May 26, 1936. L. H. BLOOD 2,042,247

MACHINE TOOL

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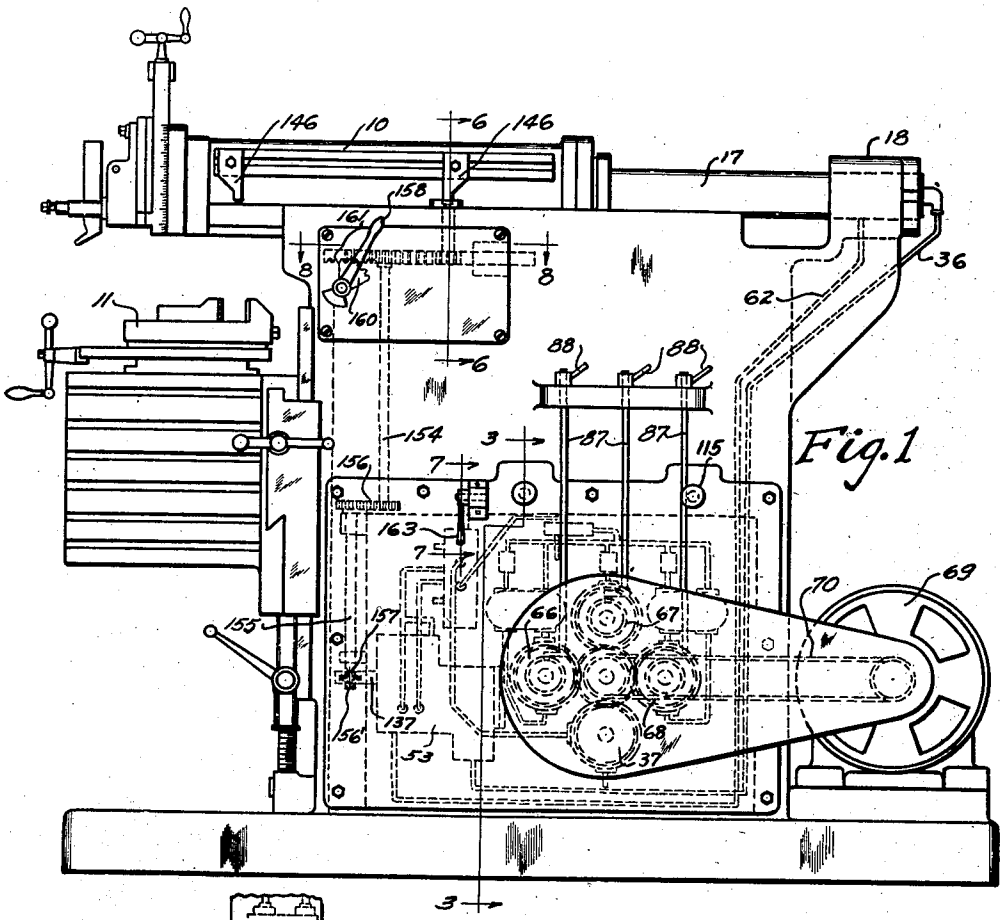


Fig. 1

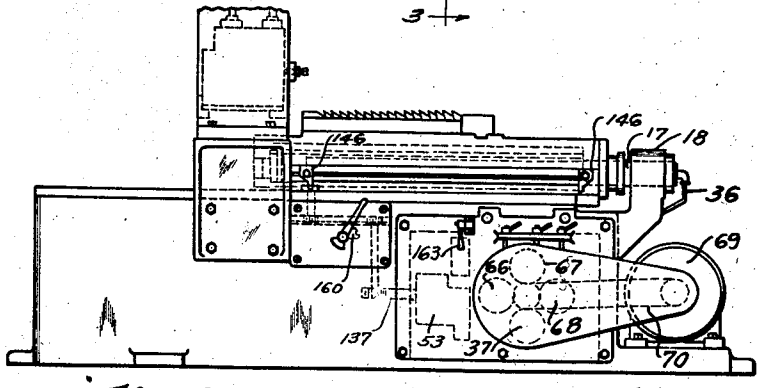


Fig. 2

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MACHINE TOOL

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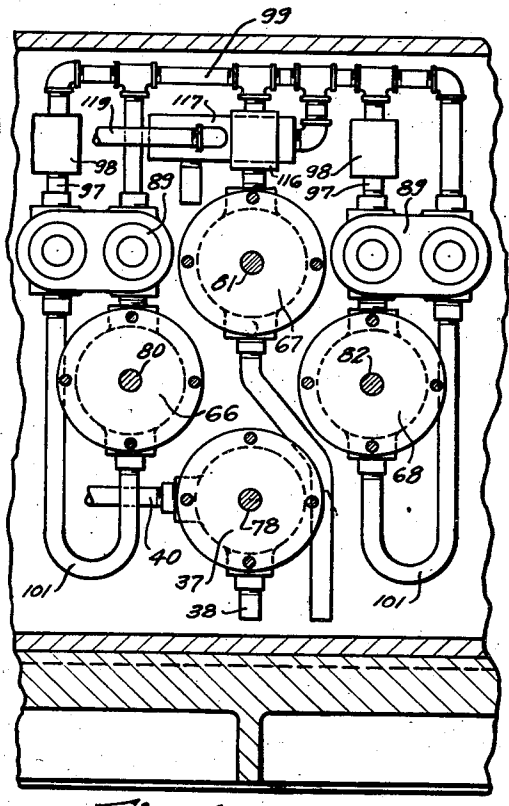


Fig. 4

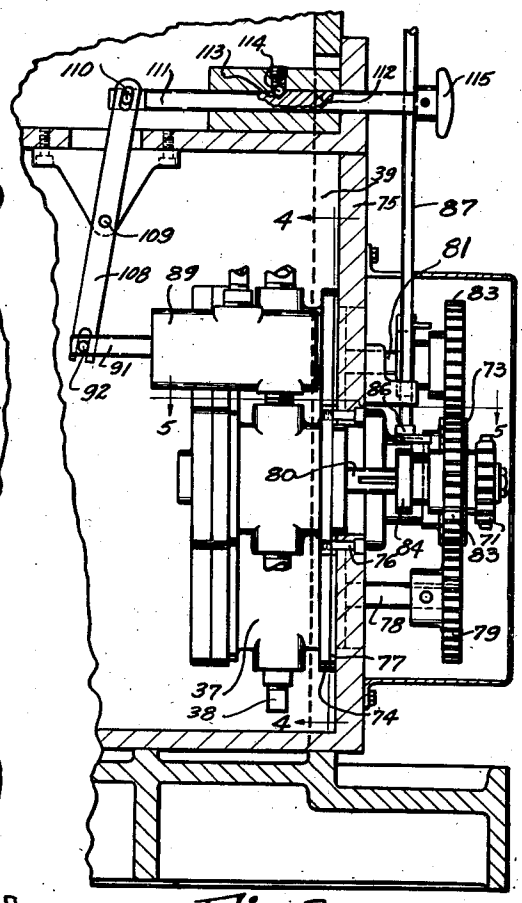


Fig. 3

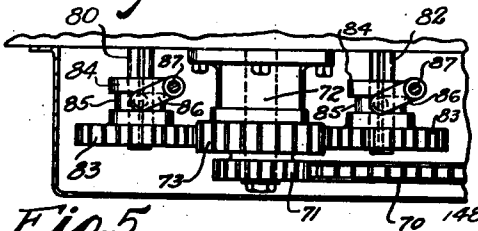


Fig. 5

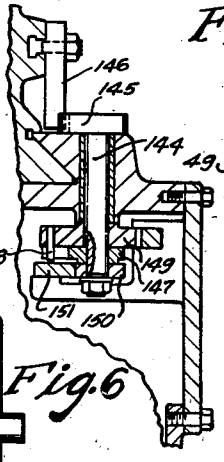


Fig. 6

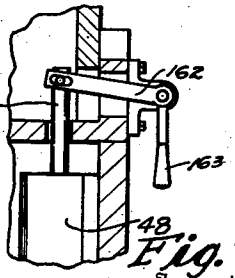


Fig. 7

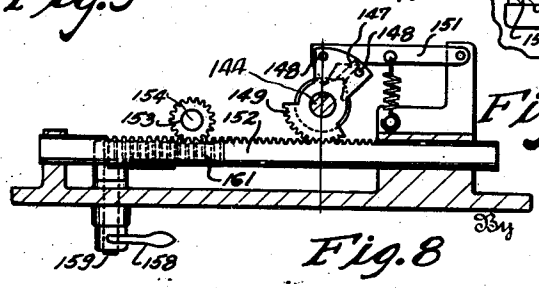


Fig. 8

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MACHINE TOOL

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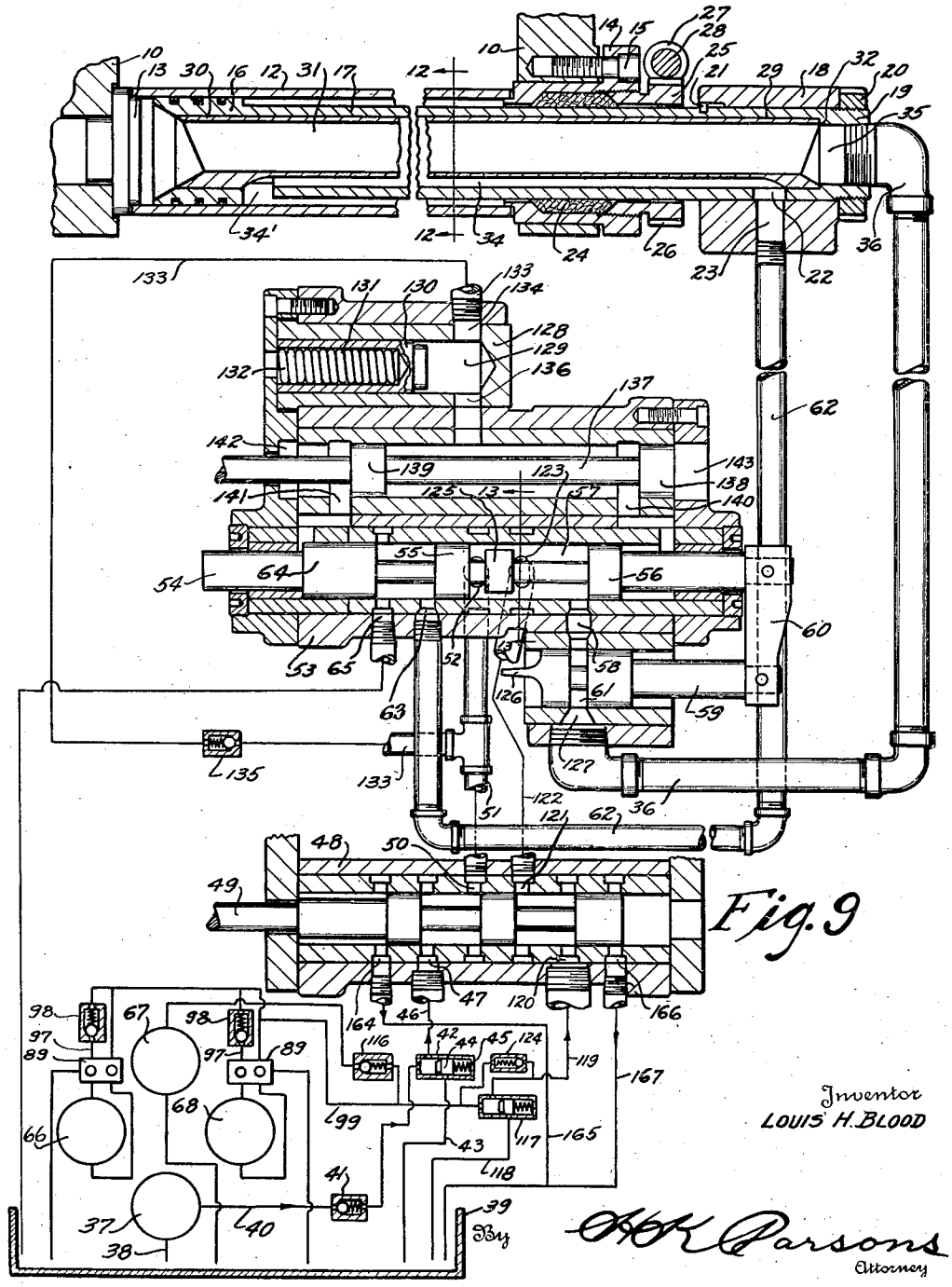


Fig. 9

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MACHINE TOOL

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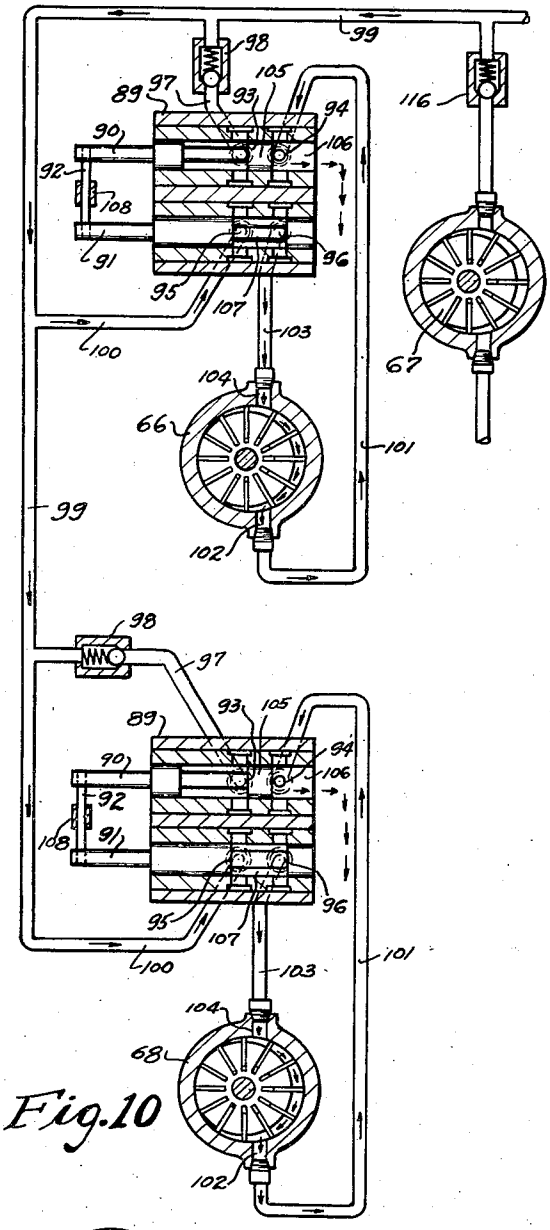


Fig. 10

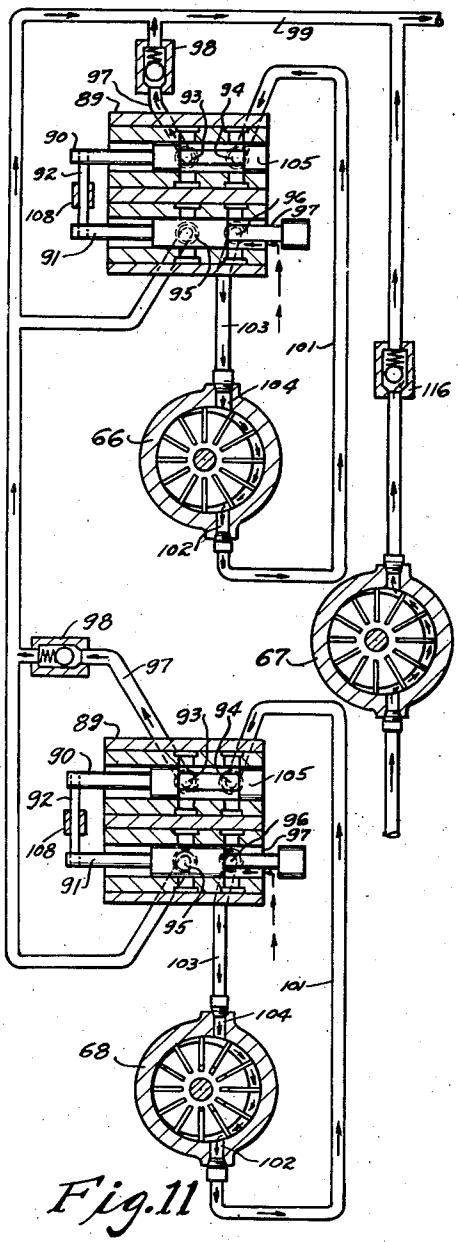


Fig. 11

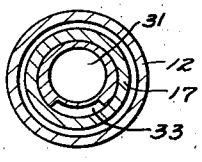


Fig. 12

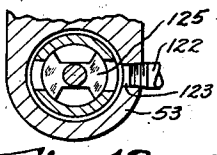


Fig. 13

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Patented May 26, 1936 2,042,247

UNITED STATES PATENT OFFICE

2,042,247

MACHINE TOOL

Louis H. Blood, Cincinnati, Ohio, assignor to The Cincinnati Milling Machine Co., Cincinnati, Ohio, a corporation of Ohio

Application September 8, 1933, Serial No. 688,637

10 Claims. (Cl. 60—52)

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

One of the objects of this invention is to provide an improved hydraulic transmission for machine tools which will yield a plurality of feed rates over a wider range than conventional hydraulic transmissions now in use, and which will be in stepped relation similar to mechanical gear transmissions.

Another object of this invention is to provide an hydraulic transmission which is capable of yielding a plurality of feed rates, but which utilizes only simple and inexpensive constant displacement pumps.

A further object of this invention is to produce a variable speed hydraulic transmission by utilizing a plurality of auxiliary pumps of different volumetric capacity for volumetrically adding to or subtracting from the delivery of a principal constant displacement pump to obtain variation in rate.

An additional object of this invention is to provide a simple control mechanism for a multiple pump transmission in which a desired combination of pumps is connected to the operating cylinder to produce a desired feed rate in one direction, and only a single same pump of that combination is connected to the operating cylinder to produce a return quick traverse rate.

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 forming a part thereof and it is to be understood that any modifications may be made in the exact structural details there shown and described, within the scope of the appended claims, without departing from or exceeding the spirit of the invention.

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

Figure 1 is a side elevation of one form of machine tool having this invention embodied therein.

Figure 2 is a side elevation showing this invention embodied in another form of machine tool.

Figure 3 is a section on the line 3—3 of Figure 1, showing the method of driving the pumps.

Figure 4 is a section on the line 4—4 of Figure 3, showing the arrangement of the various pumps in the reservoir.

Figure 5 is a section on the line 5—5 of Figure 3 showing the construction for connecting the auxiliary pumps to the main drive gear.

Figure 6 is a section on line 6—6 of Figure 1, showing details of the trip plunger.

Figure 7 is a section on the line 7—7 of Figure 1, showing the stop valve operating mechanism.

Figure 8 is a section on the line 8—8 of Figure 1, showing the details of the mechanism operated by the trip plunger.

Figure 9 is a semi-diagrammatic view of the hydraulic circuit of the machine.

Figure 10 is a diagrammatic view showing the manner in which the auxiliary pumps operate to subtract fluid from the main flow.

Figure 11 is a diagrammatic view showing the manner in which the auxiliary pumps operate to add fluid to the main flow.

Figure 12 is a detail section on the line 12—12 of Figure 9.

Figure 13 is a detail section on the line 13—13 of Figure 9.

This invention is particularly adaptable to machine tools such as planers, shapers, milling machines, broaching machines, and the like, in which a reciprocable slide is moved in one direction at a prescribed feed rate and returned in the opposite direction at a quick traverse rate and will be explained in connection with a shaper, such as shown in Figure 1, as constituting one exemplification of this invention.

In this machine the tool slide 10 is moved over the work support 11 in one direction to shave or remove a chip from the work and then returned at a rapid rate during which time the work support is indexed or given an incremental feed to prepare for the removal of a subsequent chip.

An hydraulic motor is provided for effecting this reciprocation, and as shown in Figure 9, is preferably of the piston and cylinder type. The cylinder 12 is in this construction carried by and moved with the slide 10 and consists of a tubular portion, which at one end is fitted on and supported by the shouldered member 13 attached to one end of the slide 10, and at the other end is fitted and supported by a shouldered member 14 which is adjustably mounted in the other end of the slide 10. Bolts 15 serve to force the member 14 toward the member 13 to securely clamp the cylinder there-between and prevent leakage therefrom.

A piston 16 is reciprocably mounted in the cylinder 12 and connected by the hollow piston rod 17 to a fixed bracket 18 carried by the bed of the machine. The end portion 19 of the piston rod, which fits in the bracket 18, is tapered and a

lock nut 20 is threaded on the rear end of the piston rod to securely fasten the same against axial movement relative to the bracket. If desired, a pin 21 may be provided for rotatably positioning the piston rod so as to align a port 22 formed therein with a radial bore 23 formed in the bracket 18. Since relative sliding movement takes place between the member 14 and the piston rod 17, the member 14 has been recessed to receive a packing material 24 which is adjustably compressed by the rotatable member 25 threaded in one end of the member 14. The member 25 is provided with gear teeth 26 meshing with a worm wheel 27, which is mounted on the end of a shaft 28 for manual adjustment. It will thus be seen that there is a piston rod which is fixed at one end of the bed of the machine and that the piston secured to the other end of the piston rod is supported by the cylinder 12 which is movable relative to the piston for effecting reciprocation of the slide 10.

As previously mentioned, the piston rod is hollow, or in other words, has a longitudinal bore 29 in which is fitted a tubular member 30, which, as shown in Figure 12 has an eccentric bore 31 formed therein so that one side of the member 30 is considerably thicker than the other side. The tubular member 30 is fitted within the hollow piston rod and longitudinally positioned therein by means of a shoulder 32 formed on the interior of the piston rod. The thicker side of the member 30 is milled out at 33, as shown in Figure 12, to provide a passage 34 between the port 22 and the right hand end of the piston 16. As shown in Figure 9, this passageway does not extend the full length of the member 30, but terminates at one side of the port 22 so that flow back and forth from the port 22 will enter the groove, and at the other end terminates at a radial hole 34' drilled in the side of the piston rod so as to form a connection between the passage 34 and the right hand end of the cylinder 12. The bore 31 serves to connect the left hand end of the cylinder with a port 35 formed at the right hand end of the piston rod and in which is threaded pipe 36. The port 22 serves to supply fluid for effecting return movement of the slide at a rapid traverse rate and the port 35 serves to supply fluid for the feed rate. It will be noted that the left hand end of the cylinder is of larger cubical capacity than the right hand end of the cylinder so that a given flow of fluid through the port 35 will not effect as fast a movement of the slide as the same flow through the port 22. There is thus a differential in piston area whereby if a single pump is alternately connected to ports 35 and 22, that in the former case, the pump will effect a feed rate and in the latter case the same pump will effect a rapid return movement.

An improved hydraulic circuit has been provided for supplying fluid to the cylinder which is adjustable to yield a plurality of feed rates, as well as a quick traverse rate, the feed rates being obtainable in steps similarly to a change gear mechanical transmission. In principle, the feed transmission contemplates the provision of a main hydraulic flow of constant predetermined volume which will yield an intermediate feed rate when coupled to port 35 of the slide motor and of auxiliary means for adding to or subtracting from said main flow predetermined volumetric amounts for varying the feed rate by steps above and below said intermediate rate. The manner of accomplishing this is as follows:

A main or principal constant displacement pump 37, Figure 9, is provided for supplying or delivering the main flow to the cylinder. This pump has an intake 38 for withdrawing fluid from the reservoir 39 and a delivery pipe 40 through which fluid is forced at a constant volume to the cylinder. The channel 40 may have a check valve 41 therein and an emergency relief valve 42, by means of which part of the delivery fluid may be by-passed to a reservoir through channel 43 in case of emergency. This relief valve may be of the conventional type, having a plunger 44 which is held by a spring 45 against the incoming pressure to normally close the port to the return channel 43. An intermediate channel 46 connects this relief valve to a port 47 of a stop valve 48 having a reciprocable plunger 49 mounted therein. When this plunger is in an operating position, such as shown in Figure 9, the port 47 is connected to the port 50 from which a pipe 51 extends to a port 52 formed in the rate and direction control valve 53. This valve has a reciprocable plunger 54 on which is formed a pair of spools 55 and 56 which are so spaced as to form a mixing chamber 57. When this valve is in a position, such as shown in Figure 9, to yield a feed rate, the port 52 is connected to a port 58 which is ultimately connected through the valve plunger 59 to the delivery pipe 36. The plunger 59 is integrally connected by the yoke 60 to the plunger 54 for simultaneous movement therewith. The plunger 59 has an annular groove 61 formed therein for connecting the port 58 to the delivery pipe 36 during feeding movements of the table.

During feeding movements of the table means have been provided for exhausting the fluid from the right hand end of the table cylinder and comprises a pipe 62 which connects the cylinder port 22 with port 63 formed in the valve 53. The plunger 54 is provided with an additional spool 64 spaced from the spool 55 to provide an annular groove for connecting the port 63 to an exhaust port 65. For rapid traverse movements of the table the plunger 54 is shifted to the right whereby the port 52 is connected to the port 63 and the pipe 36 is connected to reservoir through movement of the plunger 59. It will thus be seen that the valve plunger 54 not only changes the direction of movement of the slide, but due to the piston differential, it will effect feed movement in one direction and rapid traverse movement in the opposite direction. The ratio of the piston differential may be such as to provide, for instance, a feed rate of 40 feet per minute and a quick traverse rate of approximately 200 feet per minute.

The feed rate of 40 feet per minute may be considered as the intermediate rate previously mentioned and auxiliary means have been provided for increasing and decreasing this rate by predetermined steps. This means comprises a plurality of auxiliary pumps, such as 66, 67 and 68, which may be arranged as more particularly shown in Figures 4 and 9. These pumps are of different capacity, the pump 66, for instance, being capable of yielding alone a feed rate of 8 feet per minute, the pump 68 a feed rate of 16 feet per minute, and the pump 67 a feed rate of 40 feet per minute. It will thus be seen that if the pump 66 is operated to subtract from the main flow the final feed rate will be 32 feet per minute, while if the pump 68 is operated to subtract from the main flow a feed rate of 24 feet per minute will be obtained, and if both pumps are operated to subtract from the main flow a final feed rate

of 16 feet per minute will be obtained. Similarly, these pumps may be operated to add to the main flow, thereby increasing the intermediate rate of 40 feet per minute by the various increments suggested as the capacity of the various pumps. The result is that a range of feed rates, varying from 16 feet per minute up to 104 feet per minute, may be obtained.

These pumps are all driven from a common prime mover 69, which, as shown in Figure 1, may be attached to the rear of the machine and connected by suitable means such as a chain 70 to a sprocket wheel 71, shown in Figure 5. This sprocket wheel is rotatably mounted on a stud shaft 72 and has integrally secured thereto a common drive gear 73. As shown in Figure 3, the pumps are all submerged in the reservoir 39 and are each provided with a flange 74 by which they are secured to the outer wall 75 of the reservoir as by bolts 76, suitable packing 77 being inserted between the flange and the wall to prevent leakage. The pump 37 has its drive shaft 78 extending through the outer wall and provided with a gear 79 fixed to the end thereof in constant mesh with the common drive gear 73. The pump drive shafts 80, 81 and 82, of the auxiliary pumps 66, 67 and 68 also extend through the front wall of the reservoir and each is provided with a shiftable gear 83 splined on the end of the respective shafts. Each gear has an elongated hub 84 in which is formed an annular groove 85 for receiving a shifter fork 86 secured to the end of a vertical shaft 87. These shafts extend upward and are each provided with an operating handle 88, as more particularly shown in Figure 1. These shiftable gears thus serve as individual means for connecting the various auxiliary pumps for operation by the prime mover and in any desired combinations to effect prescribed feed rates. In other words, these gears and the shifters therefor constitute a feed rate selecting mechanism.

In the present construction, the pump 67 is utilized only to increase the flow, whereas the pumps 66 and 68 are utilized for both increasing or decreasing the main flow. Since these last two pumps are uni-directionally driven by the prime mover, valve mechanism has been provided for causing these pumps to act as delivery pumps or as exhaust pumps. This valve mechanism is more particularly illustrated in Figure 10, and since it is the same for both pumps, only one will be described. This valve mechanism comprises a housing 89 having two plungers 90 and 91 reciprocably mounted therein and connected together by a yoke 92 for simultaneous movement. The valve housing is also provided with four ports 93, 94, 95 and 96. The port 93 is connected by a pipe 97 having a check valve 98 therein to the line 99. The port 95 is connected by the branch line 100 to the line 99 but it will be noted that there is no check valve in this line. The port 94 is connected by channel 101 to the delivery port 102 of the pump, while the port 96 is connected by a line 103 to the intake port 104 of the pump. When the valve plungers are shifted to the left, as shown in Figure 10, a spool 105 on the plunger 90 separates the ports 93 and 94 so that no flow takes place in the channel 97, but the port 94 is connected to the reservoir through the bore 106 in which the plunger 90 slides and which is open at the end when the plunger is in the position shown. The plunger 91 has an annular groove 107 formed therein for interconnecting ports 95 and 96 when in the position shown. From this it will be seen that the intake port 104 of pump 66 is connected through channel 103, ports 96 and 95 and channel 100 to the line 99, thereby acting to withdraw fluid from that line and discharge it through port 102, channel 101, port 94 and space 106 to the reservoir. If the valve plungers 90 and 91 are shifted to the right, as shown in Figure 11, the plunger 90 will then interconnect ports 94 and 93 and the plunger 91 will disconnect port 96 from port 95 and connect the same through the annular groove 107 to the reservoir. The fluid will now be withdrawn from the reservoir through the annular groove 107, port 96, channel 103, to the intake port of pump 66 and delivered through port 102, channel 101, ports 94 and 93 to channel 97, the pressure in this channel now opening the check valve 98 to permit passage of the fluid to line 99. It will be noted that at this time the port 95 is closed by the plunger 91.

The valve plungers 90 and 91 are shifted by the mechanism more particularly shown in Figure 3 and comprises a shifter fork 108 which engages the yoke 92 intermediate the plungers 90 and 91. This shifter fork is pivotally mounted at 109 to a fixed part of the reservoir and operatively connected at the upper end by a pin and slot connection 110 to the shifter rod 111. This rod has a pair of indents 112 and 113 formed therein for engagement by a spring pressed ball 114 which serves to hold the valve in either one of its two positions. The rod 111 extends outward to the side of the machine where it is provided with an operating knob 115.

When it is desired to change the feed rate above or below the intermediate rate produced by the pump 37 the desired pumps necessary to produce the prescribed rate are connected through their shiftable gears to the common drive gear 73, while the remaining pumps that are not being used are disconnected from the main drive gear. If pumps 66 and 68 are being used, either alone or together, the operator decides whether these pumps are to add or subtract and then shifts the valve 89 to its proper position for obtaining the desired result.

The pump 67 is connected by a check valve 116 to the line 99 which is the common delivery line for all the auxiliary pumps and this line has an emergency relief valve 117 therein through which fluid is by-passed to reservoir through line 118. The relief valve 117 is similar in construction to the relief valve 42 and need not be further described. After the fluid passes through this relief valve it flows through line 119 to a port 120 formed in the stop valve 48. This port is connected when the valve plunger 49 is in the position shown in Figure 9 to a port 121, which is connected by a channel 122 to a port 123 formed in the valve 53. Due to the fact that the flow in line 119 may be in either direction it will be apparent that the relief valve 117 might tend to close when the line 99 is being utilized as a suction line for pumps 66 and 68 when the latter are operating as subtracting pumps. To provide for this contingency a check valve 124 is provided in parallel with the relief valve so that this check valve will open during return flow through channel 119 but will close during pressure flow in the opposite direction.

The port 123, it will be noted, opens into the mixing chamber 57 in valve 53 and the plunger 54 is provided with a spool 125 intermediate spools 55 and 56, and this spool is cut away on opposite sides, as more particularly shown in Fig-

ure 13, whereby the incoming fluid from port 52 will combine with the incoming fluid through port 123 to increase the feed rate, or part of the fluid incoming through port 52 will be subtracted by outward flow through the port 123. This spool serves to prevent turbulence in the flow and thereby causes smoother operation of the machine. It will also be noted that these ports are so arranged that when the plunger 64 is shifted toward the right that the port 52 will be disconnected from port 123 so that no matter what combination of auxiliary pumps is utilized to provide a prescribed feed rate only one pump will be utilized to effect the rapid traverse rate and it will always be the same pump, thereby providing a uniform quick traverse rate. Attention is also invited to the fact that the plunger 59 has a tapered end 126 which will be opposite the port 58 and the port 127 so as to prevent clashing of the return flow through pipe 36 and the exhaust flow from the auxiliary pumps when the same are being used for increasing the feed rate and thereby effecting a more streamline flow to the reservoir and preventing turbulence therein.

The rate and direction plunger 54 is adapted to be shifted by fluid operable means and to insure a copious supply of fluid for this purpose a small accumulator 128 is attached to the valve housing 53. This accumulator comprises a chamber 129 in which is reciprocably mounted a plunger 130 having a bore 131 formed in one end thereof for receiving a strong spring 132. Fluid is preferably supplied to this chamber from the pipe 51 because this pipe is supplied from the continuously actuated pump 37 and therefore is always under pressure. As shown in Figure 9, a branch line 133 connects this pipe to the port 134 of the accumulator, the pressure forcing the plunger 130 to the left, thereby enlarging the chamber and affording an auxiliary supply if for any reason the pressure in line 51 should drop below the pressure which the spring 132 is capable of developing. In order to prevent loss of pressure when the accumulator acts, a check valve 135 has been inserted in the channel 133 in order to isolate the accumulator from its supply line 51 when the pressure therein drops below a predetermined minimum.

A port 136 connects the accumulator chamber 129 with a pilot valve comprising a shiftable plunger 137 having spools 138 and 139 which are so spaced that when the plunger 137 is moved to the right, or in other words to the position shown in Figure 9, the port 136 will be connected to the port 140 through which fluid is supplied to the right hand end of valve 53 and the port 141 at the opposite end of valve 53 will be connected to the exhaust space 142. Plunger 137 is adapted to be shifted to a left hand position in order to connect port 136 with the port 141 and connect the port 140 with the exhaust space 143. It will thus be apparent that when pressure is supplied to the port 140, the valve plunger 54 and associated plunger 59 will be shifted to the left to cause feeding movement of the slide, and when pressure is supplied to the port 141 the plungers 54 and 59 will be shifted to the right to cause rapid traverse movement of the slide.

The pilot valve plunger 137 is adapted to be automatically shifted by the trip mechanism more particularly shown in Figures 6 and 8. As there shown, a trip plunger 144 is oscillatably mounted in a fixed part of the machine and has a trip lever 145 secured to the upper end and adapted to be engaged by suitably spaced trip dogs 146 and secured in the usual manner by bolts slidably mounted in a T slot carried by the slide 10. A lever arm 147 is keyed to the end of plunger 144 and is adapted to alternately engage a pair of pins 148 with a predetermined amount of lost motion, said pins being carried by a gear segment 149. Also secured to the lower end of the plunger 144 is a detent brake 150 having a pair of indents formed on the periphery thereof and adapted to be engaged by spring pressed detent 151. This constitutes a conventional form of lost motion trip mechanism.

The gear segment 149 meshes with a rack bar 152 extending longitudinally along the side of the machine and operatively engaging a pinion 153 secured to the upper end of an oscillatable shaft 154. This shaft extends downward toward the reservoir and is operatively connected with the pilot valve plunger trip shaft 155 by means of pinion gears 156. The lower end of the shaft 155 has pinion teeth 156' meshing with rack teeth 157 formed in the end of the pilot valve plunger 137. The shaft 154 may also be manually operated by means of the control lever 158 which is pivotally mounted at 159 on the side of the machine, the pivoted shaft having a gear segment 160 secured thereto and operatively meshing with rack teeth 161 formed on the under side of the rack bar 152. It will now be seen that when the plunger 144 is oscillated in either direction by the trip dogs the pilot valve plunger 137 will be shifted either to the right or to the left to effect power shifting of the rate and direction determining valve plunger 54 and that this plunger may also be power shifted under manual control of the lever 158.

Since the plunger 54 only has two operative positions and both of those are running positions, the stop valve 48 has been interposed between the pumps and valve 53 for stopping the machine. The stop valve plunger 49 is operatively connected to a crank 162, as shown in Figure 7, having integral therewith the manually operable lever 163. When the plunger 49 is shifted from the running position shown in Figure 9 toward the right the port 47 leading from pump 37 will be connected to port 164 which is connected to the reservoir through channel 165. Also the port 120 leading from the auxiliary pumps will be connected to port 166, also leading to reservoir through channel 167, and the ports 50 and 121 will be interconnected, thereby keeping these channels full of oil.

There has thus been provided an improved hydraulic transmission for machine tools such as the shaper shown in Figure 1 or to the broach as shown in Figure 2, comprising a first pump which is adapted to supply and maintain a main flow which may be utilized in conjunction with a piston differential for obtaining a feed rate in one direction and a rapid traverse rate in the opposite direction and a plurality of auxiliary pumps for adding to or subtracting from said main flow to increase or decrease the volume thereof and in which said auxiliary pumps are so connected to the main flow channel that they will be entirely disconnected from said channel during rapid traverse movement of the slide.

What is claimed is:

1. In a machine tool having a work support and a tool support the combination of means for effecting relative movement therebetween at a plurality of feed rates or at a rapid traverse rate including a piston and cylinder, said piston having differential pressure areas on opposite sides thereof, a constant displacement pump alternately connect-

ible to opposite ends of the cylinder for effecting feeding movement or quick traverse movement between the supports and a plurality of pumps automatically connectible with said constant displacement pump when effecting a feed movement to increase or decrease the flow thereof to provide additional rates of feed movement between the supports, and automatically disconnectible from said constant displacement pump when effecting a quick traverse movement whereby said quick traverse movement will always be effected at the same rate.

2. In a machine tool having a work support and tool support the combination of means for effecting relative movement therebetween at a plurality of feed rates including an hydraulic motor, a supply line for said motor, a constant displacement pump coupled to said supply line for effecting one rate of movement of the motor, an additional constant displacement pump having intake and delivery ports, means to start and stop said additional pump, a fluid reservoir, a first branch line for connecting said delivery port to the supply line, a second branch line for connecting the intake port to said supply line, valve means operable when one of said branch lines is connected to its respective port for closing the other branch line, and a check valve in the first branch line for preventing return flow to said additional pump when the same is stopped.

3. In a machine tool having a work support and a tool support the combination of means for effecting relative movement therebetween including an hydraulic motor, a constant displacement pump, a plurality of auxiliary constant displacement pumps, valve means for connecting said pumps to the motor including a valve housing having a first port connected to said constant displacement pump and a second port connected to said auxiliary pumps, a supply line to said motor for effecting feeding movement thereof, a second supply line to said motor for effecting rapid traverse movement thereof, shiftable means in said valve having a first position for simultaneously connecting both of said pump ports to the supply line and a second position for connecting only one of said pump ports to the second supply line of said motor, and additional means simultaneously operable upon movement of said valve means to its second position to connect the first supply line of the motor and the auxiliary pump port to reservoir.

4. In a machine tool having a work support and a tool support the combination of means for effecting relative movement therebetween including an hydraulic motor, a constant displacement pump, a plurality of auxiliary constant displacement pumps, valve means for connecting said pumps to the motor including a valve housing having a first port connected to said constant displacement pump and a second port connected to said auxiliary pumps, a supply line to said motor for effecting feeding movement thereof, a second supply line to said motor for effecting rapid traverse movement thereof, shiftable means in said valve having a first position for simultaneously connecting both of said pump ports to the supply line and a second position for connecting only one of said pump ports to the second supply line of said motor, and additional means simultaneously operable upon movement of said valve means to its second position to connect the first supply line of the motor and the auxiliary pump port to reservoir, said means including an auxiliary valve plunger and means on said plunger for diverting both of said flows to reservoir in stream line fashion.

5. In a machine tool having a work support and a tool support the combination of trip controlled power means for effecting relative movement therebetween including a fluid operable motor having a feed port and a rapid traverse port, a constant displacement pump, a plurality of auxiliary pumps, a rate and direction determining valve shiftable to a first position for connecting the output of all of said pumps to the feed port of said motor and to a second position for connecting only the first-named pump to the rapid traverse port of said motor, and fluid operable means for shifting said valve including an accumulator and a trip operable pilot valve for selectively coupling said accumulator for the shifting of said control valve.

6. In a machine tool having a work support and a tool support the combination of trip controlled power means for effecting relative movement therebetween including a fluid operable motor having a feed port and a rapid traverse port, a constant displacement pump, a plurality of auxiliary pumps, a rate and direction determining valve shiftable to a first position for connecting the output of all of said pumps to the feed port of said motor and to a second position for connecting only the first-named pump to the rapid traverse port of said motor, fluid operable means for shifting said valve including an accumulator and a trip operable pilot valve for selectively coupling said accumulator for the shifting of said control valve, means coupled to said constant displacement pump for supplying said accumulator, and a check valve for preventing return flow to said pump when the accumulator discharges.

7. A machine tool having a work support and a tool support, means for effecting relative movement between the supports including a piston and cylinder one of which is fixed and the other connected to one of said supports, said cylinder having a feed port and a rapid traverse port, means for supplying fluid to the feed port at various volumes for effecting a plurality of feed rates including a prime mover, a plurality of constant displacement pumps, a common drive gear for said pumps, means connecting the drive gear to said prime mover, one of said pumps being connected for constant operation by said drive gear, shiftable means for selectively coupling the remaining pumps for operation by the prime mover in accordance with the feed rate desired, valve means for selectively coupling all of said pumps to the feed port of the cylinder and a trip operable device for shifting said valve means to a position connecting only the constantly driven pump to the rapid traverse port of said motor and the remaining pumps to the reservoir.

8. In an hydraulic system having a delivery channel connected for operation of a fluid operable device, the combination of means for supplying variable quantities of fluid to said channel to effect variable operation of the device including a first constant displacement pump, a second constant displacement pump and a plurality of auxiliary constant displacement pumps, a prime mover for actuation of the pumps, means connecting the prime mover for continuous operation of the first pump, selective means for connecting the remaining pumps to the prime mover for individual or joint actuation thereby, a common reservoir for supplying the intakes of all of said pumps, individual means for connecting the output of the second pump and the auxiliary

pumps to said channel in parallel, each of said means including a check valve operable to permit flow from the pump to the channel during operation of the respective pump, but to prevent flow from the channel to the pump when the same is disconnected from the prime mover.

9. In a machine tool having a work support and a tool support, the combination of means for effecting relative movement between the supports including an hydraulic motor having a differential piston, a pair of delivery channels, a constant displacement pump permanently connected to one delivery channel, a plurality of additional constant displacement pumps of different volume selectively connectible to the other delivery channel, a pair of motor channels, valve means having a first position for connecting both delivery channels to one of said motor channels to effect different rates of motor movement in one direction, and a second position for connecting said one of said delivery channels to the remaining motor channel to effect motor movement in the opposite direction at a predetermined fixed rate.

10. In a machine tool having a work support and a tool support, the combination of means for effecting relative movement between the supports at a plurality of rates in one direction and at a first constant rate in the opposite direction including an hydraulic motor having a differential piston, a pair of fluid delivery channels, a constant displacement pump permanently connected to one of said channels, a plurality of additional constant displacement pumps of different volume selectively connectible to the other channel, a pair of motor conduits, valve means having a first position for connecting both delivery channels to the motor conduit connected to the end of the piston having the larger area, and a second position for connecting the first named constant displacement pump to the motor conduit leading to the end of the piston having the smaller area, and means trip operable by the moving support for shifting said valve means from one position to the other.

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