Dec. 12, 1933. L. F. NENNINGER ET AL 1,938,781

MILLING MACHINE

Filed May 25, 1931 5 Sheets-Sheet 1

Fig. 1

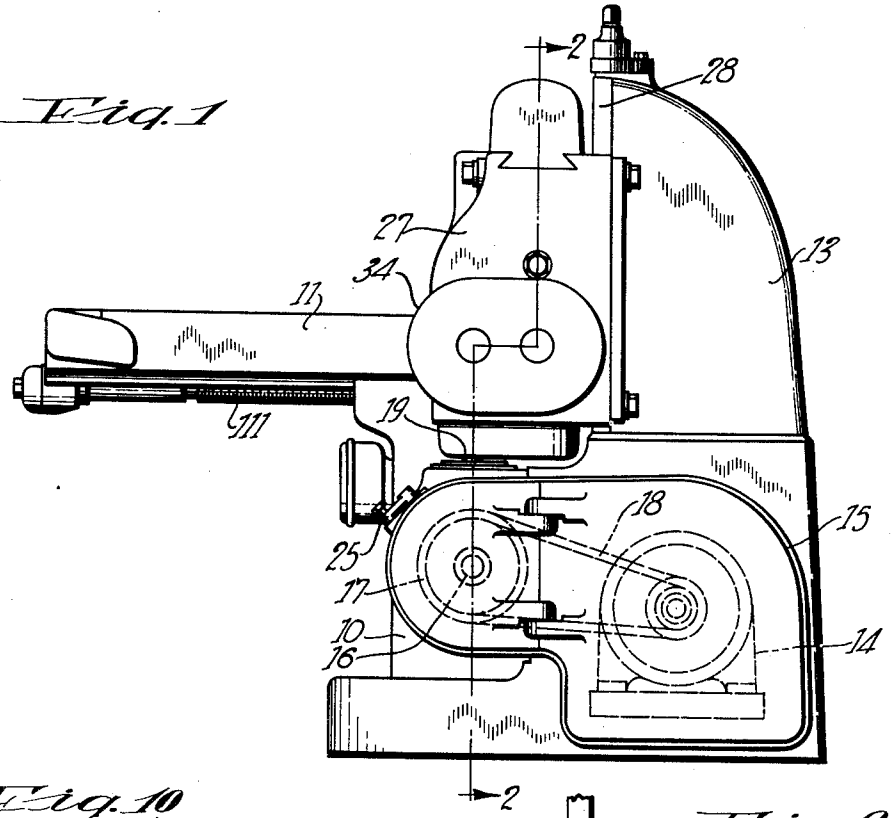


Fig. 10

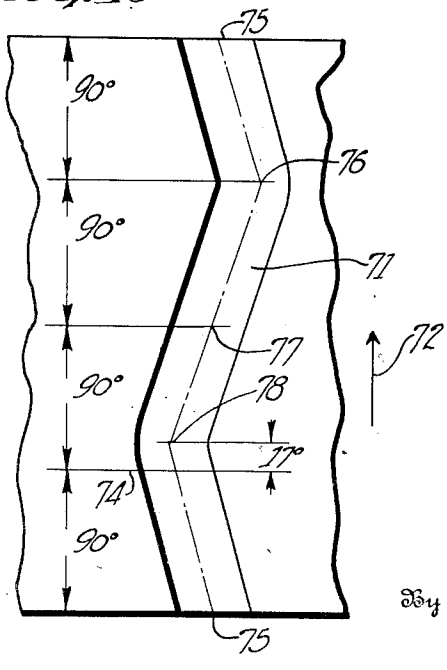
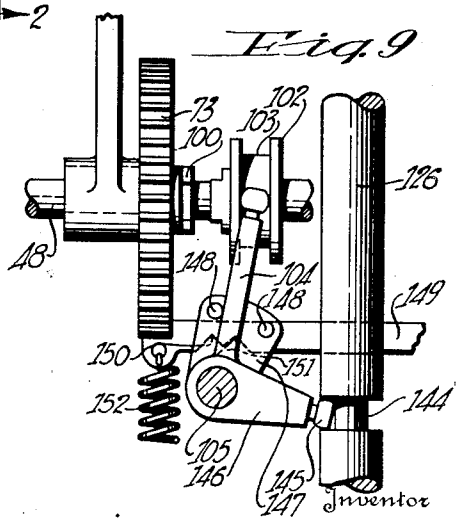


Fig. 9



Inventor

LESTER F. NENNINGER

BERNARD SASSEN

By O. K. Parsons

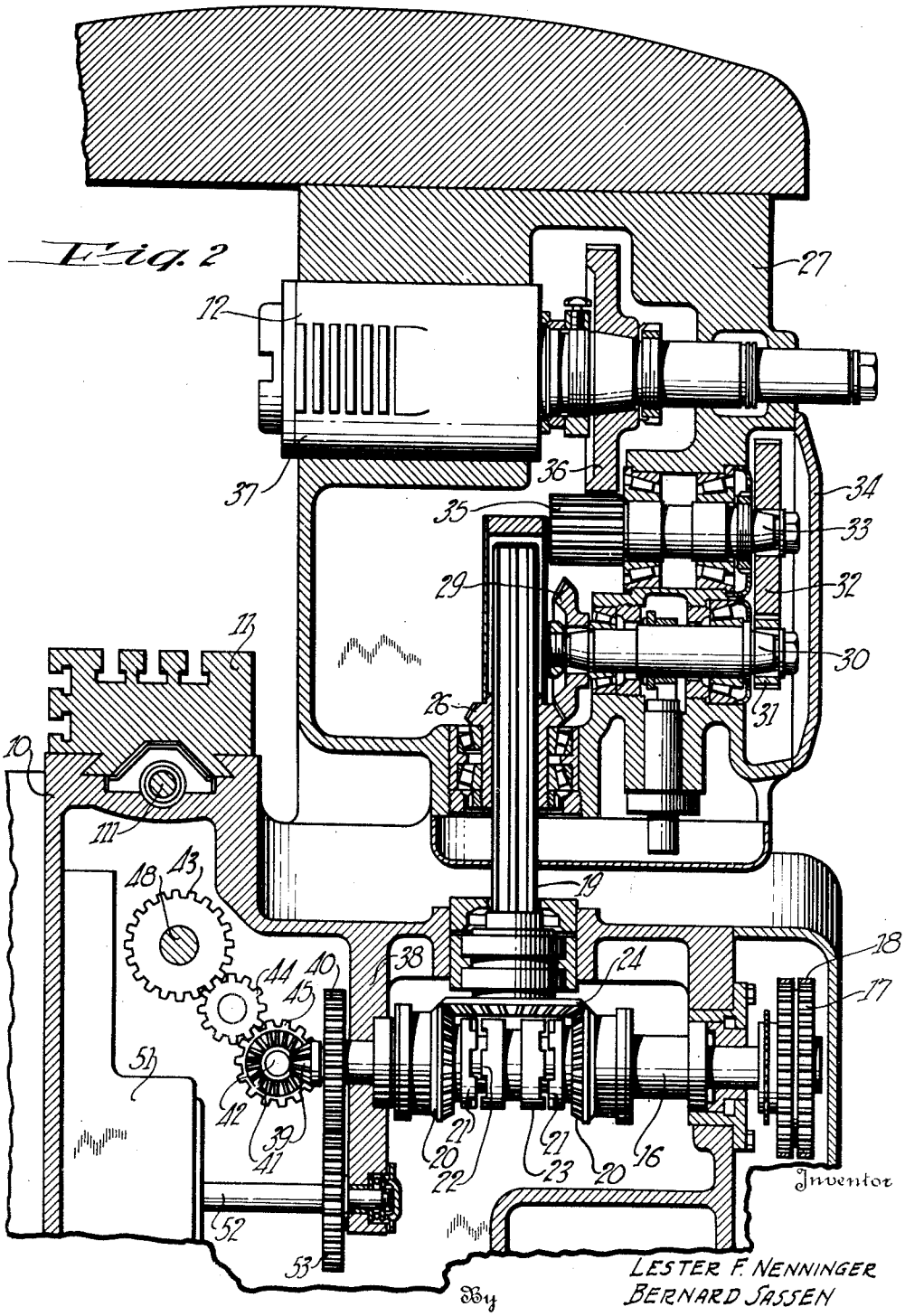
Attorney

Dec. 12, 1933. L. F. NENNINGER ET AL 1,938,781

MILLING MACHINE

Filed May 25, 1931 5 Sheets-Sheet 2

Fig. 2



Inventor

LESTER F. NENNINGER
BERNARD SASSEN

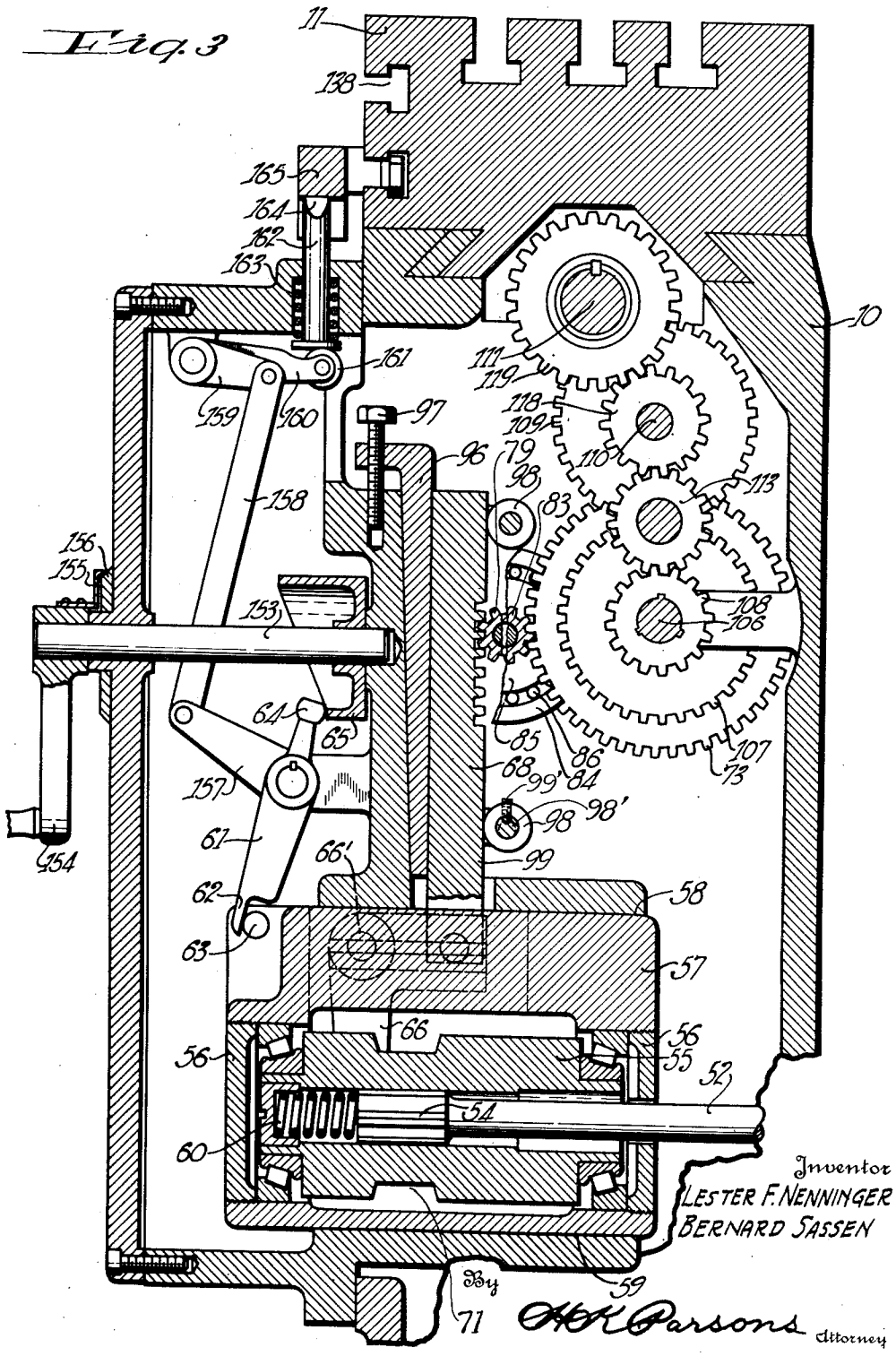
By O. K. Parsons Attorney

Dec. 12, 1933. L. F. NENNINGER ET AL 1,938,781

MILLING MACHINE

Filed May 25, 1931 5 Sheets-Sheet 3

Fig. 3



Inventor
LESTER F. NENNINGER
BERNARD SASSEN

By H. K. Parsons Attorney

Dec. 12, 1933. L. F. NENNINGER ET AL 1,938,781

MILLING MACHINE

Filed May 25, 1931 5 Sheets-Sheet 4

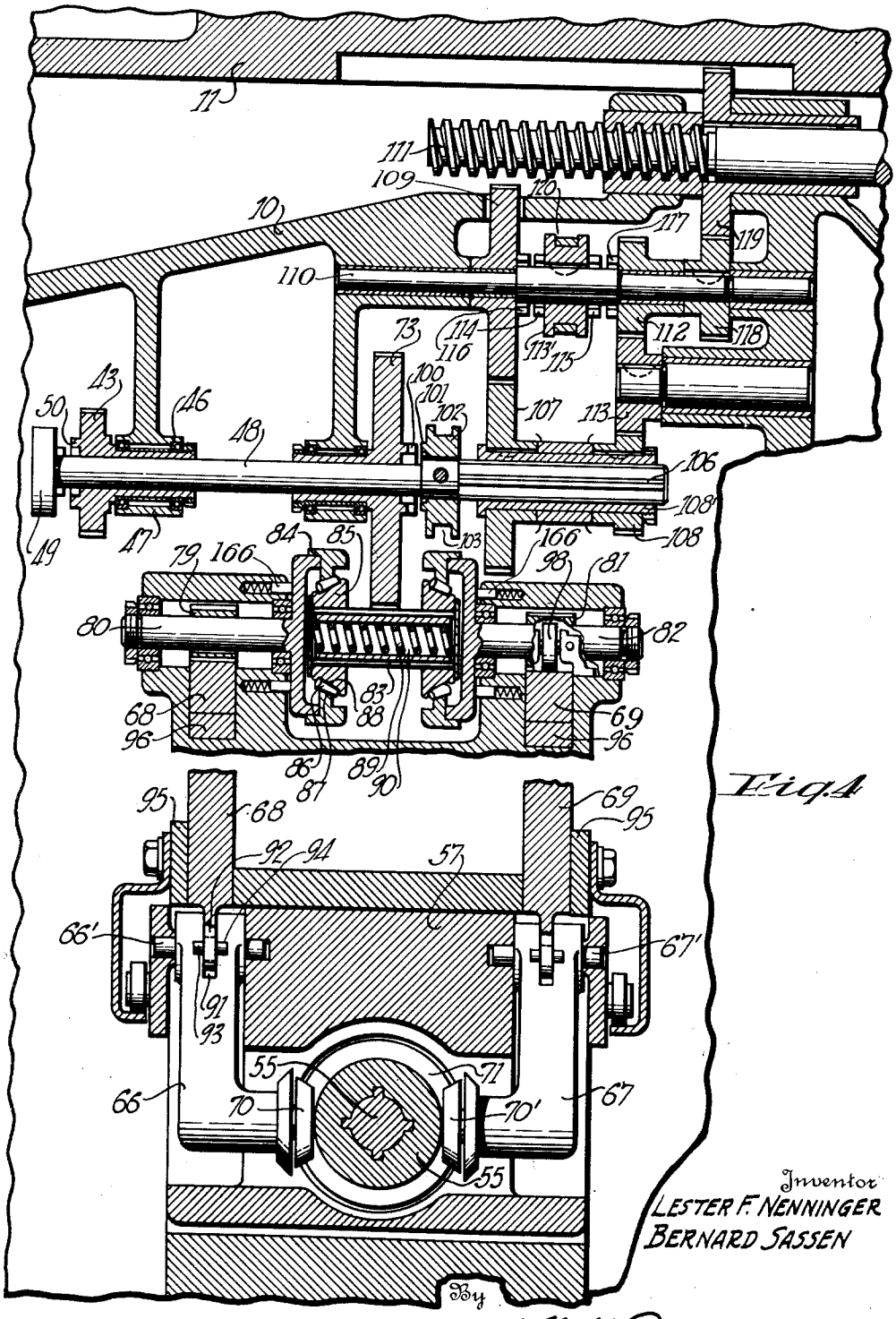


Fig. 4

Inventor
LESTER F. NENNINGER
BERNARD SASSEN

By
O. K. Parsons Attorney

Dec. 12, 1933. L. F. NENNINGER ET AL 1,938,781

MILLING MACHINE

Filed May 25, 1931 5 Sheets-Sheet 5

Fig. 5

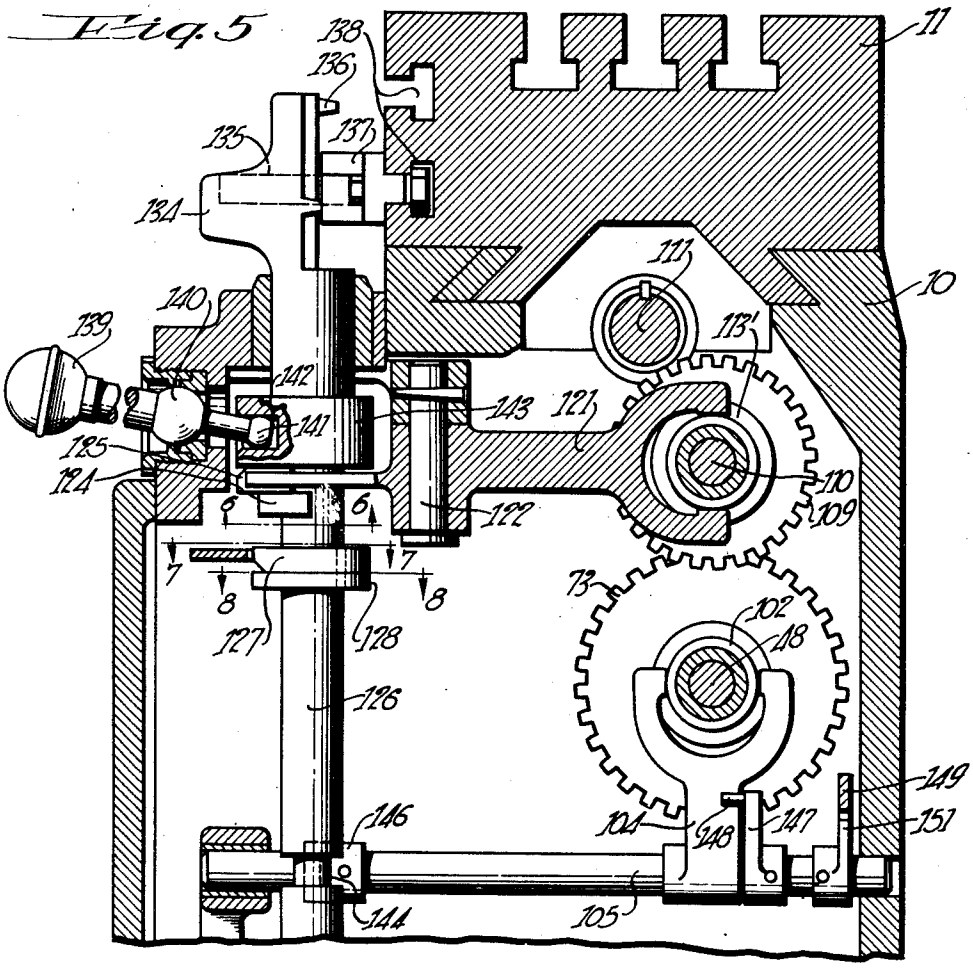


Fig. 6

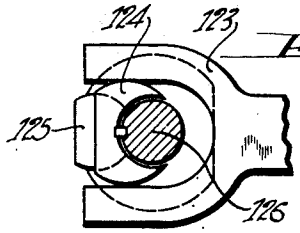
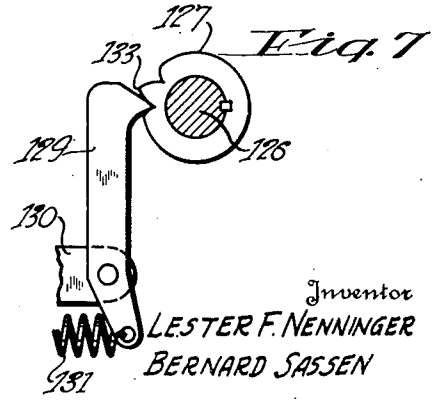


Fig. 7



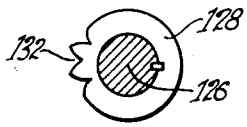


Fig. 8

Inventor
LESTER F. NENNINGER
BERNARD SASSEN

By H. K. Parsons

Attorney

Patented Dec. 12, 1933

1,938,781

UNITED STATES PATENT OFFICE

1,938,781

MILLING MACHINE

Lester F. Nenninger and Bernard Sassen, Cincinnati, Ohio, assignors to The Cincinnati Milling Machine Company, Cincinnati, Ohio, a corporation of Ohio

Application May 25, 1931. Serial No. 539,736

15 Claims. (Cl. 90—21)

This invention relates to milling machines and more particularly to an improved transmission and control mechanism therefor.

It is fundamental in the construction of machine tools that the tool and work support should be relatively movable and for the best results at variable rates. These rates have been almost universally obtained by the utilization of mechanical transmissions of the shiftable gear type capable of effecting a series of rate changes, the number of which depended proportionately upon the number of shiftable gears utilized. But irrespective of number, the rates obtainable progressively increased or decreased by steps or intervals thereby leaving certain intermediate rates which were unavailable.

This was due to the fact that the final velocity ratio must be obtained by acceleration or deceleration from some other present ratio and the amount of such variation was determined by the particular change gear utilized, and accordingly if there were no change gear in the transmission capable of imparting the necessary amount of acceleration or deceleration to produce a desired final velocity, such speed was unavailable.

It is fundamental that during acceleration or deceleration from a given rate to a desired rate that the mechanism will attain successively each rate between the two, no matter how finely divided the range may be, nor how short the period of time that it may run at the successive rates.

It is, therefore, one of the objects of this invention to provide a machine tool, such as a milling machine, with a purely mechanical variable speed transmission in which the amount of acceleration or deceleration is always under the control of the operator whereby the speed of the mechanism may be changed by infinitesimal amounts to produce an infinitesimal increase or decrease in the final velocity or feed rate of the transmission and means whereby these changes may be made either by manual or power means.

Another object of this invention is to provide a milling machine with a mechanical transmission for imparting feed or rapid traverse rates to an actuated member that may be easily controlled by the member itself or manually by the operator to vary the feed rates by infinitesimal quantities, as well as to determine between the rapid traverse and feed rate of movement.

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 hereinafter disclosed, within the scope of the appended claims, without departing from or exceeding the spirit of the invention.

In the drawings, in which like reference numerals indicate like parts:

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

Figure 2 is a vertical section on the line 2—2 of Figure 1.

Figure 3 is a detail view of the variable speed transmission shown in Figure 2.

Figure 4 is an expanded view of the transmission to the table.

Figure 5 is a section through the bed of the machine showing the control plunger and associated mechanism.

Figure 6 is a section on the line 6—6 of Figure 5.

Figure 7 is a section on the line 7—7 of Figure 5.

Figure 8 is a detail section on the line 8—8 of Figure 5.

Figure 9 is a detail of the load and fire mechanism for the reversing clutches.

Figure 10 is an expanded view of the operating cam for the feed variator unit.

For the purposes of illustration the invention has been shown and illustrated in connection with a milling machine of the type having a bed 10 upon which is reciprocably mounted a work table 11 for translation relative to a cutter spindle 12 which is journaled in a column 13 uprising from the bed 10. These parts are actuated by a prime mover 14 located in the bed of the machine and accessible through a door 15 hinged to the side of the bed.

The main driving shaft 16, illustrated more particularly in Figure 2, is provided with a suitable driver, such as a pulley or sprocket 17, by which the shaft is continuously driven from the prime mover during actuation thereof through a power transmitting band 18. A branch transmission shaft 19 is driven from the continuously rotating shaft 16 through a reverser comprising a pair of bevel gears 20 mounted for free rotation on the shaft 16 and provided with opposed clutch faces 21 for engagement with clutch faces 22 of the shiftable spool 23 splined on the shaft. A bevel gear 24 is secured to the lower end of the shaft 19 in mesh with the bevel gears 20 whereby upon movement of the spool 23 by the external manual lever 25 coupled therewith, the shaft 19 will be rotated in a clockwise or counter clock-

wise direction depending upon the direction of shifting of the clutch spool 23.

The shaft 19 extends upward into splined engagement with a bevel gear 26 journaled in the spindle carrier 27 which is adjustably mounted upon guideways 28 formed on the face of the column 13. The bevel gear 26 meshes with another bevel gear 29 secured to the end of the shaft 30 having a pinion 31 keyed to the opposite end in engagement with a spur gear 32 keyed to the end of a parallel shaft 33. Attention is invited to the fact that the gears 31 and 32 are adjacent to the outside face of the carrier and a removable cover plate 34 is provided so that these gears may be inter-changed for changing the rate of rotation imparted to the shaft 33 and, therefore, constitute a rate changer. The shaft 33 has secured thereto an elongated pinion 35 meshing with a bull gear 36 keyed to the cutter spindle 12. For the purpose of effecting longitudinal adjustment of the spindle it is journaled in a quill 37 which is manually adjustable toward and from the table.

There has thus been provided a cutter spindle which is adjustably mounted for movement in two different planes and which is driven by a branch transmission capable of rotation in opposite directions having a rate changer by means of which the speed of rotation may be varied.

The continuously rotated shaft 16 is journaled at one end in a depending bracket 38 formed inside of the bed and has secured thereto adjacent the bracket a bevel gear 39 and a spur gear 40, the bevel gear 39 actuating a rapid traverse transmission and the spur gear 40 actuating the continuous change variable feed transmission for the table. The rapid traverse transmission comprises a bevel gear 41 secured to a shaft 42 in mesh with the bevel gear 39, and driving a spur gear 43 through an idler gear 44 and a gear 45 keyed to the shaft 42. As more particularly shown in Figure 4, the gear 43 is mounted in anti-friction bearings 46 in the bracket 47 and has mounted therein for free rotation, the shaft 48 which is also axially movable to effect engagement of the clutch member 49 secured to the end of the shaft with clutch teeth 50 formed upon one face of the gear 43. Engagement of this clutch, by means to be described later, will effect rotation of the shaft 48 at a rapid traverse rate.

The infinitely variable feed transmission comprises the rate variator unit indicated generally by the reference numeral 51 which is actuated by the shaft 52 having a gear 53 secured to the end thereof in mesh with the continuously rotated gear 40 on shaft 16. The shaft 52 is longitudinally splined at 54, as shown in Figure 3, for receiving and driving a cam 55 which is longitudinally adjustable on the shaft. The cam is journaled between the ends 56 of a longitudinally slidable frame or carrier 57 guided between ways 58 and 59. A spring 60 is interposed between the end of the shaft 52 and the end 56 of the carrier thereby constantly urging it toward the left, as viewed in Figure 3. A lever 61 is pivoted to a fixed part of the bed with one end 62 engaging a pin 63 fixed with the carrier and the other end 64 in engagement with a rotatable cam 65 which is fixed against axial movement. From this it will be seen that although the spring 60 abuts the end of the shaft 52 and tends to move the carrier toward the left, the extent of this movement is controlled and determined by the cam 65.

A pair of bell cranks 66 and 67 are provided with integral laterally projecting pivot pins 66' and 67' for oscillatably mounting the bell cranks in the carrier 57 for bodily movement therewith and thereby with the cam but for relative movement with respect to the ends of reciprocating rack bars 68 and 69. The bell cranks are mounted upon opposite sides of the cam 55, as shown in Figure 4, and each is provided with an anti-frictionally mounted roller 70 and 70' engaging the continuous or closed cam groove 71 formed in the periphery of the cam drum 55. This groove is shown in expanded view in Figure 10 and its direction of movement is indicated diagrammatically by the arrow 72. It will be noted that the cam rollers are in 180° phase relation and the cam groove is formed in such a manner that while one bell crank is moving in a counter clockwise direction on its power stroke the other bell crank is moving in a clockwise direction on its return stroke.

Since it is desired that a non-pulsating flow of power be transmitted to the gear 73 it will be apparent that by the utilization of only two driving members that there must be an overlap in the movement of one with respect to the other in such a manner that when one driving member has completed its power stroke, the other member is in a position to pick up the transmission of power at the moment it is dropped by the other and in order to prevent pulsations in the power flow it must be at the same velocity as that being imparted by the preceding driving member. This will be more clearly understood by reference to Figure 10 in which it will be assumed that the roller 70 is in a starting position on the line 74 upon rotation of the cam in the direction of the arrow 72 through an angle of 180° the roller will be moved past the point 75 to the point 76. This will cause rotation of the bell crank 66 in a counter clockwise direction, as viewed in Figure 3, to impart power to its connected rack bar 68 and during this movement the roller 70' being in 180° phase will move from the point 76 past the point 77 to the starting line 74. It will be noted from Figure 10 that this return movement, as measured in an axial direction, is accomplished in less than 180° or in substantially 163° of angular rotation. Upon reaching the point 78 in the cam path the roller 70' has completed its return movement in an axial direction and theoretically has come to a stop. During the next 17° of rotation its movement in a counter clockwise direction is accelerated so that upon reaching the point 74 it has attained the same uniform velocity that the roller 70 has upon reaching the point 76 so that it may continue the transmission of power at that velocity while the roller 70 is being returned to its starting position.

The rack bar 68 engages a pinion 79 keyed to the shaft 80 which is anti-frictionally mounted in a fixed part of the machine. Similarly, the rack bar 69 engages a pinion 81 keyed to the shaft 82 which is anti-frictionally mounted in a fixed part of the machine. An elongated pinion 83 is interposed between the ends of these shafts and co-axial therewith for driving the feed gear 73. The pinion 83 is alternately rotated by the shafts 80 and 82 by means of unidirectional torque transmitting clutches which may be of any suitable type that will automatically connect the shaft 80 with the pinion 83 during oscillatory movement of the shaft 80 in one direction and positively disconnect the parts upon movement of the shaft 80 in a re-

verse direction. This connection must be positive in order to insure against slippage and thereby pulsations in the feeding stroke of the table. One type of clutch which has been found suitable in the present instance is the commercially known Humfrey-Sandberg clutch which comprises an outer member 84 and an inner member 85 having a plurality of cylindrical rollers 86 interposed between a cone surface 87 on the outer member and a cone surface 88 of different angle formed on the inner member. These rollers may be held in equally spaced relation circumferentially between the surfaces by means of spacers or separators. The rollers are mounted at an angle to a plane passed through the axis of the clutch member whereby upon rotation of the outer member in one direction the rollers 86 will tend to ride up the inclined surface 88 thereby forming a driving connection while rotation of the member 84 in the opposite direction will tend to cause the rollers to move down the inclined surface out of binding engagement and thereby act in a similar manner to the rollers of a roller bearing. A spring 89 is mounted in a bore 90 formed in the pinion 83 and engaging at opposite ends the inner members 85 of the opposed clutches to maintain them in contact with the outer members and with equal pressure thereby eliminating the possibility of any lost motion in the transmission of power. The inner members 85 are provided with a central bore having internal gear teeth formed thereon for engaging the gear teeth of the pinion 83 forming a keyed or splined connection with the pinion.

Attention is invited to the fact that one of the clutches must be a right hand clutch while the other clutch must be a left hand clutch due to the fact that power must be transmitted to the pinion 83 in the same direction by both clutches although they are mounted upon opposite ends thereof.

Each bell crank has formed longitudinally of its horizontal arm a slot 91 of cruciform cross section for receiving the reduced end 92 of the rack bar having a pin 93 therein. The pin 93 is journaled in the body portion of the rack bar and has reduced cylindrical portions projecting beyond the opposite faces of the member 92 and these cylindrical portions are flattened upon the top and bottom sides to slide in the grooves 94. This construction reduces the amount of wear and the possibility of back lash between the driving bell crank and the driven rack bar. The rack bar itself is reciprocably mounted between the vertical guides 95 and to insure that the rack teeth are in proper engagement with the teeth of the driven pinion so as to prevent any lost motion, an adjustable gib 96 is mounted between the back of the rack bar and a fixed part of the bed; and an adjusting screw or bolt 97 is provided for changing the adjustment. The rack bar is held in proper position on its guideway by a pair of rollers 98 engaging the front surfaces 99 of the rack bar.

Since adjustment of the gib will effect lateral adjustment of the rack bar, it accordingly is necessary to provide lateral adjustment for the rollers. This is accomplished by mounting the rollers on adjustable pins having eccentric portions 98′ which permit free rotation of the rollers, as well as lateral adjustment thereof. Set screws 99′ may be utilized for retaining the pins in adjusted position.

Additional means have been provided for insuring that any lost motion will always be kept on the non-driving side of the teeth. For instance, as the rack bar moves up on a non-power stroke it will be rotating the outside clutch member 84 in a direction opposite to that in which the inside member is being driven by the other clutch. Any lost motion or looseness will, therefore, be located between the bottom or non-driving side of the rack teeth and the top of the gear teeth because the top or driving side will be in engagement with the bottom side of the gear teeth. As viewed in Figure 3, the outside member 84 would then be rotating clockwise, and the inside, counter clockwise. Upon reversal of the rack for the down stroke, it will momentarily stop and likewise the member 84 will stop. During this period of rest and the initial part of the down stroke, this contact condition would still be maintained due to the slight drag between the clutch parts which means that the lost motion would have to be taken up when the load came on thereby causing a pulsation in the flow of power. To anticipate such a condition, spring pressed friction pads 166 are mounted in a fixed part of the bed parallel to the axis of the clutch which have sufficient pressure to overcome the drag between the clutch parts so that any lost motion will be taken up immediately upon reverse movement of the rack.

From the construction and description of the feed unit thus far it will be seen that the cam 55 is constantly rotated by the main shaft 16 and thereby constantly oscillates the bell cranks which in turn constantly reciprocate the rack bars but always in opposite directions to one another to transmit a unidirectional torque to the pinion 83 and thereby to the feed gear 73.

Since it is desired to vary the speed of the feed gear and by an infinite number of gradations or in other words, by such infinitesimal quantities as to constitute substantially a continuous rather than a stepped change, the housing 57 is reciprocably mounted, as hereinbefore described, so that upon longitudinal movement of the carrier, the cam and associated bell cranks will be moved with respect to the rack bars and thereby vary the effective lever arm of the bell cranks and thereby the length of reciprocating movement of the rack bars which, in turn, will vary the arc of revolution of the pinion 83 and the associated driven gear 73 imparted thereto by each revolution of the cam 71. It will be noted that this change in the angular movement of the gear 73 with respect to a single revolution of the cam 55 is effected without the necessity of changing the uniform velocity of the cam 55.

The gear 73 is provided with clutch teeth 100 upon one face thereof for engagement by clutch teeth 101 formed on the clutch spool 102 pinned to the longitudinally reciprocable shaft 48. This clutch spool has a peripheral groove 103 which receives a shifter fork 104 secured to an oscillatable shaft 105 journaled in the frame of the machine. The shaft 48 has a splined end 106 for driving the gears 107 and 108 through a splined sleeve 108′.

The gear 107 drives a gear 109 mounted for free rotation on the shaft 110 mounted in the walls of the machine parallel to the table lead screw 111. The gear 108 drives a gear 112 through an idler 113 and in an opposite direction to the gear 109. A clutch spool 113′ is splined on the shaft 110 and has clutch faces 114 and 115 on opposite sides thereof for engaging the clutch teeth 116 and 117 formed on the gears 109 and

112 respectively. Upon longitudinal movement of the clutch spool to the left the shaft 110 will be rotated in a forward direction and thereby rotate the gear 118 fixed to the end thereof in mesh with a gear 119 splined to the lead screw shaft 111. Upon movement of the clutch spool 113 to the right the direction of movement of the lead screw will be reversed. The clutch spool 113 has an annular groove 120 for receiving the shifter fork 121 which is pivotally mounted upon a stud shaft 122 secured in the bed. The clutch shifter 121 has a forked end 123 (Figure 6) adapted to engage a large cam 124 secured to a rotatable plunger 126 mounted in a forward part of the bed adjacent the front edge of the table 11.

Since the clutch 113' is utilized for stopping the table, as well as reversing its direction of movement, it is apparent that means must be provided for moving the clutch to a neutral position when so desired, as well as providing means for moving the clutch from one extreme position to the other to determine direction. Accordingly, the two cams have been provided, the large cam 124 having a substantially close fit in the shifter fork or in other words, without lost motion, while the cam 125 is considerably smaller than the shifter fork thereby permitting a considerable amount of lost motion. The plunger 126 is vertically movable between two positions to determine the rate of movement, as between feed or rapid traverse, the upper position determining the feed rate and the lower position determining the rapid traverse rate. Detent mechanism has been provided to cooperate with the plunger in either position and comprises the notched plates 127 and 128 which are keyed to the plunger, as shown in Figures 7 and 8. The detent plate 127 is adapted to cooperate with a detent 129 pivotally mounted on a lug 130 projecting from the side of the bed and held in engagement with the plate by means of a spring 131. Upon upward movement of the plunger 126 from the position shown in Figure 5 the cam 124 will move to a position between the forked ends of the lever 123 and the detent plate 128 will move upward into engagement with the detent 129. The detent is now adapted to engage the middle notch 132 formed in the plate 128 to hold the clutch in neutral position and upon rotary movement of the plunger to either clutch engaging position to maintain the parts in that position. When the plunger is moved downward it is apparent that upon rotation of the plunger 126 that the cam member 125 will move through a predetermined arc without effecting movement of the shifter fork but at the same time will be moving the plate 127 until the detent 129 passes the peak 133 after which the spring 131 will come into action to complete the movement and instantaneously move the clutch from one engaged position to the other. This movement of the plunger may be effected automatically and accordingly, the plunger is provided with a wing 134 for engagement by suitable dogs 135 while reciprocatory movement of the plunger 126 is effected by integral lugs 136 engageable by suitable dogs 137 mounted in T-slots 138 formed in the front edge of the table. The plunger may be manually rotated by lever 139 mounted in a universal joint 140 and having a ball shaped end 141 engaging a socket 142 formed in the collar 143 secured to the plunger. Due to the universal mounting of this lever it may be moved up or down to effect reciprocation of the plunger and horizontally to effect rotation thereof.

As previously mentioned, the plunger is movable vertically to change or select the rate and for this purpose is provided with an annular groove 144 for receiving the ball shaped end 145 of a bell crank 146 which is keyed to the shaft 105 journaled in the bed at right angles to the plunger. The arm 147 of the bell crank is provided with a pair of projecting pins 148 embracing the shifter fork 104 but with a certain amount of lost motion. A pivoted lever 149 is provided with a pair of notches 150 for engaging a detent 151 integral with the arm 147. A spring 152 is provided in engagement with the end of the lever 149 for maintaining the parts in contact with one another. Due to the lost motion connection the plunger 126 may be moved upward or downward a definite amount without effecting movement of the clutch but upon passage of the detent 151 past the peak between the notches 150 an instantaneous shifting of the clutch from one extreme position to the other will take place changing the rate of movement of the table from a feed to a rapid traverse or vice versa. It is thus seen that both the rate and direction of movement of the table may be controlled from a single means and either manually or automatically.

Upon determination to use a feeding movement for the table, additional means have been provided for manually or automatically varying the rate of this movement. As previously described, a cam 65 is rotatably mounted in the front of the machine and engaging the end of the lever 64 which is operatively connected with the slidable carrier 57. The cam 65 is keyed to a horizontal shaft 153 which projects through the forward wall of the machine and is provided with a manual operating lever 154 which has integrally formed therewith a pointer 155 registering with a dial 156 fixed to the front wall of the machine for indicating the feed rate selected. By this means the desired feed rate may be determined before operation of the machine so that upon subsequent engagement of the clutch 102 this rate will be imparted to the table or the rate may be increased or decreased by infinitesimal amounts during the cut. The lever 61 is provided with another arm 157 having pivotally connected to the end thereof the link 158 which is pivotally connected at the other end to a crank 159 having integral therewith the arm 160 in the end of which is journaled a roller 161. This roller engages the lower end of a reciprocable plunger 162 which is constantly urged downward by a spring 163 surrounding the plunger. The plunger has a beveled end 164 engaging a template or cam 165 secured to the front edge of the table. This template may be given any predetermined profile corresponding to the desired rates of feed movement to be imparted to the table to efficiently mill a particular shape of work piece. Attention is invited to the fact that if the cam 65 is moved to a position corresponding to the highest feed rate that the template 165 may then control the lever 61 without interference from the cam 65. It should now be apparent that suitable control mechanism has been provided for automatically or manually varying the rate of feed movement by infinitesimal amounts.

From the foregoing description taken in conjunction with the drawings it should now be evident that an improved transmission and control mechanism for a milling machine has been provided embodying a variable mechanical feed transmission, the output rate of which may be

increased or decreased by such infinitesimal increments as to be substantially a continuous change from one limit to the other and in which this variation may be effected either manually or automatically.

That which is claimed is:

1. A milling machine having a column, a bed integral with said column, a table reciprocably mounted upon said bed, a prime mover mounted in the column, a fixed rotatable drive shaft journaled in the bed, a transmission train coupling the prime mover with the drive shaft for constant actuation thereby, a slidable carrier, a driven member connected to the table, a plurality of reciprocable members alternately connected to the driven member, motion transmitting mechanism mounted in said carrier for operatively coupling the shaft with the reciprocable members including oscillatable bell cranks and actuating cam means therefor, and means to adjust the carrier axially of said shaft to vary the effective lever arm of the bell cranks relative to the reciprocable members and thereby the rate imparted to said table.

2. A milling machine having a support, a slide reciprocably mounted thereon, a prime mover, a mechanical variable feed transmission coupling the prime mover with the slide, said transmission being variable by infinitesimal increments, and independent cams for effecting said variations, said cams being coupled with the transmission so that either may effect a slower rate without disturbing the rate setting of the other.

3. A milling machine having a support, a slide reciprocably mounted upon the support, a prime mover, a mechanical feed transmission coupling the prime mover to the slide, said transmission including a pair of reciprocable members, cam means to move the members alternately through a working stroke at a uniform rate, clutch means to connect the members automatically at the beginning of each working stroke with the slide, and means to rapidly return, reverse and accelerate the working speed of one member during the working stroke of the other member whereby the slide may be continuously moved at a uniform non-pulsating feed rate.

4. A milling machine having a support, a slide reciprocably mounted upon the support, a prime mover, a feed transmission coupling the prime mover to the slide, said transmission including a pair of reciprocable members, cam actuated means for reciprocating the members through a working stroke at a uniform rate, automatic clutch means for connecting the members alternately with the slide at the beginning of each working stroke, and means to reposition successively the members after their respective working strokes including quick return, reverse and acceleration to working speed whereby the slide may be continuously moved at a uniform feed rate.

5. A milling machine having a support, a slide reciprocably mounted upon the support, a prime mover, a mechanical feed transmission coupling the prime mover to the slide, said transmission including a pair of reciprocable members, means to move the members alternately through a working stroke at a uniform rate, clutch means to connect the members automatically at the beginning of each working stroke with the slide, cam means to rapidly return, reverse and accelerate the working speed of one member during the working stroke of the other member whereby the slide may be continuously moved at a uniform non-pulsating feed rate, and means to vary the length of said working stroke by infinitesimal increments.

6. A milling machine having a support, a slide reciprocably mounted upon the support, a prime mover, a feed transmission coupling the prime mover to the slide, said transmission including a pair of reciprocable members, cam actuated means for reciprocating the members through a working stroke at a uniform rate, automatic means for connecting the members alternately with the slide at the beginning of each working stroke, means to reposition successively the members after their respective working strokes including quick return, reverse and acceleration to working speed whereby the slide may be continuously moved at a uniform feed rate, and manually actuated means for varying the length of said stroke without changing the time thereof whereby the slide movement may be gradually increased or decreased.

7. A milling machine having a support, a table reciprocably mounted upon the support, a prime mover, a drive shaft coupled to the prime mover for continuous actuation thereby, a driven shaft connected to the table, spaced gears mounted on the driven shaft, a rapid traverse gear train extending from the drive shaft to one of said spaced gears, a cam coupled to the drive shaft for rotation thereby, a feed pinion connected to the other spaced gear, alternately reciprocable members actuated by the cam for imparting uniform rotation to said pinion, said cam having one portion for moving the members alternately through a working stroke at a uniform rate, and a second portion for returning the members alternately at a rate greater than said uniform rate to successively reposition the members to maintain uniform pinion movement without pulsation, and means to connect either of said spaced gears to the driven shaft for actuation of the table at feed or rapid traverse rates.

8. A milling machine having a support, a table reciprocably mounted upon the support, a prime mover, a drive shaft coupled to the prime mover for continuous actuation thereby, a driven shaft connected to the table, spaced gears mounted on the driven shaft, a rapid traverse gear train extending from the drive shaft to one of said spaced gears, an axially reciprocable cam coupled to the drive shaft for rotation thereby, a feed pinion connected to the other spaced gear, alternately reciprocable members actuated by the cam for imparting uniform rotation to said pinion, said cam having one portion for moving the members alternately through a working stroke at a uniform rate, and a second portion for returning the members alternately at a rate greater than said uniform rate to successively reposition the members to maintain uniform pinion movement without pulsation, means to connect either of said spaced gears to the driven shaft for actuation of the table at feed or rapid traverse rates, and means to reciprocate the cam to incrementally vary the feed rate.

9. A milling machine having a support, a table reciprocably mounted upon the support, a prime mover, a drive shaft coupled to the prime mover for continuous actuation thereby, a driven shaft connected to the table, spaced gears mounted on the driven shaft, a rapid traverse gear train extending from the drive shaft to one of said spaced gears, an axially reciprocable cam coupled to the drive shaft for rotation thereby, a feed pinion connected to the other spaced gear, alternately

reciprocable members actuated by the cam for imparting uniform rotation to said pinion, said cam having one portion for moving the members alternately through a working stroke at a uniform rate, and a second portion for returning the members alternately at a rate greater than said uniform rate to successively reposition the members to maintain uniform pinion movement without pulsation, means to connect either of said spaced gears to the driven shaft for actuation of the table at feed or rapid traverse rates, and power actuated means for controlling the position of said cam and thereby automatically controlling the feed rate.

10. A milling machine having a support, a table reciprocably mounted upon the support, a prime mover, a drive shaft coupled to the prime mover for continuous actuation thereby, a driven shaft, reverser mechanism coupling the shaft to the table, spaced gears mounted on the driven shaft, a rapid traverse gear train extending from the drive shaft to one of said spaced gears, a cam coupled to the drive shaft for rotation thereby, a feed pinion connected to the other spaced gear, alternately reciprocable members actuated by the cam for imparting uniform rotation to said pinion, said cam having one portion for moving the members alternately through a working stroke at a uniform rate, and a second portion for returning the members alternately at a rate greater than said uniform rate to successively reposition the members to maintain uniform pinion movement without pulsation, and means to connect either of said spaced gears to the driven shaft for actuation of the table at feed or rapid traverse rates.

11. A milling machine including a support, a slide reciprocably mounted upon the support, a prime mover, a variable feed transmission coupling the prime mover with the support including a constantly actuated drive member, a driven member, motion transmitting linkage coupling the drive member with the driven member including a pair of reciprocable rack bars, operating bell cranks connected to the individual rack bars, cam means operatively coupled to the drive member for actuating said bell cranks to effect successive actuation of said bell cranks at a uniform nonpulsating rate, and means to vary the lever arm of the bell cranks relative to the rack bars to effect minute variations in the feed rate imparted to the table.

12. In a milling machine having a support, a cutter spindle journaled therein, a work table reciprocably mounted thereon, means for effecting rotation of the spindle and relative transverse movement between the work table and spindle including a main drive shaft, a prime mover operatively connected to the shaft for effecting continuous rotation thereof, a first branch transmission extending to the spindle, a manually actuated reverser for coupling said branch transmission to the drive shaft, a second branch transmission actuated by the drive shaft comprising a rapid traverse gear train, a third branch transmission coupled to the drive shaft including a pair of reciprocable members, operating bell cranks connected to the individual members, and adjustable relative thereto to vary the length of the working stroke, cam means for alternately moving the bell cranks and thereby the members through a working stroke at a uniform rate, a rotatable member automatically coupled in alternate succession to said reciprocable members, and trip actuated means for connecting the rapid traverse gear train or the rotatable member to the table for actuation thereby at feed or rapid traverse rates.

13. A milling machine having a tool spindle and a work support, means for effecting relative movement therebetween including a prime mover, a shaft constantly driven thereby, a branch transmission to the spindle, a clutch for connecting the branch transmission to the prime mover, a feed transmission for the work support and including a rate variator unit having a first part constantly driven by said shaft, a second part driven by and adjustable with respect to the first part to vary the output rate of said unit, means including a manually rotatable shaft to effect said adjustment, minute movements of said shaft effecting minute adjustments in said rate, dial means associated with the shaft for indicating the rate effected thereby, a pair of relatively movable members one of which is attached to the work support, means for imparting the output rate of said variator to one of said members to effect a feeding movement of the work support, a rapid traverse transmission coupled to said constantly driven shaft, and means for selectively disconnecting said rate variator unit from the work support and coupling the rapid traverse transmission thereto for causing movement of the work support at a relatively fast rate.

14. In a milling machine having a tool spindle and a work support, a transmission for effecting rotation of the spindle and translation of the support including a prime mover, a shaft constantly driven thereby, a branch transmission extending to the spindle, means for selectively connecting the branch transmission to said shaft and for determining the direction of rotation of the spindle, a second branch transmission actuated by said shaft for imparting relatively slow rates of movement to the work support, said transmission including a rate variator unit having a first part constantly driven by said shaft at a predetermined rate, a second part driven by the first part and adjustable with respect thereto to vary the output rate of said unit, means for effecting relative adjustment between the parts including a manually operable part, and indicating means associated therewith whereby the operator may observe the effect produced by any adjustment, a third branch transmission driven by said shaft, a final shaft, a first clutch for selectively connecting the second and third branch transmissions thereto, a second clutch in series with the first clutch for changing the direction of movement imparted by the final shaft to the work support, a trip operable element connected to said shafts and differently movable for actuating different of said clutches and trip dogs carried by the table for imparting different movements to said trip element for selective power actuation of said clutches.

15. A machine tool having a support, a tool spindle mounted for movement on the support, a work table carried by the support for movement transversely of the spindle, means for effecting said movements including a constantly driven shaft, a prime mover for driving said shaft, a first branch transmission extending to the spindle and actuated by said shaft, said branch transmission including means for determining the direction of rotation of the spindle, a second branch transmission extending to the work support, said transmission including a rate variator unit having a first part constantly driven from said shaft, a second part driven from the first part, means to

adjust the second part with respect to the first part to vary the output rate of said unit and thereby the feed rate of said work support including a manually actuable cam, means associated with the cam for indicating the adjustment thereof, a third branch transmission driven from said shaft and terminating in a clutch element, a shiftable member for coupling said clutch element to the work support for effecting rapid movement thereof, said element being selectively shiftable to couple said rate variator unit to the work support for movement at selected feed rates, a reverser interposed between said element and the work support for changing the direction of movement thereof or for stopping the same, and a power operable element effective on said reversing means for selectively effecting either result.

LESTER F. NENNINGER.
BERNARD SASSEN.