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POWER TRANSMISSION

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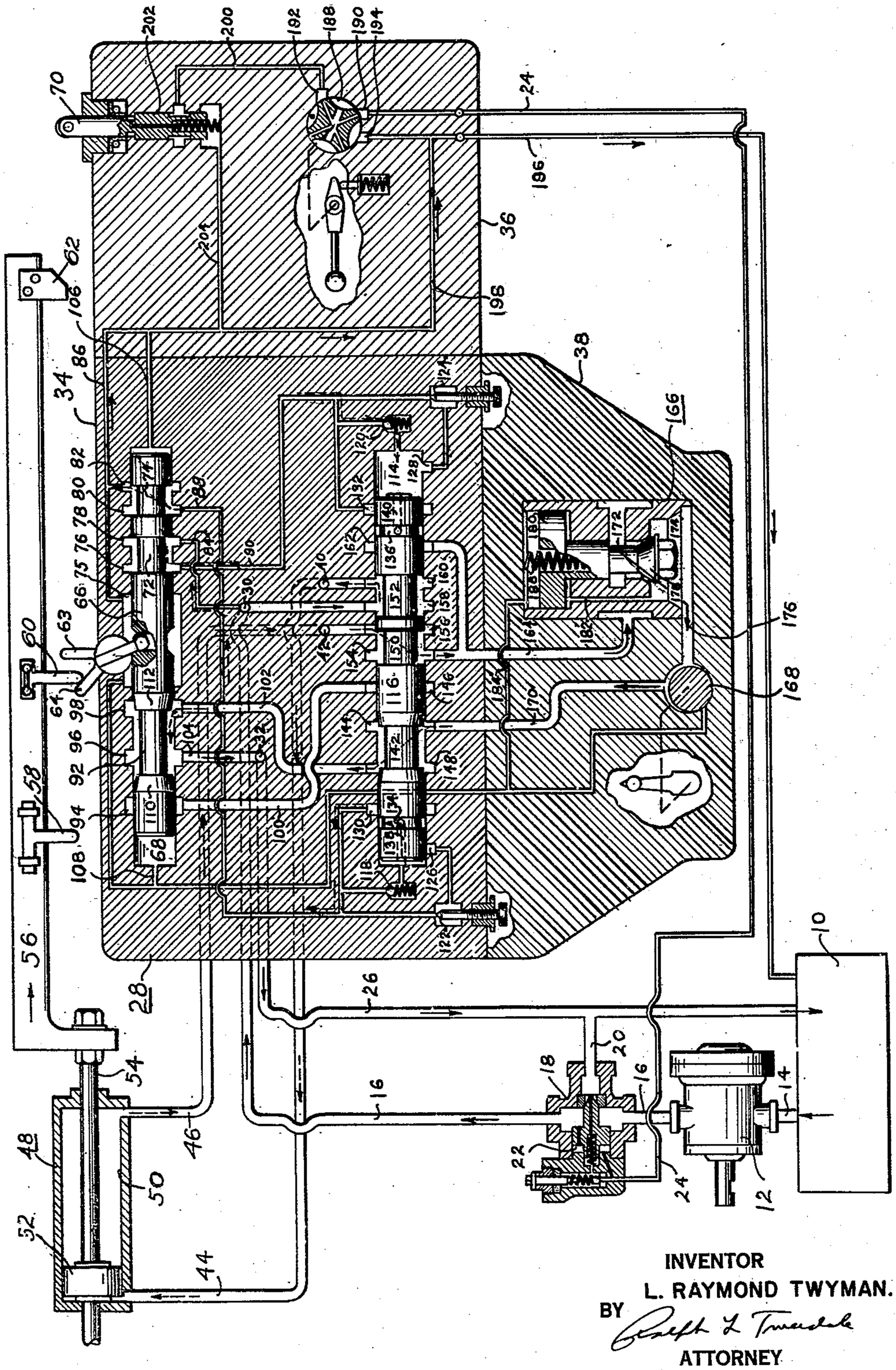

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POWER TRANSMISSION

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This invention relates to power transmissions and more particularly to those of the type comprising one or more fluid pressure energy translating devices, one of which may function as a pump and another as a fluid motor. The invention is particularly concerned with a power transmission of this character which is particularly adapted to drive an alternately reciprocable load device, for example the table of a grinding machine.

It is an object of the present invention to provide a power transmission system wherein is incorporated a control panel connected between a pump and motor for controlling the operation of the motor in a manner to provide alternate reciprocating motion of the motor in continuously repeating cycles with independently adjustable dwells at the end of each reciprocation and with adjustable speed of motion.

In the art of machine tools it is frequently desirable to operate a reciprocating member with a continuous to and fro motion. It is also necessary that the length of stroke, the speed of motion, and the time of dwell at the end of each stroke be adjustable through reasonably wide limits in order to provide for flexibility in adapting the machine to various operations on work pieces of different characters. In a tool such as a grinding machine, it is important that when once adjusted for a certain length of stroke that subsequent changes in speed of operation do not alter the stroke of the feed table since it is frequently desirable to grind at one feed rate for rough grinding and at a different feed rate for finish grinding. Were the stroke changed when the feed rate is changed, it is obvious that the surface covered by the grinding wheel during finish grinding would not be coextensive with that covered by the wheel during rough grinding. It is also essential that, after the dwell at the end of each stroke, the table be accelerated smoothly and also that a smooth deceleration be accomplished prior to the dwell.

It is accordingly an object of the present invention to provide a power transmission system incorporating a control mechanism whereby the above results are provided.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawing wherein a preferred form of the present invention is clearly shown.

Referring now to the drawing wherein is illustrated diagrammatically a power transmission system incorporating a preferred form of the present invention, 10 indicates a tank containing a suitable power transmission fluid such as oil and referred to hereinafter as such. A pump 12 of any suitable construction is mounted adjacent the tank 10 and driven by an electric motor or other prime mover, not shown. The pump 12 withdraws oil from the tank 10 through a suction pipe 14 and delivers oil to a delivery pipe 16. A relief valve 18 is mounted in the pipe 16 and is adapted to discharge oil to the tank 10 through a by-pass conduit 20 both whenever a predetermined safe pressure is exceeded in the conduit 16 and whenever the chamber 22 thereof is vented by connecting conduit 24 to the tank. The valve 18 may be of any suitable construction and the one shown is of the type illustrated in the patent to Harry F. Vickers 2,043,453. Conduit 16 and a return conduit 26 are connected to a control panel or block 28 at ports 30 and 32, respectively.

The control panel 28 is illustrated as having three sections 34, 36, and 38 which, for convenience in illustration, are shown in a single plane although it will be understood that in actual construction the parts may be more compactly arranged. Preferably, but not necessarily, the sections 34, 36, and 38 may be constructed as separate assemblies constituting standard units which may be joined together in different combinations for various purposes. The section 34 includes pilot and servo-operated reverse and blocking valves for starting, stopping, and reversing the table. The section 36 contains manual and table-operated valves for starting and stopping cyclic operation of the table while the section 38 contains feed controlling valves for regulating the speed of operation of the table.

A pair of ports 40 and 42 connect by pipes 44 and 46 to the left and right-hand ends respectively of a table operating fluid motor 48. The latter comprises a cylinder 50 containing a piston 52 having its rod 54 connected to the grinder table 56. The table 56 carries a flipper dog 58 and fixed dogs 60 and 62. The dogs may be longitudinally adjustable along the table as is well known in the art. The dogs 58 and 60 cooperate with trip arms 63 and 64 which constitute the operating means for a valve spool 66 located in a bore 68 in the block 34. Flipper dog 58 is adapted to operate the trip arm 63 clockwise when the table moves to the right and may be swung out toward the observer to pass the trip arm 63 at certain times. The fixed dog 60 is adapted to actuate trip arm 64 counterclockwise when the table moves to the left. The dog 58 and arm 63

may be located in a different plane from that of the dog 60 and arm 64. Fixed dog 62 is adapted to depress a plunger 70 when the table moves to the right after flipper dog 58 has passed the trip arm 63.

The valve spool 66 is provided on its right-hand end with two grooves 72 and 74 which, together with ports 75, 76, 78, 80 and 82 in the bore 68, constitute a pilot reverse valve for transposing connections between a pressure conduit 84 and a tank conduit 86 on the one hand and a pair of conduits 88 and 90 on the other hand. The spool 66 at its left-hand end is provided with a groove 92 which, together with ports 94, 96, and 98 formed in the bore 68, constitute a three-way blocking valve for selectively blocking either a conduit 100 or a conduit 102 while connecting the other to the tank 10 through a conduit 104. Conduits 106 and 108 connect the opposite ends of bore 68 with the tank for preventing trapping of oil as the spool 66 is operated in either direction. Spool 66 is preferably provided with tapered portions 110 and 112 adjacent the groove 92 for the purpose of providing gradual closure of the ports 94 and 98.

Mounted in a bore 114 in the block 34 is a servo-operated valve spool 116 which controls reversal of fluid flow between the pump 18 and the motor 48. The valve spool 116 is adapted to be shifted to the right and left by fluid pressure exerted on its opposite ends. This fluid pressure is controlled by the pilot valve at the right-hand end of valve spool 66 and also by certain ports on the spool 116 itself. Conduits 88 and 90 connect with the left and right-hand ends of the bore 114 through check valves 118 and 120 respectively. In parallel with the check valves are a pair of adjustable needle valves 122 and 124 which connect with the bore 114 at ports 126 and 128 respectively. The conduits 88 and 90 also communicate directly with ports 130 and 132 formed in the bore 114. The spool 116 is provided with a pair of grooves 134 and 136 which are open to the ends of the spool through internal passages 138 and 140.

The spool 116 is provided to the left of its mid-portion with a groove 142 having tapered end portions which is adapted to selectively connect a port 144 either with a port 146 or a port 148. The latter two ports connect with the conduits 100 and 102 respectively. To the right of its mid-portion, the spool 116 is provided with two grooves 150 and 152 which, together with ports 154, 156, 158, 160, and 162, constitute a four-way reversing valve for selectively reversing connections between the ports 40 and 42 on the one hand, and port 30 and a passage 164 leading into the block 38 on the other hand.

The passage 164 communicates with a hydrostatic flow controlling valve generally designated as 166 which, together with a manually adjustable restrictor 168, maintains a constant but adjustable rate of flow from passage 164 to port 144 through a passage 170. The valve 166 comprises a chamber 172 in communication with passage 164 and a chamber 174 in communication through a passage 176 with the restrictor 168. A valve member 178 is adapted to control flow from chamber 172 to 174. The valve 178 is under the control of a piston 180, the lower side of which is subjected to the pressure in chamber 174 through a conduit 182 while the upper side is subjected to tank pressure through a conduit 184. A light spring 186 urges the valve 178 downwardly.

Within the block 36 there is provided a manually operable rotary pilot valve 188 which, in the position shown, connects a port 190 with a port 192. When moved clockwise the valve is adapted to block the port 190 and when moved counterclockwise is adapted to connect port 190 with a port 194. Port 190 is connected to conduit 24. Port 194 connects to the tank through a conduit 196 which also connects by a branch 198 with the tank conduits 106 and 86 in the block 34. The port 192 connects by a conduit 200 with a valve 202 formed on the stem 70. The valve 202 is adapted when the stem 70 is depressed to connect conduit 200 with the tank line 196 through a conduit 204.

The position of the parts illustrated in the drawing represents the conditions just after the table has completed a stroke to the left and the connections have been reversed to start a stroke to the right. The fluid flow and the applied pressure in the various circuits is as indicated by the arrows on the drawing, solid line arrows indicating flow or applied pressure in circuits where the flow or applied pressure is always in the same direction while the dotted arrows indicate flow or applied pressure in circuits where such flow or applied pressure is either reversed in direction or shifted to a branch conduit during the opposite movement of the table.

In operation the pump 12 is started causing fluid to be withdrawn through suction conduit 14 and delivered to delivery pipe 16. With the relief valve 18 closed as shown, pressure builds up in the conduit 16 and is transmitted to the motor 48. In the position of the parts illustrated in the drawing the table 56 is traveling to the right, the valve spool 66 having been shifted to the right as the table reached the left-hand end of its stroke in a previous cycle. Under these conditions fluid is delivered through conduit 16, port 30, ports 158 and 160, port 40, and pipe 44 to the left-hand end of cylinder 50. Fluid returns from the right-hand end of the cylinder 50 through pipe 46, port 42, ports 156 and 154, conduit 164, chamber 172, valve 178, chamber 174, conduit 176, restrictor 168, conduit 170, ports 144 and 148, conduit 102, ports 98 and 96, conduit 104, port 32 and pipe 26 to the tank 10.

During this movement of the table the hydrostatic valve 166 acts to maintain a fixed pressure in the chamber 174 so that the rate of flow through the restrictor 168 is maintained substantially constant. Since the pressure in pipe 170 is tank pressure which is ordinarily atmospheric and since the pressure in the conduit 176 is constant, the quantity of fluid which can pass the restrictor 168 in a given interval must also be constant. Should the pressure in chamber 172 tend to rise due to relieving of the load on the table 56, this pressure is transmitted through conduit 182 to the lower side of piston 180 tending to raise the same against the spring 186 and thus tending to close the valve 178. Likewise, should the pressure tend to fall, opposite action is produced tending to open the valve 178. The valve 178 thus comes to a stabilized condition wherein there is a small pressure drop therethrough which is varied automatically to compensate for differences in load at the table 56.

As the table 56 continues to move to the right, the flipper dog 58 contacts trip arm 63 shifting valve spool 66 to the left. The tapered portion 112 accordingly gradually closes the port 98, thus blocking further flow of fluid from the right-

hand end of cylinder 50 to the tank and causing the table 56 to stop with a predetermined deceleration. At the same time the pilot valve at the right end of spool 66 reverses connections so that conduit 84 is connected to conduit 88 while conduit 86 is connected to conduit 90. Pressure fluid is thus caused to flow from the port 30 through conduit 84, ports 78 and 80, conduit 88, and check valve 118 to the left end of the bore 114. Fluid expelled from the right end of the bore 114 passes through port 128, needle valve 124, conduit 90, ports 76 and 75, conduits 86, 198 and 196 to the tank. The spool 116 accordingly moves to the right at a speed determined by the setting of the needle valve 124.

In practice it has been found most satisfactory to arrange the port spacings on the valve 66 as shown in the drawing. These are so arranged that as the tapered portion 112 just completes its closing of the port 98 in its leftward movement, the recess 74 is just cracked open to the port 78. The most satisfactory opening at this point is of the order of a few thousandths of an inch when the right-hand edge of the tapered portion 112 is in line-to-line relation with the left-hand edge of the port 98. With this arrangement the table continues to move to the right carrying the spool 66 to the left after the latter has been shifted to the aforementioned position. This continued travel arises from several causes, one of them being the momentum of the table and associated parts and another being the slight compressibility of the oil and expansion of conduits which takes place when the return line 46 from the cylinder 48 is blocked, thus causing pressure to build up therein. Still a third factor contributing to the continued movement of the table after the port 98 is closed is the unavoidable leakage around the periphery of the spool 66 from the port 98 axially toward the port 96. This leakage, of course, decreases rapidly as the spool continues its leftward movement. In addition, as the recess 74 approaches the edge of the port 78, the leakage from port 78 to port 80 increases rapidly, thus starting movement of the valve spool 116 before recess 74 actually opens to the port 78. These factors together are best compensated for and a smooth stop with the spool 66 completely shifted to its left-hand position is best insured by the arrangement of ports illustrated.

The spacing of the ports in the bore 114 and the grooves 142, 150 and 152 on the spool 116 are such that the first movement of the spool 116 to the right does not alter any of the connections. As soon as spool 116 is moved to the right sufficiently for groove 136 to open to port 132, fluid from the right-hand end of bore 114 is permitted to exhaust rapidly through conduit 140, groove 136, port 132, conduit 90, and the same other connections as before to the tank 10. Spool 116 accordingly moves rapidly to the right to the end of its stroke. Under these conditions the table 56 is caused to move to the left. Pressure fluid from port 30 passes through ports 158 and 156, port 42 and pipe 46 to the right hand end of cylinder 50. Fluid exhausted from cylinder 50 returns through pipe 44, port 40, ports 160 and 162, passage 164, valve 166, conduit 176, restrictor 168, conduit 170, ports 144 and 146, conduit 100, ports 94 and 96, conduit 104, port 32, and pipe 26 to the tank. During the interval while spool 116 is moving slowly under control of the needle valve 124, the table remains stationary causing a dwell in its cycle of operation.

It will be noted that while the return of fluid to port 32 was blocked at port 98 that there was no flow through the restrictor 168. Accordingly pressure tends to build up in chamber 174 thus completely closing valve 178. As the spool 116 completes its rapid movement and flow is again resumed through the restrictor 168, acceleration will be dependent upon the speed of opening of the valve 178. Thus with a slight restriction in the passage 182, a small but appreciable interval may elapse before valve 178 moves downwardly to its normal position of stability. It is thus insured that the table starts in motion gradually as distinguished from what has been the case with previous hydrostatic flow controlling valves which act to maintain a constant pressure drop across the restrictor, and which, when the flow is blocked through the restrictor, to move to fully open position.

As the table continues its left-ward movement, fixed dog 60 contacts trip arm 64, shifting spool 66 to the right and again blocking the flow of fluid returning from the motor 48. Blocking in this case occurs as the tapered portion 110 blocks port 94. The pilot connections to the ends of bore 114 are also reversed at this time and spool 116 is caused to travel slowly at first to the left and then to rapidly continue to the end of its stroke as previously described. The length of dwell at this end of the stroke is thus determined by the adjustment of the needle valve 122. After the spool 116 has completed its stroke, connections are made as shown in the drawing and as described heretofore for causing the table to move to the right again. This cycle of operation, including a left-ward feed, a dwell, a right-ward feed, and a dwell, is continued as long as may be desired.

When it is desired to stop the continuous cyclic motion of the table, the flipper dog 58 may be manually lifted up to pass the trip arm 63 as the table moves to the right and thereafter when dog 62 depresses plunger 70, relief valve 18 will be vented through conduit 24, ports 190 and 192, conduit 200, valve 202, conduits 204, 198 and 196, to the tank. The table will thereupon remain stationary due to the opening of relief valve 18 and the by-passing of fluid from the delivery conduit 16 through by-pass 20.

When it is again desired to start the table, the tripper arms 63 and 64 may be turned clockwise by a suitable handle, not illustrated, and thereafter when pilot valve 188 is manually turned clockwise to block off port 190, the relief valve 18 will again close, causing pressure to build up in the delivery conduit 16 and starting movement of the table to the left. When fixed dog 60 again contacts tripper arm 64, the table is caused to dwell and reverse and the cyclic operation continues as previously described.

If at any time during normal cyclic operation it is desired to stop the table instantly, the pilot valve 188 may be operated counterclockwise to connect ports 190 and 194 and thus vent relief valve 18 without waiting for table 56 to move completely to the right into stopping position. The panel block 36 has been shown and described as a convenient starting and stopping control device particularly adapted for grinder table operation although it will be understood that the same could be omitted together with dog 62 and other simpler means provided for controlling venting of the relief valve 18. It will also be apparent that the panel block 38 may be used with other forms of main control block

either of the alternately reversing type or of the intermittent unidirectional flow type.

It may also be noted that the main power circuit between the pump 12 and the motor 48 is particularly advantageous for obtaining positive control of the reversal action at the end of each motor stroke. It will be seen that the valve portions 150 and 152 act as a conventional four-way reverse valve for selectively transposing the motor conduits with respect to the supply conduit 30 and the return conduit 164. The return path after passing through the flow regulating means 166 and 168 is divided at the valve portion 142 to flow alternately either through conduit 100 or 102. The return flow is again directed to a single path at the valve portion 92 where it returns to tank through the connections 104, 32 and 26. Thus the valve portions 142 and 92 act as three-way valves connected in series with one another, the former being actuated concurrently with the reverse valve 150—152 and the latter concurrently with the pilot valve 72—74. This arrangement insures a positive stopping of the motor at the end of each stroke by the blocking of the return path at port 94 or port 98. Movement of the motor can then only be resumed after the reverse valve has shifted carrying with it the valve portion 142 to thereby again open the return path.

While the form of embodiment of the invention as herein disclosed, constitutes a preferred form, it is to be understood that other forms might be adopted, all coming within the scope of the claims which follow.

What is claimed is as follows:

1. In a hydraulic power transmission system the combination of a pump, a fluid motor operable in opposite directions, fluid supply and return connections between the pump and motor, a valve operated by the motor for blocking one of said connections after a predetermined movement of the motor, a pilot valve shiftable in opposite directions after a predetermined movement of the motor, a control valve in said connections for reversing the flow of fluid to the motor and controlled by the pilot valve, and means for reestablishing flow through said connections in the opposite direction when the control valve is shifted.

2. In a hydraulic power transmission system the combination of a pump, a fluid motor operable in opposite directions, fluid supply and return connections between the pump and motor, a three-way valve operated by the motor for blocking one of said connections after a predetermined movement of the motor, a pilot valve shiftable in opposite directions by the motor, a control valve in said connections for reversing the flow of fluid to the motor and controlled by the pilot valve, and means in a three-way series circuit with said three-way valve for reestablishing flow through said connections in the opposite direction when the control valve is shifted.

3. In a hydraulic power transmission system the combination of a pump, a fluid motor operable in opposite directions, fluid supply and return connections between the pump and motor, a three-way valve operated by the motor for blocking one of said connections after a predetermined movement of the motor, a pilot valve shiftable in opposite directions by the motor, a control valve in said connections for reversing the flow of fluid to the motor and controlled by the pilot valve, and means in a three-way series circuit with said three-way valve for reestablishing flow through said connections in the opposite direction when the control valve is shifted, said three-way valve being mechanically connected with the pilot valve.

4. In a hydraulic power transmission system the combination of a pump, a reversible fluid motor operable by fluid supplied by the pump, and a control system for causing the motor to operate in alternately reversing strokes, said control system including a valve for reversing the flow of fluid to the motor, a pilot valve actuated by the motor at the end of a stroke for initiating operation of said reversing valve, means for delaying operation of said reversing valve to effect flow reversal until a predetermined interval after operation of the pilot valve, and a third valve also operated by the motor at the end of a stroke for stopping operation of the motor until the reversing valve has been operated to reverse the fluid flow to the motor.

5. In a hydraulic power transmission system the combination of a pump, a reversible fluid motor operable by fluid supplied by the pump, and a control system for causing the motor to operate in alternately reversing cycles, said control system including means for reversing the flow of fluid to the motor, a pilot valve actuated by the motor at the end of a cycle for initiating operation of said means, manually operable means for at times preventing normal actuation of the pilot valve to prevent reversal of flow to the motor and thereby continue motor operation in one direction, means operated by the motor for stopping the motor after a predetermined travel thereof in said one direction, means for manually shifting the pilot valve, and a manually operable start-stop control member and means operated thereby upon movement to one position to start the motor from its stopped condition and, upon movement to another position, to stop the motor independently of the momentary position of the motor.

6. In a hydraulic power transmission system a pump and a fluid motor operable by fluid supplied thereto by the pump, and control means for stopping and smoothly accelerating the motor including an adjustable restrictor for controlling the speed of the motor, a valve on the outlet side of the restrictor for blocking flow of fluid to stop the motor, and an automatic valve on the inlet side of the restrictor for maintaining a fixed pressure ahead of the restrictor during flow therethrough, said valve having opposed piston areas exposed to the pressure ahead of the restrictor and to a fixed low pressure whereby the valve will close when flow through the restrictor is stopped and in opening on restoration of flow through the restrictor will serve to control the acceleration of the motor.

7. In a hydraulic power transmission system a pump and a fluid motor operable by fluid supplied thereto by the pump, and control means for stopping and smoothly accelerating the motor including an adjustable restrictor for controlling the speed of the motor, a valve on the outlet side of the restrictor for blocking flow of fluid to stop the motor, and means including a valve responsive to an increase in pressure at said restrictor for additionally blocking the path of fluid through said restrictor, and means retarding the opening of said pressure responsive valve.

8. In a hydraulic power transmission system

a pump and a fluid motor operable by fluid supplied thereto by the pump, and control means for stopping and smoothly accelerating the motor including a blocking valve for stopping the motor, and a flow controlling valve in series with the blocking valve for regulating the speed of travel of the motor, said flow controlling valve being responsive to pressure changes to close when the blocking valve is closed whereby on starting of the motor the opening movement of the flow controlling valve will serve to control the acceleration of the motor.

9. In a hydraulic power transmission system the combination of a pump, a fluid motor operable in opposite directions, fluid supply and return connections between the pump and motor, a three-way valve operated by the motor for blocking one of said connections after a predetermined movement of the motor, a pilot valve shiftable in opposite directions by the motor, a control valve in said connections for reversing the flow of fluid to the motor and controlled by the pilot valve, and means including a three-way valve mechanically connected with the control valve and connected in a three-way series circuit with the first three-way valve for reestablishing flow through said connections in the opposite direction when the control valve is shifted.

10. In a hydraulic power transmission system the combination of a pump, a fluid motor operable in opposite directions, fluid supply and return connections between the pump and motor, a valve operated by the motor for blocking the return connection after a predetermined movement of the motor, a pilot valve shiftable in opposite directions after a predetermined movement of the motor, a control valve in said connections for reversing the flow of fluid to the motor and controlled by the pilot valve, and means for reestablishing flow through said connections in the opposite direction when the control valve is shifted.

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