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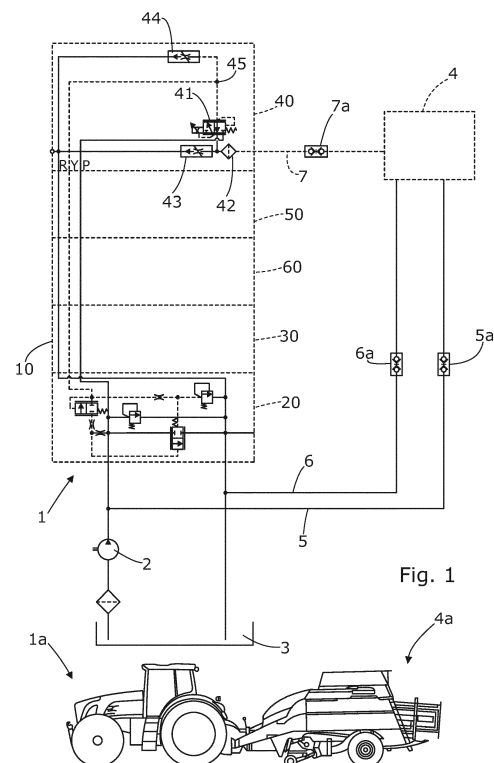
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(54) **Hydraulic pressure supply system**

(57) A pressurised fluid supply system (1) for an agricultural vehicle (1a) includes a fixed displacement pump (2) and a tank (3) to receive fluid. A first valve assembly (20) is arranged to adjust the pressure differential of the supply system, whereby the system provides two pressure differential levels and at least one of those results in a fluid flow in the direction from the pump (2) to a consumer coupling (5a). An amplifying valve (41) is arranged to superpose a load sensing pressure signal of an external consumer (4) of the fluid supply system with the pump pressure. The amplifying valve (41) is provided with first and second tank connections respectively including first (43) and second (44) valves to limit the fluid flow in the tank connection.



Description

[0001] The invention relates to a pressurised fluid supply system on an agricultural vehicle, especially a tractor, provided to supply various consumers in on a trailed, semi-mounted or fully-mounted implement, especially consumers which are controlled by control means on the implement itself and not by control means on the vehicle. More specifically, the invention relates to a supply system known as Power Beyond supply system.

Background

[0002] Mobile fluid (hydraulic) supply systems are widely used to drive consumers on agricultural or construction vehicles, e.g. a tractor or a self-propelled harvester, or on implements attached thereto. These hydraulic systems are mostly provided with a pump supply, consumers, control means (respectively control valves) and a tank to provide a fluid reservoir. The term "consumer" is used in the further description for hydraulic drives like rotary motors or linear rams but also for the respective control valves assigned to these drives. The term "control" in relation to supply systems hereby includes any adjustment of the supply system regarding direction, supply time or pressure of the fluid flow. The term "pump supply" includes the pump and all valve means which are needed to adjust the fluid flow or pressure supplied by said pump.

[0003] In a hydrostatic hydraulic system, a pressure differential is needed to provide hydrostatic work (an output). This pressure differential between pump supply (source) and consumer (hydraulic drives like rotary motors or linear rams) results in a fluid flow which is sufficient to lift a tractor three-point hitch or to operate a rotary drive on an implement or in a hydrostatic drive. Furthermore, a stand-by pressure differential is also needed when the system is otherwise in idle mode to keep control valves (assigned to consumers) responsive so that the spool of the valve can be moved on demand.

[0004] In a hydraulic system as described above, hydraulic losses are present whenever oil circulates within the system even when no consumer is operated. To mitigate this problem, it is known to provide means to forward a demand of a consumer to the pump supply. These systems are generally called Load sensing systems (the term load sensing is abbreviated to LS). In such systems the demand of the consumers is hydraulically fed back to the pump supply via pipes or hoses so that oil flow/pressure can be adjusted according to the needs of the consumers. This load sensing feedback is generated by the control valve assigned to the consumer.

[0005] In general, there are two different types of fluid supply systems with demand feedback available on the market - closed-center load sensing systems (also referred to as CC-LS) and open-center load sensing systems (also referred to as OC-LS).

[0006] Closed-center load sensing systems are equipped with variable displacement pumps whereby the demand of the consumers is hydraulically fed back to the pump supply including an adjustment means for the pump so that the displacement of the pump can be adjusted according to the needs of the consumers.

[0007] To ensure that a stand-by pressure differential is maintained in the circuit to support fast system response, the pump is kept on low displacement to compensate losses/leakage resulting in a stand-by pressure even if there is no demand by consumers. As a result of the reduction of the oil circulation, losses and power input required by pump are reduced.

[0008] Generally closed-center load sensing systems are more expensive and complex but, on the other hand, the pumps are only delivering on demand with a positive effect on the system efficiency. These systems are mainly used in high performance and high specification tractors (>100kW) used to supply complex and powerful implements.

[0009] In contrast to Closed-center load sensing systems, Open-center load sensing systems are provided with a fixed displacement pump. The pump supply is equipped with valve means for connection to the tank which serves the purposes of keeping a certain stand-by pressure differential. The valve opens the connection to tank above a defined pressure differential adjusted by a spring. The connection to tank is also opened if the pump pressure exceeds the load sensing pressure plus the stand-by pressure. Thus the oil is circulating in a short circuit reducing losses/input power of the pump.

[0010] A further improvement is offered by systems using a fixed displacement pump which are equipped with further valve means to provide two pressure differentials depending on consumer demand:

- If there is no demand, a first pressure differential, e.g. about 5 bar is kept;
- If there is a demand, the pressure differential is raised to e.g. 13 bar to improve system response and to ensure sufficient fluid flow to consumer.

These systems represent a valuable compromise between cost and efficiency and thereby are mainly installed in smaller tractors (<100 kW) e.g. vineyard tractors.

[0011] Referring to the load sensing system, there are two conditions in which the may be operated. In a first condition, referred to as static load signal, the consumer generates a load sensing signal pressure in the form of a static fluid column with minor fluid flow in the direction toward the pump supply to feed back the demand.

[0012] In contrast, a dynamic pressure signal condition is characterised in that a minor fluid flow in the direction toward the consumer is provided by the pump supply. This oil flow does not adversely affect the load sensing function. The load signal generated by a consumer is a static oil column forwarded along the pipes. The oil flow coming from the pump supply in dynamic LS condition would merge with this oil column. Thus, Load sensing systems working in the dynamic LS condition provide faster response as the oil flow amplifies the signal coming from consumer. For this reason, some hydraulic supply systems are configured to provide a dynamic load sensing condition just for faster response.

[0013] A further trend can be seen related to the supply and control means used on implements. Due to increasing automation in agricultural work, implements are provided with more and more control functions which require complex control strategies. While in the past implements were equipped with only a few controllable drives (e.g. hydraulic cylinders or motors) which were controlled by valves on the tractor, today implements are provided with numerous controllable drives which cannot be controlled by the valves installed on the tractor. A standard tractor may be installed with 6 valves for implement supply and control while for example an attached baler requires 10 hydraulic functions to be controlled in terms of flow rate and/or time. To address this, tractors are equipped with Power Beyond systems. Indicated by the name, these systems supply an uncontrolled (at the tractor) fluid flow to the implement via a respective interface, such as quick couplers. The implement itself is then equipped with control means in form of valves to adjust the parameters of the fluid supply. Similar to internal consumers these Power Beyond system also include a Load Sensing function so that the demand of consumers on the implement is fed back to the supply system on the tractor.

[0014] A major advantage of the Power Beyond system is that the costs involved with fluid supply control are moved from the tractor to the implement so that a wider range of applications can be handled by tractors with reduced hydraulic control capability. These Power Beyond systems have mainly been the preserve of tractors with higher performance (>100kW) and Closed-center load sensing systems as described above. However, a demand has been recognized for smaller tractors with Open-center load sensing systems to provide Power Beyond, for example vineyard tractors with about 70 kW have to provide a supply to complex implements such as fruit harvesters equipped with many hydraulic drives to be controlled.

[0015] For a consumer mounted on the tractor, the fluid flow from pump supply to control valves/consumer passes only short distances within piping and thereby the losses (due to friction between fluid and piping) are relatively small. In a Power Beyond system, problems arise with the supply of an implement due to the distance between the consumer (on the implement) and the tractor which result in longer piping and increased frictional losses. Furthermore, the use of quick couplers for Power Beyond connection may also increase losses. These losses are also present in the return line from consumer to tank.

[0016] The resulting losses reduce the supplied pressure differential between pump supply and consumer so that consumers may be underserved.

[0017] To mitigate this problem, means are provided on the tractor to amplify the Load Sensing signal coming from the implement so that the pressure differential is increased, i.e. the amplifying means forwards a higher demand to the pump supply to balance the losses on the way from pump supply to consumer and from consumer to tank. Physically the amplification is produced by superposing the hydraulic pressure signal (LS signal) coming from the implement with a pressure supplied by the pump of the tractor. The amplification can thereby be adjusted by the driver, e.g. depending on the implement attached

[0018] But this causes problems of its own with the dynamic LS signal condition leading to rapid spiking of hydraulic pressure levels.

[0019] It is an object of the present invention to provide a constant flow fluid supply that offers Power Beyond capability and Load Sensing signal amplification.

[0020] In accordance with a first aspect of the present invention there is provided a pressurised fluid supply system for an agricultural vehicle, comprising:

- a pump;
- a tank to receive fluid;
- means to adjust the pressure differential of said supply system in a dynamic load sensing pressure signal condition; and
- amplifying means arranged to superpose a load sensing pressure signal of an external consumer of the fluid supply system with the pump pressure, the amplifying means comprising first tank connection means to discharge fluid to the tank, the first tank connection means including a valve to limit the fluid flow in the first tank connection means to a first maximum value;

characterised in that the amplifying means is provided with a second tank connection means to discharge fluid to the tank.

[0021] Suitably, the means to adjust the pressure differential of the said supply system provides two pressure differential levels. By the provision of the second discharge means, overpressure accumulation issues are addressed to provide a constant pump supply system with a two level pressure differential supply in conjunction with load sensing signal am-

plification for systems such as Power Beyond.

[0022] Also in accordance with the present invention there is provided an agricultural vehicle including such a pressurised fluid supply system.

[0023] Further features of the invention are recited in the attached sub-claims, to which reference should now be made.

[0024] Embodiments of the invention will now be described, by way of example only, and with reference to the accompanying drawings in which:

Figure 1 is a schematic representation of a first embodiment of a pressurised fluid supply system according to the present invention;

Figure 2 shows a detail of the fluid supply system of Figure 1; and

Figure 3 shows a detail a further embodiment of a fluid supply system according to the present invention.

[0025] Figure 1 shows an OC-LS hydraulic supply system 1 of a tractor 1 a for supplying an external consumer 4 on an implement 4a connected via a Power Beyond system. The tractor supply system 1 comprises a fixed displacement pump 2, a fluid reservoir 3, and a valve manifold 10, together with lines 5, 6, 7 for the connection of the external consumer 4, whereby:

- Supply line 5 connects consumer 4 to pump 2 via quick attach coupling 5a
- Return line 6 connects consumer 4 to tank 3 via quick attach coupling 6a
- Load Sensing line 7 connects consumer 4 to valve manifold 10 via quick attach coupling 7a.

[0026] In an OC-LS hydraulic supply system the pump is constantly delivering fluid flow, whereby the pressure in the supply system depends on the resistance in the supply system. Resistance can be generated by consumers transforming the energy into mechanical work (by lifting a front loader) or even by flow resistance in the components. To keep the losses in the idle mode as low as possible, the discharge of the fluid flow to the tank may suitably occur as close as possible to the pump in order to minimise the effect of resistance in the pipes and keep the system as efficient as possible. On the other hand a certain level of pressure must be maintained to keep the fluid flow active and responsive. This requires compromises in efficiency.

[0027] Typically, the valve manifold 10 comprises various valve assemblies 20, 30, 40, 50, 60 which can be easily attached together with each valve assembly 20, 30, 40, 50, 60 being shaped like a plate with ports for the hydraulic connection being aligned to the functionally similar port of the adjacent plate. The shared ports are named P for the ports connected to pump 2, R for the ports connected to tank 3 and Y for the ports connected to Load sensing signal lines. Furthermore, exit ports A, B are for connection with a consumer, e.g. port A may be connected to one side of the piston and port B may be connected to opposing side of the piston of hydraulic lifting cylinder moving the lower links of a three-point-linkage. Such a valve manifold 10 can be designed without internal connecting pipes or hoses and is very flexible in terms of the configurations which may be achieved. An example of such a manifold is the SB23 Control Block produced by Bosch Rexroth AG of Schwieberdingen, Germany.

[0028] In the configuration of the first embodiment, the valve manifold 10 comprises first valve assembly 20 which is directly connected to pump 2 and tank 3 and final valve assembly 40 which closes or redirects ports. In between first valve assembly 20 and final valve assembly 40, intermediate valve assemblies 30, 50, and 60 are provided to control fluid flow to consumers (not shown) on the tractor 1 a (e.g. linkage cylinders) or on the implement 4a (via respective couplings which are not shown).

[0029] In an alternative to the stacked plate manifold construction, the first valve assembly 20 may be designed in that further intermediate valve assemblies can be attached on opposing sides as shown in applicant's published patent application EP 2472162A1.

[0030] In Figure 1, the intermediate valve assemblies 30, 50 and 60 are only indicated with dotted lines. The intermediate valve assemblies 30, 50 and 60 can be designed in various configurations depending on the function which has to be controlled.

[0031] The valve manifold 10 is shown in detail in Figure 2 whereby valve assemblies 50 and 60 are omitted for better clarity. Referring firstly to valve assembly 30, a prioritisation valve 31 and a control valve 32 are provided. In position 31 a, prioritisation valve 31 solely connects the pump 2 to valve 32 as long as there is demand of valve 32 (forwarded via LS port 31 b). This position is supported by spring 31 c. If the pump 2 supplies more than the demand of valve 32, prioritisation valve 31 is moved towards position 31 d so that part of the fluid flow is directed to the successional intermediate valve assemblies (50, 60 Fig. 1). If there is no demand by valve 32, prioritisation valve 31 is moved in position 31 d so that no fluid flows to valve 32.

[0032] The above described configuration is only one example. A more simple one may be that the fluid flow coming

from port P is forwarded to the successional intermediate valve assemblies 30, 50, 60 without any prioritisation so that each valve assembly would then be supplied equally (known as "social" distribution). Furthermore the configuration of valve 32 can differ, for example in the number of ports, proportional valves or two-position valves.

[0033] First valve assembly 20 (shown in more detail in Figure 2) is provided to connect valve manifold 10 conjointly to pump 2 via port P and tank 3 via ports R1, R2. Ports R, Y and P are provided for connection with attached intermediate valve assemblies, whereby port R is the return line to tank 3, port P is the pressure line and port Y is the port for the Load Sensing pressure signal LSP. Valve assembly 20 comprises:

- Main pressure limiting valve 21 (for the supply line)
- LS pressure limiting valve 22 (for the Load Sensing line)
- Sequence valve 23
- Pressure compensation valve 24
- orifices 25a, b

[0034] Main pressure limiting valve 21 and LS pressure limiting valve 22 open the connection of the respective circuit to tank when pressure level exceeds 210 bar at main pressure limiting valve 21 or 200bar at LS pressure limiting valve 22. Thereby damaging pressure levels are avoided.

[0035] Sequence valve 23 can take closed position 23a (shown) and open position 23b, whereby the fluid flow is blocked in position 23a or ports 23c and 23d are connected in position 23b accordingly. Position 23a is biased by spring 23e. Pressure charged at control port 23f counteracts the spring 23e which is set to 10 bar in the shown embodiment.

[0036] Pressure compensation valve 24 can take any position between a closed position 24a (shown) and an open position 24b, in which the fluid flow is blocked (and valve ports 24c and 24d are not connected) in position 24a biased by spring 24e. Pressure charged at valve control port 24f counteracts the spring 24e which is set to 5 bar (=PS1) in the shown embodiment plus the Load Sensing pressure signal LSP at port 24g. Pressure compensation valve 24 adjusts the pressure for pump and circuit.

[0037] The function of valve assembly 20 is explained below by reference to different operating conditions (C.....) whereby pump 2 is constantly delivering:

Condition C1: No demand by consumers

[0038] Pump 2 is charging port 24c (at pump pressure PP) and control port 24f (at pressure P1) of pressure compensation valve 24. As the load sensing pressure signal LSP= 0 bar at control port 24g, control port 24f is balanced with spring 24e (setting PS1=5bar) opening the connection to tank 3 above 5 bar according the equation for the balance of pressure compensation valve 24:

$$\begin{aligned} \text{a) } PP &= P1 \\ \text{b) } P1 - PS1 - LSP &= 0 \\ P1 &= PS1 + LSP = 5 \text{ bar} + 0 \text{ bar} \\ &= 5 \text{ bar} \end{aligned}$$

[0039] Thereby the pump pressure/supply circuit pressure PP is limited to 5 bar. Pump 2 is also charging port 23c of sequence valve 23, but as load sensing signal LSP= 0, sequence valve 23 remains in position 23a by spring 23e. In this operating condition pressure differential PD is defined according to the following equation:

$$PD = PP - LSP = 5 \text{ bar} - 0 \text{ bar} = 5 \text{ bar}$$

[0040] As valve assemblies 30, 50 or 60 are not operated this is an idle mode.

Condition C2: Consumer demand LSP < 10bar = 7 bar

[0041] Pump 2 is charging port 24c (pump pressure PP) and control port 24f (pressure P1) of pressure compensation valve 24. As the load sensing pressure is 7 bar at control port 24g, control port 24f is balanced with spring 24e opening connection to tank above 12 bar according the equation for the balance of pressure compensation valve 24:

$$\begin{aligned} \text{a) } P1 &= PP \\ \text{b) } P1 - PS1 - LSP &= 0 \end{aligned}$$

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$$\begin{aligned} P1 &= PS1 + LSP = 5 \text{ bar} + 7 \text{ bar} \\ &= 12 \text{ bar} \end{aligned}$$

[0042] Thereby the pump pressure/supply circuit pressure is adjusted to 12 bar. Pump 2 is also charging port 23c of sequence valve 23 but as LSP is charging port 23f against spring 23e and LSP is 7 bar < 10 bar, sequence valve 23 remains in position 23a.

In this operating condition, pressure differential PD is:

$$PD = PP - LSP = 12 \text{ bar} - 7 \text{ bar} = 5 \text{ bar}.$$

[0043] This pressure differential enables operation with low output (e.g. small adjustments etc.) whereby valve assemblies 30, 50 or 60 control active consumers.

Condition C3: Consumer demand LSP > 10 bar = 20 bar

[0044] In this condition, sequence valve 23 is moved to position 23b as pressure LSP at control port 23f is higher than the pressure resulting from the force applied by spring 23c. With sequence valve 23 in position 23b, the behaviour of valve assembly 20 is completely changed.

[0045] Pump 2 is still charging port 24c and control port 24f of pressure compensation valve 24. But as sequence valve 23 is moved in open position 23b, fluid flow is provided towards the consumer via orifices 25b and subsequently 25a. This fluid flow, through orifices 25a,b results in different pressures at control port 24f (pressure P1) of compensation valve 24 compared to the pump pressure. In the shown embodiment, the pressure difference D between pump pressure PP and pressure P1 is about 8.7 bar (resulting from orifice diameter) so the equation for the balance of pressure compensation valve 24:

$$\begin{aligned} \text{a) } PP - D - PS1 - LSP &= 0 \\ PP &= D + PS1 + LSP = 8.7 \text{ bar} + 5 \text{ bar} + 20 \text{ bar} \\ &= 33.7 \text{ bar} \end{aligned}$$

[0046] Thereby the pump pressure/supply circuit pressure is adjusted to 33.7 bar.

[0047] In this operating condition pressure differential is calculated as:

$$PD = PP - LSP = 33.7 \text{ bar} - 20 \text{ bar} = 13.7 \text{ bar}$$

[0048] The major change is in that fluid flow of < 1 l/min at port Y (for the Load Sensing pressure signal LSP) is provided in the direction from the pump supply to the consumers defined as dynamic pressure signal condition. As explained above, the load sensing signal coming from consumer is adversely affected.

Condition C4: Consumer demand LSP at maximum 200 bar

[0049] If a consumer is blocked (e.g. if a linkage ram runs against the stop) the load sensing signal raises up to 200 bar (set by LS pressure limiting valve 22). This results in a dynamic load sensing condition as sequence valve 23 is moved in open position 23b. In this case, the equation for the balance of pressure compensation valve 24

$$\begin{aligned} \text{a) } P1 &= PP - D \\ \text{b) } P1 - PS1 - LSP &= 0 \\ PP - D - PS1 - LSP &= 0 \\ PP &= PS1 + LSP + D = 5 \text{ bar} + 200 \text{ bar} + 8.7 \text{ bar} \\ &= 213.7 \text{ bar} \end{aligned}$$

[0050] Thereby the pump pressure/supply circuit pressure is adjusted to 213.7 bar.

[0051] In this operating condition pressure differential is calculated:

$$PD = PP - LSP = 213.7 \text{ bar} - 200 \text{ bar} = 13.7 \text{ bar}$$

Condition Summary:

[0052] The valve assembly 20 is installed to provide two different levels of pressure differential, 5 bar and 13.7 bar, whereby the level of 5 bar is needed to ensure operational availability (so that e.g. valves can be adjusted) while the level of 13.7 bar is provided if there is a load sensing signal >10 bar.

[0053] Problems arise as in condition C3 (characterised by the dynamic LS condition) wherein a fluid flow coming from pump 2 is entering the LS circuit (port Y) in direction of the intermediate valve assemblies 30, 50, and 60 or especially the Power Beyond system. If any of valve assemblies 30, 50, and 60 is operated, this fluid flow is normally passing these valve assemblies 30, 50, 60 towards the consumer and summed up with a load signal. If the valve assemblies are not operated, the fluid flow is discharged via internal connection to tank (provided in valve assemblies 30, 50, and 60).

[0054] As discussed above, a pressure differential (of 5 bar) set by valve assembly 20 would result in the supply by pump 2 being insufficient as losses would decrease the pressure differential on the way to the consumer on the implement so that work/output of the consumer would be lower than required and the responsiveness (dynamic behaviour) would be insufficient. This is mitigated by the amplifying function of valve assembly 40 comprising:

- Amplifier valve 41
- Filter element 42
- Flow control valve 43

[0055] The filter element 42 is provided to filter out debris in the fluid entering via external consumer 4 or the fast coupling 7a.

[0056] The amplifier valve 41 is provided in the LS line between the consumer 4 of the Power Beyond system 4 and the port Y connecting valve assembly 40 and valve assemblies 30, 50, and 60 with the first valve assembly 20. The amplifier valve 41 has a first port 41 a connected with the LS line coming from external consumer 4.

A second port 41 b is connected to pump 2 (via valve assemblies 30, 50, and 60 with the first valve assembly 20) and the valve can be adjusted by the driver of the vehicle 1 a to a chosen pressure amplification by means of a solenoid 41 c. Third port 41 d is connected with the load sensing signal pressure line Y of the valve manifold 10. The amplifier valve 41 is of proportional type so that it can be moved to any position between first position 41 e and second position 41 f to adjust the connection of third port 41 d with first port 41 a or/and second port 41 b. A spring 41 g plus pressure at port 41 d is biasing position 41 f while the solenoid 41 c is supported by the pressure at port 41 a for pressure control.

[0057] If no consumer is connected with the Power Beyond, the driver should normally set the lowest amplification. Two conditions for amplification can be seen:

1. Amplification without load signal

[0058] If the driver adjusts for an amplification of 15 bar via solenoid 41 c, and no load sensing signal (0 bar) coming from the consumer is provided at first port 41 a, both pressures are superposed to 15 bar which is fed via port 41 d to the valve assembly 20.

Similar to operating Condition C3: the pressure differential would be adjusted according the equation for the balance of pressure compensation valve 24:

$$\begin{aligned} \text{a) } PP-D-PS1-LSP &= 0 \\ PP &= D + PS1 + LSP = 8.7 \text{ bar} + 5 \text{ bar} + 15 \text{ bar} \\ &= 28.7 \text{ bar} \end{aligned}$$

[0059] Thereby the pump pressure/supply circuit pressure is adjusted to 28.7 bar.

[0060] In this operating condition pressure differential is calculated

$$PD = PP - LSP = 28.7 \text{ bar} - 15 \text{ bar} = 13.7 \text{ bar}$$

2. Amplification with load signal

[0061] If the driver adjusts for an amplification of 15 bar via solenoid 41 c, and a load sensing signal of 20 bar coming from the consumer is provided at first port 41 a, both pressures are superposed to 35 bar which is fed via port 41 d to the valve assembly 20.

[0062] Similar to operating Conditions C3: the pressure differential would be adjusted according the equation for the

balance of pressure compensation valve 24:

a) PP-D-PS1-LSP=0

PP = D + PS1 + LSP = 8.7 bar + 5 bar + 35 bar

= 48.7 bar

[0063] Thereby the pump pressure/supply circuit pressure is adjusted to 48.7 bar.

[0064] In this operating condition pressure differential is calculated

$$PD = PP - LSP = 48.7 \text{ bar} - 35 \text{ bar} = 13.7 \text{ bar}$$

[0065] Further Problems regarding amplification are present.

[0066] If the consumer 4 of the Power Beyond system is disconnected, a small volume of fluid would be trapped in the lines between fast couplings 7a and amplifier valve 41. This fluid may expand due to heat impact during operation resulting in a pressure rise which is forwarded to valve assembly 20 through valve 41 and the fluid trapped in the Y lines. This pressure rise would be interpreted as a load sensing pressure signal and valve assembly 20 would increase pump pressure. An increase in pump pressure would again raise the pressure so that at the end, the pressure level in the Y line would be constantly increased until the overpressure protection according to operating condition C4: would constantly discharge the fluid flow to tank 3 at a pressure level of 205 bar which is highly inefficient.

[0067] To mitigate this problem it is known from the prior art to provide flow control valve 43 and a connection to tank line R which serves the purpose to discharge a trapped fluid volume (when consumer is disconnected) to the tank. In the embodiment shown in Figures 1 and 2, flow control valve 43 limits the fluid flow to 0,5 l/min so that trapped fluid can be discharged but the load sensing signal pressure is not falsified too much when an external consumer 4 is connected.

[0068] In the prior art, such amplifier valves 41 are mainly used in systems having a variable displacement pump. These systems do not require a first valve assembly 20 offering two pressure differential levels (as described above). Thereby the problem of the change between a static load pressure signal condition (according operating conditions C1: and C2:) and a dynamic load pressure signal condition (according operating conditions C3: and C4:) is not addressed.

[0069] In case of an operating condition similar to C3 with a load sensing signal LSP >10 bar coming from the Power Beyond system, a fluid flow of <1 l/min (as to dynamic load sensing signal condition) coming from valve assembly 20 via LS line Y towards valve assembly 40 cannot be discharged to tank 3 sufficiently as the fluid flow cannot pass amplifying valve 41 completely and is dammed leading to increasing pressure. This pressure rise at amplifier valve 41 would then result in amplification by amplifier valve 41 and thereby a constant rise of the pump pressure until the overpressure level is reached. As a consequence prior art systems with constant flow pump can offer amplification or two pressure levels, but not both.

[0070] To mitigate the problem, a further flow control valve 44 (set to a limitation of 0.9 l/min) and a connection to tank line R is provided.

[0071] Due to this additional valve 44, in case of an operating condition similar to C3 with a load sensing signal LSP >10 bar coming from the Power Beyond system (as described in the next to last paragraph or two paragraphs above), the fluid flow of <1 l/min coming from valve assembly 20 (as to dynamic load sensing signal condition) . can be discharged at least partly to tank via flow control valve 44. The setting of 0.9 l/min for flow control valve 44 is chosen for the shown embodiment as the fluid flow in dynamic LS condition varies between 0.2 l/min and 0.9 l/min.

[0072] Even if part of the fluid flow passes amplifier valve 41, flow control valve 43 could additionally discharge a remaining fluid flow (up to 0.5 l/min).

[0073] The setting for valve 44 regarding the limitation of the fluid flow can be adapted to the conditions of the supply system.

[0074] The flow control valve 44 does not falsify the load sensing pressure signal coming via Power Beyond as amplifier valve 41 permanently adjusts amplification and compensates fluid discharged via flow control valve 44.

[0075] Figure 3 shows an alternative embodiment with final valve assembly 40' wherein the flow control valve 44 is replaced by a pressure compensator 46. The pressure compensator is provided to discharge the fluid flow coming from valve assembly 20 if there is no load sensing signal (demand) coming from the consumer of the Power Beyond system via amplifier valve 41. Pressure compensator 46 can take every position in between Position 46a and 46b .Position 46a is biased with spring 46c (set to 3 bar) resulting in the consumers load sensing signal being reduced by 3 bar which may be compensated by higher amplification.

[0076] This solution offers an OC-LS supply system with a two level pressure differential supply plus amplification for Power Beyond consumers. As will be readily understood, variations to the embodiments described herein are possible, and the invention could be used whenever a dynamic LS signal condition is present in combination with Power Beyond

amplifying.

[0077] Furthermore, there may be applications wherein amplification is provided for consumers on the vehicle or on implements not supplied via Power Beyond while the invention is still applicable.

Claims

1. A pressurised fluid supply system for an agricultural vehicle, comprising:

- a pump;
- a tank to receive fluid;
- means to adjust the pressure differential of said supply system in a dynamic load sensing pressure signal condition; and
- amplifying means arranged to superpose a load sensing pressure signal of an external consumer of the fluid supply system with the pump pressure, the amplifying means comprising first tank connection means to discharge fluid to the tank, the first tank connection means including a valve to limit the fluid flow in the first tank connection means to a first maximum value;

characterised in that the amplifying means is provided with a second tank connection means to discharge fluid to the tank.

2. A pressurised fluid supply system according to claim 1, wherein the means to adjust the pressure differential of said supply system provides two pressure differential levels.

3. A pressurised fluid supply system according to claim 1 or 2, wherein the second tank connection means is provided with a valve to limit the fluid flow in the second tank connection means to a second maximum value.

4. A pressurised fluid supply system according to claim 3, wherein the second maximum value is larger than the maximum fluid flow of the dynamic load sensing pressure signal condition.

5. A pressurised fluid supply system according to claim 1 or 2, wherein the second tank connection means is provided with a pressure compensator.

6. A pressurised fluid supply system according to claim 5, wherein the pressure compensator is connected to discharge a load sensing signal in dynamic load sensing condition to the tank.

7. A pressurised fluid supply system according to claim 1, wherein the pump is a fixed displacement pump.

8. An agricultural vehicle including a pressurised fluid supply system according to any preceding claim.

9. An agricultural vehicle as claimed in claim 8, wherein the pressurised fluid supply system is a Power Beyond fluid supply system.

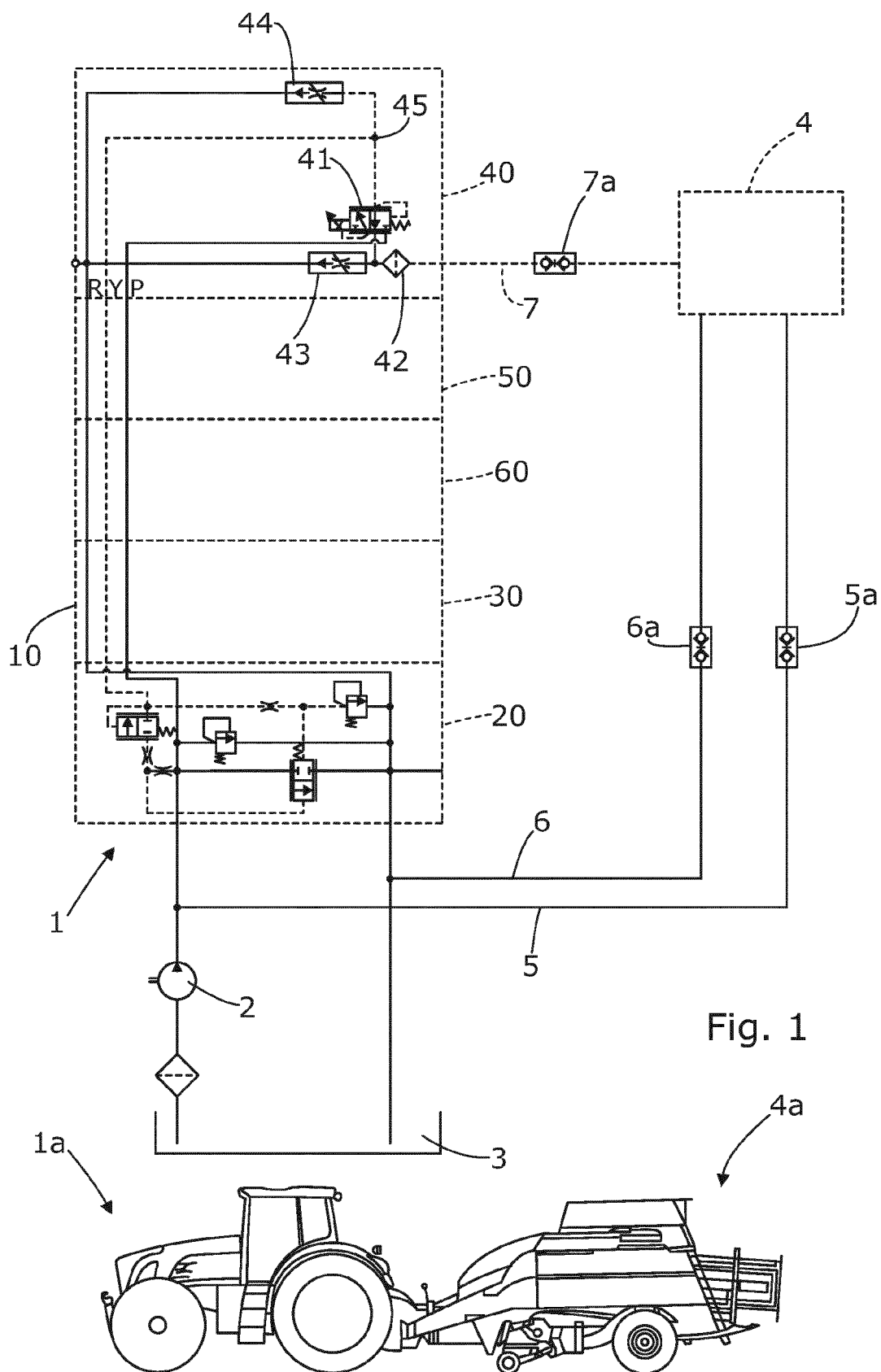


Fig. 1

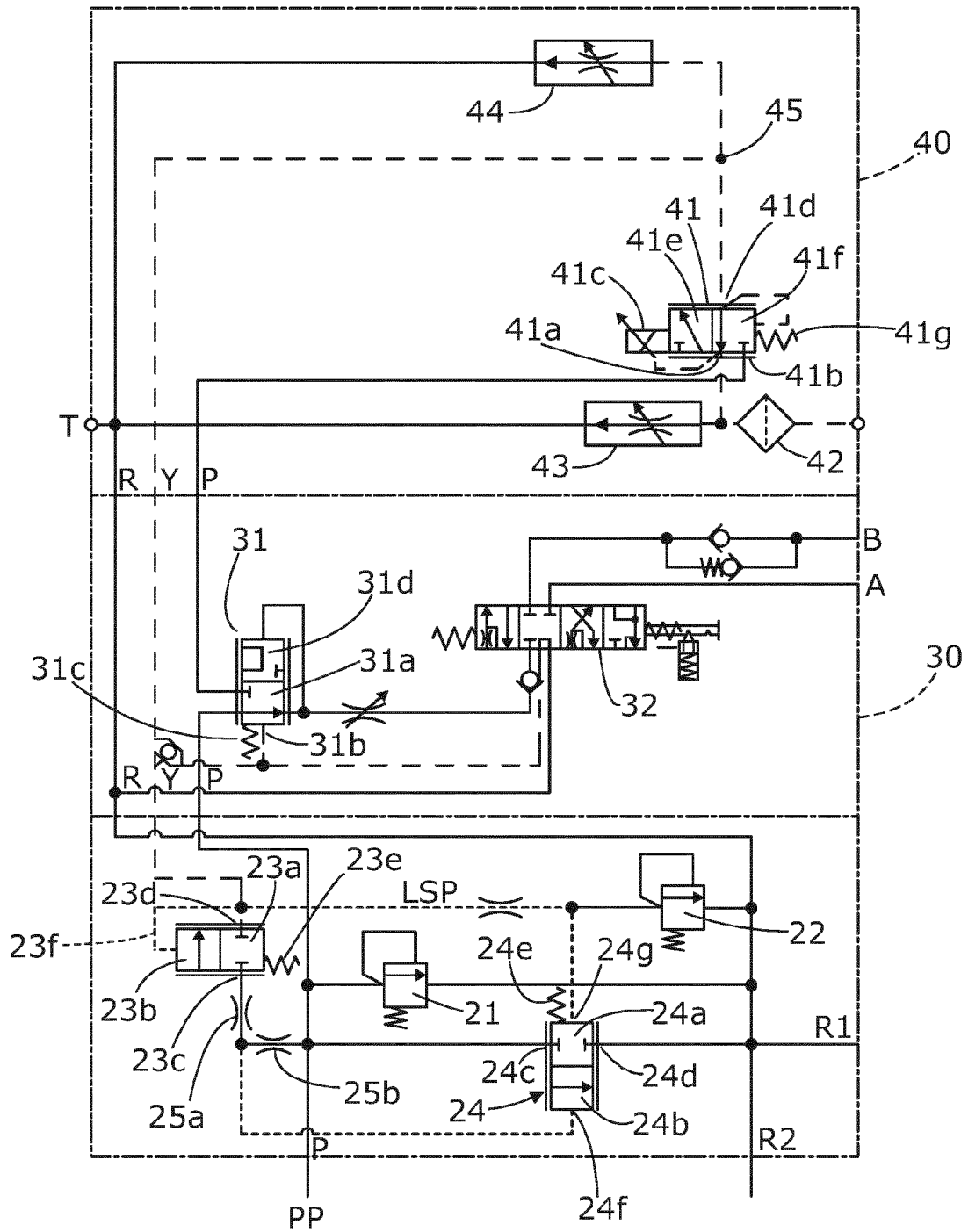


Fig. 2

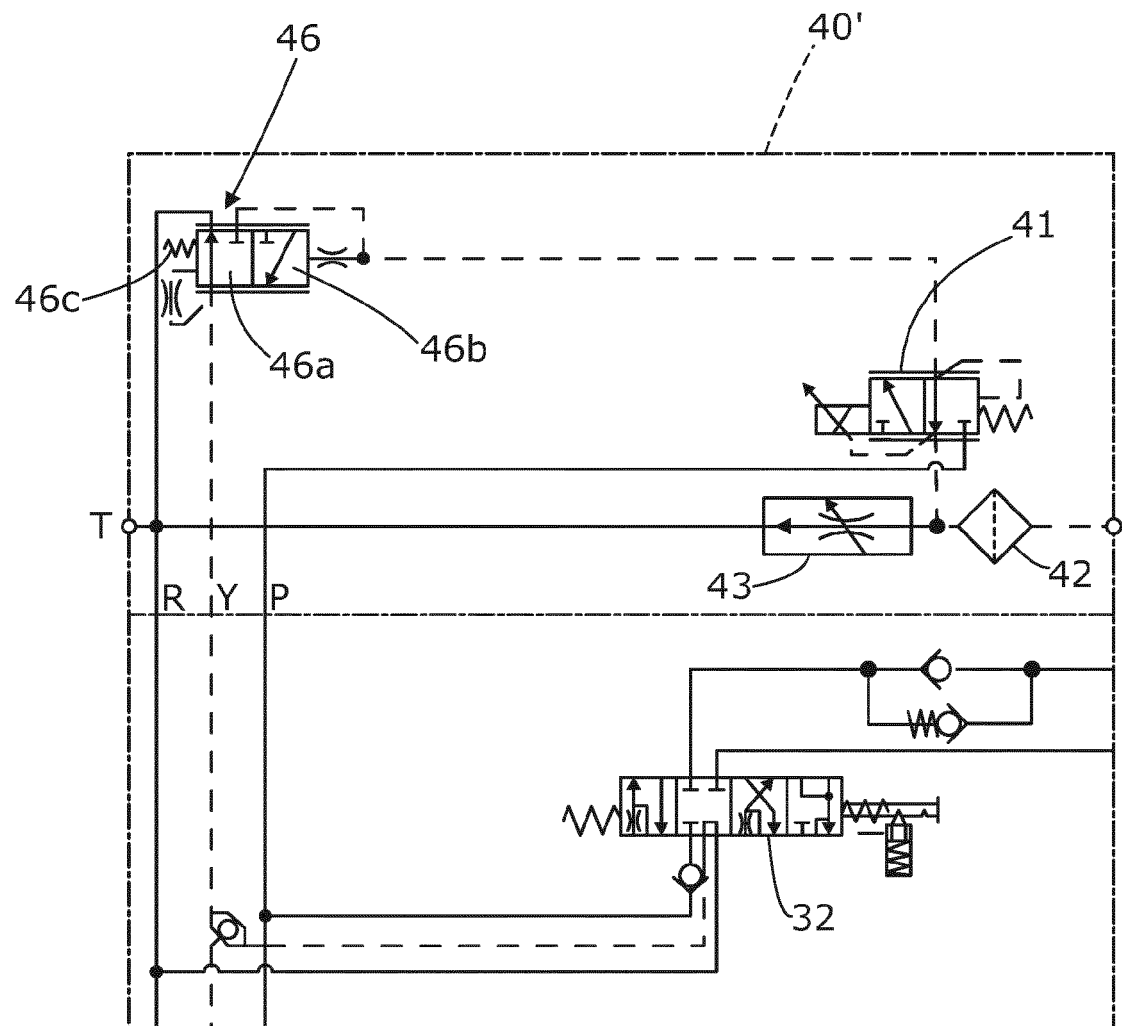


Fig. 3



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