

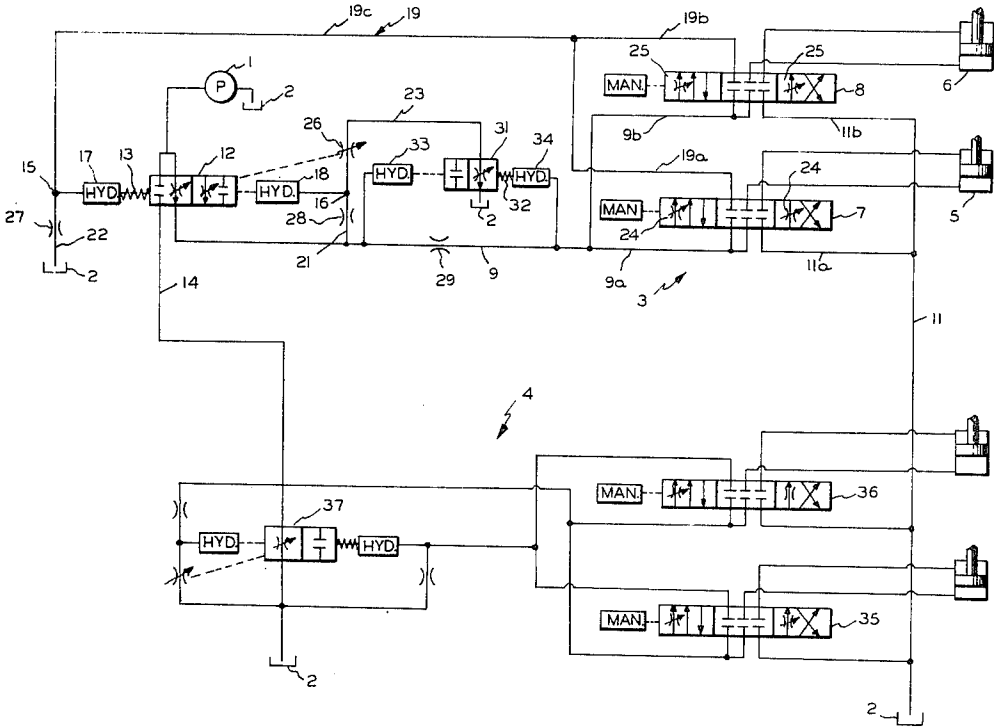
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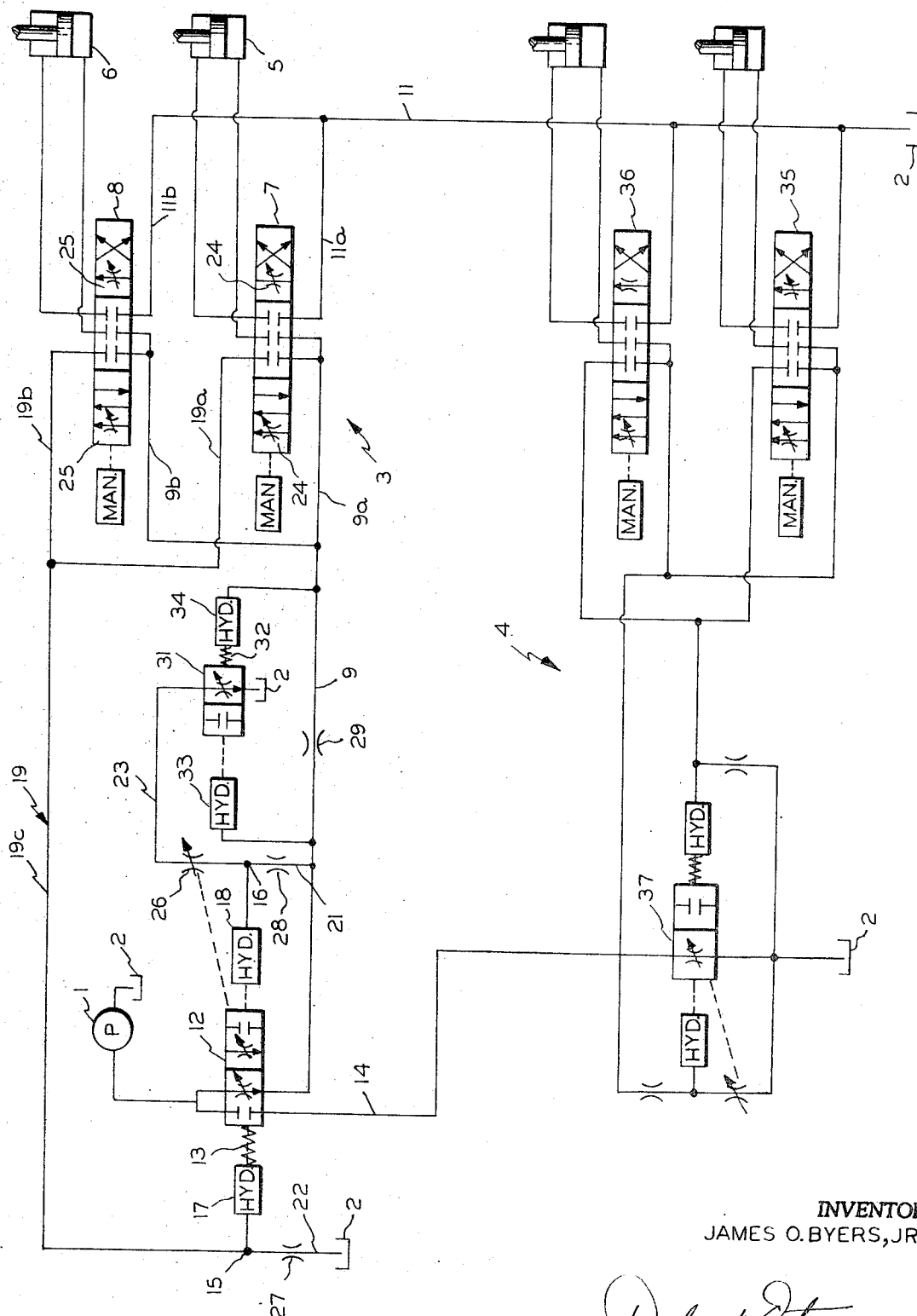
[54] **HYDRAULIC SYSTEM INCLUDING TWO WORK CIRCUITS**
2 Claims, 1 Drawing Fig.
[52] U.S. Cl. 91/411,
91/142: 60/52
[51] Int. Cl. F15b 11/16,
F15b 15/18
[50] Field of Search 91/411,
412; 60/52, 52HF

ABSTRACT: Hydraulic system for delivering fluid from a single pump to two work circuits. The system gives preference to the flow demands of the first circuit and supplies fluid to it at varying rates up to a limiting value which is less than the full output of the pump. The supply action of the system is insensitive to the relative levels of the load pressures in the two work circuits, so both circuits can always be operated simultaneously.



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3,550,505



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HYDRAULIC SYSTEM INCLUDING TWO WORK CIRCUITS

BACKGROUND AND SUMMARY OF THE INVENTION

U.S. Pat. No. 3,411,295, granted Nov. 19, 1968, discloses hydraulic circuits employing closed center distributing valves and a separate open center bypass valve which is positioned by a servo control which responds to actuation of the distributing valves. In one system, the output of the bypass valve of one circuit is fed to a second work circuit so that the excess fluid diverted from the first circuit can be utilized in the second. This scheme inherently gives preference to the demands of the first circuit and permits simultaneous actuation of the loads in both circuits in cases where the pressure in the second is lower than the pressure in the first. However, both circuits cannot be operated simultaneously when the second is subjected to the higher load pressure. Moreover, the maximum supply rates to the two circuits necessarily are equal. These characteristics limit the utility of this duplex system. For example, it cannot be used on certain backhoes whose swing and steering cylinders require a lower maximum flow rate than the lift, crowd and tilt cylinders and must be actuated simultaneously with one of the other cylinders at times when the second cylinder requires a superior pressure. The problem of providing different maximum supply rates can be solved by incorporating in the primary circuit a flow control mechanism of the type disclosed in application Ser. No. 769,858, filed Oct. 23, 1968, but this modification still leaves unanswered the problem of insuring simultaneous operation of the two circuits at times when the second circuit is more heavily loaded than the first.

The object of this invention is to provide a hydraulic system which affords all of the advantages of the duplex system of U.S. Pat. No. 3,411,295, as well as the flow control action of the improvement disclosed in application Ser. No. 769,858, and in addition provides for simultaneous operation of both work circuits regardless of which requires the higher load pressure. The improved system proceeds from the prior proposals mentioned above and is characterized in that it:

- employs a bypass valve which, in addition to its normal function of diverting fluid to the secondary circuit, also meters flow into the primary circuit;
- delivers fluid to the Wheatstone bridge control for the bypass valve from the primary circuit, rather than directly from the pump; and
- effects flow control action through an auxiliary orifice located in the feedback, rather than the command, leg of the Wheatstone bridge. These distinguishing features cooperate to enable the improved system to afford the additional advantage of permitting simultaneous operation of both work circuits without sacrificing the desirable characteristics of the basic systems from which it was derived.

BRIEF DESCRIPTION OF THE DRAWING

The preferred embodiment of the invention is described herein with reference to the accompanying drawing whose single FIG. is a schematic diagram of the new hydraulic system.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawing, the improved system includes a fixed delivery supply pump 1 which is arranged to draw oil from a tank 2 and deliver it under pressure to a pair of work circuits 3 and 4, hereafter referred to as the primary and secondary circuits, respectively. Primary circuit 3 comprises two double-acting cylinders 5 and 6 which are under the control of a pair of three-position, manually operated, closed center distributing valves 7 and 8, respectively. These valves are connected in a parallel circuit by the branches 9a and 9b of a supply line 9, and by the branches 11a and 11b of a common exhaust line 11. Each distributing valve has a neutral position in which it hydraulically locks the associated cylinder 5 or 6 and isolates its supply and exhaust branches from each other, and is shiftable in opposite directions from this position

to progressively open a supply path from branch 9a or 9b to one or the other end of the cylinder and an exhaust path from the remaining end of the cylinder to branch 11a or 11b.

Oil is supplied to the circuits 3 and 4 through a bypass valve 12 which is adapted to meter in reverse sense the flows into the circuits. Valve 12 is biased toward the illustrated limiting position by a spring 13, and in this position it interrupts flow to circuit 4 and permits free flow to circuit 3. As valve 12 moves to the left, it progressively opens a flow path from pump 1 to the line 14 leading to secondary circuit 4 and then, after this path becomes essentially unrestricted, it commences to throttle flow into the supply line 9 of primary circuit 3. Conversely, as valve 12 moves to the right from its leftmost limiting position, it first decreases to a minimum the restriction to flow through the path leading to line 9 and then begins to throttle the flow from pump 1 to line 14.

Bypass valve 12 is positioned by a servocontrol that responds both to actuation of distributing valves 7 and 8 and to the presence of an excessive flow rate through supply line 9. This control consists of a hydraulic Wheatstone bridge including a pair of output junctions 15 and 16 which are connected, respectively, with a pair of opposed hydraulic motors 17 and 18 which shift bypass valve 12, and four conduit legs 19, 21, 22 and 23; the legs 19 and 21 leading from supply line 9 to each of the junctions, and the legs 22 and 23 leading from the junctions to tank 2. Leg 19, which is the command leg of the bridge, consists of two parallel branches, each comprising one of the supply branches 9a and 9b and one of the conduits 19a and 19b, and a common portion 19c. The command branches contain variable command orifices 24 and 25 whose flow areas vary with movement of the distributing valves 7 and 8. These orifices are closed when the distributing valves are in neutral position, and each is opened progressively as the associated valve is shifted away from that position in either direction. Bridge leg 23 is the feedback leg of the bridge and contains a variable orifice 26 whose flow area varies in response to movement of bypass valve 12. The flow area of this orifice is a minimum when valve 12 is in the illustrated position and increases progressively as the valve moves to the left. The remaining legs of the bridge contain fixed reference orifices 27 and 28, respectively. It is assumed herein that motors 17 and 18 have equal effective areas; therefore, orifices 27 and 28 are so sized that the servocontrol tends to maintain the ratio of the flow area of orifice 28 to the flow area of feedback orifice 26 substantially equal to the ratio of the flow area of the command orifice 24 or 25 to the flow area of orifice 27. Of course, full equality of these ratios cannot be realized because the bias exerted by spring 13 does vary with the position of bypass valve 12.

In addition to the components already mentioned, the servocontrol also includes a device for limiting the rate at which oil can be delivered to the cylinders 5 and 6 of the primary circuit. This device comprises a reference orifice 29 interposed in supply line 9, and a variable auxiliary orifice 31 which is located in the feedback leg 23 of the Wheatstone bridge and which is controlled in accordance with the pressure differential across the reference orifice. The auxiliary orifice 31 is intended to unbalance the bridge in the sense that effects leftward movement of bypass valve 12 (i.e., that causes valve 12 to increase the amount of oil diverted to secondary circuit 4) as the flow rate to valves 7 and 8 exceeds the selected maximum; therefore, the orifice 31 is biased open by a spring 32 and is connected in series with the feedback orifice 26. A pair of opposed motors 33 and 34 which respond, respectively, to the pressures upstream and downstream of reference orifice 29, shift auxiliary orifice 31 in the closing direction as the supply rate to the distributing valves tends to exceed the set limit. This limit, of course, can be changed by altering the size of orifice 29.

It should be noted that, while this description is concerned with one specific servocontrol, the invention may utilize any one of the twelve forms of the Wheatstone bridge circuit disclosed in U.S. Pat. No. 3,411,295. In those cases, of which the

illustrated embodiment is representative wherein the flow area of feedback orifice 26 decreases as the bypass valve 12 closes the flow path leading to secondary circuit 4, the auxiliary orifice is in series with the feedback orifice and is biased open. In the other controls, wherein the flow area of the feedback orifice increases as valve 12 closes the bypass path, the auxiliary orifice is located in a parallel branch of the feedback leg 23 and is biased closed.

The secondary circuit 4 may employ either conventional open center distributing valves or, as in the illustrated embodiment, closed center distributing valves 35 and 36 and a separate pilot operated bypass valve 37. The exact design of this circuit forms no part of the present invention and therefore, since the one chosen for illustration is fully described in U.S. Pat. No. 3,411,295, further description of it would serve no useful purpose.

When the system is in service and distributing valves 7 and 8 are in their illustrated neutral positions, command orifices 24 and 25 will be closed and auxiliary orifice 31 will be open. The oil delivered to supply line 9 through bypass valve 12 escapes to tank 2 through bridge legs 21 and 23, and thereby develops at output junction 16 a pressure higher than the tank pressure prevailing at junction 15. As a result, motor 18 will shift bypass valve 12 to the left to open the flow path from pump 1 to line 14 and secondary circuit 4. As the valve moves, feedback orifice 26 opens to thereby reduce the pressure at junction 16; consequently, valve 12 will come to rest in a position in which it permits substantially free flow to the secondary circuit. The inclusion of biasing spring 13 causes valve 12 to impose some restriction to this flow, so the pressure in supply line 9 will be slightly higher, for example 40 p.s.i. higher, than tank pressure. This is necessary in order to insure development of a pressure at junction 15 sufficient to enable motor 17 to shift valve 12 to the right in those cases where one of the command orifices 24 and 25 is opened at a time when secondary circuit 4 is idle and pump 1 is being unloaded to tank 2 through bypass valve 37. Of course, if the back pressure developed inherently by line 14 or bypass valve 37 is of this magnitude, spring 13 need not be employed for this purpose.

When one of the distributing valves 7 and 8 is shifted away from neutral position to actuate cylinder 5 or 6, the associated command orifice 24 or 25 commences to open, and the pressure at junction 15 rises relatively to the pressure at junction 16. As a result, motor 17 and spring 13 move bypass valve 12 to the right to thereby gradually close the flow path to line 14. This movement of valve 12 is accompanied by a reduction in the flow area of feedback orifice 26 and an increase in the pressure at output junction 16. When the pressure at this junction reaches the level at which motor 18 balances the forces exerted by motor 17 and spring 13, the Wheatstone bridge will again be in balance, and valve 12 will come to rest. The new position of this valve will correspond to the present position of the actuated distributing valve 7 or 8 (assuming that the flow control device has not been activated). During this movement of valve 12, the pressure in supply line 9 gradually rises, assuming that secondary circuit 4 is idle or requires an operating pressure less than that needed in circuit 3. Therefore, when it exceeds the break away pressure of the active cylinder 5 or 6, i.e., the pressure required to overcome static friction and inertia, the cylinder will commence to move. This movement will be accompanied by a sudden decrease in the pressure in supply line 9, but this will have no effect upon the position of valve 12 because the pressures at output junctions 15 and 16 will change equal amounts.

In order to increase the speed of movement of the actuated cylinder, the operator shifts the distributing valve 7 or 8 farther away from the neutral position. This movement of the distributing valve increases the flow area of the associated command orifice 24 or 25, and consequently raises the pressure at output junction 15. Therefore, motor 17 moves valve 12 to a new position in which it restricts to a greater degree flow from pump 1 to line 14, and thus causes a larger portion of the output of the pump to be delivered to the actuated

cylinder 5 or 6 through supply line 9 and the appropriate distributing valve 7 or 8. As long as the flow rate through line 9 is below the setting of the flow control device, the pressure differential across reference orifice 29 will be insufficient to enable motors 33 and 34 overcome the bias of spring 32. Consequently, auxiliary orifice 31 will remain fully open, and bypass valve 12 will be positioned exclusively in accordance with movement of the actuated distributing valve 7 or 8. However, when that valve is moved beyond a position which affords the selected maximum supply rate, motors 33 and 34 will overpower spring 32 and commence to reduce the flow area of orifice 31. Closure of auxiliary orifice 31 increases the pressure at output junction 16 relatively to the pressure at junction 15 and thereby enables motor 18 to prevent further rightward movement of bypass valve 12. The flow area of orifice 31 will continue to decrease as long as the flow area of the opened command orifice 24 or 25 continues to increase, so the supply rate to the cylinder will be held substantially constant at the desired limiting value even through the distributing valve 7 or 8 is shifted all the way to one or the other of its limiting positions.

As the actuated distributing valve 7 or 8 is returned to its neutral position, the associated command orifice 24 or 25 closes, and the pressure at output junction 15 decreases. As a result, motor 18 shifts bypass valve 12 to the left to reduce the restriction to flow to line 14 and thereby decrease the rate at which oil is delivered to primary circuit 3. This effect, of course, results in a gradual reopening of auxiliary orifice 31, so at some point in the return movement of the distributing valve it will again assume exclusive control over bypass valve 12. When the distributing valve finally reaches its neutral position, bypass valve 12 will have been returned to the initial operating position in which it permits substantially free flow to secondary circuit 4.

The system operates as described above only as long as secondary circuit 4 requires a lower operating pressure than primary circuit 3. If both circuits are in use and the relative loads imposed on them change in a sense that makes circuit 4 the high pressure circuit, the mode of operation is slightly different. In this case, throttling of the flow path from pump 1 to line 14 by valve 12 will be ineffective to change the supply rate to line 9 because all flow to secondary circuit 4 will cease as soon as it becomes the higher pressure circuit. Therefore, when the change in the relative pressure levels occurs, the entire output of the pump will tend to flow into primary circuit 3. This larger supply rate will develop a pressure differential across reference orifice 29 sufficient to enable motors 33 and 34 to close auxiliary orifice 31 and thereby raise the pressure at junction 16 relatively to the pressure at junction 15. Motor 18 will now shift bypass valve 12 leftward beyond the position in which it permits free flow to line 14 to cause it to commence to throttle the flow into supply line 9. As this throttling action increases, the pressure differential across reference orifice 29 will decrease, and accordingly motors 33 and 34 will increase the flow area of auxiliary orifice 31. Therefore, bypass valve 12 will come to rest in a position in which it is throttling the flow into line 9 to the rate corresponding to the setting of orifice 29. Thus, circuit 3 will supply oil to its loads at the controlled flow rate and the low pressure they require, and the excess output of pump 1 will be delivered under a higher pressure to the loads being actuated by circuit 4.

I claim:

1. A hydraulic system of the type including:
 - a. a pump 1;
 - b. a pair of work circuits 3, 4, at least the first 3 of which contains a closed center distributing valve 7 or 8 having a control member movable from a neutral position to effect progressive opening of a flow path from a supply line 9 to a hydraulic motor 5 or 6;
 - c. a bypass valve 12 for opening and closing a flow path leading from the pump to the second work circuit 4;
 - d. a hydraulic Wheatstone bridge type of control for positioning the bypass valve, the bridge including a conduit

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leg 19 containing a command orifice 24 or 25 whose flow area changes in response to movement of said control member, and another conduit leg 23 containing a feedback orifice 26 whose flow area changes in response to movement of the bypass valve 12; and

e. an auxiliary orifice 31 in the bridge whose flow area is controlled by the pressure differential across a reference orifice 29 in the supply line 9 and which unbalances the bridge to effect opening of the bypass valve as said pressure differential rises above a predetermined value; and characterized, according to this invention, by the fact that

1. said bypass valve 12 closes and opens a flow path from

the pump 1 to said supply line 9 as it moves to open and close, respectively, said flow path leading to the second work circuit 4;

2. fluid is supplied to the Wheatstone bridge from the supply line 9; and

3. the auxiliary orifice 31 is located in the same conduit leg 23 of the bridge as the feedback orifice 26.

2. A hydraulic system as defined in claim 1 which is further characterized in that the bypass valve 12 commences to restrict to a significant extent flow through the path leading to the supply line 9 only after it has established essentially free flow through the path leading to the second work circuit 4.

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