

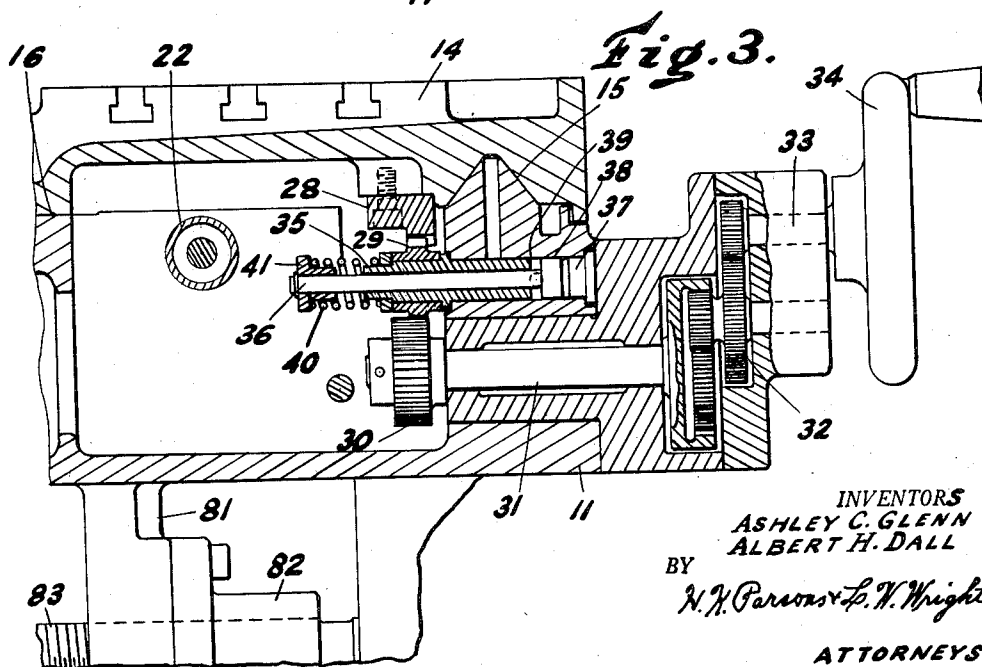
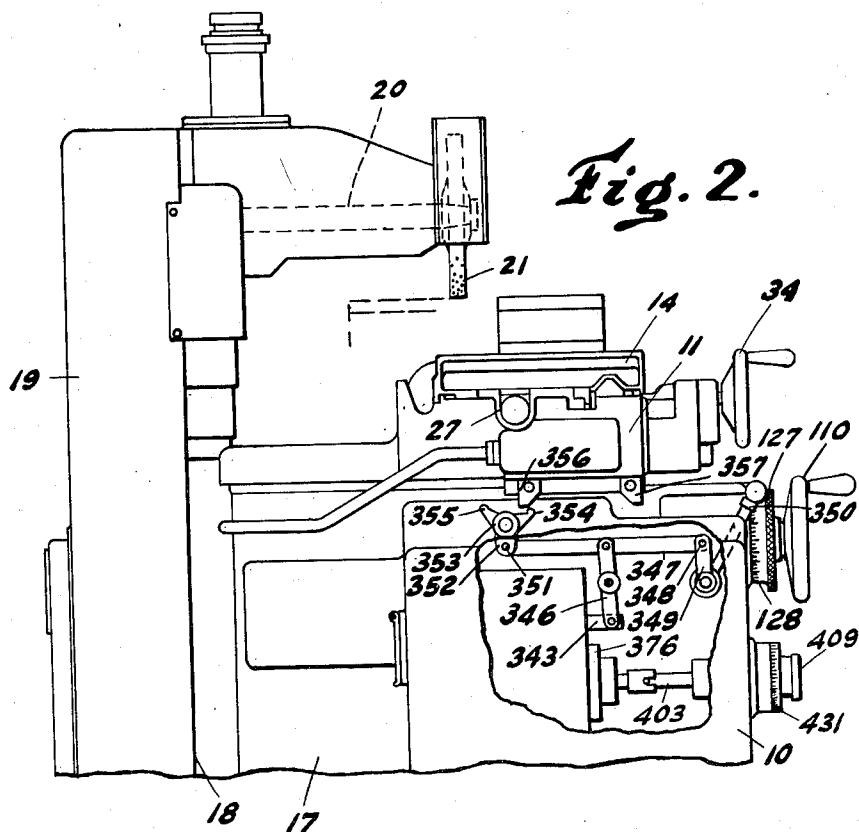
April 26, 1960

A. C. GLENN ET AL
SURFACE GRINDING MACHINE

2,933,858

Filed April 27, 1956

10 Sheets-Sheet 2



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10 Sheets-Sheet 3

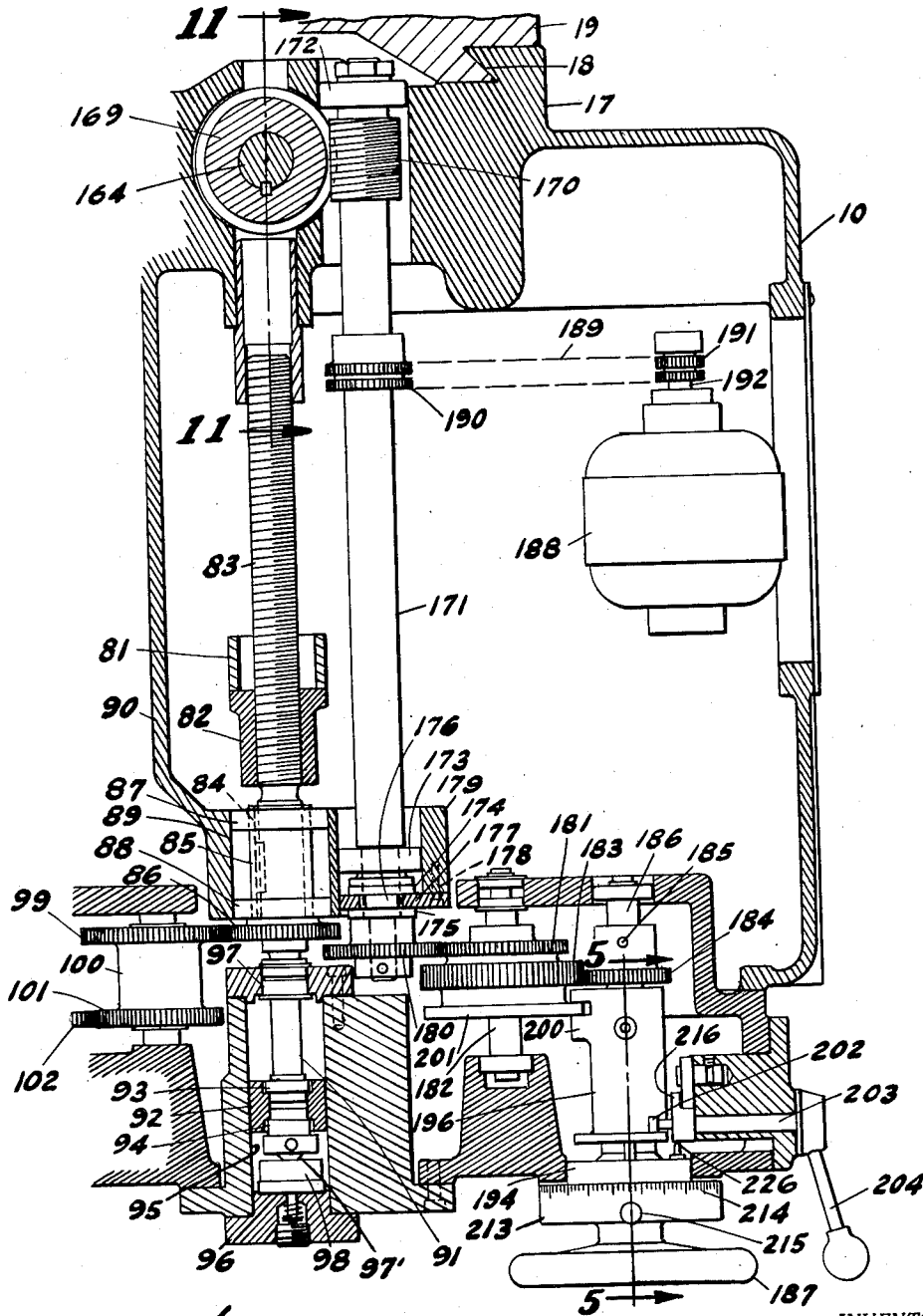


Fig. 4.

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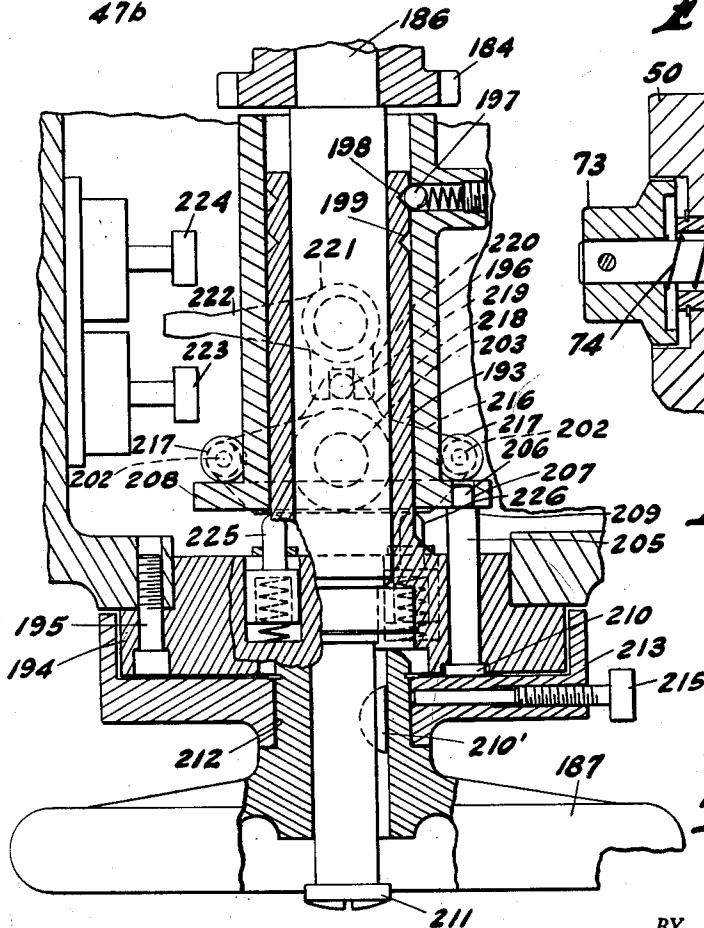
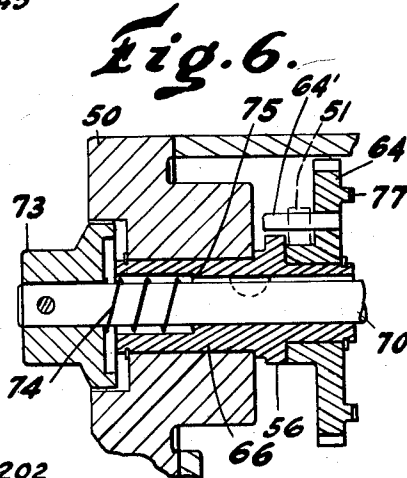
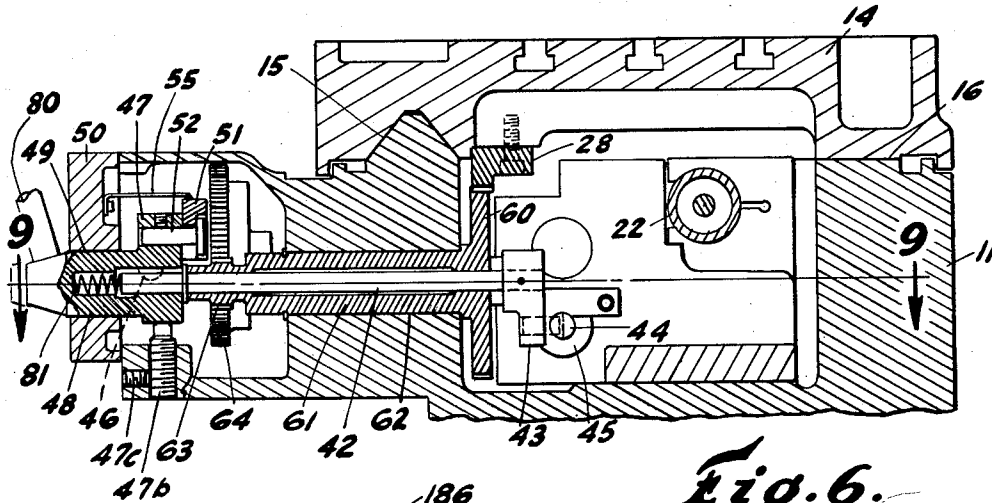
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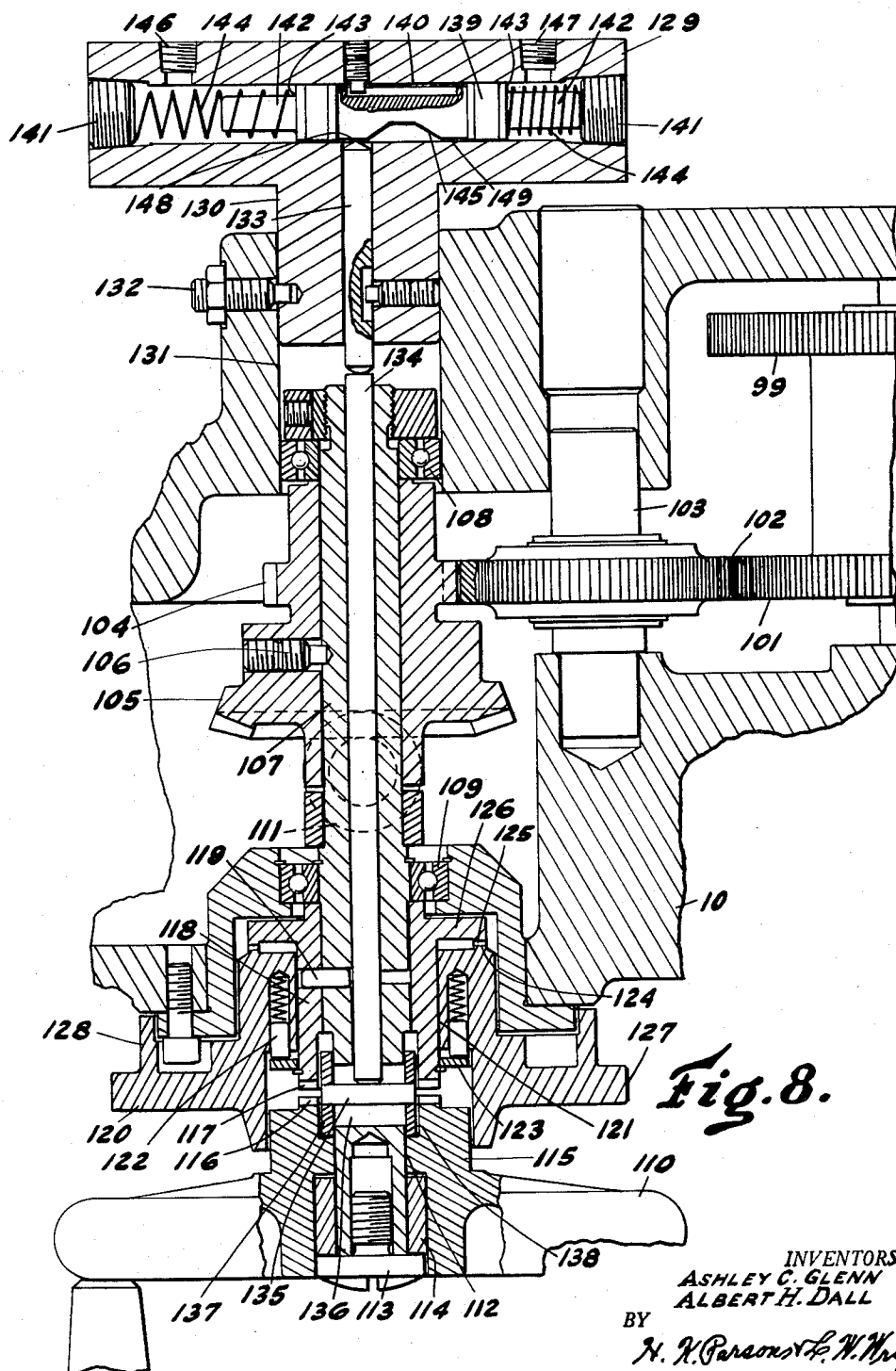


Fig. 8.

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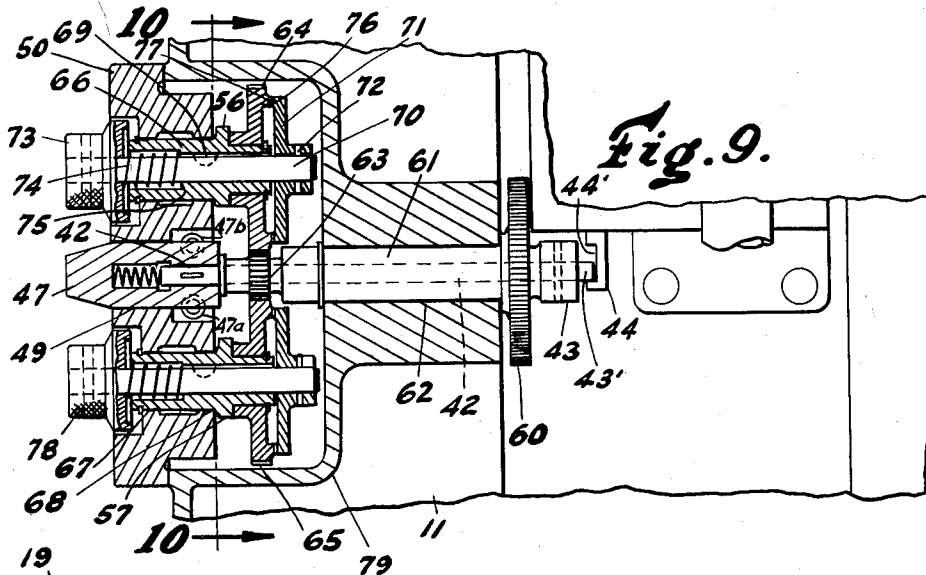


Fig. 9.

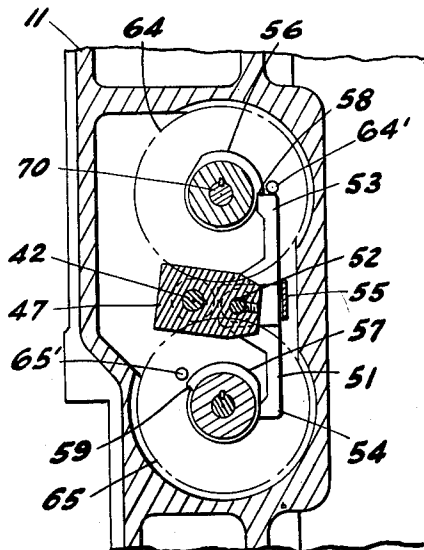
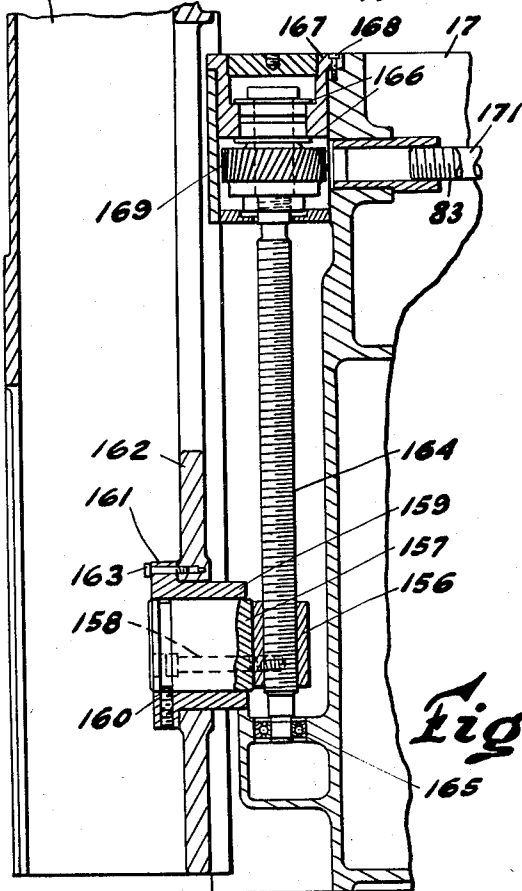


Fig. 11. Fig. 10.

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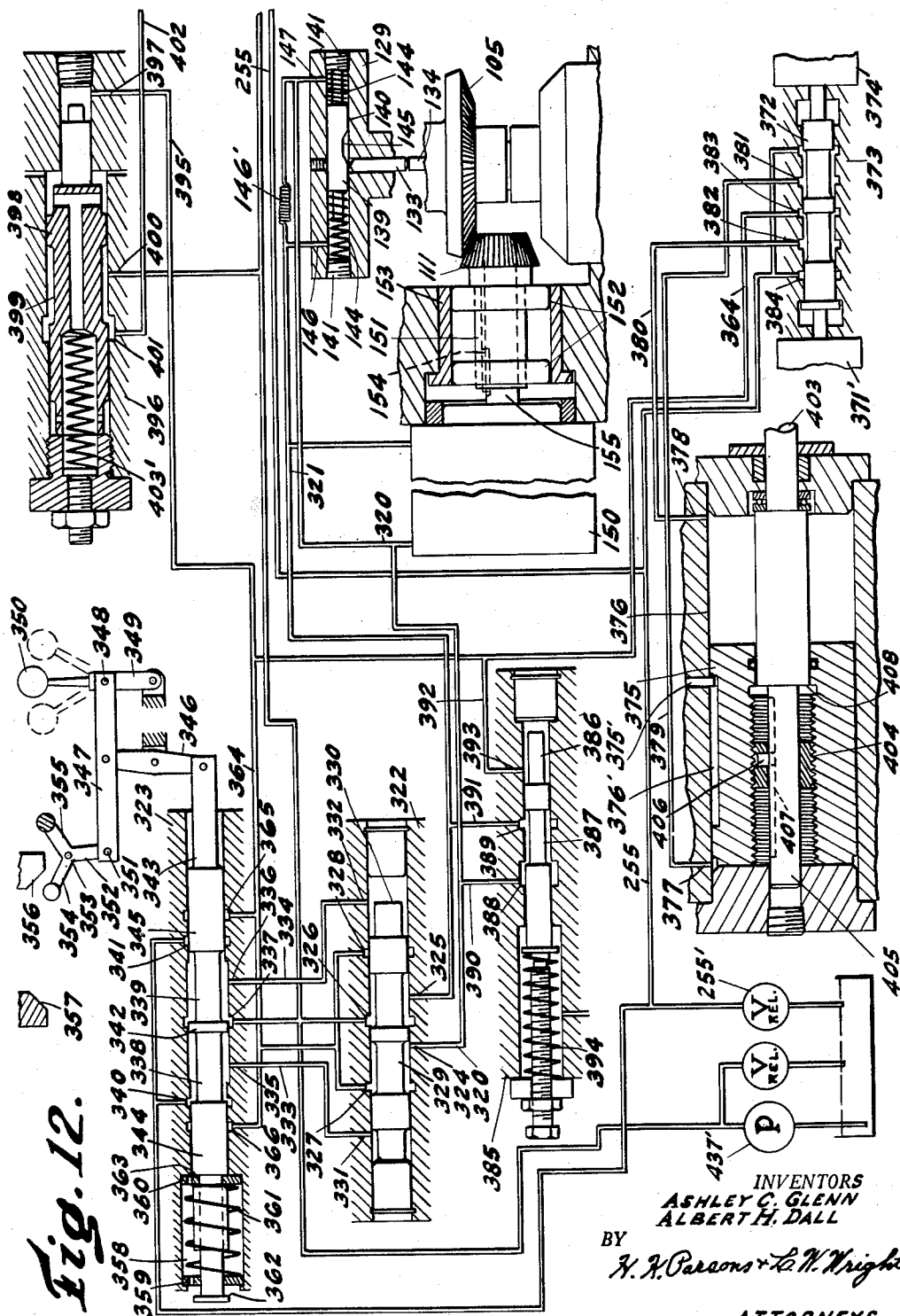
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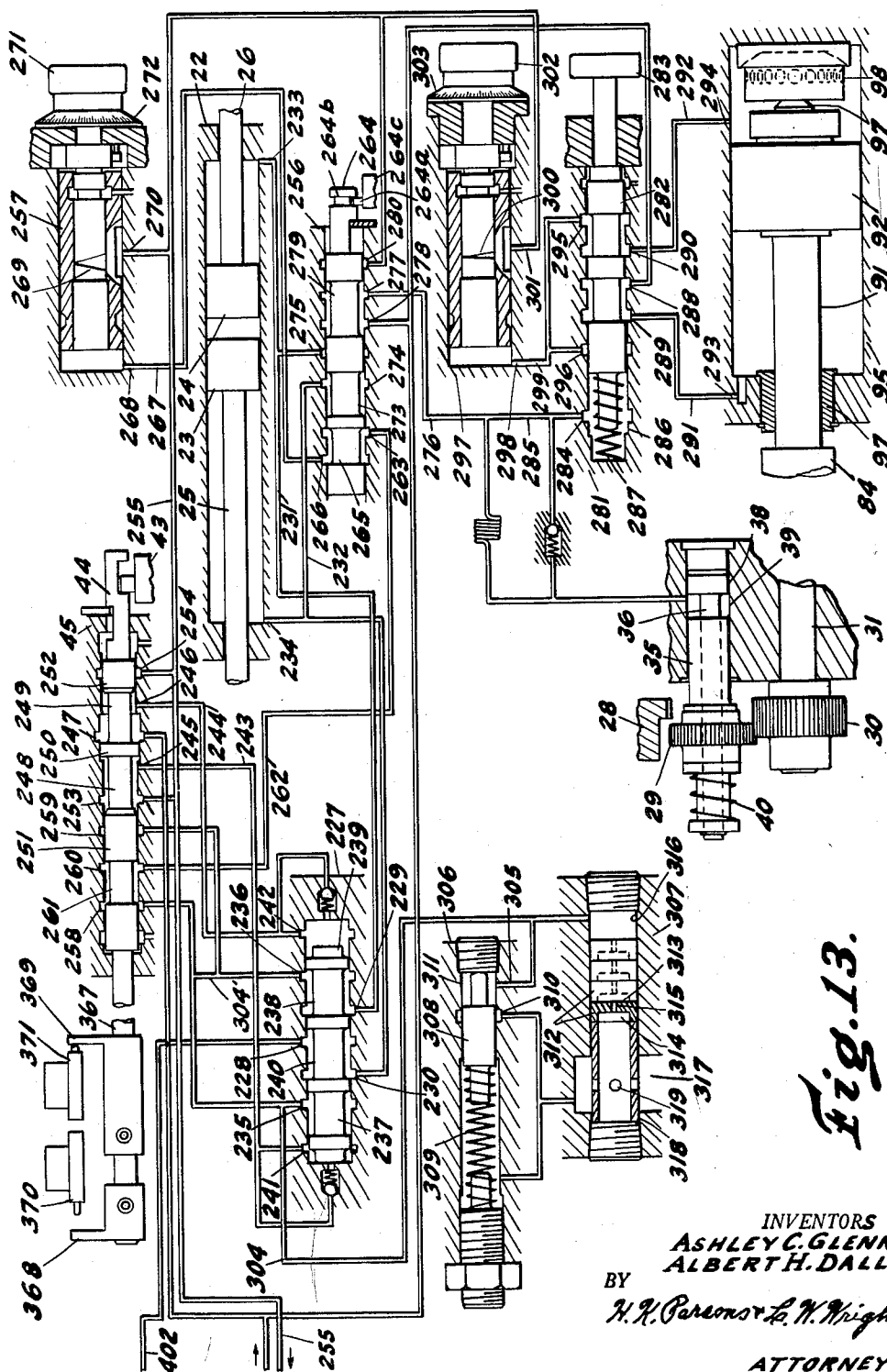
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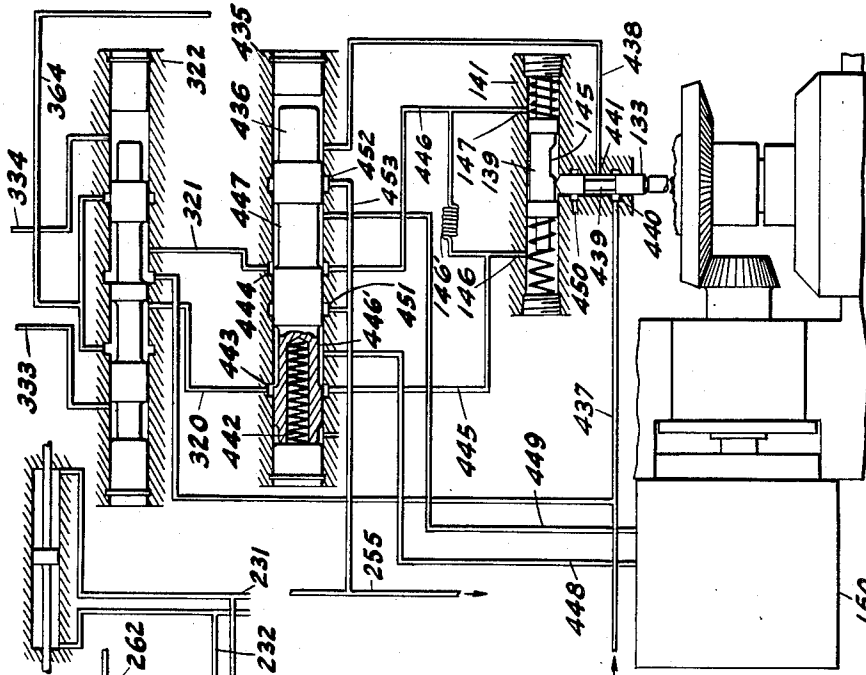


Fig. 18.

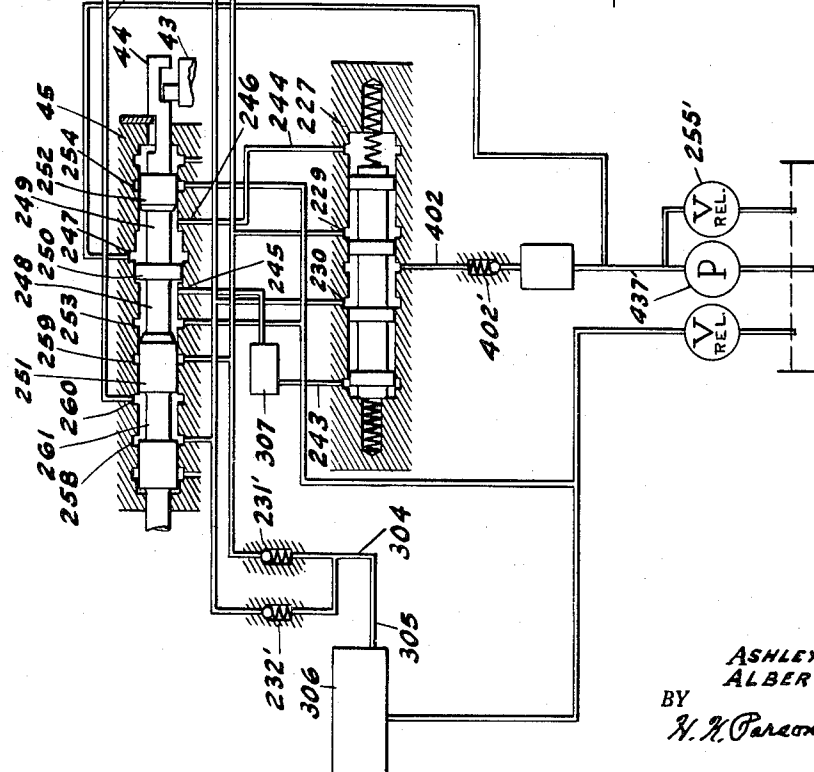


Fig. 19.

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SURFACE GRINDING MACHINE

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Application April 27, 1956, Serial No. 581,213

30 Claims. (Cl. 51—92)

This invention relates to grinding machines and more particularly to new and useful improvements in surface grinders.

One of the objects of this invention is to provide a new and improved transmission and control mechanism for a surface grinder. It is well known in the art that the table of a surface grinder reciprocates at a fast rate, which means that any projection from the side of the table, such as adjustable trip dogs may be hazardous to the operator, and therefore another object of this invention is to eliminate the use of exposed trip dogs on the table and to provide an improved and enclosed trip control mechanism for the work table of the machine.

A further object of this invention is to provide an improved traversing and control mechanism for a surface grinder table that permits manual or power traversing of the table and yet provides improved interlocking mechanism to prevent simultaneous use of both traversing means.

A still further object of this invention is to provide in a surface grinder of the type having a cross moving saddle supporting a reciprocating table with a new and improved actuating and control mechanism for the saddle which will readily yield manual operation, power operation, pick feed operation or fixed stroke operation for wheel truing purposes, and to provide new and improved interlocks between the different methods of operation.

An additional object of this invention is to provide a new and improved pick feed mechanism for the saddle which is coupled for automatic operation by the reciprocating table.

Still another object of this invention is to provide a new and improved fixed stroke truing mechanism for the saddle and new and improved interlock means to insure that the table is stopped during use of the mechanism.

Another object of this invention is to provide new and improved means for adjusting the grinding wheel relative to the table either manually or by power, including improved interlocking mechanism therewith.

Another object of this invention is to provide hydraulic traversing mechanism for the table having improved means for damping pressure surges created by fast reversal of the table and also including means for causing the table to pause at reversal to insure that pick feed operations have been completed before the table starts on a new stroke.

Other objects and advantages of the present invention should be readily apparent by reference to the following specification, considered in conjunction with the accompanying drawings forming a part thereof, and it is to be understood that any modifications may be made in the exact structural details there shown and described, within the scope of the appended claims, without departing from or exceeding the spirit of the invention.

Referring to the drawings in which like reference numerals indicate like or similar parts:

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

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Figure 2 is a side elevation of the machine shown in Figure 1 as viewed from the left end of that figure.

Figure 3 is a section on the line 3—3 of Figure 1 showing the manual table control mechanism.

Figure 4 is a horizontal section on the line 4—4 of Figure 1 showing the grinding wheel carrier elevating mechanism.

Figure 5 is a section on the line 5—5 of Figure 4.

Figure 6 is a section on the line 6—6 of Figure 1 showing the table trip drive mechanism.

Figure 7 is a detail section on the line 7—7 of Figure 1 showing one of the tripping stops for the table.

Figure 8 is a section on the line 8—8 of Figure 1 showing details of part of the saddle cross feed mechanism.

Figure 9 is a section on the line 9—9 of Figure 6.

Figure 10 is a section on the line 10—10 of Figure 9.

Figure 11 is an elevational section on the line 11—11 of Figure 4.

Figure 12 is a diagram of the hydraulic control circuit for the saddle.

Figure 13 is a diagram of the hydraulic control circuit for the table.

Figure 14 is a section on the line 14—14 of Figure 1.

Figure 15 is a section on the line 15—15 of Figure 14.

Figure 16 is a section on the line 16—16 of Figure 14.

Figure 17 is a plan view of the dial mechanism shown in Figure 14.

Figure 18 is a modified form of the hydraulic pickfeed circuit.

Figure 19 is a modified form of the table hydraulic circuit.

Referring to the drawings and more particularly to Figures 1 and 2, the reference numeral 10 indicates the main bed of the machine upon the top of which is mounted a saddle 11 which is suitably guided on ways 12 and 13 for cross movement toward and from the operator. A table 14 is slidably mounted on top of the saddle 11 on guideways 15 and 16 shown in Figure 6.

The bed 10 has an extension 17 at the rear, as shown in Figure 2, on which suitably formed guideways 18 are formed for receiving a vertically movable guiding wheel carrier 19 in which is suitably journaled a spindle 20 for supporting and power rotating a grinding wheel 21.

The table 14 is power reciprocated by means of a cylinder 22 which is mounted in the saddle 11, as shown in Figure 6, and containing pistons 23 and 24, shown in Figure 13, attached to the ends of piston rods 25 and 26 respectively, the other ends of which are attached to the opposite ends of the table 14 by brackets 27 as shown in Figure 1.

The manual control mechanism for the table 14 is more particularly shown in Figure 3, and includes a rack 28 attached to the underside of the table 14 and a pinion gear 29 supported in mesh therewith and with a gear 30 supported on the end of a shaft 31 journaled in the saddle 11. The shaft 31 is connected by reduction gearing, indicated generally by the reference numeral 32 in Figure 3, to a stub shaft 33 to which is fixed a hand wheel 34.

In order to prevent interference between the power drive mechanism and the manual control mechanism, and for safety purposes, the pinion gear 29 is mounted on a piston sleeve 35 which is slidable on a fixed guide rod 36 in a bore 38, one end of the bore being closed by the head 37 on the end of rod 36. Since the piston 35 is slidably mounted in the bore 38, admission of pressure to the chamber 39 will move the sleeve to the left, as viewed in Figure 3, to disengage the pinion 29 from the rack 28. A spring 40 is interposed between the end of the sleeve 35 and a collar 41 fixed to the end of the rod 36 to automatically effect reengagement of the pinion 29 with the

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rack upon release of pressure in the chamber 39. As will be described in connection with the hydraulic circuit, the chamber 39 is connected to the table piston control circuit in such manner that, upon coupling of pressure to the table cylinder, the manual control mechanism will be rendered inoperative. It will now be seen that the table may be either manually of power reciprocated relative to the grinding wheel 21 and that an interlock is provided to prevent simultaneous operation of both.

An automatic trip mechanism which controls the length of table movement and effects reversal of the table at each end of its stroke is more particularly shown in Figures 6 and 9. There is a trip shaft 42, Figure 6, which is operatively connected at one end by a crank arm 43 to the plunger 44 of a pilot valve 45, which controls reversing of the table. At the other end, the shaft 42 is splined at 46 to a crank arm 47 which has a bearing portion 48 rotatably mounted in a bore 49 formed in the enclosing bracket 50. Crank arm 47, as shown in Figures 6 and 10, carries a lever arm 51 pivotally connected thereto by a pin 52 whereby the arm 51 is free to rotate about the pin. The arm 51 has equal and opposite extensions 53 and 54 which, with the aid of a flat spring 55, are held in contact with the periphery of cam members 56 and 57. The cam member 56 has a shoulder 58 formed thereon, and the cam member 57 has a shoulder 59, and the method of operation is that when the cam member 56 is rotated clockwise, as viewed in Figure 10, the shoulder 58 will engage the end of the arm 53 and push it axially and thereby rotate the crank arm 47 and shaft 42. Similarly, if the cam 57 is rotated counterclockwise, the shoulder 59 will engage the end of the extension 54 and rotate the crank 47 in a counterclockwise direction. It is obvious that rotation of the shaft 42 in one direction will shift the pilot valve plunger 44 through crank 43 to one extreme position to effect one direction of movement of the table; while rotation of the shaft 42 in the other direction will shift the pilot valve plunger 44 to its other extreme position and thereby cause movement of the table in the opposite direction.

It will now be seen that it is necessary to rotate the cams 56 and 57 in synchronism with the table movement, and this is accomplished by providing a gear 60 in mesh with the table rack 28 as shown in Figure 6, and integrally connected with a sleeve 61 rotatably mounted in a bore 62 formed in the saddle 11, said sleeve also forming a bearing support for the shaft 42. The sleeve 61 has a pinion 63 formed on its other end which simultaneously meshes with gears 64 and 65 as shown in Figure 9. The gears 64 and 65 are mounted for free rotation on the end of similar bearing sleeves 66 which are supported on bearing surfaces 67 and 68 in the supporting plate 50. The cam member 56 is formed integrally on the end of sleeve 66, and the sleeve 66 is splined at 69 to a central shaft 70 which passes through the bore of the sleeve. At one end, the shaft 70 has a clutch member 71 pinned thereto at 72, and, at the other end, is provided with a manually rotatable knob 73. A spring 74 is interposed between the knob and a counterbore shoulder 75 formed interiorly of the sleeve.

The clutch member 71 has fine radially extending clutch teeth 76 formed on one face adopted to engage similarly formed teeth 77 formed around the face of the gear 64.

It will now be seen that when the pinion 63 rotates the gear 64 that the transmission of motion will be through the interengaging clutch teeth 77, 76 to the clutch member 71 and its supporting shaft 70. Since the shaft 70 is splined in the sleeve 66, this will produce rotation of the sleeve and of the cam member 56.

For set-up purposes, it is, of course, necessary to change the distance of the cam shoulder 58 circumferentially with respect to the member 53 without moving the table. This is accomplished by pushing on the knob 73 to disengage the clutch teeth 76, and simultaneously rotating the cam

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56 relative to the gear 64 which at this time will be held against rotation by intermeshing with the pinion 63.

The mechanism for adjusting the cam 57 is exactly the same as the one described and is effected by the knob 78, so that further repetition is not believed to be necessary. It will be obvious that the pinion 63 will rotate the gears 64 and 65 in the same direction, and therefore when the cam shoulder 58 is approaching the member 53, the cam shoulder 59 is retracting from the member 54, and vice versa. It will be noted that all this mechanism is enclosed within the housing 79 formed in the saddle and therefore is protected from any coolant material and the dirt and grit resulting from grinding operations. It will also be noted that this makes it possible to make the front of the table smooth in the sense that there are no projecting dogs to constitute a hazard for the operator, and since the table reciprocates at a pretty fast rate, this makes a very improved and safe construction.

The pilot valve 44 is also shiftable manually at will and to this end the member 47, shown in Figure 6, is provided with a manual control lever 80 which will directly cause rotation of the shaft 42. This manual rotation, however, is only possible when neither one of the cam shoulders 58 and 59 is in engagement with the member 51 because when the handle 80 is rotated, the crank arm 47 is also rotated. Therefore, in the situations where either one of the cam shoulders interferes with the manual operation, the lever 80 may be utilized to push the crank arm 47 and attached lever 51 relative to shaft 42 out of engagement with either cam shoulder against the resistance of spring 81 to position shown in Figure 6.

This shifts the arms 53 and 54 laterally out of the plane of the cam shoulders 58 and 59. The crank arm 43 may then be rotated at will in either direction to shift the pilot valve. This arrangement is advantageous when it is desired to have the table move beyond the range at which the cams have been set to yield a desired work stroke.

The table control circuit has been provided with a manually operable stop valve, which will be explained in connection with the hydraulic circuit and which is utilized to start and stop the table at will. Supposing that the table is moving in a direction to cause the cam shoulder 58 to approach the end of the lever 51, continued movement would cause the shoulder to trip the lever. But if it is desired that the movement continue in the same direction, beyond the setting of the cam, the lever 51 is shifted laterally by means of the lever 80 to clear the cam, whereby the lever 53 would be moved out of the plane of the shoulder into the dotted line position shown in Figure 7. The shoulder would then move past the end of the lever and continue in the same direction until the table is stopped by the stop valve. However, when the table is finally reversed and comes back, the lever 51 will automatically drop into position between the cam shoulders. This makes it possible to obtain extra movement in either direction without changing the settings already made for a given working stroke.

Attention is invited to the fact that the gears 64 and 65 carry limiting pins 64' and 65', Figure 10, as a safety measure so that when the table reaches the absolute limit of its stroke, the pin will automatically shift the lever 51 even although it is held in a displaced position, as shown in Figure 7, by lever 80. This prevents running a wreck.

Although the pilot valve has a self-contained hydraulic load and fire mechanism including means to limit its movement, means have also been provided for limiting movement of the manual control lever 80.

It will be noted that the connecting means between the lever 43 and valve plunger 44 includes a pin 43' on the lever 43 which projects into a slot 44' in the plunger. The slot is made much wider than the pin to provide lost motion, and when the pin contacts an end of the slot to move the plunger, all the lost motion is on the other side or behind the pin. This is necessary to permit the valve

to fire without interference from the pin. Since momentum causes the table to continue in the same direction after firing of the valve, the cams 56 and 57 will continue to rotate and move the lever 43 in the same direction that the valve fired until the momentum is overcome and actual reversal begins. As soon as reversal starts, rotary movement of the shaft 42 and its attached levers 43 and 80 stop and remain in whatever position they are, because the cams have also reversed their direction of rotation. No positive stops have been provided for limiting movement of the shaft and lever 80 during automatic operation, but positive stops have been provided for limiting movement under manual operation by lever 80. These stops comprise two adjustable set screws, 47a and 47b, one of which is shown in Figure 6. They are threaded in the bottom of the saddle and locked by set screw 47c. These stops are spaced on opposite sides of the shaft axis and engage abutments formed in the underside of the lever 47 as shown in plan view in Figure 9. These stops are adjusted to provide a slight clearance under automatic operating conditions so as not to cause any jamming but are effective under manual operating conditions.

During reciprocations of the table back and forth relative to the grinding wheel, it is customary to provide incremental or pick feed movements between the work and the grinding wheel transversely of the table in order to scan the entire surface of the work. Thus, a pick feed control mechanism has been provided as part of the saddle actuating control mechanism shown in Figures 4 and 8 of the drawings. As shown in Figure 3, the saddle 11 has a depending bracket or housing 81 which carries a nut 82 in threaded engagement with a feed screw 83. The feed screw 83, Figure 4, has an elongated splined portion 84 which passes through the elongated sleeve 85, to the end of which is integrally formed a drive gear 86. The sleeve 85 is part of the hub of gear 86 and is journaled in antifriction bearings 87 and 88 mounted in the bore 89 of the frame 90 which is part of the bed 10 of the machine. By means of this arrangement the gear 86 is held against axial movement, and the screw 83 is capable of axial or sliding movement relative to the gear 86.

Beyond the splined portion, the screw 83 is provided with a piston rod 91 to the end of which is attached a piston 92, the attaching means constituting anti-friction thrust bearings 93 and 94 at opposite ends of the piston which allows the piston rod 91 to rotate relative to the piston. The piston slides in a cylinder 95 formed integral with the bed, enclosed at one end by the cylinder cap 96 and at the other end by a stuffing box 97. Normally pressure is maintained in the cylinder 95 in a direction to maintain the end 97' of the piston against a self-aligning abutment 98 mounted in the cap 96. The piston 92 is only utilized for truing purposes in which case the screw 83 is reciprocated axially a limited or fixed stroke great enough to encompass the widest grinding wheel that is used on the machine.

For all other purposes the saddle is reciprocated through rotation of the actuating gear 86, which thereby effects relative rotation between the screw 83 and nut 82, and this movement may be effected by manually operable means, or continuously by power, or in pick feed increments by power.

To this end the gear 86 meshes with a gear 99 of a gear pair 100, the other gear 101 of which meshes with a gear 102.

The gear 102, as shown in Figure 8, is supported for rotation on a stub shaft 103 which is journaled in the bed. The gear 102, which is an idler gear, meshes with a pinion 104 formed integral with a bevel gear 105, and this gear combination is secured by a set screw 106 to a tubular shaft 107. The shaft 107 is suitably supported by anti-friction bearings 108 and 109 in the bed structure of the machine and held against axial movement relative thereto. The shaft 107 extends to the front of the machine where it is provided with a hand wheel 110 for

manual rotation of the pinion 104, while the bevel gear 105 meshes with a small bevel gear 111 shown in Figure 12 for receiving power rotation therefrom.

The forward end of the shaft 107 has a reduced bearing portion 112, Figure 8, upon which the hand wheel 110 is slidably mounted. An enlarged locking screw 113 and sleeve 114 prevent the hand wheel from sliding off of the end of the shaft, and limit the outward movement of the hand wheel. The hub 115 of the hand wheel 110 has clutch teeth 116 formed on the inner face thereof for interengagement with clutch teeth 117 formed on the end of a sleeve 118 which is secured to the shaft 107 for rotation therewith by a cross pin 119. Thus, upon inward movement of the hand wheel, the clutch teeth may be engaged whereby upon rotation of the hand wheel, the shaft 107 and attached pinion gear 104 may be rotated to effect adjustment of the saddle by rotation of the screw 83.

Surrounding the hub of the hand wheel is an indicator dial 120 which is journaled at 121 on the periphery of the sleeve 118. Spring pressed plungers 122 mounted within the dial 120 and engaging a fixed abutment washer 123 secured to the sleeve 118 continuously urge the dial in a direction to maintain engagement of clutch teeth 124 formed on the inner end of the dial hub with clutch teeth 125 formed on a flange 126 which is integral with the sleeve 118. The clutch teeth 124 and 125 are very fine and the operator, by grasping the knurled periphery 127 of the dial 120, Figure 2, may pull it towards him to effect disengagement of the clutch teeth and then rotate it to align graduations on the peripheral surface 128 with a fixed reference mark formed on the frame of the machine and then release the dial.

To effect automatic disengagement of the hand wheel 110 when power is applied to the driving gear 111, a hydraulic interlocking mechanism is provided in the housing 129, shown in Figure 8, having a cylindrical extension 130 which is inserted in a bore 131 formed in the frame of the machine in axial alignment with the shaft 107 supported in the bore 131 and secured therein by suitable set screw means 132. The portion 130 has an axially slidable pin 133 in alignment with an axially slidable pin 134 mounted in the bore of shaft 107 and abutting the side of a cross pin 135 mounted in a cross slot 136 formed in the shaft 107 and supported at opposite ends in a sleeve 137. The sleeve 137 is mounted in a counterbore 138 formed in the end of the hub 115 of the hand wheel 110 whereby upon outward pressure on the pin 134 the hand wheel 110 will be moved in a direction to disengage the clutch teeth 116 and 117.

This automatic disconnection of the clutch is effected by an elongated piston 139 mounted in a bore 140 formed in the housing 129 and closed at opposite ends by threaded plugs 141. The piston 139 has reduced ends 142 forming shoulders 143 at opposite ends thereof, and centralizing springs 144 are mounted in the bore 140 between the shoulders 143 and the threaded plugs whereby normally the plunger 139 is centralized longitudinally of the bore 140. This positions a depression 145 formed in the side of member 139 opposite to the pin 133. When this condition prevails, the operator may push the hand wheel 110 and thereby engage the clutch teeth without opposition from the member 139.

Hydraulic power operable means 150 are provided for effecting power rotation of the bevel gear 111 in either direction, and so separate power lines are provided which may be selectively energized to produce the opposite directions of rotation. These power lines are also operatively connected to ports 146 and 147 formed in the housing 129 so that regardless of which line is energized the piston 139 will be automatically shifted off center against the resistance of a spring 144, thereby moving the depression 145 out of alignment with the pin 133 and cause either the bevel or cam surface 148 or 149 to engage the pin 133 and shift the hand wheel free of its clutch where-

by the hand wheel 110 will not be rotated during power actuation of the saddle. A hydraulic resistance 146' is connected across these ports so that when the motor 150 is held stopped with both lines under pressure, cross leakage can occur to equalize pressures on opposite ends of piston 139, and permit centralization by springs 144.

Power operation of the bevel gear 111, shown in Figure 8, is effected by a hydraulic motor 150, shown in Figures 1 and 12 of the drawings. As shown in Figure 12, the bevel gear 111 is secured to the end of a hollow stub shaft 151 which is supported for rotation on anti-friction bearings 152 in a sleeve 153 suitably mounted in the frame of the machine. The shaft 151 has a splined bore connection 154 with the end of the motor drive shaft 155. The motor 150 is, of course, suitably attached to the frame of the machine in axial alignment with the shaft 151. It will now be obvious that the saddle may be selectively operated by power, or by hand; and that suitable interlocking mechanism has been provided for automatically disconnecting the manual control whenever the hydraulic control is utilized.

Adjustment of the grinding wheel 21 relatively toward and from the work table 14 is effected by the mechanism shown in Figures 4, 5, and 11.

As previously mentioned, in connection with Figure 2, the grinding wheel 21 is carried by a vertically movable slide 19 which is slidably mounted in guideways 18 formed on the rear extension 17 of the bed and a part of this guideway is shown in Figure 4 of the drawings.

In the vertical view shown in Figure 11, the vertical slide 19 carries a nut member 156 secured thereto by means of a plug 157 to which the nut member is secured by bolts 158, and the plug is mounted in a sleeve 159 carrying a set screw 160 for securing the plug in the sleeve. The sleeve has a flange 161 which is bolted to the wall 162 of the carrier 19 by suitable screws 163.

An elevating screw 164 is journaled at the lower end by an anti-friction bearing 165 in the bed extension 17, and at the other end by roller thrust bearings 166 secured in a sleeve 167 which is attached to the top of the extension 17 by suitable screws 168. The screw 164 has a worm gear 169 keyed thereto and meshing with a worm 170 as shown in Figure 4. Thus, by rotation of the worm 170, the screw 164 may be rotated relative to the nut 156 to effect vertical adjustment of the carrier and thereby of the grinding wheel toward and from the work table.

The worm 170 is attached to one end of a horizontal shaft 171 which is journaled at one end by an anti-friction bearing 172 mounted in the bed, and, at the other end, by an anti-friction bearing 173 mounted in the front bracket of the machine. The shaft 171 has collars 174 and 175 attached thereto to form a groove 176 in which is mounted a fork 177 attached by screws 178 to a fixed part of the bed 179 so as to hold the shaft 171 against axial movement. The end of the shaft 171 has a gear 180 suitably connected thereto in mesh with a gear 181 slidably mounted on a shaft 182 which is suitably journaled in the front bracket of the machine for rotation but held against axial movement. The gear 181 is integral with a second gear 183 which meshes with a pinion 184 pinned at 185 to a manually rotatable shaft 186. The shaft 186 extends to the front of the machine where it is provided with a hand wheel 187. By suitably connecting the hand wheel 187 to the shaft 186, it will now be obvious that rotation of the hand wheel will effect manual adjustment of the grinding wheel toward and from the work.

It is also desired, however, that the elevating screw 164 be power operable at a fast rate, and when this is done, the hand wheel 187 is disconnected for reasons of safety.

The power rotation is effected by a prime mover in the form of an electric motor 188 which is mounted within the bed 10, as shown in Figure 4, and operatively connected through flexible motion transmitting means, indicated generally by the reference numeral 189, and, in the present instance, consisting of a sprocket or tooth wheel

190 attached to the shaft 171 and a similar member 191 connected to the motor shaft 192. The flexible motion transmitting member may be a sprocket chain or equivalent toothed belt member.

The shaft 186 that carries the gear 184 is journaled in a fixed sleeve 193, Figure 5, which has a flange 194 by which the sleeve is bolted to the front bracket of the machine by suitable bolts 195. A second sleeve 196 is telescopically mounted on the sleeve 193 for sliding movement and carries a spring pressed detent 197 selectively engageable with detents 198 and 199 formed in the periphery of the sleeve 193. The sleeve 196, shown in Figure 4, has a shifter fork 200 integrally formed therewith which engages a shifter disc 201 formed integral with the gears 183 and 181 whereby movement of the sleeve by a roller on an eccentric pin 202 attached to the end of a manually rotatable shaft 203 and carrying an operating handle 204, will disengage the gear 181 from the gear 180 while still maintaining the wide faced gear 183 in engagement with the gear 184. The lever 204 is really the power operable control lever and therefore when this lever is thrown either way from a central position to a power position it automatically disconnects the gears 180 and 181 so that the prime mover 188 will not rotate the hand wheel 187.

When the lever 204 is thrown to a power position, it not only disconnects the gears 180 and 181 to prevent power rotation of the hand wheel, but it also shifts the hand wheel to an outer position or towards the operator. This is accomplished by means of a shifting pin 205, Figure 5, which is slidably mounted in the flange 194 and has a reduced end 206 which fits in a bore 207 in the flange 208 of the sleeve 196, and also a shoulder 209 whereby when the sleeve is shifted, the enlarged head 210 on the other end of the pin 205 will push the hand wheel 187 forward. The object of this is that the eccentric pins 202 on the shaft 203 can only move the shifter sleeve 196 in one direction by abutment therewith but are ineffective to move the sleeve 196 back to its original position. Therefore rotation of the lever 204 back to its central position to disconnect the power is ineffective to effect reengagement of the gears 180 and 181. However, by moving the hand wheel out, the operator has a means for rotating the shaft 186 and thereby the gear 181 relative to the gear 180, to align the respective teeth thereof for engagement and then by pushing the hand wheel in, the gears may be reengaged.

The hand wheel 187 is splined at 210' on the end of the shaft 186, and the shaft has a headed bolt 211 threaded in its outer end to prevent the hand wheel from coming off of the shaft. The hand wheel 187 also has a reduced diameter 212 upon which is mounted a flanged member 213 adapted to carry graduations 214, as shown in Figure 4, on its periphery and is secured to the hand wheel by a suitable set screw 215. As shown in Figure 5, the shaft 203, which is operated by the lever 204, has a double-ended lever 216 secured thereto, on the outer ends of which are mounted the eccentric pins 202 carrying rollers 217 which engage the flange 208 of the sleeve 196 whereby regardless of which direction of rotation is imparted to the shaft 203, the sleeve 196 will be moved in the same direction to effect disengagement of the gears 180 and 181 and to move the hand wheel 187 outward.

The double-ended lever 216 also has an outwardly extending boss 218 which carries a pin 219 fitting in the fork 220 of a bell crank lever 221. The other arm 222 of the lever 221 is mounted between limit switches 223 and 224 which are electrically connected for controlling the direction of rotation of the motor 188.

It will now be seen that the lever 204 has a normal central position in which it is normally held by spring pressed plungers 225 and 226 mounted in the flange 194 and bearing on opposite ends of the lever 216 to normally hold it in a central position. Thus, when the lever 204 is moved to one side or the other of its central position, it will cause selective actuation of either switch 223 or 224,

to cause rotation of the motor in a selected direction, and when the lever is released it will snap back to a central position. This central position provides sufficient clearance between the flange 208 and the rollers 217 whereby the operator may shift the hand wheel to effect reengagement of the gears and with the assurance that the power is disconnected from the motor 188. It is to be noted that the prime mover which drives the grinding wheel 21 is carried by the slide 19 and therefore is movable therewith, thus eliminating complicated driving connections.

The hydraulic transmission and control mechanism for the saddle and table is shown in Figures 12 and 13 of the drawings. In Figure 13, the table pilot valve 45, previously referred to in connection with Figure 6, is operatively connected for power shifting of the table direction control valve 227 which reverses the direction of table movement. The valve 227 has a pressure port 228, and motor ports 229 and 230 which are connected by channels 231 and 232 respectively to table cylinder ports 233 and 234 located at opposite ends of the cylinder 22. The valve also has a pair of exhaust ports 235 and 236 which are alternatively connectible by grooves 237 and 238 in the shiftable valve plunger 239 to motor ports 230 and 229 respectively. The valve plunger 239 also has an annular groove 240 which serves to alternately connect the pressure port 228 to the motor ports 230 and 229. It will now be evident that by shifting the reversing valve plunger 239 to one end of the valve housing the table will be moved in one direction, and when the plunger is shifted to the other end of the valve housing, the table will move in the opposite direction.

The plunger 239 is shifted hydraulically under control of the pilot valve 45, and to this end the valve 227 is provided with terminal ports 241 and 242 which are connected by channels 243 and 244 to ports 245 and 246 of the pilot valve 45. The pilot valve 45 has a pressure port 247 which is alternatively connectible by grooves 248 and 249 to ports 245 and 246. It will be noted that the piston 250 on the valve plunger 44 is larger in diameter than the pistons 251 and 252 on opposite sides thereof whereby when the piston 250 passes across the port 247 sufficient to connect the pressure to the other side of the piston, the valve becomes self-actuating due to the differential areas of the pistons, and thus produces the same effect as a mechanical load and fire mechanism to complete the shifting of the valve. The pilot valve also has a pair of exhaust ports 253 and 254 which are connected to a common reservoir line 255 whereby when one of the ports 245 or 246 is connected to pressure the other is connected to exhaust to effect shifting of the reversing valve plunger 239.

The rate of movement of the table, and the stopping of the table is controlled by operating on the return flow from the table cylinder. There is thus provided a stop valve 256 and a table rate valve 257. The exhaust ports 235 and 236 of the table reverse valve are connected to ports 258 and 259 of the pilot valve 45 and are spaced upon opposite sides of a common return port 260. The pilot valve plunger 44 has an annular groove 261 for alternately connecting the ports 258 and 259 to the port 260 upon shifting thereof. It will be noted, however, that as the plunger 44 passes through the middle of its stroke that the ports 258 and 259 are momentarily isolated from the port 260, thereby momentarily blocking all return flow from the table cylinder which tends to cushion the reversal thereof.

During normal movement of the table in either direction the return flow passes through the port 260 of the pilot valve and channel 262 to port 263 of the stop valve 256. When the plunger 264 of this valve is in the running position, as shown in the drawings, the port 263 is connected by annular groove 265 to port 266 which, in turn, is connected by channel 267 to port 268 in the rate valve 257. The rate valve has a rotatable and adjustable throttle 269 which adjusts the rate of flow from the port

268 to an exhaust port 270. The rotatable position of the rate valve is determined by a knob 271 which is operatively connected to the member 257 and is provided with a graduated dial 272 to indicate the setting of the throttle and thereby the rate of movement of the table.

When it is desired to stop the table, the plunger 264 of the stop valve is shifted to the right whereby the port 263 is isolated, thereby blocking return flow from the table cylinder, and a second annular groove 273 in the stop valve plunger interconnects a pair of ports 274 and 275 which are respectively connected to channels 232 and 231 leading to the table cylinder whereby the opposite ends of the table cylinder are interconnected. This makes it possible to effect manual adjustment of the table mechanically without interference from the hydraulic pressure in opposite ends of the table cylinder.

As previously described in connection with Figure 3, the manual table feeding mechanism has a shiftable gear 29 which is normally maintained in mesh with the rack 28 by spring 40 but upon hydraulic operation of the table, the gear 29 is disengaged by the admission of hydraulic pressure to the chamber 39. In Figure 13 it will be seen that the chamber 39 is connected by a channel 276 to port 277 of the stop valve 256. The stop valve has a pressure port 278 and an annular groove 279 whereby the port 277 is connected to pressure when the valve plunger 264 is in a running position and thereby pressure is connected to the chamber 39 to move the piston sleeve 35 and shift gear 29 out of engagement with the table rack. When the plunger 264 is shifted to its stop position, the port 277 is disconnected from the pressure port 278 and, in turn, connected to an exhaust port 280 by the groove 279 whereby the fluid may be exhausted from the chamber 39 and the spring 40 is enabled to shift the pinion 29 into engagement with the table rack.

The stop valve plunger is shifted by a pin 264a engaging a cross slot 264b in the plunger, the pin being mounted eccentrically in the end of a stub shaft 264c rotatably mounted in the front of the machine to which is attached the operating lever 264d.

It will now be seen that when the stop valve is shifted to its stop position that the exhaust flow from the table cylinders is blocked, thereby preventing loss of fluid from the table cylinder which might permit the admission of air to the table cylinder which is undesirable; and interconnects opposite ends of the table cylinder whereby upon manual operation the fluid in one end of the cylinder may be forced around through the stop valve into the other end of the cylinder; the gear 29 is automatically engaged to effect interconnection of the manual hand wheel 34 to the table rack; and the return flow to the rate valve is disconnected.

In addition to the above effects produced by the stop valve, it is also effective when the table is stopped to render a grinding wheel truing mechanism operative if so desired for truing the grinding wheel. This is accomplished by attaching a truing diamond in any suitable manner to the work table and then reciprocating the saddle back and forth through a short stroke, greater than the width of the grinding wheel. To this end a power truing reversing valve 281 is provided which has a manually shiftable plunger 282 operable by a knob 283 projecting from the front of the machine. The end of this valve is provided with a port 284 which is connected by a branch channel 285 to line 276 which controls the shifting of the gear 29. When the line 285 is under pressure because of the stop valve being in a running position, it is impossible to operate manually the plunger 282 and thus it is held in the position shown. When the line 285 is connected to exhaust by the stop valve being shifted to its stop position, the pressure in chamber 286 of valve 281 is relieved whereby the plunger 282 may be shifted against the resistance of a spring 287.

The reverse valve 281 is provided with a pressure port 288 and motor ports 289 and 290 which are connected

by channels 291 and 292 to opposite ends of the cylinder 95 which was described in connection with Figure 4 and which contains a piston 92 connected to the end of the saddle lead screw 91. By alternately shifting the plunger 282 manually, the operator may alternatively admit pressure to ports 293 and 294 in opposite ends of the cylinder 95 and thereby effect reciprocation of the saddle and movement of a diamond across the face of the grinding wheel. It will be noted that normally the pressure port 288 of the reversing valve is connected to the port 293 to hold the piston 92 against the thrust bearing 98 and that the port 290 is connected to exhaust port 295 of the reversing valve. When the reversing valve is shifted to its other position, the port 289 is connected to a second exhaust port 296 and the pressure port 288 is connected to the port 290.

The rate of movement of the truing piston 92 is controlled by a rate valve 297, one end of which has a port 298 that is connected by a channel 299 to both of the ports 295 and 296 of valve 281. This rate valve is of similar construction to the previously described rate valve and has a rotatable throttle member 300 which controls the flow from port 298 to an exhaust port 301. The member 300 is rotatably adjusted by a control knob 302 mounted on the front of the machine as shown in Figure 1, which has a graduated dial 303 to indicate the rate setting thereof.

It will now be seen that the stop valve when in a stop position renders a power truing mechanism available for use if so desired at any time that the table is stopped.

As previously mentioned in connection with the table pilot valve plunger 44, the groove 261 is of such a width that it momentarily isolates the ports 258 and 259 from the port 260 to cushion the table reversal, and the effect of this is that the momentum of the table at the moment of cut-off of the valve will tend to compress the trapped fluid in the end of the table cylinder being exhausted, and if the table is reciprocating at a high rate, this sudden rise in pressure may become excessive. In order to limit this, the exhaust ports 235 and 236 are connected to a common channel 304, one of them through bypass 304', which leads to a port 305 in the end of a table relief valve indicated generally by the reference numeral 306 and also to a dynamic resistor 307. The relief valve has a plunger 308 which is normally maintained in a closed position by a spring 309 to close exhaust port 310. When the high pressure enters the port 305, it flows into chamber 311 and acts on the end of the plunger 308 to shift it to the left against the resistance of spring 309 and thereby open the exhaust port 310.

However, since the sudden high pressure would cause pounding of the valve, the dynamic resistor 307 has been provided and connected in parallel with the valve to soften the sudden impact upon the relief valve plunger. The dynamic resistor is composed of a plurality of discs 312 which have a flat side 313 and a concave side 314, and the center of the disc is provided with a small bore 315. A series of these discs is stacked in the bore 316 whereby some of the fluid may by-pass through these to the reservoir line 317 which is also connected to the outlet port 310 of the relief valve 306. The bore 316 has a sleeve 318 in the end in which a series of radial holes 319 are drilled for escape of the fluid into the larger passage 317. It will thus be seen that when the sudden pressure surge passes through the line 304 some of it is dissipated through the dynamic resistor so that the relief valve 306 may be made smaller and the spring 309 does not have to be made so heavy to prevent pounding of the valve.

A modified form of circuit is shown in Figure 19 for dissipating pressure surges in the system caused by reversal of the table. In this modification, the two table cylinder lines 232 and 231, besides being connected to ports 229 and 230 of the reverse valve 227, as in the prior construction, are also directly connected through

individual check valves 231' and 232' to the common line 304 leading to the relief valve 306. The two motor lines are also connected to individual ports 258 and 259 of the pilot valve for alternate coupling to the line 262 leading to the stop and rate valves as before.

For purposes of explaining the operation, it should also be added that a one way check valve 402' has been inserted in the supply line 402 leading to reverse valve 227. It will be noted that the ports 235 and 236 of the reverse valve 227 shown in Figure 13 are not utilized in this modified form of circuit, with the result that the reverse valve only serves to alternately connect the pressure supply to the motor lines 231 and 232 whereby one line or the other is always under pressure.

The parallel connections of these motor lines to the pilot valve makes it possible for the pilot valve to serve as the means to directly connect the motor lines to exhaust by way of the stop and rate valves. It will now be seen that the reverse valve controls the pressure connection to the table cylinder while the pilot valve controls the exhaust connection from the table cylinder. This makes it possible to change the timing of these connections because the pilot valve moves first to effect power shifting of the reverse valve, whereby it can stop the return flow from the table cylinder before the pressure flow thereto has been stopped.

At this instantaneous second, there will be a pressure surge in the motor line serving as the exhaust line, and thus surge will blow off through one of the check valves into the relief valve 306, and since this pressure will create a momentary higher pressure than in the supply motor line, the other check valve will be held closed. For instance, if the surge passes through check valve 231', the valve 232' will be closed by the higher pressure in line 304 even although the pump pressure is now connected to line 232. Thus, there will be created a secondary pressure surge in line 232, back through the supply line 402 as a reaction to the back pressure rise, and to prevent this surge from going too far in the system, a second check valve 402' has been inserted in the supply line 402 leading to the reverse valve.

As the pilot valve continues its movement through its center position, it causes hydraulic shifting of the reverse valve, whereby the pressure supply 402 will be connected to line 231 and line 232 will be connected to exhaust.

It will be noted that the dynamic resistance valve 307 is inserted in line 243 in Figure 19 to slow down the shifting movement of the reverse valve plunger to allow a little time for the pressure surges to quiet down.

The pick feed hydraulic motor 150, Figure 12, which is utilized to effect power cross movement of the saddle, is connected by channels 320 and 321 to a reversing valve 322, the shifting of which is controlled by a pilot valve 323. The channels 320 and 321 are connected to motor ports 324 and 325 of the valve 322 which has a pressure port 326 between the motor ports and also has exhaust 327 and 328 on either side of the motor ports whereby, when the groove 329 of the valve plunger 330 interconnects the port 324 with exhaust port 327, the pressure port 326 is connected to the motor port 325. Upon shifting of the valve plunger 330 to the right, as viewed in Figure 12, these connections are reversed. To effect power shifting of the plunger 330, the valve 322 is provided with ports 331 and 332 at opposite ends which are connected by channels 333 and 334 to ports 335 and 336 respectively of pilot valve 323. The pilot valve 323 has a pressure port 337 which is alternatively connectible by grooves 338 and 339 respectively to ports 335 and 336 to effect admission of fluid pressure to shift the reversing valve. The valve 323 also has exhaust ports 340 and 341 for exhausting fluid from one side of the reverse valve when the other side is connected to pressure. It will be noted that the center spool 342 on the pilot valve plunger 343 is slightly larger in di-

ameter than the end spools 344 and 345, whereby after the spool 342 passes across center of the pressure port 337, the valve is self-actuated to complete its stroke.

The pilot valve plunger 343 is connected by a centrally pivoted lever 346 to a longitudinal link 347 which is pivotally connected by a pin 348 to a crank arm 349 of a manual control lever 350; and at the other end by a pin 351 to a crank arm 352 of a trip control lever 353 pivoted on the side of the bed adjacent the saddle. The trip lever 353 has oppositely extending trip arms 354 and 355 which are offset to be separately engaged by dogs 356 and 357 carried by the saddle.

Since the plunger 343 is shifted by hydraulic pressure after it passes the center position, it is necessary to provide means for limiting its movement in each direction. To this end the valve housing 323 is provided with a chamber 358 in which is mounted two washers 359 and 360, the washers being held apart and in engagement with abutments by spring 361. The plunger 343 is provided with spaced shoulders 362 and 363 so that when the valve is shifted to the left, the shoulder 363 will abut the washer 360 and thereby limit the movement in that direction; and when the plunger is shifted to the right, the shoulder 362 will abut the washer 359 and limit the movement in the opposite direction.

It is sometimes desirable to effect a continuous and rapid movement of the motor 150 under manual control, in which case the lever 350 has been provided, and this lever may be utilized to move the plunger 343 a greater distance to connect the channel 364, which always represents the exhaust line from the motor, directly to reservoir. In other words, the channel 364 is connected to ports 365 and 366 of valve 323, and when the plunger 343 is shifted to the left, the port 366 is connected to the exhaust port 340; or when the lever is shifted to the right, the port 365 is connected to the exhaust port 341. When this extended movement is effected, the shoulder 363 moves the washer 360 against the resistance of spring 361, whereby when the lever is released, the plunger 343 will return automatically to the position it was in before it was actuated. Similarly, if the plunger 343 is to the right with the shoulder 362 against the washer 359, further movement can be effected by moving the washer to the right against the resistance of spring 361 whereby when the lever is released the plunger 343 will assume its other position.

In the present arrangement of the valves as shown, it will be noted that the line 320 represents the exhaust line from the motor because the pressure port 326 is connected to line 321, and the exhaust fluid will therefore pass through port 327 to the line 364, and since ports 365 and 366 are blocked, no rotation of the motor will take place, even although pressure is connected to one side of it.

In order to effect incremental pickfeed of the saddle after each stroke of the table, the table pilot valve plunger 44, Figure 13, is provided with an extension 367 upon which are mounted control dogs 368 and 369 which are positioned to longitudinally engage limit switches 370 and 371 respectively. The closing of limit switch 370 energizes a solenoid 371', Figure 12, to shift the valve plunger 372 of a metering piston control valve 373 to the left, while the closing of limit switch 371 will energize solenoid 374 to shift the plunger 372 to the right.

The metering piston control valve 373 controls the movement of a metering piston 375 which is slidable in a metering cylinder 376. This cylinder has ports 377 and 378 at opposite ends which are connected by lines 379 and 380 to ports 381 and 382 respectively of the metering control valve 373.

Between these two ports is a port 383 which is connected to the channel 364. As previously mentioned, the channel 364 is always connected to the exhaust side of the motor, whichever one that may be, and the other side would then be connected to pressure by means of

the reversing valve 322, but as previously pointed out, the line 364 would be under pressure due to the fact that the ports 365 and 366 of the pilot valve 323 are blocked. Under these conditions, therefore, a predetermined pressure would exist at the port 383 of the metering piston control valve, and when this valve is shifted to the left, from the position shown in Figure 12, it will be obvious that this fluid pressure would flow through port 381, channel 379 and port 377 to the left end of the metering cylinder 376.

Since the other end of this cylinder would then be connected to exhaust through port 378, line 380, port 382, and exhaust port 384 the piston 375 would be free to move until it abutted the other end of the cylinder. This would block further return flow from the motor 150, and thereby stop the motor and further rotation of the saddle feed screw. When the piston 375 reaches the end of the cylinder the pressure in the line 364 would again build up.

It is, of course, desirable to have manual operation of the saddle screw available at all times in spite of the power operated pickfeed, but since it is obvious that there is pressure on opposite sides of the hydraulic motor 150 at all times this would prevent such manual adjustment. Therefore, a by-pass valve 385 has been provided which contains a valve plunger 386 that has a central groove 387 which when the plunger is shifted to the left will interconnect ports 388 and 389. These ports are connected by branch lines 390 and 391 to the two motor lines 320 and 321 respectively so that these lines may be interconnected, thus short circuiting the motor whereby manual operation of the saddle feed screw will cause mechanical rotation of the hydraulic motor, but the oil will simply be by-passed from one line to the other.

The valve plunger 386 is shifted into this position by the pressure in line 364 passing through branch line 392 and port 393 in the end of the valve 385 for operation on the end of the plunger 386 to shift it to the left against the resistance of a spring 394. Thus, whenever the pressure in the line 392 decreases beyond a certain point, such as when it is released to cause operation of the metering piston 375, the blocking valve will be shifted to the right to disconnect the lines 390 and 391 from each other. It is also to be noted that, when this automatic pickfeed is effected, it is desirable that the table be stopped, and to insure this, the line 364 has another branch connection 395 to a table delay valve 396 which has a port 397 at one end for admitting pressure to actuate its valve plunger 398. This valve plunger has an annular groove 399 which is held in a shifted position by the high pressure in line 364 to interconnect a pressure port 400 with port 401 that is connected by line 402 to the pressure port 228 of the table reversing valve. Therefore, when the pressure in line 364 drops, due to the pickfeed operation, the pressure in port 397 decreases, and a spring 403' shifts the valve plunger 398 to the right to disconnect pressure from the table reversing valve.

The length of the pick feed effected by the motor 150 is adjustable by means of the mechanism shown in Figures 14, 15, 16, and 17 which is connected to the control shaft 403 which extends to the cylinder 376 shown in Figures 2 and 12. The control shaft 403 has a threaded stop member 404 slidably mounted on a reduced end 405 of shaft 403 and held against relative rotation by a pin 406 slidable in keyway 407. The stop member 404 is threadably connected to the piston 375 for joint movement therewith. It will thus be seen that the shaft 403 is axially fixed, while the nut and piston move as a unit relative thereto inside of the cylinder. The piston 375 is held against rotation by a fixed pin 375' extending into elongated groove 376' formed in piston 375 but terminating short of each end thereof.

The stop member 404 acts to limit the length of movement of the piston in one direction, that is, to the right as viewed in Figure 12, by engaging the shoulder 408

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on shaft 403. The piston always returns to the same starting position in which it is shown in Figure 12. By alternately shifting the reverse valve 372, the opposite ends of the cylinder 376 are alternately connected to reservoir to permit rotation of the motor 150 in the same direction to effect intermittent indexing of the saddle, the reverse valve 322 having predetermined which direction the motor will rotate.

The adjustment of the stop nut 404 is effected by relatively rotating the nut inside the piston and thus moving the nut toward or from the stop shoulder 408.

As shown in Figure 14, the shaft 403 has a knurled knob 409 secured or pinned on the end of the shaft for imparting rotation to an eccentric 410 formed integral with the shaft. As shown in Figure 16, the eccentric fits in a central bore 411 formed in the member 412. A fixed pin 413 extending into the elongated radial slot 414 found in the member 412 prevents rotation of the member 412, but allows radial movement thereof whereby a tooth 415 may be moved into engagement with the internal gear 416. This gear is formed internally of an annular flange 417, Figure 14, projecting rearwardly from an index plate 418 mounted for free rotation on the shaft 403.

A cup-shaped cover plate 419 encloses these parts and is mounted in a counterbore 420 formed in the machine housing and secured therein by a set screw 421. The cover plate has a notched detent plate 422 secured thereto in a central bore 423 by pins 424, the plate 422 fitting around the shaft 403.

The detent plate 418 carries a detent lever 425, Figure 15, which is pivoted at one end on the plate by a pin 426. The other end of the lever is connected by a pin 427 to one end of a spring 428, the other end of which is connected to a pin 429 fixed in the plate 418. The detent lever carries a detent pin 430 which is adapted to be held in engagement with the notches 430' on the ratchet plate by the spring 428.

The knob 409 has a graduated flange 431 of the same diameter as the cover plate 419 so that graduation marks or indicia 432 thereon can register with a fixed mark 433 formed on the cover plate. The flange 431 is graduated in thousandths of an inch, as shown in Figure 17, and one revolution is equal to .050" movement of the saddle. This means that the volumetric capacity of the cylinder 376 is changed, and since the hydraulic motor consumes a certain known volume of fluid in effecting one revolution and, of course, exhausts the same volume into the cylinder, the capacity of the cylinder can be varied to determine the volume of fluid that the motor will consume and exhaust, and thus determine the amount of rotation effected by the motor. The parts are so proportioned that one rotation of the shaft will effect such a volumetric change that the motor will increase or decrease the pickfeed movement by increments of .050".

The detent plate 418 also has graduations around the periphery of its flange 417 which successively appear in the window 434 and which indicate the total of the number of complete revolutions of the control shaft. Rather than have the movement of plate 418 continuous, it is intermittent, so that only one dimension shows at a time, in order to avoid confusion in reading it. This is accomplished by the tooth 415 which as the cam 410 rotates is gradually moved by the cam 410 radially of the shaft 403 into engagement with a tooth space in the gear 416. After the tooth is inserted, it rotates the gear through a predetermined angle and then withdraws. This happens once with each revolution of the cam. Thus, the operator may add to the reading under the window 434, whatever is indicated by the dial 431 to obtain the total setting. From Figures 1 and 2, it will be seen that this mechanism is mounted on the front of the machine for easy access to the operator.

Figure 18 shows a modified form of circuit for con-

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necting the hydraulic motor 150 to its reverse valve 322 in a manner to short circuit the motor 150 during manual rotation of the saddle feed screw 83 by the hand wheel 110 shown in Figure 8. Briefly, the valve 385, shown in Figure 12, is replaced by valve 435 shown in Figure 18. This valve has a plunger 436 which is shiftable to one position for interconnecting or short circuiting the motor lines, and another position for isolating them similar to valve 385. The plunger of valve 435 is also shiftable by hydraulic pressure in one direction and spring returned the same as valve 385. However, the hydraulic connections are different. In this modified form the plunger 133 is utilized to effect a pressure connection from the pressure line 437 supplied by the main pump 437' to line 438 by means of a valve groove 439 which is positioned by the member 139 to interconnect ports 440 and 441 when the motor is running. The line 438 is connected to the right end of valve 435, thus shifting the valve plunger 436 to the left against the resistance of spring 442.

The valve 435 has the two motor lines 320 and 321 from the reversing valve 322 connected to annular ports 443 and 444 which are annular grooves completely around the valve housing and thus continuously connected to channels 445 and 446 extending to the housing 141, containing the plunger 139, and connected to the ports 146 and 147 thereof. Thus, when the motor is stopped, the pressure equalizes in lines 320 and 321 through the hydraulic resistance 146', and the plunger 139 is centralized and when the pressures are unequal due to running of the motor, the plunger is shifted off center to push down the plunger 133 and cause hydraulic shifting of the valve plunger 436 to the left.

The shifting of the plunger 436 effects interconnection of ports 443 and 444 by means of the valve grooves 446' and 447 to channels 448 and 449 leading to motor 150. The exhaust from the motor still passes to the pickfeed cylinder by way of channel 364 from valve 322.

It will now be seen that when the motor stops, the plunger 139 will be centralized, whereby the plunger 133 may be pushed by the handwheel 110 in Figure 8 by the rod 134 into the depression 145, thus connecting the port 441 to the exhaust port 450, permitting the valve plunger 436 to be shifted to the right by spring 442. This disconnects the motor channels 448 and 449 from ports 443 and 444, but connects them to ports 451 and 452. These ports are interconnected by the channel 453, so that if the motor is rotated by hand, the fluid will simply be to-passed from one side of the motor to the other. The channel 453 is connected to the common reservoir line 255, but this line connects to the low pressure relief valve 255', whereby the channel 453 and the motor 150 will always be maintained under some pressure determined by the setting of the relief valve, and fluid may still be by-passed from one side of the motor 150 to the other without causing a vacuum in the motor. It will be noted that in this modified form of circuit, the opposing pressures on the motor are the low pressures determined by the low pressure relief valve 255' while in the circuit shown in Figure 12, the opposing pressures on the motor when idle are the high pressures as determined by the pressure supply pump.

There has thus been provided a new and improved surface grinder, in which the table is hydraulically reciprocated for fast and smooth operation, including improved means for smoothing out the sudden high pressure surges at reversal to obtain speedy and accurate changes in the direction of table movement. It will be noted that the fast moving table does not have trip dogs projecting therefrom due to the provision of an improved enclosed trip control mechanism. The explanation of the saddle control mechanism will reveal that a very compact and versatile control mechanism has been provided which will yield all the diversified types of movement a saddle should have, such as continuous power

traverse, manual adjustment, automatic pickfeed operation at selectively adjustable increments, or fixed stroke operation readily available without setting dogs and making adjustments. An improved mechanism for power or manual adjustment of the grinding wheel has also been provided and all the controls for the machine are conveniently arranged for immediate access by the operator.

What is claimed is:

1. In a surface grinder having a bed, a grinding wheel and a table supported on the bed for relative traversing movement with respect to the grinding wheel, the combination of power operable means for reciprocating the table, reversing means for said power operable means, pilot control means for said reversing means, a rotatable shaft operatively connected to said pilot control means, and means including a clutch mechanism to rotate said shaft in response to movement of the table.

2. In a surface grinder having a support, and a work table reciprocally mounted on said support for traversing movement relative to a grinding wheel, the combination of hydraulic means for reciprocating the table, a reversing valve for said hydraulic means, a pilot valve within the support operatively connected to effect power shifting of said reversing valve, a manually rotatable first shaft operable from outside the support operatively connected for shifting said pilot valve, a rack and pinion mechanism operable by the table, means including clutch members within the support carried on shafts to operatively connect said first shaft to said rack and pinion mechanism to effect automatic rotation of said first shaft in opposite directions in accordance with the direction of table movement, said shafts carrying the clutch members being operable from outside the support for disengagement of said clutch members to adjust the table stroke.

3. In a machine tool having a power reciprocable table, a source of power to effect said reciprocation, and reversing means for reversely connecting said source of power to the table, the combination of actuating means for said reversing means including a rotatable shaft operatively connected for rotation by the table in one direction or the other in accordance with the direction of table movement, a pair of rotatable elements alternately driven in opposite directions by said shaft, said elements having abutment shoulders thereon, a trip lever located between said elements for alternate engagement by said shoulders, and means operatively connecting said trip lever to said reversing means.

4. In a machine tool having a power reciprocable table, a source of power to effect said reciprocation, and reversing means for reversely connecting said source of power to the table, the combination of actuating means for said reversing means including a rotatable shaft operatively connected for rotation by the table in one direction or the other in accordance with the direction of table movement, a pair of rotatable elements alternately driven in opposite directions by said shaft, said elements having abutment shoulders thereon, a trip lever located between said elements for alternate engagement by said shoulders, means operatively connecting said trip lever to said reversing means, and clutch means operatively connecting said elements to said rotatable shaft and disconnectible for relative adjustment of said elements with respect to said shaft for changing the stroke of the table.

5. In a surface grinder having a bed, a saddle reciprocally mounted on the bed, and a table reciprocally mounted on the saddle, the combination of a hydraulic motor operatively connected for effecting power movement of the saddle including a feed screw, means for manual rotation of said screw, manually operable means including a clutch for connecting said means for rotation of said screw, a pick feed control mechanism operable by the table at each reversal thereof for causing opera-

tion of said motor, and means responsive to the operation of said motor to hold said clutch disengaged.

6. In a surface grinder having a bed, a saddle mounted on the bed, and a table reciprocally mounted on the saddle, a pick feed adjusting mechanism for the saddle including a hydraulic motor, a reversing valve for the motor, a metering piston for receiving exhaust fluid from the motor to determine the length of operation thereof including a reverse valve for alternately connecting said exhaust to opposite ends of said metering cylinder, and means operated by the table for shifting said last-named reverse valve at each end of the table stroke.

7. In a surface grinding machine having a bed, a saddle reciprocally mounted on the bed, and a work supporting table reciprocally mounted on the saddle, the combination of a hydraulic motor operatively connected for pick feeding said saddle having a pair of conduits connected thereto, a blocking valve connected in said conduits and having a first position for interconnecting them to short circuit said motor, and a second position for nullifying said interconnection, hydraulic means for shifting said blocking valve in one direction, and resilient means for actuating the valve in the other direction.

8. In a surface grinding machine having a bed, a saddle reciprocally mounted on the bed, and a work supporting table reciprocally mounted on the saddle, the combination of a hydraulic motor operatively connected for pick feeding said saddle including a pair of conduits connected thereto, means to supply fluid pressure to one of said conduits, a metering mechanism connected to the other of said conduits for determining the amount of pick feed, a blocking valve connected across said conduits and having a first position for interconnecting said conduits to short circuit the motor for manual operation, and a second position for nullifying said interconnections, hydraulically operable means for shifting the valve to its first position, and means connecting said hydraulically operable means to the line from the motor to the metering mechanism whereby a pressure rise therein upon completion of the metering operation will effect shifting of said valve.

9. In a surface grinding machine having a bed, a saddle reciprocally mounted on the bed, and a work supporting table reciprocally mounted on the saddle, the combination of a hydraulic motor operatively connected for automatically pick feeding said saddle after a table stroke, including a pair of conduits connected to said motor, means to supply fluid pressure to one of said conduits, a metering mechanism connected to the other of said conduits for receiving the exhaust from said motor, valve means connected to said conduits and having a first position for interconnecting said conduits to short circuit the motor for rotation thereof independent of said metering mechanism, and a second position for nullifying said interconnections, pressure operable means for holding the valve in its second position, manually operable means for effecting said independent rotation of said motor including a hand wheel and means shiftable by the hand wheel to disconnect pressure from said pressure operable means.

10. In a surface grinder machine having a bed, a saddle reciprocally mounted on the bed, and a work supporting table reciprocally mounted on the saddle, the combination of a hydraulic motor operatively connected for automatically pick feeding said saddle after a table stroke including a pair of conduits connected to said motor, means to connect pressure to one of said conduits, a metering cylinder for receiving exhaust from the other motor conduit and thereby determining the stopping of said motor whereby both conduits are under substantially equal pressure when the motor is stopped, and means to interconnect said conduits for short circuiting said motor to effect manual rotation thereof independent of said metering cylinder.

11. In a surface grinding machine having a bed, a

saddle reciprocally mounted on the bed, and a work supporting table mounted on the saddle, the combination of a hydraulic motor operatively connected for automatically pick feeding said saddle after a table stroke, a pair of channels connected to the ports of said motor, means to connect pressure to one motor port channel, a metering cylinder connected to the channel from the other motor port to effect stoppage of said motor after a pretermined operation thereof, valve means for isolating said ports from said channels and interconnecting said ports to effect manual rotation of said motor against a lower pressure at said ports than in said channels.

12. In a surface grinding machine having a bed, a saddle reciprocally mounted on the bed, and a work supporting table reciprocally mounted on the saddle, the combination with a feed screw for said saddle, a motor operatively connected to said feed screw to effect automatic pick feeding of said saddle after a table stroke including a pair of conduits connected to said motor, means to supply fluid pressure to one of said conduits, a metering mechanism for receiving exhaust from the other conduit during power rotation of the motor, valve means connected to pressure on power rotation of said motor and operable, when disconnected from pressure, to short circuit said motor independent of said conduits, a manually operable actuator operatively connectible upon movement thereof to said feed screw, and means operable by said actuator upon movement to a connecting position to disconnect pressure from said valve means.

13. In a surface grinding machine having a bed, a saddle reciprocally mounted on the bed, and a work supporting table reciprocally mounted on the saddle, the combination with a feed screw for said saddle, a motor operatively connected to said feed screw to effect automatic pick feeding of said saddle after a table stroke including a pair of conduits connected to said motor, means to supply fluid pressure to one of said conduits, a metering mechanism for receiving exhaust from the other conduit during power rotation of the motor, valve means connected to pressure on power rotation of said motor and operable, when disconnected from pressure, to short circuit said motor independent of said conduits, a manually operable actuator operatively connectible upon movement thereof to said feed screw, means operable by said actuator upon movement to a connecting position to disconnect pressure from said valve means, and means automatically effective during power rotation of said motor to block operative connection of said actuator.

14. In a surface grinding machine having a bed, a saddle reciprocally mounted on the bed and a work supporting table reciprocally mounted on the saddle, the combination with a feed screw for said saddle, of a hydraulic motor operatively connected to said feed screw for effecting automatic pick feeding of said saddle, a pair of conduits connected to said motor for effecting power actuation thereof, a metering mechanism for determining the length of pick feed operation of said motor and determining stoppage thereof, an independent exhaust line having a relatively low back pressure therein, means to short circuit said motor by way of said exhaust line to reduce the pressure on said motor during manual operation thereof.

15. In a surface grinding machine having a bed, a saddle reciprocally mounted on the bed and a work supporting table reciprocally mounted on the saddle, the combination of a lead screw for said saddle, a motor connected for rotation of said lead screw, a hand wheel having clutch means and movable to effect clutch connection to the lead screw for manual rotation thereof and thereby of said motor, an interlock mechanism to prevent simultaneous rotation of the hand wheel during power actuation of the motor including an interlock control selector member having a central position and blocking positions on either side thereof, a control pin supported for axial movement toward and from said selector

member, means on the selector member for blocking axial movement of the pin when in a blocking position, and permitting advance of the pin when in a central position, and means operable in response to operation of the motor to shift said selector to a blocking position.

16. In a surface grinding machine having a bed, a saddle reciprocally mounted on the bed and a work supporting table reciprocally mounted on the saddle, the combination of a lead screw for said saddle, a motor connected for rotation of said lead screw, a hand wheel having clutch means and movable to effect clutch connection to the lead screw for manual rotation thereof and thereby of said motor, an interlock mechanism to prevent simultaneous rotation of the hand wheel during power actuation of the motor including an interlock control selector member having a central position and blocking positions on either side thereof, a control pin supported for axial movement toward and from said selector member, means on the selector member for blocking axial movement of the pin when in a blocking position, and permitting advance of the pin when in a central position, means operable in response to operation of the motor to shift said selector to a blocking position, and means operable by the hand wheel upon movement to effect said clutch connection to interconnect the ports of said motor and thereby decrease the opposing pressures on the motor.

17. In a surface grinding machine having a bed, and a saddle reciprocally mounted on the bed, and a work supporting table reciprocally mounted on the saddle, the combination of a pick feed mechanism for effecting incremental movements of said saddle including a pick feed cylinder having a piston movable therein, a pick feed motor having a source of pressure connected thereto, a channel for receiving exhaust from said motor, a reversing valve for connecting said channel to opposite ends of said pick feed cylinder, trip operable means actuable by the work table at each end of its movement for shifting said reverse valve, means to supply fluid pressure for reciprocating said work table including a delay valve, and means connecting said channel to said delay valve to effect closure thereof in response to each shifting movement of said reverse valve.

18. In a surface grinding machine having a bed, a saddle reciprocally mounted on the bed and a work supporting table reciprocally mounted on the saddle, the combination of hydraulic means to effect said table reciprocation, a pick feed motor to effect transverse movements of said saddle, a pressure supply line to said hydraulic means, means for connecting a source of pressure to said motor, a return channel to receive exhaust fluid from said motor during operation thereof, a pick feed piston and cylinder, a reverse valve for connecting said return channel alternately to opposite ends of said cylinder to determine intermittent operation of said motor, trip operable means actuated by the work support to effect shifting of said reversing valve, a delay valve in said pressure supply line, and means responsive to a pressure drop in said return channel to close said delay valve until the pick feed movement has been completed.

19. In a surface grinding machine having a bed, a saddle reciprocally mounted on the bed and a work supporting table reciprocally mounted on the saddle, the combination of hydraulic means to effect said table reciprocation, a pick feed motor to effect transverse movements of said saddle, a pressure supply line to said hydraulic means, means for connecting a source of pressure to said motor, a return channel to receive exhaust fluid from said motor during operation thereof, a pick feed piston and cylinder, a reverse valve for connecting said return channel alternately to opposite ends of said cylinder to determine intermittent operation of said motor, trip operable means actuated by the work support to effect shifting of said reversing valve, a delay valve in said pressure supply line, means responsive to a pressure drop in

said return channel to close said delay valve until the pick feed movement has been completed, and independent means for connecting said return channel directly to reservoir to effect continuous rotation of said hydraulic motor.

20. In a surface grinding machine having a bed, a saddle reciprocably mounted on the bed and a work supporting table reciprocably mounted on the saddle, the combination of a pick feed motor operatively connected to said saddle, a reverse valve for connecting a source of pressure to one side of said motor and connecting the other side of said motor to an exhaust channel, a pilot valve trip operable by the table for effecting power shifting of said reverse valve, a pick feed mechanism operatively connected to the exhaust channel from said reverse valve to determine the extent of operation of said motor, and means in the pilot valve for independently connecting said exhaust channel at will to reservoir independent of said pick feed mechanism to effect continuous operation of said motor.

21. In a surface grinding machine having a bed, a saddle slidably mounted on the bed, a work supporting table reciprocably mounted on the saddle and a grinding wheel supported by the bed in operative relation to the table, the combination of fluid operable means for effecting relative reciprocation between the table and the grinding wheel including a stop valve having separate positions for starting and stopping said reciprocating movement, a fixed stroke mechanism for reciprocating the saddle, a reversing valve having a normal position for connecting pressure to said mechanism to hold it in a starting position, means operable by the stop valve upon movement to a start position for connecting pressure to hold the reversing valve in said normal position during reciprocation of the table, and means operable by the stop valve to release said reversing valve for manual operation whereby the reversing valve may be shifted to effect operation of the fixed stroke mechanism during stoppage of the table.

22. In a surface grinding machine having a bed, a saddle slidably mounted on the bed, a work supporting table reciprocably mounted on the saddle and a grinding wheel supported by the bed in operative relation to the table, the combination of fluid operable means for effecting relative reciprocation between the table and the grinding wheel including a stop valve having separate positions for starting and stopping said reciprocating movement, a fixed stroke mechanism for reciprocating the saddle, a reversing valve having a normal position for connecting pressure to said mechanism to hold it in a starting position, means operable by the stop valve upon movement to a start position for connecting pressure to hold the reversing valve in said normal position during reciprocation of the table, means operable by the stop valve to release said reversing valve for manual operation whereby the reversing valve may be shifted to effect operation of the fixed stroke mechanism during stoppage of the table, and a throttle valve for controlling the rate of operation of said mechanism.

23. In a surface grinding machine having a bed and a table slidably mounted thereon for movement with respect to a grinding wheel, the combination of a hydraulic motor for reciprocating said table, said motor having a pair of channels connected thereto, a stop valve having individual ports connected to the respective channels and operable to connect and disconnect said ports, a reversing valve having separate ports connected to said channels and operable to connect a source of pressure to either of said channels, a pilot valve having individual ports connected to said channels and operable to connect either of said channels to an exhaust line, said channels terminating in check valves, means controlled by the pilot valve for automatically effecting power shifting of said reverse valve whereby a sudden surge of pressure will be created in one of said motor channels, a surge relief valve and a common channel connecting said check valves to said relief valve.

24. In a surface grinder having a support, and a work table reciprocably mounted on said support for movement relative to a grinding wheel, the combination of power means, a valve within the support operatively connecting said power means to said table, the valve having a plunger operable when reciprocated to effect reciprocation of the table, a first shaft within the support operatively connected to said valve plunger and reversely rotatable for reciprocation of said plunger, a lever outside the support operatively connected to said first shaft for rotation thereof, a pair of rotatable shafts within the support axially movable from a normal position each having an abutment shoulder carried in non-rotatable relation thereon, said shafts extending outside the support, a gear loosely carried on each of said shafts, means including a rack connected to the table for rotation of said gears in one direction on movement of the table in one direction and reverse rotation of said gears on movement of the table in the opposite direction, a clutch member secured to each of the shafts on which the abutment shoulders are carried operable to engage said gears when the shafts are in their normal position, a trip lever located between said shoulders for alternate engagement thereby, and means operatively connecting said trip lever to said first shaft for rotation thereof in one direction when the trip lever is engaged by one of said shoulders and for rotation thereof in the opposite direction when the trip lever is engaged by the other of said shoulders.

25. In a surface grinder having a saddle, a work table reciprocably mounted on said saddle for movement relative to a grinding wheel, hydraulic power means for effecting said movement, and a reversing valve for said hydraulic means, the combination of a pilot valve within the saddle having a reciprocable plunger to effect power shifting of said reversing valve, a first shaft operatively connected to said pilot valve plunger and reversely rotatable for reciprocation of said plunger, said first shaft being axially movable from a normal position, a lever outside the saddle operatively connected to said first shaft for rotation and axial movement thereof, a pair of rotatable shafts within the saddle axially movable from a normal position each having an abutment shoulder carried in non-rotatable relation thereon, said shafts extending outside the saddle, a gear loosely carried on each of said shafts, means including a rack connected to the table for rotation of said gears in one direction on movement of the table in one direction and reverse rotation of said gears on movement of the table in the opposite direction, a clutch member secured to each of the shafts on which the abutment shoulders are carried operable to engage said gears when said shafts are in their normal position, a trip lever connected to said first shaft and located between said shoulders when the first shaft is in its normal position for alternate engagement by the shoulders to rotate the first shaft in one direction when engaged by one of said shoulders and the other direction when engaged by the other of said shoulders, the trip lever being shifted out of the plane of the shoulders when the first shaft is axially moved from its normal position.

26. In a grinding machine having a reciprocating table, the combination of a piston and cylinder for reciprocating said table including channels connected to opposite ends of said cylinder, a source of hydraulic pressure alternatively connectible to said channels, valve means interposed in said channels and including a valve member operable upon reversal of the table to momentarily block the hydraulic return from said table cylinder and cushion the reversal thereof.

27. In a grinding machine having a reciprocating table, the combination of a source of hydraulic pressure, a piston and cylinder for reciprocating said table including channels connected to opposite ends of said cylinder, valve means to control the reciprocation of said table including a valve member interposed in said channels and movable between two positions, said valve means con-

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necting one of said channels to the source of pressure and the other of said channels to exhaust in one position of the valve member and oppositely connecting said channels in the other position, said valve member having a portion operable when the valve member is intermediate of said two positions to disconnect the channel from exhaust, means to move said valve member from one of said positions to the other at the end of the table stroke and thereby momentarily disconnect the cylinder from exhaust to cushion the reversal of the table.

28. In a grinding machine having a reciprocating table, the combination of a source of hydraulic pressure, a piston and cylinder for reciprocating said table including channels connected to opposite ends of said cylinder, valve means to control the reciprocation of said table including a valve member interposed in said channels and movable between two positions, said valve means connecting one of said channels to the source of pressure and the other of said channels to exhaust in one position of the valve member and oppositely connecting said channels in the other position, said valve member having a portion operable when the valve member is intermediate of said two positions to disconnect the channels from exhaust, means to move said valve member from one of said positions to the other at the end of the table stroke, and means connected to the channels to relieve the pressure when the channels are momentarily disconnected from exhaust.

29. In a surface grinding machine having a bed and a table slidably mounted thereon for movement with respect to a grinding wheel, the combination of a hydraulic motor operatively connected to the table for reciprocation thereof, a pilot valve having an exhaust port and a pair of motor ports operable when actuated to isolate momentarily said motor ports from said exhaust port

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and thereafter to connect one or the other of the motor ports to the exhaust port, a reversing valve having a pressure port and a pair of motor ports operable in response to actuation of the pilot valve to connect one or the other of said motor ports to the exhaust port, a pressure relief valve, and channels connecting the hydraulic motor to the motor ports of the reversing valve and pilot valve and to the pressure relief valve.

30. In a grinding machine having a source of pressure, a bed, a saddle movably mounted on the bed, and a table movably mounted on the saddle, control means including a stop valve shiftable between a running position and a stop position for reciprocating and stopping the table; a fixed stroke mechanism operatively connected to the saddle, a manually operated valve associated with the fixed stroke mechanism and operable to reciprocate the saddle, and means to connect the source of pressure through the stop valve when in the running position to said manually operated valve to disable the same.

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