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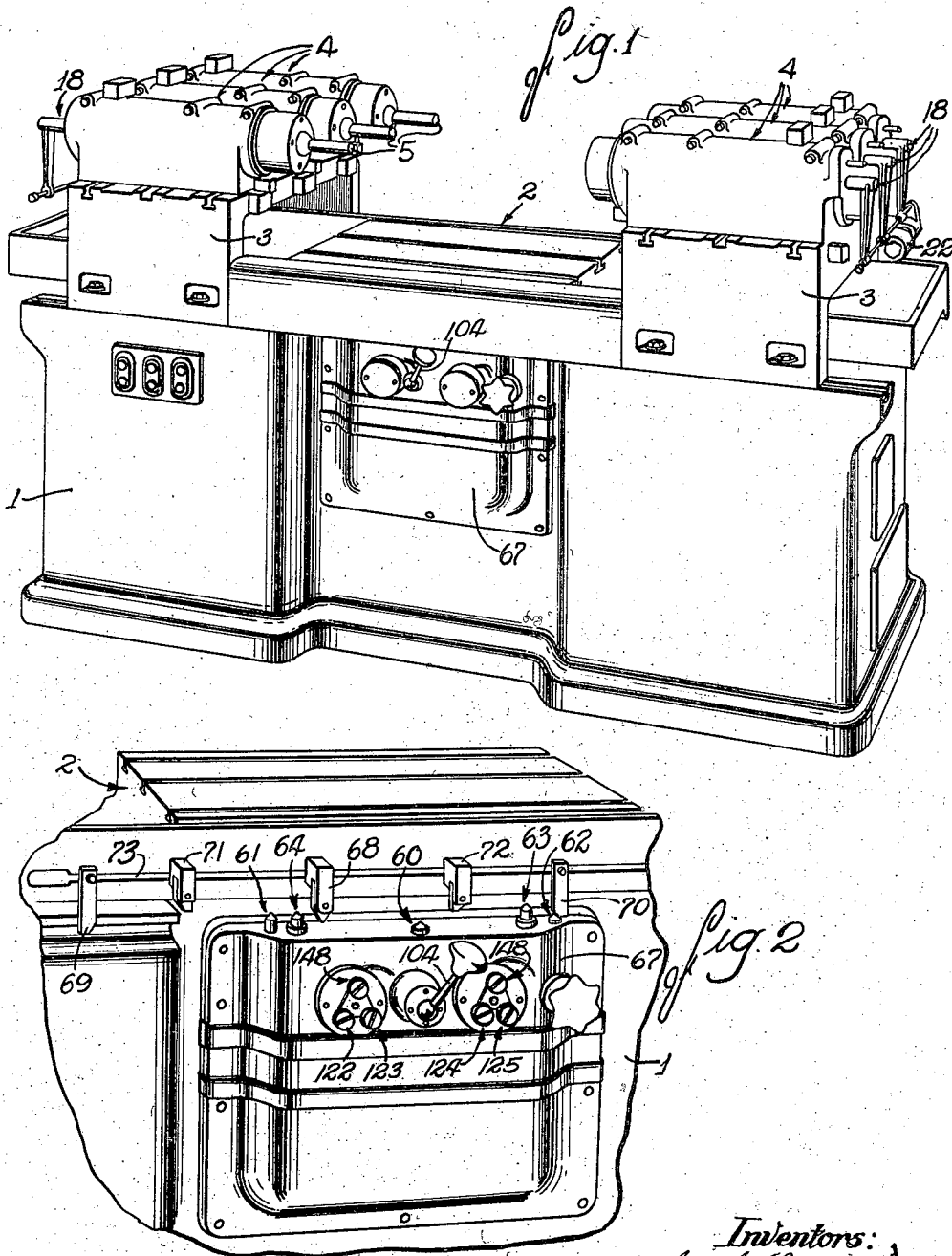
I. J. SNADER ET AL

2,375,255

HYDRAULIC TRANSMISSION FOR MACHINE TOOLS

Filed Aug. 30, 1937

4 Sheets-Sheet 1



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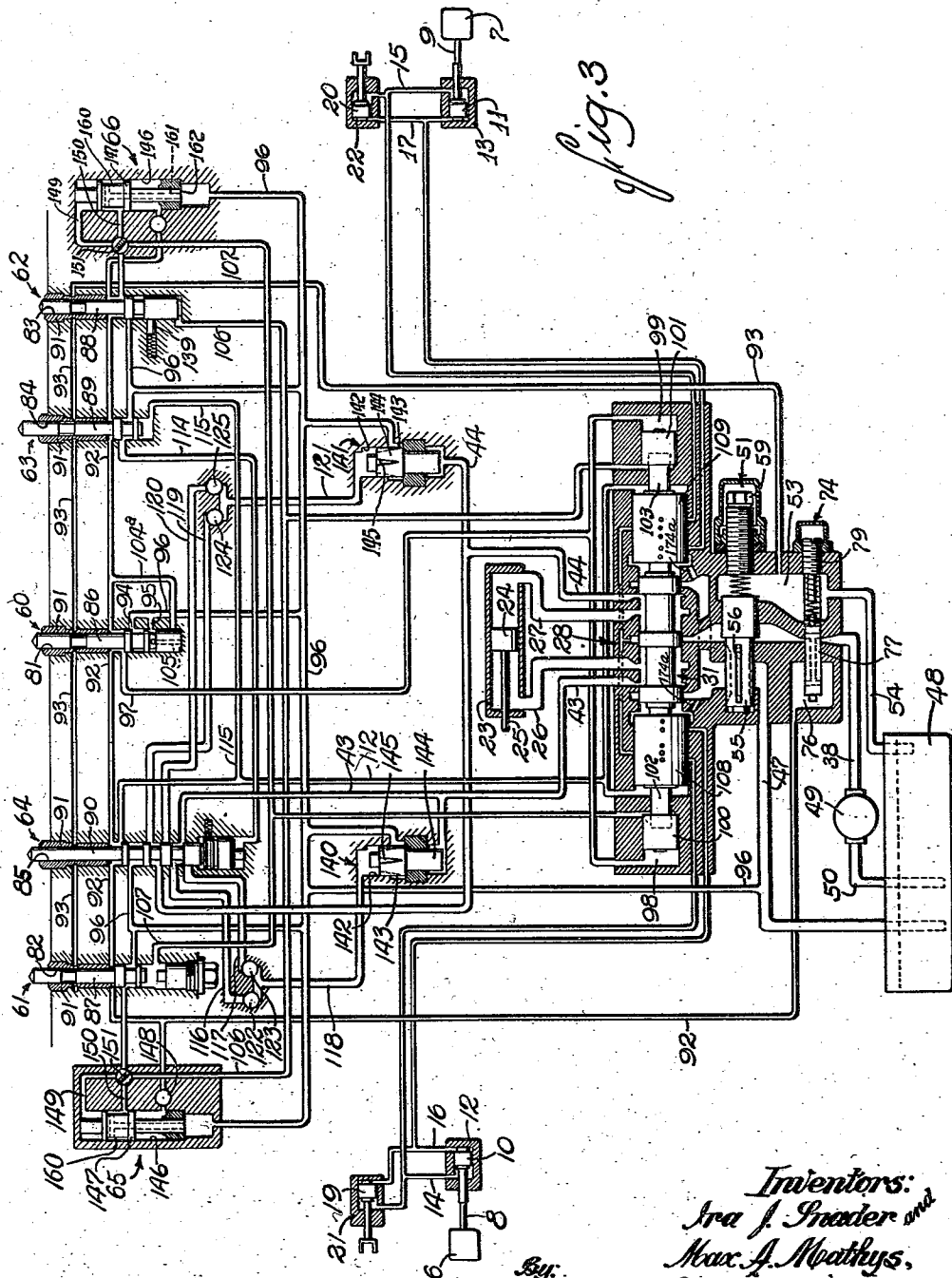
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4 Sheets-Sheet 2



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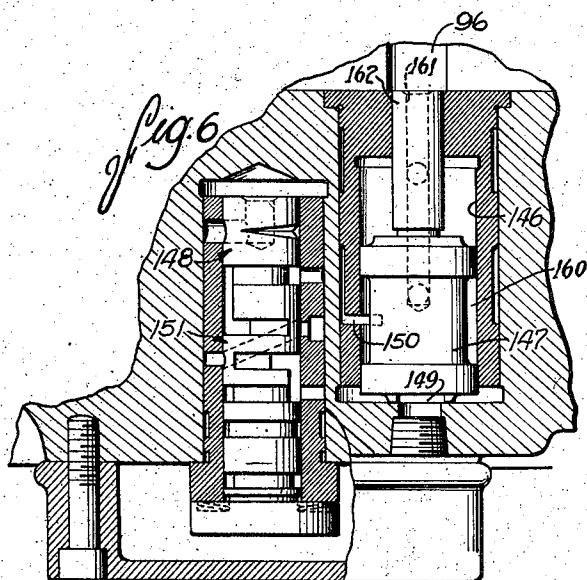
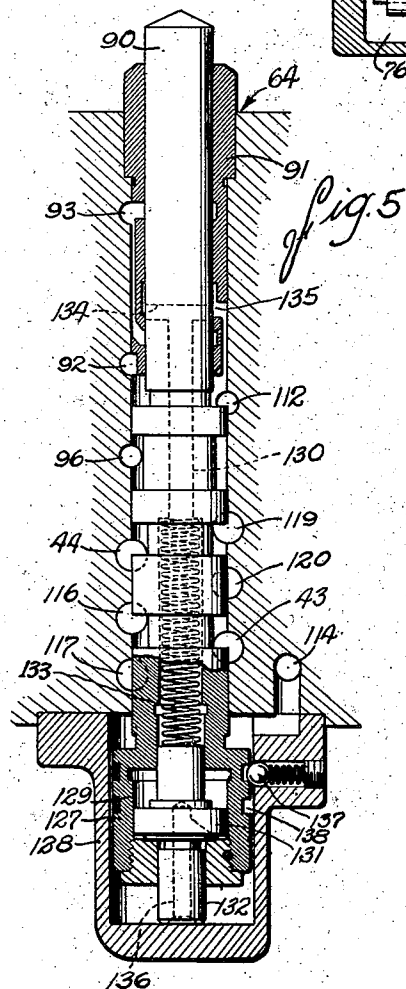
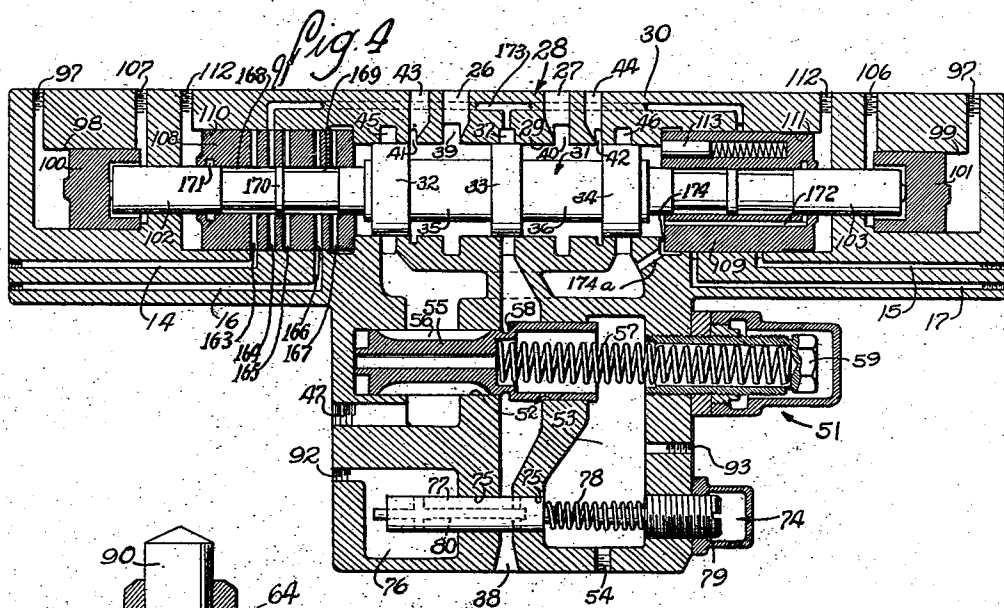
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4 Sheets-Sheet 3



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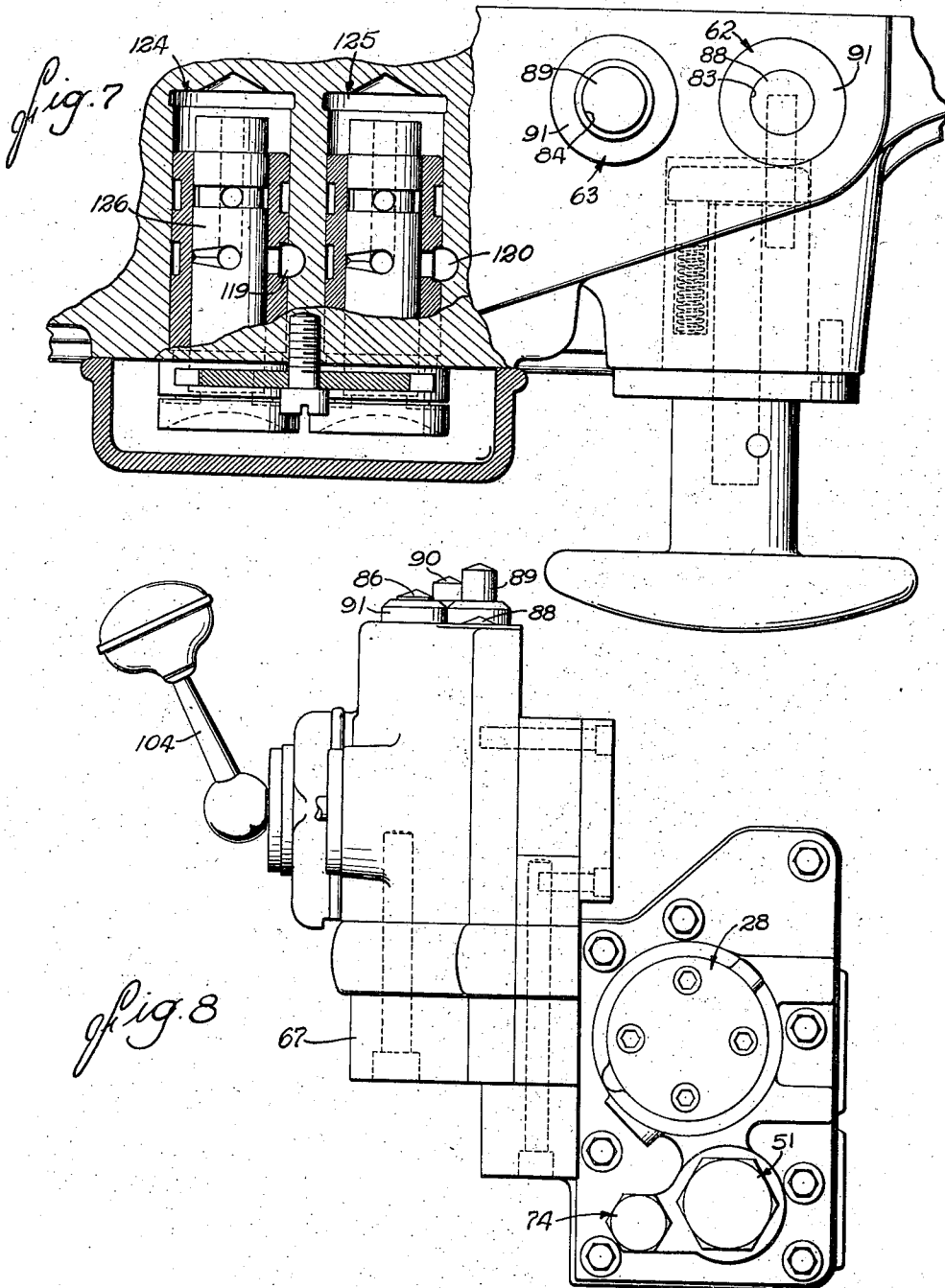
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HYDRAULIC TRANSMISSION FOR MACHINE TOOLS

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4 Sheets-Sheet 4



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## UNITED STATES PATENT OFFICE

2,375,255

## HYDRAULIC TRANSMISSION FOR MACHINE TOOLS

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Application August 30, 1937, Serial No. 161,636

17 Claims. (Cl. 60—52)

The present invention relates to improvements in machine tools and has particular reference to a new and improved hydraulic transmission.

One of the primary objects of the present invention is to provide a novel hydraulic transmission including a main control circuit and a pilot control circuit and including means for maintaining a constant relatively low pressure in the pilot control circuit regardless of pressure fluctuations in the main control circuit.

Another object is to provide a new and improved hydraulic transmission for a reciprocable carriage including selectively available dwell mechanisms for delaying the reversal at opposite ends of the reciprocation, the dwell mechanisms being connected in the pilot control circuit.

Still another object resides in the provision of novel means including a pilot feed control valve selectively operable by the carriage to effect a plurality of feed movements in each direction.

Further objects and advantages will become apparent as the description proceeds.

In the accompanying drawings,

Figure 1 is a view in perspective and on a reduced scale of a machine embodying the features of the invention.

Fig. 2 is a fragmentary view showing the machine control mechanism in front elevation.

Fig. 3 is a diagrammatic view of the hydraulic system.

Fig. 4 is an enlarged view showing the main direction valve and associated structure in longitudinal central section.

Fig. 5 is an enlarged view in longitudinal central section of the selective feed control mechanism.

Figs. 6 and 7 are similar views of the dwell control and orifice pressure control mechanisms respectively.

Fig. 8 is a view of the machine control mechanism in end elevation.

Referring more particularly to the drawings, the invention, for purposes of illustration, is disclosed as embodied in a machine tool comprising an elongated hollow base 1 on the top of which a carriage 2 is mounted for longitudinal reciprocation. Two inverted U-shaped bridge members 3 are mounted respectively on opposite ends of the base 1, and each serves as a support for one or more, for example, three parallel spindle structures 4.

Suitable spindles 5 are journaled respectively in the structures 4, and are adapted to be driven electrically, with the spindles at opposite ends of the machine under the control respectively of two

electric switches 6 and 7. These switches are adapted to close and open the spindle drive circuits to start and stop the spindles, and may be operated by any suitable means. In the present instance, the switches 6 and 7 respectively have actuating stems 8 and 9 rigidly connected to pistons 10 and 11 reciprocable in stationary hydraulic motor cylinders 12 and 13. Pressure fluid supply lines 14 and 16 open to opposite ends of the cylinder 12, and similar lines 15 and 17 open to opposite ends of the cylinder 13. This arrangement is shown diagrammatically in Fig. 3.

Each of the spindles 5 is provided with a brake 18, and the brakes for the two sets of spindles at opposite ends of the machine are connected respectively for joint actuation by two pistons 19 and 20 reciprocable in stationary hydraulic motor cylinders 21 and 22. Opposite ends of the cylinders 21 and 22 are connected respectively to the two sets of pressure fluid supply lines 14 and 16, and 15 and 17. The arrangement is such that if pressure fluid is supplied to the lines 14 and 15 and exhausted through the lines 16 and 17, the switches 6 and 7 will be open and the brakes 18 will be applied, and if pressure fluid is supplied to the lines 14 and 17, the left end spindles 4 will be idle and the right end spindles will be rotating, and if pressure fluid is supplied to the lines 15 and 16 the reverse condition will prevail.

The present invention relates primarily to an hydraulic operating mechanism for the carriage 2, the switch pistons 10 and 11, and the brake pistons 19 and 20. In its preferred form, the operating mechanism comprises an hydraulic carriage motor having a cylinder 23 mounted in fixed position within the base 1, and a piston 24 reciprocable in the cylinder and connected through a piston rod 25 to the carriage 2. Opening from the cylinder 23 respectively at opposite sides of the piston 24 are two fluid supply and discharge passages, conduits or lines 26 and 27 leading to a direction valve 28 (Figs. 3 and 4).

The direction valve may be of any desired construction, and preferably comprises an elongated bore 29 in a valve body 30. A valve piston 31 of the spool type, comprising axially spaced heads 32, 33 and 34 separated by annular spaces 35 and 36, is mounted for reciprocation in the bore 29. Formed in longitudinally spaced relation in the periphery of the bore 29 are an annular groove or pressure port 37 open to a pressure supply line 38, two annular grooves or cylinder ports 39 and 40 at opposite sides of the port 37 and open respectively to the lines 26 and 27, two annular grooves or feed exhaust ports 41 and 42 at oppo-

site sides of the ports 39 and 40 and open to restricted exhaust lines 43 and 44, and two annular grooves or rapid traverse exhaust ports 45 and 46 at opposite sides of the ports 39 and 40 and open to an unrestricted exhaust line 47 leading to a sump 48. These ports are so arranged that when the valve piston 31 is in the left end position, both ports 45 and 46 will be open to the port 39, the port 40 will be open to the pressure port 37 and the ports 42 and 46 will be closed from the space 36, thereby establishing rapid traverse of the carriage 2 to the left; when the piston is moved one step to the right, the port 41 will still be open to the port 39, but the port 45 will be closed by the head 32, thereby establishing a feed movement to the left; when the piston is located in the central position, as shown, the pressure port 37 will be closed by the head 33 and the ports 45 and 46 will be closed by the heads 32 and 34, thereby stopping the carriage 2; when the piston is moved partially to the right, the port 39 will be opened to the pressure port 37, the port 40 will be opened to the exhaust port 42, and the ports 45 and 46 will be closed from the spaces 35 and 36, thereby establishing a feed movement to the right; and when the piston is moved into the right end position, the port 46 will be opened to the port 40 to establish rapid traverse to the right.

The pressure line 38 is adapted to be connected to any suitable source of pressure fluid, such as a power driven pump 49 having an intake line 50 opening from the sump 48. The available pressure from the pump 49 is under the control of a relief valve 51 adapted to by-pass excess fluid from the passage 38 to the line 47. In the present instance, the high pressure relief or control valve 51 comprises a valve bore 52 in the body 30 opening from the pressure line 38 at opposite ends respectively to the exhaust line 47 and a chamber 53 draining through a line 54 to the sump 48. A plunger 55 is reciprocable in the bore 52, and is formed in the periphery with a plurality of longitudinal grooves 56 in communication with the exhaust line 47 and adapted for movement into and out of communication with the pressure line 38. A coil compression spring 57 in the chamber 53 tends to urge the plunger 55 in a direction to decrease or interrupt communication of the grooves 56 with the line 38. The plunger 55 is also formed with an annular face 58 defining a pressure area which is exposed to the pressure in the line 38 and acts in opposition to the spring 57. It will be evident that the relief valve 51 serves to limit the maximum pressure in the line 38. This pressure may be varied to suit the requirements of the machine work by means of an adjusting screw 59 acting against the fixed end of the spring 57.

The outer ends of the grooves 56 have a run out to the peripheral surface of the valve plunger 55. As a result, when the valve 51 is partially open, the increase in the effective opening pressure area by the transverse area of the grooves 56 exposed in the line 38 is counteracted by the kinetic pressure of the by-passing fluid against the outer end areas of the grooves. This substantial equalization of opposed forces serves to eliminate fluttering, and hence to maintain a more nearly uniform pressure in the line 38 under varying operating conditions.

The hydraulic circuits thus far described constitute the main operating circuits of the system, and are under the full pressure existing in the line 38. The main valve 28 is a five position

valve, and is operable by a pilot control comprising pilot control circuits under a relatively low pressure, and a plurality of pilot valves, namely, a start and stop valve 60, direction control valves 61 and 62, a rapid traverse valve 63 and a feed valve 64, operable by the carriage 2. The pilot control also includes two dwell mechanisms 65 and 66 for preventing immediate institution of the rapid return at the ends of the feed strokes in opposite directions.

The various operating elements of the pilot control, together with the main control valve 28 are incorporated in a unitary control panel 67 which is mounted on the front of the base 1, and which is so arranged that the pilot valves 60 to 64 are operable selectively by suitable control dogs 68 to 72 adjustably mounted in a T-slot 73 in the front side of the carriage 2. By selection and adjustment of the dogs, and by adjustment of the rate of feed and the selective use and adjustment of the dwell mechanisms 65 and 66, various machine cycles differing in movement rates and sequences may be obtained.

Fluid is supplied to the pilot control circuits at a relatively low pressure under the control of a regulating valve 74 in the body 30. The valve 74 comprises a bore 75 opening from the line 38 at one end to a pressure chamber 76 and at the other end to the drain chamber 53. A plunger 77 is slidable in the bore 75, and is urged against the pressure in the chamber 76 by a compression spring 78 having a pressure adjusting screw 79. The plunger 77 is formed with a longitudinal bore 80 open to the chamber 76, and adapted for communication with the line 38 or the chamber 53. It will be evident that the valve 74 serves to meter fluid from the line 38, which opens about the plunger 77, to the pressure chamber 76 which serves as the primary source of fluid supply for the pilot control circuits. When the pressure in the chamber 76 acting on the end of the valve member 77 balances the spring 78, the supply of fluid will be cut off. In the event of high pressure leakage past the valve 74 into the chamber 76, the resulting excess pressure will urge the plunger 77 to the right and allow fluid to escape through the bore 80 to the drain chamber 53. As a result, a balanced relatively low constant pressure is substantially maintained in the chamber 76 at all times.

The purpose in utilizing a uniform pressure in the pilot control lower than that in the operating circuits is to reduce the force required to operate the pilot valves 60 to 64, and thereby to diminish the load on the table dogs 68 to 72 and to obtain greater sensitivity and accuracy. Also, the pilot pressure will remain constant at all times regardless of pressure variations in the main operating circuits.

The pilot valves 60 to 64 comprise a plurality of vertical bores 81 to 85 formed in and opening to the top of the panel 67, and a plurality of spool valve plungers 86 to 90 reciprocable in the bores and projecting therefrom through bushings 91 for selective actuation by the dogs 68 to 72. Low pressure fluid from the chamber 76 is directed through a branched line 92 to the respective valve bores 81 to 85, and acts against the upper piston areas of the spool plungers 86 to 90. A leakage drain line 93 opens from the upper end portion of each of the valve bores 81 to 85 to the chamber 53.

The start and stop valve 60 is available to effect adjustment of the main control valve 28 into neutral position. Thus, the valve bore 81

has appropriately arranged port connections 94 and 95 with a drain line 96 connected to the line 47, and a port connection with a branched line 97 opening to the outer ends of two cylinders 98 and 99 located at opposite ends of the main valve bore 29. Two floating stop pistons 100 and 101 are slidable in the cylinders 98 and 99 and adapted for separable engagement with direction pins 102 and 103 engaging opposite ends of the main spool valve 31. When the stop plunger 86 is depressed, the lines 92 and 97 are connected, and hence the pistons 100 and 101 are held against the inner ends of the cylinders 98 and 99 to center the spool valve 31. When the plunger 86 is elevated, the line 97 is connected through the port connection 94 to the drain line 96, and the spool valve 31 is released for actuation under the control of the direction pilot valves 61 and 62 as hereinafter described.

The plunger 86 may be operated manually from the front of the panel 67 by means of a hand lever 104 to start and stop the carriage 2, and is self-maintained in either position. When the plunger 86 is elevated to start the operation, it is locked in operative position by pressure fluid in the lower end of the bore 81 supplied from the line 92 through a branch line 104<sup>a</sup>. When the plunger 86 is depressed to stop the operation, the line 104<sup>a</sup> is closed, and the lower end of the bore 81 is vented through a passage 105 in the plunger and the port connection 95 to the drain line 96.

The pilot valves 61 and 62 are operable respectively to institute the right and left movements of the carriage 2, and to reset each other alternately for coaction with the dogs 69 and 70. Each has port connections with the supply and drain lines 92 and 96, and with cross lines 106 and 107 opening respectively to the lower ends of the valve bores 83 and 82 and also to the inner ends of the cylinders 99 and 98. The port connections are so arranged that when the plunger 87 is depressed, the line 92 will be connected to the line 106, thereby causing upward movement of the plunger 88 to connect the line 107 to the drain line 96. As a result, the plunger 87 is locked in depressed position, the plunger 88 is held in its upward position, and the directional pin 103 is shifted to the left, thereby shifting the spool valve 31 in the same direction to institute the carriage movement to the left. Conversely, when the plunger 88 is depressed, pressure fluid is supplied through the line 107 to the lower end of the bore 82 to raise the plunger 87 and connect the line 106 with the drain line 96 and to the inner end of the cylinder 98. As a result of the attendant outward movement of the plunger 87, fluid is exhausted from the inner end of the cylinder 99 while the directional pin 102, together with the spool valve 31, is moved to the right to institute carriage movement to the right.

The pilot valves 89 and 90 control each other and also the valve 28 for selective rapid traverse and feed. The feed positions of the main spool valve 28 are determined by stop collars 108 and 109 reciprocable in cylinders 110 and 111 defined by enlargements of the opposite ends of the valve bore 29. A branched line 112 opens in parallel to the outer ends of the cylinders 110 and 111, and is adapted to be connected by the feed control valve 64 either to the pressure line 92 when the plunger 90 is depressed, as shown in Fig. 3, or to the drain line 96 when the plunger is fully elevated. Upon supply of pressure fluid to the line 112, the stop collars 108 and 109 are moved into their innermost position, as shown in Fig. 4, 75

against whatever pressure may exist in the inner end of one or the other of the cylinders 98 and 99, and serve to limit the range of movement of the valve member 31 so that the exhaust ports 45 and 46 will remain closed during the previously described feed movement of the table. Suitable spring actuated plungers 113 (shown only in connection with stop collar 109) tend to urge the stop collars 108 and 109 into their outermost positions when the line 112 is connected to the drain line 96.

The rapid traverse valve 63 has appropriate port connections with the pressure line 92, the drain line 96 and a cross line 114 leading to the lower end of the feed valve bore 85. The line 112, leading from the feed valve 64 has a branch cross line 115 opening to the lower end of the bore 84. Hence, the rapid traverse plunger 89 is elevated when the feed plunger 90 is depressed, and thereupon relieves the line 114 to lock the latter in depressed position. Likewise, the feed plunger 90 is moved into elevated position when the plunger 89 is depressed, and thereupon relieves the line 115 to lock the latter in depressed position.

The feed valve 64 also controls connection of the exhaust lines 43 and 44 to the drain to obtain a plurality of selective feeds in either direction of carriage movement. Thus, the bore 85 has appropriate port connections with the lines 43 and 44, two parallel lines 116 and 117 connected through a line 118 to the drain line 96, and two other parallel lines 119 and 120 connected through a line 121 to the drain line. These port connections are so arranged that when the plunger 90 is fully elevated, the lines 43 and 44 are blocked or closed; when the plunger is partially depressed, the line 43 is connected to the line 116 and the line 44 is connected to the line 119; and when the plunger is fully depressed, the lines 43 and 44 are connected respectively to the lines 117 and 120.

Suitable flow restrictions, preferably adjustable orifice valves 122 to 125, are interposed respectively in the parallel lines 116, 117, 119 and 120. Preferably, these orifice valves are alike in construction, each comprising a rotary valve plug 126 (Fig. 7) independently adjustable from the front of the panel 67. The orifice valves control the escapement of motive fluid from the motor cylinder 23, and hence their adjustment determines the rate or rates of feed in either direction of carriage travel. The two valves 122 and 124 may be adjusted to obtain a fast feed and the two valves 123 and 125 may be adjusted to obtain a slow feed. Assuming the valves to be so adjusted, partial depression of the plunger 90 will institute a rapid feed and full depression of the plunger will institute a slow feed, in either direction of carriage movement depending on which of the direction valves 61 and 62 is depressed.

To maintain the intermediate adjustment of the valve 64 for fast feed, the plunger 90 (Fig. 5) is rigid at the lower end with a hollow differential piston 127 reciprocable in a cylinder 128 connected at opposite ends to the line 114. The piston 127 defines an internal cylinder 129 open to an axial bore 130 in the plunger 90. A piston 131 is reciprocable in the cylinder 129 and has an axial stem 132 adapted to project through the lower end wall for engagement with the bottom wall of the cylinder 128. A coil compression spring 133 in the bore 130 tends to urge the piston 131 downwardly in the cylinder 129. The upper end of the bore 130 opens to a transverse bore

134 adapted for connection, when the plunger 90 is in intermediate or elevated position, with an annular groove 135 in the valve bushing 91 always in communication with the pressure line 92, and for connection when the plunger is fully depressed with the drain line 93. The lower end of the cylinder 129 is vented through a passage 136 in the piston 131 to the lower end of the cylinder 128.

In operation, when the plunger 90 is partially depressed into fast feed position, as shown in Fig. 5, the opposite ends of the cylinder 128 are exhausted. Fluid pressure acting on the upper end of the differential plunger 90 tends to urge the latter downwardly, but also projects the stem 132 to limit the downward movement. When the plunger 90 is fully depressed, the upper end of the cylinder 129 is also exhausted, and thereupon the pressure acting on the upper end of the plunger serves to lock the latter in the slow feed position.

A suitable spring detent 137 is selectively engageable in parallel annular grooves 138 in the piston 127, and serves to hold the valve 64 in position of adjustment when the pump 49 is shut off. A spring friction detent 139 (Fig. 3) engages the side of the direction valve plunger 88 for the same purpose. As a result, the cycle is maintained under control when the machine is stopped, and will continue its cycle when the machine is again started.

Interposed respectively in the drain lines 118 and 121 at the outlet ends of the orifice valves 122 to 125 are two governor or orifice pressure control valves 140 and 141. Preferably, the two valves are alike in construction and corresponding parts thereof are therefore identified by the same reference numerals. The valve 140 comprises a differential cylinder 142 connected at the small end to the line 43 and at the large end to the section of the line 118 exhausting from the orifices 122 and 123. An annular groove 143 in the large end portion of the cylinder 142 is open to the other section of the line 118 connected with the drain 96. Freely reciprocable in the cylinder 142 is a hydraulically balanced differential valve piston 144. A plurality of peripherally spaced generally longitudinal V-shaped notches or grooves 145 are formed in the periphery of the large end of the piston 144 and are movable into various degrees of communication with the annular groove 143 to provide a restricted adjustable orifice in the line 118.

The adjustable orifice defined by the grooves 145 at their points of communication with the groove 143 is in series with the orifices 122 and 123. Consequently, the pressure drop in the exhaust side of the system is divided between the orifices as determined by the ratio of the areas of the differential piston 144. For example, if the large end area of the piston is twice the size of the small end area, there will be a fifty percent pressure drop across the orifice 122 or 123 and a fifty percent pressure drop across the valve 140. This ratio will be automatically maintained regardless of pressure variation and regardless of different size adjustments of the orifices 122 and 123. Since the pressure drop is subdivided by the two orifices in series, each of the orifice flow areas is larger than if a single control orifice were employed for a given rate of table movement. The larger orifice flow area is less likely to become clogged by foreign matter in the oil, particularly when the table is moving at a slow rate of

feed. In the case of the valve 141, the large end of the cylinder is connected to the inlet section of the line 121 and the annular groove 143 is connected to the outlet section of this line, and the small end of the cylinder is connected to the exhaust line 44.

In operation, when the selective feed control plunger 90 is partially depressed into fast feed position, as shown in Figs. 3 and 5, the pressure line 92 is connected with line 112 for holding the stop collars 108 and 109 in their innermost positions, and through the line 115 to lock the rapid traverse valve 63 in its upward non-operative position. At the same time, the rapid feed control orifice valves 122 and 124, with the associated orifice pressure control valves 140 and 141, are connected to control the passage of fluid out of the motor 23 through lines 43 or 44. When the selective feed valve plunger 90 is further depressed to its slow feed position, the connections remain unchanged except that the slow feed orifice valves 123 and 125 are connected into the lines 43 and 44. Upon depression of the rapid traverse plunger 89, pressure line 92 is connected to line 114 to lift the selective feed plunger 90 to its uppermost position. Line 112 is thereby connected to exhaust line 96 to relieve the pressure from the outer ends of the stop collars 108 and 109, allowing these collars to move to their outermost position and permitting the valve piston 31 to move in the direction determined by the directional valves 61 or 62 to connect lines 26 or 27 directly with the sump through rapid traverse exhaust ports 45 or 46. For any setting of the selective feed valve 64, the direction of table travel will be determined by the direction valves 61 and 62. Thus, by proper setting of the machine controls, practically any desired series of table movements is obtainable.

On occasion, it may be desirable to delay the reversal of the carriage 2 at either end of the reciprocation, and the two dwell mechanisms 65 and 66 are selectively available for this purpose. Preferably, the dwell mechanisms are alike in construction so that a description of one will suffice for both. The mechanism 65 comprises a cylinder 146 in which a differential spool piston 147 is reciprocally disposed. One end of the cylinder 146, exposed to the small area of the piston 147, is constantly connected through an adjustable restricted orifice valve 148 to the pressure line 92. The other end of the cylinder 146, exposed to the large area of the piston 147, opens to a line 149. Another line 150 opens from an intermediate point in the cylinder 146, and is adapted to be uncovered by the piston 147, when the latter is moved into one extreme position by the application of a differential pressure. A manually adjustable two-position valve 151 is available selectively to connect the line 149 to the section of line 106 opening to the valve bore 82 for communication with the pressure line 92 when the directional feed plunger 87 is depressed, and the line 150 to the other section of line 106, or to connect the line 149 to the line 150 and the line 106 through the valve 151 directly to the valve bore 82. The valves 148 and 151 are mounted in the control panel 67, the valve 148 being associated in a unitary mounting with the orifice valves 122 and 123 for adjustment from the front of the machine.

The dwell mechanism 66 is identical except for the line connections, the valve 151 in this case being interposed in the line 107 to time the up-

ward movement of the left-hand directional plunger 87. The ends of the cylinders 146 opposite to the lines 149 are connected with the exhaust line 96 and the pistons 147 preferably have an intermediate peripheral recess 160 which communicates through a bore 161 in the piston and in a connected stem 162 with the exhaust line 96 to permit the expulsion of fluid respectively from the lines 106 and 107 when the associated piston is returned to its upward position.

When a dwell is not desired, the valve 151 is adjusted, as shown by the position of dwell mechanism 66, to connect the lines 149 and 150 and to pass fluid directly from one section of line 107 to the other. In this adjustment, the system will operate to effect immediate reversal. When the dwell is desired, the valve 151 is adjusted into the other position, as shown by dwell mechanism 65, so that the line 106 is not directly connected to the pilot valve 61, but will receive pressure fluid from the cylinder 146 or will exhaust through the piston 147. Assuming that the dwell mechanism 65 is conditioned for operation, depressing the plunger 87 at the end of the stroke will not immediately direct pressure fluid into the line 106. Instead, the carriage 2 will move into a fixed limit position, and pressure fluid will be directed through the line 149 to the large end of the cylinder 146. The piston 147 will move in response to the differential pressure at a rate determined by the setting of the orifice 148, and at the end of this movement will open the line 150 to supply pressure fluid to the line 106 and thereby effect reversal of the main valve 28.

The disposition of the switches 6 and 7 and the brakes 18, in operative or inoperative condition, is preferably under the control of the main directional valve 28. Referring to Figs. 3 and 4, the pressure fluid supply lines 14 and 16 to the left end switch 6 and brakes 18 lead through the valve body 30 to terminate at longitudinally spaced intervals opposite the stop collar 108, and the supply lines 15 and 17 for the right end switch 7 and brakes 18 similarly terminate opposite the stop collar 109. Since the stop collars 108 and 109 are substantially identical, only one need be described, but it should be noted that in Fig. 4 the lines of section through the stop collars are taken on different planes for better illustration of the passageways therein.

As shown in connection with stop collar 108, a series of longitudinally spaced radial bores 163 to 167 is provided. The stop pin 102 opposite these bores has a pair of peripheral recesses 168 and 169 separated by a head 170. Near the outer end of the stop collar 108 is an annular recess 171 surrounding the pin 102 and communicating through a bore 172 (see stop collar 109) with the inner face of the collar. A line 173 leads from the pressure port 37 to a point opposite the stop collar 108. The arrangement is such that, when the main direction valve 28 is in its centered or locked position, as shown in Fig. 4, and the feed plunger 90 is in depressed position, in which instance the stop collar 108 occupies its innermost position, pressure fluid is supplied to the line 14 through line 173, radial bore 164, recess 168 and bore 163. At the same time, the line 15 is connected with the exhaust side of the system through bore 166, recess 169, bore 167 and an escape passage 174 (see stop collar 109) around the end of the stop collar and thence through a passage 174a to the exhaust line 47. The same

connections obtain through the stop collar 109, respectively, for the lines 15 and 17, and in this position of the main direction valve 28 the pistons 19 and 20 are actuated to apply the brakes and the pistons 10 and 11 are moved to open the switches 6 and 7. The spindles are, therefore, idle. When the pilot valves are actuated to initiate a feed stroke, the brakes and switch on that end of the machine, toward which the table moves, are respectively released and closed to effect spindle operation.

Presuming that the system is actuated to establish a feed stroke to the left, the valve 31 moves to the left as limited by the stop collar 108 to establish the feed connections. The stop collar 108 is not moved, so that the connection between the line 173 and bore 164 remains established. The pin 102, however, moves to the left to carry the head 170 to the opposite side of the bore 164 effecting a reversal of the application of pressure fluid through the lines 14 and 16 to release the left end spindle brakes, and close the left end switch 6. The line 14 will drain through recess 168, groove 171 and bore 172. The connections through the stop collar 109 and pin 103 remain unchanged during this operation. Should the valve be moved in the opposite direction to effect a feed toward the right, the normal fluid pressure connections through the lines 15 and 17 would be reversed in the same manner to enable operation of the right end spindles.

When the valve 31 is in its rapid traverse position, either in right or left direction, the stop collars 108 and 109 will move to their outermost positions, thereby blocking line 173 and drain groove 174. The relative positions of the pin 102 and 103 to the stop collars 108 and 109 prevent drainage from the recesses 168 and 169. Hence, when the valve is in position for rapid traverse in either direction, both pressure and drain lines leading to the brake and switch cylinders at both ends of the machine are blocked and no action affecting any of these cylinders will take place. An interrupted or jump cut may, therefore, be performed without stopping the spindles during a rapid traverse jump between feeds, and the spindles will only stop when the machine is reversed or brought to a complete stop. The stopped condition of the spindles will be maintained until a feed movement of the machine in one direction or the other is initiated, at which time only those spindles located at the end of the machine, toward which the feed table moves, will be started.

We claim as our invention:

1. An hydraulic operating mechanism for a reciprocable element of a machine tool comprising, in combination, a reversible hydraulic piston and cylinder motor for reciprocating said element, an hydraulic operating system including control valve means for supplying pressure fluid to said motor to effect reciprocation thereof, an hydraulic pilot control system including at least one pilot valve for operatively positioning said control valve means to govern the operative movements of said motor, pump means having a discharge passage for supplying pressure fluid under relatively high pressure directly to said operating system, a branch passage for supplying pressure fluid to said pilot control system, and an automatic valve connecting said passages and operable to charge said branch passage with pressure fluid under a relatively low constant pressure from said discharge passage.

2. An hydraulic operating mechanism for a reciprocable element of a machine tool comprising, in combination, a reversible hydraulic piston and cylinder motor for reciprocating said element, an hydraulic operating system including control valve means for supplying pressure fluid to said motor to effect reciprocation thereof, an hydraulic pilot control system including pilot valves for operatively positioning said control valve means to govern the operative movements of said motor, a source of pressure fluid under relatively high pressure connected with said operating system, and branch means at the pressure side of said control valve means for connecting said source with said pilot control system including valve means for automatically limiting the pressure in the pilot control system to a predetermined maximum pressure less than that of said source.

3. An hydraulic operating mechanism for a reciprocable element of a machine tool comprising, in combination, a reversible hydraulic piston and cylinder motor for reciprocating said element, an hydraulic operating system including control valve means for supplying pressure fluid to said motor to effect reciprocation thereof, an hydraulic pilot control system including pilot valves for operatively positioning said control valve to govern the operative movements of said motor, a source of pressure fluid under relatively high pressure connected with said operating system and with said pilot control system, and a constant pressure regulating valve for maintaining the flow of pressure fluid to said pilot control system at a predetermined maximum pressure less than that of said source, said last mentioned valve including means for exhausting excess pressure fluid from said pilot control system.

4. An hydraulic operating mechanism for reciprocable machine tool element comprising, in combination, a reversible hydraulic piston and cylinder motor for reciprocating said element, two fluid supply passages leading respectively to opposite ends of said motor, a source of fluid under pressure, two exhaust passages each being branched and each branch including an adjustable restricted orifice, valve means for connecting said source alternately to said supply passages and for effecting the discharge of exhaust fluid from said motor alternately through said exhaust passages, and selective valve means for controlling the exhaust flow of fluid through one or the other of the branches of the exhaust passage connected to said motor.

5. An hydraulic operating mechanism for a reciprocable machine tool element comprising, in combination, a reversible hydraulic piston and cylinder motor for reciprocating said element, two fluid supply passages leading respectively to opposite ends of said motor, a source of fluid under pressure, independent exhaust means for each end of said motor, each of said exhaust means including two independently adjustable restriction orifices for controlling the rate of exhaust flow therethrough, direction valve means automatically operable upon movement of said element into one end position to connect one of said supply passages to said source and to effect the discharge of fluid through the exhaust means connected with the opposite end of said motor, and upon movement of said element into the other end position to connect the other supply passage to said source and to effect the discharge of fluid through the exhaust means then connected with the opposite end of said motor, and means for

directing the exhaust flow of fluid through selected restriction orifices.

6. In an hydraulic operating mechanism for a reciprocable machine tool element, the combination of a reversible hydraulic piston and cylinder motor for reciprocating said element, two fluid supply passages communicating respectively with opposite ends of said motor, a source of fluid under pressure, two exhaust passages, a reversible direction valve operable to connect said source selectively to one of said supply passages and one of said exhaust passages to the other of said supply passages and alternatively to connect said one supply passage to said other exhaust passage and said other supply passage to said source, each of said exhaust passages having two independently adjustable orifice valves connected therein in parallel, and a single means for directing a flow of exhaust fluid selectively through one or the other of the orifice valves associated with the exhaust passage which is connected with one of the supply passage, said single means having a position in which said directional control valve connects said source selectively to either of said supply passages and the other of said supply passages directly with a fluid outlet.

7. An hydraulic operating mechanism for a movable machine tool element, a base for supporting said element, a piston and cylinder motor for driving said element, valve means including two pilot valves mounted in fixed position on said base and operable respectively to effect reverse movements of said element, each pilot valve comprising a casing and a valve member movable therein and projecting therefrom, control means on said carriage, each member having an inoperative position and an operative position for engagement by said control means, a source of fluid under pressure, two passages cross-connecting said casings and controlled by said members for selective connection to said source to automatically return either member into operative position upon movement of the other member into inoperative position by said control means, and means manipulable for operative association with each cross-connecting passage for providing a dwell for said element prior to the return of one member or the other into operative position whereby to effect a delayed reversal of said element at the end of either direction of its movement.

8. A machine tool comprising, in combination, a base, a carriage reciprocable on said base, an hydraulic motor for reciprocating said carriage, an hydraulic control system for said motor and including a valve adapted for actuation to effect reversal of movement of said carriage at each end of said movement, abutment means for stopping said carriage in predetermined end position, pressure fluid responsive means for actuating said valve to effect said reversal of movement respectively in opposite directions, a source of fluid under pressure, and two selectively available adjustable time delay devices operable to connect said source respectively to said pressure fluid responsive means after a dwell period at opposite ends of said reciprocation.

9. A hydraulic operating mechanism for a movable machine tool element comprising, in combination, a reversible hydraulic motor for actuating said element, a hydraulic operating system for supplying pressure fluid to said motor and including a hydraulically operable control element and a high pressure fluid supply passage, a hydraulic pilot control system including at least one pilot

member for operatively adjusting said control element and having a low pressure fluid supply passage, and a pressure reducing valve for automatically supplying pressure fluid to said low pressure passage up to a predetermined relatively low maximum pressure from said high pressure passage and for discharging excess pressure fluid above said predetermined low maximum pressure in said low pressure passage from said pilot control system, whereby to maintain a substantially constant pressure in said low pressure passage regardless of varying demands of said pilot control system.

10. A hydraulic operating mechanism for a movable machine tool element comprising, in combination, a reversible hydraulic motor for actuating said element, a hydraulic operating system for supplying pressure fluid to said motor and including a hydraulically operable control element and a high pressure fluid supply passage, a hydraulic pilot control system including at least one pilot member for operatively adjusting said control element and having a low pressure fluid supply passage, a drain, a valve bore open intermediate its ends to said high pressure passage and opening at its ends respectively to said low pressure passage and said drain, a valve member reciprocable in said bore and having a longitudinal flow passage constantly open at one end to said low pressure passage and terminating at the other end in a port movable selectively in opposite directions into communication respectively with said high pressure passage and said drain, adjustable spring means tending to urge said member in a direction to establish communication of said port with said high pressure passage, said valve member being opposed to the pressure in said low pressure passage acting in opposition to said spring means, whereby fluid under pressure will be supplied from said high pressure passage through said flow passage to said low pressure passage up to a predetermined relatively low maximum pressure and excess pressure fluid above said predetermined pressure will be discharged from said low pressure passage through said flow passage to said drain.

11. A hydraulic operating mechanism for a movable element of a machine tool comprising, in combination, a reversible hydraulic motor for moving said element, a hydraulic operating system including control valves for governing the operation of said motor, a source of fluid under pressure communicating with said system, and means for controlling the pressure of the fluid delivered to said system, said last mentioned means including a pressure chamber open to said source, an exhaust chamber open to drain, a valve passage connecting said chambers, a differential valve reciprocable in said passage and having a longitudinal groove open to said exhaust chamber and movable into and out of communication with said pressure chamber and having a pressure area exposed to the pressure in said pressure chamber and acting in a direction to effect graduated opening of said groove to said pressure chamber, adjustable spring means acting on said valve member in a direction in opposition to the pressure in said pressure chamber, the outer end of said groove in said exhaust chamber having a runout to the periphery of said valve member disposed in the path of the kinetic pressure of the by-passing fluid whereby to compensate for variations in the effective size of said pressure area in different degrees of valve opening.

12. A hydraulic operating mechanism for a

movable element of a machine tool comprising, in combination, a reversible hydraulic motor for driving said element, a source of fluid under pressure, a direction valve for connecting said source reversibly to said motor, hydraulic means for reversing said direction valve and including two fluid supply passages, pilot valve means operable to connect said source alternately to said passages, and two dwell mechanisms associated respectively with said passages, each mechanism being operable to interrupt the flow of fluid through the associated passage for a predetermined time after connection of said associated passage by said pilot valve means to said source.

13. A hydraulic operating mechanism for a movable element of a machine tool comprising, in combination, a reversible hydraulic motor for driving said element, a source of fluid under pressure, a direction valve for connecting said source reversibly to said motor, hydraulic means for reversing said direction valve and including two fluid supply passages, pilot valve means operable to connect said source alternately to said passages, two dwell mechanisms associated respectively with said passages, and two selector valves independently operable at will to connect said mechanisms respectively into said passages in the path of fluid flow or to shunt said mechanisms, each mechanism when interposed in its associated passage being operable to interrupt the flow of fluid there-through for a predetermined time after connection of said associated passage by said pilot valve means to said source whereby to delay the reversal of said direction valve.

14. A hydraulic operating mechanism for a movable element of a machine tool comprising, in combination, a reversible hydraulic motor for driving said element, a source of fluid under pressure, a direction valve for connecting said source reversibly to said motor, hydraulic means for reversing said direction valve and including two fluid supply passages, pilot valve means operable to connect said source alternately to said passages, a two position selector valve interposed in one passage, a by-pass passage across said valve, said valve in one position connecting said pilot valve means directly to said hydraulic means and in the other position connecting said pilot valve means through said by-pass passage to said hydraulic means, and a dwell mechanism interposed in said by-pass passage, said mechanism comprising a differential valve, and means including an adjustable restricted orifice connecting said source to the small end of said differential valve normally to maintain said differential valve in closed position, the large end of said differential valve being connected to said supply passage at the up stream side of said differential valve when said selector valve is adjusted to connect said by-pass passage and acting in a direction to open said differential valve.

15. A hydraulic operating mechanism for a movable element of a machine tool comprising, in combination, a reversible hydraulic motor for driving said element, a source of fluid under pressure, two supply passages connected to opposite sides of said motor, a relatively unrestricted exhaust passage, two restricted exhaust passages associated respectively with said supply passages, a reversible direction valve operable in reverse positions to connect one or the other of said supply passages respectively to said source and in each position being adjustable to connect the supply passage receiving fluid from said motor selectively to said unrestricted passage or the

associated restricted passage, pilot valve means operable by said elements to effect adjustment of said direction valve selectively into its said positions of adjustment, and two sets of parallel restricted orifices interposed respectively in said restricted passages, said pilot valve means being operable to connect said orifices of each set selectively in said associated restricted passage concurrently with location of said direction valve in position to connect said motor to the selected one or the other of said restricted passages.

16. A hydraulic operating mechanism for a movable element of a machine tool comprising, in combination, a reversible hydraulic motor for driving said element, a source of fluid under pressure, two supply passages connected to opposite sides of said motor, a relatively unrestricted exhaust passage, two restricted exhaust passages associated respectively with said supply passages, a reversible direction valve operable in reverse positions to connect one or the other of said supply passages respectively to said source and in each position being adjustable to connect the supply passage receiving fluid from said motor selectively to said unrestricted passage or the associated restricted passage, pilot valve means operable by said element to effect adjustments of said direction valve selectively into its said positions of adjustment, and two parallel re-

stricted orifices interposed in one of said restricted passages, said pilot valve means being operable to connect said orifices selectively in the associated restricted passage concurrently with location of said direction valve in position to connect said motor to said associated restricted passage.

17. A hydraulic operating mechanism for a movable element of a machine tool comprising, in combination, a reversible hydraulic motor for driving said element, a source of fluid under pressure, a direction valve for connecting said source alternately to opposite sides of said motor, a relatively unrestricted exhaust passage, a relatively restricted exhaust passage, pilot control means operable by said element for adjusting said direction valve selectively into position to direct fluid discharging from said motor to one or the other of said passages, and two parallel restricted orifices interposed in said restricted passage, said pilot control means including a pilot valve member operable by said element to effect adjustment of said direction valve into position to connect said restricted passage and simultaneously to render one of said orifices functionally operative, and further operable by said element to render the other of said orifices functionally operative.

IRA J. SNADER,  
MAX A. MATHYS.

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CERTIFICATE OF CORRECTION.

Patent No. 2,375,255.

May 8, 1945.

IRA J. SNADER, ET AL.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 6, first column, line 50, claim 4, for "controlling" read --directing--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 9th day of October, A. D. 1945.

Leslie Frazer

(Seal)

First Assistant Commissioner of Patents.