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(19)

(54) APPARATUS FOR CONTROLLING THE DISTRIBUTION OF HYDRAULIC FLUID BETWEEN TWO LOAD SYSTEMS

(71) We, ROBERT BOSCH GMBH, a German company of Postfach 50, 7000 Stuttgart 1, Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to apparatus arranged to control the distribution of hydraulic fluid between a first hydraulic load system and a second hydraulic load system having priority over the first load system.

One example of the use of such control apparatus is where an hydraulic steering device for a farm tractor forms the priority load system and a plough and/or an actuator for an auxiliary load forms the first hydraulic load system.

With such an arrangement it is often desirable for hydraulic fluid delivered to the priority load system to be transferred to the first load system, whilst maintaining the mutual pressure influence between the load systems as low as possible, so as to improve the supply of hydraulic fluid to the first load system over the central speed range of operation.

In one prior proposal disclosed in United States Patent Specification No. 3 279 558, two hydraulic pumps driven by the same motor both deliver into the priority load steering system at low motor speeds. However, when the total quantity of hydraulic fluid delivered exceeds a predetermined quantity for steering, hydraulic fluid from one of the pumps, the driving pump, is correspondingly transferred to an increasing extent, from the steering system towards another working load system. At high motor speeds, the steering pump can deliver a residual flow into the working load system through a three-way flow regulator. The main disadvantage of that arrangement is that, within the low and middle speed ranges, the working load system is badly supplied with hydraulic fluid. Furthermore, there is always the danger that both load systems will mutually influence each other in accordance with pressure. Another disadvantage lies in the expensive construction of the flow regulator which cannot be assembled from normally available commercial valves. Also two pumps with different delivery rates are required, mainly so as to achieve to some extent, a satisfactory supply of hydraulic fluid to both load systems.

In accordance with the invention, apparatus arranged to control the distribution of hydraulic fluid between a first hydraulic load system and a second hydraulic load system having priority over the first load system, comprises a first hydraulic pump associated with the first load system and a second hydraulic pump associated with the second load system, a flow regulator arranged in the delivery line from the second hydraulic pump and provided with an outlet for residual fluid, a transverse fluid line connecting the residual fluid outlet to the delivery side of the first hydraulic pump, a branch fluid line arranged between the transverse fluid line and the suction side of the second hydraulic pump, a shut-off valve arranged in the branch line and a throttle arranged in the transverse fluid line between the residual fluid outlet and the shut-off valve, the shut-off valve being arranged to open in response to a predetermined pressure drop across the throttle so that, below the said predetermined pressure drop, residual fluid from the flow regulator is delivered to the first load system, whereas above the said predetermined pressure drop, residual fluid from the flow regulator is returned to the suction side of the second hydraulic pump.

Such an apparatus has the advantage that a good supply of hydraulic fluid to the first load system, which may also be provided

with additional loads, is possible, even in the central speed range. Moreover, the control apparatus can be assembled from normal commercially available valves whereby it is of simple and cheap construction. Furthermore, the control apparatus operates with a considerable saving in energy.

To prevent mutual interference between the pressures in the load systems, especially in the upper and lower speed ranges, a non-return valve may be arranged in the transverse fluid line between the throttle and the delivery side of the first hydraulic pump, the non-return valve opening away from the throttle.

Preferably, the shut-off valve is a 2-port 2-position valve provided with a valve member loaded towards the closed position of the valve by a spring and biassed towards the open position of the valve by the pressure drop across the throttle.

When a steering device for a tractor is to form the priority load system, the flow regulator may be provided with a constant flow delivery port for connection to the steering device.

The use of two similar hydraulic pumps, preferably with the same delivery rate, leads to further simpifications of the control apparatus.

The apparatus may be used in combination with a farm tractor used, for example, to draw an hydraulically controlled plough. In that case, hydraulically operated means for raising and lowering the plough would form the first load system and a steering device for the tractor would form the second, priority, load system.

The first load system may also include an hydraulic actuator for an auxiliary load system, in which case a change-over valve would be provided for selective operation of the actuator and other parts of the first load system.

If desired, the change-over valve could be a 6-port 3-position valve with a central position for the plough and two reversing positions for the actuator.

In order that the invention may be clearly understood and readily carried into effect, an apparatus in accordance therewith will now be described with reference to the acompanying drawings in which:

Figure 1 is a simplified representation of apparatus arranged to control the distribution of hydraulic fluid between a plough and/or an actuator, and a steering device for a tractor; and

Figure 2 shows a characteristic operating curve for the first load system in which the speed of an engine driving the supply pumps is plotted against the quantity of hydraulic fluid supplied.

The control apparatus 10 shown in Figure 1 comprises a first hydraulic pump 11 for supplying hydraulic fluid to a first load system 12 which is in the form of an hydraulically controlled plough 15 and in this instance, also includes an hydraulic actuator 13. The plough 15 and the actuator 13 form a non-priority load system and are connected to the delivery line 16 from the pump 11 through a 6-port 3-position change-over valve 14.

The apparatus also comprises a second hydraulic pump 17 for supplying hydraulic fluid to a second load system 18 in the form of an hydrostatic steering device, for example for a tractor drawing the plough 15. The steering device 18 forms a priority load system and is connected to the delivery line 19 from the second pump 17 through a 3-port flow regulator 21.

The flow regulator 21 has a fluid supply port 23, a constant flow delivery port 24 and a residual fluid outlet in the form of a port 25. A transverse fluid line 26 connects the residual fluid outlet port 25 to the delivery side of the pump 11. The transverse line 16 leads through a throttle 27 and a non-return valve 28, opening away from the throttle 27, and joins the delivery line 16 from the pump 11 upstream of the change-over valve 14. The non-return valve 28 protects the second load system 18 from influences by the pressure in the first load system 12.

A branch line 29 leads from the line 26, through a 2-port 2-position shut-off valve 31, to the suction side 32 of the pump 17. The branch line is connected to the line 26 between the throttle 27 and the non-return valve 28 so that the throttle 27 is, in effect, arranged in the line 26 between the residual fluid outlet port 25 and the valve 31.

The shut-off valve 31 has a valve member 33 loaded towards the closed position 36 of the valve by a spring 34 and by fluid pressure in the line 26 downstream of the throttle 27, through a control line 35. The valve member 33 is also biassed towards the open position 38 of the valve, by the pressure in the line 26 upstream of the throttle 27, through a control line 37.

The shut-off valve 31 is arranged to open against the force of its loading spring 34 in response to a predetermined pressure drop across the throttle 27 transmitted to the valve member 33 through the control lines 35 and 37. Thus, below the said predetermined pressure drop, residual fluid from the flow regulator 21 is delivered through the line 26 to the first load system 12 whereas, above the said predetermined pressure drop, residual fluid from the flow regulator 21 is returned, through the valve 31 in its open position, to the suction side of the second hydraulic pump 17, with the non-return valve 28 closed by the pressure

in the first load system.

The pumps 11 and 17 are of similar construction and each has the same delivery rate. They are driven by a common motor 39 and both withdraw hydraulic fluid from a common reservoir 41.

The method of operation of the control apparatus 10 of Figure 1 will now be described with specific reference to Figure 2.

At low speeds of the motor 39, the first pump 11 delivers hydraulic fluid to the first load system 12 and the second pump 17 delivers hydraulic fluid to the second priority load system 18. Moreover, as long as the quantity of fluid delivered by the pump 17 is less than the constant quantity at which the flow regulator 21 is set to deliver at the port 24, all the fluid flows to the steering device 18 and none leaves the residual fluid outlet port 25. This is represented in Figure 2 by a first section 42 of a curve 43 which shows the quantity of hydraulic fluid Q for the first load system 12 depending on the motor speed n.

If, with an increasing motor speed, delivery of fluid from the second pump 17 exceeds the said constant amount, then excess fluid is diverted by the flow regulator 21 to the residual fluid outlet port 25. From there, the residual fluid flows through the transverse line 26 into the delivery line 16 of the pump 11 for the first load system 12. Thus, a quantity of hydraulic fluid is available for operating the actuator 13 or the plough 15, which is made up of the quantity delivered by the first pump 11 and the residual fluid flow. Figure 2 shows this as a second section 44 of the curve 43.

With advantage, the control apparatus 10 is so designed that, at about 2/3 of the maximum motor speed, about 4/3 of the maximum amount of pressure medium from the pump 11 is available for the first load system 12. In the region of the curve 43, illustrated by the section 44, the shut-off valve 31 is in the closed position 36 by reason of the force of the spring 34. If, with a still greater increase in speed of the motor 39, the quantity of fluid delivered by the second pump 17 increases and therewith the amount of residual fluid also increases, then the throttle 27 comes more and more into effect until finally, above a predetermined pressure drop across the throttle, its pressure difference brings the closure member 33 of the shut-off valve 31 into its open position 38 against the force of the spring 34 and the residual fluid is discharged from the transverse line 26 through the branch line 29, directly to the suction side 32 of the pump 17. A third section 45 of the curve 43 illustrates this change-over procedure in which the quantity of fluid available for the first load system 12 drops below the maximum delivery rate of the first pump 11. Then, with a still further increase in motor speed to n_{max}, the delivery rate for the first load system 12 rises to Q_{max} of the first pump 11. A fourth section 46 of the curve 43 shows these conditions. Moreover, a constant quantity of hydraulic fluid always flows to the steering device 18 whilst the residual fluid flow, which has then become greater, is short-circuited through the shut-off valve 31.

The non-return valve 28 prevents pressure from the first load system 12 disturbing the second load system 18 when residual hydraulic fluid is being delivered from the second load system 18 into the first load system 12. In this manner, the first system is relatively well supplied with hydraulic fluid whereby a mutual disturbing pressure influence is also maintained as low as possible. This is important in connection with farm tractors because, in that instance, the motor speed is mainly suited to the desired traction speed and the two pumps deliver at delivery rates dependent on the motor speed. Only during ploughing at the ends of the field or during turning is the motor speed reduced, however, at the same time, there is an increased need for oil raising the plough as rapidly as possible. On the other hand, having regard to the high hydraulic losses and the heating of the oil associated therewith, determined limits are set on the use of a larger pump for the non-priority first load system. These circumstances are sufficiently considered in the control apparatus 10 which, in addition, is simply constructed from commercially available components and operates with a relative saving of energy.

Obviously, it is possible to undertake variations of the control apparatus described and illustrated, without departing from the general concept of the invention. Thus, the steepness of the section 45 can very well be influenced by the shut-off valve 33. Also, pumps having different delivery rates can be used.

WHAT WE CLAIM IS:

1. Apparatus arranged to control the distribution of hydraulic fluid between a first hydraulic load system and a second hydraulic load system having priority over the first load system, comprising a first hydraulic pump associated with the first load system and a second hydraulic pump associated with the second load system, a flow regulator arranged in the delivery line from the second hydraulic pump and provided with an outlet for residual fluid, a transverse fluid line connecting the residual fluid outlet to the delivery side of the first hydraulic pump, a branch fluid line arranged between the transverse fluid line and the suction side of the second hy-

draulic pump, a shut-off valve arranged in the branch line and a throttle arranged in the transverse fluid line between the residual fluid outlet and the shut-off valve, the shut-off valve being arranged to open in response to a predetermined pressure drop across the throttle so that, below the said predetermined pressure drop, residual fluid from the flow regulator is delivered to the first load system, whereas above the said predetermined pressure drop, residual fluid from the flow regulator is returned to the suction side of the second hydraulic pump.

2. Apparatus according to claim 1, in which a non-return valve is arranged in the transverse fluid line between the throttle and the delivery side of the first hydraulic pump, the non-return valve opening away from the throttle.

3. Apparatus according to claim 1 or claim 2, in which the shut-off valve is a 2-port 2-position valve provided with a valve member loaded towards the closed position of the valve by a spring and biassed towards the open position of the valve by the pressure drop across the throttle.

4. Apparatus according to any one of claims 1 to 3, in which the flow regulator is provided with a constant flow delivery port for connection to the second load sys-

5. Apparatus according to any pretem.

ceding claim, in which the first and second hydraulic pumps have the same delivery rate.

6. Apparatus according to any preceding claim, in combination with a farm tractor.

7. Apparatus according to any one of claims 1 to 5, in combination with a farm tractor and a plough.

8. Apparatus according to claim 7, in which hydraulically operated means for raising and lowering the plough form the first hydraulic load system and a steering device for the tractor forms the second hydraulic load system.

9. Apparatus according to claim 7 or claim 8, comprising an hydraulic actuator for an auxiliary load system, in which a change-over valve is provided for selective operation of the actuator and the plough.

10. Apparatus arranged to control the distribution of hydraulic fluid between first and second hydraulic load systems substantially as herein described with refrence to the accompanying drawings.

11. Apparatus arranged to control the distribution of hydraulic fluid between a first hydraulic load system comprising an hydraulic actuator and a plough, and a second hydraulic load system in the form of a steering device for a tractor, substantially as herein described with reference to the accompanying drawings.

12. Apparatus according to any preceding claim constructed and arranged so as to operate in accordance with the characteristic curve of Figure 2.

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1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

Fig. 1

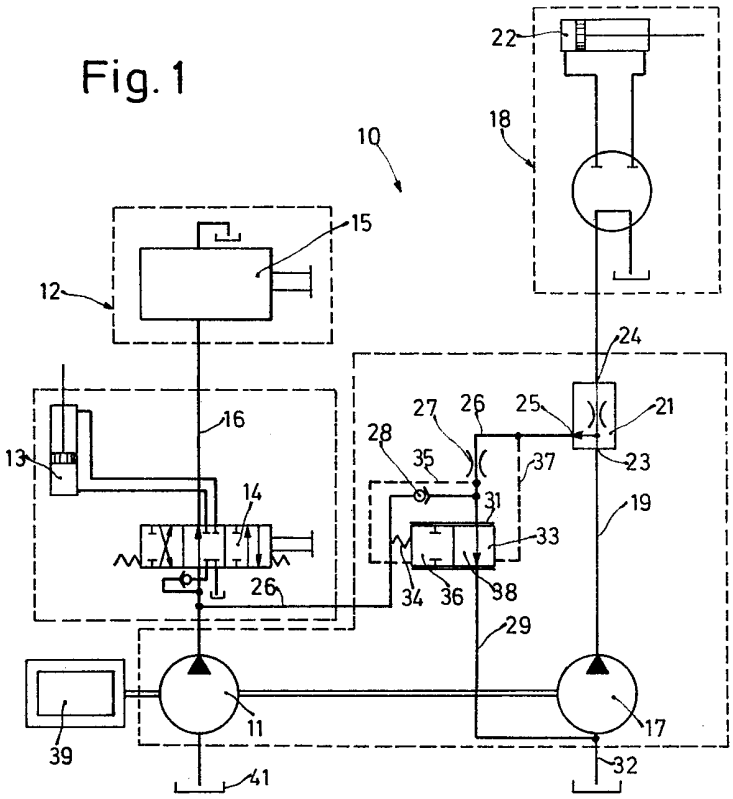

Fig. 2