Oct. 15, 1940. W. I. SENGER 2,218,182

MACHINE TOOL

Filed Jan. 10, 1936 5 Sheets-Sheet 1

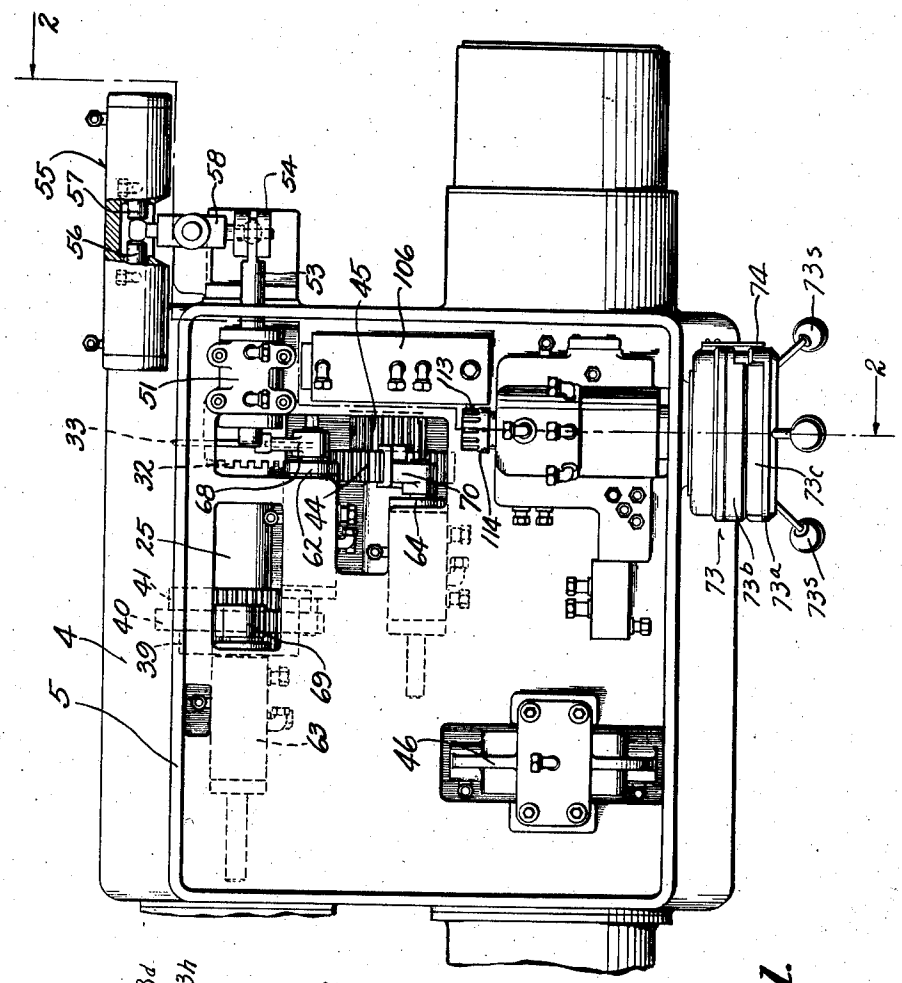

Fig. 1.

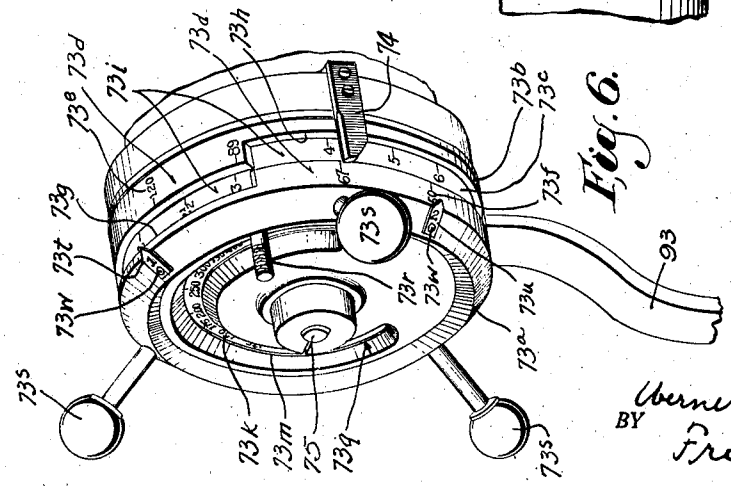

Fig. 6.

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Oct. 15, 1940. W. I. SENGER 2,218,182

MACHINE TOOL

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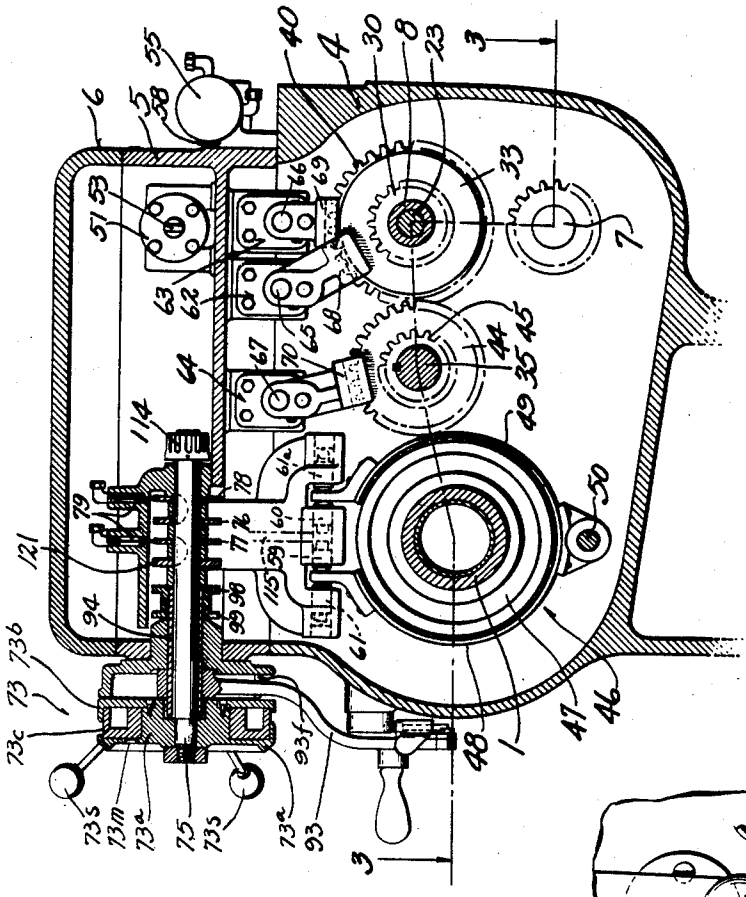

Fig. 2.

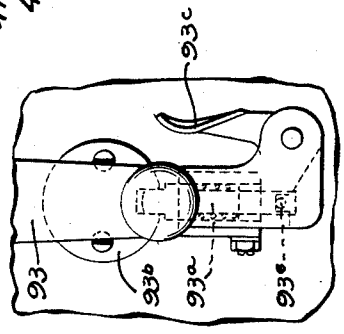

Fig. 9.

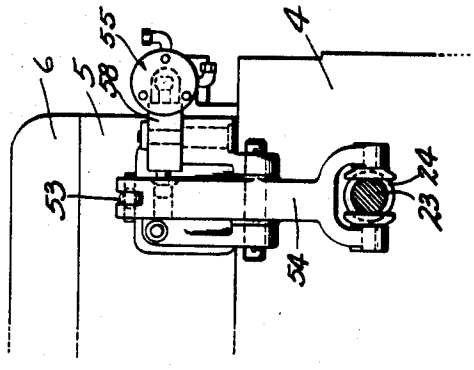

Fig. 7.

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MACHINE TOOL

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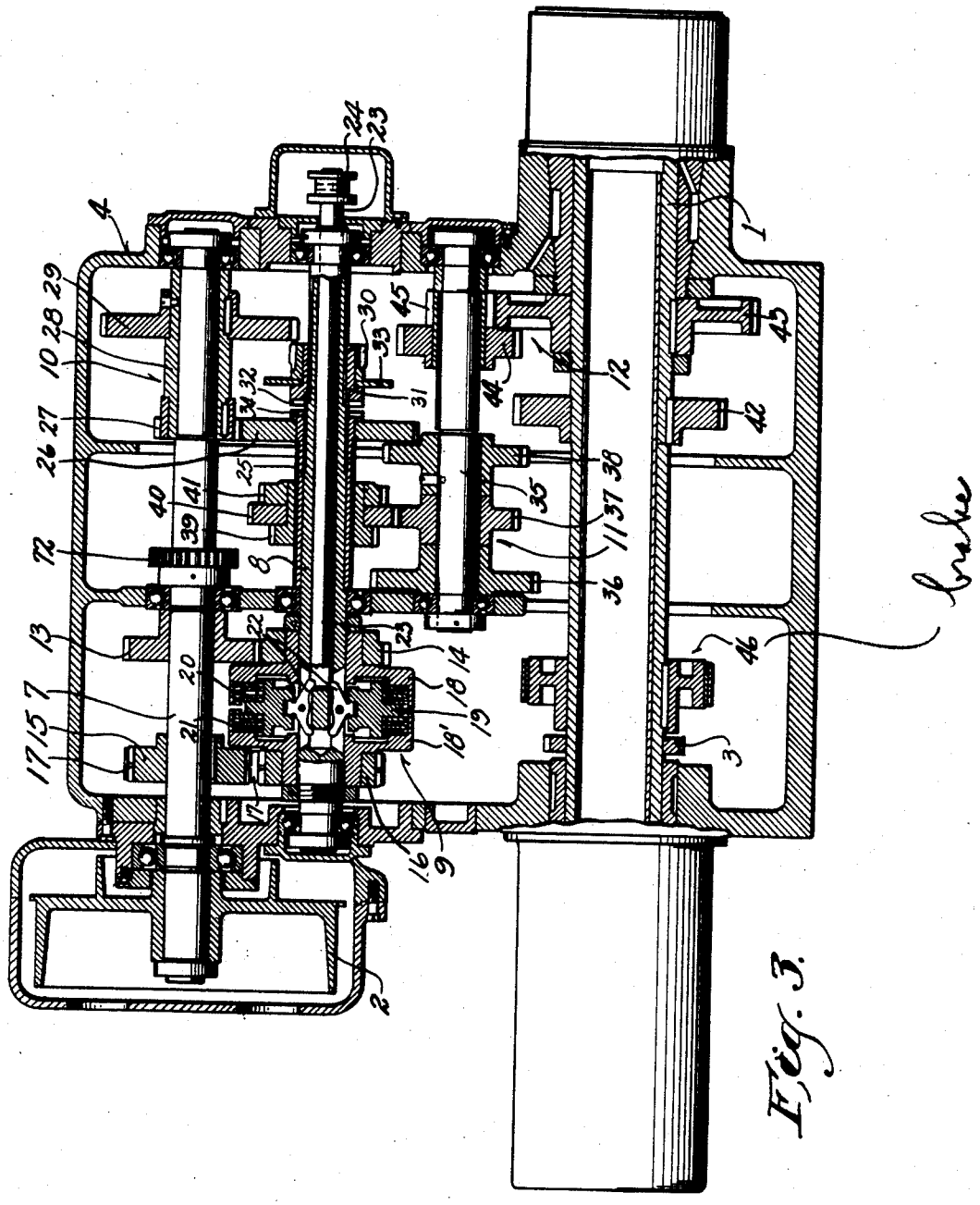

Fig. 3.

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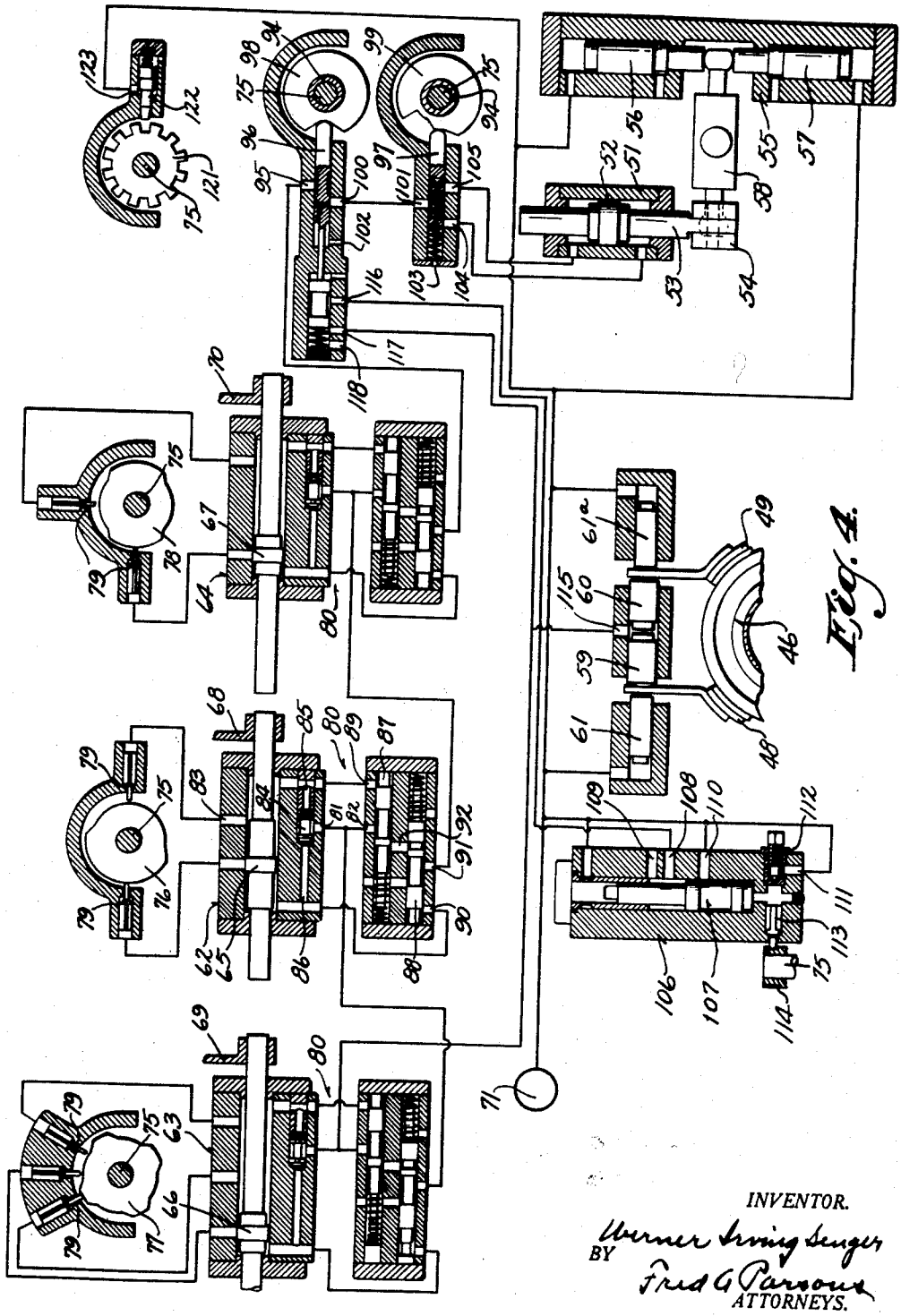

Fig. 4.

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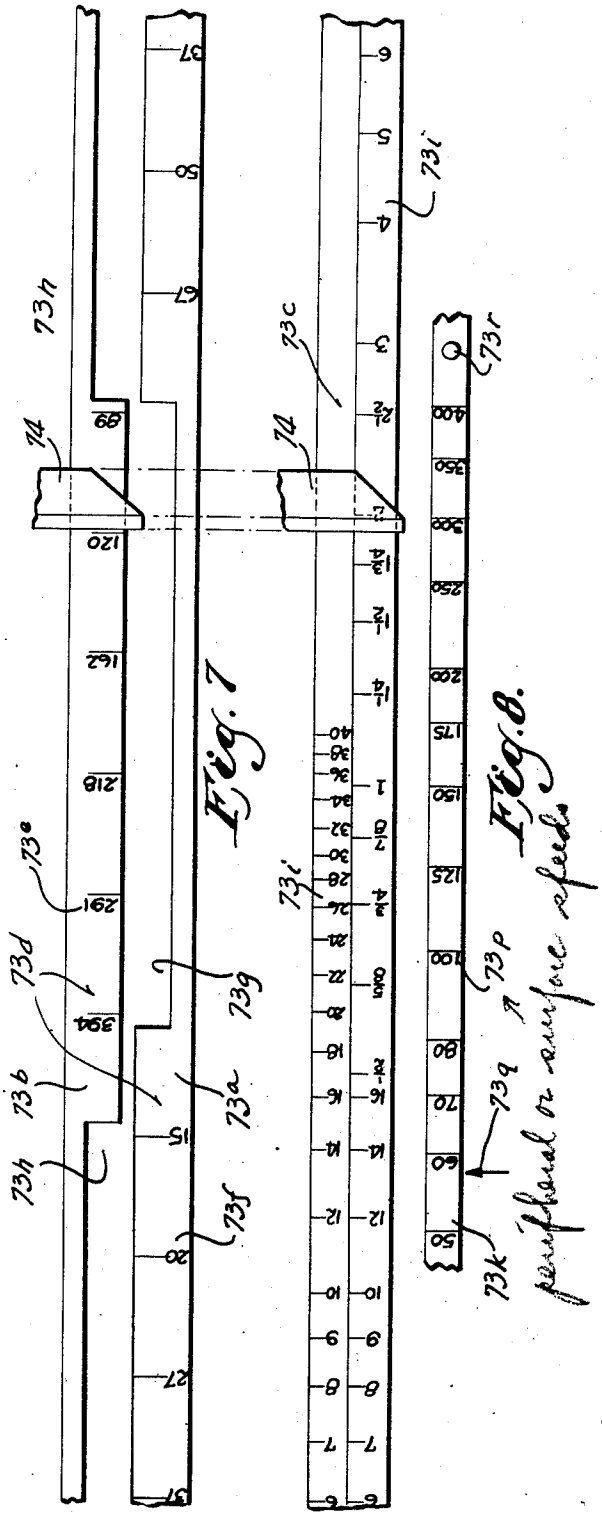
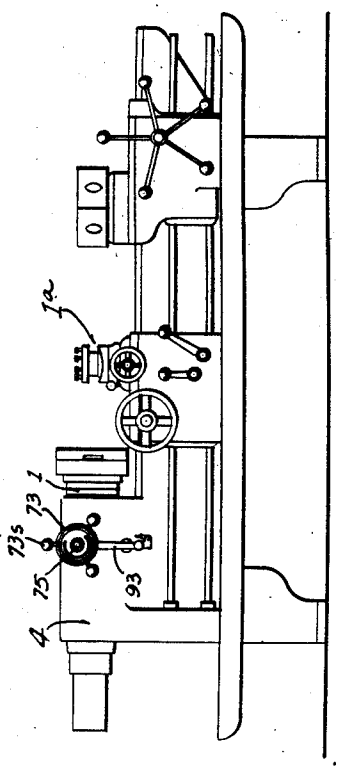


Fig. 7

Fig. 8.

Fig. 10.



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UNITED STATES PATENT OFFICE

2,218,182

MACHINE TOOL

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Application January 10, 1936, Serial No. 58,549

19 Claims. (Cl. 82—29)

This invention relates to machine tools and more particularly to transmission and control mechanism therefor.

A purpose of the invention is to provide an improved rate change mechanism and improved control mechanism therefor, more particularly in a form adapted for rotating spindles, and especially for the work carrying spindle of a lathe.

Another purpose is to provide improved mechanism to effect changes in the rotative rate of an object such as a cutter or a work piece together with improved means for determining the peripheral speed thereby effected at a known diameter of the object.

Another purpose is to provide improved mechanism for changes in the rotative rate of an object to effect a preferred peripheral speed without necessity for consideration of the actual rotative rate required for the desired peripheral speed.

Another object is to provide improved rate change and control mechanism which is operative either to directly visibly indicate the peripheral speed of an object of known diameter rotating at known rate, or to directly visibly indicate the rotative rate necessary to effect a preferred peripheral speed at a preferred diameter.

Another purpose is to provide an improved rate changer and control therefor, in which the control mechanism may be pre-set to select a preferred peripheral speed on suitable indicating devices associated therewith and subsequently the control mechanism may be directly shifted in accordance with the indicating devices to effect the desired result.

Another purpose is to provide the pre-selective mechanism just mentioned in a form which will enable the subsequent direct shifting of the control mechanism to a variety of positions corresponding to different diameters and respectively operative to effect the pre-selected peripheral speed on an object of the corresponding diameter.

Another purpose is to provide transmission and control mechanism for one or more of the purposes previously mentioned in which the control mechanism includes improved power means for effecting the shifting of the transmission mechanism.

Another purpose is to supplement or modify the control mechanism of the co-pending application Serial No. 24,201, filed May 31, 1935 in a manner to effect an improved device, particularly with respect to one or more of the purposes previously mentioned.

Another purpose is to simplify and improve the construction and operation of machine tools generally and particularly for lathes.

The invention consists in the construction and arrangement of parts as herein illustrated, described and claimed, and in such modifications thereof as are equivalent to the combinations claimed.

The same reference characters have been used to indicate the same parts throughout the specification and in the drawings:

Fig. 1 shows a top view of the headstock and spindle drive portion of a lathe in which the invention is incorporated, a cover plate being removed to show certain control devices.

Fig. 2 shows a partial vertical section of the same machine, taken along line 2—2 of Fig. 1.

Fig. 3 is a development of the drive train leading to the spindle of the machine on a section taken approximately along the line 3—3 in Fig. 2.

Fig. 4 is a more or less diagrammatic view showing certain control mechanism for the machine of Fig. 1 and certain interconnection thereof.

Fig. 5 is a partial view from the left in Fig. 1 showing part of the mechanism for shifting the reverser of the drive train shown in Fig. 3.

Fig. 6 is an enlarged perspective view of the manually operable portion of the control device, shown at the lower portion of Fig. 1.

Figs. 7, 8, are a development of certain elements of the control device of Fig. 6 which provide relatively movable chart and indicator means readable to indicate the rotative speed effected in different positions of adjustment of the control mechanism, pre-selection of preferred peripheral speeds, etc.

Fig. 9 is an enlarged front view of a portion of a hand lever shown in Fig. 2.

Fig. 10 is a reduced scale front view of a lathe incorporating the invention.

The machine tool shown in the drawings is a lathe having a work spindle 1, a power source associated with the machine, which in this case is a drive pulley 2, and a feed train, mostly not shown, driven from the pulley 2 through spindle 1 and originating in a gear, such as 3, fixed with spindle 1. It will be understood that the lathe has suitable tool supports, such as 1a (Fig. 10) of any well known form, operable at feed rate through a gear such as gear 3 in any suitable manner.

A transmission mechanism for rotation of spindle 1 is housed in a hollow casing or headstock 4, Fig. 2, having a cover plate or member 5, which carries a number of shifting and control

devices and is removable for exposing the transmission for inspection, etc., and having another cover plate 6, which is removable for exposing the control devices.

The pulley 2 is preferably driven at constant speed, and drives a shaft 7 on which the pulley is fixed, a shaft 8 driven from shaft 7 through a reverser and motion interruptor generally denoted by the numeral 9, and serially arranged rate change devices including a shiftable rate change device generally denoted by the numeral 10, a shiftable rate change device generally denoted by the numeral 11, and a shiftable rate change device generally denoted by the numeral 12.

The reverser-interrupter 9 includes a pair of meshed gears 13, 14 respectively fixed on shafts 7 and rotatable on shaft 8, and a pair of sprockets, 15, 16, not meshed, respectively fixed on shaft 7 and rotatable on shaft 8, the sprockets 15 driving the sprocket 16 through a chain 17 engaging both sprockets. This arrangement continuously drives gears 14, 16 in opposite direction. Fixed with gears 14, 16 respectively are outer clutch members 18, 18', and slidably keyed on shaft 8 is an inner clutch member 19. Groups of friction plates 20, 21 are respectively associated with the different clutch members 17, 18, the alternate plates of each group being slidably keyed to the outer and inner clutch members. The inner clutch member 19 is engaged by pivoted lever members such as 22 which may be swung on their pivots by the axial movement of a shifter rod 23 extending through an axial bore of shaft 8 and having a shifter spool 24 by which the rod may be shifted in the one direction or the other to frictionally engage the opposed plates of either group 20, 21 whereby to drive shaft 8 in either direction. The rod 23 may also be shifted to an intermediate position in which the plates of both groups 20, 21 are disengaged and shaft 8 is disconnected from the drive pulley 2.

The spindle may be driven at different rates by the means of transmission mechanism as follows:—Shaft 8 drives a sleeve 25, rotatably supported thereon, through the rate change device 10, which includes a pair of meshed gears 26, 27 respectively fixed on the sleeve 25 and on a sleeve 28 rotatably supported on the shaft 7, a gear 29 also fixed on sleeve 28, and a shiftable unit including a gear 30 fixed with a sleeve 31 which is slidably keyed on the extended end of shaft 8, and a clutch member 32 at the end of sleeve 31. Sleeve 31 also carries a shifter element 33, by the means of which it may be shifted in the one direction to engage gear 30 to drive sleeve 25 from shaft 8 through the gears 29, 27, 26, or may be shifted in the other direction to drive sleeve 25 directly from shaft 8 through the clutch member 32 and a complementary clutch member 34 fixed on the end of sleeve 25. Sleeve 25 drives a shaft 35 through the rate change device 11 which includes gears 36, 37, 38 fixed on shaft 35 and gears 39, 40, 41 fixed together and slidably keyed on sleeve 25 for engagement one at a time with gears 36, 37, 38 respectively. Shaft 35 drives spindle 1 through the rate change device 12 which includes gears 42, 43 fixed on spindle 1 and gears 44, 45 fixed together and slidably keyed on shaft 35 for engagement one at a time with the gears 42, 43 respectively. The several rate change devices 10, 11, 12 provide a rate changer which, together with reverser 9 provides 12 different rates of spindle rotation in either direction and substantially in geometrical progression.

A brake generally denoted by the numeral 46, Fig. 2 is provided for spindle 1 and includes a brake drum 47 fixed on the spindle, and a pair of brake shoes 48, 49 each pivoted on a pin 50 fixed in housing 4, to frictionally engage the brake drum when the upper end portions of the shoes 48, 49 are forced toward one another.

Power operable means are connected for the operation of reverser 9, rate change devices 10, 11, 12 and brake 46 as follows:

For the reverser-interrupter 9, a first piston device generally denoted by the numeral 51, Figs. 1, 4 is fixed on plate 5 and includes a piston 52 having a piston rod 53 connected for movement of a pivoted lever 54, Figs. 4, 5, which, at its lower end has pivoted shoes engaging the annular groove of the spool 24 fixed on the end of shifter rod 23. A second piston device 55 for the reverser interruptor includes two pistons 56, 57 continuously urging a pivoted lever 58, which engages the upper end of lever 54, toward central position. The piston 52 is of larger effective area than the pistons 56, 57 and if fluid is admitted to either face of piston 52 the pistons 56, 57 will be overcome and the reverser 9 moved by piston 52 to the one or the other of its engaged positions, but if the pressure is released on piston 52 the pistons 56, 57 will immediately move the reverser 9 to motion interrupting position.

For the spindle brake 46 there are provided two pistons 59, 60 Figs. 2, 4, respectively for urging the different brake members 48, 49 to release position, and two pistons 61, 61*a* continuously urging the members 48, 49 to engaged position, the pistons 59, 60 being of largest area whereby, when supplied with fluid, to overcome pistons 61, 61*a*. The pistons 61, 61*a* are continuously supplied with fluid and therefore whenever the fluid supply is interrupted to the pistons 59, 60 the spindle brake 46 will operate.

For the respective speed change devices 10, 11, 12 there are provided piston devices 62, 63, 64 Figs. 1, 4 having similar pistons 65, 66, 67, and having fixed on the piston rod thereof the shifter members or forks 68, 69, 70, respectively engaging the shifter element 33 and the gears 40 and 44.

For the operation of the several piston devices fluid under pressure is constantly supplied, at least whenever the pulley 2 is running, from any suitable source, preferably a pump of any suitable type, as indicated at 71, Fig. 4, and connected to be driven from shaft 7, as for instance from a gear 72, Fig. 3, and drawing oil from a sump in the bottom of the hollow casing 4. Waste oil and surplus oil from the pump 71 may be used to lubricate the transmission mechanism shown and other portions of the machine which require lubrication.

Control means for the operation of the rate change mechanism includes rate selector means as follows:

A selector device, generally denoted by the numeral 73, Figs. 1, 2, 6 includes a plurality of members 73*a*, 73*b*, fixed for rotation together relative to an indicator pointer 74 and with a shaft 75. Another selector member 73*c* is rotatable relative to the pointer 74 and relative to members 73*a*, 73*b*, independently of the last mentioned members and of shaft 75. The several members 73*a*, 73*b*, 73*c* are provided with charts or dials, which include a first chart generally denoted by the numeral 73*d*, Figs. 6, 7 providing a series of numerals such as 73*e*, 73*f* corresponding to the different revolutions per minute of spindle 1 which

are obtained as the rate change transmission therefor is shifted to its various effective positions.

The members 73a and 73b have peripheral flanges of which portions are cut away, as at 73g and 73h, whereby to expose a portion of a chart or scale on the periphery of the members 73c and generally denoted by the reference character 73i, Figs. 6, 8, the chart 73i including two scales arranged side by side and together providing the upper and lower range of a series of numerals corresponding to different diameters, in this instance ranging from five-eighths to forty inches diameter.

Another chart, generally denoted by the reference character 73k, Figs. 5, 8, is arranged on the outer face of the member 73c, whereby to be visible through an opening or window 73m in the front wall of the member 73a, the construction being such that the charts 73i and 73k are in fixed relation to one another. Chart 73k includes a series of numerals such as 73p, Fig. 8, collectively covering a range of peripheral or surface speeds, in this instance from 50 to 400 feet per minute. Chart 73k is readable against a relatively movable index line or pointer 73q, Fig. 6, fixed with member 73a, and relative to which the chart can be adjusted to indicate various surface speeds by the means of a member 73r which is fixed with member 73c and projects outside the member 73a through the opening or window 73m.

The shaft 75, upon which are fixed the members 73a, 73b of the selector device 73, also has fixed thereon the cams 76, 77, 78, Figs. 2, 4, respectively for the control of the piston devices 62, 63, 64. These cams are formed for operation of pressure releasing poppet valves such as the valves 79 arranged adjacent to the cams, the position of the several valves and the shape of the cams being such that in each of the 12 positions of speed chart 73a one of the poppet valves associated with each of the cams is open and the others are closed. The valve positions and cam forms also provides that during rotation of chart 73a the opening of the one or the other poppet valve for the speed change units proceeds in a sequence corresponding to the shifting movements required in order to produce the various spindle speeds in the position of the selector device 73 where the corresponding speed is indicated by pointer 74 on the chart 73a.

Also associated with each of the piston devices 62, 63, 64 are valve means similar to the valve means 80, Fig. 4, which are controlled by the poppet valves 79 to effect the piston movements corresponding to the operation of the poppet valves. These valve means are substantially the same for each piston device and will therefore be described in detail only for the piston device 62.

Referring to the valve means 80, and the piston device 62, in Fig. 4, fluid is delivered to the device through the valve ports 81, 82. The piston 65 is there shown in its left hand position, which is the position assumed whenever the cam 76 forces the left hand poppet valve 79 open, as there shown. But when the cam 76 is turned to open the right hand poppet valve 79 the left hand valve closes, and then a sequence of events will occur, resulting in movement of the piston to the right, as follows. The pressure will then be relieved in the right hand end of the cylinder of piston 65 through a port 83 leading to the open poppet valve, oil will flow through a channel 85 from port 81, and thereupon a blocking valve or plunger 84 is urged to the right by the flow of fluid through the channel 85, seating the blocking valve 84 to the right and closing the channel 85 to prevent further leakage from the supply port 81 through the poppet valve. A channel 86, continues to supply pressure fluid to the left hand end of the piston 65, and since there is no pressure on the right hand end, the piston moves to the right. Two valves 87, 88 are continuously spring urged in opposite directions to the positions shown in Fig. 4, but are normally forced to the left and right respectively, against the spring pressure, by the pressure of fluid acting on the valve ends, respectively through ports 89, 90. In the positions shown both valves block any passage of fluid to a port 91 which leads to the next of the valve devices of the series, but it will be seen that if the valves were in the normal position a passage exists from port 82 to the port 91 through the annular grooves of the valves and through the intermediate passage 92. At the start, and during the movement of piston 65 to the right, the valve 88 continues in the normal position to the right of the position shown in Fig. 4. But immediately when the right hand poppet valve 79 was opened the fluid pressure holding valve 87 in normal position bleeds off through port 89 and the open poppet valve and therefore, during the entire right hand movement of piston 65, the fluid path past valve 87 is closed. Similarly, during a left hand movement the fluid path would be closed by the valve 88, although the valve 87 would then be open. But when the piston 65 has completed its movement in either direction, the leak path to the open poppet valve is closed by the piston, and the pressure then rises and opens the closed valve 87 or 88, whereby the fluid may pass from port 82 to the port 91 and on to similarly operate the next piston device in the series. By this arrangement of valves similar to the valve means 80, the speed shifter piston devices 63, 62, 64 are restricted to act separately, one after another in the order just stated.

It will be noted that although the piston 66 has three positions, corresponding to the three positions of the gear set 39, 40, 41 the operation upon opening any one of the three poppet valves 79 associated with cam 77 is the same as that just described for piston 65. The piston 66 moves until it covers the port leading to the open poppet valve, and except that there are three such ports instead of two, the operations are identical.

Should it occur that the adjustment of selector device 73 does not require movement of one or more of the rate change devices 10, 11, 12 then the action above described does not take place as to the piston and valves for those devices. The piston remains in previous position and the valve means corresponding to valve means 80 continue in normal position, permitting the fluid to pass freely to operate the next device in the series, whenever a rate selective movement effects no change in the positions of the poppet valves of that piston.

The entire selector device 73, may be rotated by the manually operable levers 73s, thus rotating shaft 75 and the various cams fixed thereon, to effect the different rate change positions of the control mechanism.

The selector and shifter arrangement described, and the position, arrangement and markings of the various charts, and relatively movable indicators is such that when scale 73k is adjusted for a preferred peripheral speed to be readable

against indicator pointer 73q, then the indicator pointer 74 will indicate on chart 73i the diameter of work piece or cutter which will have such peripheral speed at the rotary speed at which spindle I is then operating, as indicated by the reading of chart 73a against the indicator pointer 74. Also in any position of chart 73i the work diameter indicated by pointer 74 will have a peripheral speed as indicated by pointer 73q.

Then, if the indicated diameter does not correspond with the cutter or work diameter to be used in the subsequent operation, the selector device may be rotated by manipulation of the levers 73s until the indicated diameter does correspond with the diameter to be used, at which point the resulting rotative speed of spindle I will be the rotative speed which will produce the desired peripheral speed.

It will be noted that, so far as concerns the mode of operation just described it would be unnecessary to refer to the chart 73a in order to operate the machine. In the majority of operations the operator is not concerned with the rotative speed of the spindle, but only with the peripheral or cutting speed. This is true whether the machine is one in which the rate change mechanism is used to drive a work spindle, as in the lathe here shown, or one in which the mechanism drives a tool spindle, as for instance in a milling machine.

It may be noted that, ordinarily the operator is not concerned with rotative speeds but only with peripheral or cutting speeds. Before starting an operation he knows the limit of cutting speed at which the work material of the proposed operation can be cut while still producing a satisfactory finish and reasonable life for the cutting tool. He also knows the diameter of the work to be cut, or the milling cutter to be used, as the case may be. Where the control device provides only a chart readable in rotative speeds it is therefore necessary for the operator to compute the available rotative speed which will most nearly produce the desired cutting speed with the given diameter. Such computations are unnecessary with the device here shown, and possible errors in computation are avoided.

In any machine where the feed rate per minute is increased in correspondence to the increase in spindle speed, for instance where the feed train is driven through the spindle of the machine as in the lathe here shown, and in some milling machines it is of greatest importance that the spindle speed should be kept as high as possible for each operation. In such machines an increase in spindle speed reduces the operating time, which varies in accordance with the rate of feed per minute. Since the operator, as previously stated, knows the limit of cutting speed for the work material in use, and the diameter of the tool or work, he may with the device here shown, proceed directly to set the machine for maximum production without any computations and even without necessity for knowledge of the rotative speed used to obtain maximum production.

It may be noted that, even in machines where the feed rate is not changed in accordance with the spindle speed, it is advantageous to use a spindle speed which is as high as the nature of the operation will permit. For any given rate of feed per minute, an increase in rotative speed will reduce the thickness of the chip which is cut from the work, thereby reducing the cutting pressures reacting on the bearings and slides of the machine, and also providing a better finish on the work.

Although the control device 73, as explained, could dispense with the chart 73a for some operations it is preferable to retain this chart for various reasons. Operators are accustomed to charts reading in terms of rotative speed and will find in this chart a means of comparison and of assurance that the adjustments obtained are in accord with their experience. The chart also provides a convenient and direct means for determining the direction in which the device 73 shall be rotated to increase or decrease the cutting speed. Also, when the cutting speeds available are obtained in a series of speeds, without intermediate speeds, as in the machine here shown the chart 73a indicates the point at which the device 73 should stand to effect one of the available speeds. It is contemplated, however, that the control device, suitably modified may be similarly used to control the adjustment of suitable rate changers of any well known form in which all rates are available between the minimum and maximum rate of the rate changer

When the chart 73a is incorporated in the control device, for any reason, it is preferable that it shall read against the same index pointer as is used for the chart 73i, as here shown.

It will be noted that the diameter chart 73i is in two sections or parts having different range of values, namely one-half to sixteen inches and six inches to forty inches in the present instance. The cut away portions, or openings 73h, 73g in the flanges of the members 73a, 73b are such as to simultaneously expose only a part of each portion of the chart, but sufficient together to form a chart visibly extended around the complete periphery of the member 73c. The chart thus visibly exposed varies in accordance with the position of adjustment of member 73c relative to member 73 and therefore in accordance with the reading of the chart 73k against the pointer 73q. The relative position of the two portions of chart 73i with respect to one another, and to the other elements of the device is such that, for any peripheral or cutting speed indicated by pointer 73q on chart 73k the chart 73i will visibly indicate the range of diameters which may be used to obtain the indicated cutting speeds with the rotative speeds available from the rate changer. There are practical limitations on the range of rate change speeds which may be made available in a given machine, and the device immediately discloses these limitations in terms which will enable the operator to determine, without any computation, whether a desired cutting speed is within the range of a particular machine.

The construction also provides for wider spaced and more readily readable graduations or markings on chart 73i with any given diameter of the member 73c. Thus, although only the portion corresponding to one diameter of 73c is exposed on chart 73i, the effective length of the complete chart may be considerably greater, as in this instance.

The reverser 9 is controlled manually by a hand lever 93, Fig. 2 which has a central position where the reverser is disengaged and positions at either side of central respectively for reverser engagement for the different directions of spindle rotation. The central position of lever 93 is defined by a spring plunger 93a Fig. 9 which engages a suitable slot in a member 93b and may be disengaged for shifting lever 93 by the means of a pivoted thumb latch 93c engaging with a

pin 93e fixed in the plunger. The shifted positions of lever 93 are defined by suitable abutments, such as 93f, Fig. 2, formed by slotting the flange through which lever 93 projects. In either shifted position the plunger 93a co-acts with the surface of member 93b to provide a detent retaining the lever in shifted position.

The control mechanism operative from lever 93 is as follows. Lever 93 is fixed with a sleeve 94 co-axial with shaft 75 but independently rotatable. Reverser piston 52, Fig. 4, is shifted by fluid derived from a port 95 through two valves 96, 97 which are spring pressed against the cams 98, 99, Figs. 2, 4, respectively, each of the cams being fixed on sleeve 94. Cam 98 and valve 96 are of such form and relationship that when lever 93 is in central position the port 95 is closed to a port 100 which communicates with the supply port 101 of the valve 97, and the port 100 then communicates through the grooves and small channels shown in Fig. 4 with a drain port 102, whereby to relieve the pressure on piston 52 and permitting the pistons 56, 57 to operate to shift the reverser 9 to central disengaged position. In either of the other positions of lever 93, the valve 96 is positioned to close the drain port 102 and to supply fluid to the valve 97. Valve 97 and cam 99 are of such form and relationship that in the central position of lever 93 both ends of piston 52 communicate with ports 101 and 100, and therefore the fluid will drain as described from piston 52, to permit the clutch 9 to return to neutral position from either engaged position. But in either clutch engaged position of lever 93 one end of the piston 52 is connected to the fluid supply port 101 while the other end is connected to the drain channels 103, either directly, in the instance of the port 104, which supplies the one end of the piston, or through the small axial bore shown in the valve 97, in the instance of the port 105, which supplies the other end of the piston. By the means described the reverser-interruptor clutch 9 may be shifted by fluid pressure to any of its three operative positions accordingly as hand lever 93 is correspondingly positioned.

Before the spindle rate changer is shifted to effect any change in speed, the reverser clutch 9 is disengaged and the spindle brake 46 is engaged to stop or to slow down spindle rotation. This result is obtained in the following manner.

The fluid from pump 71 for operation of the rate change devices 10, 11, 12 is derived through a timer device generally denoted by the numeral 106, Figs. 1, 4 and which includes a plunger valve 107 continuously urged by fluid pressure on the small end of the valve. The plunger valve 107 is, however, normally held, by means of fluid pressure on the large end of valve 107, in a position for a port 108, which is connected to the rate change shifters 62, 63, 64, to receive fluid from a supply port 110. The pressure on the larger valve end is derived from a port 111 through an adjustable needle valve device 112. A poppet valve 113 may be opened to relieve the pressure acting on the larger end, upon which the valve 107 is immediately forced by the pressure on the small end to a position where no fluid is supplied to the port 108, the port 108 then being connected to a drain port 109, and the valve does not return to normal position again until after an interval in which sufficient fluid can leak through the needle valve 112 to force the valve back against the pressure on the small end.

Mounted on the end of the shaft 75 is a notched cam 114, Figs. 1, 4, the notches of which are so positioned relative to the cams 76, 77, 78 and speed dial 73 that in each speed position of the selector 73 and shaft 75 the exposed end of poppet valve 113 is opposite a notch, and the poppet valve is closed. But in passing from any one to another speed position the end of the poppet valve will be forced back by at least one of the intermediate high portions of cam 114, the poppet valve will be opened, and the valve 107 will move to the position where the port 108 receives no fluid and is open to the drain port 109. Immediately the selector 73 and shaft 75 have arrived at the desired speed position the poppet valve end again is opposite a notch and the poppet valve closes, but as previously pointed out, valve 107 remains in the position draining the port 108 and the speed change pistons until sufficient fluid has leaked through the needle valve 112 to force the valve 107 back to the position where ports 108 and 109 again communicate with one another. This interval can be varied by the adjustment of the needle valve 112, but is always sufficient for the operation of the reverser 9 to disengaged position and for application and release of the spindle brake 46, before the start of the movement of the speed change pistons, these operations being effected as follows:

The reverser operating piston device 51 is supplied with fluid through port 101 as previously stated. Port 101 receives fluid from the last operated of the rate change devices 62, 63, 64, and therefore, when the port 108 of the supply line leading to the shifter pistons is connected with the drain port 109 as described, the pressure is also relieved on the reverser piston 52, and the reverser pistons 56, 57 then immediately shift the reverser to central disengaged position. And even after fluid is again supplied to the port 108 by the return of the valve 107 to its normal position, the reverser supply port 101 will receive no fluid until the 1st of the series of rate shifter piston devices 62, 63, 64 has operated, by reason of the explained mode of operation of the valve means 80. It will thus be seen that, preceding each rate change the reverser 9 will be disengaged, and will not engage again until the rate change is completed, after which the reverser piston 52 will again be supplied with fluid to overcome the pistons 56, 57, whereby to return the reverser to whatever position it occupied, before the rate change was started, since the reverser direction valve 97 has not been disturbed by the rate change operation.

As stated, the brake 46 is applied to spindle 1 to stop the spindle before each speed shift. The operation is as follows: The brake releasing pistons 59, 60 are supplied with fluid from a port 115, Fig. 4, which derives its fluid from the port 108 of the timer device 106, and therefore when the timer device operates, preceding each rate change, to connect the port 108 to the drain port 109, as previously described, the pistons 59, 60 then fail to oppose the continuously supplied pistons 61, 61a and the brake becomes effective. But since the port 115 is connected with the supply line leading from port 108 to the first of the speed shift devices 62, 63, 64 the brake will be released again after the operation of the timer device 106 and before or simultaneously with the operation of the first of the rate change devices.

Brake 46 is also operated to stop the spindle quickly, and to lock it in position when the reverser control hand lever 93 is moved to the central position to disengage the reverser 9. This is accomplished by directing the fluid supply to the port 115 of the brake release pistons 59, 60 through ports 116, 117 of reverser valve 96. When valve 96 is moved to the position, shown in Fig. 4, corresponding to the disengaged position of reverser 9, then the line leading from port 117 to brake pistons 59, 60 is connected to the drain port 118, and the continuously supplied pistons 61, 61a then operate to apply the brake.

The connections from port 108 through ports 116, 117 as just described also operate to make it impossible to effect a rate change when the reverser control lever 93 is positioned in the central position for disengagement of reverser clutch 9. The speed shift devices 62, 63, 64 as well as brake 46 are supplied with fluid through port 117, and when that port is connected to the drain port 118 as just described no rate change can take place.

From the foregoing description it will be seen that the manner of reverser clutch and brake operation depends upon whether such operation originates in the movement of the selector 73 or in the control lever 93. When operation is from lever 93 either the reverser clutch or the brake is engaged. But when the operation is from the selector device it occurs first that the reverser clutch is disengaged at substantially the same time that the brake is engaged, thus quickly interrupting the drive. Following this the brake is disengaged and both the brake and reverser clutch remain disengaged during the engagement of the rate change units 10, 11, 12, in their new positions. When the brake and clutch are both disengaged friction or oil drag between the plates of the one or the other of the sets of clutch plates 20, 21 normally causes a slow impositive rotation of shaft 8 and the shafts driven therefrom, which prevents the ends of engaging rate change elements from abutting in positions which might delay their engagement, and expedites the rate change operation.

In some instances it is not desirable to permit the speed indicating chart 73a and shaft 75 to be moved at times when the port 117 is connected to the drain port 118, as above described, whereby there is no fluid available for the shifting of the speed change devices. In the co-pending application previously identified means are provided, preventing movement of shaft 75, when reverser control lever 93 is in central position, as there explained. A similar interlock could obviously be similarly used here, to prevent movement of members 73a, 73b and shaft 75 when lever 93 is in central position.

In the present instance, however, no such interlock is provided, and the selector mechanism, including the selector chart 73a may, if desired, be positioned while the lever 93 is in central position and reverser 9 is disengaged. In such case the rate indicated by chart 73a will subsequently become effective immediately when the lever 93 is shifted to either engaged position.

The shaft is locked to prevent movement in the event that, for any reason, the pressure of the fluid supply falls below the point where it will effect the control operations previously described. For this result there is provided a disc 121, Fig. 2, 4 fixed on shaft 75 and having notches adapted to be engaged by a spring pressed plunger 122, in any speed position of the dial 73 and shaft 75, and to prevent shaft movement when engaged. The plunger spring is continuously opposed by fluid pressure derived directly from pump 71 through the port 123, and therefore only engages the notches when the fluid pressure fails for any reason, as, for instance when there is no power supplied to the drive shaft 7.

It will be understood that the ports or channels of the various piston and other devices are suitably connected by piping and pipe fittings indicated by the line connections shown in Fig. 4. The connecting piping, for clearness, is not shown in the other views.

In some operations, as for instance where a number of different diameters are to be finished one after another in a lathe, it may be advantageous to use special devices which indicate the sequence of positions required of the speed selector. Thus, for instance, the periphery of member 73a may be provided with interchangeable serially numbered pointers such as 73t, 73u, Fig. 6, in any number up to the number of speeds available. These may be fixed, as by screws 73w, adjacent to the markings on chart 73a in any order, to indicate the order in which the different speeds are to be used. In such case it is unnecessary to refer to any of the charts after the machine is set up for the operation, the serially numbered pointers being merely brought to alignment with indicator pointer 74 one after another in their numbered and pre-arranged order. But unless the machine includes means preventing the operations from proceeding in any but predetermined sequence it is ordinarily preferable to refer directly to the diameter chart 73i, and as the operation proceeds, to successively rotate the selector 73 to the position as indicated for the diameter to be finished. There is then less possibility of error in establishing a spindle speed which does not correspond to the diameter to be finished.

What is claimed is:

1. In a machine tool the combination of a rotatable support, a transmission for said support including a shiftable clutch and rate change means driven through said clutch and adjustable for effecting a variety of rotative speeds, selector means including a member adjustable to a plurality of positions respectively corresponding to different of said speeds, said selector means also including a plurality of charts respectively having markings representing a series of diameters and a series of peripheral speeds and indicator means including a portion movable relative to one of said charts in accordance with the adjustment of said member, a power operable shifter means for adjusting said rate change means, a power operable shifter for shifting said clutch, power means connectible with each of said shifters, and control means for altering the connection of said power means and each of said shifters upon adjustment of said member.

2. In a machine tool the combination of a rotatable support, a transmission for said support including rate change means adjustable for effecting a variety of rotative speeds, a shifter device including portions adjustable to a plurality of position combinations respectively corresponding to different of said speeds, selector means including a plurality of charts respectively having markings representing a series of diameters and a series of peripheral speeds and indicator

means including a portion movable relative to one of said charts in accordance with the adjustment of said device, a power source connectible for adjustment of said shifter device, and control means for connecting said source and shifter device to effect different of said rotative speeds in accordance with the position of adjustment of said indicator means, said selector means including a portion adjustable relative to one of said charts in advance of the movement of said indicator portion for preselection of a preferred peripheral speed to be subsequently effected at a predetermined diameter upon movement of said indicator portion to the marking corresponding to the diameter last mentioned.

3. In a machine tool the combination of a rotatable support, a transmission for said support including rate change means adjustable for effecting a variety of rotative speeds, selector means including a member adjustable to a plurality of positions respectively corresponding to different of said speeds, said selector means also including a plurality of charts respectively having markings representing a series of diameters and a series of peripheral speeds and indicator means including a portion movable relative to one of said charts in accordance with the adjustment of said member, and shifter means for adjusting said rate change means to effect one or another of said rotative speeds in accordance with the adjustment of said device, one of said charts being adjustable relative to said indicator portion independently of the adjustment of said selector member.

4. In a machine tool, the combination of a rotatable support, a transmission for said support including rate change means adjustable for effecting a variety of rotative speeds, selector means including a member adjustable to a plurality of positions respectively corresponding to different of said speeds, said selector means also including a plurality of charts respectively having markings representing different of said rotative speeds, a series of diameters and a series of peripheral speeds, and indicator means including said rotative speed and diameter charts and an indicator portion simultaneously movable relative thereto in accordance with the adjustment of said member, and shifter means for adjusting said rate change means to alternatively effect one or another of said rotative speeds in accordance with the adjustment of said member, said diameter and peripheral speed charts being adjustable relative to said indicator portion independently of the adjustment of said member.

5. In a machine tool, the combination of a rotatable support, a transmission for said support including rate change means adjustable for effecting a variety of rotative speeds, selector means including a member adjustable to a plurality of positions respectively corresponding to different speeds of said series, said selector means also including a plurality of charts respectively having markings representing different of said rotative speeds, a series of diameters and a series of peripheral speeds and indicator means including said rotative speed and diameter charts and an indicator portion movable simultaneously relative thereto in accordance with the adjustment of said member, and shifter means for adjusting said rate change means to alternatively effect one or another of said rotative speeds in accordance with the adjustment of said member, said peripheral speed chart being movable relative to said indicator portion independently of the adjustment of said selector member and subsequently simultaneously with said selector member.

6. In a machine tool, the combination of a rotatable support, a transmission for said support including rate change means adjustable for effecting a variety of rotative speeds, selector means including a member adjustable to a plurality of positions respectively corresponding to different of said speeds, said selector means also including a plurality of charts respectively having markings representing different of said rotative speeds, a series of diameters and a series of peripheral speeds and indicator means including two of said charts and an indicator portion movable relative thereto simultaneously in accordance with the adjustment of said member, shifter means for adjusting said rate change means to alternatively effect one or another of said rotative speeds in accordance with the adjustment of said member, and means independently operable in advance of shifter operation for selection of a preferred peripheral speed to be effective upon operation of said shifter.

7. In a machine tool, the combination of a rotatable support, a transmission for said support including rate change means adjustable for effecting a variety of rotative speeds, selector means including a member adjustable to a plurality of positions respectively corresponding to different of said speeds, said selector means also including a plurality of charts respectively having markings representing different of said rotative speeds, a series of diameters and a series of peripheral speeds and indicator means including two of said charts and an indicator portion movable relative thereto simultaneously in accordance with the adjustment of said member, and shifter means for adjusting said rate change means to alternatively effect one or another of said rotative speeds in accordance with the adjustment of said member, said selector means providing visual indication on said charts of the peripheral speed resulting at a selected diameter from operation of said shifter in each position of said member.

8. In a machine tool, the combination of a rotatable support, a transmission for said support including rate change means adjustable for effecting a variety of rotative speeds, selector means including a member adjustable to a plurality of positions respectively corresponding to different of said speeds, said selector means also including a plurality of charts respectively having markings representing a series of said speeds, a series of diameters and a series of peripheral speeds and indicator means including two of said charts and an indicator portion movable simultaneously relative thereto in accordance with the adjustment of said member, power operable shifter means for adjusting said rate change means, a power source connectible with said shifter means, and means controlling the power connection of said source and shifter means to alternatively effect one or another of said rotative speeds in accordance with the adjustment of said member, said selector means providing in each position of said member visual indication on said charts both of the rotational speed and of the peripheral speed simultaneously corresponding thereto for a diameter selected on said diameter chart.

9. In a machine tool, the combination of a rotatable support, a transmission for said support including rate change means adjustable for

effecting a variety of spindle rotative speeds and a clutch, selector means including a member adjustable to a plurality of positions respectively corresponding to different of said speeds, said selector means also including a plurality of charts respectively having markings representing a series of said rotative speeds, a series of diameters and a series of peripheral speeds and indicator means including two of said charts and a portion movable relative thereto in accordance with the adjustment of said member, a shifter for adjustment of said rate change means, a shifter for shifting said clutch, and means for operation of both said shifters upon adjustment of said member.

10. In a machine tool, the combination of a rotatable support, a transmission for said support including rate change means adjustable for effecting a variety of rotative speeds, and a clutch, selector means including a member adjustable to a plurality of positions respectively corresponding to the different of said speeds, said selector means also including a plurality of charts respectively having markings representing a series of said rotative speeds, a series of diameters and a series of peripheral speeds and indicator means including two of said charts and a portion movable relative thereto in accordance with the adjustment of said member, a shifter for adjustment of said rate change means, a shifter for shifting said clutch, and means interlocking said shifters.

11. In a lathe, the combination of a bed, a hollow headstock carried thereon, a spindle journaled in said headstock and providing an exposed work carrying end, a transmission housed within said headstock and connected to drive said spindle, said transmission including a plurality of rate change elements shiftable into various position combinations respectively productive of different spindle rotary speeds, selector means including a plurality of associated charts carried on said headstock and respectively providing numerals corresponding to a series of said rotative speeds, numerals corresponding to a series of work diameters, and numerals corresponding to a series of peripheral speeds, one of said charts being movable adjacent another for altering the relative position of the charted values, a shaft rotatable into various positions corresponding respectively to the different values of said series of rotative speeds, shifter means for shifting said elements, and means operative in accordance with the position of rotation of said shaft for controlling operation of said shifter means, said selector means visibly indicating on said charts the peripheral speed resulting at a diameter simultaneously indicated upon operation of said shifter means and in various positions of said shaft.

12. In a machine tool the combination of a tool support and a relatively movable work support, one of said supports being rotatable, a transmission including rate change means adjustable for effecting a variety of rotative speeds of said rotatable support and a drive member for said relative movement and driven through said rate changer, a member adjustable to a plurality of positions respectively corresponding to different of said speeds, indicator means including a plurality of charts respectively having markings indicating a series of diameters and a series of peripheral speeds and a portion movable relative to one of said charts in accordance with the adjustment of said member, and means for adjusting said rate changer in accordance with the adjustment of said member, said indicator means visibly indicating the peripheral speed corresponding to an indicated diameter on said charts in various positions of said indicator means.

13. In a machine tool, the combination of a rotatable shaft, a transmission for rotation of said shaft including a rate changer adjustable into various positions respectively effecting different speeds of said shaft, a plurality of annular charts co-axially arranged and respectively having markings representing values of different kind, a member having a plurality of positions respectively corresponding to different of said rate changer positions and progressively arranged in accordance with the numerical order of said different shaft speeds, indicator means movable relative to one of said charts, a connection from said member for relative movement between the last mentioned chart and said indicator means, one of said charts being adjustable to effect different positions thereof relative to said member, and shifter means for said elements operative in accordance with the position of said member.

14. In a machine tool the combination of a rotatable shaft, a shaft transmission including a rate changer adjustable into various positions respectively effecting different rotative speeds of said shaft, a control shaft having a plurality of rotative positions respectively corresponding to different of said rate changer positions and progressively arranged in the order of the numerical value of said rotative speeds, a plurality of annular charts each co-axial with said control shaft and having numerical markings respectively representing values of different diameters and of different linear speeds and arranged in the numerical order of said markings, an indicator device movable relative to said diameter chart in accordance with the rotation of said control shaft, and means for effecting said various element position combinations in correspondence with the position of said control shaft, one of said charts being adjustable relative to said control shaft.

15. In a machine tool the combination of a movable support, transmission mechanism for said support including a plurality of elements shiftable to various position combinations respectively effecting different speeds, and speed selector means including a plurality of charts each having numerical markings arranged in numerical order, the markings of the different charts respectively representing values of different kind, and indicator means movable relative to one of said charts in accordance with the shifting of said elements, one of said charts being movable relative to said indicator means independently of the shifting of said elements.

16. In a machine tool the combination of a movable support, transmission mechanism for said support including rate change means adjustable to a plurality of positions respectively effecting different speeds, selector means including a plurality of charts each having numerical markings arranged in numerical order, the markings of the different charts respectively representing values of different kind, and indicator means movable relative to one of said charts in accordance with the adjustment of said rate change means, one of said charts being movable relative to said indicator means independently of the adjustment of said rate change means.

17. In a machine tool the combination of a movable support, transmission mechanism for movement of said support including a rate

changer adjustable to various positions respectively for effecting different support speeds, selector means including a member rotatable to various angular positions respectively corresponding to different of said speeds and arranged in the numerical order of the different speeds of said support, said selector means also including a plurality of annular charts co-axial with said member and each having numerical markings arranged in numerical order, the markings of different of said charts respectively representing values of different kind, and indicator means progressively movable relative to one of said charts to indicate successive markings thereof in accordance with the progressive rotation of said member, one of said charts being movable relative to said indicator means independently of the adjustment of said rate changer.

18. In a machine tool the combination of a rotatable support, a transmission for said support including rate change means adjustable for effecting a variety of rotative speeds, selector means including a member adjustable to a plurality of positions respectively corresponding to different of said speeds, a plurality of associated charts respectively having markings representing a series of diameters and a series of peripheral speeds, indicator means movable relative to said diameter chart in accordance with the adjustment of said member, means for adjusting said rate changer in accordance with the adjustment of said member, the range of one of said charts being extended relative to the other to provide a range of values which would require operation of said rotatable support at rotative speeds outside the range available from said rate changer, and means masking the visibility of a portion of said extended chart in various positions of adjustment of said member to limit the visible range thereof to substantially correspond with the range of rotative speeds available from said rate changer.

19. In a machine tool the combination of a movable support, transmission mechanism for said support including a rate changer adjustable to various speed positions, speed selector means including a member adjustable to various positions respectively indicating the different rate changer positions and connections operative between said member and rate changer to effect the indicated rate changer position, and other selector means includinig a series of sequence indicating symbols and a pointer relatively movable in accordance with the movement of said speed selector member.

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