

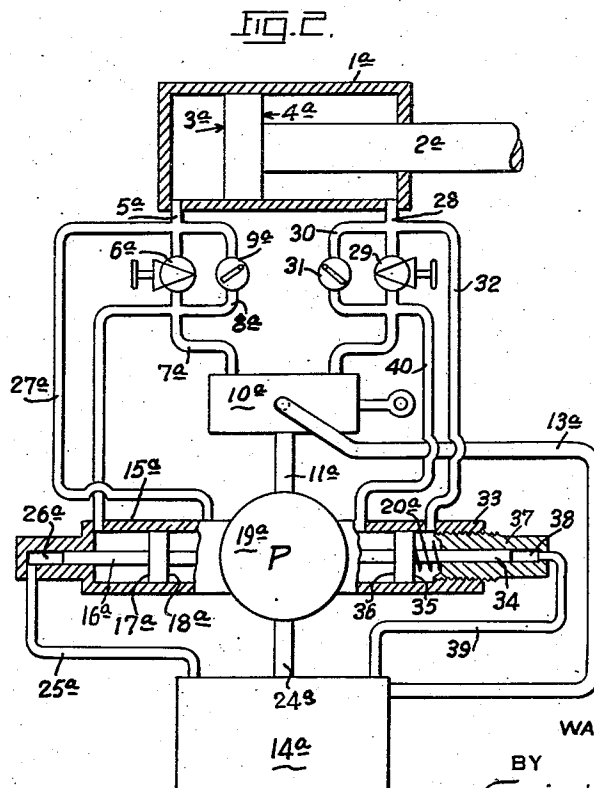
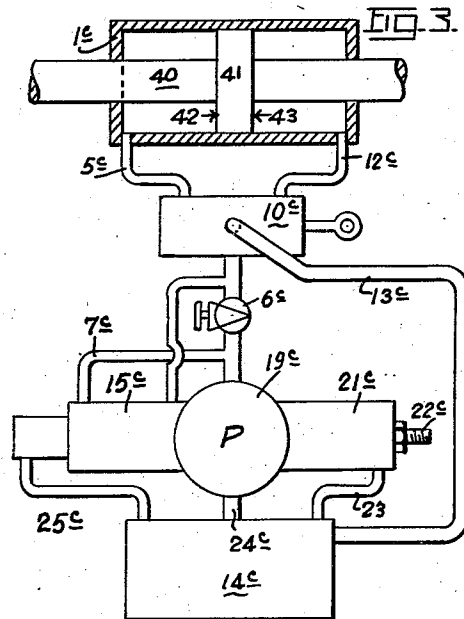
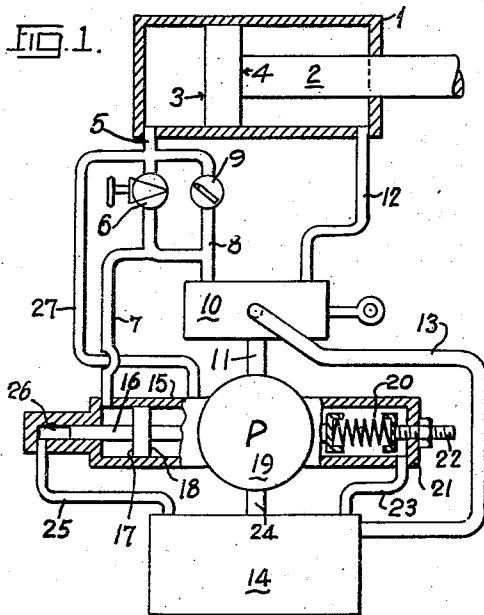
Sept. 24, 1946.

W. ERNST

2,408,303

CONTROL SYSTEM

Filed May 10, 1943



INVENTOR
WALTER ERNST,

BY
Toumin & Toulmin
ATTORNEYS

UNITED STATES PATENT OFFICE

2,408,303

CONTROL SYSTEM

Walter Ernst, Mount Gilead, Ohio, assignor to
The Hydraulic Development Corporation, Inc.,
Wilmington, Del., a corporation of Delaware

Application May 10, 1943, Serial No. 486,283

4 Claims. (Cl. 60—52)

1

This invention relates to hydraulic systems and, in particular, to hydraulic control systems including a fluid pressure source of the variable delivery type.

It is an object of this invention to provide a hydraulic system which includes a reciprocable plunger and a pressure fluid source of variable delivery for supplying pressure fluid to said plunger, and in which the delivery of the pressure fluid source to said plunger is controlled automatically in response to the resistance encountered by said motor.

It is another object to provide a hydraulic system including a fluid operable plunger actuated by a pressure fluid source of variable delivery, in which a fluid flow restriction is interposed between the fluid source and the plunger, and in which the delivery of the fluid source is automatically controlled so as to hold the pressure drop across said restriction substantially constant during the working stroke of said plunger.

It is a further object to provide a hydraulic system including a pressure fluid source of variable delivery and a plunger operable by fluid from said fluid source, in which a fluid flow restriction is interposed between said fluid source and said plunger and is hydraulically connected with control plunger means varying the delivery of said fluid source in response to variations in the pressure drop across said restriction.

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

Figure 1 diagrammatically illustrates a hydraulic system according to the invention.

Figure 2 shows a hydraulic system for controlling a differential plunger in both directions.

Figure 3 is a diagrammatic illustration of a further hydraulic system according to the invention in which the plunger to be controlled is double acting and has substantially equal opposed areas.

General arrangement

The hydraulic system according to the invention substantially comprises a fluid source of variable delivery, such as a variable delivery pump, and a fluid operable plunger, while a fluid flow restriction, such as a choke valve, is interposed between the delivery side of the fluid source and at least the advancing side of the plunger to be controlled. The arrangement is such that the delivery of the fluid source to the advancing side of the plunger must pass through the fluid flow

2

restriction. Both sides of the fluid flow restriction are connected with two opposed substantially equal areas of a fluid operable control plunger adapted when moving to vary the delivery of the fluid source. Therefore, any substantial variation in the pressure drop across the fluid flow restriction will cause the control plunger to vary the delivery of said fluid source in such a manner that the initial pressure drop is restored.

Structural arrangement

Referring now to the drawing and to Figure 1 thereof in particular, the system shown therein comprises a cylinder 1 having reciprocally mounted therein a plunger 2 with an advancing area 3 and a retraction area 4. Connected to one end of the cylinder 1 is a conduit 5 comprising a preferably adjustable choke 6 and leading to a conduit 7. One end of the conduit 7 communicates with a conduit 8 comprising a check valve 9 and communicating with the conduit 5. The conduit 8 furthermore communicates with a four-way valve 10 of any standard design adapted, when in one extreme position, to effect fluid communication between the pressure line 11 and the line 8 while simultaneously connecting the conduit 12, communicating with the retraction side of the plunger 2, with the exhaust line 13 leading to a fluid reservoir or tank 14. When the valve 10 occupies its other extreme position fluid communication is established between the pressure line 11 and the conduit 12, while simultaneously the conduit 13 is connected with the conduit 8. When the valve 10 occupies its intermediate or center position, no fluid passes through the valve. The check valve 9 in the conduit 8 is so arranged as to permit the flow of fluid there-through from the conduit 5 to the four-way valve 10, while preventing the flow of fluid in the reverse direction.

The conduit 7 leads to a control cylinder 15 having reciprocally mounted therein a plunger 16 of substantially equal opposed areas 17 and 18. The plunger 16 is connected to the flow control member of a variable delivery pump 19 so that rightward movement of the plunger 16 with regard to Figure 1 decreases the delivery of the pump 19, whereas leftward movement of the plunger 16 causes a spring 20 in the spring chamber 21 to act upon the flow control member of the pump 19 so as to increase the delivery of the pump 19. The spring 20, which continuously urges the pump 19 into full delivery position, is adjustable with regard to its thrust by means of an adjusting screw 22. The spring chamber 21

is hydraulically connected through a conduit 23 with the fluid tank 14. The fluid tank furthermore communicates through a conduit 24 with the suction side of the pump 19 and also communicates through a conduit 25 with a bore 26 in an extension of the control cylinder 15. This bore serves for guiding the control plunger 16. The area 18 of the control plunger 16 is hydraulically connected through a conduit 27 with the conduit 5.

Opposition

It may be assumed that all parts of the system shown in Figure 1 occupy the position in which they appear in the said figure. If it is now desired to have the plunger 2 perform a working cycle, the operator shifts the valve 10 into position for establishing fluid connection between the pressure line 11 and the conduit 8 while simultaneously connecting the conduits 12 and 13 with each other. Provided the pump 19 has been started, pressure fluid delivered by the pump 19 will now pass through line 11, valve 10, conduits 8, 7 and 6. From there the pressure fluid will pass through conduit 5 into the left hand position of the cylinder 1. Here it will act upon the advancing area 3 of the plunger 2 and move the latter rightwardly. The fluid expelled by the plunger 2 from the cylinder 1 during this rightward movement escapes through the conduit 12, the valve 11 and the conduit 13 into the tank 14.

When the fluid delivered by the pump 19 passes through the choke valve 6, a pressure drop will occur across this choke valve which pressure drop will make itself felt on the opposed areas 17 and 18 of the control plunger 16. Since the pressure in the conduit 7 and therefore on the areas 17 of plunger 16 will be greater than the pressure in the conduit 27, and therefore upon the area 18, the pressure acting on the area 17 will somewhat counteract the spring 20 and slightly reduce the delivery of the pump 19 until the pressure acting on the area 17 balances the pressure acting on the area 18 plus the thrust of the spring 20. When this balancing position has been reached, the flow through the choke valve 6 and thereby the pressure drop created thereby will under normal conditions remain substantially constant, and the plunger 2 will perform its working stroke at a substantially constant speed.

If it should not occur that, for some reason, the plunger 2 encounters increased resistance, this will temporarily slow down the movement of the plunger 2. As a result thereof the pressure in the left hand portion of the cylinder 1 and therefore, also in the conduit 27 will increase to a greater extent than the pressure in the conduit 7. Consequently the previously mentioned balancing condition will be disturbed, and the plunger 16 will be moved leftwardly until the pressure acting upon the area 17 will again be balanced by the pressure acting on the area 18 plus the thrust of the spring 20. In view of the thus effected leftward movement of the plunger 16, the spring 23 acts upon the control member of the pump 19 so as to increase the delivery of the pump 19. In view of this increase in the delivery of the pump 19, the previous flow across the choke 6 will be restored and therefore also the previous pressure drop across the choke 6. The plunger 2 will consequently resume its previous speed. The control plunger 16 will maintain its new position, i. e., the thus changed delivery of the pump 19 will now be maintained as long as the resistance encountered by the plunger 2 remains the same.

If it should occur that, for some reason, the

resistance encountered by the plunger 2 during its advancing movement drops, the plunger 2 will tend to increase its advancing speed. As a result thereof the pressure in the conduit 27 will drop to a greater extent than the pressure in the conduit 7 so that the pressure acting upon the area 17 will overcome the pressure acting upon the area 18 plus the thrust of the spring 20, and will move the plunger 16 rightwardly. This control will result in a decrease in the delivery of the pump 19 so that the previous flow across the choke 6 and thereby the pressure drop across the choke will be restored. Therefore the plunger 2 will again move at its initial speed, and the control plunger 16 will maintain its position as long as no further variation in the resistance encountered by the plunger 2 occurs.

When the plunger has reached the end of its working stroke, and it is now desired to reverse the plunger 2, the operator shifts the valve 10 into position for establishing fluid connection between the pressure line 11 and the conduit 12, while simultaneously connecting the conduits 8 and 13 with each other. Pressure fluid delivered by the pump 19 now passes through conduits 11 and 12 into the right hand portion of the cylinder 1. Here it acts upon the retraction area 4 of plunger 2, thereby causing the plunger 2 to move leftwardly. The fluid expelled from the left hand portion of the cylinder 1 during this leftward movement of the plunger 2 escapes through the conduit 5, check valve 9 and conduits 8 and 13 into the tank 14. It will be noticed that during this retraction stroke the choke 6 is by-passed and therefore is ineffective, so that no speed control is exerted upon the plunger 2 during its retraction stroke. However, in general, no speed control is necessary during the retraction stroke of the plunger 2 since, as a rule, no variations in resistance occur during the retraction stroke of the plunger 2.

When it is desired to bring the plunger 2 to a stop, the valve 10 is moved into its neutral position and the pump 19 is either stalled or standard servomotor means, which may be associated with the pump 19, will cause the pump 19 to shift into substantially neutral or no delivery position.

Second embodiment

Referring now to Figure 2, the structure shown therein substantially corresponds to the structure of Figure 1 with the exception that additional control means are provided for effecting a speed control also during the retraction stroke of the plunger. To more clearly indicate the similarity between Figures 1 and 2, the elements of Figure 2 corresponding to those of Figure 1 have been designated with the same reference numerals as in Figure 1 however, with the additional character *a*. The difference between the structure of Figure 2 and the structure of Figure 1 consists in that the control mechanism associated with the advancing side of the plunger 2a is duplicated for the retraction area 4a. To this end the righthand portion of the cylinder 1a is connected with a conduit 28 comprising a choke 29 and leading to the four-way valve 10a. Branching off from the conduit 28 is a conduit 30 containing a check valve 31 adapted to allow the flow of fluid therethrough from the right hand portion of the cylinder 1a to the check valve 10a while preventing the flow of fluid in the opposite direction. Also branching off from the conduit 28 is a conduit 32 leading to the control cylinder 33. The control cylinder 33 has re-

5

reciprocally mounted therein a plunger 34 with two opposed substantially equal area 35 and 36. The area 35 is engaged by a spring 20a continuously urging the plunger 34 leftwardly to thereby cause the plunger 34 to move the pump 19a into full delivery position. The thrust of the spring 20a is adjustable by a threaded extension member 37 comprising a bore 38 for guidance of the plunger 34. The bore 38 is connected through a conduit 39 with the tank 14a. The area 36 of the plunger 34 is hydraulically connected through a conduit 40 with the conduit 28.

The control of the plunger 2a during its advancing movement fully corresponds to the control of the plunger 2 during the advancing movement thereof, and therefore the description of the advancing movement of the plunger 2a appears to be superfluous. However, as previously mentioned, in the arrangement of Figure 2 also the retraction stroke of the plunger 2a will be controlled as to its speed.

It may be assumed that the valve 10a occupies the position in which the pressure line 11a is in fluid communication with the conduit 28 while simultaneously the conduit 7a communicates with the conduit 13a. Pressure fluid will then be delivered by the pump 19a through the choke 29 into the right hand portion of the cylinder 1a, thereby causing the plunger 2a to move leftwardly. The fluid expelled from the left hand portion of the cylinder 1a escapes through the check valve 9a, the conduit 7a and the conduit 13a into the tank 14a. If now, for some reason, the resistance encountered by the plunger 2 during its retraction stroke should change, the pressure drop across the choke 29 will also change so that the pressure conditions in the control cylinder 33 will vary accordingly. As a result thereof, the plunger 34 will be moved in a manner similar to that described above in connection with the plunger 16, and will bring about a corresponding change in the delivery of the pump 19a. Therefore, the initial flow of fluid across the choke 29, and thereby also the original pressure drop across this choke will be restored and the plunger 2 will be moved at substantially its original speed.

It will be obvious that by varying the setting of the chokes 6, 6a and 29 the desired speed of the plungers 2 and 2a may be varied. It will also be clear that by setting the chokes 6a and 29 differently the advancing speed and the retracting speed of the plunger 2 may be independently controlled.

Third embodiment

The system shown in Figure 3 makes use of the same principle illustrated in Figures 1 and 2 and similar parts are designated by the same numerals as in Figure 1, but with the additional character c. However, in Figure 3 the plunger 40 to be controlled has a piston portion 41 with substantially equal areas 42 and 43. Furthermore, the position of the four-way valve 10c and the choke 6c has been reversed with regard to the pump 19c. In other words, the delivery of the pump 19a to either the area 42 or the area 43 must always pass through the choke 6a so that the advancing as well as the retraction stroke of the plunger 40 is controlled. However, the setting of the choke 6a will equally affect the control of the plunger 40 in its advancing and retracting directions. Otherwise, the operation of the system shown in Figure 3 fully corresponds

6

to that of Figures 1 and 2 so that no further description thereof appears necessary.

It will be understood that the present invention is by no means limited to the particular structure shown in the drawing, but also embraces any modification falling within the scope of the appended claims.

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

1. In a hydraulic system, the combination with a variable delivery source of pressure fluid, of a reversible fluid motor having a pair of ports and operable in both directions by fluid supplied to said ports from said source, a first flow restricting means hydraulically connecting said source with one of said ports, a second flow restricting means connecting said source with the other of said ports, conduit means adapted freely to exhaust either of said ports when the other is being supplied with pressure fluid from said source, yielding means for continuously urging said fluid source toward maximum delivery position, a first and a second double acting plunger each having two opposed and substantially equal areas thereon respectively connected with the inlet and the outlet of said first and second flow restricting means respectively, said plungers being connected to vary the delivery of said fluid source.

2. In a hydraulic system, in combination with a variable delivery source of fluid and a reversible fluid operable motor having a pair of ports and operable in both directions by fluid supplied to said ports by said source, a first adjustable choke valve connecting said source with one of said ports, a second adjustable choke valve connecting said source with the other of said ports, conduit means associated with said ports and adapted freely to exhaust one of said ports when the other is being supplied with actuating fluid, yielding means continuously urging said source toward maximum delivery position, a first and a second double acting plunger each having two substantially equal opposed areas thereon, said first and second plungers having their opposed areas respectively connected with the inlet and the outlet of said first and second choke valves respectively, said plungers being connected to vary the delivery of said fluid source.

3. In a hydraulic system, a reversible fluid operable motor having a pair of ports, a variable delivery source of pressure fluid for selectively supplying actuating fluid to said ports, means for connecting said source with one of said ports including a first adjustable restriction, means connecting said source with the other of said ports and including a second adjustable restriction, a first and a second check valve bypassing said first and second restriction respectively, each of said check valves being adapted to conduct fluid away from said motor but not vice-versa, adjustable yielding means for continuously urging said fluid source toward maximum delivery position, a first and a second double acting plunger having two substantially equal opposed areas thereon associated with said source and connected to vary the delivery thereof, said first and said second plungers each having the opposed areas thereof respectively connected with the inlet and the outlet of said first and second flow restrictions respectively.

4. In a hydraulic system, in combination with a fluid source of variable delivery, a reversible fluid motor having a first and a second port, first

7

and second flow restricting means connecting said source with said first and second ports respectively and each operable to establish a predetermined pressure difference between its inlet and outlet in response to fluid flow toward the associated port but to permit free flow from the said port, yielding means continuously urging

8

said source toward maximum delivery position, and first and second flow controlling means connected to vary the delivery of said source and each comprising oppositely effective fluid operable means connected respectively with the inlet and the outlet of one of said flow restricting means.

WALTER ERNST.