Oct. 5, 1948. A. M. LANE ET AL 2,450,733

POWER TRANSMISSION

Filed Dec. 21, 1945 2 Sheets-Sheet 1

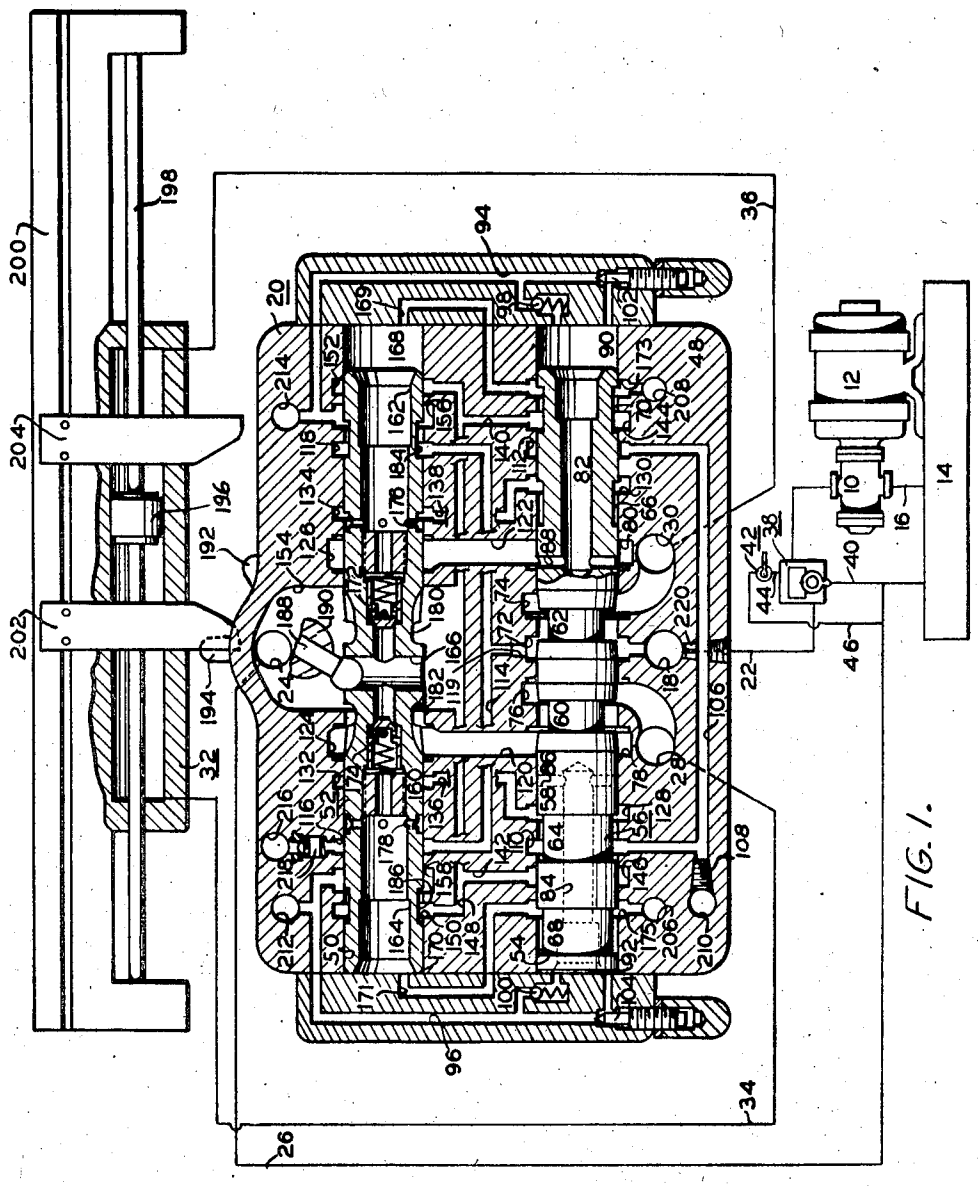

FIG. 1.

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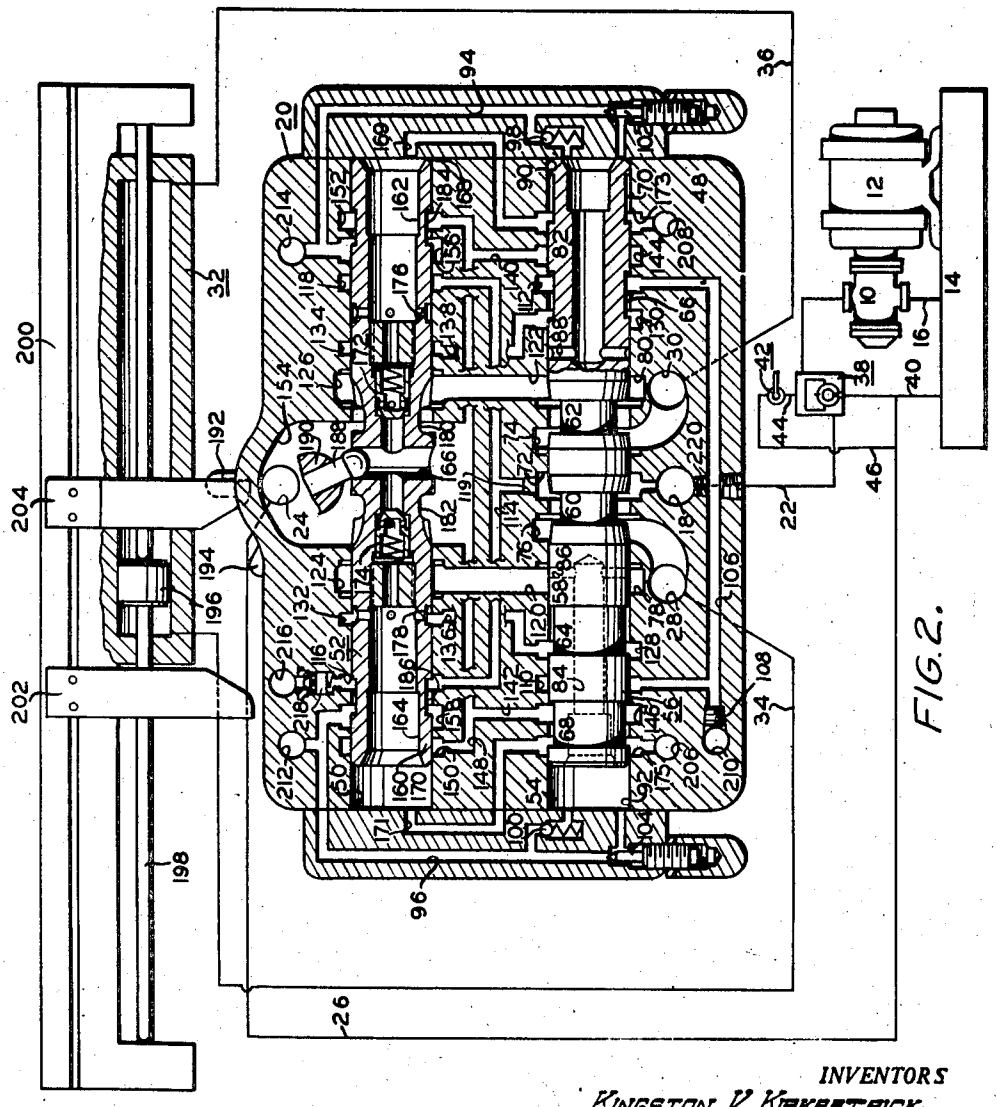

FIG. 2.

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POWER TRANSMISSION

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19 Claims. (Cl. 60—52)

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This invention relates to power transmissions, particularly to those of the type comprising two or more fluid pressure energy translating devices, one of which may function as a pump and another as a fluid motor.

This invention is more particularly concerned with imparting a reciprocating movement to a reversible fluid motor to which is mechanically attached a load device, such as a slide or table of a grinding machine, and automatically controlling such movement so as to provide a uniformly controlled stopping and restarting of the motor at a predetermined point together with a smooth acceleration and deceleration of said motor.

In the operation of a reciprocating grinding machine, the slide or table may carry a clamped work piece to and from a stationary grinding tool or may carry the grinding tool to and from a stationary work piece. During such operation it is necessary to impart a continuous reciprocating motion to the motor, and some means must be provided for automatically reversing the motor at the end of each stroke until the work piece has been ground to the required size.

It has been a problem in the past to provide a unitary control panel for use in a hydraulic transmission for operating a grinding machine which would not only be simple in design and contain a minimum number of control valves but which at the same time would be appropriate to perform effectively under a variety of operating conditions. It has also been a problem to design a simple control panel for use in a transmission as mentioned above which not only would provide for smooth acceleration and deceleration of the motor but which would automatically control the range of movement of the motor stroke and consistently stop the motor always at the same point during its operational stroke.

It is an object of this invention to provide an improved unitary control panel for use in a hydraulic transmission containing a reversible fluid motor which contains a minimum number of operating controls and parts for automatically producing and controlling a continuous reciprocating movement of said motor.

It is also an object of this invention to provide a unitary control panel especially adapted for use in a hydraulic transmission for operating grinders which will dispense with a large amount of piping, connections and valves.

It is also an object of this invention to provide a control panel for a transmission, as above mentioned, which will produce an automatically

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controlled, constantly accurate deceleration, stopping, restarting and acceleration of the reversible fluid motor at each end of the motor stroke, and which is completely adequate in itself to meet varying operating conditions.

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

In the drawings:

Fig. 1 is a diagrammatic view of a hydraulic transmission incorporating a preferred form of the present invention.

Figure 2 is a diagrammatic view of the same hydraulic transmission shown in Figure 1 but showing the parts in a different position.

Referring now to Figure 1, there is shown a pump 10 which may be driven by an electric motor 12. Pump 10 is connected to a tank 14 by a suction conduit 16 and connected to a pressure port 18 of a unitary control panel 20 by means of a delivery conduit 22. Panel 20 also has a tank port 24 connected to tank 14 by means of a conduit 26 and motor ports 28 and 30 connected to opposite ends of a reversible fluid motor 32 by means of conduits 34 and 36.

Incorporated in pump delivery conduit 22 is a combined flow control and relief valve 38 which serves the dual purpose of regulating the amount of fluid flowing to motor 32 from pump 10 so as to regulate the speed of motor 32 and also limits the pressure in conduit 22 to a predetermined maximum by exhausting excessive fluid under pressure to tank 14 by means of an exhaust conduit 40. Valve 38 is well known in the prior art and preferably is constructed in accordance with the patent to Vickers, No. 2,102,865. A manually-operated, two-way control valve 42 is connected to valve 38 by means of a conduit 44 and to tank 14 by means of a conduit 46 so as to provide a controlling means to vent the control chamber of valve 38 to tank 14 in order to completely unload pump 10 to stop motor 32 at the end of an operation or to close said vent in order to start said motor at the beginning of an operation.

Panel 20 consists of a body 48 containing a longitudinal bore 50 in which is shiftable a pilot valve 52 and a longitudinal bore 54 in which is shiftable a reversing valve 56. Reversing valve 56 is comprised of a spool 58 having grooves 60 and 62 to the left and right of its central portion, grooves 64 and 66 spaced apart from grooves 60 and 62, respectively, and grooves 68 and 70 spaced apart from grooves 64 and 66 and located

near each end of spool 58. Spaced along bore 54 is a pressure port 72, motor ports 74 and 76 and return ports 78 and 80. Spool 58 has duplicate longitudinal bores 82 and 84 extending from each end thereof to duplicate radial passages 86 and 88.

Reversing valve 56 is adapted to be operated by fluid pressure admitted alternately to chambers 90 and 92 located in bore 54 at each extreme end of spool 58. A passage 94 in communication with chamber 90 and a passage 96 in communication with chamber 92 have duplicate check valves 98 and 100 and similar adjustable needle valves 102 and 104 interposed in said passages for the well-known purpose of controlling the entrance and exit of fluid to and from chambers 90 and 92 and regulating the speed of spool 58.

A passage 106 having an external entrance 210 normally blocked by a solid plug 108 is connected to pressure port 18 and branches so as to connect to similar ports 110 and 112 spaced along bore 54. A passage 114 connected to pressure port 18 not only intersects bore 54 at reversing valve pressure port 72 but also branches to connect to similar ports 116 and 118 spaced along bore 50. The passage 114 may be closed beyond the pressure port 72 at a point indicated by the numeral 119 by a solid plug, not shown, when the reversing valve is to be operated by substitute means to be later described. Duplicate return passages 120 and 122 connect the return ports 78 and 80 of reversing valve 56 with duplicate pilot valve return ports 124 and 126 spaced along bore 50. Similar ports 128 and 130 spaced along bore 54 are connected to duplicate ports 132 and 134 spaced along bore 50 by passages 136 and 138, respectively. Passages 140 and 142 connect duplicate ports 144 and 146 spaced along bore 54 with a passage 148 which is connected to duplicate ports 150 and 152 spaced along bore 50. Passage 148 is in communication with an enlarged recess 154 which is connected to tank port 24.

Passages 94 and 96 which are connected to chambers 90 and 92, respectively, of reversing valve 56 are connected to similar ports 156 and 158 spaced along bore 50.

Pilot valve 52 consists of a spool 160 shiftable within bore 50. Spool 160 has two identical stepped bores 162 and 164 extending from the right and left end, respectively, of spool 160 to a centrally-located cut-out portion 166 which is in communication with recess 154. Bore 162 is in communication with a chamber 168 at the right end of spool 160 in bore 50, and bore 164 is in communication with a chamber 170 at the left end of spool 160 in bore 50. Similar passages 169 and 171 connect similar ports 173 and 175 spaced along bore 54 with chambers 168 and 170. Duplicate check valves 172 and 174 are mounted in bores 162 and 164 to permit entrance of fluid to chambers 168 and 170 during initial mechanical movement of pilot valve 52 and to alternately block flow of pressure fluid from said chambers to tank 14 when the pilot valve 52 is subsequently operated by fluid pressure.

A plurality of ports 176 in spool 160 which are in communication with bore 162 and a plurality of similar ports 178 which are in communication with bore 164 are adapted to cooperate with ports 134 and 132 to alternately admit pressure fluid to chambers 168 and 170 after a certain range of mechanical movement of the pilot valve 52 in order to rapidly complete the operation thereof by fluid pressure.

Similar cut-away portions 180 and 182 in spool 160 to the right and left of portion 166 are adapted to alternately gradually close pilot valve return ports 126 and 124 depending upon a shifting of pilot valve 52 to the right or left during operation thereof.

Grooves 60 and 62 of valve spool 58 control the delivery of fluid to and from motor 32 by directing fluid to the motor through pressure port 72 alternately to motor ports 74 and 76 and to tank 14 by directing fluid returning from the motor 32 through either motor ports 74 or 76 to return ports 80 or 78.

The reversing valve return ports 78 and 80 are connected to the pilot valve return ports 124 and 126 by the passages 120 and 122 so that fluid returning from the motor 32 through one of the reversing valve return ports is delivered to the corresponding pilot valve return port. The pilot valve return ports 124 and 126 are adapted to be alternately gradually blocked during initial mechanical reciprocation of pilot valve 52 by portions 182 or 180 gradually passing over said return ports so as to decelerate the motor 32.

Groove 64 of spool 58 controls the ports 110 and 128, and groove 66 controls ports 112 and 130, so as to direct pressure fluid in passage 106, which is connected to ports 110 and 112, to pilot valve ports 132 or 134 in order to rapidly complete the operation of pilot valve 52 after a certain range of controlled mechanical movement thereof. During the initial mechanical movement of pilot valve 52, the ports 132 and 134, which are connected to reversing valve ports 128 and 130 by means of passages 136 and 138, are blocked from communication with pilot valve ports 178 and 176. After a certain range of rightward movement of pilot valve 52, ports 178 will register with port 132, and, after a certain range of leftward movement thereof, ports 176 will register with port 134 so as to admit pressure fluid in either passage 136 or 138 to chambers 170 or 168 of pilot valve 52 in order to rapidly complete the operation of pilot valve 52.

Grooves 68 and 70 of spool 58 merely permit the passage of fluid to either chamber 170 or 168 of pilot valve 52 by means of passages 142 or 140 when a substitute valve means is used to control pilot valve 52. When pilot valve 52 is initially mechanically operated and completely operated hydraulically, grooves 70 and 68 of spool 58 will direct fluid discharging from chambers 168 or 170 during the shifting of said valve rightwardly or leftwardly to passage 148 by means of either passage 140 or passage 142.

Similar grooves 184 and 186 in spool 160 control the admission of pressure fluid to passages 94 and 96 in order to control the operation of reversing valve 56. The ball end of a rod 188 fits into portion 166 and secured to rod 188 is a rotatable shaft 190 to which is rigidly fastened two arms 192 and 194.

Motor 32 contains a piston 196 to which is secured a piston rod 198 attached to each end of which is a table slide 200. Adjustably mounted on slide 200 is a pair of dogs 202 and 204. The arms 192 and 194 and dogs 202 and 204 are located in such a plane that, after a certain leftward range of movement of piston 196, dog 204 will contact arm 194 and, after a certain rightward range of movement of piston 196, dog 202 will contact arm 192 in order to mechanically initiate operation of pilot valve 52 in each direction.

Substitute means for operating pilot valve 52 entirely by pressure fluid are provided by external connections 206 and 208 which are normally

plugged. If for some reason it is undesirable to produce the snap action of pilot valve 52 by pressure fluid directly from pump 10, a different source of pressure fluid may be connected to the external entrance 210 of passage 106, in which case a restriction plug is inserted in place of solid plug 108 in the passage 106. If connection 210 is used, a restriction plug 220 in the passage 106 ahead of the pressure port 18 is removed and a solid plug inserted in its place.

If it is desired to operate an additional valve device under the control of panel 20, external connections 212 and 214 are provided for that purpose. If it is desired to substitute another source of pressure to operate reversing valve 56, an external connnection 216 containing a check valve 218 is provided for that purpose, and a solid plug would be inserted in the passage 114 at the point indicated by the numeral 119.

Referring now to Figure 1, in operation with the electric motor 12 running and operating pump 10 and with control valve 42 shifted so as to vent valve 38 to tank 14, pump 10 will be unloaded, motor 32 will be stopped, and the full delivery of pump 10 will be exhausted to tank 14 through valve 38 and conduit 40.

If control valve 42 is shifted so as to block the control vent of valve 38, pump delivery will be directed by means of delivery conduit 22 through valve 38 to the pressure port 18 of valve 20. In the position shown, piston 196 of motor 32 has already completed a rightward movement, and pilot valve 52 and reversing valve 56 have been operated completely so as to direct fluid to motor 32 to shift piston 196 thereof leftward. Pressure fluid from pump 10 entering pressure port 18 is directed by reversing valve 56 because of groove 62 through motor port 74 and external connection port 30 to the right end of motor 32 by means of conduit 36. Discharging fluid from motor 32 is delivered by conduit 34 to external motor port 28 and is directed by reversing valve 56 because of groove 60 through motor port 76, return port 78, return passage 120, pilot valve return port 124, recess 154, tank port 24 and conduit 26 to tank 14. Pressure fluid entering pressure port 18 also enters passage 114 and by means of groove 184 in pilot valve 52 flows through ports 118 and 156 thereof and passage 94 through check valve 98 to chamber 90 of reversing valve 56.

Due to the fact that reversing valve 56 has already completed a leftward movement thereof, the further admission of pressure fluid to chamber 90 by means of the ports and passages hereinbefore mentioned will have no effect. Also, due to the fact that pilot valve 52 and reversing valve 56 have completed their leftward movement, pressure fluid entering pressure port 18 and flowing through restriction 220 and passage 106 is blocked by reversing valve 56 from flowing into either port 144 or port 130. Fluid in passage 106 flowing through ports 110 and 128 of reversing valve 56 to passage 136 is blocked at port 132 by pilot valve 52. Fluid in passage 106 is prevented from flowing out the optional entrance 210 by the solid plug 108.

As piston 196 continues its leftward movement, the amount of fluid being directed by panel 20 to the right end of motor 32 will be regulated by valve 38 so as to regulate the speed of piston 196. Due to the fact that dog 202 is in a different plane than arm 194 and will pass thereby, piston 196 will continue its leftward movement, and dog 204 will contact arm 194, rotating shaft 190 to which is attached rod 188. Upon dog 204 contacting arm 194, pilot valve 52 will shift to the right, and its

speed of movement will be determined by the speed of movement of piston 196.

As pilot valve 52 shifts rightward, cut-away portion 182 of spool 160 will gradually pass over return port 124, gradually making the opening thereof smaller. Due to the fact that fluid being discharged from the left end of motor 32 must return to tank 14 through return port 124, the gradual closing of return port 124 will gradually restrict the amount of fluid discharging from motor 32 and have the effect of producing a smooth deceleration thereof.

As pilot valve 52 is shifting rightward due to contact of dog 204 with arm 194, chamber 170 and bore 164 will be supplied with fluid through check valve 174. This fluid is the identical fluid being discharged from chamber 168 and bore 162 of pilot valve 52, as this fluid must return to tank 14 by means of passage 169, port 173, groove 70, port 144, passages 140 and 148, recess 154, passage 166 and check valve 174.

Just before return port 124 is completely blocked, ports 178 will register with port 132, and pressure fluid in passage 136 which previously had been blocked by pilot valve 52 may now enter bore 164 and chamber 170 and rapidly complete the rightward movement of pilot valve 52. During this rapid completion of operation of pilot valve 52, return port 124 is completely blocked so as to instantly stop motor 32. Check valve 174 cooperates in this rapid completion of operation of pilot valve 52 by preventing pressure fluid escaping from bore 164 to portion 166.

While pilot valve 52 is shifted rightward, fluid in chamber 168 and bore 162 may discharge to tank 14 by means of passage 169, port 173, groove 70, port 144, passage 140, passage 148, recess 154, tank port 24 and conduit 26.

Upon pilot valve 52 shifting completely to the right, fluid under pressure from pump 10 entering pressure port 18 and passage 114 which had been previously blocked at port 116 is now free to flow through port 158 by means of groove 186 and by means of passage 96 and check valve 100 to chamber 92 and bore 84 and shift reversing valve 56 to the right. The initial movement of reversing valve 56 rightward will be rapid because discharging fluid from the right end of reversing valve 56 in chamber 90 and bore 82 does not have to flow through needle valve 102 but has a free outlet to tank 14 by means of bore 82, passage 88, return passage 122, return port 126, portion 180, recess 154, tank port 24 and conduit 26.

As shown in Figure 2, when pilot valve 52 moved completely to the right, cut-away portion 180 opened up port 126 to recess 154. When reversing valve 56 has shifted to the right a distance great enough to block off passage 88 from return port 80, discharging fluid in chamber 90 and bore 82 must flow to tank 14 through needle valve 102, and the movement of spool 58 becomes regulated in speed according to the original adjustment of needle valve 102. Fluid discharging from the right end of reversing valve 56 will reach tank 14 by means of needle valve 102, passage 94, port 156, groove 184, port 152, passage 148, recess 154, tank port 24 and conduit 26.

When needle valve 102 becomes effective to regulate the speed of reversing valve 56 rightwardly, the changeover of the reversing valve ports is just taking place, and pressure fluid entering pressure port 72 from pump 10 is gradually allowed to enter port 76 through groove 60, dependent upon the speed of opening of motor port 76 which is dependent upon the original ad-

justment of needle valve 102. Fluid entering port 76 flows through such port and port 28 to conduit 34 where it is delivered to the left end of motor 32. Piston 196 will begin to shift rightward and will gradually and smoothly accelerate as motor port 76 gradually opens flow to port 28. Discharging fluid from the right end of motor 32 may flow to tank 14 by means of conduit 36, port 30, port 74, groove 62, port 80, return passage 122, return port 126, portion 180, recess 154, tank port 24 and conduit 26. Piston 196 will continue to smoothly accelerate to a speed of movement dictated by the original setting of valve 38. Piston 196 will continue to shift rightwardly at such regulated speed, and dog 204, being on a different plane than arm 192, will pass thereby, and a continued movement of piston 196 results in dog 202 contacting arm 192.

Pilot valve 52 will begin to shift to the left as dictated by the speed of piston 196, and the continued movement of pilot valve 52 to the left results in cut-away portion 180 slowly passing over return port 126 to gradually close the size of opening of said port. This results in gradually increasingly restricting the flow of fluid discharging from motor 32 through return port 126 to tank 14 and again has the effect of smoothly decelerating motor 32. During initial leftward mechanical movement of pilot valve 52, chamber 168 and bore 162 thereof are supplied with fluid in the same manner as bore 164 and chamber 170 were supplied with fluid during initial rightward mechanical movement thereof.

After a certain predetermined range of leftward mechanical movement of spool 160, ports 176 will register with port 134, and pressure fluid which had been delivered by pump 10 through pressure port 18, restriction 220, passage 106, port 112, groove 66, port 130 and passage 138 and which had been blocked by pilot valve spool 160 is now free to enter bore 162 and chamber 168 and rapidly complete the movement of spool 160 to the left. Check valve 172 cooperates in this movement by preventing flow of pressure fluid from bore 162 to portion 166. Fluid in bore 164 and chamber 170 has a free outlet to tank 14 by means of passage 171, port 175, groove 68, port 146, passages 142 and 148, recess 154, tank port 24 and conduit 26. This snap-action completion of operation of pilot valve 52 results in return port 126 being suddenly and completely closed to discharging fluid from the right end of motor 32, and the rapid complete shifting of spool 160 again results in taking advantage of the greatest amount of sealing space in the shortest possible time so as to instantly stop the movement of piston 196.

Upon the completion of movement of spool 160 leftwardly as shown in Figure 1, fluid under pressure from pump 10 delivered through pressure port 18 and port 72 into passage 114 is now free to enter chamber 90 and bore 82 of reversing valve 56 by means of port 118, groove 184, port 156, passage 94 and check valve 98. Discharging fluid from chamber 92 and bore 84 of reversing valve 56 initially has a free outlet to tank 14 by means of passage 86, port 78, return passage 120, pilot valve return port 124, portion 182, recess 154, tank port 24 and conduit 26. This rapid movement of spool 58 continues until passage 86 is blocked from communication with return port 78, at which time fluid from chamber 92 and bore 84 must flow to tank 14 through needle valve 104 so as to regulate further movement of spool 58 in a leftward direction.

This operation of reversing valve 56 in a leftward direction is identical with the operation of reversing valve 56 in a rightward direction as previously described. The changeover of communication between the reversing valve ports will again take place just as the speed of spool 58 is beginning to be regulated. Communication between reversing valve pressure port 72 and motor port 74 is opened gradually and results in a smooth acceleration of motor 32. When needle valve 104 becomes effective so as to regulate the speed of movement of spool 58, discharging fluid from chamber 92 and bore 84 must flow to tank 14 by means of needle valve 104, passage 96, port 158, groove 186, port 150, passage 148, recess 154, tank port 24 and conduit 26. This automatic reciprocation of motor 32 continues until the grinding operation has been completely performed, at which time motor 32 may be stopped by shifting valve 42 to vent valve 38 to tank 14, and the complete delivery of pump 10 will be unloaded to tank 14 by means of conduit 22, valve 38 and conduit 40.

It should be noted that pilot valve 52 is initially operated by mechanical means, that is, contact of either dog 204 with arm 194 or of dog 202 with arm 192 near the completion of each stroke of the motor 32, and that, during this initial mechanical operation thereof, the return ports 124 and 126 are alternately gradually closed to discharging fluid from the motor 32 so as to smoothly decelerate said motor.

It should also be noted that, just before the return port 124 or the return port 126 of pilot valve 52 is completely blocked, the operation of pilot valve 52 is rapidly completed by means of pressure fluid so as to take advantage of the greatest amount of sealing overlap, preventing overtravel of piston 196 and consistently stopping motor 32 at a predetermined point during operation thereof.

It should also be noted that the momentary dwell at the end of each motor stroke is greatly shortened by the initial rapid operation of reversing valve 56 and that this rapid movement of reversing valve 56 will only continue to the point of changeover between the reversing valve ports. This changeover takes place gradually due to the action of either needle valve 102 or 104 when passages 86 or 88 are blocked from communication with return ports 78 or 80 so as to restart and produce a smooth acceleration of motor 32.

It should also be noted that the pilot valve and the reversing valve each have two different steps of operation and that each one of these steps of operation are under separate means of control. The first step of operation of the pilot valve is controlled relative to the speed of the motor in order to gradually close a pilot valve return port through which fluid is returning from the motor. The second step of operation of the pilot valve, namely, rapid movement thereof to a point of completion of operation, followed by the first step of operation of the reversing valve, namely, rapid movement thereof to the point of changeover of the reversing valve ports, may be considered as intermediate steps of operation. The second step of operation of the reversing valve, namely, a movement thereof controlled by an adjustable restriction during the changeover of the reversing valve ports, is the final step of operation. The first step of operation of the pilot valve results in a smooth, controlled deceleration of the motor, while the second step of operation

of the reversing valve results in a smooth, controlled acceleration of the motor.

In addition, substitute means have been provided for operating pilot valve 52 completely by fluid pressure, in which case dogs 202 and 204, arms 192 and 194, rod 188 and shaft 190 will be removed. In such case, external connection ports 206 and 208 which are normally plugged will be used by connecting thereto an external source of pressure which may be that of pump 10, and additional control means must be used therewith. Provided that such operation does not demand a snap operation of pilot valve 52, a solid plug may be inserted in place of restriction plug 220. If in the same operation it is desirable to have a snap completion of operation of pilot valve 52 and a substitute source of pressure other than that from pump 10 be used for such action, this substitute source of pressure may be connected into external connection port 210, which is normally plugged, a restriction plug of suitable proportion inserted in place of the solid plug 108 and a solid plug inserted in the passage 106 in place of the restriction plug 220.

If for some reason it is desired to initially operate pilot valve 52 by means of mechanical linkage with motor 32 and to rapidly complete the operation thereof by a source of fluid pressure other than directly from pump 10, said substitute source of pressure may be connected into external port 210, a restriction plug inserted in place of solid plug 108, and restriction plug 220 would be replaced by a solid plug.

Also, if it is desirable to operate another load device in addition to slide 200, connections are provided for such a purpose at ports 212 and 214. Conduits would be connected to ports 212 and 214 and to the load device, and the same source of pressure, namely, pump 10, would be utilized to operate said load device, and panel 20 would control the operation of said load device so as to produce a reciprocal movement thereof at the completion of each stroke of motor 32. Substitute means for operating reversing valve 56 have also been provided by an external connection port 216 having a check valve 218 to which a source of pressure fluid may be connected, and in such case a solid plug may be inserted in the passage 114 at the point indicated by the numeral 119. When the operation is such as is shown in Figures 1 and 2, however, substitute external connection ports 206, 208, 210, 212, 214 and 216 are not in use and consequently are plugged.

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 having a pump and a fluid motor and supply and return connections for the motor, the combination of a first shiftable valve element, means thereon for controlling the cut-off of return fluid from the motor, a second shiftable valve element, means thereon for controlling the reversal of the supply and return connections to the motor, means operated by the motor for shifting the first element at a controlled speed to an intermediate position, means for shifting the first element rapidly through the remainder of its stroke, means controlled by the first element for initiating a rapid movement of the second element to an intermediate position, and means for causing

the shifting of the second element through the remainder of its stroke to take place at a controlled speed.

2. In a hydraulic power transmission system having a pump and a fluid motor and supply and return connections for the motor, the combination of a first shiftable valve element, means thereon for controlling the cut-off of return fluid from the motor, a second shiftable valve element, means thereon for controlling the reversal of the supply and return connections to the motor, and means for shifting each valve element in two separate steps, each step being under independent control.

3. In a hydraulic power transmission system having a pump and a fluid motor and supply and return connections for the motor, the combination of a hydraulically-operated, shiftable valve spool, means thereon for controlling the reversal of the supply and return connections to the motor, a shiftable valve element, means operated by the motor for automatically mechanically shifting the valve element at a controlled speed to an intermediate position, means controlled by the valve element during the controlled speed movement thereof for gradually cutting off the flow of return fluid from the motor, means for hydraulically shifting the valve element rapidly through the remainder of its stroke, means controlled by the valve element for directing fluid to and from the valve spool for operating the latter, means for permitting a rapid shifting of the valve spool to an intermediate position, and means for controlling the speed of the valve spool through the remainder of its stroke.

4. In a hydraulic power transmission system having a pump and a fluid motor and supply and return connections for the motor, the combination of a hydraulically-operated, shiftable valve spool, means thereon for controlling the reversal of the supply and return connections to the motor, a shiftable valve element, means operated by the motor for automatically mechanically shifting the valve element at a controlled speed to an intermediate position, means controlled by the valve element during the controlled speed movement thereof for gradually cutting off the flow of return fluid from the motor, means controlled by the valve element for hydraulically shifting the valve element rapidly through the remainder of its stroke, means controlled by the valve element for directing fluid to and from the valve spool for operating the latter, means for permitting a rapid shifting of the valve spool to an intermediate position, and means for controlling the speed of the valve spool through the remainder of its stroke during the reversal of the supply and return connections to the motor.

5. A unitary control panel for use in a hydraulic power transmission having a fluid pump and reversible fluid motor for causing the motor to operate in alternately reversing cycles and comprising in combination, a body, a first shiftable valve element mounted therein, said first valve element including return ports through which fluid is adapted to flow from the motor, means on said first valve element for blocking said return ports, a second shiftable valve element mounted in the body, means thereon for directing fluid to and from said motor, means operated by the motor for shifting the first element at a controlled speed to an intermediate position, means for shifting the first element rapidly through the remainder of its stroke, means controlled by the first element for initiating a rapid movement of the second ele-

ment to an intermediate position, and means for causing the shifting of the second element through the remainder of its stroke to take place at a controlled speed.

6. A unitary control panel for use in a hydraulic power transmission having a fluid pump and reversible fluid motor for causing the motor to operate in alternately reversing cycles and comprising in combination, a body, a first shiftable valve element mounted therein, said first valve element including return ports through which fluid is adapted to flow from the motor, means on said first valve element for blocking said return ports, a second shiftable valve element mounted in the body, means thereon for directing fluid to and from said motor, and means for shifting each valve element in two separate steps, each step being under independent control.

7. A unitary control panel for use in a hydraulic power transmission having a fluid pump and reversible fluid motor for causing the motor to operate in alternately reversing cycles and comprising in combination, a body, a pilot valve reciprocably mounted therein, said pilot valve including return ports through which fluid is adapted to flow from the motor, means for initially mechanically operating the pilot valve at each end of the motor stroke, means controlled by the pilot valve during initial mechanical operation thereof for gradually closing a return port through which fluid is flowing from the motor, means controlled by the pilot valve for rapidly completing the operation thereof by pressure fluid after a predetermined range of mechanical movement thereof, and a fluid pressure operated reversing valve reciprocably mounted in said body controlled by the pilot valve for directing fluid to and from said motor.

8. A unitary control panel for use in a hydraulic power transmission having a fluid pump and reversible fluid motor for causing the motor to operate in alternately reversing cycles and comprising in combination, a body, a pilot valve reciprocably mounted therein, said pilot valve including return ports through which fluid is adapted to flow from the motor, means for initially mechanically operating the pilot valve at each end of the motor stroke, means controlled by the pilot valve during initial mechanical operation thereof for gradually closing a return port through which fluid is flowing from the motor, means controlled by the pilot valve for rapidly completing the operation thereof by pressure fluid after a predetermined range of mechanical movement thereof, a fluid pressure operated reversing valve reciprocably mounted in said body controlled by the pilot valve for directing fluid to and from said motor, means for regulating the speed of operation of the reversing valve, means forming a bypass around said regulating means causing rapid movement of the reversing valve, and means controlled by the reversing valve for closing said bypass after a predetermined range of reversing valve operational movement.

9. A unitary control panel for use in a hydraulic power transmission having a fluid pump and reversible fluid motor for causing the motor to operate in alternately reversing cycles and comprising in combination, a body, a pilot valve reciprocably mounted therein, said pilot valve including return ports through which fluid is adapted to flow from the motor, means for initially mechanically operating the pilot valve at each end of the motor stroke, means controlled by the pilot valve during initial mechanical operation thereof for gradually closing a return port through which fluid is flowing from the motor, means controlled by the pilot valve for rapidly completing the operation thereof by pressure fluid just before said return port is completely blocked, a reversing valve, an adjustable restriction for controlling the speed of operation of the reversing valve, means forming a bypass around said restriction, and means controlled by the reversing valve closing said bypass after a predetermined range of rapid movement thereof causing said restriction to become effective.

10. In a hydraulic transmission system the combination of a fluid pump, a reversible fluid motor, fluid supply and return connections between said pump and motor, and a control system contained within a panel in said connections for automatically causing the motor to operate in alternately reversing cycles, said control system comprising a fluid pressure operated reversing valve for alternately directing fluid to and from opposite ends of said motor, a pilot valve for controlling said reversing valve, means for automatically mechanically initiating operation of the pilot valve by the motor near the end of each motor stroke, and fluid pressure means controlled by the pilot valve for rapidly completing the operation of the pilot valve after a predetermined range of mechanical movement of said pilot valve.

11. In a hydraulic transmission system the combination of a fluid pump, a reversible fluid motor, fluid supply and return connections between said pump and motor, and a control system contained within a panel in said connections for automatically causing the motor to operate in alternately reversing cycles, said control system comprising a fluid pressure operated reversing valve for alternately directing fluid to and from opposite ends of said motor, means for regulating the speed of operation of the reversing valve, means forming a bypass around said regulating means, means controlled by the reversing valve for closing said bypass after a predetermined range of movement of said reversing valve, a pilot valve for controlling said reversing valve, means for automatically mechanically initiating operation of the pilot valve by the motor near the end of each motor stroke, and fluid pressure means controlled by the pilot valve for rapidly completing the operation of the pilot valve after a predetermined range of mechanical movement of said pilot valve.

12. In a hydraulic transmission system the combination of a fluid pump, a reversible fluid motor, fluid supply and return connections between said pump and motor, and a control system contained within a panel in said connections for automatically causing the motor to operate in alternately reversing cycles, said control system comprising a fluid pressure operated reversing valve for alternately directing fluid to and from opposite ends of said motor, a pilot valve for controlling said reversing valve, said pilot valve including return ports through which fluid is adapted to flow from the motor, means for automatically initiating operation of the pilot valve by the motor near the end of each motor stroke, means controlled by the pilot valve during initial mechanical movement thereof for gradually closing a return port through which fluid is returning from the motor, and fluid pressure means controlled by the pilot valve for rapidly completing the operation of the pilot valve after a predetermined range of mechanical movement of said pilot valve.

13. In a hydraulic transmission system the combination of a fluid pump, a reversible fluid motor, fluid supply and return connections between said pump and motor, and a control system contained within a panel in said connections for automatically causing the motor to operate in alternately reversing cycles, said control system comprising a fluid pressure operated reversing valve for alternately directing fluid to and from opposite ends of said motor, an adjustable restriction for regulating the speed of operation of the reversing valve, means forming a bypass around said adjustable restriction for producing rapid initial operation of said reversing valve, means controlled by the reversing valve for closing said bypass to cause said restriction to become effective after a predetermined range of rapid movement of said reversing valve, a pilot valve for controlling said reversing valve, means for automatically mechanically initiating operation of the pilot valve by the motor near the end of each motor stroke, and fluid pressure means controlled by the pilot valve for rapidly completing the operation of the pilot valve after a predetermined range of mechanical movement of said pilot valve.

14. A unitary control panel for use in a hydraulic power transmission having a fluid pump and reversible fluid motor for causing the motor to operate in alternately reversing cycles and comprising in combination, a valve block, a pilot valve reciprocably mounted therein, said pilot valve including return ports through which fluid is adapted to flow from the motor, fluid pressure chambers at opposite ends of said pilot valve, connections for said chambers, a passage adapted to be connected to a source of pressure in the system and to said connections, a fluid pressure operated reversing valve reciprocably mounted within said valve block controlled by said pilot valve for directing fluid to and from said motor, said reversing valve including duplicate return ports connected by passages to said pilot valve return ports, means for mechanically initiating operation of the pilot valve near each end of the motor stroke, means controlled by the pilot valve during initial mechanical operation for gradually closing a pilot valve return port through which fluid is returning from the motor through a reversing valve return port, and means controlled by the pilot valve after a predetermined range of mechanical movement for alternately opening a pressure chamber connection and rapidly completing the operation of the pilot valve by fluid pressure.

15. A unitary control panel for use in a hydraulic power transmission having a fluid pump and reversible fluid motor for causing the motor to operate in alternately reversing cycles and comprising in combination, a valve block, a pilot valve reciprocably mounted therein, said pilot valve including return ports through which fluid is adapted to flow from the motor, fluid pressure chambers at opposite ends of said pilot valve, connections for said chambers, a passage adapted to be connected to a source of pressure in the system and to said connections, a fluid pressure operated reversing valve reciprocably mounted within said valve block controlled by said pilot valve for directing fluid to and from said motor, said reversing valve including duplicate return ports connected by passages to said pilot valve return ports, means for mechanically initiating operation of the pilot valve near each end of the motor stroke, means controlled by the pilot valve during initial mechanical operation for gradually closing a pilot valve return port through which fluid is returning from the motor through a reversing valve return port, means controlled by the pilot valve after a predetermined range of mechanical movement for alternately opening a pressure chamber connection and rapidly completing the operation of the pilot valve by fluid pressure, whereby the pilot valve return port through which fluid is returning from the motor is suddenly completely blocked, an adjustable restriction for controlling the speed of operation of the reversing valve, means forming a bypass around said restriction for permitting rapid movement of the reversing valve, and means controlled by the reversing valve closing said bypass after a predetermined range of rapid movement thereof causing said restriction to become effective.

16. In a hydraulic power transmission system the combination of a pump, a reversible fluid motor, fluid supply and return connections between the pump and motor, and a control system contained within a panel in said connections for automatically causing the motor to operate in alternately reversing cycles, said control system comprising a fluid pressure operated reversing valve for reversing the flow of fluid to the motor, a pilot valve for controlling said reversing valve, means for initially mechanically actuating the pilot valve by the motor near the end of a motor stroke, means controlled by the pilot valve during initial mechanical operation for smoothly decelerating said motor, and fluid pressure means controlled by the pilot valve for snap action completion of operation of said pilot valve after a predetermined range of mechanical movement thereof causing said motor to stop at a predetermined, constantly uniform point during operation.

17. In a hydraulic power transmission system the combination of a pump, a reversible fluid motor, fluid supply and return connections between the pump and motor, and a control system contained within a panel in said connections for automatically causing the motor to operate in alternately reversing cycles, said control system comprising a fluid pressure operated reversing valve for reversing the flow of fluid to the motor, a pilot valve for controlling said reversing valve, means for initially mechanically actuating the pilot valve by the motor near the end of a motor stroke, means controlled by the pilot valve during initial mechanical operation for smoothly decelerating said motor, fluid pressure means controlled by the pilot valve for snap action completion of operation of said pilot valve after a predetermined range of mechanical movement thereof causing said motor to stop at a predetermined, constantly uniform point during operation, and means controlled by the said reversing valve for restarting and smoothly accelerating said motor.

18. In a hydraulic power transmission system the combination of a pump, a reversible fluid motor, fluid supply and return connections between the pump and motor, and a control system contained within a panel in said connections for automatically causing the motor to operate in alternately reversing cycles, said control system comprising a fluid pressure operated reversing valve for reversing the flow of fluid to the motor, a pilot valve for controlling said reversing valve, means for initially mechanically actuating the pilot valve by the motor near the end of a motor

stroke, means controlled by the pilot valve during initial mechanical operation for smoothly decelerating said motor, fluid pressure means controlled by the pilot valve for snap action completion of operation of said pilot valve after a predetermined range of mechanical movement thereof causing said motor to stop at a predetermined, constantly uniform point during operation, an adjustable restriction for regulating the speed of the reversing valve, means forming a bypass around said restriction, and means for closing said bypass after a predetermined range of movement of the reversing valve, said reversing valve restarting and providing a smooth acceleration of said motor.

19. A unitary control panel for use in a hydraulic power transmission having a fluid pump and reversible fluid motor for causing the motor to operate in alternately reversing cycles and comprising in combination, a reciprocable pilot valve, said pilot valve including return ports through which fluid is adapted to flow from the motor, a reversing valve adapted to be operated by fluid pressure and controlled by the pilot valve, said reversing valve including pressure and motor connections and return ports in communication with the pilot valve return ports, means adapted for initial mechanical operation of the

pilot valve, means controlled by the pilot valve for gradually blocking a pilot valve return port through which fluid is flowing from the motor during initial mechanical operation thereof, fluid pressure means controlled by the pilot valve for rapidly completing the operation of the pilot valve just before the return port thereof is completely blocked, fluid pressure means controlled by the reversing valve for rapid initial operation of the reversing valve after complete operation of the pilot valve, and means for regulating the speed of the reversing valve after a predetermined range of rapid movement thereof, producing a gradual changeover of the reversing valve connections.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,237,871	Stone	Apr. 8, 1941
2,267,177	Twyman	Dec. 23, 1941
2,303,946	Miller	Dec. 1, 1942