the hydraulic system.

In some cases it may be found desirable to provide for a quick retraction of the work slide in-

dependently of and without effecting the feed adjustment between the lead screw and the lead nut as previously described. Such a construction is illustrated in Figures 13 to 16, inclusive, wherein instead of forming the lead screw as a solid screw, it is formed as a sleeve 62a within which is slidably and non-rotatably mounted a splined shaft 100. This splined shaft 100 is journaled against axial motion in the bracket 67, and is provided with a collar 101 forming a shoulder against which a shoulder 102 on the outer end of the lead sleeve 62a may impinge. When these parts are in contact, as shown in Figure 13, the feed of the carriage 5 is controlled either by the rotation of the lead screw or the lead nut in the same manner as in the constructions illustrated in Figures 8, 9, 18, 19, and 20, but when desired the carriage may be moved forwardly as is shown in Figure 14, causing the collar 101 to be moved away from the shoulder 102. This may be done, for example, by fluid pressure means as illustrated in Figure 13. A fluid pressure cylinder 105 having a piston 106 therein is secured to the bed of the machine as by the screws 107, and the piston rod 108 carries at its forward end a spool shaped member 109 mounted for sliding motion in a trough shaped guide member 110. Depending from the carriage 5 is a headed pin 111 having a forked end portion 112 which engages between the heads 113 and 114 of the member 109 and preferably extends down on each side of its central reduced diameter portion as shown best in Figure 15. By allowing fluid under pressure to enter back of the piston 106 as through the pipe 115, and allowing fluid to escape through the pipe 116, the carriage 5 may be pushed forwardly into the position shown in Figure 14 with a quick motion. By introducing fluid under pressure to the pipe 116 on the forward face of the piston 106 and discharging through the pipe 115, the piston 106 may be returned to the position of Figure 13, whereupon the normal motion of the carriage 5 through rotation of its lead screw or nut may be resumed. This quick motion under fluid pressure may be done without in any way disturbing the settings of the screw and nut mechanism.

TOOL CARRIAGE MOUNTING AND CONTROL

The tool herein shown as a grinding wheel 150 is carried by a rotatable shaft 151 journaled in a long quill 152 carried by a wheel head bracket 1520 and there may be, if desired, a second tool or grinding wheel 153 carried by a shaft (not shown) journaled in a quill 154 in a second wheel head bracket 155. These brackets are shown as carried by a base 156 which has dovetail connection with a supporting hollow block 157 and support the grinding wheel shafts outwardly of the bore 156 allowing a long grinding stroke with rigid support of the grinding wheels. This block 157 is carried by a carriage 158. This carriage is rockably supported by a tube or hollow bar 159 which is slidably and rockably mounted on semi-cylindrical bearing members 181. Extending into the tube 159 is a shaft 160 provided with an enlarged diameter portion 161 which slidably fits within the tube 159 and forms a piston therefor.

The shaft 160 has reduced diameter end portions 162 and 163. The portion 162 is hollow and through the center thereof passes a pipe 164 which extends into the piston portion 161 and communicates through a port 165 to the interior of the tube 159 to the right of the piston as shown in Figure 5. The space outwardly of the pipe 164 and between it and the inside of the shaft portion 162 communicates through the port 166 with the left hand side of the piston 161. The shaft portion 163 is solid in cross section and is slidably guided through a sleeve 167 which engages a larger internal diameter portion of the tube 159 and forms a closed end to the pressure cylinder which travels relative to the piston 161. The right hand end of the tube 159 is open but the left hand end is closed by a bushing 170 having a portion filling the space between the outside of the shaft portion 162 and the inside of the tube 159. A second collar 171 secured against the left hand end of the tube 159 and a reduced diameter portion of the collar 170 completes the closure of this end of the tube 159 to the hollow piston rod portion 162. The inner end of the bushing 170 and the adjacent face of the piston 161 have mating concentric stepped portions which act as a dash pot to cushion the slide motion at the outer limit of its motion.

This tube 159 thus forms a fluid pressure cylinder, fluid under pressure being introduced into the pipe 164 and discharging through the port 166 and pipe 175 serving to force the tube 159 and the tool carriage carried thereby to the right from the position in Figure 5, while fluid introduced into the space between the pipe 164 and the inside of the shaft section 162 through the pipe 175 while the escape of fluid is permitted through the pipe 164 acts to move the tool slide to the left or toward the work spindle. The left hand end of the shaft portion 162 extends through a bushing 176 loosely mounted in an end wall member 177 secured as by screws to the machine base 1, and on the left hand end of this portion 162 there is positioned a nut 178 which holds the shaft 162 in position. The loose mounting of the bushing 176 prevents cramping of the shaft portion 162, and a yieldable sealing ring 178a prevents the escape of oil around this bushing. The pipe 175 then enters into an opening in an end cap 179 into which also extends the pipe 164 with which communicates a second pipe 180. The right hand end of the tube 159 may be covered by a hood 182 which is telescopically related to a second hood member 183 into which the right hand end of the tube 159 may pass when the tool carrier is retracted to its greatest extent. A guard or shield 184 is secured to the left hand end of the carriage 158 and having downwardly and outwardly sloping top faces overlying the tube 159 extends beneath the bed 1 and has transversely extending top ribs for directing foreign matter laterally.

The carriage 158 and the member 182 are provided wih a pair of spaced inclined ways 185 and 186, respectively, on which may be adjustably supported a pair of slides 187 and 188 which support between them belt tightener pulleys 189 and 190. These pulleys engage belts 191 and 192, respectively, which pass over a driving pulley 193 of a driving motor 194 and over pulleys 195 and 196 on the grinding wheel shafts 151 and one (not shown) journaled within the quill 154, respectively. The motor 194 is carried by the tool carriage as shown in Figure 6, being bolted to the lower face thereof, so that it partakes of the motion of this carriage and remains in the same relation to the grinding wheel pulleys 195 and 196 at all times.

It will be noted that the tool carriage extends rearwardly of the tube 159 which rockably supports it to a much larger extent than forwardly

thereof so that its rear end may be supported by gravity on a support by which it may be guided in its reciprocating motions. Referring to Figures 4 and 6, the support for the rear end of the tool carriage comprises a block 200 rockably supported on a pin 201 between spaced portions 202 and 203 of a bracket 204 secured to the machine frame. Resting upon this block 200 is a former cam 205 which is carried by the tool carriage with capability of adjustment relative thereto. As shown it is supported on a screw 206 which passes through a pivot bushing 207 extending through a foot member 208 which may be integral with the tool carriage. The inner end of the screw 206 carries a washer 209 pressed against the forward end of the bracket 203 as by a spring 210 surrounding this pin and reacting between the washer 209 and a nut 211 threaded on the forward end of the pivot pin. Opposite end portions of the former cam 205 may be adjusted up and down and for this purpose the top of the former cam is shown as backwardly and downwardly tapered as at 212 for cooperation with the reversely tapered face 213 of an adjusting block 214. Each adjusting block is mounted for sliding motion between spaced splined faces 215 and 216 of the portion 208 and may be adjusted forwardly and backwardly as desired by the rotation of an adjusting rod 217 which at its rearward end is threaded into the corresponding block 214. A spring 218 surrounding the rear end portion of the bar 217 and reacting between the forward face of the block 214 and a rear face 219 of the member 208, forces the block 214 rearwardly as far as is permitted by the engagement of a collar 220 engaging a portion at 221 of larger diameter than the threaded end portion of the bar 217 on the forward face of the member 208. The two bars 127 extend through the tool carriage and terminate at their forward ends in socketed extremities 223 with which a suitable tool may be engaged by which the corresponding bar 217 may be turned, thus to adjust the corresponding end of the former cam 205 about its pivotal axis. The contour of the lower face of this former cam and the angular adjustment thereof determine the positions of the grinding wheels with relation to the rocking axis of the carriage for the various traverse positions of the tool carriage. If this former cam is flat on its lower face and is arranged parallel to the axis of the wheel and the work axis is in the same plane with the slide bar axis, a cylindrical hole will be formed in the work, but if the former cam is tilted, a tapered hole is formed, and if the former cam has a guiding surface other than flat, a surface having a corresponding contour will be ground in the work, with or without an additional taper component, depending on the angular setting of the former cam.

Where two wheels are employed as shown, the wheel 150 may be employed for internal grinding and the large wheel 153 may be employed for face grinding the end of the work carried in the chuck 42. The former cam would, of course, be used to control the position of the grinding wheel 150 in the various portions of its grinding path. The grinding wheel 153 when used for face grinding would receive no benefit from this former cam since this grinding wheel then performs no grinding action on an axial surface of the work.

While the feed of the work may be produced by movement of the work holder itself and the former cam be employed to control the shape of the surface ground as heretofore described, it is, of course, possible to produce a relative feed between the wheel and the work by tilting the tool carriage, in addition to the control by the former cam in accordance with the axial position of the wheel at any given time. In Figures 12 and 17 is illustrated a modified construction wherein this additional feed independent of the former cam contour and angular position may be afforded. The abutment on which the former cam rests as shown in Figure 12 is a block or roller 230 which may be held as on a pivot 231 between a pair of spaced jaws 232 at the upper end of a plunger 233 mounted for up and down motion within a bushing 234 to which it is shown keyed as by the key 235. This bushing 234 is mounted in a bracket 236 suitably secured to the back of the machine base. The lower end of the plunger 233 as at 237 is shown as threaded through a sleeve 238 journaled in a bushing 239 carried by the bracket 236. The lower end of this sleeve 238 has a bevel gear 240 secured thereto with which meshes a bevel pinion 241 on a shaft 242. This shaft 242 extends to the forward face of the machine where it has fixed thereto a gear 243. This gear 243 meshes with a gear 244 journaled on a stub shaft 245 and this gear 244 in turn meshes with a driving pinion 246 on a feed sleeve 247 journaled on a stub shaft 248. A hand operated feed wheel 249 is shown as keyed to the sleeve 247, by the turning of which through the gear train described, the plunger 233 is adjusted vertically, thus to produce a tilting feed motion of the wheel carriage.

In Figures 12*a* and 12*b* a further modification is shown in which the former cam 2050 is carried by the machine frame and supports a follower roll 2051 carried by the tool carriage. This roll 2051 is journaled on an eccentric central portion 2052 of a shaft 2053 journaled in spaced walls of the tool carriage, and this shaft 2053 may be angularly adjusted by rocking an arm 2054 secured to its outer end and secured by a screw and slot connection at 2055 to the carriage in adjusted angular position. The former cam 2050 is pivoted on a pin 2056 in a recess 2057 in the machine frame and is retained in position in the recess by a cover plate 2058 secured in position as by screws 2059. Opposite ends of the former cam 2050 are supported on the adjusting studs 2060 having locking nuts 2061 thereon seated in recesses 2062 in the outer face of the machine frame. Angular adjustment of the arm 2054 provides a fine angular adjustment of the tool carriage about the axis of the tube 159 as does angular adjustment of the pin 201 in the construction of Figure 6, while angular adjustment of the former cam 2050 may be employed to determine the angular positions of the carriage in relation to its axial positions, as in the construction of Figure 6.

Positive Stop Mechanism

In machines of this type it is often found desirable to provide for a positive stop of the feed of the tool carriage in order to work up to a shoulder in the work or to face grind the work to a predetermined dimension. Devices for this purpose are shown in Figures 21 to 25, inclusive. Referring to the construction shown in Figures 21, 22 and 23, one of the parts such as the tool carriage will be provided with a bracket 260. Parallel with the line of traverse of the tool carriage this bracket 260 is provided with a bore for the slidable reception of a stop bar 261. This bar, as shown, is provided with spaced rack teeth

262 along one side and a different portion of its periphery, as shown on its opposite side, is provided with a longitudinal notch 263. Either of these surface portions may be presented upwardly by rocking the bar 261 within its bore. When the rack teeth are presented upwardly, the bar may be latched in any selected of a plurality of axial positions differing from each other by fixed increments determined by the spacing of the rack teeth 262. This latching may be accomplished by a latch pin 264 vertically slidable in a bore 265. The lower end of the latch pin 264 is provided with a tooth 266 shaped to engage between adjacent teeth 262 of the rack bar. The tooth 266 is held in proper angular position to cooperate with the rack bar 261 as by means of a key plug 267 engaging in a slot 268 cut longitudinally in the latch pin and provided at its outer end with a head 269 by which it may be removed when desired. The latch pin is provided with a head 270 riding in an enlarged diameter portion 271 of the bore 266 and on this head engages the lower end of a coil spring 272 which reacts against a closure plug 273 threaded into the upper end of the bore portion 271. By rocking the bar 261 as through a handle 274, latched in position therein by a spring pressed ball 275, the latch pin 265 may be forced upwardly out of engagement between the rack teeth, whereupon the bar 261 may be shifted axially to the desired extent and the bar then returned to its former angular position, allowing the latch to lock it in axial position. The latch may, however, be held in retracted position as by the engagement of an axially moving locking pin 276 in a socket 277 in the latch pin. This locking pin may be secured in sliding position by a set screw 278 having its inner end engaged in a slot 279 in the locking pin, and a head 277 thereon facilitates its manipulation.

The stop bar 261 forms one of the stop elements, which when contacting with the other, limits the inward motion of the tool carriage with respect to the work carriage. As, however, this stop element is adjusted by definite increments, its cooperating stop element should be adjustable for all positions intermediate these definite increments. The cooperating stop element shown, therefore, comprises a stop bar 280 having a stop member 281 adjustably threaded on the extension 282 threaded into the member 280. A plunger 283 slidable within a bore 284 in the externally threaded portion of the extension 282 and spring pressed by the spring 285 against the base of the externally threaded portion of the member 281 produces friction tending to prevent accidental turning of the stop member 281.

The rear end of the bar 280 is shown as threaded into a sleeve 290 within a housing 291 secured to the other portion of the machine such as the frame. Thus sleeve 290 is shown as provided with peripheral worm teeth at 292 for engagement with a worm 293 on an adjusting shaft 294. This shaft 294, as shown in Figure 20, may extend out to the forward face of the machine and have secured thereto a hand wheel 295 by which it may be turned.

In place of adjusting the bar 261 by definite increments, this construction provides for the use of gaging blocks of predetermined sizes which may be changed as desired. Where this type of adjustment is desired, the bar 261 is turned to present its groove 263 upwardly, the latch 265 being held in retracted position as shown in Figure 22. The desired gage block 300 may then be placed in the groove 263 between its end shoulder 263a and a hardened socket plug 301 inserted in an opening 302 of the bracket 260, these parts then determining the stopping position of the outer end of the stop bar 261. The sides of the bar 261 adjacent to the shoulder 263a may be cut away to facilitate the placement and removal of the gage block 300.

A further arrangement of stop elements may be employed as shown in Figures 24 and 25. As shown in Figure 24, the stop bar 261 is replaced by a bar 305 having a flange 306 separated by a narrow slot 3060 from an abutment block 307 and this block 307 and also the flange 306 may have mating perforations for the reception of the threaded ends 309 of a series of adjustable stop plugs 310 arranged in circular series about the axis of the bar 305. Tightening of screws 308 seated in the part 307 and threaded into the flange 306 narrows the slot 3060 and restrains the plugs 310 against turning by vibration or other accidental cause. The bracket 260 may be provided with a series of perforations 315 arranged in circular series and of such size as to permit the ends of the stop plugs 310 to enter therein in case they are of sufficient length to do this. The bar 305 is so angularly adjusted that any selected one of these stop plugs 310 is in position to engage the socket plug 301 and the stop plug 310 in this position determines the stop limit of the bar 305 at that time, while any of the stop plugs 310 which are longer than the one in controlling position may project backwardly into the corresponding perforation 315 and be ineffective. Any stop plugs 310 which happen to be shorter than the one in the controlling position, of course, do not reach the face of the bracket 260 when the bar 305 is in its limiting position.

Hydraulic Driving Mechanism and Control

Tool carriage traverse

The hydraulic mechanism for effecting traverse and control of the tool carriage is shown in detail in Figures 26 to 35, inclusive. Referring first to Figure 31, at 350 is shown a tank having a liquid such as oil which is employed to drive the tool carriage, being supplied and discharged through the pipes 175 and 180 shown in detail in Figure 5 as previously described. The movable cylinder 159 is indicated diagrammatically in Figure 31, this cylinder supporting the tool carriage. Liquid is pumped from the tank 350 by the pump 351 into the pipe 352. A limiting pressure valve 353 communicating with the pipe 352 and discharging to the tank 350 through the pipe 354 acts to maintain pressure in the pipe 352 at the desired amount. This pipe 352 leads to a valve casing 3540 within which is positioned a pilot valve 355 and a reversing valve 356. It also leads through the pipe 357 to a valve casing 358 containing an operator actuable controlling valve 359 and a shut off valve 360, which may be actuated at suitable times to cut out the automatic valve within the casing 3540 when hand control of the traverse is desired. In the position shown in Figure 31 for automatic grinding traverse, liquid under pressure passes from the pipe 352 through the passages 365 and 368, the valve port 369, to the pilot valve, through the longitudinal passage 371 in this valve, through the port 372, the passage 373 and the passage 374, through the check valve 3730 and

throttle valve 3731 and later through the pipe 439 only, when the valve closes the port 4370 to the left end of the reversing valve 366, thus forcing the reversing valve 356 into the position shown, the fluid under pressure escaping from the right hand end of this valve first through the pipes 438 and 439, and later through the pipe 439 only, when the valve closes the port 4370 the throttle valve 4390, passage 438, port 437, through the valve passage 435, port 3711, passage 443 and pipe 444 to the discharge pipe 419. A check valve 4391 in the pipe 439 prevents free discharge through the pipe 439 so that the rate of flow and thus the rate of motion of the reversing valve near the end of its stroke is determined by the setting of the throttle valve 4390. This adjustment of the speed of motion of the reversing valve allows for a sharp control of the cut off for the tool slide so that the slide is stopped at a definite point. In this position of the reversing valve, fluid under pressure around the neck 366 of the reversing valve may pass through the passage 375 around the neck 376 of the valve 360, port 377, around the neck 378 of the hand operated valve 359 and out through the port 379 to the pipe 175, thus forcing the cylinder 159 to the left. The discharge from the opposite end of the cylinder takes place through the pipe 180, the port 380, around the neck 381 of the manual control valve 359, through the port 382, around the neck 383 of the valve 360, through the pipe 385, through the port 386, around the neck 387 of the reversing valve, through the port 388 and passage 389, the port 390 of the pilot valve, around the neck 391 of this valve, the port 392, and the pipe 393 to a valve casing 394. Within this valve casing 394 is a rocker valve 395 having two ports 396 and 397 therearound. The port 396 is a restricted port, the extent of opening of which may be adjusted by turning the valve 395, thus to determine the rate of discharge of fluid from the cylinder 159 and thus to determine the traverse rate. The port 397 is always wide open until after port 396 is wholly closed, but in grinding position no liquid passes therethrough as will later appear. The parts in this figure are in the grinding condition during which the port 396 allows the discharge through the pipe 398 into the port 399 of the manual control valve 400 which is verticallly movable to any selected of four positions in any of which it may be yieldably retained as by a ball detent 401 shown in Figure 27, and determines in order whether the control is set for grinding, dressing, stop or fast speed.

In Figure 29 these four positions, grinding, dressing, stop and fast speed are shown indicated by the corresponding angular positions in a vertical plane of a control handle 408 which carries a mutilated gear 402 meshing with a pinion 403, which, in turn, meshes with a rack portion 404 and the valve 400. This valve is also permitted a rocking motion, this for the purpose of controlling the axial position of the pilot valve 355, one end of which is formed as a rack bar 405 with which meshes a gear 406 on the lower end of the valve 400. The rocking motion of this valve 400 does not, however, affect in any way its control of its valve ports and the handle 408 rocks with it in a horizontal plane.

In the grinding position shown for this valve 400 in Figure 31, the discharge from the pipe 398 and the port 399 passes around the valve 400 to the pipe 413, around the valve neck 410 and through the port 412 and pipe 414, both pipes 413 and 414 leading to a valve casing 415 within which is a rockable valve 416. The pipe 413 is always open to the pipe 398 through an annular passage around the outside of the valve 400 regardless of the position of the valve 400. The valve 416 has a pair of ports 417 and 418, both of which, in the position shown in Figure 31, communicate with the discharge pipe 419 leading back to the tank 350. Beside passing through the pipe 398 to the valve 400 there is also a by-pass discharge from the pipe 398 through an adjustable restricted rocker valve 420 having the V port 421, through the pipe 422, the port 423 of the valve 400, which also leads around the neck 410 of this valve from which the discharge takes place, as previously described. The port 397 of the adjustable valve 395 leads through a pipe 426 to a port 427 of the valve 400, but in this position of the parts, this port 427 is closed by the part 428 of the valve 400 so that in grind position the traverse speed is controlled by the extent of opening of the port 396 of the valve 395. The pilot valve is also forced fully to its right hand position by a "load and fire" hydraulic means, since as soon as this valve has been moved far enough to open the valve passage 371 to pressure, this pressure acts on the left hand face of the valve shoulder 3550 while the shoulder 3551 at the right hand end of the pilot valve is open to discharge through the valve passage 435.

When the tool carriage approaches the left hand end of its travel, a dog 430 thereon engages the head 431 of the valve 400 and continued motion of the carriage rocks the valve 400 and moves the pilot valve 355 axially toward the position shown in Figure 32 to which it is forced by the hydraulic "load and fire," fluid under pressure passing to the right hand face of the shoulder 3551 through the valve passage 435 and being discharged from the left hand face of the shoulder 3550 through the valve passage 371, as will appear. In this position of the valve 355, the valve passage 371 has been moved out of registry with the port 369 and a valve passage 435 placed in registry therewith, thus permitting the fluid under pressure to pass through this passage 435 through the valve passage 436 and the port 437, the passage 438, and the passage 439 to the right hand end of the reversing valve 356, thus driving the reversing valve to the left to the position shown in Figure 32, while the left hand end of the reversing valve discharges through the pipe 374, the passage 373, the valve port 440 around the neck 441 of the pilot valve through the valve passage 371, the port 442, passage 443, and pipe 444 to the discharge line 419, With the reversing valve in this position, fluid under pressure passes from the pipe 352 and port 365 around the neck 387 of the reversing valve, port 386 to the pipe 385 leading to the manual traversing valve casing, around the neck 383 of the valve 360, passage 382, around the neck 381 of the hand control valve, and through the pipe 180 to the power cylinder 159 to drive the carriage in the reverse direction or to the right, the discharge taking place through the pipe 175, past the neck 378 of the hand control valve, neck 376 of the valve 360, the passage 375, around the neck 366 of the reversing valve, through the port 445, passage 446, port 447, around the neck 391, through pipe 393, past the valve 395 and from thence back around the valve 400 and through the valve 416 to discharge. This takes place until the dog 448 impinges on the valve 400 and

rocks it back toward its initial position to which it is forced by the hydraulic load and fire mechanism previously described, whereupon the cycle is repeated. It will be noted that neck 391 of the pilot valve is provided with conical ends which effect initial and final throttling through the ports controlled thereby, thus slowing the traverse before reversing and returning.

In the dress position the valve 400 is lowered to the position shown in Figure 33 in which it is too low to be affected by the dog 448 so that the tool carriage is permitted an extended outward traverse at which time the dog 449 becomes effective to reverse the traverse at one end while the dog 430 is still in effective relation at the other end. From an inspection of Figure 33 it will be seen that in this position of the valve 400 it shuts off port 399 from around the neck 410 and the discharge through the pipe 414, but does not prevent flow from this port around the valve to the pipe 413. This permits the tool slide to retract and remove the wheel from the work at normal traverse speed until the wheel approaches "dress" position, whereupon the dog 465 engages the rabbit ears 466 and shuts off the valve port 417 while leaving open the port 418. All the discharge is then forced to take place through the throttle valve 421, pipe 422, around the valve neck 419 and through pipe 414, so that the outward travel of the wheel carriage is slowed for dressing. The wheel, therefore, comes out of the hole in the work and returns at grinding speed, but its traverse is slowed during the truing portion of its extended traverse. Automatic reversal of this extended stroke is produced by the dog 449, turning the valve 400.

On depressing the handle 408 to the stop position indicated in Figure 29, the valve 400 is brought into the position shown in Figure 34. In this position of the valve, it will be noted that there is open communication through ports 455 and 456 between the pipes 457 and 458. These pipes communicate with the pipes 385 and 375, respectively, which in the inoperative position of the hand traverse valve 359, communicate with the pipes 175 and 180 which lead to opposite ends of the power cylinder 159. The pressures in opposite ends of the cylinder 159 are thus balanced and the wheel slide stops. The tool carriage may now be moved freely by hand or by actuation of the hand traverse mechanism, which, as will later be shown, shuts off the pipes 375 and 385 from the cylinder 159. In all of the positions of the valve 400, except the stop position, the pipes 457 and 458 are cut off from each other by suitable parts of the valve 400.

Further depression of the handle 401 bringing the valve 400 into fast position is shown in Figure 35. In this position of the valve 400 the discharge port 423 is closed, but the unrestricted discharge pipe 426 is open through the port 427 and around the neck 410 of the valve 400 through the discharge pipe 414, thus permitting unrestricted discharge of fluid from one or the other side of the power cylinder 159, depending upon the setting of the reversing valve. In this position of the parts, also, the top of the valve 400 is lowered to a point where it is unaffected by the stop 449 so that the traverse may be further extended in an outward direction. The stop 430 is long enough to reverse the traverse at the inner end of its stroke automatically.

The stop dog 465 which controls the angular position of the valve 416 and the dog 467 which actuates a work drive valve 657 to be later described are fixed to blocks such as 510 adjustable within a T slot 511 in a bracket 512 secured to the tool carriage, as best shown in Figure 6, while the dogs 430, 448, and 449 are similarly secured in an under cut groove 513 of the same bracket 512. As shown best in Figures 26 and 29, the handle 408 may be rocked angularly by hand in a horizontal plane to turn the valve 400, thus to effect reversal of the direction of traverse at will.

Hand traverse control

As before mentioned, the traverse may be controlled by the operator by a manual control of the valve 359, actuation of this valve for such control serving automatically to cut out the automatic traverse conrol. In the inoperative position of the hand control, the parts being in the position of Figures 27 and 31, a hand lever 475 is in vertical position, this lever, as shown in Fig. 31, being pivoted to a link 476, which, in turn, is pivoted to an ear 477 on the cap 478 closing the end of the valve casing 358. The lower end of the hand lever 475 is pivoted at 480 to a rod 481 extending from one end of the valve 359. In Figure 27 a slightly different mounting of the hand lever 475 is shown in which it is fulcrumed on a fixed pivot 475a and its lower end engages between flanges of a spool 475b carried by the valve rod 481. At each end of this valve 359 is positioned a spring centering device, this comprising a pair of spring seat members 482 and 483. The seat member 482 is perforated for the passage of the rod 481 and is normally pressed against an end shoulder 484 of the valve by a spring 485 seated in a socket 486 in the cap 478. The spring seat 483 normally engages the opposite end of the valve 359 and is spring pressed by a spring 488 seated in a socket 489 in the end wall member 490 of the valve casing 358. Both of these spring seats 482 and 483 are limited in their inward motion by annular shoulders 490 and 491, respectively, at the ends of the valve casing 358. By pulling the handle 475 outwardly toward the dotted line position shown in Figure 31, the valve 359 is moved to the right against the pressure of the spring 488, this causing the left hand edge of central valve portion 495 to uncover the port 496 to which the pressure pipe 357 leads from the pressure pipe 352. This allows fluid under pressure to pass directly from the port 496 to the port 379 and to the power cylinder 159 through the pipe 175, while its shoulder 497 uncovers the port 498 leading to the discharge pipe 499, thus opening up the opposite pipe 180 from the power cylinder 159 to discharge, thus causing the cylinder 159 to be moved to the left. At the same time fluid under pressure from the port 496 passing around the valve neck 378 escapes through the passage 500 to the left end of the valve 360, driving it to the right against the pressure of the spring 501 reacting against its right hand end, and shuts off passages leading to the pipes 375 and 385, thus cutting off the automatic traverse mechanism. On moving the lever 475 inwardly toward the right hand dotted line position of Figure 31, the valve 359 is moved in the reverse direction, opening up the port 496 at the right hand end of the valve port 495 and connecting through the port 380 directly to the pipe 180 leading to the opposite end of the power cylinder 159 so that this power cylinder is driven to the right, the discharge taking place through the pipe 175, passage 379, passage 502 to the discharge pipe 499. Likewise the fluid under pressure may then pass around the

neck 381 of this valve through the passage 500 to the left hand end of the valve 360, thus driving this valve 360 in the same direction as before and cutting off the pipes 375 and 385. The traverse is thus in the reverse direction, but as before the automatic traverse mechanism is cut off by the same position of the valve 360. It will be noted that the valve portion 495 has tapered ends so that the port 496 is opened or closed gradually on motion of this valve. Thus the speed of traverse as controlled by this valve depends on the extent of its displacement so that the further the handle 475 is moved from its central position, the faster is the speed of traverse of the wheel slide.

Power Cross Feed

The power cross feed which actuates the plunger 95 is operative only when the valve 400 is in grinding position, in which position only, the pipe 550 leading from a port 551 of the casing of the valve 400 is open to fluid under pressure through port 552 and pipe 553 from the port 369 of the pilot valve, around the neck 554 of the valve 400. This establishes hydraulic pressure in the pipe 550 regardless of the direction of traverse of the wheel and leads to the two cylinders 555 and 556 (see Figure 31) containing the piston valves 557 and 558, respectively. In the positions shown in Figure 31 with the plunger 95 in its upper position and with both of the pistons 557 and 558 in the lowered positions shown, fluid pressure from the pipe 550 may pass around the neck 559 of the valve 558 out through the pipe 560 above the piston of the plunger 95 so as to force this plunger downwardly and effect a feeding oscillation to the bell crank feed lever. At the same time fluid under pressure in the pipe 560 passing the throttle valve 561 builds up pressure above the piston valve 562 slidable in a cylinder 563, forcing this valve downwardly, fluid under pressure escaping from beneath the valve 562 through the pipe 566, around the neck 567 of the valve 558, and through the discharge pipe 568. When the valve 562 is driven downwardly to a sufficient distance, it opens connection to the fluid pressure above it through the pipe 569 beneath the piston valve 557 while fluid escapes from above this valve 557 through the pipe 573, around the valve neck 564 to the return line 565, thus raising this valve 557, permitting fluid to pass from the pipe 550 around the neck 570 of the valve 557 and the pipe 571 beneath the valve 558 while discharging from above the valve 558 through the pipe 5880, around the neck 5570 of the valve 557 to the discharge pipe 572. This lifts the valve 558, shutting off the connection from the pipe 550 to the pipe 560 and opening the pipe 560 to the pipe 572 which leads to the discharge. This allows the spring 97 to lift the plunger 95 and permits the slow escape of fluid under pressure through the throttle valve 561 from above the valve 562 past the neck 559 and pipe 572 to discharge. This position of the valve 558 opens connection from the pressure pipe 550 past the neck 567 of the valve 558, through the pipe 566 and beneath the valve 562 lifting this valve. As soon as the valve 562 is raised sufficiently, fluid under pressure beneath this valve passes through the pipe 573 to the upper end of the cylinder 555 and so forces the piston 557 downwardly, fluid under pressure escaping from beneath the valve 557, through the pipe 569, around the neck 564 of the valve 562, and out through the discharge pipe 565. These various discharge pipes from this mechanism may, of course, lead to a common discharge pipe passing to the fluid pressure tank. It will thus be seen that whenever the valve 400 is in grind position and in that position only, there is an intermittent feed produced, depending for its speed of action on the setting of the throttle valve 561 which controls the rate of motion of the valve. The hydraulic driving mechanism and control is not claimed herein but forms subject matter of a divisional application Serial No. 450,866, Metal working machine, filed July 14, 1942.

Work Spindle Rotating and Control Means

This is shown diagrammmatically in Figure 36. Referring to this figure, the hydraulic fluid is taken from the tank 350 by a double motor driven pump having the two pumping portions 351 and 601. The pump portion 351 supplies oil under pressure to the tool carrier traverse as has previously been described and it also supplies oil under pressure for other mechanism to be described. The pump portion 601 delivers into the pipe 602, the maximum pressure therein being, say, 800 pounds per square inch as controlled by a relief valve 603 in a discharge line 604 leading back to the tank 350. This high pressure line furnishes the fluid pressure for driving the motor 50, and supply of this high pressure fluid is controlled with respect to this motor 50 by a fluid pressure actuated piston valve 605 in a casing 606. As will later appear, the controlling fluid pressure for this valve 605 is derived from the low pressure pump 351. The pressure pipe 602 leads through the port 607 of the casing 606 and ports 608 and 609 lead through the pipes 610 and 611 to opposite sides of the hydraulic motor 50, it being understood that when fluid under pressure is delivered to one of these pipes 610 and 611 and discharged through the other, the motor 50 is driven in the corresponding direction. Thus in the position shown in Figure 36, the fluid under pressure from the port 607 passes around the neck 612 of the valve 605 into the port 608 to the pipe 610, while the discharge from the motor passes through the pipe 611 and the port 609, around a neck 614 of the valve 605, through a central passage 615 of this valve, out through the end 618 of the passage 615, around the neck 617 of the valve 605, and out through the port 618 and pipe 619 to the back pressure valve 620 and to the tank 350. This back pressure valve is set to maintain a back pressure of, say, 25 pounds, in order that the hydraulic system may be under fluid pressure at all times, thus to prevent any leakage of air into the system. By moving the valve 605 to the right, the ports 609 may be placed in communication with the pressure space around the neck 612 to permit fluid under pressure to pass to the motor 50 through the pipe 611, and the discharge passage 615 opening at 625 at the neck 626 of the valve 605 receives the discharge from the pipe 610 and conducts it to the discharge port 618 and the discharge pipe 619, thus to drive the motor in the reverse direction. The valve 605 tends to be centered in neutral position in its casing 606 by coil springs 630 at each end reacting between heads 631 and 632 of the valve casing and spring seats 633 movable in enlarged recesses 634 adjacent to the ends of the valve casing. Opposite ends of the valve casing are connected by pipes 640 and 641 to a four-way valve 642 which may be controlled by hand so as to reverse the connections from the

low pressure control pump 351 thus to control the direction of motion of the motor 50 by displacement of the valve 605 in one or the other direction from its neutral central position. The low pressure fluid from the pump 351 is delivered into the pipe 352 and from which leads the pressure pipe 651. This pipe 651 leads through a pipe 652 to a valve casing 653 within which is positioned an oscillating hand control valve 654.

In order to simplify the diagram, the valve casing 653 and the valve 654 have been shown in two places connected by a dot and dash line to indicate that they belong to the same structure.

In the automatic position shown, the motor 50 is under the control of an automatic valve 657 having the rabbit ears 659 which may be contacted to turn the valve by the carriage stop or dog 467 which has been previously mentioned. When this dog 467 strikes the right hand ear 659 and rocks the valve to the dotted line position shown in Figure 36, the motor 50 is stopped, and when the carriage is moved in the opposite direction to bring the grinding wheel up to the work, this dog 467, impinging on the left hand ear 659, rocks this valve to start the rotation of the motor 50. In the full line position shown, fluid under pressure passes from the pipe 651 through the port 660 of the valve 657, pipe 661, the valve passage 662 of the manually controlled valve 654, the pipe 663, the four-way valve 642, and to one or the other ends of the valve casing 606, depending upon the angular position of the four-way valve 642. In the position shown it directs the fluid under pressure through the pipe 641 to the right hand end of the valve casing 606, moving and holding the valve 605 in the position wherein the pipe 610 leading to the motor receives the fluid under pressure while the discharge takes place through the pipe 611 as heretofore described. At the same time the fluid under pressure is discharged from the left hand end of the valve casing 606 through the pipe 640, the four-way valve 642, and the discharge line 665. When the automatic valve is rocked to its dotted line position, the fluid under pressure from the pipe 651 is shut off from the pipe 661 and the pipe 661 is opened through valve passage 660 to the pipe 671 which leads to the discharge. The valve casing 606 is thus open to the discharge at both ends. Thus the valve 605 is permitted to assume its mid or neutral position where both ports 608 and 609 are closed. In this position of the automatic reversing valve 657 it will be noted that the port 670 registers with the pipe 656, thus connecting the pipe 656 to the discharge pipe 671 through the center of the automatic valve 657. This pipe 656, in the automatic position of the hand control valve 654, is open through the port 672 to the pipe 673. This pipe leads to a valve casing 674 which contains therein a valve 675. The valve 675 normally closes a discharge port 676 communicating with the pipe 677 leading from the valve casing 674 to the pipe 619. Fluid under pressure from the pipe 602 passes above the valve 675 through a bleeder port 6750 and tends to hold this valve 675 to its seat, thus closing off the pressure pipe 602 from the back pressure valve 620. When the pipe 673 is opened to the discharge, however, the pressure is led off from above the valve 675 faster than it can build up through the bleeder port 6750 and when sufficiently reduced, the back pressure within the pipe 677 unseats the valve 675 so that the pressure in the pipe 602 is reduced to the back pressure of the back pressure valve 620. This, therefore, equalizes the pressure in the pressure pipe 602 and in the discharge pipe 619 so that there is no pressure differential to operate the motor 50 no matter what the position of the valve 605 may be.

The automatic control valve may, however, be thrown out of control by turning the hand control valve 654 to either of two other positions indicated, respectively, as "stop" and "run." In the "stop" position the hand valve passage 680 opens the pipe 673 leading to the valve casing 674 to discharge through the center of the valve to the pipe 671, thus stopping the motor 50. At the same time the port 662 is moved out of registry with the pipe 661 and the port 655 and port 672 are blanked, thus cutting off the automatic valve 657 from any controlling function. If the hand valve 654 is turned to the "run" position, the pressure pipe 651 leading through the pipe 652, communicates through the port 655 with the pipe 663, so that pressure is applied to one or the other ends of the valve 605, depending upon the setting of the four-way valve 642, and the discharge from the bleeder pipe 673 through the discharge port 680 and the center of the valve 654 is cut off. Thus the hand control valve may be employed to cut out the automatic stop and start of the work-rotating motor from the position of the carriage, and it may be set in either of two positions with the automatic valve out of control, in one of which the motor 50 is stopped and in the other of which the motor 50 is in operation.

From the foregoing description of an embodiment of this invention it should be evident to those skilled in the art that various changes and modifications may be made without departing from the spirit or scope of this invention.

I claim:

1. A machine of the class described having a bed, a work support carried by said bed, a tool carriage rockably supported by said bed on an axis extending toward said work support and movable along said axis, a tool supported by said carriage above said axis and in position to operate on work carried by said work support, means for reciprocating said carriage, and means for adjusting the angular position of said carriage during its reciprocation.

2. A machine of the class described having a bed, a work support supported by said bed for motion transversely thereof, a tool carriage rockably supported by said bed on an axis extending lengthwise thereof and movable along said axis, a tool supported by said carriage above said axis and in position to operate on work carried by said work support, means for reciprocating said carriage, and means for adjusting the angular position of said carriage during its reciprocation.

3. A machine of the class described having a bed, a work support carried by said bed, a fulcrum member extending outwardly from beneath said support, a tool carriage rockable about the axis of said member and supported thereon, and a guard extending from said tool carriage over said member and underlying said work support.

4. A machine of the class described having a bed, a work support carried by said bed, a fulcrum member extending outwardly from beneath said support, a tool carriage rockable about the axis of said member and supported thereon, and a guard extending from said tool carriage over said member and underlying said work support,

said guard having a downwardly and outwardly sloping face provided with transverse upstanding ribs.

5. A machine of the class described having a bed, a work support carried by said bed, a fulcrum member extending outwardly from beneath said support, a tool carriage rockable about the axis of said member and supported thereon, means for reciprocating said tool carriage lengthwise of said member, and means for controlling the angular position of said tool carriage during its reciprocation.

6. A machine of the class described having a bed, a work support carried by said bed, a fulcrum member extending outwardly from beneath said support, a tool carriage rockable about the axis of said member and supported thereon, means for reciprocating said tool carriage lengthwise of said member, and relatively movable members, one on said tool carriage and the other on said bed, for controlling the angular position of said tool carriage during its reciprocation.

7. A machine of the class described having a bed, a work support carried by said bed, a fulcrum member extending outwardly from beneath said support, a tool carriage rockable about the axis of said member and supported thereon, means for reciprocating said tool carriage lengthwise of said member, a support carried by said bed, and a member on said tool carriage engaging said support for determining the angular position of said tool carriage about its fulcrum during its reciprocation.

8. A machine of the class described having a bed, a work support carried by said bed, a fulcrum member extending outwardly from beneath said support, a tool carriage rockable about the axis of said member and supported thereon, means for reciprocating said tool carriage lengthwise of said member, a support carried by said bed, a member pivoted to said tool carriage and engaging said support for determining the angular position of said tool carriage about its fulcrum during its reciprocation, and means for adjusting the angular position of said tool carriage member about its pivot.

9. A machine of the class described having a bed, a work support carried by said bed, a fulcrum member extending outwardly from beneath said support, a tool carriage rockable about the axis of said member and supported thereon, means for reciprocating said tool carriage lengthwise of said member, a support carried by said bed, a member pivoted to said tool carriage and engaging said support, and means extending through said tool carriage and accessible for operation on the opposite side thereof from said tool carriage member for adjusting the angular position of said tool carriage member about its pivot.

10. A grinding machine comprising a bed, a work carriage, means for supporting work on said carriage for rotation about an axis, a grinding wheel carriage on said bed, a face grinding wheel journaled for rotation on said wheel carriage about an axis substantially parallel to the axis of rotation of the work, means for moving said carriages relatively to bring said wheel and work into and out of cooperative relation, and means for adjusting one of said carriages relative to the other to bring certain planes containing said axes into accurate parallelism to thereby permit said wheel to operate on the work at both sides of said work axis when said axes have been brought into parallel relation in said planes.

11. A machine of the class described having a bed, a work support carried by said bed, a tool carriage rockably supported by said bed on an axis tending toward said work support and movable along said axis, and a tool supported by said carriage above said axis and in position to operate on work carried by said work support.

12. A machine of the class described having a bed, a work support carried by said bed, a tool carriage rockably supported by said bed on an axis extending toward said work support and movable along said axis, a tool supported by said carriage above said axis and in position to operate on work carried by said work support, and means for reciprocating said carriage in line with said axis.

13. A machine of the class described having a bed, a work support carried by said bed, a tool carriage rockably supported by said bed on an axis extending toward said work support and movable along said axis, a tool supported by said carriage above said axis and in position to operate on work carried by said work support, means for reciprocating said carriage in line with said axis, a member carried by said bed, and a member carried by said carriage engaging said bed-carried member for determining the angular position of said carriage in its various axial positions.

14. A machine of the class described comprising a bed, a work support carried by said bed, an axially movable bar rockably carried by said bed beneath the level of said work support, a tool carriage supported on said bar for axial and rocking motion, and means for controlling the angular position of said carriage.

15. A machine of the class described comprising a bed, a work support carried by said bed, an axially movable bar rockably carried by said bed beneath the level of said work support, a tool carriage supported on said bar for axial and rocking motion, means for controlling the angular position of said carriage, and means for moving said tool carriage axially.

16. A machine of the class described comprising a bed, a work support carried by said bed, a rockable and axially movable bar supported by said bed, a tool carriage above and supported on said bar for axial motion therewith, means determining the angular position of said tool carriage about the axis of said bar in accordance with the axial position of said tool carriage, and a tool mounted on said tool carriage in position to operate on work on said work support.

17. A machine of the class described comprising a bed, a work support carried by said bed, a rockable and axially movable bar supported by said bed and extending beneath and outwardly of said work support, a tool carriage above and supported on said bar for axial motion therewith, means determining the angular position of said tool carriage about the axis of said bar in accordance with the axial position of said tool carriage, and a tool mounted on said tool carriage in position to operate on work on said work support.

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