This invention relates to machine tools, and has for a principal object the provision of improved means for actuating a support thereof in a positive and steady manner so that the tooling operation will not cause any inadvertent reactionary movements not dictated by the feeding mechanism.

Another object of this invention is the provision of an improved and simplified backlash eliminating mechanism for machine tools.

A further object of this invention is to provide improved and simplified means for controlling the backlash eliminating mechanism automatically whereby it will be effective during feeding movements in either direction, and ineffective during quick traverse movements.

Other objects and advantages of the present invention should be readily apparent by reference to the following specification considered in conjunction with the accompanying drawings illustrative of one embodiment thereof, but it will be understood that any modifications may be made in the specific structural details within the scope of the appended claims without departing from or exceeding the spirit of the invention.

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

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

Figure 2 is a detail view partly in section showing the motion transmitting connection between the power transmission and the moving support.

Figure 3 is an expanded view of the feed-rapid traverse transmission.

Figure 4 is a detail view of the reversing clutch shifter.

Figure 5 is a detail view of the shifter for the feed-rapid traverse selector.

Figure 6 is a detail view of the stop plunger and associated connections.

Figure 7 is a diagrammatic view of the hydraulic control circuit with the pilot valve in a position to yield quick traverse left.

Figure 8 is a diagrammatic view of the hydraulic control circuit with the pilot valve in a position to yield feed left.

Figure 9 is a diagrammatic view of the hydraulic control circuit with the pilot valve in a position to yield feed right.

Figure 10 is a diagrammatic view of the hydraulic control circuit with the pilot valve in a position to yield quick traverse right.

Figure 11 is a diagrammatic view of the hydraulic control circuit showing the connections to the backlash eliminating mechanism.

In Figure 1 of the drawings there is shown a milling machine as an example of a machine tool to which this invention is particularly adaptable, because in such a machine the tooling operation can produce force components which are capable of causing inadvertent movement of the moving support if any lost motion exists in the actuating mechanism therefor. Since a milling machine constitutes a good example for the application of this invention, it will be explained in connection therewith.

The exemplary milling machine illustrated has a pedestal from which uprises a column, in the upper portion of which is rotatably mounted a cutter spindle for supporting and rotating a tool or cutter. Any conventional mechanism may be utilized for power rotating the spindle. The front of the column is provided with guide surfaces upon which a knee is vertically slidable. The knee in turn has horizontal guideways for receiving a work table which is movable transversely to the axis of the spindle. The table may be provided with suitable means for securing work thereto, such as the T-slot in which T-bolts may be mounted for clamping a work piece.

A transmission for effectsing relative movement between the work support and the tool support is illustrated in Figure 3 of the drawings. This transmission comprises a constantly driven train including a power actuated shaft, which may be continuously rotated by any suitable source of power such as an electric motor not shown. This shaft is journaled in the column and connected by bevel gearing to a vertical spline shaft, the bevel gearing being fixed with the column and the spline shaft fixed with the knee whereby upon vertical adjustment of the knee, the shaft will slide through the bevel gear. The spline shaft drives through a second set of bevel gearing, a horizontal shaft which has a spur gear fixed therewith for rotating the rapid traverse gear.

The gear is keyed to shaft for effecting rotation thereof, and this shaft has a second gear keyed to the end thereof for actuating the feed transmission.

The feed transmission comprises a gear which is keyed to a shaft and driven by the gear. The shaft extends the full width of the transmission and drives a change gear. The change gear intermeshes with a second change gear, and by removing the cover
these change gears may be removed and reversed, or other pairs of gears of different ratio substituted therefor, whereby a variety of feed ratios is provided for adjustment of the work table. The gear 33 is secured to the hub of a gear 35 which is supported for free rotation on the end of shaft 28, and the gear 35 intermeshes with a gear 36 keyed to a sleeve 37 which is supported for free rotation on the shaft 31. The sleeve 37 has an integral pinion 39 gear couple 40 which is also supported for free rotation on the shaft 28. The pinion 41 of couple 40 drives a large gear 42 which is keyed to a sleeve 43 supported for relative rotation with respect to the shaft 31. The sleeve 43 also has a drive member 44 keyed to the other end thereof. A pair of parallel gear trains terminate in gears 45 and 46 respectively which are supported for free rotation on the sleeve 43. These gears are driven through a pair of overrunning clutches 47 by gear 42 and actuator 44 respectively.

It will be noted that each of the driving gears in the train between gear 32 and the gear 42 was smaller than the driven gear whereby a desirable rate reduction is effected whereby the gears 45 and 46 are rotated at a slower speed than the gears 42 and 44. These gears rotate at a faster rate without interfering with the constant rotation of the actuators.

Rotation at a fast or quick traverse rate is effected by the gear 27 which is in continuous mesh with a gear 48 supported for free rotation on the sleeve 43. This gear has clutch teeth 49 on one end for interengagement with clutch teeth 50 formed on the face of gear 45; and clutch teeth 51 on the other end for interengagement with clutch teeth 52 on the face of the gear 45. The gear 45 is shifted from one extreme position to the other by a fluid actuated shifter 53 which, as shown in Figure 5, has piston portions 54 and 55 on opposite ends slidable in cylinders 56 and 57 respectively. The shifter is connected to the gear 45 by means of a shifter fork 58.

It will now be apparent that when the gear 45 is in driving engagement with the gear 46 that the gear 45 will be rotated at a fast rate due to slippage in the overrunning clutch 47, and the gear 45 will continue to be driven at a slow or feeding rate.

The gear 45 continuously meshes with a gear 59 which is supported for free rotation on a sleeve 60 surrounding shaft 61. The gear 45 drives a gear 62 through an intermediate idler 63 whereby the gear 62 rotates in a direction opposite to that in which the gear 59 rotates. The opposing faces of gears 59 and 62 are provided with clutch teeth 64 and 65 respectively which are adapted to interengage similar clutch teeth formed on opposite sides of the shiftable clutch member 66. The clutch member 66 is splined at 67 on the sleeve 60. The sleeve 60 is fixed with the shaft 61 for rotation thereof, and this shaft has a gear 68 keyed thereto which intermeshes with gear 65 keyed to a parallel shaft 70. The shaft 70 drives through bevel gears 71 and 72, as shown in Figure 2. a vertical shaft 73 which extends upward to the under side of the work supporting table 17. At this point the shaft 73 is connected by bevel gear 74 to a rotatable screw 75, the screw being antifrictionally journaled at opposite ends in the table 17 for bodily movement therewith. The bevel gear 74 is held against rotation whereby the screw 75 moves axially relative thereto.

It will now be seen that the shaft 61 shown in Figure 3 is the final shaft of the transmission which is adapted to be rotated at feed or rapid traverse rates in accordance with the position of the shiftable members 48 and 55, and that the direction of rotation will depend solely upon the position of the direction determining clutch 66.

This clutch is shifted by a shifter fork 76 secured to the actuator 71, as shown in Figure 4. This actuator has piston portions 78 and 79 formed on opposite ends and slidably mounted in neutralizing sleeves 80 and 81 respectively. These sleeves are slidably mounted in cylinders 82 and 83 whereby when pressure is admitted to one of these cylinders, such as the cylinder 83, the actuator 75 moves to the limit of its stroke to the left moving the sleeve 80 with it whereby engaging is effected with gear 55. Similarly, when pressure is admitted to cylinder 82, the actuator is moved to the extreme right moving the sleeve 81 with it and effecting driving engagement with the gear 46. The shifter 75 is moved to a central position and the clutch 65 is out of engagement with gears 59 and 62 whereby the movement of the table stops.

When the reversing clutch 66 is in a neutral position, the table may be manually moved by means of a manually operable lever 84 which is mounted on the projecting end 85 of shaft 61.

As shown in Figure 11, the screw 75 has a threaded connection with a nut 86 which is rigidly fixed in a housing 87 attached to the knee 15. It is the relative rotation between the screw 75 and the nut 86 that causes traversing movement of the table 17.

It will be noted from Figure 11 that if the cutter 13 rotates in a clockwise direction, and the table 17 is moved at a feeding rate toward the left, that the teeth of the cutter engage and the work will create a force component parallel to the direction of movement of the table, and thereby tend to pull the table in that direction, and if any load motion exists between the screw 75 and the nut 86, an inertial movement of the table will result whereby the table will momentarily move at a rate faster than that dictated by the rate of rotation of the screw creating a possibility of damage to the cutter. It is therefore desirable that if the machine is to be used in this manner, that all looseness or backlash between the screw 75 and the nut 86 be eliminated to prevent this possibility. This invention deals with a simplified mechanism for eliminating this backlash automatically and in a proper direction in accordance with the direction of feed, and so controlled by the rate and direction control mechanism that it is ineffective during the rapid traverse rate.

The backlash eliminating mechanism comprises a piston 88 which surrounds the screw 75, and is operated by means of threads cut on the interior bore thereof. Means are provided for holding the piston against rotation whereby the screw may move spirally through the nut portion of the piston.
but upon application of fluid pressure to the piston, the nut will bodily move the screw axially. If this axial movement takes place, it will be apparent that the table will be advanced until all lost motion is eliminated between the advancing side of the threads on the screw 75 and the correspondingly engaged surfaces in the nut 88, whereby upon engagement of the cutter with the work, the possibility of inadvertent advancing movement will be eliminated.

The piston 88 is slidably mounted in a cylinder 89 which is formed in the housing 81, and the piston 88 has reduced ends 90 and 91 which simulate piston rods sliding relative to cylinder heads 92 and 93, which serve to close opposite ends of the cylinder. The cylinder head 92 is provided with a series of axially extending lugs 94 which interengage with notches 95 formed in one face of the piston for preventing rotation thereof without interfering with its axial movement.

The opposite ends of cylinder 89 are connected by channels 96 and 97 to a transposition valve 98 having a plunger 99, which in one position will connect channels 96 and 97 to channels 100 and 101 and in the other position will transverse these connections whereby the channel 97 will be connected to the channel 100 and the channel 96 will be connected to the channel 101. The channels 102 and 103 terminate in ports 102 and 103 of cylinder blocks 104 and 105. These blocks have diametrical bores 106 and 107 which are adapted to cooperate with annular grooves 108 and 109 formed in the shifter plunger 110 for determining the connection of pressure to the ends of the backlash cylinder. The bores 106 and 107 are connected by channels 108' and 109' to ports 110 and 111 of a pilot control valve 112. This valve has a port 113 which is supplied with pressure from a suitable pump 114 having an intake 115 through which fluid is withdrawn from a reservoir 116. An emergency relief valve 117 may be connected to the pump delivery channel 118 for relieving excessively high pressures therein.

The pilot valve 112 has a plunger 118 which is adapted to be manually or automatically operated for controlling the fluid actuation of the rate and direction shifters, and it is to be noted that the opposite ends of the backslash cylinder are connected to the same ports of the pilot valve, that is, the ports 110 and 111, that the cylinders 82 and 83 are connected to, whereby fluid is supplied to one end or the other of the backslash cylinder in accordance with the direction of movement of the table, but should the rate in this direction change to rapid traverse, either the piston portion 84, or the piston portion 85 will be shifted into a position to stop the flow to the backslash cylinder whereby neither end of the cylinder will be supplied with pressure and the backslash eliminator will be released.

The channels 108' and 109' have branch connections to ports 120 and 121 of a step valve 122. In the running position of this valve, annular grooves 123 and 124 in plunger 125 interconnect ports 120 and 121 to ports 126 and 127 to which channels are connected leading to cylinders 82 and 83.

When the pilot valve 112 is in the position shown in Figure 11, it connects the source of pressure to channel 108' and thereby to cylinder 83 whereby the direction cutch 66 is shifted to its extreme left position, which causes movement of the table to the left. At the same time pressure is connected to cylinder 86 whereby the clutch gear 48 is shifted to its right hand position, thus permitting the gear 88 to be rotated at a feed rate. Since the shifter 88 is to the right, the annular groove 109 will connect pressure in channel 109' to the right hand end of the backlash cylinder thereby shifting the piston actuated nut 88 to the left, or in other words, in the same direction that the table is feeding. The screw 75 will also be shifted axially to the left eliminating any lost motion between itself and the nut 88, whereby when the clockwise rotating cutter 12 engages the work, it will not cause any inadvertent movement of the table.

In Figures 7, 8, 9 and 10 there are diagrammatically shown the different hydraulic connections that the pilot valve can effect for causing feeding movements to the right or left, or quick traverse movement to the right or left with the cutter rotating in a direction to effect a hook-in cut, that is, in a direction in which it tends to create a pull on the table in the direction of table movement.

In Figure 7, the parts are shown in a position to cause quick traverse movement to the left. The pilot valve has a sleev 129 which is formed an annular pressure groove 128 which is continuously supplied with pressure through port 113. The sleeve also has annular grooves 130, 131, 132 and 133 which are permanently connected to ports 116, 114, 112 and 111, the last two ports being connected by channels 136 and 137 to cylinders 56 and 57, as shown in Figure 11. The plunger 119 is adapted to be moved axially relative to the sleeve into either one of two positions, and is also adapted to be rotated while in either one of these two positions whereby the pilot valve has a total of four different positions.

The plunger has two axial bores 138 and 139 which are closed at both ends, and a series of radial bores intersect these axial bores whereby the pressure from annular groove 129 may enter these axial bores and be selectively distributed in a predetermined manner to the annular grooves 130, 131, 132 and 133. The plunger also has a second pair of axial bores 140 and 141 which are opened at one end to form exhaust or return channels, and radial bores are also provided which intersect these two sets of axial bores for selectively connecting the annular grooves 130, 131, 132 and 133 to the reservoir.

The pump 114 must be continuously connected to the pressure bores 130 and 133 regardless of the various positions of the pilot valve plunger, and to make this possible, the annular groove 129 is provided with two radial bores 142 and 143 which communicate with a wide annular groove 144 formed in the periphery of the plunger 119 whereby the plunger may be shifted axially without breaking the connection. The annular groove 144 has a pair of radial bores 145 and 146 which intersect the axial bores 139 and 138 respectively. Thus regardless of the position of plunger 119, the bores 138 and 139 are always under pressure.

In Figure 7, the pressure bore 136 is connected to annular groove 131 by coinciding radial bores 147 and 148 formed in the sleeve and plunger respectively; and to annular groove 133 by a second pair of coinciding radial bores. The axial bore 139 is similarly connected to annular grooves 131 and 133, the purpose being to provide a second connection which is 180° from the first connection so that the valve will be hydraulically balanced. At the same time, the annular grooves 130 and 132 are connected to the exhaust bores.
4. 40 and f4 by pairs of coinciding radial bores. By means of these connections, the reversing clutch 76 is shifted to the left, and the rapid traverse clutch gear 48 is shifted to the left whereby the table moves toward the left at a quick traverse rate, and it will be noted that one end of the backlash cylinder is disconnected from pressure by the piston 85, and that the other end is connected to reservoir by the annular groove 108 whereby the backlash mechanism is ineffective during this movement.

The pilot valve trip plunger 119 is supported adjacent the front of the table 17, and when the table is moving toward the left, the wing 149 on the plunger is rotated to the right of a central position, as shown in Figure 1. This results in a flat face 159 on the plunger being parallel to the direction of table movement, and on this face is formed a lug 151. As the table moves toward the left at a rapid traverse rate, an inclined face 152 on dog 153 engages the under side of the lug 151 and vertically raises the pilot valve plunger 119 into the position in which it is shown in Figure 1 and 17.

This axial movement corresponds to movement of the plunger 119 from the position shown in Figure 7 to the position shown in Figure 8. This results in the pressure bores 138 and 139 being connected by coinciding radial bores to grooves 131 and 132, whereby pressure will still flow in channel 109 thereby maintaining the same direction of movement, but the pressure in channel 132 will cause shifting of the clutch gear 48 to its right hand position whereby the gear 59 will now rotate at a feed rate. The shifting of plunger 53 to the right will establish a pressure connection with the backlash eliminator whereby the eliminator will now automatically become effective. The other two annular grooves 130 and 133 will be connected to the reservoir channels 140 and 141.

It will be noted that when the plunger 53 shifts to the right to connect pressure through channel 101 to the backlash eliminator, that it also prevented return flow from the other end of the backlash cylinder to the pilot valve. Since the fluid in the left hand end of the backlash cylinder 99 must be exhausted in order to permit the necessary movement of the piston 88, a bleeder coil 164 is connected to a branch 159 of channel 165 whereby the oil will be forced through the bleeder coil to a return channel 176. A second bleeder coil 157 is branch connected to channel 101 so that when pressure is admitted to channel 101, fluid can be exhausted from the other end of the backlash cylinder in a similar manner to return line 156.

As the table approaches the end of its feeding stroke to the left, a reversing dog 159 engages the wing 149 on the pilot valve plunger and rotates the plunger into a rapid traverse right position. This corresponds to the position of the parts shown in Figure 9 in which the pressure bores 138 and 139 are connected through coinciding radial bores to annular grooves 130 and 132, and grooves 131 and 133 are connected to reservoir. This reverses the conditions existing in channels 108 and 109, the former now being under pressure whereby the reversing clutch 76 will be shifted into its right hand position. Since the rapid traverse gear 48 is already in its right hand position, the table will move toward the right at a rapid traverse rate, and since the port 106 is closed and the port 167 is connected to reservoir, the backlash eliminator will be off.

Should it be desirable to change the traverse rate from rapid traverse to feed, an additional dog 159 may be attached to the table having a downwardly inclined surface 160 for engaging a lug 161 formed on the plunger 119 and now positioned in projection relating to the table due to rotation of the plunger by the reversing dog 159. This would put the pilot valve plunger in the position shown in Figure 10, in which the pressure bores 138 and 139 are interconnected by coinciding radial bores to annular grooves 130 and 133 whereby pressure still remains in channel 109, but channel 132 will be connected to pressure shifting the rapid traverse gear 48 to the left whereby the gear 62 may rotate at a feed rate. The shifting of plunger 53 to the left to cause shifting of gear 48 results in the annular groove 108 in plunger 53 connecting the pressure line 108' to the left hand end of the backlash eliminating cylinder whereby the backlash eliminator becomes effective and in the proper direction.

The table may be stopped either manually or automatically by shifting the stop valve plunger 125 to the left, as viewed in Figure 1 and 25, whereby pressure will be admitted to both cylinders 82 and 83 in the manner previously described. The plunger 125 is held in the position shown by a latch member 162 which engages a shoulder 163 formed on the end of the plunger, as shown in Figure 6. This latch is withdrawn manually by providing a dog 164 on the table which will depress the plunger 165 and thereby through the pivoted connection 166 cause rotation of the lever 167 integral with the latch member 162 in a counterclockwise direction. A spring 168 surrounds the plunger 168 and is interposed between a fixed part 169 of the knee and a collar 170 secured to the plunger. Thus, the spring continuously urges the plunger upward, the movement being limited by a second collar 171 secured to the plunger below the fixed part 169, and when the latch 162 is withdrawn from engagement with plunger 125, pressure in the chamber 172 at the right hand end of valve casing 122 urges the plunger 125 to the left. This chamber is continuously connected with the pump 144 by a channel 173. The stop valve can only be set in a running position manually by means of a lever 174 secured to the front of the machine, as shown in Figure 1, and attached to the end of a shaft 175, which shaft, as shown in Figure 6, has a ball 176 engaging a notch 171 formed in the plunger 125. When the lever is rotated in a counterclockwise direction, the plunger 125 moves toward the right, and the movement is continued until the latch 162 drops into position. When the table is to be stopped manually, the lever 174 is rotated in a clockwise direction whereby a lug 178 engages a lug 179 integral with the latch 162 withdrawing the same from engagement with the plunger 125 whereby the hydraulic pressure will again shift the valve to a stop position. In order to permit this movement, the ball ended lever 176 has a lost motion connection with the plunger 125 so that the lever 174 may be rotated a sufficient distance to effect removal of the latch.

There has thus been provided an improved backlash eliminating mechanism for machine tools, such as milling machines, together with improved control mechanism which makes it especially adaptable for machines having feeding rates and quick traverse rates, because means are provided whereby the eliminator will be auto-
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matically effective during feeding rates and ineffective during quick traverse rates.

What is claimed is:

1. In a milling machine having a cutter support and a work support, the combination of a transmission means for effecting relative movement between said supports including a relatively movable thread and nut, one of which is attached to the work support, a transmission train for effecting relative rotation between said screw and nut including a member shiftable to change the rate of said rotation, a fluid shiftable non-rotatable nut engaging said screw, hydraulic means for shifting said member, and means responsive to a feed rate position of said member for controlling hydraulic pressure to effect shifting of the second named nut in the direction of support movement.

2. In a milling machine having a cutter support and a work support, the combination of transmission means for effecting relative movement between said supports including cooperating threaded elements, one of which is attached to the moving support, a piston actuated nut for eliminating backlash between said threaded elements, said transmission having a pair of shiftable elements differently positionable for yielding feed and quick traverse rates, a source of fluid pressure, a valve for controlling hydraulic actuation of said rapid traverse rate, a valve in series with said pilot valve and one of said shiftable elements for disconnecting said element from the pilot valve, and valve means in the other shiftable element and arranged in series with said piston actuated nut for determining actuation thereof in accordance with the rate of movement of the moving support.

3. In a milling machine having a work support and a cutter support, the combination of transmission means for effecting relative movement between said supports including relatively movable threaded members, one of which is attached to said support, means for effecting relative rotation between said members to effect movement of said support including a direction determining clutch, a rapid traverse control clutch having different positions for a given position of said direction clutch to yield a feed rate or a rapid traverse rate, a piston actuated nut for eliminating backlash between said threaded elements, channels leading to opposite ends of said piston, a valve for controlling hydraulic actuation of said rapid traverse clutch and the connection of pressure to said channels, and means operable by said rapid traverse clutch for determining flow in said channels.

4. In a milling machine having a cutter support and a work support, the combination of transmission means for effecting relative movement between said supports, cooperating relatively movable threaded elements for transmitting motion from said transmission to the movable support, a piston nut for eliminating lost motion between said threaded elements, said transmission having shiftable feed-rapid traverse rate selecting means, a source of pressure, a pilot valve for variably connecting said source of pressure to said selecting means for determining the rate of movement of said support, channels for supplying fluid pressure to said piston nut, said pilot valve also having means for determining the coupling of fluid pressure to said channel means, and valve means operable by said rate selecting means for determining which end of said piston nut will be connected to said channels.

5. In a milling machine having relatively movable cutter and work supports, the combination of transmission means for effecting relative movement between said supports, said transmission including a fluid operable backlash eliminator and fluid shiftable elements for determining different rates and directions of movement, a source of fluid pressure, a pilot valve for connecting said fluid pressure to determine the position of said elements and thereby the rate and direction of movement of said movable support, channels for supplying fluid pressure to said backlash eliminator, said pilot valve having means for determining the coupling of fluid pressure to said channels, and valve means controlled by said shiftable elements for determining which one of said channels shall be connected to said eliminator.

6. In a milling machine having relatively movable cutter and work supports, the combination of transmission means for effecting relative movement between said supports including a pair of final gear trains, a feed transmission, a rapid traverse transmission, a shifter for selectively determining actuation of said transmissions, a backlash eliminator including a piston and cylinder, a pilot valve, a source of fluid pressure connected to said pilot valve, means in said shifter for determining which end of said backlash cylinder is connected to the pilot valve, a second shifter for selectively connecting one of said final trains for actuation of the movable support, means in the pilot valve for connecting said cylinder to the source of pressure or to exhaust in accordance as said last named shifter is connected to a feed operated train or a rapid traverse operated train.

7. In a milling machine having a rotatable cutter spindle, a support, a table reciprocally mounted on said support for movement transversely to the axis of said spindle, means for effecting movement of said table including a screw rotatably supported by said table, power operable means for rotating said screw, a housing mounted on said support, a first nut fixed in said housing and engaging said screw, a second nut mounted in said housing in intermeshing relation with said screw, means to hold said second nut against rotation, a piston portion formed on said second nut, a cylinder formed in said housing and containing said piston, and trip controlled means for governing the admission of pressure to said cylinder to effect directional shifting of said second nut in accordance with the rate and direction of movement of said support.

8. In a machine tool having a relatively movable tool and work support, the combination of transmission means for effecting relative movement between said supports including shiftable means for determining different rates of relative movement, a relatively rotatable screw and nut, one of which is carried by the moving support, motion transmitting connections from said transmission to effect said relative rotation, a piston surrounding said screw and operatively connected thereto for effecting relative axial movement between the screw and nut, a source of fluid pressure, a first control means for potentially connecting a source of pressure to said piston, and additional means controlled by said shiftable means for finally determining if the connection shall be made.
9. In a machine tool having a tool support and a work support, the combination of transmission means for effecting relative movement between said supports including a relatively rotatable screw and nut, or a pair of said elements having different combinational positions to effect a feed rate, a piston surrounding said screw and operatively connected for effecting relative axial movement between the screw and nut, a source of fluid pressure, a valve for controlling said source of pressure to said piston, and means operable by said shiftable elements for finally controlling the connection of fluid pressure to said piston.

10. In a machine tool having a relatively movable tool and work support, the combination of transmission means for effecting relative recirculation between said supports including a screw and nut, one of which is attached to the moving support, a piston surrounding said screw, a threaded connection between said piston and screw, a direction determining clutch, a source of pressure, a valve for controlling said source of pressure to said clutch and to said piston and thus determining the direction of movement between said supports and eliminating backlash between the screw and nut in that direction of movement, an element shiftable to increase the rate of said relative movement, and means operable by said element to interrupt the flow of fluid pressure to said piston during operation at the increased rate.

11. In a machine tool having a relatively movable tool and work support, the combination of transmission means for effecting relative movement between said supports including a relatively rotatable screw and nut, one of which is carried by the moving support, means for eliminating backlash between said screw and nut during operation at feed rates including a piston surrounding said screw and having a threaded connection therewith, a fixed cylinder for containing said piston, a pair of channels connected to opposite ends of said cylinder, means for admitting fluid pressure to one or the other of said channels, a reservoir connected thereto, and hydraulic connections from each of said channels to said reservoir chamber whereby upon admittance of pressure to one end of said cylinder, the fluid will be exhausted from the other end through its hydraulic connection to the reservoir chamber.

12. In a machine tool having a work support and a cutter support, the combination of transmission means for effecting relative movement between said supports including a relatively rotatable screw and nut, one of which is attached to the movable support, transmission means for effecting relative rotation between the screw and nut including a plurality of shiftable control elements for determining the rate of relative movement between said supports, hydraulic means for positioning said elements to yield a feed rate, a piston nut for eliminating backlash between said screw and nut, a source of fluid pressure therefor and means in one of said control elements effective when the element is shifted to a feed position for connecting said fluid pressure to said piston and for eliminating backlash during the feeding movement.

13. In a machine tool having a pair of relatively movable supports and relatively rotatable threaded members for effecting said movement, the combination of means for removing lost motion from a thread element including a piston operatively connected for shifting one of said elements axially of the other, a transmission for effecting relative rotation between said threaded members including a reverser, a pair of channels connected to opposite ends of said reverser, a source of pressure, means for selectively connecting said source of pressure to the other of said channels in accordance with the position of said reverser, a shifter rod operatively connected to a rate change element in said transmission, said shifter rod having portions intercommunicating connected therefor and receiving the flow therein and grooves formed in said portions for permitting flow only when said rate change element is in a feed position.

14. In a machine tool having a translatable support and transmission means for effecting said translation including shiftable clutches for changing the rate and direction of said translation, the combination of a piston for removing backlash in the final elements of said transmission, a source of fluid pressure, control means for controlling said source of pressure to effect fluid shifting of said clutches including a pair of channels connected in parallel to one of said clutches and to said piston whereby said channels may be alternately connected to pressure to control the direction of movement of said support and means associated with the other clutch for ultimately determining the direction of movement, and means operable by said element to interrupt the flow of fluid pressure to said piston during operation at the increased rate.

15. A backlash control for the actuating mechanism of a machine tool or the like which includes a reverser and control means for controlling said reverser, a hydraulic power circuit for reaction on said piston member including a source of hydraulic medium, conduits intervening said medium and the piston for variably controlling the medium therewith for opposite reactions thereon, a shiftable rate selector, and valve means shiftable with the rate selector and reacting on the conduits for neutralizing the pressure effect of the hydraulic medium as respects said piston member.

16. A backlash control for the actuating mechanism of a machine tool or the like which includes a reverser and control means for controlling said reverser, a hydraulic power circuit for reaction on said piston member including a source of hydraulic medium, conduits intervening said medium and the piston for variably controlling the medium therewith for opposite reactions thereon, a shiftable rate selector, and valve means shiftable with the rate selector and reacting on the conduits for neutralizing the pressure effect of the hydraulic medium as respects said piston member.
hydraulic medium as respects said piston member, a hydraulically actuable reverser for the nut and screw mechanism, conduits coupling the reverser in parallel with the piston for jointly determining the actuations of the reverser and piston, control valve means for intervening said conduits and the source of hydraulic medium for concurrently reversing the flow of medium for both piston and piston, and a transposition valve intervening the piston and reverser devices and shiftable selectively to interchange pressure connections to effect corresponding or opposite movement of the parts for a given position of the control valve means.

18. A control for the drive transmission of a machine tool comprising a translatable member, relatively rotatable nut and screw device for effecting translation of the member, driving means and rate changing and direction changing devices intervening the driving means and the nut and screw mechanism, said control including a source of hydraulic actuating medium, a piston member coupled with the screw element, conduits coupled with the source of hydraulic medium and potentially coupleable with said piston and control means for determining the directional coupling of the hydraulic medium with the piston and with one of said devices, and additional valve means operatively connected with the other of said devices for neutralizing the effect of the hydraulic medium as respects said piston.

19. A control for the drive transmission of a machine tool comprising a translatable member, relatively rotatable nut and screw device for effecting translation of the member, driving means and rate changing and direction changing devices intervening the driving means and the nut and screw mechanism, said control including a source of hydraulic actuating medium, a piston member coupled with the screw element, conduits coupled with the source of hydraulic medium and potentially coupleable with said piston and with the rate and direction changing devices of the transmission, a first valve means for determining the directional coupling of the hydraulic medium with the piston and with one of said devices, additional valve means operatively connected with the other of said devices for neutralizing the effect of the hydraulic medium on the piston for a given position of the first-mentioned valve means.

20. In a means for reducing or eliminating backlash between two machine elements the combination of a number of members relatively movable in accordance with backlash between said elements to increase the volume of a restricted space, means for supply of liquid to said space, and means preventing escape of liquid from said space except at a relatively slow rate.

21. A backlash eliminator for a machine mechanism comprising two members relatively movable in accordance with backlash in said mechanism to increase the volume of a restricted space, a source of pressure liquid, means substantially freely admitting liquid from said source to said space, and restricting means limiting outflow of liquid from said space to a relatively slow rate.

22. The combination of a feed screw, nut means therefor including two nut portions relatively adjustable for eliminating backlash of the nut means relative to said screw, means operative for the relative adjustment of said nut portions in the direction eliminating backlash, and means subsequently operative to permit reverse direction of movement of the adjusted nut portion and additional means for restricting the rate of said reverse movement thereof.

23. The combination of a feed screw, nut means therefor including two nut portions relatively adjustable for eliminating backlash of the nut means relative to said screw, means operative for said relative adjustment of the nut portions in the direction eliminating backlash including a piston, a cylinder and a liquid supply source therefor, and means subsequently operative to limit the rate of reverse adjustment of the adjusted nut portion including a restricted outlet for liquid from said cylinder.

24. The combination of a feed screw, nut means therefor including two nut portions relatively axially adjustable, the threads of one of said nut portions contacting the screw threads at the one side thereof to prevent relative movement therebetween in one axial direction, means for directing the reverse movement of the threads of the other nut portion contact said screw threads at the other side thereof, and means subsequently operative to permit the reverse direction of adjustment of the adjusted nut portion and additional means for restricting the rate of said reverse movement thereof.

25. The combination of a feed screw for relative support movement, nut means for said feed screw including two nut portions relatively axially adjustable, means operative to axially relatively adjust said nut portions until the threads of the other nut portion contact said screw threads at the other side thereof, and means subsequently operative to permit reverse direction of adjustment of the adjusted nut portion means for automatically controlling the rate of said reverse adjustment.

26. The combination of a feed screw, nut means therefor including two nut portions relatively axially adjustable, the threads of one of said nut portions contacting the screw threads at one side thereof to prevent relative movement therebetween in one axial direction, means operative to axially relatively adjust said nut portions until the threads of the other nut portion contact said screw threads at the other side thereof, and means subsequently operative to permit the reverse direction of adjustment of the adjusted nut portion including piston and cylinder means having a restricted outlet limiting the rate of said reverse adjustment.

27. The combination of a feed screw, a support, nut means for said screw including a first nut portion, positive abutment means for said support and first nut portion limiting the relative movement therebetween in one direction axially of said screw, said nut means including a second nut portion movable in said reverse direction to simultaneously eliminate lost motion between said nut means and said screw and between said abutment means, means for movement of said second nut portion in said direction to effect said lost motion elimination, and means subsequently operative to permit reverse movement of said second nut portion including means for restricting the rate of said reverse movement thereof.
28. The combination of a feed screw, a support, nut means for said screw including a first nut portion, positive abutment means for said support and first nut portion limiting the relative movement therebetween in one direction axially of said screw, said nut means including a second nut portion movable in said direction, whereby to simultaneously eliminate lost motion between said nut means and said screw and between said abutment means, means for movement of said second nut portion in said direction to effect said lost motion elimination, and means subsequently operative to permit the opposite movement of said second nut portion including piston and cylinder means having outlet restricting means limiting the rate of said opposite movements.

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