June 16, 1953 E. L. POTTS 2,642,045

FLUID MOTOR HAVING PISTON ACTUATED PILOT VALVE

Filed Feb. 20, 1950 5 Sheets-Sheet 1

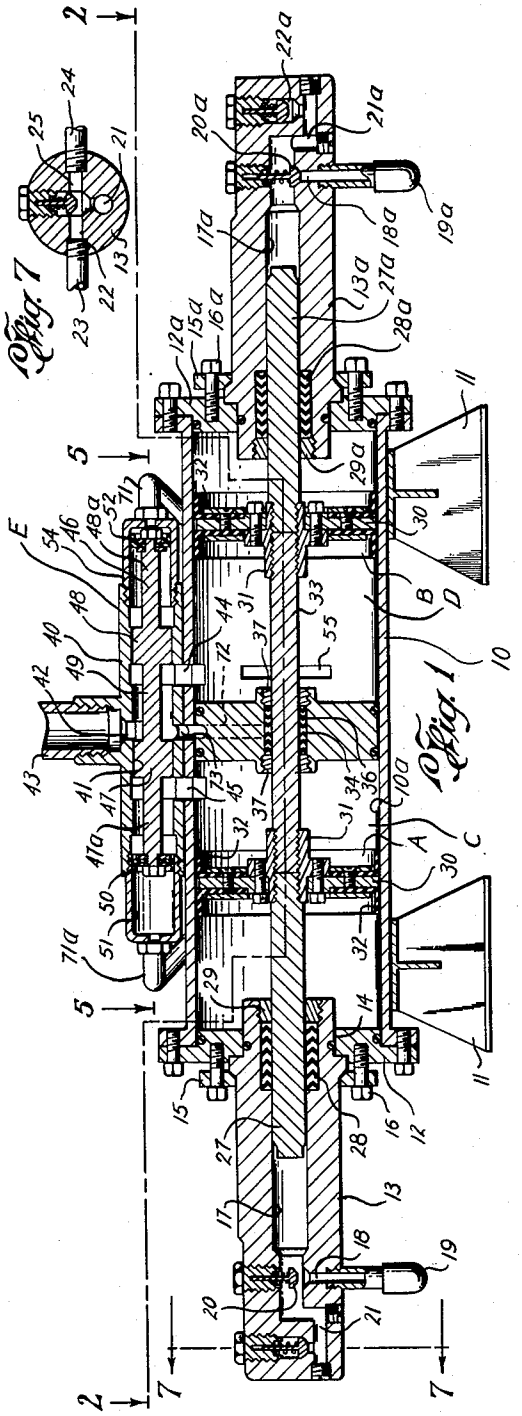


Fig. 1

Fig. 2

Fig. 7

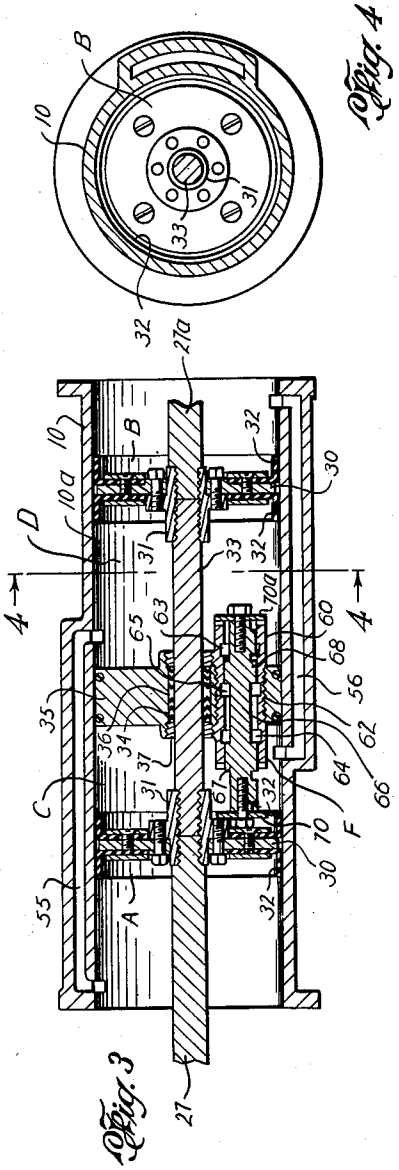


Fig. 3

Fig. 4

Ernest L. Potts
INVENTOR.

BY J. Vincent Martin
and
Joe E. Edwards
ATTORNEYS

June 16, 1953 E. L. POTTS 2,642,045

FLUID MOTOR HAVING PISTON ACTUATED PILOT VALVE

Filed Feb. 20, 1950 5 Sheets-Sheet 2

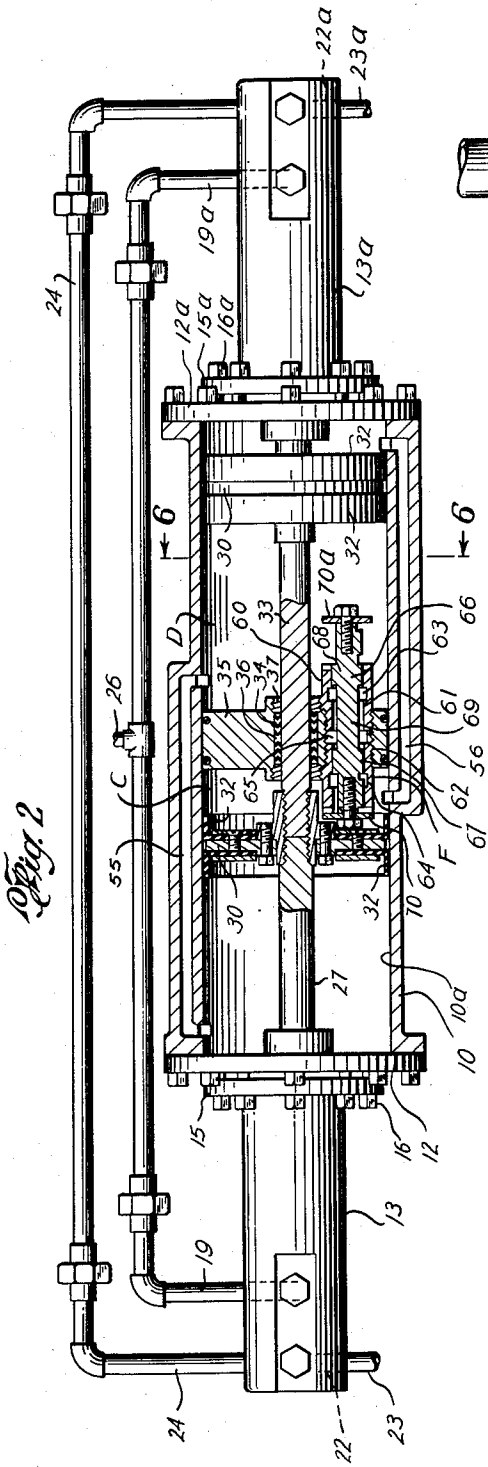


Fig. 2

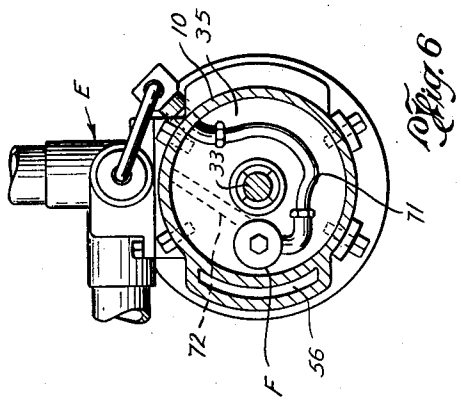


Fig. 6

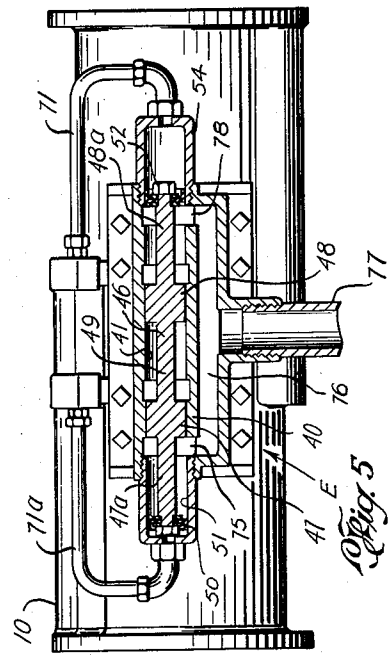


Fig. 5

Ernest L. Potts
INVENTOR.
BY J. Vincent Martin
and
Jos. E. Edwards
ATTORNEYS

June 16, 1953 E. L. POTTS 2,642,045

FLUID MOTOR HAVING PISTON ACTUATED PILOT VALVE

Filed Feb. 20, 1950 5 Sheets-Sheet 3

Fig. 8

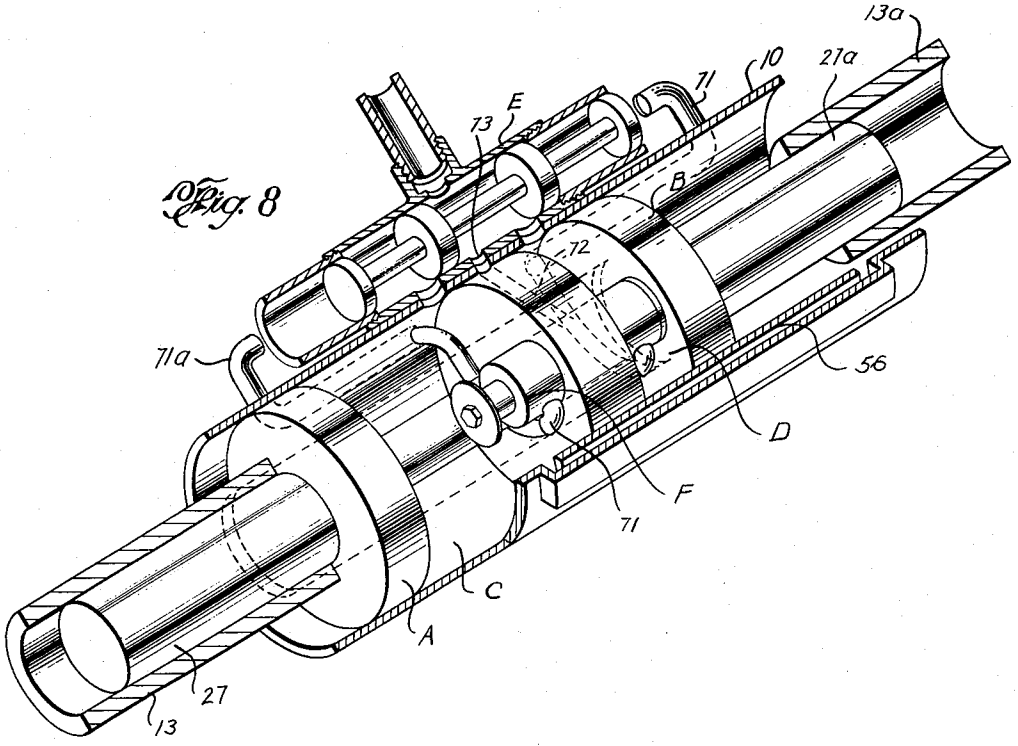
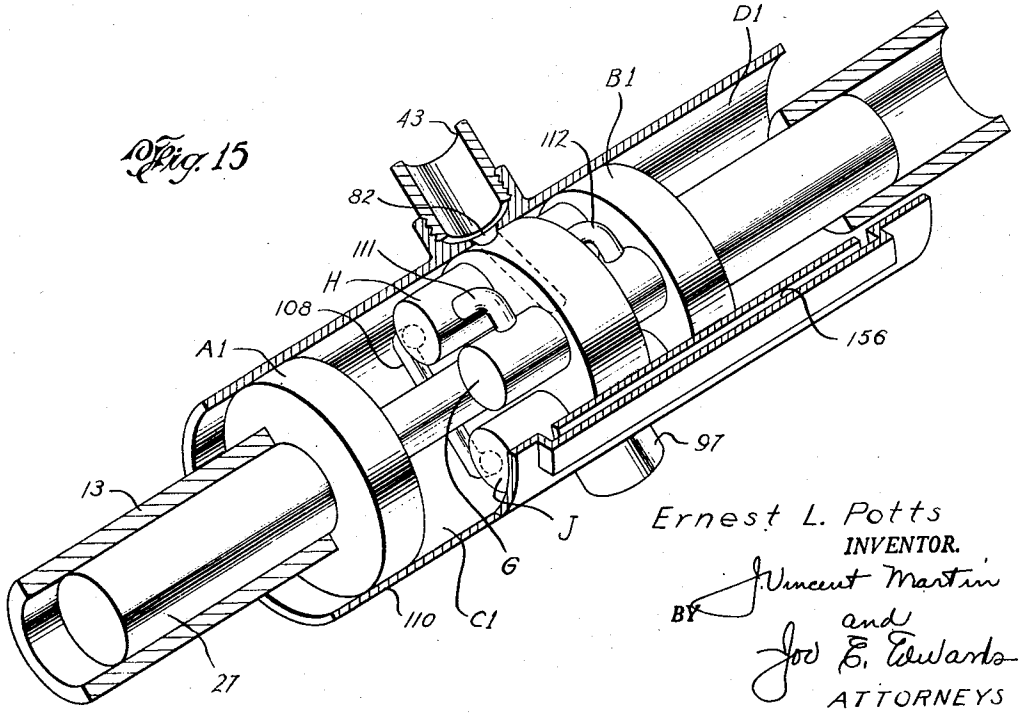


Fig. 15



Ernest L. Potts
INVENTOR.
BY J. Vincent Martin
and
Joe E. Edwards
ATTORNEYS

June 16, 1953 E. L. POTTS 2,642,045

FLUID MOTOR HAVING PISTON ACTUATED PILOT VALVE

Filed Feb. 20, 1950 5 Sheets-Sheet 4

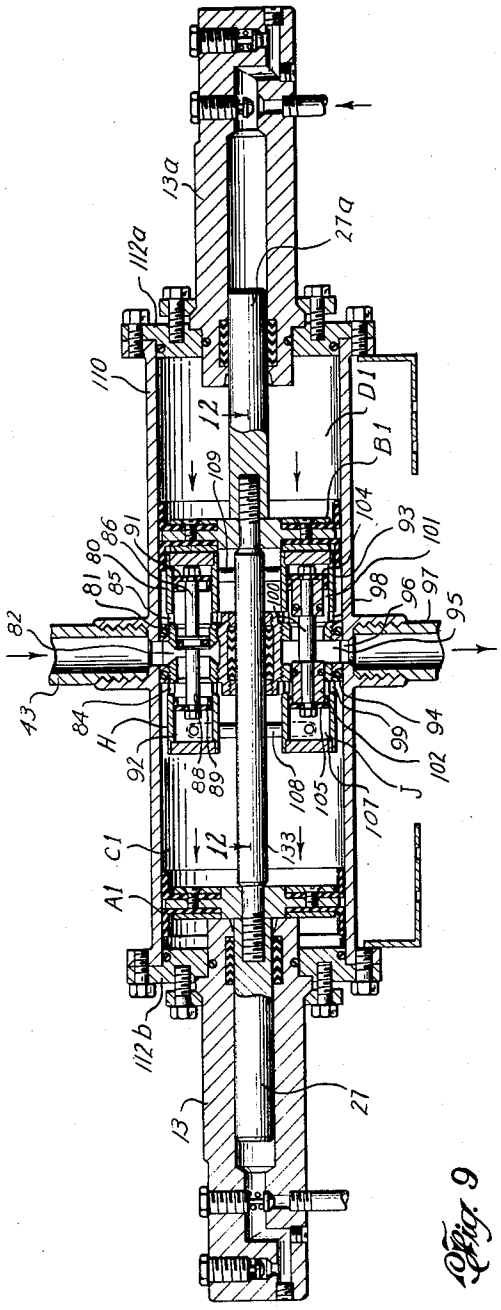


Fig. 9

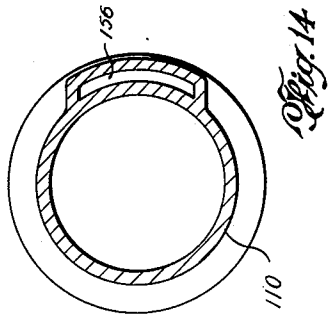


Fig. 14

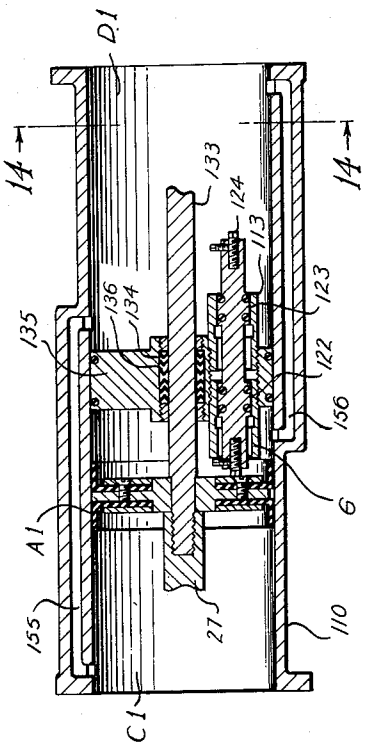


Fig. 12

Ernest L. Potts
INVENTOR.
BY J. Vincent Martin
and
Joe E. Edwards
ATTORNEYS

June 16, 1953 E. L. POTTS 2,642,045

FLUID MOTOR HAVING PISTON ACTUATED PILOT VALVE

Filed Feb. 20, 1950 5 Sheets-Sheet 5

Fig. 10

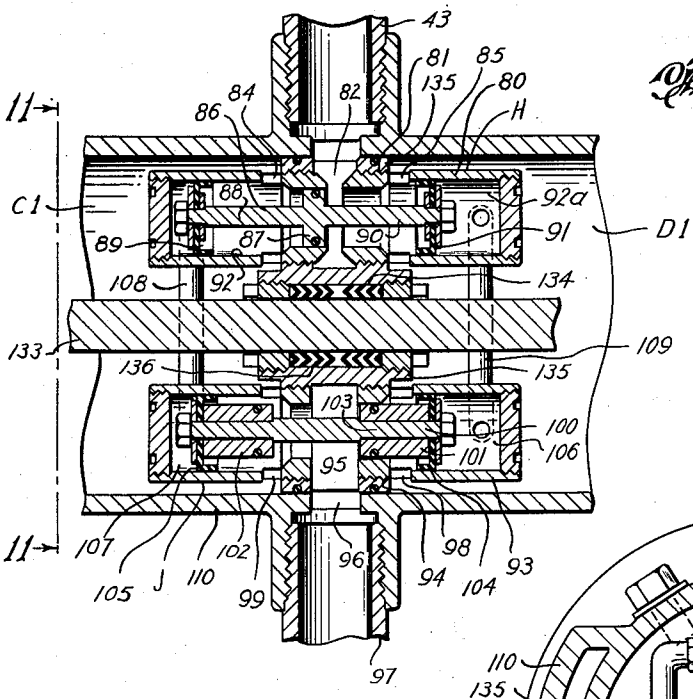


Fig. 11

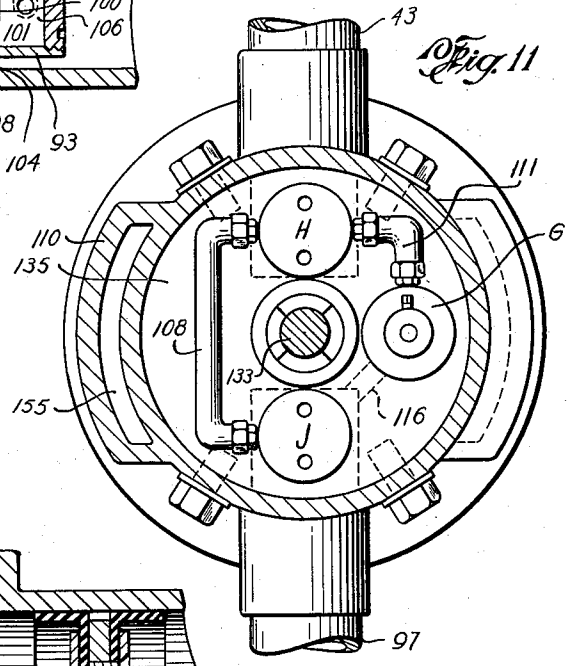
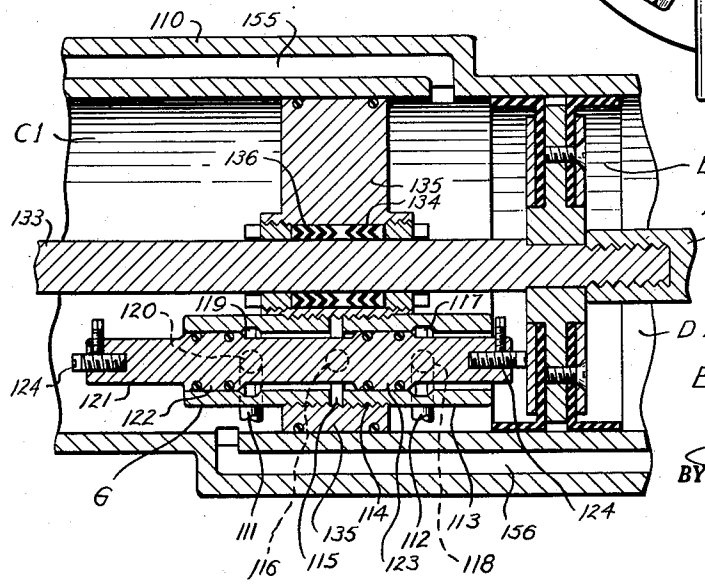


Fig. 13



Ernest L. Potts
INVENTOR.

BY J. Vincent Martin
and
Joe E. Edwards
ATTORNEYS

Patented June 16, 1953 2,642,045

UNITED STATES PATENT OFFICE

2,642,045

FLUID MOTOR HAVING PISTON ACTUATED PILOT VALVE

Ernest L. Potts, Houston, Tex., assignor to Brown Oil Tools, Inc., Houston, Tex., a corporation of Texas

Application February 20, 1950, Serial No. 145,249

11 Claims. (Cl. 121—157)

1

This invention relates to new and useful improvements in pump apparatus.

One object of the invention is to provide an improved high pressure pump apparatus which is particularly adaptable for use in building up and maintaining a pressure in a boiler, pipe line or other system, whereby pressure testing of the system under test may be efficiently accomplished.

An important object of the invention is to provide an improved pump apparatus wherein a relatively low pressure medium may be employed to actuate the apparatus to build up and maintain a desired high pressure in the pressure system under test and also wherein an accurate control of the pressure in the system under test may be maintained.

A particular object of the invention is to provide a pump apparatus of the character described, having an improved control valve mechanism which is not exposed to the high pressure in the pressure system under test, whereby the usual "D" slide valve, together with its inherent disadvantages, is eliminated and more efficient operation with less wear on the valve mechanism is assured.

A further object is to provide a pump apparatus having a reciprocating piston assembly whereby a double stroke pump action is produced; said piston assembly including relatively large power pistons which are not exposed to the high pressure in the system under test and which may therefore be of the simple plunger type which decreases cost of manufacture and maintenance.

Another object is to provide an apparatus, of the character described, having a power piston connected with and actuating the high pressure pump piston, with the ratio of the area of the power piston to the area of the pump piston being predetermined and controlled, whereby a predetermined operating pressure applied to the power piston will result in the building up and maintenance of a predetermined high pressure in the pressure system under test.

Still another object is to provide a pump apparatus having a control valve mechanism for controlling the application of the operating pressure fluid to the reciprocating power piston assembly, together with an actuator valve device for controlling actuation of the control valve mechanism; said actuator valve device being operated by the power piston assembly whereby reversal of the direction of movement of the piston assembly is automatically effected by the

2

coaction of said assembly with said actuator device.

A particular object of the invention is to provide a pump apparatus having a control valve mechanism for controlling the application of the operating pressure fluid to the reciprocating power piston assembly and having means for utilizing the pressure of the operating fluid for actuating the control valve mechanism and also for maintaining the control valve mechanism in a locked position during the travel of the power pistons.

A further object is to provide a pump apparatus of the character described wherein an actuator valve device, the position of which is controlled by the power pistons, controls the application and exhaust of pressure to the control valve mechanism whereby as the power piston assembly completes its movement in one direction, the actuator automatically shifts the control valve to reverse the direction of movement of the piston assembly.

A still further object is to provide a pump apparatus of the character described, wherein a main cylinder is divided into two chambers and wherein a double power piston assembly is employed, with one piston being movable in each chamber; the apparatus also including a control valve arrangement whereby the flow and exhaust of the operating pressure fluid to both chambers is automatically controlled to impart reciprocation to the double power piston assembly.

Another object is to provide a pump apparatus of the character described, which is of simplified construction and which has the various working parts, such as pistons and packing, readily accessible for repair or replacement, whereby maintenance and repair costs are minimized.

The construction designed to carry out the invention will be hereinafter described together with other features thereof.

The invention will be more readily understood from a reading of the following specification and by reference to the accompanying drawings forming a part thereof, wherein an example of the invention is shown, and wherein:

Figure 1 is a longitudinal sectional view of a pump apparatus constructed in accordance with the invention,

Figure 2 is a horizontal cross-sectional view taken on the line 2—2 of Figure 1 and illustrating the actuator valve device in one position,

Figure 3 is a view of the central portion of

Figure 2 showing the actuator valve device in a shifted position,

Figure 4 is a transverse sectional view taken on the line 4—4 of Figure 3,

Figure 5 is a horizontal cross-sectional view taken on the line 5—5 of Figure 1 with the control valve in a position shifted from that illustrated in Figure 1,

Figure 6 is a transverse sectional view taken on the line 6—6 of Figure 2,

Figure 7 is a transverse sectional view taken on the line 7—7 of Figure 1,

Figure 8 is a schematic view of the apparatus and diagrammatically illustrating the working parts thereof,

Figure 9 is a longitudinal sectional view of a modified form of the apparatus wherein inlet and exhaust control valves are provided,

Figure 10 is an enlarged longitudinal sectional view of the inlet and exhaust valves of Figure 9, with said valves shifted from that illustrated in Figure 9.

Figure 11 is a transverse sectional view taken on the line 11—11 of Figure 10,

Figure 12 is a horizontal cross-sectional view taken on the line 12—12 of Figure 9 and illustrating the actuator valve device of this form in one position,

Figure 13 is an enlarged view of the actuator valve device of Figure 12 showing said device in a shifted position,

Figure 14 is a transverse sectional view taken on the line 14—14 of Figure 12, and

Figure 15 is a schematic view showing the working parts of the modified form of apparatus illustrated in Figures 9–14.

In the drawings, the numeral 10 designates a main cylinder which is mounted on suitable base supports 11. One end of the cylinder 10 is closed by a flanged closure plate 12 and a pump cylinder 13 has its inner end mounted within a central opening 14 in the plate, being secured to said plate by a retaining ring 15 and bolts 16. The cylinder 13 is formed with an axial bore 17 which is of a considerably reduced diameter as compared to the bore 10*a* of the main cylinder.

The bore 17 of the cylinder 13 is provided with an inlet passage 18 which has connection with a pressure inlet line 19. An intake valve 20 controls flow through the intake passage 18. An angular passage 21 establishes communication between the bore 17 and exhaust opening 22, said exhaust having connection with an outlet line 23 (Figure 2). A second pump piston 13*a* which is identical in construction with the pump piston 13 is mounted at the opposite end of the main cylinder 10, being secured to a closure plate 12*a* by a retaining ring 15*a* and bolts 16*a*. The cylinder 13*a* has a reduced bore 17*a* which has communication with an inlet passage 18*a* having an inlet valve 20*a* disposed therein. The bore 17*a* also communicates through an angular passage 21*a* with an exhaust opening 22*a*. A manifold 24 has one end connected to the exhaust 22*a* and its opposite end connected to a port 25 formed in the cylinder 13 opposite the exhaust port 22 (Figure 7) and thus, the exhaust from both cylinders 13 and 13*a* may be directed outwardly through the exhaust line 23 extending from the cylinder 13. The conductor or line 19 which extends from the inlet 18 of the cylinder 13 has connection with an inlet pipe 26 and this pipe is also connected through a line 19*a* with the inlet 18*a* of the cylinder 13*a*. It will be understood that the inlet pipe 26 is connected to a suitable pressure fluid source while the exhaust line 23 has connection with the pressure system to be tested, such as a boiler, pipe line or the like.

For building up a pressure within the system to be tested a piston 27 is mounted to reciprocate within the bore 17 of the cylinder 13, and this piston is in the form of a cylindrical rod or plunger. A suitable packing 28 is mounted at the inner end of the cylinder around the piston plunger 27 and is retained in position by a packing nut 29.

A similar piston plunger 27*a* is mounted to reciprocate within the bore 17*a* of the cylinder 13*a* and a suitable packing 28*a* surrounds this plunger and is retained in position by a packing nut 29*a*. As will be explained, the piston plungers 27 and 27*a* reciprocate within their respective cylinders and provide a double stroke pump. The plungers are operated in unison and upon the intake stroke of the plunger 27 the plunger 27*a* moves through its pressure stroke; similarly, upon a reversal of movement the plunger 27 applies pressure while the plunger 27*a* moves through its intake or suction stroke. The plungers 27 and 27*a* are operated to build up the desired pressure in the system under test and to maintain said system under the desired pressure for the predetermined testing time.

For imparting a reciprocating movement to the pump plungers 27 and 27*a* a pair of power pistons A and B are mounted within the main cylinder 10 and are adapted to reciprocate therein. Each piston includes a circular plate or body 30 which is bolted to an axial collar 31. Oppositely directed annular sealing cups 32 are attached to the body and engage the wall of the bore 10*a* of the main cylinder 10. The inner end of the pump plunger 27 is threaded into the axial collar 31 of the piston A while the inner end of the pump plunger 27*a* is connected to the collar 31 of the piston B. A piston rod 33 has its ends also connected to the collars 31 of the pistons A and B and functions to connect the pistons to each other. The rod 33 is guided within an axial opening 34 formed in an annular block member 35 which is mounted centrally within the main piston 10. Suitable packing 36 surrounds the piston rod 33 and is retained in position by packing nuts 37.

It will be evident that the central block 35 divides the main cylinder 10 into two chambers C and D with the piston A being movable within chamber C while the piston B is movable within chamber D (Figure 1). The piston rod 33 connects the pistons A and B to each other and these pistons are in turn directly connected to the pump plungers 27 and 27*a* so that the pistons and the pump plungers move as a unit. It will be obvious that as the pistons A and B reciprocate within their respective chambers C and D the pump plungers 27 and 27*a* will reciprocate within their respective cylinders to thereby build up the desired pressure in the exhaust or outlet line 23 leading to the pressure system under test.

For controlling the operation of the main power pistons A and B by means of a pressure fluid, a control valve assembly E is mounted on the main cylinder 10 and is suitably attached thereto. The control valve assembly includes a cylinder 40 having an axial bore 41 and provided with an inlet port 42 preferably in its upper surface. A pressure inlet line 43 connects with the inlet 42. A radial port 44 establishes communication between the bore 41 of the valve cylinder 40 and the chamber D of the main cylin-

der, while a similar port 45 establishes communication between the bore 41 of the valve cylinder and the chamber C of the main cylinder. Thus, the operating pressure fluid may be directed from the inlet line 43 through the inlet port 42 and through port 44 to move the pistons and plungers in a direction to the right in Figure 1; when directed from the inlet port 42 through the port 45 into the chamber C, the pistons A and B are moved in a direction to the left in Figure 1.

For controlling the application of pressure into either the chamber C or the chamber D of the main cylinder 10 a reciprocating valve 46 is slidable within the bore 41 of the valve cylinder 40. This valve has a pair of enlarged valve heads 47 and 48 which are connected by a reduced stem 49. Beyond the head 47 a reduced piston rod 47*a* is provided and carries a piston 50 which is slidable within a cylinder 51 which is attached to the end of the valve cylinder 40. A similar piston 52 attached to a piston rod 48*a* extending from the valve head 48 is provided at the opposite end of the valve assembly and is movable within a cylinder 54 attached to the opposite end of the valve cylinder.

When the control valve 46 is in the position shown in Figure 1 the valve head 47 is disposed between the inlet 42 and the port 45 whereby pressure fluid cannot pass to the chamber C; at this time the valve head 48 has uncovered the port 44 so that the operating pressure fluid from the inlet 42 may pass into the chamber D and act upon the piston B to move the same in a direction to the right in Figure 1. This pressure in chamber D may also flow through a connecting passage 55 (Figure 2) which establishes communication between the chamber D adjacent the central block 35 and that end of the chamber C adjacent the inner end of the pump cylinder 13. Thus, when the control valve 46 is in the position shown in Figure 1 the operating pressure is applied to the surfaces of the pistons A and B whereby the pistons are moved in a direction to the right in this figure. The exhaust of pressure from the main cylinder 10 in advance of the pistons as they move to the right will be hereinafter explained and the exhaust areas are in communication with each other through a passage 56 which establishes communication between the chamber C adjacent the central block 35 and that end of the chamber D adjacent the cylinder 29*a*.

When the control valve 46 is shifted to the position shown in Figure 5 the valve head 48 shuts off the communication between the inlet 42 and the port 44 whereby pressure fluid cannot pass to the chamber D between the piston B and the central head 35. At the same time the valve head 47 moves to a position which establishes communication between the inlet 42 and the port 45 and thus, pressure fluid may flow into the chamber C between the piston A and the central block 35. This pressure fluid may then pass through the passage 56 and into the chamber D between the piston B and the end plate 12*a* so that pressure fluid is thus applied to both pistons in a direction to move these pistons to the left in Figure 1. The by-pass 55 in this case permits the exhaust of pressure from in advance of the pistons in their movement to the left, as will be explained.

The operation of the valve 46 which controls the application of pressure to either one side or the other of the main pistons A and B is effected by means of a control device F (Figure 2) which is mounted within the central block 35. The control device includes a cylinder 60 having an axial bore 61. It is preferable that the cylinder be formed in two sections which may be threaded into an opening 62 provided in the block. An annular recess 63 is formed nearer one end of the cylinder with a recess 64 being formed nearer the opposite end of said cylinder. A central annular recess 65 is provided at the central portion of the cylinder and the recesses 63 and 64 are adapted to be alternately placed in communication with the central recess 65. A valve plunger 66 is adapted to reciprocate within the bore 61 of the cylinder 60 and has a pair of spaced valve heads 67 and 68 which are connected by a reduced section 69. Stop members 70 and 70*a* are secured to opposite ends of the valve plunger and limit the movement of said plunger with respect to the cylinder. In one position of said plunger as shown in Figure 2, the valve heads 67 and 68 are located to establish communication between the internal recesses 63 and 65 while in the opposite position of the plunger 66, as shown in Figure 3, a communication is established between the recesses 64 and 65. It is noted that the particular recess which is shut off from the central recess 65 by the position of the valve plunger 66 is in communication with the adjacent chamber C or D, that is, the recess 64 communicates with the chamber C in Figure 2 while the recess 63 communicates with the chamber D in Figure 3.

The internal recess 63 of the actuator device F is directly connected through a conductor 71 with one end of the control valve assembly E so that pressure passing through the conductor may act against the piston 52 of said assembly. Similarly, the internal recess 64 of the actuator has connection through a conductor 71*a* with the opposite end of the control valve assembly E whereby pressure within the conductor 71*a* may act against the piston 50 of said assembly. The central recess 65 of the actuator device communicates through a passage 72 which extends through the block 35 (Figure 8) with a port 73 extending into the valve cylinder 40 diametrically opposite the inlet port 42. It will be obvious by observing Figure 1 that the port 73 remains open at all times and irrespective of the position of the valve heads 47 and 48. Thus, the operating fluid pressure is at all times directed through the port 73 and passage 72 to the central annular recess 65 of the actuator device F. From this point the pressure flows to the communicating recess, either 63 or 64 of the actuator device and then either through conductors 71 or 71*a* to opposite ends of the control valve assembly E. It is the application of this pressure to either the piston 50 or the piston 52 which moves the valve 46 to one position or the other to thereby control application of pressure to the pistons A and B.

The ports 44 and 45 which function to admit pressure to the chambers C and D, depending upon the position of the valve 46 also function as exhaust ports. With the valve 46 in the position shown in Figure 1 pressure is applied to the pistons in a direction to move said pistons to the right. The pressure in advance of the pistons passes from the area from the right of piston B through the passage 56 (Figure 2) and into the chamber C between the piston A and the central block 35. This pressure then flows through the port 45 and around the piston rod 49 from where it passes through a lateral exhaust port 75 (Fig-

ure 5) and into an exhaust passage 76 which is disposed at one side of the valve cylinder 40. An exhaust line 77 extends from the passage 76. A similar exhaust port 78 establishes communication between the valve cylinder 40 and the exhaust passage 76 so that when the valve 46 is moved to the position shown in Figure 5 the valve head 48 has moved to a position which allows communication between said ports 78 and the port 44 which leads to the chamber D of the main cylinder.

Exhausting of pressure which is acting upon the pistons 50 and 52 of the valve assembly E is effected through the lines 71 and 71a and through the bore 61 of the actuator device F. As has been pointed out the particular annular recess 63 or 64 which is not in communication with the central recess 65 is in communication with the adjacent chamber which is at that time exhausting into the exhaust chamber 76 at the side of the control valve E.

In the operation of the device it will be assumed that the parts are in the position shown in Figure 1 and the pistons A and B have almost but not quite completed their movement in a direction to the right in this figure. At such time the control device E is in the position shown in Figure 1 with the actuator device F in the position shown in Figure 3. In this position the operating pressure fluid is being applied into the chamber D through the port 44 and into the area of this chamber between the central block 35 and the piston B. This pressure is also acting through the passage 55 in the chamber C between the piston A and the end plate 12 of said chamber. At the same time the operating pressure fluid is conducted through the open port 73 and passage 72 and then through the control device F and conductor 71a so that it is applied to the piston 50 of the valve assembly E, thereby holding said valve assembly in the position shown in Figure 1.

As the main pistons A and B complete their movement to the right the piston A engages the end of the valve plunger 66 of the actuator device and moves said valve plunger to the position shown in Figure 2. As the plunger 66 of the control device F moves from the position of Figure 3 to the position of Figure 2, communication between the pressure inlet passage 72 and the conductor 71a leading to the piston 50 of the control valve E is shut off and at the same time a communication is established between the pressure passage 72 and the conductor 71 which leads to the piston 52 at the opposite end of the valve assembly. Simultaneously with the shutting off of communication between the pressure passage 72 and the conductor 71a the conductor 71a is opened through the end of the cylinder 60 of the device F to communicate with the exhaust portion of the chamber C which is that portion between the piston A and the central block. It is therefore obvious that as the plunger 56 is shifted from the position shown in Figure 3 to that shown in Figure 2, the cylindeh 51 in advance of the piston 50 is exhausted. Since pressure is simultaneously applied to the piston 52 of the valve assembly E the valve is shifted from the position shown in Figure 1 to that shown in Figure 5.

When the valve shifts, the valve head 47 moves to a position establishing communication between the pressure inlet 42 and the port 45 and at the same time the valve head 48 shuts off communication between the inlet 42 and the port 44 leading to the chamber D. However, at the same time the valve head 48 moving beyond or to the left of the port 44 in Figure 1 establishes communication between the port 44 and the exhaust port 78 (Figure 5) so that the port 44 becomes an exhaust port. It is therefore evident that upon movement of the valve to the position shown in Figure 5 pressure is applied to that side of the piston A which will move the piston in a direction to the left in Figure 1. This pressure may pass through the by-pass 56 to the chamber D between the piston B and the end plate 12a and thus pressure is applied to both pistons in a direction causing them to travel to the left. At this time pressure continues to be applied through the actuator device F and through the conductor 71 to the piston 52 of the control valve E to maintain the valve in the position shown in Figure 5. Also, as pressure enters the chamber C between the piston A and the central block 35 this pressure may flow into the conductor 71a and act against piston 50 but since this is the same pressure acting against piston 52 there will be no movement of the valve from the position shown in Figure 5 until the pressure acting against piston 52 is relieved.

The piston assembly thus moves to the left and continues such movement with the pressure in advance of the pistons A and B exhausting through port 44 and port 78 into the exhaust passage 76. As the pistons A and B complete their movement to the left in Figure 1 the piston B strikes the valve plunger 66 of the device F and returns this plunger to the position shown in Figure 3. As this movement of the valve plunger occurs the conductor 71 is connected with exhaust through the annular recess 63 and the end of the cylinder 60 of the actuator device. When this occurs the pressure present in conductor 71a immediately moves the valve 46 back to its initial position as illustrated in Figure 1 at which time pressure is reversed to move the pistons A and B in an opposite direction. This completes one cycle of the pistons and obviously as long as the pistons reciprocate to coact with the actuator device the reciprocating action is maintained.

The pistons A and B which are the main power pistons are of considerably larger diameter than the pump plungers 27 and 27a and thus a relatively low pressure operating fluid may be employed to build up a considerably higher pressure in the system under test. When water or other non-compressible fluid is employed as the operating fluid the ratio between the size of the pistons A and B to the size of the plungers 27 and 27a will control the amount of pressure built up in the system under test by merely controlling the pressure of the operating fluid. When the desired pressure is built up in the system under test the device will automatically stop. Any lowering of the pressure in the system under test will result in an automatic operation of the pistons A and B whereby the desired pressure is constantly maintained over the desired time.

The device is relatively simple in construction and provides an assembly wherein the working parts are readily accessible. The pump cylinders 13 and 13a may be readily removed and the packing 28 and 28a easily replaced. Each piston A and B may be removed from its respective end of the cylinder for replacement of its packing cups. Similarly, the valve assembly E is constructed so that the cylinders 50 and 54 at each end thereof may be readily removed to permit access to the valve 46. The apparatus may be employed to build up any desired pressure and is

completely automatic upon the introduction of the operating pressure through the line 43. The single valve assembly E is located exteriorly of the main cylinder and functions to control both the inlet and exhaust of pressures from the areas on either side of the main pistons A and B.

In Figures 9–15 a modified form of the invention is illustrated. This form is somewhat similar to the first form of the invention and is identical so far as the pump cylinders 13 and 13a together with plungers 27 and 27a are concerned. However, in this form an actuating device G is substituted for the actuating device F while an inlet control valve H and an exhaust control valve J are substituted for the single control valve E.

A main cylinder 110 having closure plates 112a and 112b at its ends has the main power pistons A1 and B1 adapted to reciprocate within chambers C1 and D1 formed on opposite sides of a central block member 135. A piston rod 133 has its ends extending through the pistons A1 and B1 and secured respectively to the pump plungers 27 and 27a. The rod is movable through a central opening 134 in the block 135 and suitable packing 136 seals off around said rod. It is evident that as the pistons A1 and B1 are reciprocated within the main cylinder 110 the plungers 27 and 27a are reciprocated within their respective cylinders.

The inlet control valve H is disposed within the main cylinder 110 and inclueds a valve cylinder 80 which has its central portion mounted within an opening 81 in the central block 135. An inlet 82 which may be in the form of an annular opening at the central portion of the cylinder communicates with the operating pressure inlet pipe 43, whereby the operating pressure may be introduced into the valve cylinder 80. The cylinder is provided with inlet ports 84 which communicate with the chamber C1 in the area between the piston A1 and the central block 35 and said cylinder is also provided with similar ports 85 which are adapted to establish communication between the valve cylinder and the chamber D1 in the area between the piston B1 and central block.

For controlling the flow of pressure from the inlet 82 to either the ports 84 or the ports 85 a valve element 86 is mounted within the valve cylinder 80 and has an enlarged valve head 87 which is movable to one side or the other of the inlet 82. A piston rod 88 which is preferably made integral with the head extends axially therefrom and carries a piston 89 at its outer end. A similar piston rod 90 extends from the opposite end of the valve head and has a piston 91 secured to its outer end. The piston 89 is movable within a chamber 92 formed at one end of the valve cylinder while the piston 91 is movable within a similar chamber 92a formed at the opposite end of the cylinder.

When the valve 86 is in the position shown in Figure 9 pressure fluid may flow from the inlet pipe 43 through the inlet 82 and through ports 84 into the main cylinder chamber C1 between the piston A1 and the central block 135. This area of the chamber C1 communicates through a passage 156 with that end of the chamber D1 of the cylinder 110 adjacent the closure plate 112b and thus the operating pressure fluid is introduced into the chambers C1 and D1 against that area of the pistons A1 and B1 which will move the pistons in a direction to the left in Figure 9.

The exhaust of pressure in advance of the piston A1 as said piston moves to the left in Figure 9 is effected through a passage 155 which connects the end of the chamber C1 adjacent the closure plate 112a with the chamber D1 adjacent the central block 135. Exhaust of pressure fluid from the chamber D1 in advance of the piston B1 which is moving to the left in Figure 9 is effected through the exhaust control valve J.

The exhaust control valve J includes a valve cylinder 93 which may be made in two sections and mounted within an opening 94 in the central block 135 with the space between the inner ends of the cylinder sections forming an exhaust port 95 which communicates with an exhaust outlet 96 having connection with an exhaust line 97. Ports 98 are formed in the cylinder and are disposed within the chamber D1 while similar ports 99 are formed in the cylinder and are disposed within the chamber C1. A valve element 100 having valve heads 101 and 102 connected by a reduced stem 103 are slidable within the cylinder 93 and the ends of the valve heads are provided with pistons 104 and 105. The pistons are slidable within chambers 106 and 107 which are formed by the ends of the cylinder 93.

With the valve element 100 in the position shown in Figure 9 pressure fluid may exhaust from the chamber D1 between the piston B1 and the central block 135 through the ports 98, exhaust 95 and exhaust line 97. At this time the head 102 is in a position closing the ports 99 which ports are in communication with the pressure area of the chamber C1. When the exhaust valve is moved to the left in Figure 9 or to the position shown in Figure 10, then the head 101 closes the ports 98 and places the chamber C1 into communication with the exhaust line 97 through the ports 99.

For controlling the operation of the inlet and exhaust control valves H and J the end chambers of these valves are connected to each other with a conductor 108 connecting the chamber 92 of the valve H with the chamber 107 of the valve J and a similar conductor 109 connecting the chamber 92a of valve H with the chamber 106 of valve J. The chambers 92 and 92a of the inlet valve H are also connected by short elbow conduits 111 and 112 with the actuator device G.

The actuator device is clearly shown in Figure 13 and includes a cylinder 113 which may be made in sections and mounted within an opening 114 provided in the central supporting block 135. The area or space between the inner ends of the cylinder sections forms an annular exhaust opening 115 which communicates through a passage 116 (Figure 11) with the exhaust area 95 of the valve J. An annular recess 117 is formed in one end of the cylinder 113 and has communication with an opening 118 to which the conduit 112 connecting to the chamber 92a of valve H communicates. The opposite end of the cylinder 113 has an annular internal recess 119 which communicates with a port 120 having the conduit 111 connected thereto. The valve element 121 having spaced valve heads 122 and 123 thereon is slidable within the cylinder 113 and the position of the valve heads 122 and 123 with respect to the ports 116, 118 and 120 control communication between the exhaust passage 116 and either one or the other of the ports 118 or 120. Because the ports 118 and 120 are connected through the conduits 111 and 112 with the piston chambers 92 and 92a of valve H it will be evident that one or the other of these chambers is connected to exhaust, depending upon the position of the valve element 121 of the actuator device G. Each end

of the valve element 121 projects from the end of the cylinder 113 and may have an adjusting screw 124 mounted therein with said screws being arranged to be engaged by the cylinders A1 and B1 as they reciprocate within the cylinder.

In the operation of this form, assuming the inlet and exhaust valves H and J to be in the position shown in Figure 9, the actuator device G is in the position shown in Figure 12. In this position the valve element 121 of the device G is disposed so that the chamber 92a of valve H is connected to the exhaust line 97 because the port 118 of device G is in communication with the exhaust passage 116. The conductor 109 establishes communication between the chamber 92a of the valve H and chamber 106 of the valve J and thus there is no pressure acting against the pistons 91 and 104 of the valve H and J. Pressure from the inlet line 43 has entered the chamber C1 between the piston A1 and the central block 135 through the ports 84 and has also been directed through the passage 156 to the area of the chamber D1 in the main cylinder between the piston B1 and the end plate 112. The pressure acting against the piston A1 may pass into the end of the cylinder 113 of the control device G and through the port 20 and conduit 111 which leads to the chamber 92 of the valve H whereby this pressure acts against the piston 89 to maintain the valve in the position shown in Figure 9. This pressure also acts through the conductor 108 against the piston 105 of the exhaust valve to maintain said valve in the position shown in Figure 9. It is therefore obvious that the pressure is utilized not only to move the main power pistons A1 and B1 in a direction to the left but is also utilized to hold the valves H and J in a position continuing the application of pressure to the pistons so as to continue their movement to the left in Figure 9.

As the pistons approach the end of their stroke in a direction to the left in Figure 9, the piston B1 strikes the valve element 121 of the actuator device G and shifts said piston to the position shown in Figure 13. Shifting of the valve element 121 of the actuator connects the port 120 of the actuator with the exhaust 116 and at the same time shuts off the port 118 from the exhaust. As port 120 of the actuator device G is connected to exhaust 116 the pressure within the chamber 92 of the inlet valve H and the pressure within the chamber 107 of the exhaust valve J may be released through the conductor 108 and the conduit 111. The pressure which is between the piston B1 and the central block 135 which had previously been connected through exhaust to the port 118 is thus shut off from the exhaust passage 116 and this pressure is exerted through the conduit 112 to the chamber 92a of the inlet valve and simultaneously through the conductor 109 into the chamber 106 of the exhaust valve J, whereby the pressure is applied against the piston 91 of the inlet valve and the piston 104 of the exhaust valve. Because the pressure in the chambers of the opposite pistons 89 and 105 of these valves has been connected to exhaust by shifting of the actuator valve element 121 the application of pressure to pistons 91 and 104 will shift the valves to the position shown in Figure 10. In such position the operating pressure fluid from the inlet line 43 is directed through ports 85 and into the chamber D1 between the piston B1 and the central block 135. From this area pressure flows through the passage 155 and into the chamber C1 between the piston A1 and the end plate 112b, and thus pressure is applied to the pistons to move said pistons in a direction to the right in Figure 9.

Movement of the pistons continues until the piston A1 strikes the end of the valve element 121 of the actuator G to move said actuator from the position shown in Figure 13 back to the position shown in Figure 12. When this occurs, the chambers 92a of the inlet valve and 106 of the exhaust valve are connected to the exhaust line 97 while the chambers 92 of the inlet valve and 107 of the exhaust are connected to the area between the piston A1 and the central block 135. This results in the application of pressure to pistons 89 and 105 of the inlet and exhaust valves, respectively, whereby the valves are again returned or shifted to their original position which is that shown in Figure 9. This reverses the application of pressure to the main power pistons and results in the pistons again being moved to the left in Figure 9.

It will be evident that the inlet and exhaust valves H and J control the application and exhaust of pressures as the main pistons undergo reciprocating movement within the main cylinder 110. The pistons coact with the actuator G at the end of each stroke and shift the valve element of the actuator to apply an exhaust pressure from the valves H and J to effect a shifting of the valves. Thus, the operation is completely automatic with the control valves controlling the pressure and with the pistons coacting with the actuator to in turn control the position of the valves. As in the first form, the ratio between the area of the power pistons A1 and B1 with respect to the cross-sectional area of the plungers will determine the amount of operating fluid pressure which will be necessary to build up and maintain a desired pressure in the system under test. In both forms the operation is substantially identical and actually the basic difference in the two forms is that in the first form the control of pressure is accomplished by the single unit valve E. In both forms the operating pressure which moves the main power pistons is utilized to maintain the pressure control valve or valves in proper position until such time as the pistons coact with the actuator to permit the shifting or operation of said control valve or valves.

From the foregoing it will be seen that this invention is one well adapted to attain all of the ends and objects hereinabove set forth, together with other advantages which are obvious and which are inherent to the structure.

It will be understood that certain features and subcombinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of the claims.

As many possible embodiments may be made of the invention without departing from the scope thereof, it is to be understood that all matter herein set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

Having described the invention, I claim:

1. A hydraulic motor including, a cylinder having a central partition block dividing the cylinder into two chambers, a piston assembly comprising a pair of connected pistons with one of said pistons being slidable within one chamber and the other piston being slidable within the other chamber of the cylinder, each chamber having a pressure fluid inlet and a pressure fluid exhaust, valve means movable to two extreme positions for controlling the flow of pressure fluid

to and from the cylinder, one position of the valve means directing pressure fluid into the chambers against one side of each piston and exhausting pressure from the chambers on the opposite side of each piston whereby the piston assembly is moved in one direction within the cylinder, the second position of the valve means reversing the application and exhaust of pressure fluid with respect to the piston assembly to move the same in an opposite direction within the cylinder, and an actuator device within the central partition block and engageable by one of the pistons as the piston assembly approaches the end of its stroke for directing pressure fluid through the actuator device to the valve means to momentarily unbalance pressures across the valve means and move it from one extreme position to the other to reverse the direction of movement of the piston assembly within the cylinder.

2. A hydraulic motor as set forth in claim 1, together with means for utilizing the pressure which reciprocates the piston assembly for locking the valve means against operation during the travel of the piston assembly.

3. A hydraulic motor including, a cylinder having a central partition block dividing the cylinder into two chambers, a piston assembly comprising a pair of connected pistons with one of said pistons being slidable within one chamber and the other piston being slidable within the other chamber of the cylinder, each chamber having a pressure fluid inlet and a pressure fluid exhaust, valve means movable to two extreme positions for controlling the flow of pressure fluid to and from the cylinder, one position of the valve means directing pressure fluid into the chambers against one side of each piston and exhausting pressure from the chambers on the opposite side of each piston whereby the piston assembly is moved in one direction within the cylinder, the second position of the valve means reversing the application and exhaust of pressure fluid with respect to the piston assembly to move the same in an opposite direction within the cylinder, means for conducting the pressure fluid which actuates the piston assembly to the valve means, and an actuator device mounted in the central dividing block and connected in the conducting means for controlling the application of pressure to the valve means to control the position thereof and thereby control the direction of movement of the piston assembly, the actuator device having means when operated to momentarily unbalance the pressure applied to opposite sides of the valve means to shift the valve means after which said actuator device balances the pressures acting on the valve means to maintain said valve means in its shifted position, said actuator device being engaged and operated by the pistons of the piston assembly as said assembly approaches the end of each stroke, whereby the valve means reverses the flow of pressure fluid to the piston chambers each time a piston stroke is completed.

4. A hydraulic motor as set forth in claim 1, wherein the valve means comprises a single valve assembly mounted exteriorly of the cylinder.

5. A hydraulic motor as set forth in claim 1, wherein the valve means comprises an inlet control valve assembly and an exhaust control valve assembly with both assemblies being mounted within the central partition block within the cylinder.

6. A hydraulic motor including, a cylinder, a power piston adapted to reciprocate within the cylinder, the cylinder having a pressure fluid inlet and a pressure fluid exhaust, a control valve assembly having communication with the pressure fluid inlet and the pressure fluid exhaust and including a slide valve movable to two extreme positions, one position of the valve directing fluid to one side of the piston and exhausting fluid from the opposite side thereof and the other position of said slide valve reversing the application and exhaust of pressure fluid with respect to the piston, an actuator valve mounted within the cylinder and movable to two positions, means for conducting the pressure fluid to said actuator valve, a conductor extending from one end of the actuator valve to one side of the slide valve, a second conductor extending from the other end of the actuator valve to the opposite side of the slide valve, whereby in one position of the actuator valve pressure fluid is conducted to one side of the slide valve directly through one of the conductors with the opposite side of the slide valve being in communication with the interior of the cylinder through the other conductor, the other position of said actuator valve reversing the application of direct pressure to said slide valve, and means on said actuator valve engageable by the piston for effecting a shift of the actuator valve as the piston completes its stroke to alternately shift the slide valve from one position to the other.

7. A hydraulic motor including, a cylinder, a power piston adapted to reciprocate within the cylinder, the cylinder having a pressure fluid inlet and a pressure fluid exhaust, a control valve assembly having communication with the pressure fluid inlet and the pressure fluid exhaust and including a slide valve movable to two extreme positions, one position of the valve directing fluid to one side of the piston and exhausting fluid from the opposite side thereof and the other position of said slide valve reversing the application and exhaust of pressure fluid with respect to the piston, an actuator device for controlling the movement of the slide valve and mounted within the cylinder, said actuator device including a housing having its ends in communication with the interior of the cylinder, a pressure fluid inlet at substantially the central portion of the housing, a first conductor intermediate the fluid inlet and one end of said housing and communicating with one side of the slide valve, a second conductor intermediate the fluid inlet and the other end of said housing and communicating with the other side of the slide valve, a valve member movable to one position to establish communication between the pressure fluid inlet of the actuator device and the first conductor while establishing communication between the second conductor and the interior of the main cylinder, said member being movable to a second position to establish communication between the pressure fluid inlet of the actuator device and the second conductor while setting up communication between the first conductor and the interior of the cylinder, and means operated as the piston in the main cylinder reaches the end of each stroke to move the valve member of the actuator device from one position to another to thereby shift the slide valve of the control valve assembly and reverse the direction of movement of the piston within its cylinder.

8. A hydraulic motor including, a cylinder having a central partition block dividing the cylinder into two chambers, a piston assembly com-

prising a pair of connected pistons with one of said pistons being slidable within one chamber and the other piston being slidable within the other chamber of the cylinder, each chamber having a pressure fluid inlet and a pressure fluid exhaust, valve means movable to two extreme positions for controlling the flow of pressure fluid to and from the cylinder, one position of the valve means directing pressure fluid into the chambers against one side of each piston and exhausting pressure from the chambers on the opposite side of each piston whereby the piston assembly is moved in one direction within the cylinder, the second position of the valve means reversing the application and exhaust of pressure fluid with respect to the piston assembly to move the same in an opposite direction within the cylinder, an actuator device mounted within the central partition block and including a housing having its ends in communication with the cylinder on opposite sides of the block, a pressure fluid inlet extending to the housing of the actuator device, a first conductor extending from the housing to one side of the valve means, a second conductor extending from said housing to the other side of the valve means, a movable valve member within the housing engageable by the pistons as the piston assembly approaches the end of each stroke for momentarily unbalancing the pressures acting upon the valve means to alternately shift said valve means to alternately reverse the direction of travel of the piston within the cylinder as the piston assembly completes each stroke.

9. A hydraulic motor as set forth in claim 8, wherein the valve member of said actuator device balances the pressures acting upon the valve means after said valve means has been shifted to lock the valve means against operation during the travel of the piston assembly.

10. A hydraulic motor including, a cylinder having a central partition block dividing the cylinder into two chambers, a piston assembly comprising a pair of connected pistons with one of said pistons being slidable within one chamber and the other piston being slidable within the other chamber of the cylinder, each chamber having a pressure fluid inlet and a pressure fluid exhaust, valve means movable to two extreme positions for controlling the flow of pressure fluid to and from the cylinder, one position of the valve means directing pressure fluid into the chambers against one side of each piston and exhausting pressure from the chambers on the opposite side of each piston whereby the piston assembly is moved in one direction within the

cylinder, the second position of the valve means reversing the application and exhaust of pressure fluid with respect to the piston assembly to move the same in an opposite direction within the cylinder, an actuator device mounted within the central partition block and including a housing having its ends in communication with the cylinder on opposite sides of the block, a pressure fluid inlet extending to the housing of the actuator device, a first conductor extending from the housing to one side of the valve means, a second conductor extending from said housing to the other side of the valve means, a valve member within the housing movable to one position therein to establish communication between the first conductor and the pressure fluid inlet and to at the same time establish communication between the second conductor and the area of the cylinder on one side of the partition block, said valve member being movable to a second position to establish communication between the second conductor and the valve means and at the same time establish communication between the first conductor and the area on the other side of the partition, and means on said valve member engageable by the pistons of the piston assemby as said assembly approaches the end of each stroke whereby said valve member is shifted by the piston assembly to control the application of pressure to the valve means.

11. A hydraulic motor as set forth in claim 10, wherein upon initial movement of the valve member pressure conditions across the valve means are unbalanced to shift said valve means from one position to another after which pressure conditions across the valve means are equalized to hold the valve means in the position to which it has been shifted until the next subsequent operation of the valve member of the actuator device.

ERNEST L. POTTS.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
523,064	Babcock	July 17, 1894
880,737	Humphrey	Mar. 3, 1908
1,025,163	Schreidt	May 7, 1912
2,141,731	Wolfrom et al.	Dec. 27, 1938
2,186,970	Hambly	Jan. 16, 1940
2,239,715	Hollander et al.	Apr. 29, 1941
2,296,647	McCormick	Sept. 22, 1942
2,370,068	Palm	Feb. 20, 1945
2,555,018	Seggern	May 29, 1951