

April 15, 1952

C. B. LIVERS ET AL

2,593,039

VALVE FOR SEQUENTIAL OPERATION OF HYDRAULIC MOTORS

Filed July 26, 1949

Fig. 1

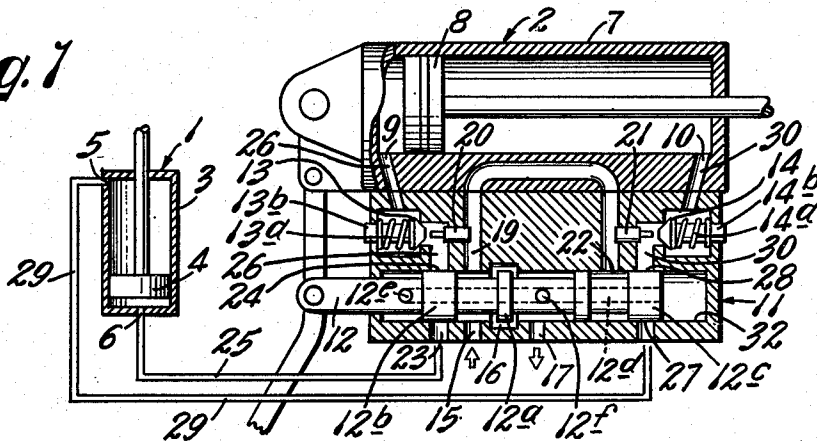


Fig. 2

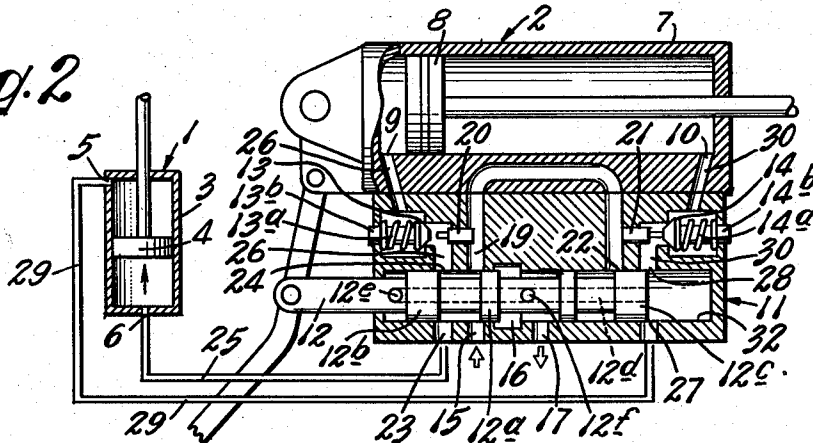
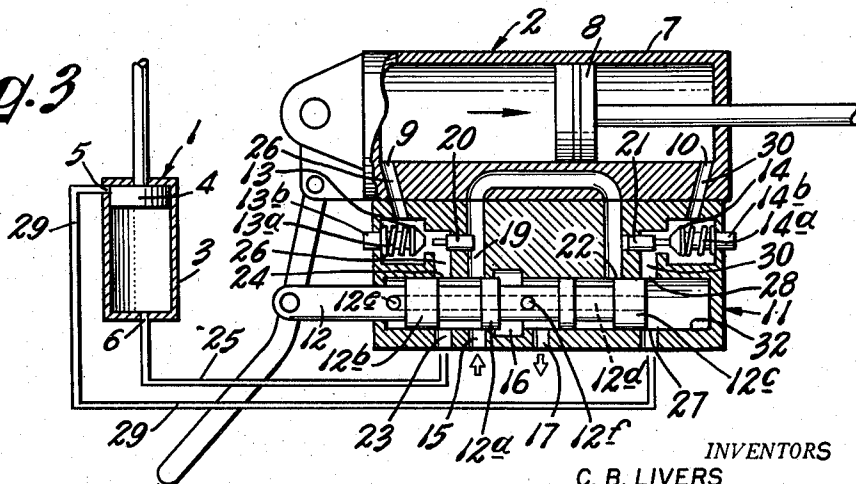


Fig. 3



INVENTORS
C. B. LIVERS
AND
A. A. MEDDOCK

BY *Ellwoodbury*
ATTORNEY

UNITED STATES PATENT OFFICE

2,593,039

VALVE FOR SEQUENTIAL OPERATION OF
HYDRAULIC MOTORS

Carlos B. Livers, North Hollywood, and Alvin A. Meddock, Van Nuys, Calif., assignors to Bendix Aviation Corporation, South Bend, Ind., a corporation of Delaware

Application July 26, 1949; Serial No. 106,934

1 Claim. (Cl. 60—97)

1

This invention relates to hydraulic power systems in which a pair of motor cylinders actuated from a common source of pressure fluid are to be operated in sequence.

An object of the invention is to provide a simple and practical valve for automatically delivering pressure fluid to one motor until it has moved through its stroke and thereafter switching the fluid to a second motor to move it.

Another object is to provide a sequence valve for reversible motors that actuates the motors always in the same sequence irrespective of the direction of movement.

Another object is to provide a sequence valve which, although depending upon a rise in line pressure to switch from the first to the second motor, is capable of applying the full line pressure to the second motor.

Other more specific objects and features of the invention will become apparent from the description to follow:

Briefly the invention resides in a valve arrangement comprising, in part, a conventional control valve of the 4-way type which, in a neutral position bypasses the actuating pressure fluid directly to exhaust; in one end position closes the bypass to exhaust and directs the pressure fluid to one end of each of the two motors while connecting the other ends of those motors to exhaust; and in the other end position cuts off the bypass of pressure fluid to exhaust while connecting the pressure fluid to the other ends of the motors in parallel and connecting their first ends to exhaust. Such control valves are old and, without any additional control means, the motor having the lesser load would respond to the pressure fluid and move through its stroke, after which the motor having the greater load would move through its stroke. The invention includes additional automatic valve means for confining the fluid flow to a selected one of the motors until it has completed its stroke irrespective to the relative loads on the two motors. This additional valve means includes a spring-closed valve in each of the ducts leading to the motor that is to be actuated last, with pressure responsive means for opening these valves only after the pressure in the system has risen to a predetermined value, such predetermined pressure being so chosen that it is higher than the pressure required to move the first motor under maximum load conditions thereof. The spring-closed valves are so disposed as to be opened directly in response to fluid pressure directed toward the motor cylinder, but these valves have opposite

2

pressure faces exposed to atmosphere, so that they remain open so long as the pressure in the ducts is sufficient to overcome the spring, thereby permitting the full pressure of the fluid to be effective on the motor. In operation, only one of the valves, the one in the inlet duct to the motor, is opened directly by the fluid pressure thereon. The spring-closed valve in the exhaust duct from the cylinder is not affected by pressure in the duct on the motor side thereof but, in accordance with the invention, such valve is opened by an auxiliary piston that is exposed on its front face to the full inlet pressure, and on its opposite face to exhaust pressure. Therefore, when the first motor has completed its stroke and the fluid pressure rises to the predetermined value, the valves in both ducts leading to the second motor are opened by such pressure, and the second motor is moved through its stroke. The automatic valve arrangement is symmetrical with respect to the two ducts leading to the motor so that it is reversible and functions equally well for movement of the second motor in both directions. However, regardless of the direction of movement, the first motor always moves first, and the second motor moves last.

A full understanding of the invention may be had from the following detailed description which refers to the drawing:

In the drawing:

Fig. 1 is a schematic diagram showing a hydraulic system incorporating the invention, in which two motors are in one end position and the control valve is in neutral position.

Fig. 2 is a view similar to Fig. 1 but showing the control valve moved into one end position, and the first motor partially moved through its stroke.

Fig. 3 is similar to Fig. 2 but shows the condition of the system after the first motor has completed its stroke and the second motor is moving through its stroke.

Referring first to Fig. 1, there is shown a first motor 1 and a second motor 2. The motor 1 comprises a cylinder 3 having a piston 4 therein and having ports 5 and 6 at opposite ends for the entry and exhaust of actuating fluid. The second motor 2 comprises a cylinder 7 having a piston 8 therein and having ports 9 and 10 at opposite ends thereof for the entry and discharge of fluid.

Flow of fluid to and from the motors 1 and 2 is controlled by the valve assembly 11 that is shown mounted on the motor 2 although it is not necessary that it be adjacent or attached

3

to the motor. This valve assembly 11 includes a manually operable control valve 12 and a pair of spring-closed pressure actuated valves 13 and 14 respectively. The control valve piston 12 is shown in mid position in Fig. 1, in which it directs fluid from a supply port 15 through an annular recess 16 around a land 12a on the valve piston and out through an exhaust port 17, so that no pressure is developed in the system. The inlet port 15 is permanently connected to a duct 19 which applies the inlet pressure to one end of a pair of valve actuating pistons 20 and 21 respectively, and also applies the inlet pressure to a port 22 displaced from the port 15 and co-operating with another portion of the control valve 12.

The control valve also has juxtaposed ports 23 and 24. Port 23 is connected to a duct 25 leading to the port 6 of the first motor 1, and port 24 communicates with a duct 26 leading to the port 9 of the second motor 2. The control valve has another pair of juxtaposed ports 27 and 28 respectively which are connected by ducts 29 and 30 respectively to the port 5 of the first motor 1 and the port 10 of the second motor 2. When the valve 12 is in neutral position, the ports 23 and 24 are closed by a land 12b thereon and the ports 27 and 28 are closed by a land 12c thereon.

Opposite ends of the cylinder 32 in which the control valve 12 reciprocates are at all times connected to the exhaust port 17 by a passage 12d in the valve 12, the right end of which passage communicates with the right end of the cylinder 32, the left end of which communicates through a port 12e with the left end of the cylinder, and a port 12f of which communicates with the mid portion of the cylinder where the port 17 is located.

Referring now to Fig. 2, in which the control valve 12 has been moved to the left, it will be observed that the land 12a has cut off direct flow of fluid from the inlet port 15 to the exhaust port 17, and has connected the inlet port to the ports 23 and 24. No flow of fluid occurs through port 24 at this time because the spring-closed valve 13 is closed. Therefore all fluid flows through the port 23 and duct 25 to the lower end of motor 1, moving it upward, it being shown in about mid stroke position in Fig. 2.

It is to be assumed that the stiffness of the spring 13a on the spring-closed valve 13 is such that it can only be overcome by a pressure applied against the right end of the valve of a predetermined magnitude greater than the pressure required to move the piston of the first motor 1 under maximum load condition thereof. Hence this valve 13 cannot open until the first motor 1 has completed its movement, as shown in Fig. 3. The pressure applied through the port 24 to the lower end of duct 26 then rises, and, when it reaches the predetermined value, it overcomes the spring 13a and opens the valve 13, whereupon fluid can flow through the duct 26 into the left end of the second motor 2. Of course the piston 8 of the second motor cannot move in response to pressure fluid in the left end of the motor unless the valve 14 is opened to permit exhaust of fluid from the right end of the motor. Such opening of the valve 14 is effected simultaneously with or slightly after the opening of the valve 13, by the piston 21, the left end of which is at all times exposed to the inlet pressure in duct 19, whereas, with the control valve 12 in the position shown in Fig. 3, the lower end

4

of duct 30 is connected by port 28, the passage 12d and the port 12f, with the exhaust port 17. Although the pistons 20 and 21 are approximately the same diameter as the seats against which the valves 13 and 14 close, they are preferably slightly smaller than the seats, to insure that actuating pressure fluid will be applied to one end of the second motor 2 before the other end is connected to exhaust.

It will be noted that each of the valves 13 and 14 extends through the valve casing to the exterior thereof so that its outer end is exposed to atmospheric pressure. Furthermore the shank portion 13b of valve 13 and 14b of valve 14 are of substantially the same diameter as the seats against which the valves close, so that when the valves are closed, as shown in Figs. 1 and 2, pressure in the upper ends of the ducts 26 and 30 respectively are ineffective to hold the valves closed. These valves 13 and 14 are therefore balanced and non-responsive to pressure in the upper ends of the ducts 26 and 30, but are responsive to pressure in the lower ends of those ducts.

It will be noted that in Figs. 2 and 3 both ends of the piston 20 are exposed to the inlet fluid pressure which is applied both to the lower end of the duct 26 and the duct 19, so that the pressures are balanced on the piston and it has no effect on the operation of the valve 13.

Because of the fact that the operation of the valves 13 and 14 is independent of the pressure in the upper ends of the ducts 26 and 30, these valves, when once opened in response to an inlet pressure exceeding the predetermined value, remain open so long as this pressure is maintained, and the full inlet pressure is effective on the second motor 2. Such would not be the case if the outer end of the valve 13 were exposed to the pressure of fluid in the upper end of the duct 26 instead of to the atmospheric pressure.

When the piston 8 of the second motor 2 has completed its movement to the right, and the control valve 12 is restored to the neutral position shown in Fig. 1, both the first and second motors will be locked into the positions into which they were last moved by closure of the ports 23 and 24 by the valve land 12b, and closure of the ports 27 and 28 by the valve land 12c.

If the control valve 12 is moved into its right end position, the valve land 12a is carried beyond the annular groove 16 to block direct flow from the port 15 to the exhaust port 17, and pressure fluid is then delivered from port 15 through the duct 19 to the ports 27 and 28, so that pressure fluid is applied through the duct 29 to the upper end of the first motor, and to the lower end of the duct 30, which is initially closed by the valve 14. At the same time, the ports 23 and 24 are connected through the port 12e, the passage 12d and the port 12f to the exhaust port 17, so that the first motor moves downward. When it has completed its movement, the inlet pressure will rise to the predetermined value, causing the valve 14 to be opened directly by the pressure thereagainst, and causing the valve 13 to be opened by the piston 20 so that the second motor is then moved from right to left.

Although for the purpose of explaining the invention one specific embodiment thereof has been shown and described, obvious modifications will occur to a person skilled in the art, and we do not desire to be limited to the exact details shown and described.

5

We claim:

A hydraulic valve for sequentially controlling the flow of fluid to and from first and second reversible motors comprising: a valve body defining a valve cylinder having a first pair of longitudinally displaced motor ports adapted to be connected to said first motor, a second pair of motor ports respectively juxtaposed to said first pair of ports, and pressure and exhaust ports longitudinally displaced from each other and from said motor ports; a valve piston reciprocable in said cylinder from a neutral position in either direction into two end positions, said piston having a pair of spaced lands each covering one of the ports of each pair of motor ports and sealing them from the other ports when said piston is in neutral position; means including said piston and cylinder defining a chamber on the inner side of each said land connected to said pressure port, and a chamber on the outer side of each said land connected to said exhaust port, whereby movement of said piston into one end position connects one of the ports of each pair of motor ports to said pressure port, and the other port of each pair to said exhaust port, and vice versa in response to movement of said piston into the other end position; said body defining a pair of motor passages extending from said second pair of motor ports for connecting them to said second

6

motor and defining a pair of auxiliary cylinders associated with said respective motor passages; each auxiliary cylinder extending from and communicating its associated motor passage with said pressure port; a spring-closed valve in each motor passage movable into open position in response to predetermined pressure in said passage; and a pressure-responsive piston in each auxiliary cylinder and movable therein to abut against and open the spring-closed valve in the associated motor passage in response to pressure in said pressure port exceeding the pressure in said associated motor passage by substantially said predetermined pressure.

CARLOS B. LIVERS.
ALVIN A. MEDDOCK.

REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
1,677,860	Ferris	July 17, 1928
1,823,426	Ferris	Sept. 15, 1931
1,955,154	Temple	Apr. 17, 1934
1,994,974	Wiedmann	Mar. 19, 1935
2,154,038	Evrell	Apr. 11, 1939
2,301,028	Esch	Nov. 3, 1942
2,354,860	Hartsock et al.	Aug. 1, 1944