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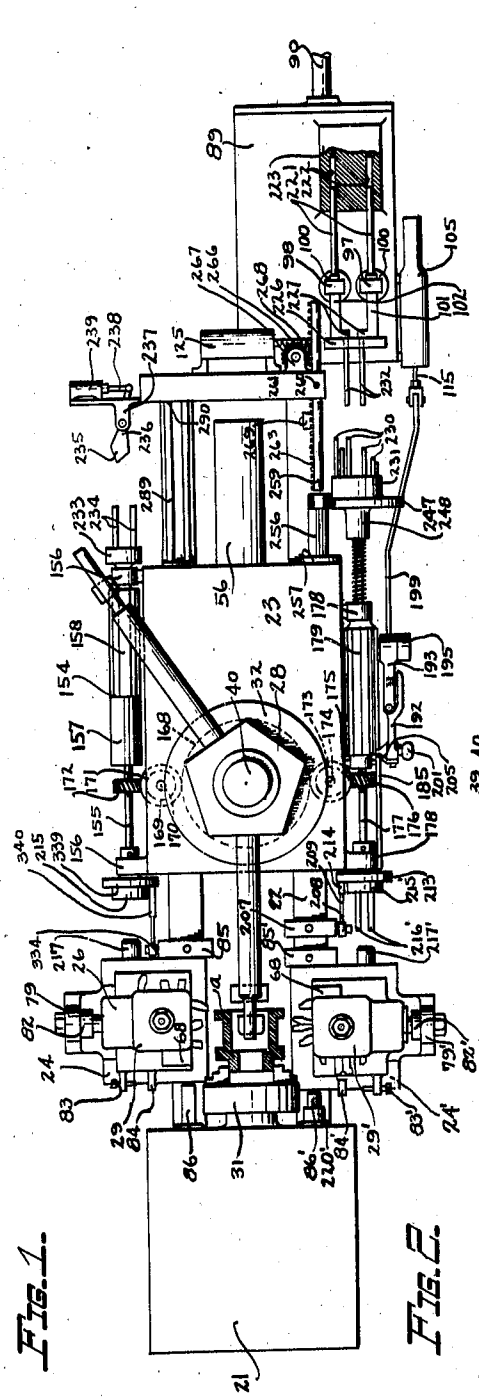


FIG. 1.

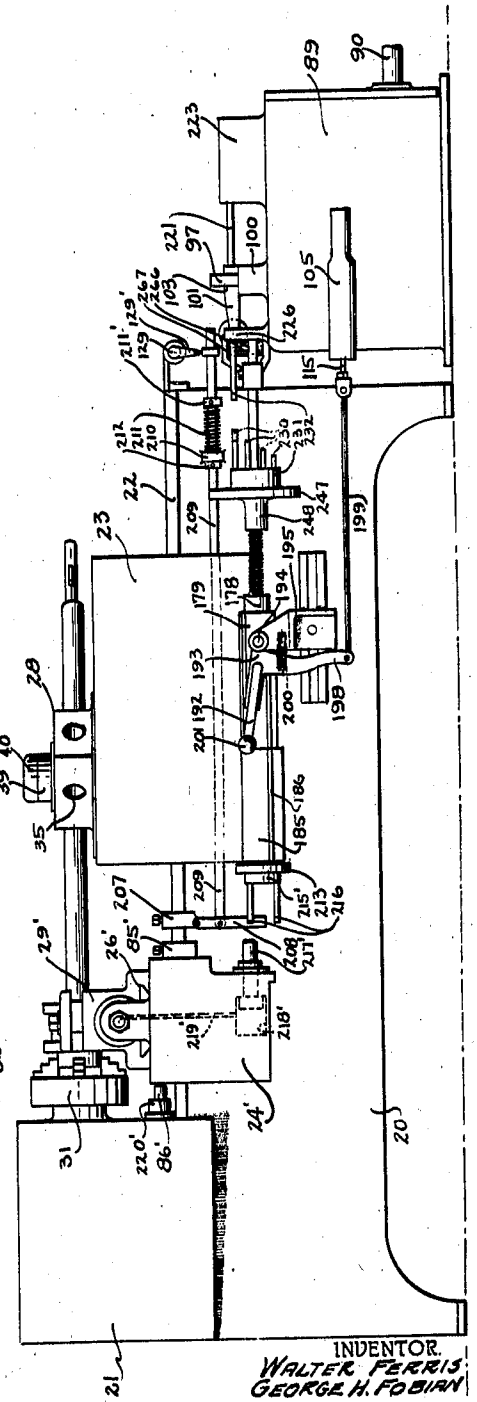


FIG. 2.

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FIG. 3

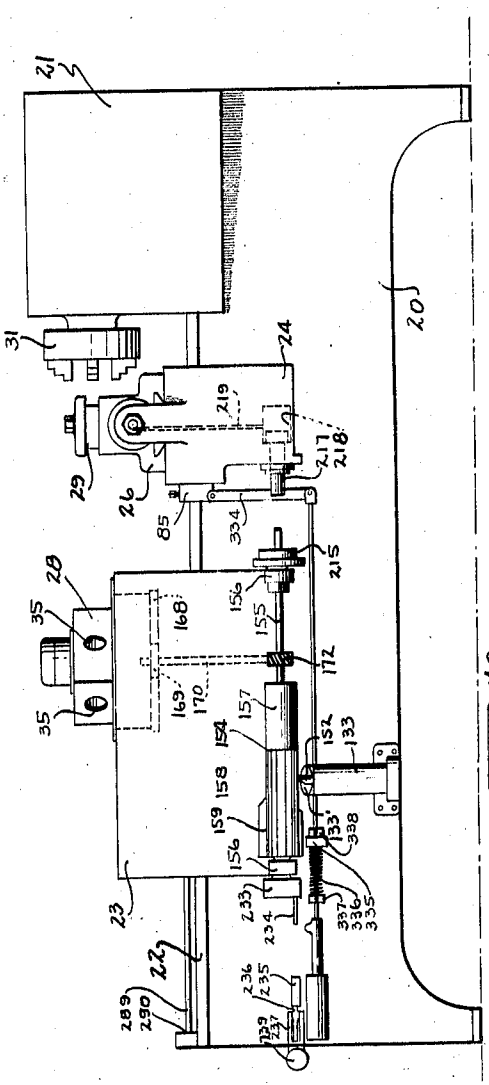


FIG. 5

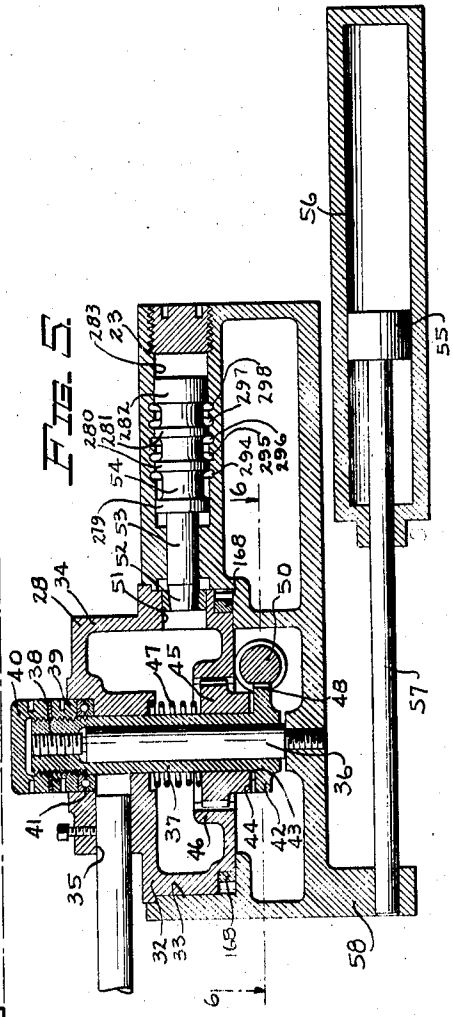
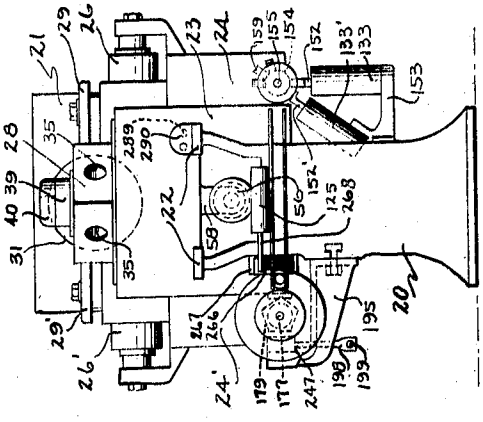


FIG. 4

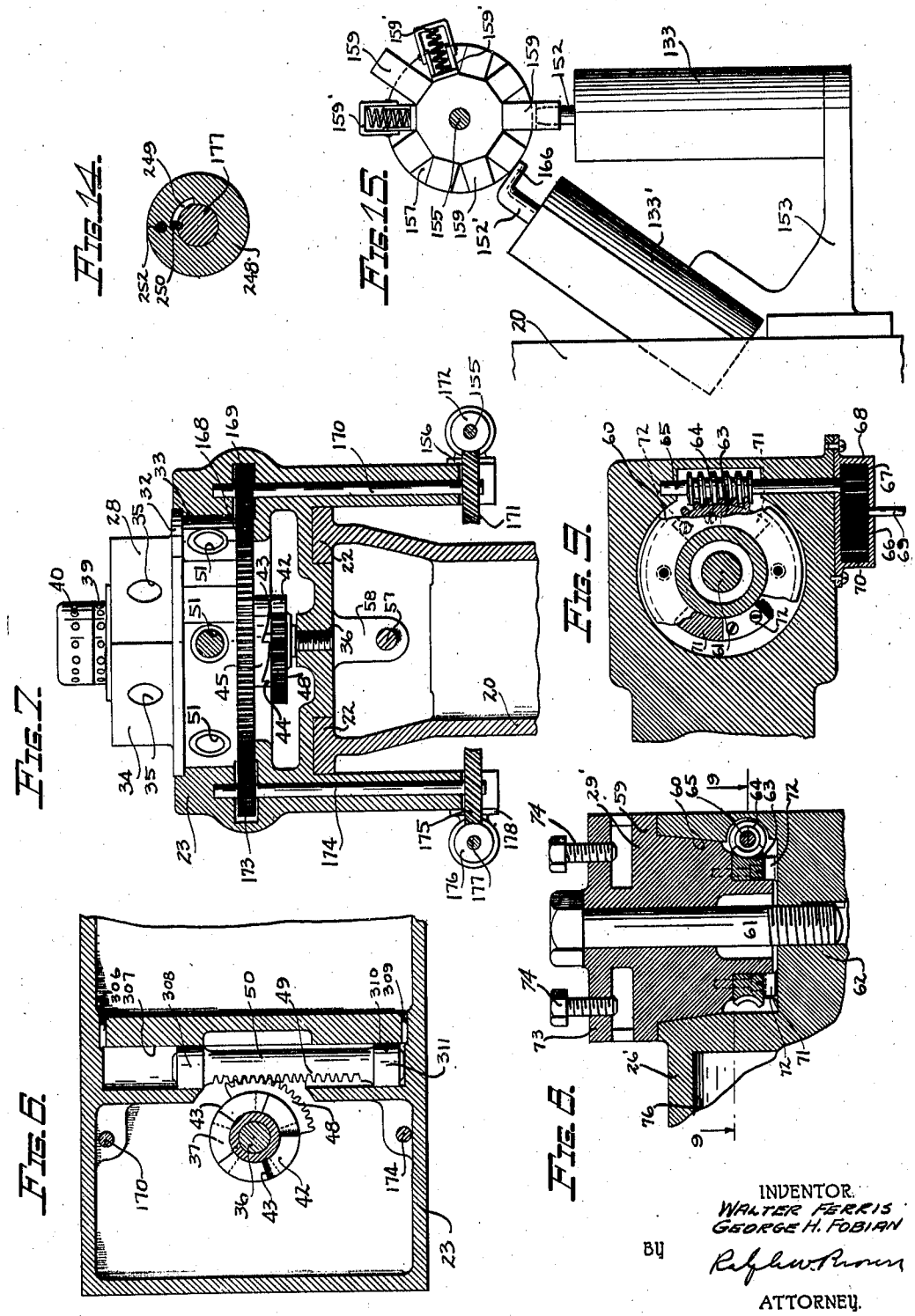


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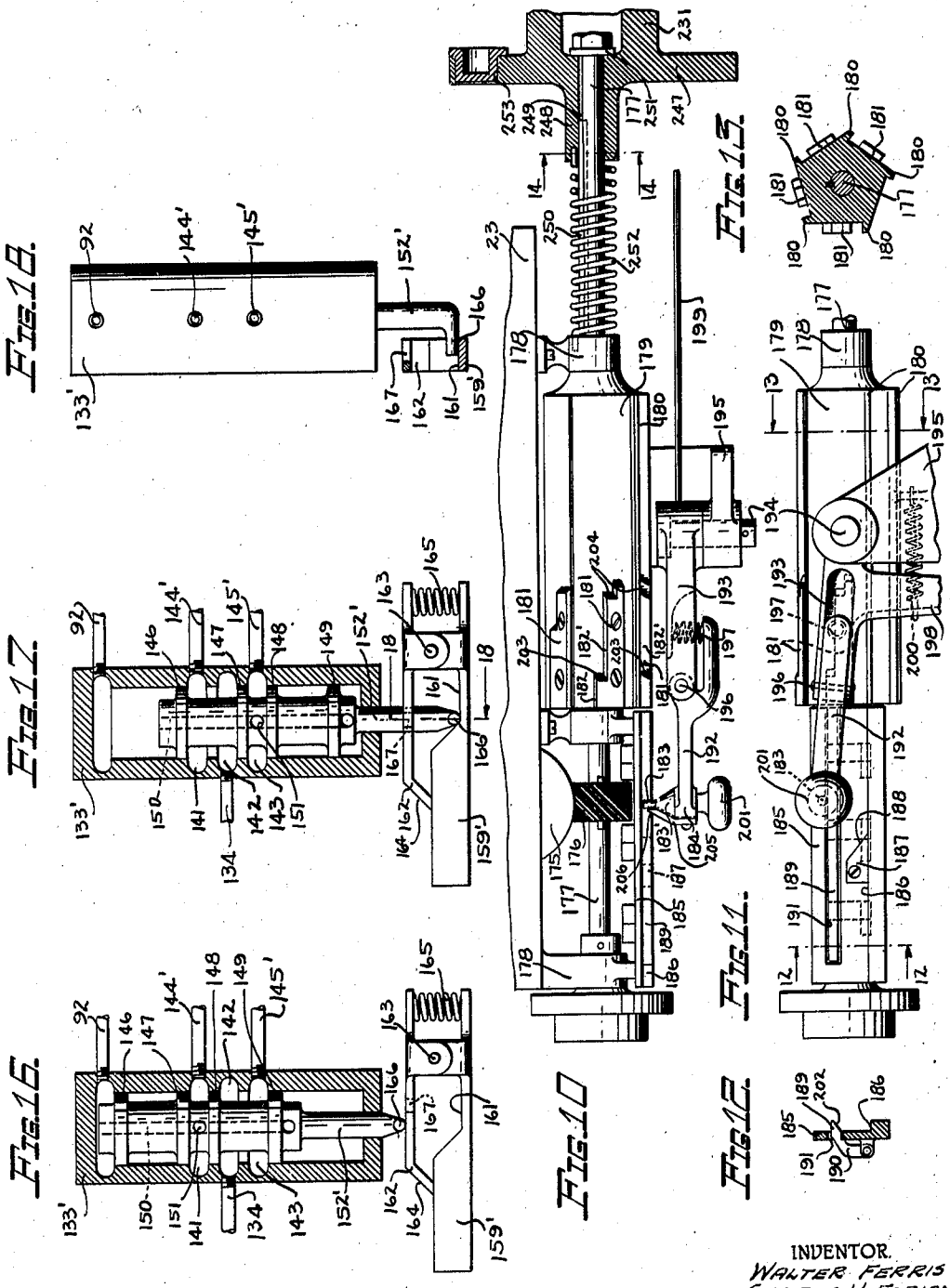


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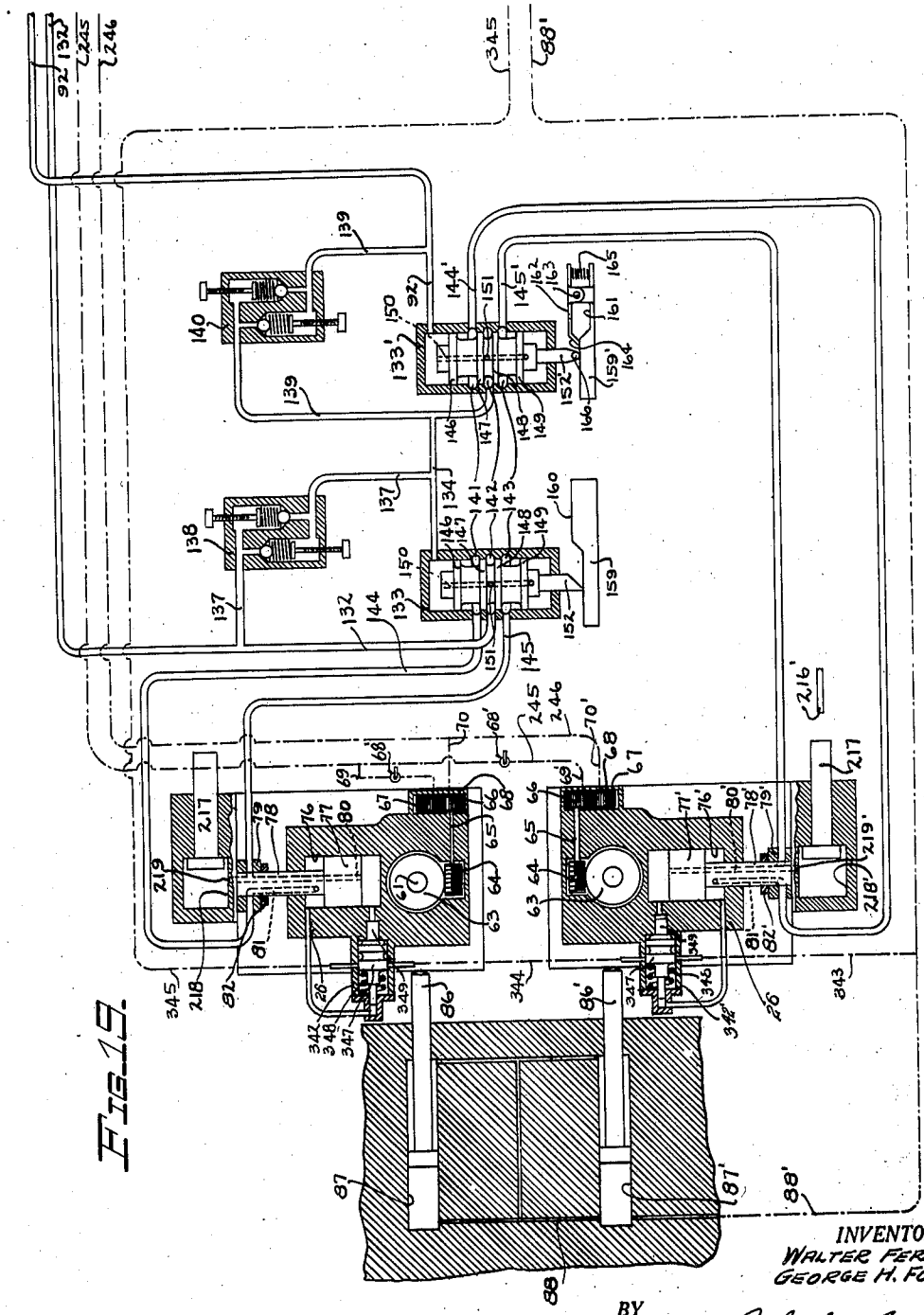


Fig. 13.

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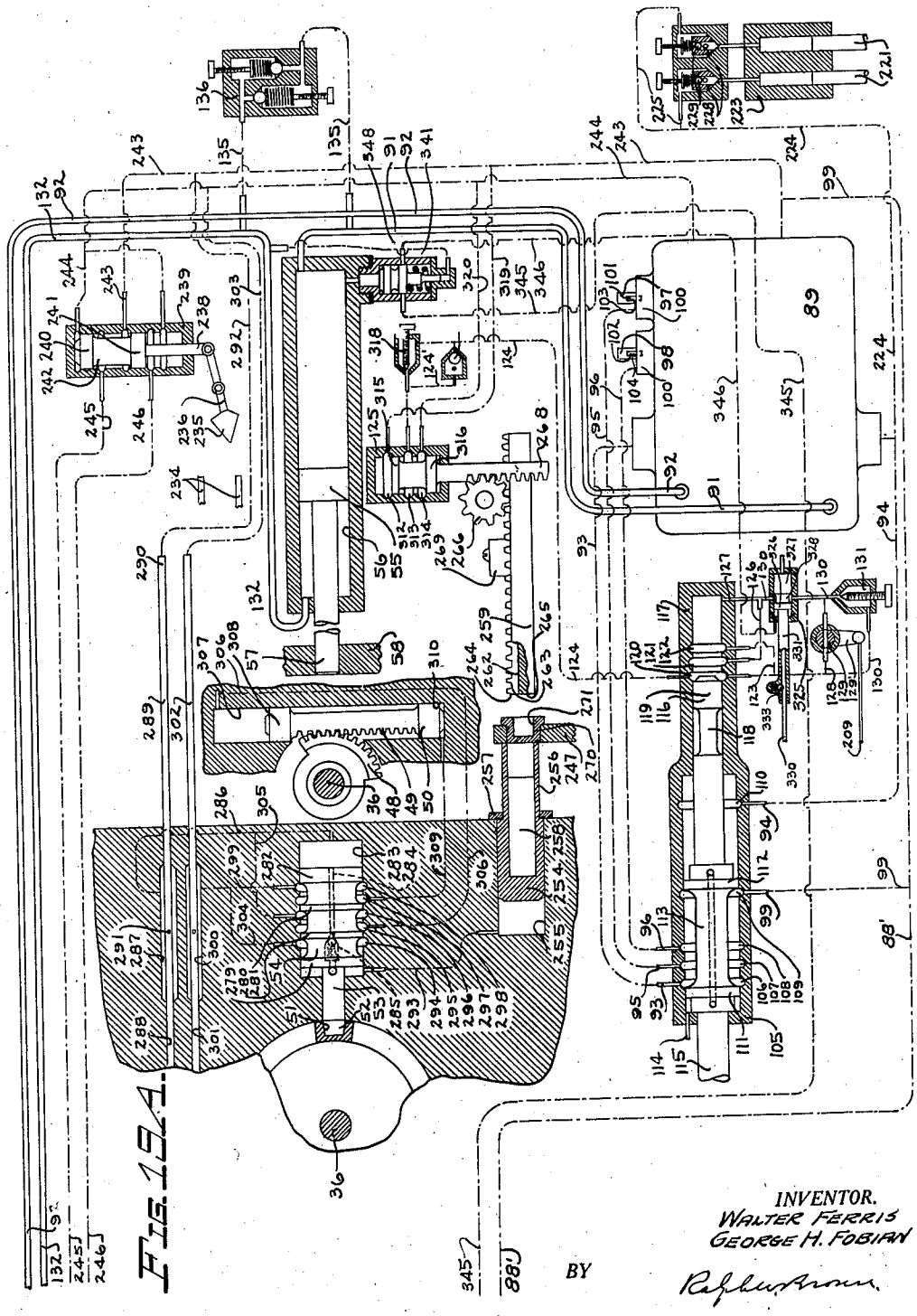


FIG. 15A.

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FIG. 20.

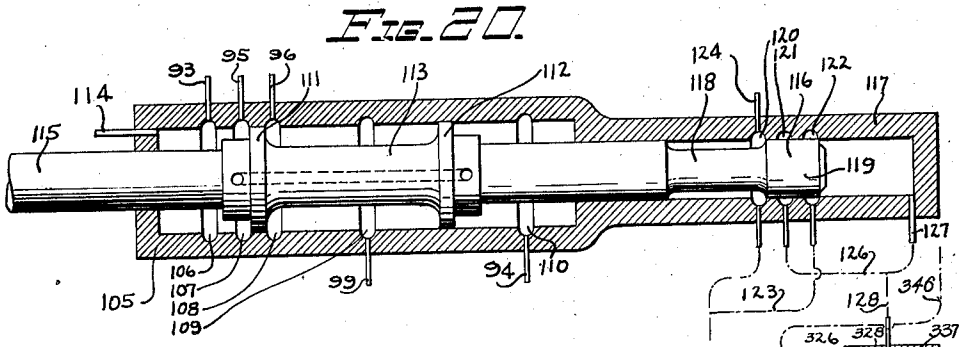


FIG. 21.

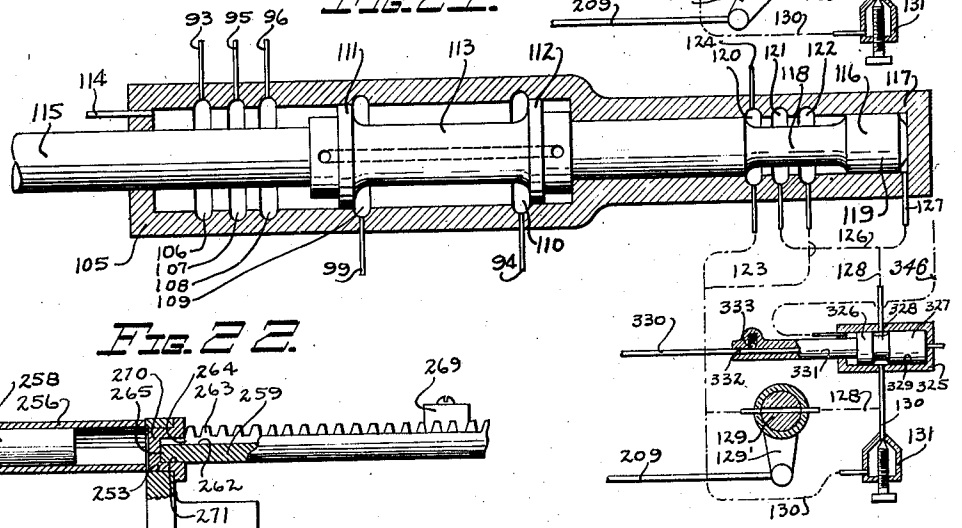


FIG. 22.

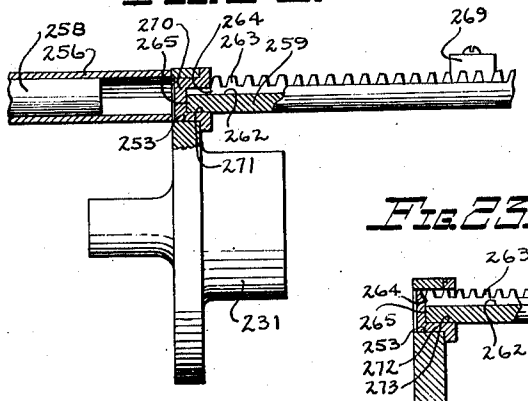
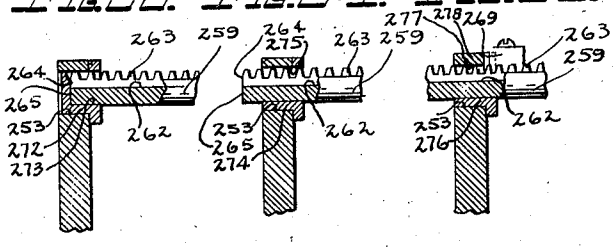


FIG. 23. FIG. 24. FIG. 25.



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UNITED STATES PATENT OFFICE

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LATHE

Walter Ferris and George H. Fobian, Milwaukee, Wis., assignors to The Oilgear Company, Milwaukee, Wis., a corporation of Wisconsin

Application March 22, 1929, Serial No. 349,022

54 Claims. (Cl. 29—42)

This invention relates to machine tools and particularly to improved feed and control mechanisms therefor.

For purposes of illustration and explanation the invention will be described as embodied in a multiple turret lathe although the novel features thereof may be applied to advantage in various other types of machine tools and the like.

One object of the present invention is the provision of a wholly automatic machine tool involving a plurality of carriers capable of executing different movements during successive stages of a complete operating cycle as predetermined by or during a preceding stage.

Another object is the provision of improved means for accurately regulating and controlling the rate, direction, and extent of movement of each carrier.

Another object is the provision in a machine involving a plurality of hydraulic motors driven from one hydraulic circuit of means for automatically controlling and accurately regulating the operation of each motor.

Another object is the provision of improved turret indexing mechanism for effecting intermittent rotation of the turret through successive predetermined angles and for automatically securing the same in each indexed position.

Another object is the provision in a machine involving a plurality of carriers of turret controlled means for predetermining and controlling the movement of the carriers.

Numerous other objects and advantages will appear from the following description of an illustrative embodiment of the present invention.

In the drawings:—

Figure 1 is a plan view of a multiple turret lathe equipped with automatic control and feed mechanisms embodying the novel features of the present invention.

Fig. 2 is a view in elevation of the front side of the lathe.

Fig. 3 is a similar view of the rear side of the lathe.

Fig. 4 is a view in elevation of the right end of the lathe.

Fig. 5 is a longitudinal sectional view of the main carriage showing the main turret and indexing mechanism therefor.

Fig. 6 is a horizontal sectional view on the line 6—6 of Fig. 5.

Fig. 7 is a transverse sectional view of the main carriage.

Fig. 8 is a sectional view of an auxiliary turret on one of the cross-slides.

Fig. 9 is a horizontal sectional view on the line 9—9 of Fig. 8.

Fig. 10 is a plan view of the control mechanism for the main carriage.

Fig. 11 is a side elevational view of the mechanism shown in Fig. 10.

Fig. 12 is a sectional view on the line 12—12 of Fig. 11.

Fig. 13 is a sectional view on the line 13—13 of Fig. 11.

Fig. 14 is a sectional view on the line 14—14 of Fig. 10.

Fig. 15 is a detail view showing the control mechanism for the cross-slides.

Figs. 16, 17, and 18 are detail views of one of the valves and its coacting cam shown in Fig. 15, and illustrating the action thereof.

Figs. 19 and 19A together constitute a diagrammatic illustration of the hydraulic feeding and control circuit and parts connected therewith.

Figs. 20 and 21 are sectional views on a larger scale of the main control valve and associated parts shown in Fig. 19A and illustrating two other characteristic positions thereof.

Figs. 22, 23, 24 and 25 are detail sectional views of different marginal portions of a control disk, shown in Figs. 1 and 10, together with coacting parts associated therewith.

The lathe shown is of the multiple turret type and comprises a bed 20 of conventional design supporting the usual headstock 21 and provided with the usual longitudinal ways 22 upon which the main carriage 23 is mounted for lengthwise travel toward and from the headstock. A rear carriage 24 and front carriage 24' are independently mounted on the ways 22 for movement lengthwise of the bed between the main carriage and the head stock. Each of the rear and front carriages 24 and 24' carries a cross-slide 26—26', of a well known type, movable thereon toward and from the longitudinal axis of the bed. Rotatably mounted on the main carriage 23 is a five-position tool-carrying turret 28, and auxiliary two-position tool-carrying turrets 29 and 29' are carried by the cross-slides 26 and 26', respectively. The headstock supports the usual chuck 31 driven in a well known manner for receiving and rotating the work *a*.

The main turret 28, shown in detail in Figs. 5, 6 and 7, comprises a hollow casting having a substantially cylindrical base 32, fitted for rotation in a circular opening 33 formed in the main carriage 23, and a five sided head 34 formed integral with the base and having appropriate tool receiv-

ing sockets 35 therein. A stud 36, anchored at its lower end in the carriage, projects upwardly through the center of the turret and carries a sleeve 37 rotatable thereon. The upper end of the sleeve 37 is threaded upon the upper reduced end 38 of the stud so that vertical motion is imparted to the sleeve when rotated upon the stud. The upper end of the sleeve 37 also carries a clamp collar 39 which, when the sleeve is screwed downwardly, presses the turret downwardly upon its seat and thereby holds the same against rotation. In this instance the collar 39 is in the form of a nut screwed onto the sleeve and locked in place by a lock nut 40, an anti-friction bearing 41 being interposed between the collar 39 and turret head 34 to prevent a cramping action between the collar and head.

The sleeve 37 carries an actuating flange 42 at the lower end thereof the upper annular face of the flange having ratchet teeth 43 formed thereon for coaction with mating teeth 44 formed upon the lower face of a ratchet element 45 loosely mounted on the sleeve and splined within an inner hub 46 of the turret. The ratchet element 45 is vertically movable with respect to both the hub 46 and sleeve 37 but is held in coacting relation with the collar 42 by a spring 47. The collar 42 also carries a segmental gear 48 which meshes with a rack 49 constituting a part of a double acting hydraulic plunger 50 to be later described. The stroke of the plunger 50 is such as to impart a ninety degree rotation to the flange 42 and sleeve 37, but as indicated in Fig. 7 the ratchet teeth 43 and 44 are so set as to provide a definite amount of lost motion therebetween so that the ratchet element is rotated through an angle of only seventy two degrees for each stroke of the plunger. This eighteen degree idle motion of the sleeve is sufficient to release the clamping pressure of the collar 39 upon the turret so as to permit free rotation of the turret under the action of the ratchet element 45 throughout the final seventy two degree rotation of the sleeve. Upon each return stroke of the plunger the sleeve is returned through the full ninety degree angle and the clamping pressure between collar 39 and turret is reestablished.

In order to accurately center and securely lock the main turret 28 in each indexed position the cylindrical base 32 thereof is provided with a series of five holes 51 adapted to receive the tapered end 52 of an indexing pin 53 mounted for lengthwise reciprocation in the main carriage. This pin is automatically advanced and withdrawn by a hydraulic plunger 54 to be hereinafter described.

The main carriage 23 is hydraulically advanced and retracted along the ways 22 by a piston 55, reciprocable in a cylinder 56 disposed lengthwise of and secured to the bed 20 below the carriage. The piston 55 is connected to the carriage through a rod 57 the forward end of which is anchored to a lug 58 depending from the carriage.

The two auxiliary turrets 29 and 29' are substantially identical so that a description of one will suffice for both. As indicated in Figs. 8 and 9 each comprises a flanged base 59 rotatably seated in a circular recess 60 formed in its supporting cross-slide 26 or 26'. Each rotates about a vertical stud 61 anchored in an internal hub 62 in the cross-slide and extending upwardly through the base 59. A worm wheel 63 fixed on the lower end of the base 59 meshes with a worm 64 fixed to a shaft 65 journalled horizontally in the cross-slide. The shaft 65 is driven by a small hydraulic motor of a well known type comprising a pair of intermeshing gears 66 and 67, closely confined within a housing 68 fixed to the side of the cross-slide. This motor is actuated in one direction or the other by liquid supplied thereto through one or the other of two pipes 69 and 70 (or 69' or 70') connected to the housing above and below the gears, respectively. Each turret is oscillatable, under the action of the motor driven worm 64, through an angle which is limited to exactly ninety degrees or to any other desired angle by a pair of segmental lugs 71 on the worm wheel which coact with a pair of segmental stops 72 fixed in the base of the recess 60. The worm also coacts with the worm wheel to securely lock the turret in either of its ninety degree positions. The turret carries an appropriate top plate 73 spaced therefrom and carrying a plurality of clamp screws 74 for clamping appropriate tools to the turret.

Each cross-slide 26—26' contains a cylinder bore 76—76' which coacts with a stationary piston 77—77' connected through a rod 78—78' with a lug 79—79' on the supporting carriage 24—24' to effect horizontal movement of the cross-slide toward and from the longitudinal axis of the work. Each rod 78—78' contains a liquid conducting passage 80—80', which communicates with the forward end of the bore 76—76', and a second passage 81—81', which communicates with the rear end of the bore, through which each cross-slide is hydraulically actuated. A stop collar 82—82' on each rod 78—78' limits the rearward movement of the cross-slide (see Fig. 1) and an adjustable stop screw 83—83' on each cross-slide coacts with a lug 84—84' on the supporting carriage to limit the forward movement thereof. Each cross-slide is also movable with its supporting carriage 24—24' along the ways 22 in a direction parallel to the axis of the work. Adjustable stops 85—85' on the ways limit the movement of the carriages 24—24' in a direction away from the headstock and hydraulically urged plungers 86—86' in the headstock yieldably maintain the carriages against these stops. In this instance each plunger 86—86' is closely fitted in a horizontal bore 87—87' in the headstock, each bore being maintained flooded with liquid under pressure through a pipe 88—88' from a source to be later described.

The feed cylinder 56 of the main carriage 23 and the feed cylinders 76 and 76' of the cross-slides 26 and 26' are supplied with driving liquid from an appropriate variable displacement pump 89. The pump shown in Figs. 1, 2, and 19A is of the type described and claimed in Patent No. 1,854,127 issued April 12, 1932 to Walter Ferris. It is driven at constant speed from any appropriate power source through a drive shaft 90, and delivers liquid under pressure and at variable rates into either of the two main circuit pipes 91 and 92. The rate and direction of pump discharge is controlled by the application of fluid pressure to the several control pipes 93, 94, 95 and 96. When no pressure exists in any of these pipes pump displacement is zero and there is no flow in pipes 91 and 92. When pressure is established in pipe 93 the pump discharges at a high rate into pipe 91; when pressure is established in pipe 94 the pump discharges at a high rate into pipe 92; when pressure is established in pipe 95 the pump discharges into pipe 91 at a relatively low rate determined by the setting of a longitudinally adjustable stem 97; and when

pressure is established in pipe 96 the pump discharges into pipe 91 at a relatively low rate determined by the setting of a similar stem 98. The pump also maintains a predetermined pressure in a pipe 99 leading therefrom irrespective of the conditions in the circuit pipes 91 and 92 or in the control pipes 93, 94, 95 and 96. Since the various instrumentalities for effecting the above functions are fully described in the patent hereinabove identified a further detailed description thereof is deemed unnecessary.

In this instance however the adjustment of the stems 97 and 98 is effected in a new manner. Each is shown mounted for vertical adjustment in hollow bosses 100 provided on the top of the pump housing, and each is penetrated by a horizontal wedge bar 101—102 which rides upon the associated boss and projects through a slot 103—104 in each stem. The stems may thus be independently raised or lowered by longitudinal adjustment of the wedge bars therein.

The several control pipes 93, 94, 95 and 96 are controlled by an appropriate valve 105 which in this instance is mounted in the side of the pump casing as indicated in Figs. 1 and 2. This valve, which is shown in section in Figs. 19A, 20 and 21, is substantially identical with the main control valve described in detail in the patent hereinabove identified. It comprises a housing having a cylindrical bore containing five spaced annular grooves 106, 107, 108, 109 and 110. Grooves 106, 107, 108, and 110 are permanently connected to control pipes 93, 95, 96 and 94, respectively, and groove 109 is connected to the pressure pipe 99. A hollow piston valve having two spaced heads 111 and 112 connected by a reduced portion 113 is closely fitted for lengthwise movement in the bore, the space surrounding the reduced portion being always exposed to the pressure in the pipe 99 and groove 109. The two ends of the bore communicate through the hollow valve and both are thus open to an exhaust pipe 114 at one end of the bore. Thus in the position shown in Fig. 19A the control pipes 93, 95 and 96 are exposed to the pressure in pipe 99 and the control pipe 94 is open to the exhaust pipe 114. By shifting the valve toward the right from this position the pipes 93, 95 and 96 are opened successively to the drain pipe 114 and when the valve reaches its right extreme position the pipe 94 is exposed to the pressure in pipe 99.

The valve is provided at one end with an operating stem 115 actuated by mechanism to be later described under the control of the main carriage. In this instance it is also equipped with a hydraulic attachment automatically operable to shift the valve element from right extreme position into the left extreme position of Fig. 19A and to check or retard the return movement thereof into the right extreme position. This attachment comprises a plunger 116 attached to the right end of the valve element and closely fitted for reciprocation in a bore formed in an extension housing 117. This plunger is provided with a reduced portion 118 and an end head 119. The bore contains three annular grooves 120, 121 and 122. A pipe 123 connects grooves 120 and 122. This pipe is also connected to a pipe 124 which is exposed either to pressure or exhaust under control of a valve 125 to be later described. A pipe 126 connects groove 121 with a port 127 in the rear end of the bore. A pipe 128, controlled by a cut-off valve 129, connects pipes 126 and 123, and a pipe 130, controlled by a needle valve 131, connects pipes 128 and 123. The pipe 128 also contains a normally open piston valve 325 to be later described. Valve 129 is controlled by a lever arm 129' by mechanism to be later described to open or close communication through pipe 128, and the needle valve provides a variable choke for controlling the rate of flow through pipe 130. The arrangement is such that when the piston of the main valve and the plunger 116 are in the right extreme position of Fig. 21, and the pipe 124 is exposed to pressure, this pressure is transmitted through grooves 120, and 121, pipe 126 and port 127 to the end of the plunger to shift the plunger 116 and the piston of valve 105 toward the left. As the head 119 of the plunger in its movement toward the left passes beyond the groove 122, this pressure is transmitted to the end of the plunger directly through this groove. This movement therefore continues until the main valve assumes the position shown in Fig. 19A.

Movement of the piston of valve 105 toward the right is effected by the stem 115. When there is no pressure in the pipe 124 and when the valve 129 is in the open position of Figs. 19A and 21, the plunger 116 offers no resistance to movement in this direction since in all positions thereof the end of the bore communicates with pipe 124 through the port 127, pipe 128 and groove 120. When the valve 129 is closed, however, as indicated in Fig. 20, movement of the piston 116 toward the right is checked when it reaches the position shown in Fig. 20, since grooves 121 and 122 are then covered by the head 119 and the liquid in the end of the bore can escape only through pipe 130 and at a slow rate, as determined by the setting of the needle valve 131. The piston and valve then moves very slowly until the groove 121 is uncovered after which the liquid may escape from the end of the bore through pipe 126 and grooves 121 and 120. The delay thus effected is for a purpose which will later appear.

As indicated in Figs. 19 and 19A the main circuit pipe 91 leading from the pump is connected to the rear end of the feed cylinder 56 of the main carriage, and a pipe 132 from the forward end of this cylinder leads to a switch valve 133 which controls the operation of the rear cross-slide 26. A pipe 134 from the switch valve 133 leads to a second switch valve 133' which controls the operation of the front cross-slide 26'. The other main circuit pipe 92 leads from the switch valve 133' back to the pump. A by-pass connection 135 between pipes 91 and 132, controlled by a two-way pressure relief valve 136, permits a flow of liquid between these pipes whenever the piston 55 becomes stalled; a similar by-pass connection 137 between pipes 132 and 134, controlled by a two-way relief valve 138, permits a flow of liquid between these pipes whenever the flow through valve 133 is blocked; and a similar by-pass connection 139 between pipes 134 and 92, controlled by a two-way relief valve 140, permits a flow of liquid between these pipes whenever the flow through the valve 133 is blocked.

The two switch valves 133 and 133' are substantially similar. Each comprises a casing having a cylindrical bore with three annular grooves 141, 142, and 143 formed therein. Pipe 132 communicates with the middle groove 142 of valve 133, and pipe 134, leading from the upper end of the bore of this valve, communicates with the middle groove 142 of valve 133'. Pipe 92 communicates with the upper end of the bore of valve 133'. A pipe 144 leading from groove 141 of valve 133 com-

municates with the rear end of cylinder 76 through the passage 81 in the piston rod 78, and a pipe 145 leading from the groove 143 communicates with the forward end of cylinder 76 through the passage 80. Similarly a pipe 144' leading from groove 141 of valve 133' communicates with the rear end of cylinder 76' through passage 81', and a pipe 145' leading from the groove 143 of valve 133' communicates with the forward end of cylinder 76' through passage 80'. A piston valve having four spaced heads 146, 147, 148 and 149 is mounted for lengthwise movement in each bore. This valve contains a longitudinal passage 150 through which communication is maintained between the ends of the bore. Passage 150 also communicates with the space between the central heads 147 and 148 of the valve through a port 151 therein. It will be noted that the upper end of the piston is of greater area than the lower end thereof so that the pressure supplied through pipe 92 urges the piston downwardly.

With the piston valve of each in the intermediate position shown in Fig. 19 grooves 141 and 143 are open to the dead spaces between heads 146 and 147 and heads 148 and 149, respectively, so that the pipes leading therefrom to the cylinders 76 and 76' are effectively blocked, but the intermediate groove 142 is open to the upper end of the bore, so that pipe 132 communicates with pipe 134 and pipe 134 with pipe 92. Thus with both valves in intermediate position the piston 55 of the main carriage may be operated in either direction while both cross-slides remain at rest. When the piston of valve 133' is elevated into the position shown in Fig. 16 pipe 134 communicates with pipe 145' so that liquid is fed into the forward end of cylinder 76' to advance the front cross slide 26', and pipe 144' communicates with pipe 92 through the port 151 and passage 150, so that liquid discharged from the rear end of cylinder 76' may flow back to the pump. Similarly when the piston of this valve is lowered into the position shown in Fig. 17, pipe 134 is opened to pipe 144' and pipe 145' is opened to pipe 92 so that the cross-slide 26' is retracted. In a similar manner the rear cross-slide 26 may be advanced or retracted by elevating or lowering the piston of valve 133. The piston of each valve is actuated and controlled by a stem 152—152' connected therewith and placed under the control of mechanism to be hereinafter described.

From the foregoing it will be noted that by adjustment of the switch valves 133 and 133' in the manner described either or both of the cylinders 76 and 76' may be connected in series with the cylinder 56 for operation at a definite rate dependent upon the rate of flow in the pipes 91 and 92. It will also be remembered that the rate and direction of this flow is determined by adjustment of the pump 89.

In the machine shown the two switch valves 133 and 133' are fixed to an appropriate bracket 153 projecting from the rear side of the bed 20, as indicated in Fig. 4, and are placed under the control of mechanism carried by and movable with the main carriage 23. This mechanism comprises a drum 154 fixed to and rotatable with a shaft 155 horizontally journalled in appropriate brackets 156 projecting from the rear side of the main carriage. The forward portion 157 of the drum is substantially cylindrical and so positioned that when the main carriage is in retracted position, the outer ends of the stems 152 and 152' of the valves 133 and 133' rest thereon with the valves in the intermediate position shown in Fig. 19. (See Figs. 3, 4 and 19.) The rear portion 158 of this drum is fashioned to receive five longitudinal cam rails 159, symmetrically disposed about the periphery of the drum for coaction with the stem 152 of valve 133, and five longitudinal cam rails 159' intermediate the rails 159 for coaction with the stem 152' of valve 133'. By intermittent rotation of the shaft 155 the drum is indexed to bring the rails 159 and 159', successively, into coacting relation with their respective valve stems. The outer or active edge of each rail is given any desired contour to effect elevation or depression of the coacting valve stem and valve at any point or points desired in the advance of the main carriage. For instance the rail 159 shown in Fig. 19 has an elevated portion 160 which, as the rail advances, elevates the valve so as to open communication between pipe 132 and the forward end of cylinder 76 to effect advance of the cross-slide 26; although any of the rails may have a depressed portion 161 such as is provided in the rail 159' shown in Fig. 19, which will permit the coacting valve to assume a depressed position. In this latter instance the depressed portion is actually covered by an automatic gate 162 which is shown in detail in Figs. 16, 17, and 18.

This gate is in the form of a horizontal lever 162 rockably supported on a horizontal pivot pin 163 and having a forward inclined end 164 which rests upon the edge of the rail in advance of the depressed portion. A spring 165 acting on the other end of the lever yieldably retains the same in the position shown so that, as the rail advances, the valve stem 152' is elevated thereby. In this instance the rail coacts with a laterally bent portion 166 on the end of the stem. This portion 166 rides on the lever 162 until it reaches an opening 167 provided therein, at which point it drops through this opening onto the depressed portion 161 to thereby reverse the valve 133', as indicated in Fig. 17. This occurs substantially as the main carriage 23 reaches the forward limit of an advance movement. Upon reversal of the main carriage the rail 159' moves toward the right and the stem 152' climbs out of the depressed portion and passes beneath the end 164 of the gate to thereby return the valve 133' into its neutral position.

The shaft 155 carrying drum 154 is intermittently rotated through successive angles of seventy-two degrees to thereby index the drum and bring the several cam rails 159 and 159' successively into coacting relation with their respective valve stems 152 and 152'. This rotation occurs while the main carriage 23 is retracted and while the valve stems are resting upon the forward cylindrical portion 157 of the drum where they do not interfere with this rotation. This rotation is imparted to the shaft 155 from the turret 28 on the main carriage 23 through appropriate gearing shown particularly in Fig. 7. This gearing includes a ring gear 168 fixed to the base 32 of the main turret and meshing with a pinion 169 fixed to the upper end of a vertical shaft 170 journalled in the main carriage. The lower end of shaft 170 carries a large spiral gear 171 which meshes with a small spiral gear 172 keyed or otherwise fixed to the shaft 155. The gear ratios are such that each seventy-two degree rotation of the main turret imparts a seventy-two degree rotation to the shaft 155 and drum. A second gear train including a pinion 173, meshing with ring gear

168 on a vertical shaft 174, and a spiral gear 175 on vertical shaft 174, meshing with a spiral gear 176 on a horizontal shaft 177, imparts intermittent rotation through successive seventy-two degree angles to the shaft 177 in a similar manner. Shaft 177 is journalled in appropriate brackets 178 on the front side of the main carriage 23, and carries a drum 179 which coacts with mechanism such as will be later described for operating and controlling the pump control valve 105 hereinabove described.

The drum 179 is five sided and is provided with five longitudinal flanges or rails 180 which extend along the lower margin of each face (see particularly Figs. 10 to 13). A cam plate 181 of appropriate form is fixed to each face of the drum above and spaced from the lower rail 180 thereof, the upper edge 182 of each plate being of stepped form to provide a cam surface for coaction with a roller or pin 183 which projects horizontally from the conical end 183' of the head 184 of a lever mechanism to be later described. A plate 185 mounted upon the brackets 178 in advance of the drum 179 carries a fixed lower rail 186 positioned to register with one of the drum rails 180 in each rotative position of the drum. This plate also carries a cam plate 187 fixed against the rail 186 and having an inclined edge 188 sloping toward the drum and to the rail 186. A disappearing upper rail 189, rockably supported on upright arms 190 pivotally mounted behind the plate, normally projects through a longitudinal slot 191 in the plate above the cam plate 187. In its normal position the upper edge of this rail 189 registers with the upper edge of one of the cam plates 181 on the drum. The plate 185 is so positioned as to receive and support the cam roller or pin 183 when the main carriage 23 is in retracted position so that the drum 179 may then be rotated without interference with this roller.

The roller carrying head 184 is mounted on the end of an extension 192 of a lever 193 which is rockably supported upon a horizontal pivot pin 194 anchored in the outer end of an appropriate bracket 195 projecting from the front of the bed 20 of the machine. The extension 192 is connected to the lever 193 through an upright pivot pin 196 and is yieldingly urged by a spring 197 toward the drum 179 and plate 185. The lever 193 carries a depending arm 198 whose lower end is connected to the stem 115 of the main control valve 105 through an appropriate link 199. The lever 193 is urged downwardly by a tension spring 200 between the arm 198 and bracket 195. The head 184 also carries an appropriate handle in the form of a knob 201 by which the lever 193 and extension 192 may be manipulated by the attendant. It will be noted that by swinging the extension 192 outwardly about the pivot pin 196 the cam roller 183 may be made to clear the drum 179 and plate 185 and, when so withdrawn, it may be raised or lowered at will to thereby adjust the valve 105 to any position desired to change the rate or direction of table movement.

The arrangement is such that during the return movement of the main carriage 23 the cam roller 183 normally rides from right to left (Figs. 10 and 11) upon one of the lower rails 180 of the drum and onto the lower rail 186 of the plate until it reaches and climbs upwardly upon the inclined edge 188 of the cam plate 187. During its travel along the rails 180 and 186 the lever 193 assumes a lower extreme position and the piston of the pump control valve 105 assumes a right extreme position of Fig. 21, in which position the pump control pipe 94 is exposed to the pressure in pipe 99 and the pump discharges at a high rate into the main circuit pipe 92. As the cam roller 183 climbs upwardly upon the inclined edge 188, the lever 193 rises and the piston of valve 105 moves toward the left until it reaches an intermediate position wherein no pressure exists in any of the control pipes 93, 94, 95 or 96, so that pump discharge is reduced to zero and the main carriage comes to rest. The drum 179 is then rotated, under the action of the gear train hereinabove described, through an angle of seventy-two degrees to thereby align the next cam plate 181 thereof with the plate 185. The main carriage 23 is then ready to start an advance movement which is initiated by elevating the lever 193 until the cam roller 183 has passed upwardly to a point above the upper rail 189 on the plate 185. As the roller 183 is thus elevated it engages the rail 189 upon the bevelled face 202 thereof, forces it backward through the slot 191 in the plate 185 and passes above it. The rail 189 then swings forward into its normal position beneath the roller, as shown in Fig. 12. In this upper position of roller 183 and lever 193, the piston of valve 105 assumes the left extreme position shown in Fig. 19A in which position the three control pipes 93, 95 and 96 are exposed to the pressure in pipe 99 so that the pump then discharges at a high rate into the main circuit pipe 91 causing the piston 55 and the main carriage 23 to advance rapidly. During the advance the cam roller 183 travels toward the right along the rail 189 and onto the upper edge 182 of the cam plate 181 until it reaches the first shoulder 203 thereof. The roller then passes over this shoulder and drops onto a depressed portion 182' of the cam plate causing the piston of valve 105 to shift slightly toward the right, so that the pressure in control pipe 93 is destroyed and the pump adjusted to discharge liquid into the pipe 91 at a lower rate determined by the setting of the stem 97. The rate of advance of the carriage is thus reduced and the carriage continues to advance at this new rate until the cam roller passes over the second shoulder 204 of the cam plate onto a further depressed portion thereof. When this occurs the piston of valve 105 is shifted further to the right to the position of Fig. 20, destroying the pressure in control pipe 95 and thereby adjusting the pump so that it discharges at a lower rate into pipe 91, this rate being determined by the setting of stem 98. The carriage continues to advance at this further reduced rate until the cam roller passes over the end of the cam plate 181 and drops onto the lower rail 180. When this occurs the piston of valve 105 is returned into its right extreme position of Fig. 21 to thereby destroy the pressure in pipe 96 and establish pressure in pipe 94 so that the pump then delivers liquid into the pipe 92 at a rapid rate and the carriage starts a rapid return movement.

The roller carrying head 184 also carries a diagonally disposed guard finger 205 for the cam roller 183. This finger lies against the conical end 183' of the head and is formed with a tapered end 206 disposed adjacent and in advance of the roller. The shoulders 203 and 204 as

well as the end of each of the several cam plates 181 are bevelled off, as indicated in Fig. 10, so as to coact with the outer edge of the finger 205 to force the finger and roller outwardly from the cam plate to thereby clear the same, should the finger strike such shoulder or end during the return stroke of the carriage. This finger also coacts with the upper edge 182 of the cam plate, during the forward advance of the carriage, to support the lever 193 after the roller has passed one of the shoulders and until the finger has actually cleared that shoulder, to thereby effect a more abrupt lowering of the lever than would ordinarily result by a normal rolling action of the roller over the upper corner of that shoulder.

The advance of the main carriage 23 is limited by a stop 207 adjustably fixed on one of the ways 22. The length of each of the several cam plates 181 is such that the cam roller 183 and finger 205 clear the end thereof an instant prior to impingement of the carriage against this stop, provision being made for delaying the return of the piston of valve 105 to its extreme right position, so that actual reversal of carriage movement is delayed. The carriage is thus held in advanced position against the stop 207 for a period of sufficient length to permit the tool, then operating on the work, to finish and smooth up the cut. This delay is effected in the manner hereinabove described by moving the valve 129 into the closed position shown in Fig. 20. To accomplish this automatically the stop 207 carries a depending lever 208 rockably supported thereon and connected through a link 209 with the arm 129' of the valve 129. This link extends through a lug 210 on the bed of the machine. A spring 211 between this lug and a collar 211' on the link cooperates with a stop collar 212 on the link to yieldably retain the valve in open position. A disk 213, fixed to the forward end of the shaft 177, carries one or more removable push pins 214 which, upon rotation of the shaft 177, may be so aligned as to strike and rock the lever as the carriage approaches the stop 207. This action of the lever transmitted through the link 209 and arm 129' closes the valve 129, the valve remaining closed until the return movement of the carriage has withdrawn the pin 214 from contact with the lever, when the valve automatically returns to open position under the action of spring 211. If on the next advance of the carriage and corresponding rotation of the shaft 177 there is no push pin aligned with the lever 208, then the valve 129 remains open and the carriage is promptly reversed.

Provision is made in the machine shown for advancing either or both of the auxiliary carriages 24 and 24' along the ways 22 toward the head stock 21. This movement is effected by the advance of the main carriage through mechanism which will now be described. For this purpose heads 215 and 215' are fixed to the forward ends of the shafts 155 and 177 respectively, each head being fashioned to removably receive one or more push pins, such as shown at 216' in Figs. 1, 2 and 19. (There are no corresponding pins actually shown in the head 215 because the particular work piece *a* does not actually require an advance of the auxiliary carriage 24.) The arrangement is such that upon rotation of the shaft 155 or 177 any one of the pins may be aligned with one of the push plungers 217 or 217' projecting rearwardly from the auxiliary carriages, respectively. Each plunger 217—217' is mounted within a bore 218—218' in its auxiliary carriage, each bore communicating through a passage 219—219' with the passage 80—80' leading to the forward end of the cylinder 76—76' of the associated cross-slide. (See Figs. 2, 3, and 19.) Each bore 218—218' is thus maintained flooded with liquid from passage 80—80' and the working pressure in the forward end of cylinder 76—76', thus transmitted to this bore, is sufficient to normally maintain the plunger 217—217' in the projected position shown.

Thus for example if one of the pins 216' is aligned with plunger 217' during an advance of the main carriage 23 it will strike the plunger and force the auxiliary carriage 24' away from its stop 85' and against the yielding resistance of the plunger 86' in the headstock. A sleeve 220' of appropriate length on the headstock and surrounding the plunger 86' serves to positively limit the advance of auxiliary carriage 24' in that direction. When further advance of the auxiliary carriage is thus arrested by engagement with the stop sleeve 220', continued advance of the main carriage 23 is permitted since the plunger 217' may recede into its bore 218' squeezing liquid therefrom against the working pressure in the passage 219'. Then when the main carriage executes a return movement the plunger 217' is returned to its normal projected position and the auxiliary carriage 24' is returned into position against its stop 85' under the thrust of the plunger 86'. A similar movement may be imparted to the rear carriage 24 whenever a properly positioned pin is inserted in the head 215.

As hereinabove pointed out the rate at which the pump 89 discharges into the circuit pipe 91, when control pipes 95 and 96 are exposed to pressure, is determined by the setting of the stems 97 and 98, these stems being adjusted by lengthwise movement of the wedge bars 101 and 102 respectively. These bars are automatically actuated and reset by the return movements of the carriage 23 through means which will now be described. Each bar is provided with a tail rod 221 closely fitted for lengthwise movement in a bore 222 formed in a block 223 carried by the housing of the pump. Both bores are connected through a pipe 224 and branch pipes 225 with one of the pump control pipes 94 (see Fig. 19A), so that, when pipe 94 is exposed to pressure to thereby cause the pump to discharge into the circuit pipe 92 and thereby cause the carriage to begin a return stroke, this pressure is transmitted to the bores 222 and the rods 221 and bars 101 and 102 are thrust forwardly. A guide bracket 226 for the bars coacts with shoulders 227 on the bars to limit this forward movement thereof. (See Figs. 1 and 2.) As indicated in Fig. 19A, a spring loaded check valve 228 within each branch pipe 225 yieldably resists the escape of liquid from the bores so that the rods 221 and bars are yieldably retained in this advanced position. A reversely arranged check valve 229 contained within each valve 228 permits a free flow of liquid therethrough from pipe 224 to the bores in the manner just described. With the bars 101 and 102 in fully advanced position the stems 97 and 98 are fully elevated and as the bars are retracted from this position the stems are lowered.

Provision is made for forcing each of the bars 101 and 102 rearwardly a predetermined distance upon each return stroke of the main carriage 23 to thereby reset the stems 97 and 98 and thus

predetermine the rates of pump delivery and the rates of feed motion for the main carriage during the next advance thereof. Mechanism for this purpose comprises five pairs of push pins 230 of various lengths removably mounted in a head 231 carried by the end of shaft 177 and so arranged as to be successively aligned with the forward ends 232 of the bars by rotation of the shaft 177. Thus upon each return movement of the carriage one of the several pairs of push pins 230 impinge upon and force the bars 101 and 102 rearwardly through distances dependent upon the lengths of those pins, the tail rods 221 forcing liquid from the bores 222 against the resistance of the spring loaded valves 228 and the pressure in pipe 224. Then when the piston of the main valve 105 is shifted to effect an advance of the main carriage the pressure in control pipe 94, and pipe 224, is destroyed so that the bars 101 and 102 retain these adjusted positions throughout the advance of the carriage.

The indexing of the two auxiliary turrets 29 and 29' is also effected, when required, by mechanism under the control of the main carriage 23 during the return stroke thereof. Mechanism for this purpose comprises a head 233 fixed to the rear end of shaft 155 and carrying removable push pins 234, which, upon rotation of the shaft 155, may be so aligned as to engage one side or the other of a cam head 235 on a lever 236, during the return of the carriage, to thereby rock this lever in either of two directions. This lever is rockably supported in an appropriate bracket 237 on the bed of the machine, and is connected to the stem 238 of a valve 239. This valve is shown in section in Fig. 19A. It comprises a housing having a cylindrical bore containing a piston having two spaced heads 240 and 241 connected by a reduced portion 242. A pipe 243 connected with pressure pipe 99 maintains liquid under pressure in the space surrounding the reduced portion 242. An exhaust pipe 244, connected to the opposite ends of the bore, leads to the casing of the pump 89. Two pipes 245 and 246 leading from the valve housing are controlled by the heads 240 and 241 respectively. Pipe 245 communicates with pipes 69 and 69' leading to one side of the hydraulic driving motors 68 of the auxiliary turrets; and pipe 246 communicates with pipes 70 and 70' leading to the other sides of these motors. With the piston of the valve 239 in the upper position of Fig. 19A pressure pipe 243 communicates with pipe 245 and pipes 69 and 69' to thereby rotate the turrets 29 and 29' in one direction, the motors discharging through pipes 70, 70' and 246 into the exhaust pipe 244. When the piston of this valve is shifted into its lower extreme position, by the action of one of the pins 234 upon the head 235 of the lever, pressure pipe 243 is connected to pipes 246, 70 and 70' to thereby rotate the turrets in the other direction, the motors thereof discharging through pipes 69, 69', 245 and 244. Appropriate cut off valves 68' provided within the pipe line 69 and 69' makes it possible to index either turret 29 or 29' to the exclusion of the other.

Indexing of the main turret 28 is also controlled by the main carriage 23 and is effected upon each return stroke of the carriage. Mechanism for this purpose includes a disk 247 formed as an integral part of the head 231 and having an extended hub 248 on the rear end of shaft 177, shown particularly in Fig. 10. As indicated in Fig. 14 the hub 248 contains a wide keyway 249 for cooperation with a long key 250 fixed in the shaft. This keyway is of such width as to permit rotation of the hub through an angle of seventy-two degrees, with respect to the shaft. A stop washer 251 fixed to the end of the shaft retains the hub thereon. A coil spring 252 is connected at one end to the hub and at its other end to one of the brackets 178. The spring 252 is under torsional stress and coacts with the key 250 to yieldably retain the hub and disk 247 in a definite rotative position on the shaft, and it is also under compressive stress so as to yieldably retain the hub against the stop washer 251. The disk 247 contains five perforations 253 adjacent the periphery thereof for receiving any of the four types of flanged bushings shown in Figs. 22, 23, 24 and 25. A hollow plunger 254 mounted within a bore 255 in the main carriage 23, has a reduced end 256 which normally projects rearwardly into alignment with and adjacent one of the perforations 253. A collar 257 fixed to the carriage limits the outward movement of this plunger. The plunger 254 contains a filler rod 258 of any desired length.

A stop rod 259 adjustably fixed by a set screw 260 in a bracket 261 on the machine is always aligned with the plunger 254. The stop rod 259 is formed with a longitudinal channel 262 which contains a rack bar 263 lengthwise movable therein. The forward end 264 of the rack bar is normally flush with the forward end 265 of the rod. The rack bar meshes with a broad faced pinion 266 journalled in an appropriate bracket 267 on the bed. The valve 125 hereinabove referred to is provided with an operating stem 268 having rack teeth which mesh with the pinion 266. When de-meshed from the pinion the rack bar 263 and the stop rod 259 may be adjusted longitudinally, as a unit, without disturbing the position of the valve stem 268. The rack bar 263 carries a rack dog 269 removably fixed thereto and capable of attachment at various points along the length thereof.

The bushing 270, shown in Fig. 22, contains a socket 271 adapted to receive the end 265 of the stop rod 259 only. When so engaged the rack bar 263 is forced rearwardly along the rod by contact of the end 264 thereof with the face of the bushing. The bushing 272, shown in Fig. 23, contains a socket 273 which is shaped to receive the end 264 of the rack bar as well as the end 265 of the stop rod, and when so engaged the rack bar retains its normal position with its ends 264 flush with the end 265 of the rod. The bushing 274, shown in Fig. 24, contains a keyhole slot 275 which permits free passage of the stop rod and rack bar therethrough, so that the rack bar is not moved until the dog 269 strikes the face of the bushing. The bushing 276, shown in Fig. 25 is provided with a similar keyhole slot 277 and the flange thereof is cut away as at 278 to avoid contact with the dog 269.

As the disk 247 is intermittently rotated by rotation of shaft 177 and spring 252 the five bushings are advanced successively into alignment with and between the plunger 254 and the stop rod 259. Whenever a bushing of the type shown at 276 is so aligned, the return movement of the carriage 23 continues until the stop rod 259 has projected through the bushing into the hollow plunger 254, and until the rod has engaged the filler rod 258 and thereby forced the plunger 754 inwardly. Just before the plunger actually reaches the end of the bore 255 the cam roller 183 has climbed upwardly on the edge 188 of the cam plate 187 so as to bring the carriage to rest in the manner hereinabove described. In this position of the

parts the dog 269 has entered the cut-away portion 278 of the bushing flange and the rack bar 263 has not been actuated. The inward movement of the plunger 254 however has set into action mechanism, to be later described, which automatically effects indexing of the main turret. Whenever a bushing of the type shown at 274 in Fig. 24 is aligned with the rod 259 the return movement of the carriage continues in a similar manner, but just before it comes to rest the dog 269 strikes the bushing and the rack bar 263 is forced rearwardly to thereby operate the stem 268 of the valve 125. This action of the valve 125 energizes the plunger 116 in a manner to be shortly described, to thereby shift the main control valve 105 and restart the carriage on an advance stroke. The turret indexing mechanism is of course again energized by the inward movement of the plunger 254 under the thrust of rod 259.

Whenever a bushing of the type shown at 270 in Fig. 22 is aligned with the rod 259 the return movement of the carriage continues until the rod, engaged in the bushing has forced the entire disk 247 forwardly along the shaft 177 and thereby forced the plunger 254 inwardly against the end of its bore 255, the rack bar 263 having been forced rearwardly by the engagement of the end 264 thereof with the face of the bushing. The main turret is again indexed due to this inward movement of plunger 254, and the carriage is again started on its next advance by the shifting of the rack bar. The functioning is thus much the same as when the bushing 274 is aligned with the rod, except that the carriage does not return its maximum distance. A similar effect is produced when a bushing of the type shown at 272 in Fig. 23 is aligned with the rod, the carriage making a short return stroke and the turret 28 being indexed, but the carriage is not automatically restarted on an advance stroke because the rack bar does not move, since the end 264 thereof enters the socket 273 with the rod.

The mechanism shown for effecting the automatic indexing of the main turret 28 will now be described. This mechanism includes the actuating plunger 54 for the index pin 53 and the rack plunger 50 hereinabove mentioned and shown in Figs. 5 and 19A. The plunger 54 is provided with four spaced heads 279, 280, 281 and 282 and is closely fitted for lengthwise reciprocation in a bore 283 formed in the carriage. A longitudinal passage 284 in the plunger connects the opposite ends of the bore, a check valve 285 therein permitting liquid to flow only from right to left therethrough. A duct 286 connects the right end of this bore with the enlarged portion 287 of a long bore 288 in the carriage. A pipe 289 fixed at one end 290 to the bed of the machine has a close sliding fit in the bore 288 in the carriage and is provided with a port 291 which is always open to the enlarged portion 287 of the bore in all positions of the carriage. A pipe 292 connects pipe 289 with pressure pipe 99 so that the duct 286 and both ends of the bore 283 are always flooded with liquid under pressure. Since the effective area of the left end head 279 of the plunger is reduced by the area of the index pin 53, connected therewith, the effective area of the other end head 282 is the greater, so that the plunger is normally urged toward the left by the hydraulic pressure in the bore 283. The index pin 53 is thus yieldably urged and held in the locking position shown. A duct 293 connects the left end of bore 283 with the bore 255 of plunger 254 so that this bore is also normally flooded with liquid under pressure and the plunger 254 is yieldably retained in the projected position shown.

The bore 283 contains five annular grooves 294, 295, 296, 297 and 298 which are controlled by the intermediate heads 280 and 281 of the plunger. A duct 299 connects groove 298 with the enlarged portion 300 of a second bore 301 containing a slide pipe 302 similar to pipe 289. Pipe 302 is connected to an exhaust pipe 303. Groove 298 is always open to the space between the plunger heads 281 and 282. Groove 294 which is always open to the space between the plunger heads 279 and 280 is also connected to the enlarged portion 300 of bore 301 through a duct 304. Groove 296 which is always open to the space between the intermediate plunger heads 280 and 281 is maintained flooded with liquid under pressure supplied through a duct 305 connected with duct 286. A duct 306 connects groove 295 with one end 307 of a bore containing the end head 308 of plunger 50, and a duct 309 connects groove 297 with the other end 310 of the bore containing the other end head 311 of plunger 50.

The arrangement is such that with the plunger 54 in the position shown the end head 308 of plunger 50 is exposed to pressure transmitted through ducts 305 and 306 to the bore 307, while the other end bore 310 is open to exhaust through the ducts 309 and 299. When the plunger 254 is forced inwardly under the thrust of the stop rod 259, in the manner above explained, liquid is forced from the bore 255 through duct 293 into the left end of the bore 283. Since the check valve 285 prevents escape of this liquid through passage 285 the plunger 54 is forced toward the right, so that the index pin 53 is withdrawn and the duct 309 is connected with the pressure carrying duct 305. This pressure transmitted to the end head 311 of plunger 50, shifts this plunger into its other extreme position to thereby unclamp the turret and rotate the same through an angle of seventy-two degrees in the manner hereinbefore explained. With the plunger 54 in this position duct 306 is connected with the exhaust duct 304 and the liquid from end bore 307 is free to escape therethrough. Then as the pressure in the bore 255 and duct 293 is relieved by ordinary leakage or by the subsequent advance of the carriage, the sustained pressure in the duct 286 and the right end of the bore 283 returns the plunger 54 into the position shown, thereby advancing the index pin 53 into the next hole 51 in the turret, and also reconnecting duct 306 with pressure duct 305 and duct 309 with exhaust duct 299 so that the plunger 50 is again returned to the position shown. This action of plunger 50 effects reclamping of the turret in the manner hereinbefore described and places the parts in position for the next indexing operation.

It will be noted that the main turret 28 is indexed while the main carriage 23 is retracted and while the stop rod 259 is engaged with one of the bushings in the disk 247. It will also be remembered that the shaft 177, carrying this disk, is rotated with and by the main turret. The wide keyway 249 in the hub 248 to the disk permits the shaft 177 to rotate within this hub, against the torsional resistance in the spring 252, while the disk is thus interlocked with the stop rod. When the disk is freed from the stop rod by the next advance of the carriage 23, it rotates under the action of spring 252 into its normal rotative position on the shaft 177. and

the next bushing is thus aligned with and between the plunger 254 and stop rod.

As hereinabove mentioned, automatic re-starting of the main carriage 23 after it has reached the end of a return movement is effected by the rearward shifting of the rack bar 263 and the consequent operation of the stem 268 of the valve 125, whereby the piston 116 connected with valve 105, is energized. The valve 125 will now be described. This valve, as shown in section in Fig. 19A, comprises a casing having a bore provided with three annular grooves 312, 313, and 314. A plunger having two spaced heads 315 and 316 is closely fitted for lengthwise movement in the bore and is connected to the stem 268. The intermediate groove 313 is always open to the space between the heads and is connected with the pipe 124 which leads to the groove 120 in the bore containing piston 116. The pipe 124 is divided into two branch pipes 124' one of which contains a check valve 317 which permits free flow of liquid toward the groove 313, and the other of which contains a needle valve 318 which provides a variable choke for retarding the flow of liquid from the groove 313. The groove 312 is connected through a pipe 319 with the pressure pipe 99, and the groove 314 is connected through a pipe 320 with the exhaust pipe 244.

The arrangement is such that when the plunger of valve 125 is in the lower position shown in Fig. 19A, pipe 124 is connected with exhaust pipe 244 through pipe 320 and no pressure exists therein. When the plunger is elevated by the action of the rack bar 263, pinion 266, and stem 268, pipe 320 is blocked from pipe 124 by the lower head 316 and pipe 124 is connected through pipe 319 with the pressure pipe 99. Liquid then flows at a slow rate past the needle valve 318 and into the bore containing piston 116, to thereby shift the plunger of the main control valve 105 toward the left in the manner hereinabove described. The carriage 23 is thus restarted on an advance stroke. By regulation of the needle valve 318 the time required to thus shift the valve 105 into carriage advancing position may be varied at will to thereby allow ample time to complete the indexing of the main turret 28.

As previously pointed out the switch valves 133 and 133' are shiftable to connect either or both feed cylinders 76 and 76' of the cross-slides in series with the feed cylinder 56 of the main carriage 23 and, when so connected, either or both cross-slides as well as the main carriage are simultaneously reversed whenever the pump 89 is reversed. Since the pump is controlled by the main carriage, reversal of the cross-slides may occur prematurely, should the main carriage complete its advance stroke before the cross-slides have reached the limits of their advance. To avoid this undesirable condition provision is made for making pump reversal contingent upon the cross-slides completing their movements. Although this may be accomplished in various ways a hydraulic system well adapted for the purpose will now be described. This system comprises a valve 325 interposed within the pipe line 128 between pipes 126 and 130. This valve is normally in the open position shown in Figs. 19A and 21, but, when in the closed position of Fig. 20, it prevents flow of liquid through pipe 128. In this instance this valve comprises a plunger, having two spaced heads 326 and 327 connected by a reduced portion 328, closely fitted for lengthwise reciprocation within a cylindrical bore 329 of the valve housing. When in the right extreme position of Figs. 19A and 21 the space surrounding the reduced portion 328 permits a free flow of liquid through pipe 128, but when shifted into the left extreme position of Fig. 20 the head 327 blocks this flow.

The plunger of valve 325 is mechanically shifted toward the left by a rod 330 one end of which is slidably engaged within the stem 331 of the valve. The rod 330 contains a notch 332 for engagement with an appropriate spring loaded detent 333 in the stem. The other end of the rod 330 is connected to a lever 334 rockably supported on and depending from the stop 85, as indicated in Figs. 1 and 3. This rod extends through an appropriate lug 335 on the bed of the machine, and a spring 336 between lug 335 and a collar 337 on the rod coacts with a stop collar 338 to yieldably retain the lever and rod in the position shown in Fig. 3. A disk 339 carried by the shaft 155, and indexed therewith, is adapted to receive one or more push pins 340, which may be so aligned with the lever 334 as to engage and rock the same as the main carriage 23 approaches the end of its advance. When so actuated the rod 330 is shifted longitudinally and this movement, transmitted to the valve stem 331 through the notch 332 and detent 333, causes the valve 325 to assume the closed position of Fig. 20. When thus closed the flow through pipe 128 is blocked and the main control valve 105 is effectively held against shifting beyond the position shown in Fig. 20 by reason of the body of liquid thus trapped ahead of the piston 118.

The valve 325 remains in this closed condition until both cross-slides as well as the main carriage have reached the ends of their advance movements, at which time the valve 325 is reopened by hydraulic means now to be described. This means comprises three pressure responsive valves 341, 342, and 342' connected with the cylinders 56, 76 and 76', respectively. (See Figs. 19 and 19A.) A pipe 343 connected with the pressure pipe 88' leads to valve 342'; a pipe 344 leads from valve 342' to valve 342; a pipe 345 leads from valve 342 to valve 341; and a pipe 346 leads from valve 341 to the left end of the bore of valve 325. Each valve 341, 342 and 342' includes a piston 347 which is yieldably held by a spring 348 in the advanced position shown so as to normally block the flow through pipes 343, 344, 345, and 346. A plunger 349, projecting from one face of the piston 347, is exposed to the hydraulic pressure in that end of the cylinder 56, 76, or 76' to which the valve is attached. This plunger tends to retract the piston against the pressure of spring 348. A second smaller plunger, projecting from the opposite face of the piston 347 of each of the valves 342 and 342', is exposed to the hydraulic pressure in the opposite end of the cylinder 76 or 76' and functions to oppose the thrust of plunger 349, so that the piston in each instance is made to respond to the difference in pressures in the opposite ends of the cylinder to which the valve is connected. The ratio of the cross sectional areas of plungers on opposite ends of the piston of each of the valves 342 and 342' is preferably equal to the ratio of the effective areas of the two faces of the piston 77 or 77' with which the valve is associated. The piston 347 in each of the valves 342 and 342' is provided with a peripheral groove which, when the piston 347 is retracted, opens communication between the pipes 343—344 or 344—345, or so that, when the pistons of all three valves are retracted, pressure is transmitted through the pipes from pipe 88' to the valve 325

which is thereby shifted into the open position of Figures 19A and 21.

It will be remembered that the advance of the main carriage 23 and each of the cross-slides 26 and 26' are limited by positive stops. As each of these members stalls against its stop the pressure in the working end of its feed cylinder immediately increases over the pressure in the discharge end of that cylinder, the difference in pressure thus established in the opposite ends of each cylinder being sufficient to retract the piston 347 against the pressure of spring 348; so that when all three have stalled against their respective stops, the three valves 341, 342, and 342' have been opened and the piston 327 of valve 325 is returned to the open position of Figures 19A and 21. When this occurs liquid may then escape from the rear end of the housing 117 through pipe 128, or pipes 128 and 130, to thereby permit the main control valve 105 to assume the position of Fig. 21 and thus reverse the pump and cause the cross-slides and main carriage to begin their return strokes.

It will thus be noted that when a pin 340 is aligned with the lever 334 the valve 325 is automatically closed by the advance of the main carriage to thereby prevent reversal of the pump until this valve is again reopened, and this valve remains closed until the main carriage and the cross-slides have all reached the limits of their advance.

From the foregoing description it will be noted the main tool carriage 23 is advanced and retracted toward and from the work at accurately controlled rates dependent upon the rate and direction of flow of liquid from the pump 89 through the main circuit, which comprises pipes 91, 132, 134 and 92, the direction and rate of flow being determined at all times by the position of the primary control valve 105. During each advance this valve is controlled by the main carriage, through the lever 193, roller 183 and one of the cam plates 181 carried thereby and advancing therewith. The first portion of each advance (which is an idle motion by which the tool is carried to the work) is executed at a rapid rate with the valve in the left extreme position of Fig. 19A, after which the rate is reduced to a feed rate appropriate for the particular work in hand by automatically shifting the valve toward the right into an intermediate position. A further reduction in the rate of advance is effected automatically by further shifting of the valve toward the right into a second intermediate position shown in Fig. 20. This second intermediate position is ordinarily utilized only when the latter portion of the cut is heavier than the first portion and thus requires a slower feed motion, as for instance when a cut runs into a heavy fillet.

The two different rates of feed available in the two intermediate positions of the valve, just mentioned, are predetermined by suitable adjustment of the control stems 97 and 98 effected in the manner hereinabove described. The points at which these changes in rates of advance occur depend of course upon the shape of the particular cam plate 181 employed, and in the absence of a cam plate the valve 105 shifts from the left extreme position of Fig. 19A into the right extreme position of Fig. 21, as the roller 183 passes over the right hand end of the upper rail 189 onto the left hand end of one of the lower rails 180 of the drum 179, to thereby reverse the motion of the carriage. Automatic reversal also takes place in a similar manner when the roller 183 passes over the end of a cam plate 181 and drops onto a lower rail 180 of the drum 179. This type of cycle is employed to repeat the indexing and bring the turret around past an idle position.

It will also be noted that provision is made for automatically delaying this reversal, when desired, in order that the tool may be held against the work for an interval of time sufficient to permit it to finish and smooth up a facing cut. In the machine shown mechanism for this purpose includes the positive stop 207 (Figs. 1 and 2) which accurately limits the advance of the carriage to thereby accurately gauge the extent or depth of cut and which also supports the lever 208, connected to the operating arm 129' of the valve 129 (Figs. 19A to 21) and depending into the path of advance of the push pin 214 carried by the carriage. As the carriage approaches the stop 207 the lever 208 is engaged by the advancing pin 214 and swung toward the left to thereby rock the valve 129 into the closed position shown in Fig. 20. The carriage continues to advance until arrested by engagement with the stop at which time the cam roller 183 has cleared the end of the cam plate 181 and is ready to fall onto the rail 180 to thereby shift the valve 105 toward the right. When valve 129 is closed however and the control valve 105 and piston 116 have reached the position shown in Fig. 20 the liquid ahead of the piston 116 can escape only through the needle valve 131, the grooves 121 and 122 being closed by the head 119, so that further movement of the valve and piston toward the right is effectively delayed for a time interval dependent upon the setting of the needle valve. During this time interval the pump 89 continues to deliver liquid through the pipe 91 to the rear end of cylinder 56 thereby forcibly holding the carriage against the stop 207, the relief valve 136 permitting liquid to escape through pipes 132, 134 and 92 back to the pump but maintaining a predetermined pressure within the pipe 91 and cylinder. When the valve 105 and piston 116 have finally moved toward the right from the position of Fig. 20 to uncover the groove 121, the liquid ahead of the head 119 is free to escape therethrough into the pipe 124, and the movement of the valve 105 is thereafter promptly completed and the carriage begins a return stroke.

In the machine shown the carriage 23 may execute either a long return stroke, when such is necessary to clear the tool from the work, or a short return stroke, and in either case it may remain at rest when it reaches the end of the return stroke or it may be automatically re-started on the next advance stroke. A long return stroke is effected whenever a hollow bushing of the type shown at 274 in Fig. 24 or at 276 in Fig. 25 is aligned with the stop rod 259, since the rod may then enter the hollow plunger 254 through such a bushing. In the case of a long return stroke the carriage is automatically brought to rest by the return of the valve 105 into neutral position under the action of the cam 183 as it rides upwardly along the edge 188 of the cam plate 187. This action being timed to stop the carriage as the re-starting dog 269 enters the notch in the bushing (Fig. 25). If re-starting is required a bushing without a notch is used, as shown in Fig. 24, thus causing dog 269 to operate valve 125 as already explained. A short return stroke is effected whenever a blind bushing of the type shown at 270 in Fig. 22 or at 272 in Fig. 23 is aligned with the stop rod 259 and prevents entry of the rod into the plunger 254. In the case of

a short stroke the carriage comes to rest by stalling against the stop rod 259 when the plunger 254 strikes the end of the bore 255. Automatic re-starting is effected whenever the rack bar 263 is actuated and the valve 125 thereby shifted in such direction as to transmit liquid under pressure through pipe 124 to the end of the piston 116 to thereby return the valve 105 into the left extreme position of Fig. 19A in the manner hereinabove described. This occurs whenever a bushing of the type shown at 270 is aligned with the rod 259.

It will also be noted that the main turret 28 is automatically indexed as the carriage 23 completes each return stroke. This action is initiated by the inward movement of the plunger 254 in its bore 255 under the thrust of the stop rod 259 and by which liquid is forced from the bore 255 into the left end of the bore 283 to effect withdrawal of the index pin 53 from locking engagement with the turret. When the pin 53 is thus withdrawn the actuating plunger 54 thereof, acting as a valve, admits liquid under pressure to the end 311 of the rack plunger 50 to operate the same and the sleeve 37 in such direction as to rotate the turret into the next position. The index pin 53 is then returned into interlocking engagement with the turret under the action of its plunger 54 and this plunger, again acting as a valve, admits liquid under pressure to the head 308 of the rack plunger 50 whereby the plunger 50 and sleeve 37 are returned into position in readiness for the next indexing operation.

It will be further noted that either or both of the auxiliary carriages 24 and 24' may be advanced and retracted along the ways 22, so as to effect a feed motion thereof parallel to the axis of the work. This is effected when desired by the bodily advance and retraction of the main carriage 23. For instance the carriage 24' is advanced whenever a push pin 216', (Figs. 1, 2 and 19) carried by the main carriage 23, is aligned with a push plunger 217' carried by the carriage 24', so as to engage the same and thereby force the carriage 24' to travel with the main carriage. Upon the next return stroke of the main carriage, carriage 24' is returned against its stop 85' under the yielding thrust of plunger 86'. The carriage 24' is limited in its advance by the stop collar 220', the hydraulic pressure on the plunger 217' permitting the main carriage to continue its advance after the advance of carriage 24' has thus been positively arrested.

Either or both cross-slides 26 and 26' may be fed either toward or from the axis of the work during either the advanced or return motion of the main carriage, by shifting either of the switch valves 133 or 133' in either direction from the neutral position shown in Fig. 19. This is accomplished automatically by the cam rails 159 and 159' carried by and movable with the main carriage. When either is elevated during the advance of the main carriage the cylinder 76 or 76' of the corresponding cross slide is connected in series with the cylinder 56 of the main carriage 23 and advances at a rate corresponding to the rate of advance of the main carriage. Whenever either of these valves is elevated during the return movement of the main carriage 23 the corresponding cross-slide is retracted in a similar manner. Similarly when either of these valves is lowered during the advance of the main carriage the corresponding cross-slide is retracted, and during the return movement of the main carriage the corresponding cross-slide is advanced. The advance of each cross-slide is limited by an adjustable stop in the form of a screw 83—83' and coacting stop lug 84—84', and the return stroke of each is limited by a replaceable collar 82—82' of appropriate length. The stroke of each is short as compared with the stroke of the main carriage and each ordinarily stalls at both ends of its stroke before the corresponding stroke of the main carriage is completed. The main carriage is permitted to complete its stroke in every instance by virtue of the relief valves 138 and 139 which bridge across the valves 133 and 133', respectively. These valves are set to open at pressures less than those required to open the two-way relief valve 136 bridged across the cylinder 56 of the main carriage.

The cam rail 159 shown in Fig. 19 is designed to effect an advance of the cross-slide 26 toward the axis of the work when the main carriage 23 is advancing and to retract that cross-slide during the return of the main carriage. So long as the stem 152 of the valve 133 is riding on the low portion of cam 159 valve 133 remains in neutral position and the cross-slide is inactive, but as this cam advances with the main carriage, the stem 152 climbs up onto the high portion 160 of the cam and the cross-slide starts to advance. This advance continues until arrested by engagement of screw 83 with stop 84 on the carriage 24 (Fig. 1). Then when the main carriage reverses the cross-slide starts back, by reason of the reversal of flow in the main circuit, this return stroke continuing until the cross-slide is arrested by the collar 82.

The cam rail 159' is designed to impart a back and forth cross movement to the cross-slide 26' in addition to the movement imparted to it by the movement of its carriage 24' back and forth along the ways 22. In this instance the advance of cross-slide 26' toward the axis of the work is initiated by the action of the stem 152' of valve 133', as the laterally bent end 166 thereof climbs up the inclined end 164 of the gate 162, during the advance of the rail 159' with the main carriage. (See Figs. 16, 17, 18 and 19.) This cross-slide then advances until arrested by the engagement of screw 83' with stop 84'. Thereafter the main carriage continues to advance, the push pin 216' striking plunger 217' of the carriage 24' and advancing the carriage 24' and cross-slide 26' with it along the ways 22. This condition continues until the end 166 of the stem 152' drops through the opening 167 in the gate 162 thereby shifting valve 133' into the lower position of Fig. 17 and cause the cross-slide to begin a return stroke, away from the work. This occurs as the main carriage 23 reaches the forward limit of its advance. The return stroke of main carriage is then delayed by valve 129 which is closed by lever 208 and push pin 209 as already explained. This delay is timed by adjustment of needle valve 131 to be sufficient to permit completion of out-stroke cross-slide before the return stroke of the main carriage begins. When the carriage 23 begins its return stroke the end 166 of the stem 152' rides upwardly from the depressed portion 161 of the cam 159' and passes under the end 164 of the gate onto the intermediate portion of the cam to thereby return the valve 133' into the neutral position of Fig. 19. The cross-slide then remains in its retracted position while the carriage 24' on which it is mounted returns into position against the stop 85'. The cross-slide 26' has thus been made to

execute a "picture frame" movement, first toward the axis of the work, then parallel thereto and toward the head stock, then away from the work, and finally parallel to the work and away from the head stock.

It will also be noted that in the machine shown both auxiliary turrets 29 and 29' may be simultaneously indexed by rotating them through an angle of ninety degrees in one direction or the other under the control of valve 239, which may be automatically shifted into either of two positions during the return stroke of the main carriage 23 by the action of a push pin 234 upon the cam end 235 of the control lever 236. When shifted into the upper position of Fig. 19A this valve admits liquid under pressure from pipe 243 to pipe 245 and pipes 69 and 69' to thereby energize the hydraulic motors 68 and 68' and effect rotation of both turrets in one direction through their respective worm and worm wheels 64 and 63. The rotation of each is limited by the coacting lugs 71 and stops 72 (Fig. 9) and each is locked in this position by the worm and worm wheel and by the pressure in pipes 69—69' upon the hydraulic motor 68—68'. This new position of each is retained until the valve 239 is returned into the lower position of Fig. 1 by the action of another of the push pins 234, when the pressure pipe 243 is thereby connected to the pipes 246, 70 and 70' and both turrets are reversely rotated through the same angle and in a similar manner. In cases where only one of the auxiliary turrets is to be indexed, appropriate shut off valves 68—68' may be employed in the pipes leading to that indexing motor which it is not desired to operate.

It will be further noted that the machine shown is capable of carrying out several successive stages of a complete cycle wholly automatically. That is,—the main carriage 23 may be made to automatically execute five advance strokes and five return strokes, the first advance stroke being initiated by the attendant by lifting the knob 201 and elevating the roller 183 onto the top rail 189 of the plate 185. Thereafter the main carriage may be automatically reversed in the manner previously described at the end of each advance stroke and also automatically restarted at the end of each return stroke except the last. At the end of the last stroke it ordinarily remains at rest. Also the main turret 28 is automatically indexed at the end of each return stroke.

Also the operating characteristics of the main carriage 23, the auxiliary carriages 24 and 24', and the cross-slides 26 and 26' are predetermined for each stage by mechanism which is automatically reset during the return stroke of the next preceding stage. This mechanism includes the two shafts 155 and 177 which are carried by and with the main carriage and which are indexed by and with the main turret 28. Thus when it is desired to delay the reversal of the main carriage at the end of its advance a push pin 214 is so positioned in the flange 213 as to be shifted into alignment with the lever 208 by the indexing of shaft 177 at the end of the preceding stage. Similarly the length of the return stroke of the main carriage is predetermined by the arrangement and type of bushings 270, 272, 274 and 276 in the disk 247, automatic restarting at the end of a return stroke being effected whenever a bushing 270 or 274 has been previously aligned with the stop rod 259, and the carriage remaining at rest whenever bushing 272 or 276 is so aligned. Also points at which the motion of the main carriage 23 is changed during any advance stroke thereof is predetermined by the shape of the particular cam plate 181 which has been brought into coacting relation with roller 183 by the indexing of drum 179 during the previous return stroke. Also the actual feed rate during any advance is predetermined by the lengths of the particular pair of push pins 230 which have been aligned with the ends 232 of the wedge bars 101 and 102, by the previous indexing of the head 231.

Similarly either or both auxiliary carriages 24 and 24' may be advanced and retracted during any stage whenever the previous indexing of the head 215 or 215' has aligned a push pin with one or both of the plungers 217 or 217'; and either of the cross-slides 26 and 26' may be either advanced or retracted toward or from the axis of the work dependent upon the particular cam 159 or 159' which has been brought into coacting relation with the stems of valves 133 and 133' by the previous indexing of the drum 154. Also the auxiliary turrets 29 and 29' may or may not be indexed in preparation for the next stage depending upon the positioning of the pins 234 in the head 233.

When the cross-slide 26 is not functioning as a tool holder the piston 77 and cylinder 76 thereof may be used in the following manner to effect feed motion of the cross-slide 26' at any of three different rates for each rate of discharge by the pump 89. For purposes of explanation let it be assumed that the internal bores of the main cylinder 56 and auxiliary cylinders 76 and 76' are of equal diameters and that the diameter of each piston rod 57, 78 and 78' is equal to one half the diameter of the cylinder bore. Then the resultant cross sectional area of that end of each bore containing the rod is only three quarters of the area of the other end thereof. When the valve 133 is in the intermediate position shown in Fig. 19 so that the cross-slide 26 is inactive, and the valve 133' is raised the cross-slide 26' is advanced at a definite rate dependent upon the rate of flow of liquid through pipes 132, 134 and 92. When the valve 133 is elevated (the valve 133' remaining in elevated position) liquid, flowing at the same rate through pipe 132, enters the large end of cylinder 76 through pipe 145 and passage 86, and, as the cross-slide 26 advances, liquid discharged from the rod end of cylinder 76 passes through passage 81, pipes 144 and 134, valve 133', pipe 145', and passage 80' to the large end of cylinder 76'. Since the area of the rod end of cylinder 76 is only three quarters the area of the large end thereof, the rate of liquid discharged from the rod end is only three quarters of the rate of admission to the large end, so that when valve 133 is thus elevated the rate of flow through pipe 134 is only three quarters of what it was when the valve 133 was in neutral position. The cross-slide 26' thus advances at a rate only three quarters as fast as when valve 133 is in neutral position. When valve 133 is lowered the condition is reversed, liquid being admitted to the small end of cylinder 76 from pipe 132 and discharging from the large end thereof through pipe 134 into the forward end of cylinder 76'. Under this condition the rate of discharge from the large end of cylinder 76 is greater than the rate of admission to the small end and the rate of flow in pipe 134 is correspondingly increased to thereby

increase the rate of advance of the cross-slide 26'. Thus for a given rate of flow of liquid in pipe 132, the cross-slide 26' will advance at one rate when valve 133 is in neutral position, at a slower rate when the valve 133 is elevated, and at a higher rate when the valve 133 is lowered.

Various changes may be made in the embodiment of the invention hereinabove specifically described without departing from or sacrificing any of the advantages of the invention as defined in the appended claims.

We claim:

1. In a machine tool or the like the combination of a support, a carriage movable lengthwise thereof, hydraulically actuated means for driving said carriage, means including a pump-fed hydraulic circuit for driving said hydraulically actuated means, a cross-slide movable transversely of said support, a separate hydraulically actuated means for driving said cross-slide, and means automatically operable to hydraulically connect said last named hydraulically actuated means in series in said circuit to thereby effect movement of said cross-slide at a rate corresponding to the rate of flow in said circuit.

2. In a machine tool or the like the combination of a support, a carriage movable lengthwise thereof, a hydraulic motor for driving said carriage, means including a pump-fed hydraulic circuit for driving said motor, means automatically operable to regulate the rate of flow in said circuit to thereby regulate the rate of movement of said carriage, a cross-slide movable transversely of said support, a separate hydraulic motor for driving said cross-slide, and means automatically operable to hydraulically connect said last named motor in series in said circuit to thereby effect movement of said cross-slide at a rate corresponding to the rate of flow in said circuit.

3. In a machine tool or the like the combination of a support, a carriage movable lengthwise thereof, a hydraulic motor for driving said carriage, means including a pump-fed hydraulic circuit for driving said carriage, means controlled by said carriage for automatically varying the rate of flow in said circuit during movement of said carriage to thereby vary the rate of movement thereof, a cross-slide movable transversely of said support, a second hydraulic motor for driving said cross-slide, and means controlled by said carriage for automatically connecting and disconnecting said last named motor in series in said circuit.

4. In a machine tool or the like the combination of a support, a carriage movable lengthwise of said support, a hydraulic motor for driving said carriage, means including a pump-fed hydraulic circuit for driving said motor, means automatically operable to vary the rate of flow in said circuit to thereby vary the rate of movement of said carriage, a cross-slide movable transversely of said support, a hydraulic motor for driving said cross-slide, and means for connecting said last named motor in series in said circuit to thereby effect movement of said cross-slide at a rate corresponding to the rate of flow in said circuit.

5. In a machine tool or the like the combination of a plurality of movable carriers, separate hydraulic motors for driving the same, means including a hydraulic circuit for driving one of said motors to effect movement of one of said carriers at a regulated rate, and means automatically operable to connect other of said motors in series in said circuit to thereby effect movement of other of said carriers at a regulated rate.

6. The combination of a plurality of hydraulic motors, means including a hydraulic circuit for driving one of said motors, means controlled by said last mentioned motor for regulating the rate of flow in said circuit to thereby automatically regulate the rate of operation of said motor, and means for connecting the other of said motors in series in said circuit to effect operation thereof at rates corresponding to the rates of flow therein.

7. The combination of a hydraulic motor, a member driven thereby, a hydraulic circuit for driving said motor, means controlled by said member for automatically regulating the rate of flow in said circuit to thereby automatically regulate the rate of movement of said member, a second member, a second hydraulic motor for driving the same, and means for connecting said second motor in series in said circuit to effect operation of said second member at rates corresponding to the rates of flow in said circuit.

8. The combination of a hydraulic motor, a member driven thereby, a hydraulic circuit for driving said motor, means controlled by said member for automatically regulating the rate of flow in said circuit, a second member, a second hydraulic motor for driving the same, means for connecting said second motor in series in said circuit to effect movement of said second member at rates corresponding to the rates of flow in said circuit, and a positive stop for limiting the movement of said second member.

9. The combination of a hydraulic motor, a member driven thereby, a hydraulic circuit for driving said motor, means automatically operable to regulate the rate of flow in said circuit, a second member, a second hydraulic motor for driving the same, means for connecting said second motor in series in said circuit, means for arresting the movement of said second member, and pressure responsive mechanism operable to permit a continued flow in said circuit upon arresting the movement of said second member.

10. The combination of a member, a hydraulic motor for driving the same, a hydraulic circuit for driving said motor, a cylinder, a differential piston therein, and means operable to connect and disconnect said cylinder in series in said circuit in advance of said motor to thereby vary the rate of operation of said motor.

11. The combination of a member, a hydraulic motor for driving said member, a hydraulic circuit for driving said motor, a cylinder, a differential piston therein, and means operable to connect and disconnect said cylinder in series in said circuit in advance of said motor to thereby vary the rate of operation of said motor, said means comprising a valve operable to reverse the connections between said circuit and cylinder to thereby further vary the rate of operation of said motor.

12. The combination of a member, a hydraulic motor for driving said member, a hydraulic circuit for driving said motor at definite rates, a plurality of additional members, separate motors for driving said last named members, respectively, and means for connecting said last named motors in series in said circuit to thereby effect operation of said last named motors at definite rates.

13. The combination of a support, a carrier movable lengthwise thereof, a hydraulic motor for driving said carrier, a hydraulic circuit for

driving said motor, additional carriers movable transversely of said support, separate hydraulic motors for driving said additional carriers, respectively, and means operable to connect one or more of said last named motors in series in said circuit.

14. The combination of a support, a carriage movable lengthwise thereof, a hydraulic motor for driving said carriage, a hydraulic circuit for driving said motor, an auxiliary carriage movable lengthwise of said support, a cross-slide movable on said auxiliary carriage transversely of said support, a second auxiliary carriage, a cross-slide movable on said last named carriage transversely of said support, separate hydraulic motors for driving said cross-slides, respectively, and means for connecting said last named motors in series in said circuit.

15. The combination of a support, a carriage movable lengthwise thereof, a hydraulic motor for driving said carriage, a hydraulic circuit for driving said motor, an auxiliary carriage movable lengthwise of said support, a cross-slide movable on said auxiliary carriage transversely of said support, a hydraulic motor for driving said cross-slide, means operable to connect said last named motor in series in said circuit to thereby operate said cross-slide, and automatic means for regulating the rate of flow in said circuit and for operating said last named means.

16. The combination of a support, a carriage movable lengthwise thereof, a hydraulic motor for driving said carriage, an auxiliary carriage movable lengthwise of said support, coacting means through which motion is imparted to said auxiliary carriage by the advance of said first named carriage, a cross-slide movable on said auxiliary carriage transversely of said support, a hydraulic motor for driving said cross-slide, means for supplying driving liquid to said motors, and means automatically operable to regulate the rate and direction of operation of said motors.

17. In a machine tool or the like the combination of a support, a carriage movable lengthwise thereof, means for driving said carriage, an auxiliary carriage movable lengthwise of said support, coacting means between said carriages through which motion is imparted to said auxiliary carriage by the advance of said first named carriage, and means for limiting the movement of said auxiliary carriage, said coacting means including a fluid cushion yieldable to permit the continued advance of said main carriage after said auxiliary carriage has stopped.

18. In a machine tool or the like the combination of a support, a carriage movable lengthwise thereof, means for driving said carriage, an auxiliary carriage, hydraulic thrust transmitting means between said carriages for advancing said auxiliary carriage by the advance of said first named carriage, and means automatically operable to render said thrust transmitting means active or inactive to thereby render the said auxiliary carriage movable or immovable during the advance of said main carriage.

19. In a machine tool or the like the combination of a support, a carriage movable thereon, means for advancing and retracting said carriage, an auxiliary carriage movable on said support, coacting means including a fluid sustained plunger between said carriages for advancing said auxiliary carriage by the advance of said first named carriage, and means controlled by said first named carriage during the return stroke thereof for rendering said coacting means active or inactive.

20. In a machine tool or the like the combination of a support, a main carriage movable thereon, means for advancing and retracting said main carriage, an auxiliary carriage movable on said support, means for advancing said auxiliary carriage by the advance of said main carriage, a cross-slide movable on said auxiliary carriage, means operable independently of said advancing means for moving said cross-slide in a direction transversely of the direction of motion of said main carriage, means controlled by said main carriage for controlling the movement of said auxiliary carriage and said cross-slide, and means controlled by said main carriage for adjusting said control means to thereby predetermine the motion of said auxiliary carriage and cross-slide for each advance of said main carriage.

21. In a machine tool or the like the combination of a support, a main carrier movable thereon, means for advancing and retracting said carrier, an auxiliary carrier movable in a direction transversely of said main carrier, hydraulicly actuated means for advancing and retracting said auxiliary carrier, means controlled by said main carrier for controlling the movement of said auxiliary carrier, and means controlled by said main carrier for adjusting said control means to thereby predetermine the motion of said auxiliary carrier for each advance of said main carrier.

22. In a machine tool or the like the combination of a main carrier, a hydraulic motor for advancing and retracting the same, an auxiliary carrier, a separate hydraulic motor for advancing and retracting said auxiliary carrier, automatic means for controlling said second motor, and means controlled by said main carrier for adjusting said control means to vary the operating characteristics of said auxiliary carrier.

23. In a machine tool or the like the combination of a main carrier, a hydraulic motor for advancing and retracting the same, hydraulic circuit for driving said motor, means for regulating the rate of flow in said circuit to thereby regulate the rate of movement of said carrier, an auxiliary carrier, a separate hydraulic motor for advancing and retracting the same, means automatically operable to connect and disconnect said second motor in series in said circuit, and means controlled by said main carrier for adjusting said last named means to thereby vary the operating characteristics of said auxiliary carrier.

24. In a machine tool or the like the combination of a main carrier, a hydraulic motor for advancing and retracting the same, a hydraulic circuit for driving said motor, means for regulating the rate of flow in said circuit, an auxiliary carrier, a separate hydraulic motor for advancing and retracting said auxiliary carrier, a valve for connecting and disconnecting said second motor in series in said circuit, control mechanism including a plurality of means movable with said main carrier and selectively active to control said valve, and means controlled by said main carrier for rendering any of said last named means active to thereby predetermine the operating characteristics of said auxiliary carrier.

25. In a machine tool or the like the combination of a movable member, a hydraulic motor for advancing said member, a hydraulic circuit including a variable delivery pump for driving said motor, means for modifying the mechanical action of said pump, control means for effecting operation of said last named means at any point

in the path of travel of said member, and means automatically operable to adjust said delivery varying means to thereby regulate the extent of variation in pump delivery.

26. In a machine tool or the like the combination of a work holder, a tool holder, means for advancing and retracting one of said holders toward and from the other, means for automatically reversing the motion of said last mentioned holder at the end of each advance stroke, means for delaying such reversal to permit the tool to finish its cut, and means automatically operable to render said last named means active or inactive.

27. In a machine tool or the like the combination of a work holder, a tool holder, hydraulic means for advancing and retracting one of said holders toward and from the other, means controlled by movement of said last mentioned holder for regulating the rate of movement thereof and for reversing the movement thereof at the end of each advance, hydraulic means for retarding such reversal, and means responsive to the retraction of said last mentioned holder for rendering said retarding means active or inactive during the next advance.

28. In a machine tool or the like the combination of a work holder, a tool holder, means including a variable delivery pump for advancing and retracting one of said holders toward and from the other, means controlled by movement of said last mentioned holder for regulating pump delivery, means for retarding reversal of movement of said last mentioned holder, and means automatically operable to render said retarding means active or inactive.

29. In a machine tool or the like the combination of a carriage, means for advancing and retracting said carriage, a turret rotatable on said carriage, fluid actuated means for indexing said turret, an index pin for locking said turret in each indexed position, means responsive to movement of said carriage for operating said pin, and means controlled by the position of said pin for controlling said fluid actuated means.

30. In a machine tool having a reciprocable carriage and means for advancing and retracting said carriage, the combination of a turret carried by said carriage to rotate thereon intermittently from station to station, a hydraulic motor for indexing said turret from station to station, an index pin for locking said turret at each station, and fluid actuated means for operating said index pin and for controlling said hydraulic motor.

31. In a machine tool or the like the combination of a support, a turret rotatable thereon, clamping means for said turret, reciprocating mechanism for releasing and applying said clamping means, and means including ratchet mechanism actuated by said reciprocating mechanism for intermittently rotating said turret, said last named means containing a lost motion connection to permit a release of said clamping means prior to rotation of said turret.

32. In a machine tool or the like the combination of separate tool and work supports, means for advancing and retracting one of said supports toward and from the other, a turret rotatable on one of said supports, separate means for indexing said turret, means automatically operable to regulate the extent of advance of the movable support, and means responsive to the rotative position of said turret for regulating the extent of retraction of the movable support.

33. In a machine tool or the like the combination of separate tool and work supports, means for advancing and retracting one of said supports toward and from the other, means for automatically reversing the movement of said movable support at the end of each advance stroke, a turret on one of said supports, separate means for indexing said turret, means responsive to the rotative position of said turret for stopping said movable support at predetermined points in the return movement thereof, means automatically operable to re-start said movable support on the next advance stroke, and means controlled by the rotative position of said turret for rendering said re-starting means active or inactive.

34. In a machine tool or the like the combination of a main carrier, a turret thereon, means for indexing said turret, an auxiliary carrier, means for moving said auxiliary carrier, means for moving said main carrier, means controlled by said main carrier for controlling the movement of said auxiliary carrier, and means controlled by said turret for varying the action of said last named means.

35. In a machine tool or the like the combination of a main turret, indexing means therefor, an auxiliary turret, separate means for indexing said auxiliary turret, and means controlled by the rotative position of said main turret for controlling the action of said last named indexing means.

36. In a machine tool or the like the combination of a main carrier, a turret thereon, means for advancing and retracting said carrier, means for indexing said turret, an auxiliary carrier, means for moving said auxiliary carrier, an auxiliary turret on said auxiliary carrier, means for indexing said auxiliary turret, means controlled by said main carrier for controlling the motion of said auxiliary carrier and the indexing of said auxiliary turret, and means controlled by the rotative position of said main turret for controlling the action of said last named means.

37. In a machine tool or the like the combination of a carriage, a turret thereon, a cross-slide, a turret on said cross-slide, means for advancing and retracting said carriage, means controlled by the movement of said carriage for indexing said first named turret, means controlled by the movement of said carriage for advancing and retracting said cross-slide, means controlled by the movement of said carriage for indexing said last named turret, and means controlled by the rotative position of said first named turret for controlling the action of said two last named means.

38. In a machine tool or the like the combination of a movable carriage, means for driving said carriage, a control element for controlling said driving means, a cam carrier movable relative to said element in response to movement of said carriage, said control element being movable across the face of said cam carrier, a plurality of cams on said carrier for coaction with said element selectively, means for indexing said cam carrier to selectively position said cams for coaction with said element, and means for sustaining said element in a predetermined position during indexing of said cam carrier.

39. In a machine tool or the like the combination of a movable carriage, means for driving said carriage, a member movable on said carriage, a member fixed on said carriage adjacent said movable member, a control element, a plurality

of means on said movable member for coaction selectively with said control element, said control element being arranged to pass from said movable member to said fixed member during movement of said carriage, and means for moving said movable member to position one of said plurality of means in coacting relation with said control element while said element is on said fixed member.

40. A control mechanism for machine tools or the like comprising a rotary drum having a substantially cylindrical portion, a series of longitudinally extending cams on another portion of said drum, a control element for coaction with said cams, selectively, said element being arranged to travel from said cam carrying portion to the cylindrical portion of said drum, and means for rotating said drum while said element is on the cylindrical portion thereof to shift any of said cams into coacting relation with said element.

41. In a machine tool or the like the combination of a support, a turret rotatable thereon, means for limiting the rotation of said turret, a worm and worm wheel for rotating said turret, and a fluid motor for rotating said worm to thereby index said turret, said worm and worm wheel coacting to lock said turret in indexed position.

42. In a machine tool or the like the combination of a support, a turret rotatable thereon, fluid actuated means for rotating said turret, means for positively limiting the rotation thereof in both directions, to thereby accurately position said turret in each indexed position, and a valve for controlling said fluid actuated means.

43. In a machine tool or the like the combination of a plurality of turrets, a fluid pressure source, separate means actuated from said source for indexing said turrets, control means for normally effecting the simultaneous operation of said separate means, and valves adjustable to effect indexing of one of said turrets to the exclusion of another.

44. In a machine tool or the like the combination of a plurality of translatable carriers, separate hydraulically actuated means for driving the same, a pump fed hydraulic circuit connecting said separate means in series to thereby effect simultaneous motion of said carriers at predetermined rates, reversing means for said circuit, and means for preventing operation of said reversing means until all of said carriers have completed their respective strokes.

45. In a machine tool or the like the combination of a plurality of fluid actuated members, means including a fluid pressure source and fluid connections for simultaneously driving said members, a stop for limiting the movement of each member, means for simultaneously reversing the movement of said members, and means for preventing operation of said reversing means until all of said members have reached their respective stops.

46. In a machine tool or the like the combination of a plurality of fluid actuated members, means including a fluid pressure source and fluid connections for simultaneously driving said members, a stop for limiting the movement of each member, means for simultaneously reversing the movement of said members, and means including a pressure responsive valve associated with each member for preventing operation of said reversing means until all of said members have reached their respective stops.

47. In a machine tool or the like the combination of a plurality of fluid actuated translatable members, means for simultaneously reversing the movement of said members, means for preventing operation of said reversing means until all of said members have completed their respective strokes, and means adjustable to render said last named means active or inactive.

48. In a machine tool or the like the combination of a hydraulically actuated member, a pump for supplying driving liquid to said member, a control element translatable in a plane for regulating the movement of said member, a second element normally projecting into said plane for coaction with said control element, and a support for said second element permitting free withdrawal thereof from said plane under the action of said control element in one direction.

49. A control mechanism for the purpose mentioned comprising a control element, a rail coacting therewith to normally restrain the movement of said element in one direction, and a support for said rail permitting free withdrawal thereof under the action of said element upon movement of said element in the opposite direction.

50. In a control mechanism for the purpose described the combination of a control element, a cam having relatively high and low portions for coaction with said element, said element being arranged to follow said high and low portions in the order named during relative movement between said cam and element in one direction, a shoulder on said cam between said portions, said shoulder having a bevelled face to force said element clear of said cam upon relative movement between said cam and element in the opposite direction.

51. In a control mechanism for the purpose described the combination of a cam having relatively high and low portions and an abrupt shoulder therebetween, a cam roller arranged to follow said high and low portions in the order named during relative movement between said cam and roller in one direction, and a guard element mounted adjacent said roller, said guard element having a bevelled face for coaction with said shoulder to force said roller clear of said cam upon relative movement between said cam and roller in the opposite direction.

52. In a control mechanism for the purpose described the combination of a cam having relatively high and low portions, a cam roller arranged to follow said high and low portions in the order named during relative movement between said cam and roller, and an element adjacent said roller for coaction with said high portion during passage of said roller from said high to said low portion, said element being arranged to sustain said roller until said element has cleared said high portion to thereby effect an abrupt movement of said roller onto said low portion.

53. In an automatic lathe the combination of a plurality of tool carriers, separate hydraulic motors for actuating the same and arranged to be connected in series, a variable delivery pump, hydraulic connections through which said motors are driven by said pump, and means controlled by one of said carriers for automatically regulating the rate and direction of movement of said plurality of carriers.

54. In a hydraulic system of control, a plurality of fluid operated actuators, means for supplying fluid under pressure, a valve mechanism con-

nected with said fluid supplying means, said valve mechanism having a plurality of ports and shiftable to at least three positions, ducts connecting said valve with said actuators, said valve in one shifted position being adapted to direct fluid from said supplying means to one actuator and to receive fluid from another actuator, and connecting means for rendering said last mentioned actuator operable in response to the actuation of said first mentioned actuator.

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