

July 14, 1936.

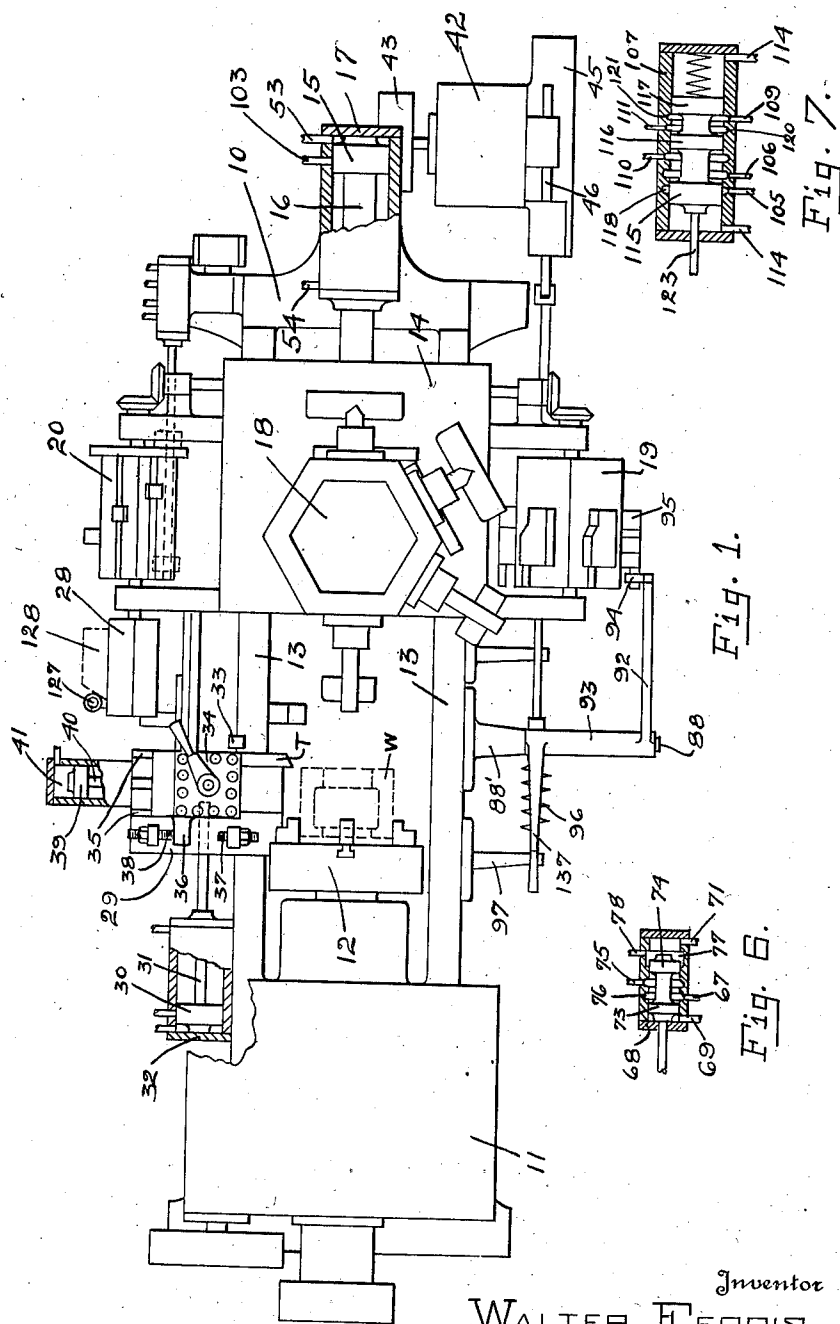
W. FERRIS

2,047,181

HYDRAULIC FEED FOR MACHINE TOOLS

Filed Nov. 18, 1929

4 Sheets-Sheet 1



Inventor
WALTER FERRIS.

Ralph C. Brown

Attorney

July 14, 1936.

W. FERRIS

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HYDRAULIC FEED FOR MACHINE TOOLS

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4 Sheets-Sheet 2

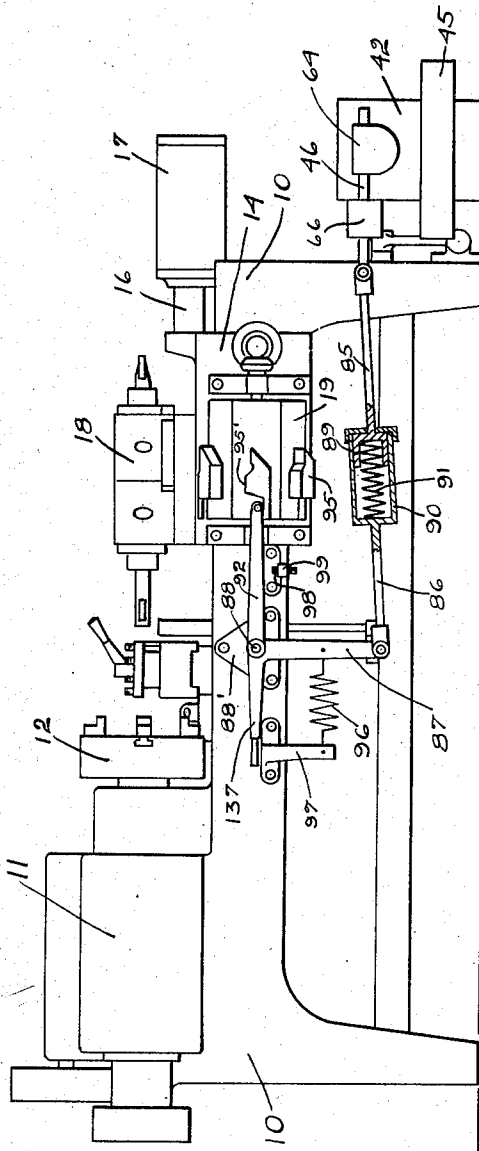


Fig. 2.

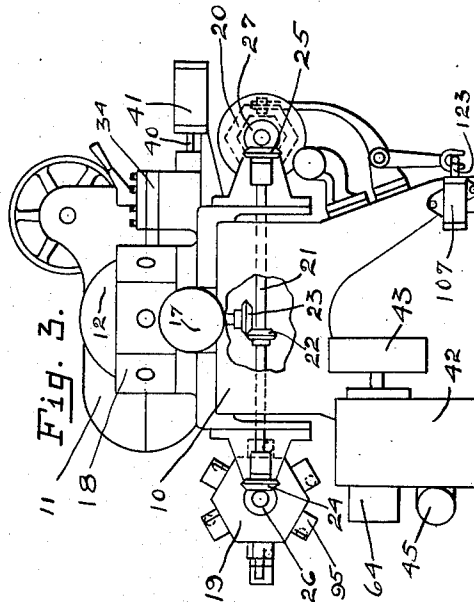


Fig. 3.

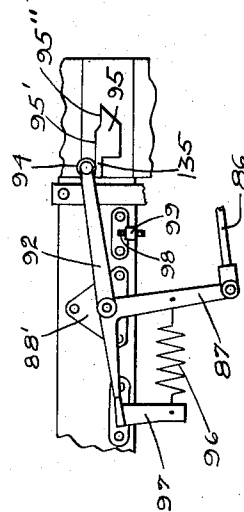


Fig. 4.

Inventor
WALTER FERRIS.

By

Ralph Brown

Attorney

July 14, 1936.

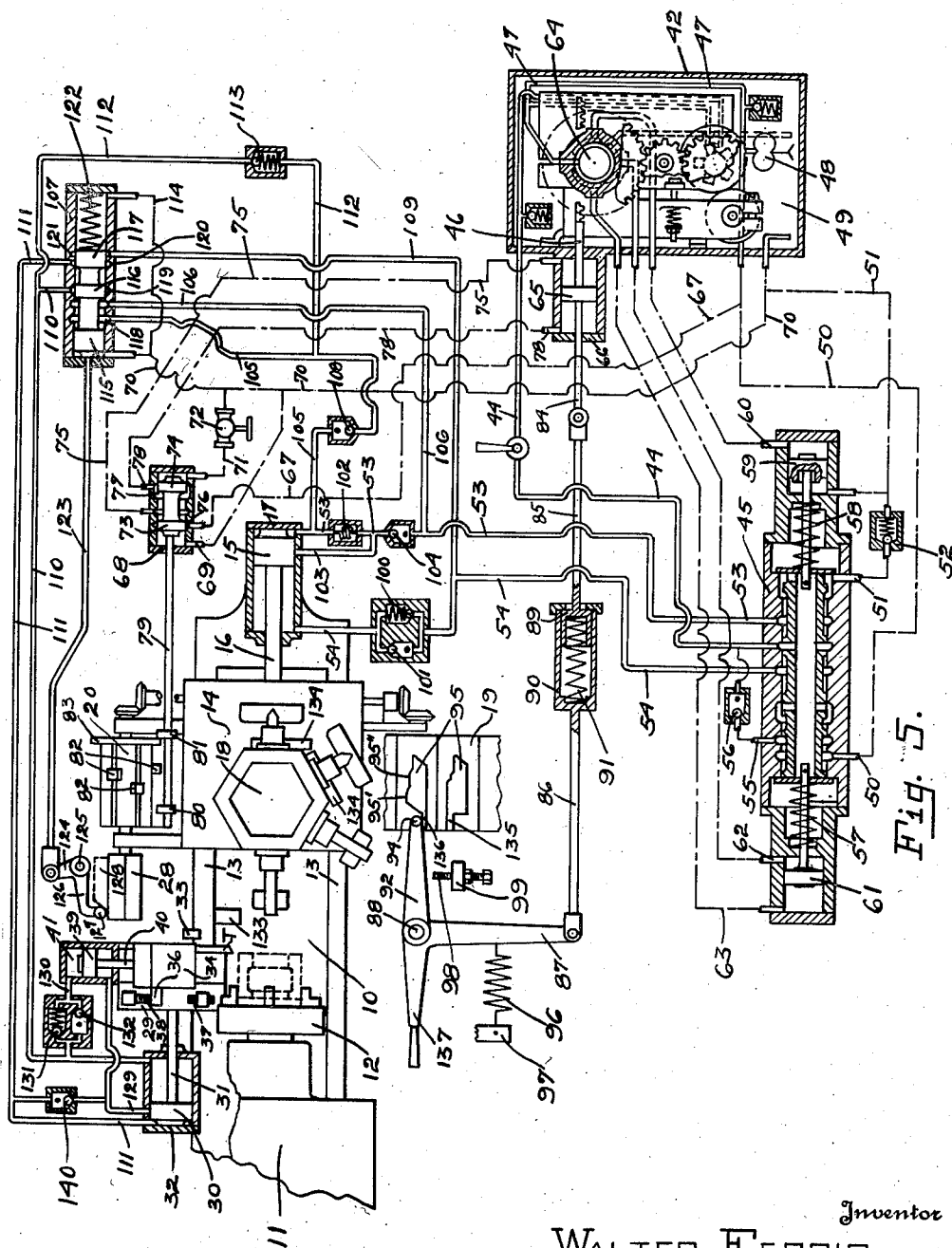
W. FERRIS

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HYDRAULIC FEED FOR MACHINE TOOLS

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4 Sheets-Sheet 3



Inventor
WALTER FERRIS.

By *Rafael Armas*

Attorney

July 14, 1936.

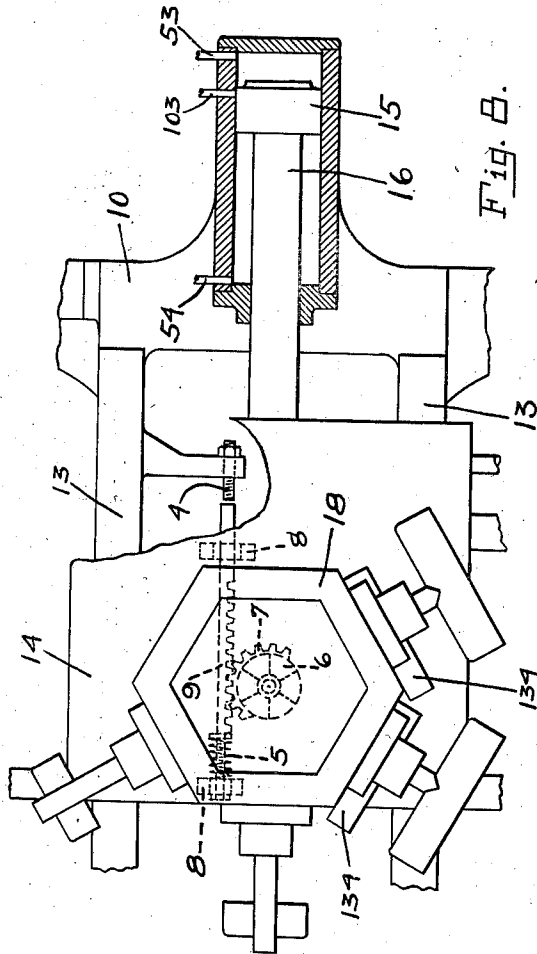
W. FERRIS

2,047,181

HYDRAULIC FEED FOR MACHINE TOOLS

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4 Sheets-Sheet 4



Inventor
WALTER FERRIS.

By

Ralph H. Brown

Attorney

UNITED STATES PATENT OFFICE

2,047,181

HYDRAULIC FEED FOR MACHINE TOOLS

Walter Ferris, Milwaukee, Wis., assignor to The
Oilgear Company, Milwaukee, Wis., a corpora-
tion of Wisconsin

Application November 18, 1929, Serial No. 407,920

6 Claims. (Cl. 29—42)

This invention relates to hydraulic feeds primarily for lathes although the novel features thereof may also be applied to advantage to other types of machine tools involving a member to be translated.

One object of the present invention is the provision in a hydraulic feed mechanism of new and improved means for automatically regulating and controlling the rate and direction of movement of the driven member. In my copending application Serial No. 349,022 filed March 22, 1929, I disclosed a hydraulic feed mechanism for lathes involving a variable delivery pump under the control of a cam on the driven member which functions automatically to effect rapid traverse movement in either direction and a feed movement at either of two speeds during travel in one direction. The present invention provides a cam control responsive to movement of the driven member for automatically effecting a feed movement at any of an infinite number of speeds as predetermined by the contour of the cam, in addition to the rapid traverse movements heretofore provided.

Another object of the present invention is the provision in a machine tool having a plurality of separate members to be driven of a new and improved automatic control for effecting the movement of said members at predetermined speeds and in different directions in predetermined sequence.

Other more specific objects and advantages will appear from the following description of an illustrative embodiment of the present invention.

In the accompanying drawings:—

Figure 1 is a top plan view of an automatic lathe equipped with a hydraulic feed mechanism embodying the present invention.

Fig. 2 is a view in front elevation.

Fig. 3 is a view in end elevation of the right end of the machine.

Fig. 4 is a detail view of a portion of the control mechanism shown in Fig. 1, with the control lever in a different position.

Fig. 5 is a diagrammatic view of the hydraulic system.

Fig. 6 is a sectional view of a pilot valve shown in Fig. 5 illustrating a second position thereof.

Fig. 7 is a sectional view of an auxiliary control valve shown in Fig. 5, illustrating a second position thereof.

Fig. 8 is a top plan view of the main carriage of the lathe.

The lathe shown comprises the usual bed 10 supporting a conventional head stock 11 provided with a rotary jaw chuck 12 for receiving the work

W. The bed is also provided with the usual longitudinal ways 13 upon which the main carriage 14 is mounted in a well known manner for lengthwise travel toward and from the work. In this instance the main carriage 14 is hydraulically driven by a piston 15 connected thereto by a rod 16 and fitted for reciprocation within a motor cylinder 17 fixed to the bed 10. The main carriage 14 supports a multi-position tool-carrying turret 18 of conventional design. The turret 18 shown may assume any of six positions and is automatically rotated from one position to the next during completion of each return stroke of the carriage. This automatic step-by-step rotation of the turret 18 is effected in this instance by a rack bar 9 mounted for lengthwise reciprocation in appropriate brackets 8 fixed to the bottom of the carriage 14, (see Fig. 8). The rack bar 9 meshes with a segmental gear 7 on the driving element 6 of a ratchet clutch of the type described in the copending application hereinabove identified. A compression spring 5 urges the rack bar 9 toward the right, the bar 9 being shifted toward the left against the pressure of this spring by a stop element 4, fixed to the bed 10 of the machine, during each return stroke of the carriage.

The main carriage 14 also carries two multi-position control drums 19 and 20 which are both intermittently rotated from position to position by the turret 18 through a cross-shaft 21 (Fig. 3). Shaft 21 carries a gear 22, which meshes with a gear 23 driven by the turret, and two gears 24 and 25, which mesh with gears 26 and 27 connected to the respective control drums. A third auxiliary control drum 28 is also carried by the main carriage and is permanently connected to the control drum 20 for rotation therewith.

The lathe shown is also equipped with a back carriage 29 mounted for travel lengthwise of one of the ways 13. The back carriage is hydraulically actuated by a piston 30 connected thereto through a rod 31 and fitted for reciprocation in a cylinder 32 on the lathe bed. A stop 33 on the lathe bed limits the movement of carriage 29 toward the right (Fig. 1) movement in the other direction being limited by the abutting engagement of the piston 30 against the left end head of the cylinder 32. A tool holder 34 of conventional design is mounted on ways 35 in the carriage 29 for movement with the carriage lengthwise of the lathe and for movement along ways 35 transversely of the lathe. A lug 36 on the holder 34 coacts with adjustable stop screws 37 and 38 on the carriage 29 to limit the transverse movement

of the tool holder in both directions. The tool holder 34 is hydraulically actuated by a piston 33 connected thereto by a rod 40 and fitted for reciprocation in a cylinder 41 fixed to the back carriage 29.

Driving liquid is supplied to the several cylinders 17, 32, and 41 from a variable delivery pump 42 which is placed under the joint control of the two control drums 19 and 20 hereinabove referred to. The pump 42, diagrammatically indicated in Figs. 1, 2, 3 and 5, is of a type fully described in my copending application Serial No. 407,921, filed November 18, 1929 (Patent No. 1,966,814). It will be sufficient here to state that this pump is driven at constant speed through appropriate means such as a pulley 43, and delivers liquid through a pipe 44 to a main distributing valve 45 at a rate dependent upon the position of a control stem 46 (Fig. 5). This pump receives its supply of liquid through a pipe 47 from an auxiliary gear pump 48 which in turn receives its supply from a reservoir 49 in the base of the pump housing. The gear pump is also connected to the distributing valve 45 through a pipe 50 connected with pipe 47. An exhaust pipe 51 from the distributing valve 45 leads back into the reservoir 49 through a low pressure resistance valve 52. Pipes 53 and 54 connected with the valve 45 at opposite sides of the delivery pipe 44 constitute two sides of the hydraulic motor circuit. A pipe 55 leading from the distributing valve leads through a check valve 56 to the delivery pipe 44.

A pair of opposed springs 57 and 58 yieldably retain the distributing valve in the intermediate or neutral position of Fig. 5, in which position pipe 44 is connected to pipe 51 and the pump circuit is by-passed. A piston 59 which responds to pressure supplied through a pipe 60 functions to shift the valve one step toward the left to thereby connect pipe 44 with pipe 53 and to connect pipe 54 with exhaust pipe 51 to thus set up a flow in the motor circuit in one direction. In this position of the valve pipe 50 is blocked from pipe 55 and the motor circuit is supplied from the main pump alone. A second piston 61 which responds to pressure supplied through a pipe 62 functions to shift the valve 45 further to the left, in which position pipe 44 is still connected with pipe 53 and pipe 54 with pipe 51, but pipe 50 is then connected through pipe 55 with pipe 44 to thereby add the discharge from the gear pump to that of the main pump, and thus increase the flow in the motor circuit. The piston 61 also functions under pressure supplied through a pipe 63 to shift the valve into a right extreme position, in which position pipe 44 is connected with pipe 54 and pipe 53 with pipe 51 so that the flow in the motor circuit is reversed, and in this position pipe 50 is again connected through pipe 55 with pipe 44 so that the flow in the motor circuit is increased by thus adding the discharge from the gear pump to the flow in pipe 44. The several pipes 60, 62, and 63 are controlled by a rotary pilot valve 64 which is actuated and controlled by the stem 46.

The arrangement is such that with the stem 46 of the distributing valve in the intermediate position of Fig. 5 none of the pipes 60, 62, or 63 contain pressure and the distributing valve assumes the intermediate neutral position of this figure and the motor circuit is at rest. Slight movement of the stem 46 toward the right from this position opens the pipe 60 to the gear pump pressure in pipe 47 to thereby energize the piston 59 to shift the distributing valve one step toward the left to thereby set up a flow in the pipes 53 and 54

at a rate corresponding to the rate of flow in pipe 44. Further movement of the stem 46 toward the right effects a gradual increase in the rate of flow in pipe 44 and pipes 53 and 54 up to the maximum displacement of the main pump and further movement in the same direction opens the pipe 62 to gear pump pressure to thereby shift the valve 45 into a left extreme position so as to connect pipe 50 from the gear pump to pipe 44 and thereby further increase the flow in pipes 53 and 54. Upon shifting the stem 46 toward the left from the position of Fig. 5 pipe 63 is opened to gear pump pressure to thereby shift valve 45 into a right extreme position and thus set up a rapid flow through pipes 54 and 53 in a reverse direction. Since the pump including the control stem 46, pilot valve 64, and distributing valve 45 are all fully described in my co-pending application last above mentioned, a further explanation thereof at this time is deemed unnecessary.

In this instance the control stem 46 is actuated hydraulically by a piston 65 working in a cylinder 66. The piston 65 is energized by gear pump pressure supplied through a pipe 67 connected with pipe 50 and controlled by a pilot valve 68. The valve 68, shown in Figs. 5 and 6, comprises a housing having a longitudinal bore therein. A pipe 69 from the left end of the bore connects with a drain pipe 70, and a pipe 71 from the right end of the bore also connects with drain pipe 70. Pipe 71 contains a needle valve 72 for regulating the rate of flow therethrough. A plunger having two spaced heads 73 and 74 is closely fitted for lengthwise movement in the bore. A pipe 75 connected with the right end of cylinder 66 communicates at all times with that portion of the bore between the heads 73 and 74. Pressure pipe 67 leads to an annular groove 76 in the bore controlled by head 73. An annular channel 77 wider than the head 74 but controlled thereby connects with a pipe 78 communicating with the left end of cylinder 66. With the plunger of pilot valve 68 in the right position of Fig. 5 pressure pipe 67 is blocked by head 73 and pipes 75 and 78 are in open communication through the channel 77 so that there is no pressure in either end of cylinder 66 and piston 65 is freely movable therein. But when the plunger of valve 68 is in the left position of Fig. 6 pipe 75 is exposed to the pressure pipe 67 and pipe 78 is connected to the pipe 71 so that the piston 65 is then forced toward the left at a rate dependent upon the setting of the needle valve 72.

The pilot valve 68 is placed under the control of the control drum 20 hereinabove mentioned and for this purpose the plunger thereof is connected to a rod 79 having a pair of stops 80 and 81 fixed thereon. Stop 80 is arranged to coast with any one of a series of stops 82 each adjustably fixed to one of the six sides of the control drum. The arrangement is such that upon each forward advance of the main carriage 14, one of the stops 82 moving with the carriage and drum, engages the stop 80 so as to shift the plunger of valve 68 into the left position of Fig. 6. The adjusted position of each stop 82 thus approximately determines the extent of advance of the main carriage for each indexed position of the drum 20. By adjustment of the needle valve 72 the rate of discharge from the left end of cylinder 66 may be controlled to thereby, if desired, delay the movement of piston 65 and thus delay the reversal of motion of the main carriage. Upon each return movement of the main carriage 14 a collar 75

83 on the right end of drum 20 engages the stop 81 to thereby return the plunger of valve 68 to the right to the position of Fig. 5 and thereby destroy the pressure in the right end of the cylinder 66 and connect the opposite ends thereof through pipes 75 and 78.

The control stem 46 is also mechanically actuated through mechanism now to be described under the control of the drum 19 and for this purpose the piston 65 is provided with a tail rod 84 which is connected through links 85 and 86 to the depending arm 87 of a bell-crank rockably supported on a horizontal shaft 88 anchored in a fixed bracket 88' on the side of the lathe bed. A hollow plunger 89 on the link 85 fitted to slide within a cylinder 90 on the link 86 provides a collapsible telescopic connection therebetween. A compression spring 91 yieldably maintains this connection in expanded condition. An arm 92 rigidly connected with the bell-crank through a sleeve 93 carries a roller 94 for coaction with one of a series of cams 95 on the drum 19. A spring 96 connected with the arm 87 and with an appropriate fixed bracket 97 yieldably urges the bell-crank to rock clockwise so as to depress the cam roller 94. An adjustable stop screw 98 threaded in a fixed bracket 99 limits the downward throw of the arm 92. In each of the six rotative positions of this drum 19 one of the cams 95 coacts with the roller 94 to adjust the piston 65 and thereby regulate the pump 42 and distributing valve 45 and thus regulate the rate of movement of the main carriage 14 during each advance and return movement thereof in a manner to be later described.

Pipe 54 constituting one side of the hydraulic circuit leads from the distributing valve 45 to the left end of the driving cylinder 17 of the main carriage. Pipe 54 contains a spring loaded valve 100 which is set to open at a low pressure and which offers a predetermined resistance to the flow of liquid to the cylinder 17. A check valve 101 connected across the resistance valve 100 opens freely in the opposite direction so as to permit a free flow of liquid from the cylinder 17. Pipe 53 constituting the other side of the hydraulic circuit leads from the right end of cylinder 17 to the distributing valve 45. This pipe contains a choke coil 102 of small bore tubing adjacent the cylinder which restricts the escape of liquid therefrom. A pipe 103 controlled by the piston 15 connects with the pipe 53 beyond the choke coil 102 so as to by-pass the choke coil and thus permit a free escape of liquid from the right end of the cylinder 17 until blocked by the piston as the piston approaches the right end of its stroke. Pipe 53 also contains a check valve 104 which prevents a direct flow therethrough to the cylinder 17. A pipe 105, connected with pipe 53 between the cylinder 17 and choke coil 102, cooperates with a pipe 106, connected with pipe 53 between the check valve 104 and distributing valve 45 to provide a by-pass connection around the check valve and choke. These pipes 105 and 106 are controlled by a valve 107 to be later described. A check valve 108 within the pipe 105 prevents flow therethrough from the cylinder 17. A branch pipe 109 connected to pipe 54 between the resistance valve 100 and the distributing valve 45 leads to the valve 107. The valve 107 also controls communication between pipe 106 and a pipe 110 leading to the right end of cylinder 32 and between pipe 109 and a pipe 111 leading to the left end of cylinder 32. A pipe 112 forms a direct connection between pipes 110 and 105

and includes a spring loaded resistance valve 113 which offers a predetermined resistance to flow therethrough from pipe 110 and prevents flow in the opposite direction.

Valve 107 shown in section in Figs. 5 and 7 comprises a housing containing a longitudinal bore whose opposite ends are in open communication through a pipe 114 connected to the drain pipe 70. A plunger having three spaced piston heads 115, 116 and 117 is closely fitted to slide longitudinally of the bore. Pipe 106 communicates at all times with the space between the heads 115 and 116. Pipe 105 communicates with an annular groove 118 in the bore and controlled by head 115. Pipe 110 communicates with a similar groove 119 controlled by head 116. Head 117 controls two grooves 120 and 121 which communicate with pipes 111 and 109, respectively. A spring 122 yieldably maintains the valve plunger in the left position of Fig. 5 in which position pipe 106 is open to pipe 105 so that liquid is free to flow from pipe 53 through these pipes to the right end of cylinder 17 to thereby advance the piston 15 and main carriage 14 toward the left; and in this position head 116 blocks pipe 110 and head 117 blocks pipes 111 and 109. The plunger of valve 107 is movable into the right position of Fig. 7 by a rod 123 connected to one arm 124 of a bell-crank rockably supported on a stub shaft 125 and having a second arm 126 carrying a roller 127 for coaction with a cam 128 on the drum 28. The drum 28 may be equipped with one or more of these cams which are movable into or out of alignment with the roller 127 as the drum is indexed with the drum 20. When the roller 127 rises onto a high portion of the cam 128 during an advance of the main carriage 14 the plunger of valve 107 is shifted into the position of Fig. 7 in which position pipe 105 is blocked, pipe 106 is connected with pipe 110, and pipe 109 is connected with pipe 111.

A pipe 129 leading from a point adjacent the left end of cylinder 32 and controlled by piston 30 connects with the forward end of cylinder 41. A pipe 130 connecting pipe 110 with the rear end of cylinder 41 contains a resistance valve 131 which offers a predetermined resistance to the flow of liquid to the cylinder 41. A check valve 132 connected across the valve 131 permits a free flow through pipe 130 from the cylinder 41.

As previously pointed out the stop 80 coacts with one of the stops 82 on the drum 20 to automatically reverse the movement of the main carriage 14 and thus approximately determine the extent of advance thereof. The limit of advance may be determined with extreme accuracy when required by the provision of a positive stop in the form of an upright abutment member 133 adjustably fixed to one of the ways 13 and arranged to coact with one or another of the stop members 134 removably fixed to the sides of the turret 18. The arrangement is such that whenever the turret 18 is so positioned as to align one of the stop members 134 thereon with the abutment member 133 the main carriage 14 advances until arrested by engagement of member 134 against member 133 to thereby accurately limit the advance thereof. This occurs immediately after one of the stops 82 in the drum 20 has engaged the stop 80 on rod 79 and shifted the pilot valve 68 into the left position of Fig. 6 to thereby expose the right end of cylinder 66 to the pressure in pipe 67 and thus cause the piston 65 and control stem 46 to shift toward the left to reverse the circuit. Since the needle valve 72 de-

termines the rate at which liquid escapes from the left end of cylinder 66 it governs the rate of movement of piston 65 and thus determines the interval of time required to effect complete reversal. This interval of time is ordinarily such as to insure the engagement of stop 134 against stop 133 and to retain the main carriage in this advanced position until the tool carried thereby has had an opportunity to smooth off the face of the cut.

The lathe equipped with the system described is capable of automatically executing a complete cycle involving six advance movements of the main carriage, the operating characteristics during each advance being predetermined by the relative position of the turret 18 during that advance. As previously pointed out the turret 18 is automatically indexed to a new position at the end of each return stroke of the main carriage by a known type of mechanism such for instance as that described in the copending application first above mentioned, and each of the three control drums 19, 20, and 28 which are driven by the turret also assumes a new position at the end of each return stroke. The several cams 95 on the drum 19 come into position successively to regulate the rate of flow in pipes 53 and 54 during each advance of the main carriage, the several stops 82 on the drum 20 come into position successively to effect reversal of movement of the main carriage at the end of the advance thereof, and the cam or cams 128 on the drum 28 are brought into position to render the tool holder 34 active at a predetermined stage of the cycle.

Each of the cams 95 on the drum 19, except the first cam of the series, is provided with a relatively high nose portion 135 which upon each rotation of the drum (the carriage 14 being at the end of a return stroke) acts upon the cam roller 94 to elevate the same into the position of Fig. 4 and thereby shift the control stem 46 toward the right to start the main carriage on its next advance stroke. The nose portion 136 on the first cam 95 of the series is relatively low so that when it is rotated into position at the end of the last return stroke it acts on the roller 94 to shift the same into the intermediate position of Fig. 5 to thereby return the piston 65 and control stem 46 into the neutral position of that figure and thus bring the machine to rest.

To start an operating cycle the attendant depresses the hand lever 137 to thereby lift the cam roller 94 from the nose 136 of the cam 95 and to force the control stem 46 into its right extreme position, in which position the valve 45 assumes a left extreme position and the pump 42 delivers liquid at a maximum rate through pipe 44, through the distributing valve 45, and through pipes 53, 106, and 105 to the right end of the cylinder 17 to thereby cause the piston 15 and main carriage 14 to advance toward the work at a rapid rate. In this position of the control stem the discharge from the gear pump 48 is added to the discharge from the main pump so that the speed of advance of the main carriage is at a maximum. The attendant holds the hand lever 137 in this depressed position until the high portion 95' of the cam has advanced beneath the roller 94. The carriage then continues to advance at this rapid rate until the roller 94 passes onto a depressed portion 95'' of the cam and thus shifts the stem 46 slightly toward the left from its right extreme position to thereby block the discharge from the gear pump from the pipe 44 so that thereafter the pipe 53 is supplied

from the main pump alone, and the rate of advance of the carriage 14 is correspondingly reduced. This occurs just before a tool on the turret 18 engages the work. Since further movement of stem 46 toward the left effects a gradual reduction in the rate of discharge from the main pump the rate of advance of the carriage 14 is made to correspond to the pattern of the cam. Each cam 95 is so patterned as to effect the proper rate of advance for the particular operation to be performed. In this instance the rear end of the depressed portion 95'' is shown further depressed to thereby further reduce the rate of advance of the carriage as the cut approaches completion.

During this advance the plunger of pilot valve 68 remains in the right position of Fig. 5, so that pipes 75 and 78 are connected and the piston 65 is free to move in response to movement of the cam roller 94, until the stop 82 on drum 20 has engaged stop 80 on rod 79 and shifted the plunger of this valve toward the left. As this plunger moves toward the left, head 74 thereof blocks communication between pipes 75 and 78 and establishes communication between pipe 78 and pipe 71 and between pressure pipe 67 and pipe 75. This occurs as the roller 94 is passing beyond the end of its coacting cam 95, and the piston 65 and control stem 46 are shifted into a left extreme position to thereby direct the liquid from pipe 44 into pipe 54 to thus reverse the flow in the hydraulic circuit and consequently start the main carriage 14 on a return stroke. This movement of piston 65 is transmitted to the arm 92 to cause it to lower against the stop 98, so that during the return stroke the cam roller 94 is disposed below its coacting cam 95. When it is desired to accurately limit the advance of the main carriage 14 the needle valve 72 is partially closed to thereby reduce the rate of movement of piston 65 toward the left and thus delay actual reversal until after the advance of the main carriage has been arrested by engagement of one of the stop members 134 on the turret against the abutment 133 on the lathe bed.

During the return movement of the main carriage 14 the plunger of pilot valve 68 remains in the left position of Fig. 6 so that the right end of the cylinder 66 is exposed to the pressure in pipe 67 through pipe 75. As the carriage approaches the end of its return stroke the turret 18 is indexed into a new position and drum 19 is rotated correspondingly to lift the next cam 95 into position. The nose 135 on this new cam acts on the cam roller 94 to elevate the same and the arm 92 into the position of Fig. 4, and to thereby compress the spring 91 contained within the telescopic connection between the links 85 and 86. Thereafter the plunger of the pilot valve 68 is returned to the right position of Fig. 5 by the action of collar 83 on stop 81, to thereby again connect pipes 75 and 79 and permit the piston 65 and control stem 46 to move to their right extreme position under the action of spring 91. This action reconnects pipe 44 with pipe 53 and the carriage begins its next advance under the control of the new cam 95.

The main carriage 14 thus continues to advance and return continuously until on the last return stroke the last cam 95 of the series is rotated into position and the nose 136 thereof returns the cam roller 94 and consequently the piston 65 and control stem 46 into intermediate or neutral position of Fig. 5 to thus bring the machine to rest.

One or more of the advance and return strokes 75

of the main carriage 14 may be idle strokes with none of the tools in cutting position, executed for the purpose of indexing the turret 18 and for effecting and controlling the movements of the tool holder 34. The tool holder 34 is brought into action whenever a cam 128 is brought into alignment with the roller 127 by indexing of the drum 28. When the cam 128 is thus aligned and advanced by the next advance of the main carriage it acts upon the roller 127 to shift the plunger of valve 107 into the position of Fig. 7 to thereby block the pipe 105 and connect the pipe 106 with pipe 110 so that the liquid delivered through pipe 53 is directed into the right end of cylinder 32 to thereby shift the piston 32 and back carriage 29 into the left extreme position of Figs. 1 and 5, and thus properly align the tool T with the end face of the work W. When the piston 30 stalls against the left end of the cylinder 32, the pressure in the right end thereof immediately rises and opens the resistance valve 131, so that liquid then flows through pipe 130 into the rear end of cylinder 41 to thereby advance the piston 39 and tool holder 34 toward the work. Since the pipe 105 is blocked piston 15 remains at rest and the entire discharge from the pump through pipes 44, 53, and 106 is directed to cylinder 41 so that the tool holder 34 advances at a rate corresponding to the rate of pump delivery. The rate of pump delivery at this time is of course determined by the particular cam 95 which is then in engagement with the roller 93. During this advance of the piston 39 and tool holder 34 liquid escapes from the forward end of cylinder 41 through pipe 129, check valve 140, and pipes 111, 109, and 54 to the distributing valve 45.

This advance of the tool holder 34 continues until arrested by impingement of stop 36 thereon against the stop screw 37. When this occurs the pressure in pipe 110 immediately rises sufficiently to open the resistance valve 113 so that thereafter liquid flows through pipes 112, 105, and 53 into the rear end of cylinder 17 to advance the piston 15 and main carriage 14. As the main carriage thus advances the tool holder 34 remains at rest until the hydraulic circuit is reversed, in the manner previously described, by the action of one of the stops 82 against the stop 80 on rod 79. When this reversal occurs liquid from pipe 44 is directed through pipes 54, 109, and 111 to the left end of cylinder 32 to thereby shift the piston 30 and carriage 29 toward the right so as to retract the tool T from the face of the work. The stop 33 limits this retracting movement of carriage 29. As soon as the end of pipe 129 is uncovered by this movement of piston 30 the liquid flows through pipe 129 into the forward end of cylinder 41 to thereby shift the piston 39 and tool holder 34 rearwardly, liquid escaping from the rear end of cylinder 41 through pipes 130, 110, 106, and 53 to and through the valve 45.

This return movement of the carriage 34 continues until arrested by engagement of stop 36 against stop screw 38, at which time the pressure in pipe 54 rises sufficiently to open the resistance valve 100, and the liquid delivered from pipe 44 is thereafter directed through this valve into the left end of cylinder 17, so as to drive the piston 15 toward the right to effect a return stroke of the main carriage 14. As the main carriage approaches the rear end of its return stroke the roller 127 again clears the cam 128 and the plunger of valve 107 is returned to the position of Fig. 5 by the spring 122. Then as the turret 18 is

indexed with a new position the drum 28 is rotated thereby to shift the cam 128 out of alignment with roller 127 and the carriage 29 and tool holder 34 remain inactive until a cam 128 is again aligned with the roller 127.

Each return stroke of the main carriage 14 is ordinarily executed at a rapid rate and to avoid undue shock and jar by a sudden arresting thereof provision is made for reducing the speed of movement thereof during completion of each return stroke. Thus during the beginning of each return stroke liquid escapes freely from the right end of cylinder 17 through the pipe 103 to pipe 53 at a point beyond the choke coil 102. But as the piston 15 approaches the end of its return stroke it blocks pipe 103 so that thereafter liquid can escape from the right end of the cylinder 17 through the choke coil 102 only, the check valve 108 preventing escape through pipe 105. The movement of the piston 15 is thus suddenly checked by a dash-pot action so as to cushion the return stroke of the carriage. The pipe 103 is preferably so positioned as to be blocked by the piston 15 just prior to the engagement of the bar 9 against the stop 4, so that this cushioning or checking of the return stroke of the carriage occurs prior to the operation of the turret indexing mechanism. Thereafter as the carriage 14 continues to move slowly toward the right the ratchet element 6 is rotated counter-clockwise by the reaction of the stop 4 on the bar 9 to thereby index the turret into its next position. During the next advance stroke of the carriage the bar 9 and element 6 execute an idle movement under the action of spring 5.

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

I claim:—

1. In a machine tool or the like the combination of a support, a carrier movable thereon, hydraulically actuated means for driving said carrier, a variable delivery-pumping means, a hydraulic circuit fed by said pumping means for driving said means, a control element, means responsive to movement of said element through a limited range for effecting a gradual variation in the rate of delivery of said pumping means to thereby regulate the rate of movement of said carrier, additional means responsive to movement of said element beyond said range for effecting an abrupt increase in the rate of flow in said circuit to thereby increase the rate of movement of said carrier, and means controlled by the movement of said carrier for controlling said element.

2. In a machine tool or the like the combination of a support, a carrier movable thereon, hydraulically actuated means for driving said carrier, a variable delivery pump, a hydraulic circuit fed by said pump for driving said means, a control element, means actuated by said element for varying the rate of pump delivery to thereby regulate the rate of flow in said circuit, fluid actuated means controlled by said element for reversing the direction of flow in said circuit, and means actuated by movement of said carrier for controlling said element.

3. In a machine tool or the like the combination of a support, a carrier movable thereon, hydraulically actuated means for driving said carrier, a variable delivery pump, a hydraulic circuit fed by said pump for driving said means, a con-

trol element, means actuated by said element for varying the rate of pump delivery to thereby regulate the rate of flow in said circuit, a fluid actuated valve controlled by said element for reversing the direction of flow in said circuit, and means controlled by said carrier for controlling said element.

4. In a machine tool or the like the combination of a support, a carrier movable thereon, hydraulically actuated means for advancing and retracting said carrier, a reversible hydraulic circuit for energizing said means, an auxiliary carrier, a second hydraulically actuated means for advancing and retracting said auxiliary carrier, and valve mechanism controlled by said first named carrier independently of said auxiliary carrier for rendering said first named hydraulically actuated means inactive and connecting said second hydraulically actuated means in driving relation with said circuit.

5. In a machine tool or the like the combination of a support, a carrier movable thereon, hydraulically actuated means for advancing and retracting said carrier, a reversible hydraulic circuit for energizing said means, an auxiliary carrier, a second hydraulically actuated means for advancing and retracting said auxiliary carrier, a third hydraulically actuated means for shifting said auxiliary carrier transversely of the direction of advance thereof, means controlled by

said carrier for interrupting the action of said first named hydraulically actuated means and connecting said second and third hydraulically actuated means in driving relation with said circuit, and means automatically operable to determine the sequence of operation of said second and third hydraulically actuated means.

6. In a machine tool of the like the combination of a support, a carrier movable thereon, hydraulically actuated means for advancing and retracting said carrier, a reversible hydraulic circuit for energizing said means, and auxiliary carrier, a second hydraulically actuated means for advancing and retracting said auxiliary carrier, a third hydraulically actuated means for shifting said auxiliary carrier transversely of the direction of advance thereof, means automatically operable to interrupt the advance of said carrier and to connect said second and third hydraulically actuated means to said circuit to thereby operate said auxiliary carrier during the inactive condition of said first named carrier, means automatically operable to renew the advance of said first named carrier, means controlled by said first named carrier for reversing said hydraulic circuit, and means automatically operable to determine the sequence of operation of said three hydraulically actuated means after reversal of said circuit.

WALTER FERRIS.