

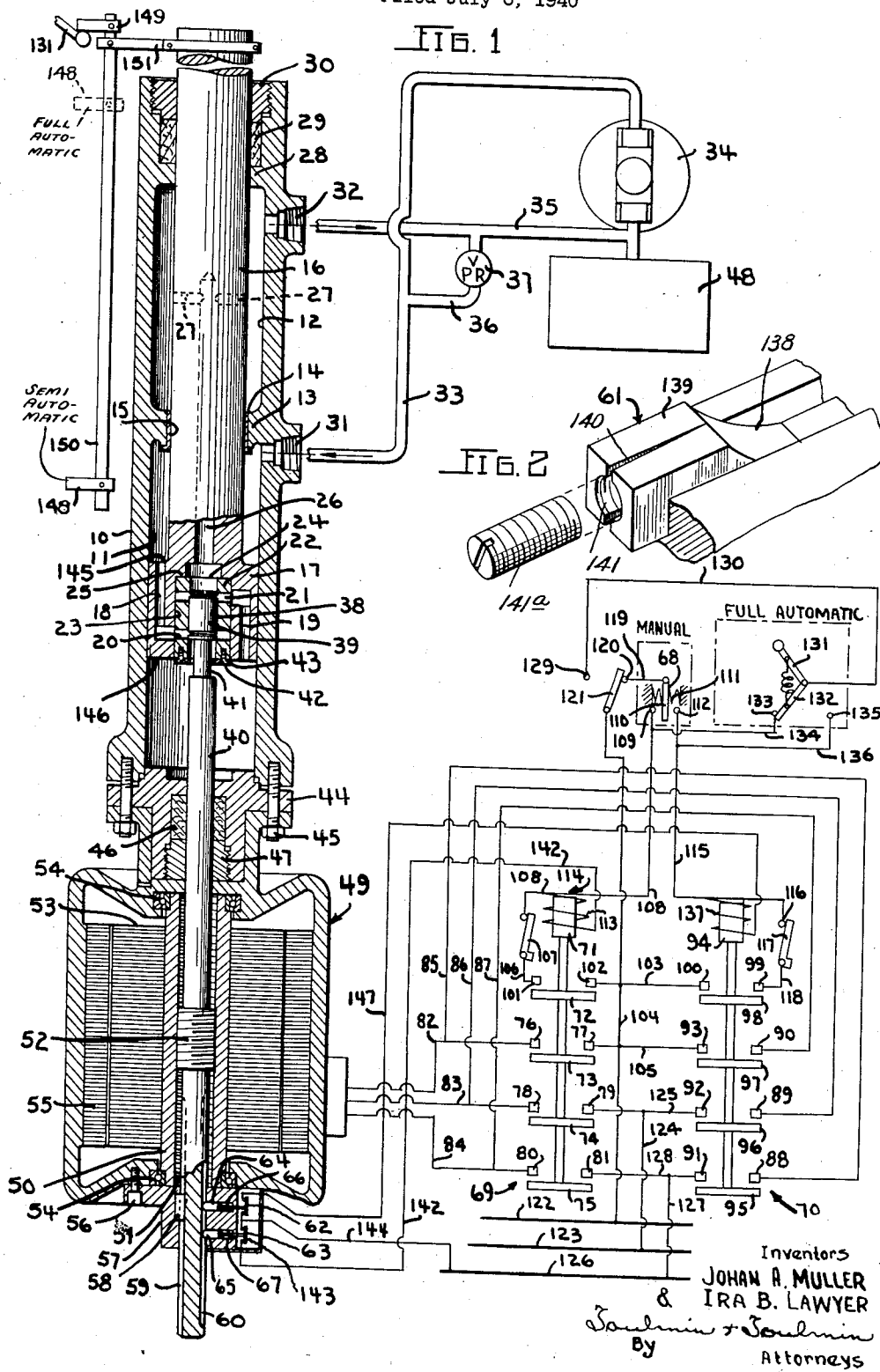
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ELECTRICALLY CONTROLLED RECIPROCATING FLUID MOTOR

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ELECTRICALLY CONTROLLED RECIPROCATING FLUID MOTOR

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This invention relates to hydraulic motors and, in particular, to reciprocating motors.

One object of this invention is to provide a hydraulic motor having a reciprocating plunger which moves at the same rate and distance as a control member, but delivering a much greater force than is applied to the control member.

Another object is to provide a hydraulic motor having a reciprocating plunger with a piston valve member cooperating with ports in the head of the plunger so as to provide a point-for-point travel of the plunger with the piston valve member, but with the output of a relatively great force for a given force applied to the piston valve member.

Another object is to provide a hydraulic motor having a reciprocating plunger with a head having a chamber therein with ports cooperating with the head of a piston valve member in such a manner as to uncover one of these ports to permit pressure fluid to flow through the plunger head to the opposite side thereof when the piston valve member is moved in one direction, but to uncover another port permitting the discharge of pressure fluid from one side of the plunger head when the piston valve member is moved in the opposite direction, thereby providing a follow-up motion of the plunger in correspondence with the motion of the piston valve member.

Still another object of the invention consists in the provision of a hydraulic motor of the type set forth above, in which the reciprocating plunger may selectively be operated semi-automatically or full automatically.

A further object of the invention is to provide a hydraulic motor having a reciprocating plunger with a piston valve member operating with ports in the head of the plunger, in which the stroke of the reciprocating plunger is variable.

It is a still further object of the invention to provide a hydraulic motor having a reciprocating plunger with a piston valve member cooperating with ports in the head of the plunger, in which the piston valve member is operable electrically.

These and other objects and advantages of the invention will appear more clearly from the following specification in connection with the accompanying drawing, in which:

Figure 1 is a diagrammatic illustration of the entire assembly of a device according to the invention, while Figure 2 illustrates a detail thereof.

General arrangement

In general, the hydraulic motor of this inven-

tion consists of a cylinder with a double-acting plunger therein. The plunger has a head with passages from opposite sides communicating with ports in a chamber within the head, these ports cooperating with the head of a piston valve member in such a manner as to selectively open and close one or the other of the ports. When one port is uncovered by the piston valve head, pressure fluid is enabled to engage both sides of the plunger head and urge the latter in one direction as a result of the differential piston area provided by the rod portion of the plunger. When this port is covered and the other port uncovered, however, fluid is permitted to act against but one side of the plunger head, thereby urging the plunger in the opposite direction. The device gives a follow-up motion by reason of the fact that when the piston valve head is moved a given distance in one direction, the uncovering of the ports within the plunger head causes the plunger to be moved in the same direction as the piston valve head, thereby again covering up the ports when a like distance has been traveled by the plunger head as was traveled by the piston valve head. The motor of this invention, however, gives a greatly increased mechanical advantage because the force produced by the motion of the plunger is vastly greater than the force necessary to move the piston valve head in one direction or the other. In other words, a point-for-point correspondence is effected between the motion of the piston valve member and the resulting motion of the plunger.

The piston valve member cooperating with the ports in the plunger head is operable by an electric motor having a hollow shaft connected with the rotor and provided on the inside thereof with a thread which engages a correspondingly threaded portion on the piston valve member. In this way, rotation of the motor rotor will cause movement of the piston valve member in one or the other direction in correspondence with the rotation of said rotor. The piston valve member, furthermore, cooperates with switches controlling the energization circuit of the motor so as to interrupt the said energization circuit after the piston valve member has traveled a predetermined distance.

According to a further feature of the invention, the energization circuit of the motor has associated therewith a controlling circuit to enable selectively manual, semi-automatic and full automatic operation of the device.

This invention is capable of use as a servomotor or as an auxiliary motor for controlling

the servomotors of large hydraulic pumps. It may be used, however, in any position where it is desired to obtain a greatly increased force with a corresponding rate and distance of motion, such as in controlling the positions of members in heavy machinery, such as steel mill machinery. Another application is for regulating the position of the blade of a road grader so as to regulate the cutting depth. The invention may further be used in connection with a smaller press for forcing bushings, for riveting, or for assembling. The device may also be used as a hydraulic jack or hoist.

Structural arrangement

Referring to the drawing in detail, Figure 1 shows a preferred embodiment of the hydraulic motor of this invention as consisting of a casing 10 with bores 11 and 12 therein, separated by an annular partition 13, having a bore with a bushing 15 therein. The bushing 15, which may be a bronze bushing, fits closely around the motor plunger 16 so as to prevent excessive leakage. The motor plunger 16 is provided with a head 17 having L-shaped passageways 18 and 19 communicating with ports 20 and 21 in a sleeve 22 mounted within a longitudinal bore 23 within the plunger head 17. The bore 23 continues in the counterbore 24 to provide an annular wall 25 against which the sleeve 22 abuts.

Beyond the counter bore 24 is a longitudinal bore or passageway 26 extending through the plunger 16 to the cross passageways 27 opening out into the bore 12. Beyond the cross passageways 27 the motor plunger 16 passes through an annular end wall 28, having beyond it a packing 29, compressed by a gland 30, for preventing leakage from the device. Threaded ports 31 and 32 open, respectively, into the bores 11 and 12. The port 31 is connected by means of a conduit 33 with one side of a variable delivery pump 34, while the other side of the variable delivery pump 34 communicates on one hand with a conduit 35 leading to the port 32, and on the other hand with a fluid reservoir or tank 48. A conduit 36 branching off from the conduit 33 comprises a pressure relief valve 37 and leads to the conduit 35. The purpose of the pressure relief valve 37 consists in relieving excessive pressure in the conduit 33.

The inner surface of the sleeve 22 forms a bore 38 for receiving a piston valve head 39 upon a piston valve rod 40, having a reduced diameter portion 41 connected with the piston valve head 39. Secured to the end of the sleeve 22, as by screws 42, is a retaining ring 43, for preventing the piston valve head 39 from being withdrawn from the bore 38, in the event that the valve rod 40 is moved when no pressure fluid is being supplied at the pressure inlet port 31.

The bore 11 serves as a pressure chamber and is provided with a cylindrical head 44 secured to the casing 10, by any convenient means, for instance by screws 45, and containing a packing 46 compressed by a gland 47, for preventing leakage around the valve rod 40. Also mounted upon the cylinder head 44, by means of screws 48, is an electric motor, generally designated 49. The motor 49 has a hollow shaft 50 with an inner thread 51 engaging a correspondingly threaded portion 52 on the piston valve rod 40. The hollow shaft 56 carries the rotor 53. The entire assembly runs in ball bearings 54. The stator is indicated by the reference numeral 55.

Attached to the end of the motor, for instance

by means of screws 56, is a bracket 57, in which is held a key 58 which engages a keyway 59 provided in the piston valve rod 40. The provision of the key 58 and keyway 59 allows the piston valve rod 40 to slide but not to rotate. At the same end of the piston valve rod 40, at which the key 58 is provided but on the opposite side thereof, is a groove 60 which either acts itself as a cam or has inserted therein cam members 61 (see Figure 2) to actuate limit switches 62 and 63 through plungers 64 and 65 which are held against the groove 60 or cams 61 by springs 66, 67.

The motor 49 may be controlled by an electric circuit, as shown. The double throw switch 68 is adapted to start, stop and reverse the motor through contactors, generally designated 69 and 70. The contactor 69 comprises an armature 71 with blades 72, 73, 74 and 75. The blades 73, 74 and 75 are adapted, respectively, to bridge the terminals 76, 77, 78, 79, 80 and 81. The terminals 76, 78 and 80 are respectively connected with the motor through lines 82, 83 and 84. The lines 82, 83 and 84 are respectively connected through lines 85, 86 and 87 with the terminals 88, 89 and 90, pertaining to the contactor 70.

Cooperating with the terminals 88, 89, 90, are terminals 91, 92, 93 respectively connected with the terminals 81, 79 and 77. The armature 94 of the contactor 70 comprises blades 95, 96, 97, 98, adapted to bridge the terminals 88, 91, 89, 92, 90, 93, 99 and 100. The blade 72 of the contactor 69 is adapted to bridge the terminals 101 and 102, the latter of which is connected by a line 103 with a line 104 and the terminal 100. The line 104 is also connected with the terminals 77 and 93 through the line 105.

The terminal 101 communicates through the line 106 with a switch lever 107 which, in its closed position, connects the line 106 with the line 108 leading to the terminal 109. The terminal 109 pertains to the double throw switch 68 and is adapted to be contacted with a switch lever 110 of the double throw switch 68. The switch lever 110 is urged, by means of a spring 111, into an intermediate position in which it neither contacts the terminal 109 nor the terminal 112, likewise pertaining to the switch 68. Branching off from the line 108 is the energizing coil 113 of the solenoid, generally designated 114, associated with the armature 71. The terminal 112 is connected by means of a line 115 with a terminal 116 adapted to be connected by means of a switch lever 117 with a line 118 leading to the terminal 99.

The switch lever 110 of the double throw switch 68 is connected by line 119 with a contact 120, adapted to be contacted by the switch arm 121 which, in its turn, is connected by line 104 with the main supply line 122. A second main supply line 123 is connected by means of a line 124 with a line 125, interconnecting the terminals 79 and 92. A third main supply line 126 is connected by means of the lines 127 and 128 with the terminals 81 and 91.

The switch arm 121 is also adapted to contact a terminal 129 connected by means of the line 130 with a toggle lever switch arm 131, which is adapted, by means of its arm 132, selectively to contact the terminal 133 connected by line 134 with the line 108, or the terminal 135 connected by line 136 with the line 115. Branching off from the line 115 is the energizing coil 137 of the contactor 70. The toggle lever 131 is adapted to be operated in one direction by an

arm 148 and in the other direction by an arm 149. The arms 148 and 149 are adjustably mounted on a rod 150 which is connected with the plunger 16 by means of the connecting member 151.

Referring to Figure 2 illustrating the cam 61, it will be noted that the cam 61 has a curved sloped portion 138, enabling the plungers 64 and 65 of the limit switches 62 and 63 to slide upon the elevated plane surface 139 of the cam 61. The cam 61 has a split member with a slot 140 which may be spread apart by screwing screw 141a into the threaded portion 141 after the cam 61 has been inserted at a desired place in the groove 60 of the piston valve rod 40.

Operation

Supposing that it is desired to move the piston head 17 upwardly from the position shown in Figure 1. To this end the pump 34 is started, which thereupon delivers pressure fluid through the conduit 33 and the port 31 into the bore 11, from where it passes downwardly through the L-shaped passageway 18 into the port 20. Now the switch lever 110 is shifted toward its left-hand position so as to contact the terminal 109. Current will then flow from the main supply line 122, through line 104, the switch arm 121, the line 119, the switch lever 110, the line 108, the coil 113, the line 142, the blade 143 of the limit switch 63 and through the line 144 to the main supply line 126. Due to the energization of the coil 113 the armature 71 is attracted, thereby having its blades 72, 73, 74 and 75 close the adjacent terminals. The blade 72 engaging the terminals 101 and 102 closes the holding circuit which comprises the main supply line 122, the line 104, line 103, terminal 102, blade 72, terminal 101, line 106, lever arm 107, line 108, coil 113, line 142, blade 143 and lines 144 and 126. Furthermore, the blades 73, 74 and 75, in cooperation with adjacent terminals, close the energizing circuit for the motor 49 so that, due to the rotation of the rotor 53, the engagement of the motor shaft 50 with the threaded portion 52 causes an upward movement of the valve rod 40 with its piston head 39. As a result of this upward movement of the piston valve head 39, fluid will flow from the L-shaped passageway 18 through the bore 38 of the sleeve 22 into the space beneath the plunger head 17. The plunger head 17 is provided with upper and lower head areas 145 and 146, respectively, the difference between these areas providing a differential piston area which is effective when both of the head areas 145 and 146 are supplied simultaneously with pressure fluid. This occurs when the upper movement of the valve rod 40 and valve head 39 uncovers the sleeve port 20 so that pressure fluid acts simultaneously on the small annular area 145 and the large annular area 146. The effective piston head area thus brought into play is equal to the difference in the areas of the portions 145 and 146, with the balance in favor of the lower head area 146. As a consequence, the plunger 16 and plunger head 17 are moved upwardly. When this occurs, however, the port 20 likewise is moved upwardly and will tend to pass the lower edge of the valve head 39 to again cover up the port 20. Similarly, the port 21 will tend to cut off communication between the head passageway 19 and the longitudinal bore 26 in the plunger 16. However, since the motor 49 is still running, the piston valve head 39 will continuously move upwardly.

The plunger head 17 will, therefore, carry out a follow-up movement until the plunger head 17 has reached its uppermost position or, if a shorter stroke is desired, until the limit switch 63 is actuated either by the cam surface of the groove 60 or the cam member 61 in the said groove. Actuation of the limit switch 63 causes interruption of the holding circuit for the solenoid 114 so that the energizing circuit for the motor 49 will be interrupted and the motor will come to a standstill.

If it is now desired to retract the motor plunger 16, the switch lever 110 which, after its previous actuation was returned to its neutral position by the spring 111, is now shifted to contact the terminal 112. Current will then flow from the main supply line 122 to the line 104, the switch lever arm 121, the line 119, the lever 110, the line 115, the coil 137 and the line 147, through the limit switch 62, from where it will flow through the line 144 to the main supply line 126. This circuit will energize the coil 137, thereby causing attraction of the armature 94. The switch blade 98 will then contact the terminals 99 and 100, thereby establishing a holding circuit comprising the main supply line 122, the line 104, terminal 100, switch blade 98, terminal 99, lever arm 117, line 115, coil 137, line 147, limit switch 62 and line 144 and the main supply line 126. The switch blades 95, 96 and 97 will then close the energizing circuit for the motor 49 so that the latter rotates in a direction opposite to its previous direction of rotation. As a result thereof, the threaded portion 52 of the valve rod and, thereby, also the valve head 39 will be moved downwardly. This opens up the L-shaped head passageway 19 for communication through the port 21 with the longitudinal passageway 26 and, at the same time, closes off the port 20 of the L-shaped head passageway 18 against the discharge of pressure fluid therethrough. Consequently, the pressure fluid from the pump 34 is applied only within the upper end of the bore 11 against the annular plunger head area 145, while all pressure is released against the lower plunger head area 146. The plunger 16, therefore, moves downwardly and the fluid displaced from beneath the plunger 16 is moving upwardly through the passageway 19, the port 21, the counterbore 24, the plunger passageway 26, the cross passageway 27, the cylinder bore 12, the outlet port 32 and the conduit 35, a part to the suction side of the pump 34 and a part to the fluid tank 48. Since the motor 49 continues running, there will be a follow-up movement of the plunger head 17, similar to the follow-up movement described above in connection with the upward movement of the plunger 16. The plunger head 17 will come to a standstill either when it engages the head 44 or, if an earlier stop is desired, when the limit switch 62 is actuated by the cam surface of the groove 60 or the cam member 61 therein, thereby interrupting the energizing circuit for the motor 49.

It should be noted that the movement of the valve rod 40 may be stopped at any desired point and time by mere operation of the lever arm 107 or 117, respectively, to break the energizing circuit for the coil 113 and 137, respectively.

So far, manual operation has been described. If semi-automatic operation is desired, in other words, if the plunger 16 is to carry out an upward and a downward stroke and is then automatically to stop, the lever arm 121 is to be shifted so as to disengage the terminal 120 and engage the terminal 129. Furthermore, the cam

member 61 in the groove 50 is so adjusted that it will not engage the limit switch 63 at the end of the upward stroke of the plunger 16. On the other hand, the arm 148 is so adjusted that, at the desired end of the upward stroke of the plunger 16, it will engage and shift the toggle lever switch arm 131, so that the toggle lever switch arm 132 disengages the terminal 133 and engages the terminal 135. The operation of the device, in this instance, will be the same as described above with the exception that the limit switch 63 will not be operated but instead thereof the direction of rotation of the motor 49 will be changed at the end of the upward stroke of the plunger 16 by the shifting movement of the toggle lever arm 131. At the end of its desired downward stroke, the plunger 16 will come to a standstill, in the manner described above.

If full automatic operation is desired, it will be necessary, in addition to the adjustment to be effected for semi-automatic operation, also to make the limit switch 62 inoperative by correspondingly adjusting the cam member 61 pertaining thereto. Furthermore, the arm 149 will be adjusted on the rod 150 so that, at the end of the downward stroke of the plunger 16, the arm 149 switches the toggle lever arm 131 in a direction opposite to the direction in which the lever arm 131 is shifted by the arm 148. It will be obvious that, after effecting of the said adjustment, the plunger 16 will continuously carry out a desired number of cycles. The stroke of the plunger 16 may, in this instance, be controlled by the position of the arms 148 and 149. As previously stated, the operation of the device may, at any

desired time, be interrupted by operation of the lever arm 107 or 117.

It will be understood that we desire to comprehend within our invention such modifications as come within the scope of the claims and the invention.

Having thus fully described our invention, what we claim as new and desire to secure by Letters Patent, is:

1. In combination in a servomotor, a valve, a reversible electric motor, a reciprocable control rod arranged in alignment with the motor shaft of said electric motor for operating said valve, means for positively preventing rotation of said control rod in all positions of its movement, screw means directly interconnecting said motor shaft and said control rod and responsive to a rotation of said motor shaft for effecting longitudinal movement of said control rod, and electric means for selectively varying the length of the stroke of said control rod.

2. In combination in a servomotor, a valve, a reciprocable control rod, means for preventing rotation of said control rod in all positions of its movement, an electric circuit including a reversible electric motor having its motor shaft threadedly engaged by said control rod for imparting longitudinal movement thereon to operate said valve, and adjustable cam means supported by said control rod and adapted in response to the travel of said control rod selectively to open and close said circuit for controlling said motor.

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