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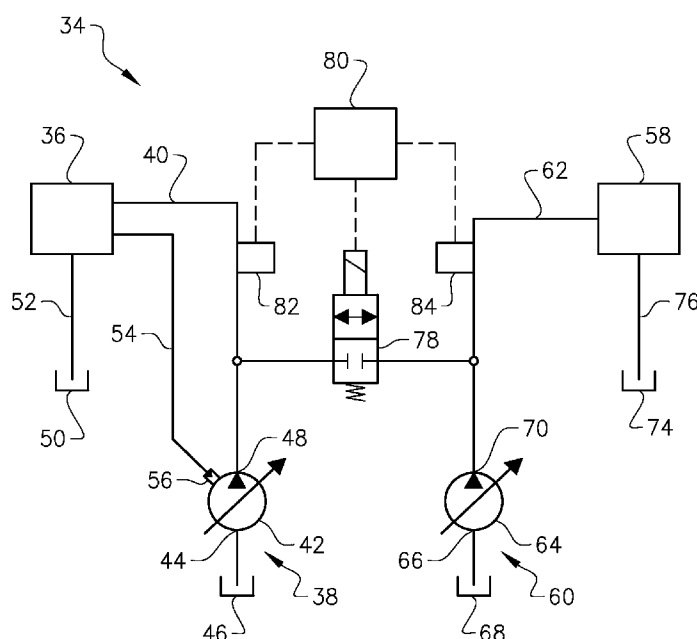


FIG. 2

(57) Abstract: The present invention relates to a hydraulic system (34) comprising a first actuator (36), a first pump assembly (38) and a first hydraulic circuit (40) for providing hydraulic fluid from the first pump assembly (38) to the first actuator (36). The hydraulic system (34) is adapted to control the pump pressure of the first pump assembly (38) to exceed a first load pressure existing in the first actuator (36) by a predetermined first margin. The hydraulic system (34) further comprises a second actuator (58), a second pump assembly (60) and a second hydraulic circuit (62) for providing hydraulic fluid from the second pump assembly (60) to the second actuator (58). The hydraulic system (34) is adapted to assume a connected condition in which the first and second hydraulic circuits (40, 62) are fluidly connected to each other and a disconnected condition in which the first and second hydraulic circuits (40, 62) are fluidly disconnected from each other.

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HYDRAULIC SYSTEM

TECHNICAL FIELD

The present invention relates to a hydraulic system according to the preamble of claim 1. Moreover, the present invention relates to a working machine. Furthermore, the present
5 invention relates to a control unit. Additionally, the present invention relates to a method for operating a hydraulic system.

BACKGROUND OF THE INVENTION

10 Hydraulic systems of today may comprise a so called load sensing system. A load sensing system generally comprises a pump feeding hydraulic fluid to an actuator. The pressure output from the pump is controlled by determining a load pressure at the actuator and controlling the pump so as to provide a hydraulic output fluid resulting in that an output pressure at a high pressure side of the pump exceeds the load pressure by a
15 predetermined amount. In this way, it is ensured that hydraulic fluid with sufficient pressure can be supplied to the actuator.

A hydraulic load sensing system may include two or more actuators and the pump is then controlled so as to discharge hydraulic fluid such that the pump pressure exceeds the
20 highest load pressure in the actuators by a predetermined amount. In such an event, the fluid pressure fed to the actuator(s) not associated with the highest load pressure may have to be reduced before reaching the actuator(s). Such a pressure reduction may result in energy losses e.g. thermal losses.

25 As such, it would be desired to obtain a hydraulic system that includes a load sensing system but wherein the energy losses can be reduced.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a hydraulic system comprising a load
30 sensing system which hydraulic system is associated with appropriately low energy losses during use.

The above object is achieved by a hydraulic system according to claim 1.

As such, the present invention relates to a hydraulic system comprising a first actuator, a first pump assembly and a first hydraulic circuit for providing hydraulic fluid from the first pump assembly to the first actuator. The hydraulic system is adapted to control the pump pressure of the first pump assembly to exceed a first load pressure existing in the first actuator by a predetermined first margin. The hydraulic system further comprises a second actuator, a second pump assembly and a second hydraulic circuit for providing hydraulic fluid from the second pump assembly to the second actuator.

- 10 According to the present invention, the hydraulic system is adapted to assume a connected condition in which the first and second hydraulic circuits are fluidly connected to each other and a disconnected condition in which the first and second hydraulic circuits are fluidly disconnected from each other.
- 15 By virtue of the above hydraulic system, the first hydraulic circuit, which is a load sensing hydraulic circuit, may be operated individually when desired and it may also be operated in conjunction with the second hydraulic circuit when desired.

For instance, in operating conditions in which hydraulic fluid from the first hydraulic circuit fed to the second hydraulic circuit could result in large energy losses in portions of the second hydraulic circuit, it may be desired to operate the first and second hydraulic circuits individually.

As another example, in operating conditions in which hydraulic fluid from the first hydraulic circuit fed to the second hydraulic circuit could result in tolerable energy losses in portions of the second hydraulic circuit and in which one or more actuators in the second hydraulic circuit could benefit from receiving additional hydraulic fluid from the first hydraulic circuit, it may be desired to fluidly connect the first and second hydraulic circuits to each other.

- 30 As may be realized from the above, the hydraulic system according to the present invention implies a versatile use of the first and second first pump assemblies.

Optionally, the hydraulic system is adapted to control the pump pressure of the second pump assembly to exceed a second load pressure existing in the second actuator by a

predetermined second margin. As such, the second hydraulic circuit may also be a load sensing circuit.

Optionally, the hydraulic system comprises a circuit communication valve assembly
5 connecting the first hydraulic circuit and the second hydraulic circuit to each other. The circuit communication valve assembly is adapted to assume an open condition for obtaining the connected condition and a closed condition for obtaining the disconnected condition.

10 A circuit communication valve assembly may be a preferred implementation for obtaining the connected and disconnected conditions of the hydraulic system.

Optionally, the hydraulic system further comprises a connection control unit adapted to control the condition of the hydraulic system between the connected condition and the
15 disconnected condition on the basis of a current and/or predicted fluid condition in at least one of the first and second hydraulic circuits.

Optionally, the connection control unit is adapted to control the condition of the hydraulic system by controlling the condition of the circuit communication valve assembly.
20

Optionally, the current and/or predicted fluid condition is a current and/or predicted required fluid flow. The required fluid flow may be used as an indication for determining whether the first and second hydraulic circuits should be connected or disconnected.

25 Optionally, the required fluid flow is a current and/or predicted required fluid flow discharged from at least one of the first and second pump assemblies.

Optionally, the connection control unit is adapted to determine if the pump assembly associated with the required fluid flow is capable of producing a fluid flow in the circuit at
30 or above the required fluid flow. If it is determined that the pump assembly associated with the required fluid flow is not capable of producing the required fluid flow on its own, this may be an indication that the first and second hydraulic circuits should be connected so as to allow the other pump assembly to feed hydraulic fluid into the hydraulic circuit associated with the required fluid flow.

35

Optionally, the connection control unit is adapted to determine a pressure difference value indicative of a current and/or predicted pressure difference between the fluid pressure in at least a portion of the first hydraulic circuit and the fluid pressure in at least a portion of the second hydraulic circuit.

5

As has been intimated hereinabove, relatively large pressure differences between the first and second hydraulic circuits may result in undesirably high energy losses in at least one of the systems. Thus, information indicative of the pressure difference between the two circuits may be valuable when deciding how to operate the hydraulic system, e.g. whether
10 or not the first and second hydraulic circuits should be fluidly connected or disconnected. Purely by way of example, the pressure difference may be determined after it has been determined that the pump assembly associated with the required fluid flow is not capable of producing the required fluid flow on its own. As such, if it has been concluded that it would be beneficial to connect the two circuits since the pump assembly associated with
15 the required fluid flow could need an additional flow from the other pump assembly, the above-mentioned pressure difference could be determined in order to ensure that e.g. the pressure levels in the two circuits are not too different.

Optionally, the current and/or predicted pressure difference is a current and/or predicted
20 pressure difference between the first load pressure existing in the first actuator and the fluid pressure in at least a portion of the second hydraulic circuit. As such, the first load pressure, which has an implication on the pressure discharged from the first pump assembly, may be used as a parameter when determining the pressure difference.

25 Optionally, the current and/or predicted pressure difference is a current and/or predicted pressure difference between the first load pressure existing in the first actuator and the second load pressure existing in the second actuator. As such, the second load pressure, which has an implication on the pressure discharged from the second pump assembly, may be used as a parameter when determining the pressure difference.

30

Optionally, the connection control unit is adapted to issue a signal such that the hydraulic system assumes the connected condition as a response to the determination of the pressure difference value being within a predetermined pressure difference value range. When the pressure difference is within the predetermined pressure difference value
35 range, for instance when the absolute value of the pressure difference is relatively low,

there is generally a low risk for encountering excessive energy losses in the hydraulic system. As such, in such a condition, it may be appropriate to connect the first and second hydraulic circuits.

- 5 Optionally, the connection control unit is adapted to issue a signal such that the hydraulic system assumes the disconnected condition as a response to the determination of the pressure difference value being outside the predetermined pressure difference value range. When the pressure difference is outside the predetermined pressure difference value range, for instance when the absolute value of the pressure difference is relatively
- 10 large, there is generally an increased risk for encountering excessive energy losses in the hydraulic system. As such, in such a condition, it may be appropriate to disconnect the first and second hydraulic circuits from each other.

- Optionally, the hydraulic system comprises a first sensor for determining the fluid pressure
- 15 in at least a portion of the first hydraulic circuit. The first sensor is in communication with the connection control unit.

- Optionally, the hydraulic system comprises a second sensor for determining the fluid pressure in at least a portion of the second hydraulic circuit. The second sensor is in
- 20 communication with the connection control unit.

- Optionally, the hydraulic system comprises a first pump assembly control unit adapted to control the flow discharged from the first pump assembly. The first pump assembly control unit is in communication with the connection control unit.
- 25

- Optionally, the hydraulic system comprises a second pump assembly control unit adapted to control the flow discharged from the second pump assembly. The second pump assembly control unit is in communication with the connection control unit.

- 30 Optionally, the first actuator is adapted to be controlled by a first actuator control. The first actuator control is in communication with the connection control unit.

- Optionally, the second actuator is adapted to be controlled by a second actuator control. The second actuator control is in communication with the connection control unit.
- 35

A second aspect of the present invention relates to a working machine comprising the hydraulic system according to the first aspect of the present invention.

A third aspect of the present invention relates to a connection control unit, preferably an
5 electronic control unit, for a hydraulic system. The hydraulic system comprises a first actuator, a first pump assembly and a first hydraulic circuit for providing hydraulic fluid from the first pump assembly to the first actuator. The hydraulic system is adapted to control the pump pressure of the first pump assembly to exceed a first load pressure existing in the first actuator by a predetermined first margin. The hydraulic system further
10 comprises a second actuator, a second pump assembly and a second hydraulic circuit for providing hydraulic fluid from the second pump assembly to the second actuator.

According to the third aspect of the present invention, the connection control unit control unit is adapted to issue a signal for controlling the hydraulic system to assume at least
15 either a connected condition in which the first and second hydraulic circuits are fluidly connected to each other or a disconnected condition in which the first and second hydraulic circuits are fluidly disconnected from each other.

Optionally, the connection control unit control unit is adapted to control the condition of the
20 hydraulic system on the basis of a current and/or predicted fluid condition in at least one of the first and second hydraulic circuits.

Optionally, the current and/or predicted fluid condition is a current and/or predicted required fluid flow, preferably a current and/or predicted required fluid flow discharged
25 from at least one of the first and second pump assemblies.

Optionally, the connection control unit is adapted to determine if the pump assembly associated with the required fluid flow is capable of producing a fluid flow in the circuit at or above the required fluid flow.

30

Optionally, the connection control unit is adapted to determine a pressure difference value indicative of a current and/or predicted pressure difference between the fluid pressure in at least a portion of the first hydraulic circuit and the fluid pressure in at least a portion of the second hydraulic circuit.

Optionally, the current and/or predicted pressure difference is a current and/or predicted pressure difference between the first load pressure existing in the first actuator and the fluid pressure in at least a portion of the second hydraulic circuit.

- 5 Optionally, the connection control unit is adapted to issue a signal such that the hydraulic system assumes the connected condition as a response to the determination of the pressure difference value being within a predetermined pressure difference value range.

- Optionally, the connection control unit is adapted to issue a signal such that the hydraulic
10 system assumes the disconnected condition as a response to the determination of the pressure difference value being outside the predetermined pressure difference value range.

- Optionally, the connection control unit is adapted to receive a signal from a first sensor of
15 the hydraulic system. The first sensor is adapted to determine the fluid pressure in at least a portion of the first hydraulic circuit. The first sensor is in communication with the control unit.

- Optionally, the connection control unit is adapted to receive a signal from a second sensor
20 of the hydraulic system. The second sensor is adapted to determine the fluid pressure in at least a portion of the second hydraulic circuit. The second sensor is in communication with the connection control unit.

- Optionally, the hydraulic system comprises a first pump assembly control unit adapted to
25 control the flow discharged from the first pump assembly. The control unit is adapted to receive a signal from the first pump assembly control unit.

- Optionally, the hydraulic system comprises a second pump assembly control unit adapted to control the flow discharged from the second pump assembly. The connection control
30 unit is adapted to receive a signal from the second pump assembly control unit.

Optionally, the first actuator is adapted to be controlled by a first actuator control. The connection control unit is adapted to receive a signal from the first actuator control.

Optionally, the second actuator is adapted to be controlled by a second actuator control. The connection control unit is adapted to receive a signal from the second actuator control.

- 5 Optionally, the hydraulic system comprises a circuit communication valve assembly connecting the first hydraulic circuit and the second hydraulic circuit to each other. The circuit communication valve assembly is adapted to assume an open condition for obtaining the connected condition and a closed condition for obtaining the disconnected condition. The connection control unit is adapted to issue a signal for controlling the circuit
10 communication valve to assume at least either the open condition or the closed condition.

A fourth aspect of the present invention relates to a method for operating a hydraulic system. The hydraulic system comprises a first actuator, a first pump assembly and a first hydraulic circuit for providing hydraulic fluid from the first pump assembly to the first
15 actuator. The hydraulic system is adapted to control the pump pressure of the first pump assembly to exceed a first load pressure existing in the first actuator by a predetermined first margin. The hydraulic system further comprises a second actuator, a second pump assembly and a second hydraulic circuit for providing hydraulic fluid from the second pump assembly to the second actuator.

20

According to the fourth aspect of the present invention, the method further comprises controlling the hydraulic system so as to assume at least either one of a connected condition in which the first and second hydraulic circuits are fluidly connected to each other and a disconnected condition in which the first and second hydraulic circuits are
25 fluidly disconnected from each other.

Optionally, the hydraulic system is adapted to control the pump pressure of the second pump assembly to exceed a second load pressure existing in the second actuator by a predetermined second margin.

30

Optionally, the method further comprises controlling the condition of the hydraulic system between the connected condition and the disconnected condition on the basis of a current and/or predicted fluid condition in at least one of the first and second hydraulic circuits.

Optionally, the current and/or predicted fluid condition is a current and/or predicted required fluid flow.

Optionally, the required fluid flow is a current and/or predicted required fluid flow
5 discharged from at least one of the first and second pump assemblies.

Optionally, the method further comprises determining if the pump assembly associated with the required fluid flow is capable of producing a fluid flow in the circuit at or above the required fluid flow.

10

Optionally, the method further comprises determining a pressure difference value indicative of a current and/or predicted pressure difference between the fluid pressure in at least a portion of the first hydraulic circuit and the fluid pressure in at least a portion of the second hydraulic circuit.

15

Optionally, the current and/or predicted pressure difference is a current and/or predicted pressure difference between the first load pressure existing in the first actuator and the fluid pressure in at least a portion of the second hydraulic circuit.

20 Optionally, the current and/or predicted pressure difference is a current and/or predicted pressure difference between the first load pressure existing in the first actuator and second load pressure existing in the second actuator.

Optionally, the method further comprises controlling the hydraulic system so as to assume
25 the connected condition as a response to the determination of the pressure difference value being within a predetermined pressure difference value range.

Optionally, the method further comprises controlling the hydraulic system so as to assume the disconnected condition as a response to the determination of the pressure difference
30 value being outside the predetermined pressure difference value range.

Optionally, the hydraulic system comprises a circuit communication valve assembly connecting the first hydraulic circuit and the second hydraulic circuit to each other. The circuit communication valve assembly is adapted to assume an open condition for
35 obtaining the connected condition and a closed condition for obtaining the disconnected

condition. The method comprises controlling the hydraulic system so as to assume the connected condition by controlling the circuit communication valve assembly so as to assume the open condition. The method further comprises controlling the hydraulic system so as to assume the disconnected condition by controlling the circuit

5 communication valve assembly so as to assume the closed condition.

BRIEF DESCRIPTION OF THE DRAWINGS

With reference to the appended drawings, below follows a more detailed description of embodiments of the invention cited as examples.

10

In the drawings:

Fig. 1 illustrates an excavator;

15 Fig. 2 schematically illustrates an embodiment of a hydraulic system;

Fig. 3 schematically illustrates an example of a circuit communication valve assembly;

Fig. 4 schematically illustrates an embodiment of a hydraulic system;

20

Fig. 5 schematically illustrates an embodiment of a hydraulic system;

Fig. 6 schematically illustrates an embodiment of a hydraulic system, and

25 Fig. 7 is a flow chart of a method.

It should be noted that the appended drawings are not necessarily drawn to scale and that the dimensions of some features of the present invention may have been exaggerated for the sake of clarity.

30

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The invention will be described in the following for a vehicle in the form of a working machine 10. The Fig. 1 working machine 10 is an excavator. The Fig. 1 vehicle 10

comprises ground engaging elements 12 for propelling the vehicle 10. In the Fig. 1 embodiment, the ground engaging elements 12 comprises wheels 14. However, it is also envisioned that the ground engaging elements 12 instead of, or in addition to, wheels may comprise other means for propelling the vehicle 10. As non-limiting example, 5 implementations of the ground engaging elements 12 may comprise crawlers (not shown).

The Fig. 1 vehicle 10 comprises a lower frame 16. In the Fig. 1 embodiment, the lower frame is an undercarriage. The lower frame 16 may comprise the ground engaging elements 12. Moreover, the Fig. 1 vehicle 10 comprises an upper frame 18. In the Fig. 1 10 embodiment, the upper frame 18 is a superstructure. In embodiments of the vehicle 10, such as the excavator illustrated in Fig. 1, the upper frame 18 may be pivotable relative to the lower frame 16. To this end, the Fig. 1 vehicle 10 may comprise a swing system 20 allowing the upper frame 18 to pivot in relation to the lower frame 16. The lower frame 16, the upper frame 18 and the swing system 20 may form part of a main body 22 of the 15 vehicle 10.

Moreover, the Fig. 1 vehicle 10 comprises an implement 24 and a connector 26 connecting the main body 22 to the implement 24. As a non-limiting example, the vehicle 10 may be constituted by the main body 22, the implement 24 and the connector 26. In 20 such an example, the main body 22 is constituted by the whole vehicle 10 except for the implement 14 and the connector 16.

Moreover, the Fig. 1 vehicle comprises a set of hydraulic actuators 28, 30, 32 for moving the implement 24 relative to the main body 22. In the Fig. 1 embodiment, each one of the 25 hydraulic actuators 28, 30, 32 is exemplified as a cylinder. However, it is also envisioned that embodiments of the vehicle 10 may comprise other types of hydraulic actuators. As a non-limiting example, embodiments of the vehicle 10 may comprise one or more hydraulic motors (not shown) adapted to contribute to the displacement of the implement 24 relative to the main body 22.

30

The Fig. 1 vehicle 10 may be propelled by a hydraulic system. Moreover, the hydraulic actuators 28, 30, 32 may be powered by the hydraulic system.

Fig. 2 illustrates an embodiment of a hydraulic system 34 according to the present 35 invention. The Fig. 2 hydraulic system 34 comprises a first actuator 36, a first pump

assembly 38 and a first hydraulic circuit 40 adapted to guide pressurized hydraulic fluid from the first pump assembly 38 to the first actuator 36.

In the Fig. 2 implementation, the first pump assembly 38 comprises a single first pump 42.

5 However, it is envisioned that implementations of the first pump assembly 38 may comprise a plurality of pumps (not shown).

Irrespective of the implementation of the first pump assembly 38, the first pump assembly 38 generally comprises a low pressure side 44 in fluid communication with a first supply
10 tank 46 and a high pressure side 48 adapted to be in fluid communication with the first actuator 36. To this end, the first hydraulic circuit 40 may be adapted to provide a fluid communication between the high pressure side 48 and the first actuator 36. As is indicated in Fig. 2, the first hydraulic circuit 40 may be constituted by a first conduit assembly comprising one or more conduits.

15

Moreover, the hydraulic system 34 may comprise means for providing a fluid communication between the first actuator 36 and a first return tank 50, for instance by means of a first return conduit 52.

20 The first supply tank 46 and the first return tank 50 may be in fluid communication with each other. In fact, it is envisioned that the first supply tank 46 and the first return tank 50 may be constituted by the same tank.

The hydraulic system 34 is adapted to control the pump pressure of the first pump
25 assembly 38 to exceed a first load pressure existing in the first actuator 36 by a predetermined first margin. As such, the first actuator, the first pump assembly and the first hydraulic circuit form part of a first load sensing circuit of the hydraulic system 34.

Generally, the function of a load sensing circuit comprising a pump assembly, an actuator
30 and a hydraulic circuit for providing hydraulic fluid from the pump assembly to the actuator may be defined in accordance with the following: a hydraulic output from the pump assembly is controllable such that an output pressure in a high pressure side of the pump assembly exceeds a load pressure existing in the actuator by a predetermined margin.

Purely by way of example, the hydraulic output from the first pump assembly 38 is controlled on the basis of a measured pressure corresponding to the load pressure in the actuator 36. The Fig. 2 hydraulic system 34 comprises a first hydraulic signal conduit 54, which also may be referred to as a pipe or lead, adapted to transport a first hydraulic
5 signal indicative of the first load pressure to a regulator 56 of the first pump assembly 38. Purely by way of example, the predetermined first margin may be fixed. Moreover, again purely by way of example, the predetermined first margin may be within the range of 10 to 40 bar, preferably within the range of 20 to 30 bar.

10 As an alternative to being adapted to receive a hydraulic signal as indicated hereinabove, the first pump assembly 38 may be adapted to receive an electronic signal indicative of the of the first load pressure. In such an embodiment, the hydraulic system 34 may comprise a first load pressure sensor (not shown) adapted to measure the first load pressure and to issue an electronic signal to the first pump assembly 38.

15

The first actuator 36 illustrated in the Fig. 2 may be at least one of the hydraulic actuators 28, 30, 32 presented hereinabove in relation to Fig. 1. It is also contemplated that the first hydraulic circuit 40 is adapted to guide pressurized hydraulic fluid from the first pump assembly 38 to a plurality of first actuators (not shown). In such an event, the above-
20 mentioned hydraulic signal is indicative of the largest pressure at the plurality of first actuators.

The hydraulic system 34 further comprises a second actuator 58, a second pump assembly 60 and a second hydraulic circuit 62 adapted to guide pressurized hydraulic
25 fluid from the second pump assembly 60 towards the second actuator 58. As is indicated in Fig. 2, the second hydraulic circuit 62 may be constituted by a second conduit assembly comprising one or more conduits.

In the Fig. 2 implementation, the second pump assembly 60 comprises a single second
30 pump 64. However, it is envisioned that implementations of the second pump assembly 60 may comprise a plurality of pumps (not shown).

Irrespective of the implementation of the second pump assembly 60, the second pump assembly 60 generally comprises a low pressure side 66 in fluid communication with a
35 second supply tank 68 and a high pressure side 70 adapted to be in fluid communication

with the second actuator 58. To this end, the second hydraulic circuit 62 may be adapted to provide a fluid communication between the high pressure side 70 and the second actuator 58. As is indicated in Fig. 2, the second hydraulic circuit 62 may be constituted by a second conduit assembly comprising one or more conduits.

5

Moreover, the hydraulic system 34 comprises means for providing a fluid communication between the second actuator 58 and a second return tank 74, for instance by means of a second return conduit 76.

- 10 The second supply tank 68 and the second return tank 74 may be in fluid communication with each other. In fact, it is envisioned that the second supply tank 68 and the second return tank 74 may be constituted by the same tank.

Moreover, it is contemplated that the first supply tank 46, the first return tank 50, the
15 second supply tank 68 and the second return tank 74 may be in fluid communication with each other. In fact, it is envisioned that all the above-mentioned four tanks 44, 50, 68, 74 may be constituted by the same tank.

The second actuator 58 may for instance be a hydraulic motor for propelling one or more
20 wheels (not shown in Fig. 2) of the Fig. 1 vehicle.

Moreover, as is indicated in Fig. 2, the hydraulic system 34 is adapted to assume a connected condition in which the first and second hydraulic circuits 40, 62 are fluidly connected to each other and a disconnected condition in which the first and second
25 hydraulic circuits 40, 62 are fluidly disconnected from each other.

The above connected and disconnected conditions may be obtained in a plurality of ways. Purely by way of example, the hydraulic system 34 may comprise a connecting conduit (not shown) that may be temporarily connected to each one of the first and second
30 hydraulic circuits 40, 62 in order to obtain the connected condition. In order to obtain the disconnected condition, such a connecting conduit may be disconnected from at least one of the hydraulic circuits 40, 62.

However, the Fig. 2 embodiment of the hydraulic system 34 comprises a preferred
35 example of a means that can be used for obtaining the connected and disconnected

conditions. To this end, the Fig. 2 embodiment comprises a circuit communication valve assembly 78 connecting the first hydraulic circuit 40 and the second hydraulic circuit 62 to each other.

- 5 In the Fig. 2 embodiment, the circuit communication valve assembly 78 comprises a single valve but it is also envisioned that other examples of the circuit communication valve assembly 78 may comprise two or more valves (not shown) and/or additional components such as conduits (not shown).
- 10 Moreover, in the Fig. 2 embodiment, the circuit communication valve assembly 78 is adapted to assume an open condition for obtaining the connected condition and a closed condition for obtaining the disconnected condition.

However, other implementations of circuit communication valve assemblies 78 are also
15 envisioned. To this end, reference is made to Fig. 3 illustrating an example of a circuit communication valve assembly 78 which comprises a valve being adapted to assume three different conditions: a first condition (illustrated by the upper position in Fig. 3) allowing hydraulic fluid to flow from the second circuit 62 to the first circuit 40 but preventing hydraulic fluid flow in the opposite direction, a second condition (illustrated by
20 the centre position in Fig. 3) allowing hydraulic fluid to flow from the first circuit 40 to the second circuit 62 but preventing hydraulic fluid flow in the opposite direction and a third condition (illustrated by the lower position in Fig. 3) preventing hydraulic fluid flow between the first and the second circuits 40, 62. As such, the Fig. 3 circuit communication valve assemblies 78 can assume two open conditions and one closed condition.

25

The Fig. 3 implementation of the circuit communication valve assembly 78 may be used in any embodiment of the hydraulic system 34, in particular any embodiment of the hydraulic system 34 which is presented hereinabove or hereinbelow.

- 30 It is also envisioned that the circuit communication valve assembly 78 may comprise a proportional valve.

Moreover, and as is indicated in Fig. 2, the Fig. 2 embodiment of the hydraulic system 34 comprises a connection control unit 80 adapted to control the condition of the hydraulic
35 system 34 between the connected condition and the disconnected condition on the basis

of a current and/or predicted fluid condition in at least one of the first and second hydraulic circuits 40, 62.

The Fig. 2 example of the connection control unit 80 is adapted to receive information
5 indicative of a current hydraulic fluid condition of the first hydraulic circuit 40 from a first hydraulic circuit sensor 82 in communication with the connection control unit 80 and information indicative of the current hydraulic fluid condition of the second hydraulic circuit 62 from a second hydraulic circuit sensor 84 in communication with the connection control unit 80.

10

Purely by way of example, each one of the first and second hydraulic circuit sensors 82, 84 may be adapted to determine at least one of the hydraulic pressure and the hydraulic fluid flow in the corresponding hydraulic circuit 40, 62.

15 Further details as regards the connection control unit 80 are presented hereinbelow.

Fig. 4 illustrates another embodiment of the hydraulic system 34. In the Fig. 4 embodiment, the hydraulic system 34 is adapted to control the pump pressure of the second pump assembly 60 to exceed a second load pressure existing in the second
20 actuator 58 by a predetermined second margin. As such, also the second pump assembly 60, the second actuator 58 and the second hydraulic circuit 62 may form part of a load sensing circuit.

To this end, the hydraulic system 34 comprises a second hydraulic signal conduit 86,
25 which also may be referred to as a pipe or lead, adapted to transport a second hydraulic signal indicative of the second load pressure to a regulator 88 of the second pump assembly 60.

Depending on the type of load sensing system, the hydraulic signal or signals may be
30 determined at different locations of the hydraulic system 34.

To this end, reference is made to Fig. 5 illustrating an embodiment of a hydraulic system 34 which comprises a first main control valve 90 located between the first pump assembly 38 and the first actuator 36 in an intended direction of flow from the first pump assembly
35 38 to the first actuator 36. In the Fig. 5 embodiment, the first hydraulic signal is indicative

of the fluid pressure of the hydraulic fluid fed from the first main control valve 90 to the first actuator 36.

To this end, in the Fig. 5 embodiment, the first hydraulic signal conduit 54 is in fluid communication with the first main control valve 90. The first main control valve 90 comprises a first port 92 and a second port 94 each one of which being adapted to be in fluid communication with the first actuator 36. Moreover, depending on the condition of the first main control valve 90, a fluid communication may be provided between the first pump assembly 38 and one of the first and second ports 92, 94 and a fluid communication may be provided between the other of the first and second ports 92, 94 and the first return tank 50. Additionally, the first main control valve 90 may be adapted to control the hydraulic fluid flow from the first pump assembly 38 to the first actuator 36 and/or the hydraulic fluid flow from the first actuator 36 to the first return tank 50.

Furthermore, the first main control valve 90 comprises a third port 96. The pressure level at the third port 96 is the same as the pressure level at the one of the first and second ports 92, 94 via which a fluid communication between the pump assembly 38 and the first actuator 36 currently is provided. The third port 96 is in fluid communication with the regulator 56, for instance by means of the first hydraulic signal conduit 54.

20

The first main control valve 90 is controlled by a first actuator control 98. As is indicated in Fig. 5, the first actuator control 98 may be in communication with the connection control unit 80.

Fig. 5 also illustrates an embodiment of a hydraulic system 34 which comprises a second main control valve 100 located between the second pump assembly 60 and the second actuator 58 in an intended direction of flow from the first pump assembly 60 to the first actuator 58. In the Fig. 5 embodiment, the second hydraulic signal is indicative of the fluid pressure of hydraulic fluid fed from the second main control valve 100 to the second actuator 58.

30

The second main control valve 100 is controlled by a second actuator control 102. As is indicated in Fig. 5, the second actuator control 102 may be in communication with the connection control unit 80.

35

Instead of a main control valve with three ports as has been discussed hereinabove with reference to the first main control valve 90, the second hydraulic signal may be determined by means of shuttle valve 108 which is connected to conduits 104, 106 connecting the second main control valve 100 and the second actuator 58. The shuttle
5 valve 108 is in fluid communication with the regulator 88 of the second pump assembly 60 via the second hydraulic signal conduit 86. The largest pressure in the conduits 104, 106 is output by the shuttle valve 108. As such, as for the first hydraulic signal, the second hydraulic signal may be indicative of the fluid pressure of hydraulic fluid fed from a second main control valve 100 to the second actuator 58.

10

It should be noted that the first main control valve 90 and the shuttle valve 108 have been included in the same embodiment in order to be able to condense the presentation of various means for issuing a hydraulic signal to a regulator 56, 88, which hydraulic signal is indicative of a fluid pressure of hydraulic fluid fed from a main control valve 90, 100 to an
15 actuator 36, 58. However, it is of course contemplated that embodiments of the hydraulic system 34 may comprise two or more control valves with three ports or two or more shuttle valves 108.

As non-limiting examples, it is envisioned that embodiments of the hydraulic system 34
20 comprising a first and a second actuator 36, 58 may comprise two control valves with three ports, a first control valves located between the first pump assembly 38 and the first actuator 36 and a second control valve located between the second pump assembly 60 and the second actuator 58.

25 Instead of, or in addition to, being controlled by a main control valve, the actuation, e.g. the movement, of an actuator may be controlled by a variable displacement hydraulic motor unit. To this end, reference is made to Fig. 6.

In the Fig. 6 embodiment, the movements of the second actuator 58 are controlled by a
30 variable displacement hydraulic motor unit 110. The Fig. 6 variable displacement hydraulic motor unit 110 is located between the second actuator 58 and the second return tank 74. As such, hydraulic fluid that leaves the second actuator 58 towards the second return tank 74 passes the variable displacement hydraulic motor unit 110. By controlling the displacement of the hydraulic motor unit 110, for instance by means of a hydraulic
35 motor control unit 112, the flow resistance through the hydraulic motor unit 110 and thus

the movement of the second actuator is controlled. The hydraulic motor unit 110 may be used for recovering energy from the hydraulic fluid leaving the second actuator 58. As is indicated in Fig. 6, the hydraulic motor control unit 112 may be in communication with the connection control unit 80.

5

Purely by way of example, and as is indicated in Fig. 6, the hydraulic motor unit 110 may be mechanically connected to the second pump assembly 60, for instance by means of a connecting shaft 114.

- 10 Moreover, the Fig. 6 embodiment comprises a second valve 116 located between the second pump assembly 60 and the second actuator 58 in an intended direction of flow from the second pump assembly 60 to the second actuator 58. The second valve 116 need not necessarily control the flow of the hydraulic fluid that is fed to the second actuator 58. Instead, the second valve 116 may only be adapted to selectively provide a
- 15 fluid communication between the second pump assembly 60 and one of the conduits 104, 106 as well as selectively providing a fluid communication between other conduit 104, 106 and the hydraulic motor unit 110.

- It should be noted that in embodiments of the hydraulic system 34, a hydraulic motor unit,
- 20 similar to the above discussed hydraulic motor unit 110, may also and/or instead be provided between the first actuator 36 and the first return tank 50.

- For any one of the above discussed embodiments of the hydraulic system 34, the hydraulic system 34 is adapted to assume a connected condition in which the first and
- 25 second hydraulic circuits 40, 62 are fluidly connected to each other and a disconnected condition in which the first and second hydraulic circuits 40, 62 are fluidly disconnected from each other. Examples of how such connected and disconnected conditions are controlled are presented hereinbelow.

- 30 For instance, the connected and disconnected conditions may be manually controlled by an operator.

However, as another non-limiting example, the connection control unit 80 may be adapted to control the condition of the hydraulic system 34 between the connected condition and

the disconnected condition on the basis of a current and/or predicted fluid condition in at least one of the first and second hydraulic circuits 40, 62.

Purely by way of example, the connection control unit 80 may receive information from the first and second hydraulic circuit sensors 82, 84 which have been discussed hereinabove in relation to Fig. 2. For instance, the information may comprise at least one of the hydraulic pressure and the hydraulic fluid flow in the corresponding hydraulic circuit 40, 62.

Fig. 7 illustrates a flow chart of an embodiment of a method for operating a hydraulic system 34, e.g. an embodiment of the hydraulic system 34 which has been presented hereinabove with reference to any one of Fig. 2, Fig. 4, Fig. 5 or Fig. 6. The Fig. 7 steps may be performed by the connection control unit 80.

In the embodiment of the method illustrated in Fig. 7, the hydraulic fluid condition is a hydraulic flow. As such, the Fig. 7 embodiment comprises a step S10 of determining a required fluid flow being a current and/or predicted required fluid flow in at least a portion of at least one of the first and second hydraulic circuits 40, 62.

Purely by way of example, the required fluid flow is a current and/or predicted required fluid flow discharged from at least one of the first and second pump assemblies.

For instance, the connection control unit 80 may be adapted to determine if the pump assembly associated with the required fluid flow is capable of producing a fluid flow in the circuit corresponding to the required fluid flow. Purely by way of example, the connection control unit 80 may be adapted to determine if the pump assembly associated with the required fluid flow has a maximum flow capacity that exceeds the required fluid flow. As a non-limiting example, the connection control unit 80 may be adapted to determine a ratio between the required fluid flow and the maximum flow capacity of the associated pump assembly.

If it is determined that the pump assembly associated with the required fluid flow is not capable of producing the required fluid flow, for instance if the above-mentioned ratio is larger than a predetermined threshold value, this may be an indication that the first and

second hydraulic circuits should be connected so as to allow the other pump assembly to feed hydraulic fluid into the hydraulic circuit associated with the required fluid flow.

As a non-limiting example, the predetermined threshold value for the ratio may be within
5 the range of 60% - 90%, preferably within the range of 70% - 80%.

Purely by way of example, embodiments of the hydraulic system 34 may comprise a first pump assembly control unit 118 adapted to control the flow discharged from the first pump assembly 38. The first pump assembly control unit 118 is in communication with the
10 connection control unit 80. The first pump assembly control unit 118 is illustrated in Fig. 6 only but it is envisioned that each hydraulic system embodiment illustrated in Fig. 2, Fig. 4 and Fig. 5 may also comprise a first pump assembly control unit 118. Generally, the first pump assembly control unit 118 sets the fluid flow produced by the first pump assembly 38 and the first pump assembly control unit 118 may also be adapted to communicate that
15 fluid flow to the connection control unit 80.

In a similar vein, embodiments of the hydraulic system 34 may comprise a second pump assembly control unit 120 adapted to control the flow discharged from the second pump assembly 60. The second pump assembly control unit 120 is in communication with the
20 connection control unit 80.

Moreover, and as is also indicated in Fig. 7, a step S12 may comprise issuing signals indicative of whether or not the pump assembly associated with the required fluid flow is capable of producing the required fluid flow. For instance, the step may evaluate whether
25 the above-mentioned ratio is smaller or larger than the predetermined threshold value.

If it is concluded in S12 that the pump assembly associated with the required fluid flow is capable of producing the required fluid flow, the Fig. 7 method proceeds to step S14 of setting the hydraulic system 34 in the disconnected condition, or if the hydraulic system
30 34 already is in the disconnected condition, maintaining the hydraulic system 34 in the disconnected condition.

In embodiments the hydraulic system 34 which comprises a circuit communication valve assembly 78, the disconnected condition may be obtained by setting the circuit
35 communication valve assembly 78 in an closed condition, or if the circuit communication

valve assembly 78 already is in the closed condition, maintaining the circuit communication valve assembly 78 in the closed condition.

On the other hand, if it is concluded in S12 that the pump assembly associated with the
5 required fluid flow is not capable of producing the required fluid flow, for instance if it is concluded that the above-mentioned ratio is larger than the predetermined threshold value, the Fig. 7 may method proceed to a step S18 of setting the hydraulic system 34 in the connected condition, or if the hydraulic system 34 already is in the connected condition, maintaining the hydraulic system 34 in the connected condition.

10

Again, in embodiments the hydraulic system 34 which comprises a circuit communication valve assembly 78, the connected condition may be obtained by setting the circuit communication valve assembly 78 in an open condition or, if the circuit communication valve assembly 78 already is in an open condition, maintaining the circuit communication
15 valve assembly 78 in the open condition.

In embodiments of the method, the method may go directly from step S12 to step S18. However, in the Fig. 7 embodiment, if it is concluded in S12 that the pump assembly associated with the required fluid flow is not capable of producing the required fluid flow,
20 the method proceeds to a step S16 of determining a pressure difference ΔP value indicative of a current and/or predicted pressure difference between the fluid pressure P_1 in at least a portion of the first hydraulic circuit 40 and the fluid pressure P_2 in at least a portion of the second hydraulic circuit 62.

25 Purely by way of example, and as is indicated in e.g. Fig. 2, the fluid pressure P_1 in at least a portion of the first hydraulic circuit 40 may be determined at a position between the first pump assembly 38 and the first actuator 36 as seen in an intended direction of flow from the first pump assembly 38 to the first actuator 36. In a similar vein, the fluid pressure P_2 in at least a portion of the second hydraulic circuit 62 may be determined at a
30 position between the second pump assembly 60 and the second actuator 58 as seen in an intended direction of flow from the second pump assembly 60 to the second actuator 58.

However, it is also envisioned that the fluid pressure P_1 in at least a portion of the first
35 hydraulic circuit 40 may be indicative of the first load pressure existing in the first actuator

36. To this end, reference is made to Fig. 5 wherein the first hydraulic circuit sensor 82 is in fluid communication with the first hydraulic signal conduit 54.

In a similar vein, the fluid pressure P_2 in at least a portion of the second hydraulic circuit 5 62 may be indicative of the second load pressure existing in the second actuator 58. To this end, reference is again made to Fig. 5 wherein the second hydraulic circuit sensor 84 is in fluid communication with the second hydraulic signal conduit 86.

Moreover, instead of, or in addition to, determining the current fluid pressures in the first 10 and second hydraulic circuits 40, 62, it is also envisioned that a predicted fluid pressure in at least one of the hydraulic circuits 40, 62 is used. Purely by way of example, the fluid pressure in at least one of the hydraulic circuits 40, 62 may be predicted by determining the position of control units (not shown) adapted to control the movement of the relevant actuator. As another example, if the hydraulic system 36 is adapted to perform a work 15 cycle, it could be possible to foresee future steps in the work cycle and based on such future steps, it may be possible to predict future pressure levels in the first hydraulic circuit 40 and/or the second hydraulic circuit 62.

Irrespective of how the fluid pressures P_1 , P_2 are determined, the step S16 in the Fig. 7 20 method evaluates whether or not the pressure difference value is within a predetermined pressure difference value range. Purely by way of example, the above evaluation may be issued by the connection control unit 80.

Moreover, upon the response that the pressure difference value is within a predetermined 25 pressure difference value range, the Fig. 7 method may proceed from step S16 to step S18 of setting the hydraulic system 34 in an connected condition or, if the hydraulic system 34 already is in an connected condition, maintaining the hydraulic system 34 in the connected condition.

30 As has been discussed hereinabove, in embodiments of the hydraulic system 34 that comprises a circuit communication valve assembly 78, the above setting may be achieved by setting the circuit communication valve assembly 78 to an open condition or, if the circuit communication valve assembly 78 already is in an open condition, maintaining the circuit communication valve assembly 78 in the open condition.

Moreover, upon the response that the pressure difference value is outside a predetermined pressure difference value range, the Fig. 7 method may go from step S16 to step S14 of setting the hydraulic system 34 in an disconnected condition or, if the hydraulic system 34 already is in an disconnected condition, maintaining the hydraulic
5 system 34 in the disconnected condition.

As has been discussed hereinabove, in embodiments of the hydraulic system 34 that comprises a circuit communication valve assembly 78, the above setting may be achieved by setting the circuit communication valve assembly 78 to an closed condition or, if the
10 circuit communication valve assembly 78 already is in an closed condition, maintaining the circuit communication valve assembly 78 in the closed condition.

It is to be understood that the present invention is not limited to the embodiments described above and illustrated in the drawings; rather, the skilled person will recognize
15 that many changes and modifications may be made.

CLAIMS

1. A hydraulic system (34) comprising a first actuator (36), a first pump assembly (38) and a first hydraulic circuit (40) for providing hydraulic fluid from said first pump assembly (38) to said first actuator (36), said hydraulic system (34) being adapted
5 to control the pump pressure of said first pump assembly (38) to exceed a first load pressure existing in said first actuator (36) by a predetermined first margin, said hydraulic system (34) further comprising a second actuator (58), a second pump assembly (60) and a second hydraulic circuit (62) for providing hydraulic fluid from said second pump assembly (60) to said second actuator (58),
10 characterized in that said hydraulic system (34) is adapted to assume a connected condition in which said first and second hydraulic circuits (40, 62) are fluidly connected to each other and a disconnected condition in which said first and second hydraulic circuits (40, 62) are fluidly disconnected from each other.
- 15 2. The hydraulic system (34) according to claim 1, wherein said hydraulic system (34) is adapted to control the pump pressure of said second pump assembly (60) to exceed a second load pressure existing in said second actuator (58) by a predetermined second margin.
- 20 3. The hydraulic system (34) according to claim 1 or claim 2, wherein said hydraulic system (34) comprises a circuit communication valve assembly (78) connecting the first hydraulic circuit (40) and the second hydraulic circuit (62) to each other, the circuit communication valve assembly (78) being adapted to assume an open condition for obtaining said connected condition and a closed condition for
25 obtaining said disconnected condition.
4. The hydraulic system (34) according to any one of the preceding claims, further comprising a connection control unit (80) adapted to control the condition of said hydraulic system (34) between said connected condition and said disconnected
30 condition on the basis of a current and/or predicted fluid condition in at least one of said first and second hydraulic circuits (40, 62).
5. The hydraulic system (34) according to claim 4, when dependent on claim 3, wherein said connection control unit (80) is adapted to control the condition of said

hydraulic system (34) by controlling the condition of said circuit communication valve assembly (78).

- 5 6. The hydraulic system (34) according to claim 4 or claim 5, wherein the current and/or predicted fluid condition is a current and/or predicted required fluid flow.
7. The hydraulic system (34) according to claim 6, wherein said required fluid flow is a current and/or predicted required fluid flow discharged from at least one of said first and second pump assemblies (38, 60).
- 10 8. The hydraulic system (34) according to claim 7, wherein said connection control unit (80) is adapted to determine if the pump assembly associated with the required fluid flow is capable of producing a fluid flow in the circuit at or above said required fluid flow.
- 15 9. The hydraulic system (34) according to any one of claims 4 to 8, wherein said connection control unit (80) is adapted to determine a pressure difference (ΔP) value indicative of a current and/or predicted pressure difference (ΔP) between the fluid pressure in at least a portion of said first hydraulic circuit (40) and the fluid
20 pressure in at least a portion of said second hydraulic circuit (62).
10. The hydraulic system (34) according to claim 9, wherein said current and/or predicted pressure difference (ΔP) is a current and/or predicted pressure difference (ΔP) between the first load pressure existing in the first actuator (36)
25 and the fluid pressure in at least a portion of said second hydraulic circuit (62).
11. The hydraulic system (34) according to claim 10, wherein said current and/or predicted pressure difference (ΔP) is a current and/or predicted pressure difference (ΔP) between the first load pressure existing in the first actuator (36)
30 and the second load pressure existing in the second actuator (58).
12. The hydraulic system (34) according to any one of claims 9 to 11, wherein said connection control unit (80) is adapted to issue a signal such that said hydraulic system (34) assumes said connected condition as a response to the determination
35 of said pressure difference (ΔP) value being within a predetermined pressure difference value range.

13. The hydraulic system (34) according to any one of claims 9 to 12, wherein said connection control unit (80) is adapted to issue a signal such that said hydraulic system (34) assumes said disconnected condition as a response to the determination of said pressure difference (ΔP) value being outside said predetermined pressure difference value range.
14. The hydraulic system (34) according to any one of claims 9 to 13, wherein said hydraulic system (34) comprises a first sensor (82) for determining the fluid pressure in at least a portion of said first hydraulic circuit (40), said first sensor (82) being in communication with said connection control unit (80).
15. The hydraulic system (34) according to any one of claims 9 to 14, wherein said hydraulic system (34) comprises a second sensor (84) for determining the fluid pressure in at least a portion of said second hydraulic circuit (62), said second sensor (84) being in communication with said connection control unit (80).
16. The hydraulic system (34) according to any one of claims 4 to 15, wherein said hydraulic system (34) comprises a first pump assembly control unit (118) adapted to control the flow discharged from the first pump assembly (38), the first pump assembly control unit (118) being in communication with said connection control unit (80).
17. The hydraulic system (34) according to any one of claims 4 to 16, wherein said hydraulic system (34) comprises a second pump assembly control unit (120) adapted to control the flow discharged from the second pump assembly (60), the second pump assembly control unit (120) being in communication with said connection control unit (80).
18. The hydraulic system (34) according to any one of claims 4 to 17, wherein said first actuator (36) is adapted to be controlled by a first actuator control (98), said first actuator control (98) being in communication with said connection control unit (80).
19. The hydraulic system (34) according to any one of claims 4 to 18, wherein said second actuator (58) is adapted to be controlled by a second actuator control

(102), said second actuator control (102) being in communication with said connection control unit (80).

20. A working machine (10) comprising the hydraulic system (34) according to any
5 one of the preceding claims.

21. A connection control unit (80), preferably an electronic control unit, for a hydraulic
system (34), said hydraulic system (34) comprising a first actuator (36), a first
pump assembly (38) and a first hydraulic circuit (40) for providing hydraulic fluid
10 from said first pump assembly (38) to said first actuator (36), said hydraulic system
(34) being adapted to control the pump pressure of said first pump assembly (38)
to exceed a first load pressure existing in said first actuator (36) by a
predetermined first margin, said hydraulic system (34) further comprising a second
actuator (58), a second pump assembly (60) and a second hydraulic circuit (62) for
15 providing hydraulic fluid from said second pump assembly (60) to said second
actuator (58), characterized in that said connection control unit control
unit (80) is adapted to issue a signal for controlling said hydraulic system (34) to
assume at least either a connected condition in which said first and second
hydraulic circuits (40, 62) are fluidly connected to each other or a disconnected
20 condition in which said first and second hydraulic circuits (40, 62) are fluidly
disconnected from each other.

22. The connection control unit control unit (80) according to claim 21, wherein said
connection control unit control unit (80) is adapted to control the condition of said
25 hydraulic system (34) on the basis of a current and/or predicted fluid condition in at
least one of said first and second hydraulic circuits (40, 62).

23. The control unit (80) according to claim 22, wherein the current and/or predicted
fluid condition is a current and/or predicted required fluid flow, preferably a current
30 and/or predicted required fluid flow discharged from at least one of said first and
second pump assemblies (38, 60).

24. The control unit (80) according to claim 23, wherein said connection control unit
(80) is adapted to determine if the pump assembly associated with the required
35 fluid flow is capable of producing a fluid flow in the circuit at or above said required
fluid flow.

25. The connection control unit (80) according to any one of claims 22 to 24, wherein said connection control unit (80) is adapted to determine a pressure difference (ΔP) value indicative of a current and/or predicted pressure difference (ΔP)
5 between the fluid pressure in at least a portion of said first hydraulic circuit (40) and the fluid pressure in at least a portion of said second hydraulic circuit (62).
26. The connection control unit (80) according to claim 25, wherein said current and/or predicted pressure difference (ΔP) is a current and/or predicted pressure
10 difference (ΔP) between the first load pressure existing in the first actuator (36) and the fluid pressure in at least a portion of said second hydraulic circuit (62).
27. The connection control unit (80) according to claim 25 or claim 26, wherein said connection control unit (80) is adapted to issue a signal such that said hydraulic
15 system (34) assumes said connected condition as a response to the determination of said pressure difference (ΔP) value being within a predetermined pressure difference value range.
28. The connection control unit (80) according to any one of claims 25 to 27, wherein said connection control unit (80) is adapted to issue a signal such that said
20 hydraulic system (34) assumes said disconnected condition as a response to the determination of said pressure difference (ΔP) value being outside said predetermined pressure difference value range.
29. The connection control unit (80) according to any one of claims 22 to 28, wherein said connection control unit (80) is adapted to receive a signal from a first sensor
25 (82) of said hydraulic system (34), said first sensor (82) being adapted to determine the fluid pressure in at least a portion of said first hydraulic circuit (40), said first sensor (82) being in communication with said control unit.
30. The connection control unit (80) according to any one of claims 22 to 29, wherein said connection control unit (80) is adapted to receive a signal from a second
30 sensor (84) of said hydraulic system (34), said second sensor (84) being adapted to determine the fluid pressure in at least a portion of said second hydraulic circuit

(62), said second sensor (84) being in communication with said connection control unit (80).

- 5 31. The connection control unit (80) according to any one of claims 22 to 30, wherein said hydraulic system (34) comprises a first pump assembly control unit (118) adapted to control the flow discharged from the first pump assembly (38), said control unit being adapted to receive a signal from the first pump assembly control unit (118).
- 10 32. The connection control unit (80) according to any one of claims 22 to 31, wherein said hydraulic system (34) comprises a second pump assembly control unit (120) adapted to control the flow discharged from the second pump assembly (60), said connection control unit (80) being adapted to receive a signal from the second pump assembly control unit (120).
- 15 33. The connection control unit (80) according to any one of claims 22 to 32, wherein said first actuator (36) is adapted to be controlled by a first actuator control (98), said connection control unit (80) being adapted to receive a signal from said first actuator control (98).
- 20 34. The connection control unit (80) according to any one of claims 22 to 33, wherein said second actuator (58) is adapted to be controlled by a second actuator control (102), said connection control unit (80) being adapted to receive a signal from said second actuator control (102).
- 25 35. The connection control unit (80) according to any one of claims 21 to 34, wherein said hydraulic system (34) comprises a circuit communication valve assembly (78) connecting the first hydraulic circuit (40) and the second hydraulic circuit (62) to each other, the circuit communication valve assembly (78) being adapted to
- 30 assume an open condition for obtaining said connected condition and a closed condition for obtaining said disconnected condition, said connection control unit (80) being adapted to issue a signal for controlling said circuit communication valve (78) to assume at least either said open condition or said closed condition.
- 35 36. A method for operating a hydraulic system (34), said hydraulic system (34) comprising a first actuator (36), a first pump assembly (38) and a first hydraulic

circuit (40) for providing hydraulic fluid from said first pump assembly (38) to said first actuator (36), said hydraulic system (34) being adapted to control the pump pressure of said first pump assembly (38) to exceed a first load pressure existing in said first actuator (36) by a predetermined first margin, said hydraulic system
5 (34) further comprising a second actuator (58), a second pump assembly (60) and a second hydraulic circuit (62) for providing hydraulic fluid from said second pump assembly (60) to said second actuator (58), characterized by controlling said hydraulic system (34) so as to assume at least either one of a connected condition in which said first and second hydraulic circuits (40, 62) are fluidly
10 connected to each other and a disconnected condition in which said first and second hydraulic circuits (40, 62) are fluidly disconnected from each other.

37. The method according to claim 36, wherein said hydraulic system (34) is adapted to control the pump pressure of said second pump assembly (60) to exceed a
15 second load pressure existing in said second actuator (58) by a predetermined second margin.

38. The method according to claim 36 or claim 37, further comprising controlling the condition of said hydraulic system (34) between said connected condition and
20 said disconnected condition on the basis of a current and/or predicted fluid condition in at least one of said first and second hydraulic circuits (40, 62).

39. The method according to claim 38, wherein the current and/or predicted fluid condition is a current and/or predicted required fluid flow.

25 40. The method according to claim 39, wherein said required fluid flow is a current and/or predicted required fluid flow discharged from at least one of said first and second pump assemblies (38, 60).

30 41. The method according to claim 40, further comprising determining if the pump assembly associated with the required fluid flow is capable of producing a fluid flow in the circuit at or above said required fluid flow.

42. The method according to any one of claims 38 to 41, comprising determining a
35 pressure difference (ΔP) value indicative of a current and/or predicted pressure difference (ΔP) between the fluid pressure in at least a portion of said first

hydraulic circuit (40) and the fluid pressure in at least a portion of said second hydraulic circuit (62).

- 5 43. The method according to claim 42, wherein said current and/or predicted pressure difference (ΔP) is a current and/or predicted pressure difference (ΔP) between the first load pressure existing in the first actuator (36) and the fluid pressure in at least a portion of said second hydraulic circuit (62).
- 10 44. The method according to claim 43, wherein said current and/or predicted pressure difference (ΔP) is a current and/or predicted pressure difference (ΔP) between the first load pressure existing in the first actuator (36) and second load pressure existing in the second actuator (58).
- 15 45. The method according to any one of claims 42 to 44, further comprising controlling said hydraulic system (34) so as to assume said connected condition as a response to the determination of said pressure difference (ΔP) value being within a predetermined pressure difference value range.
- 20 46. The method according to any one of claims 42 to 45, further comprising controlling said hydraulic system (34) so as to assume said disconnected condition as a response to the determination of said pressure difference (ΔP) value being outside said predetermined pressure difference value range.
- 25 47. The method according to any one of claims 36 to 46, wherein said hydraulic system (34) comprises a circuit communication valve assembly (78) connecting the first hydraulic circuit (40) and the second hydraulic circuit (62) to each other, the circuit communication valve assembly (78) being adapted to assume an open condition for obtaining said connected condition and a closed condition for obtaining said disconnected condition, said method comprises controlling said
- 30 hydraulic system (34) so as to assume said connected condition by controlling said circuit communication valve assembly (78) so as to assume said open condition, said method further comprises controlling said hydraulic system (34) so as to assume said disconnected condition by controlling said circuit communication valve assembly (78) so as to assume said closed condition.

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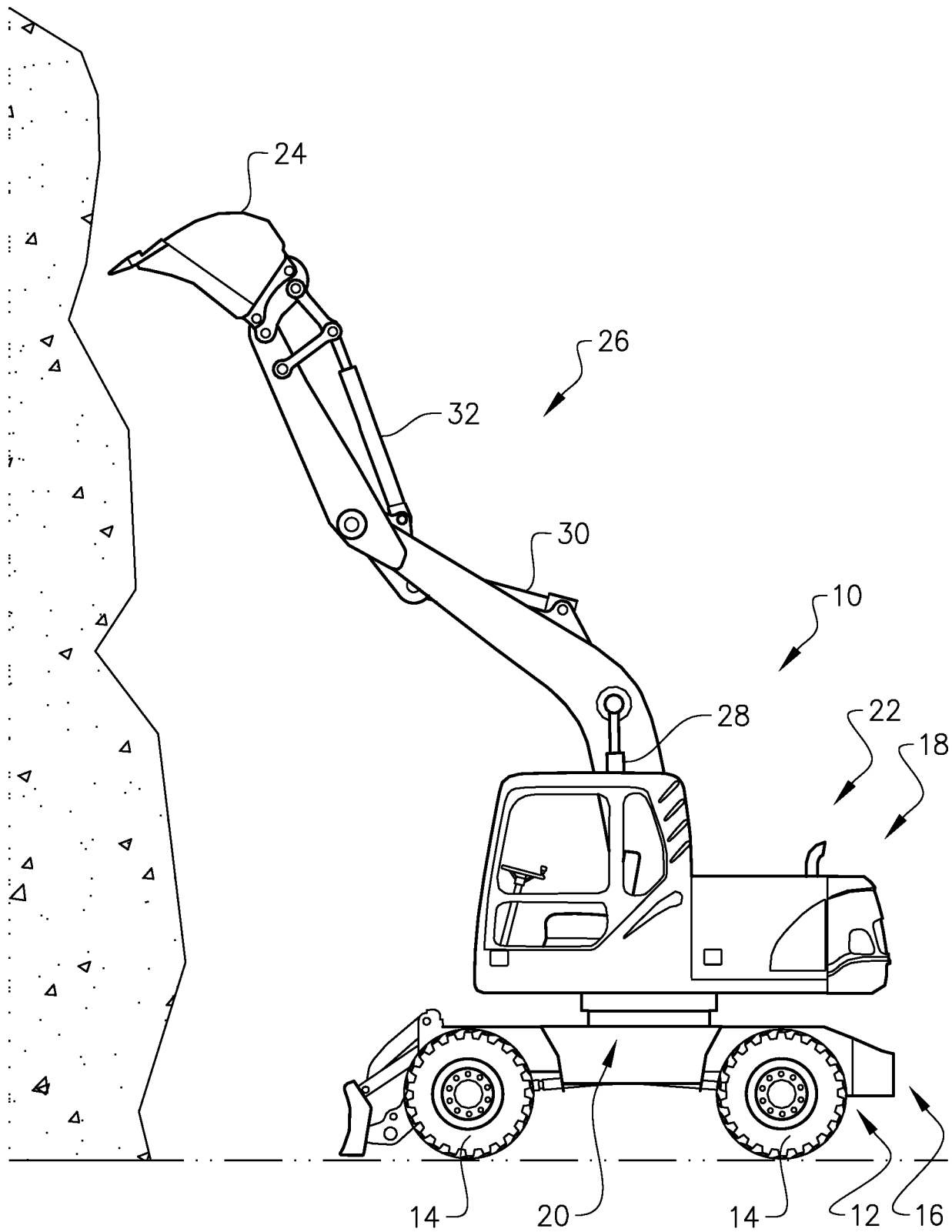


FIG. 1

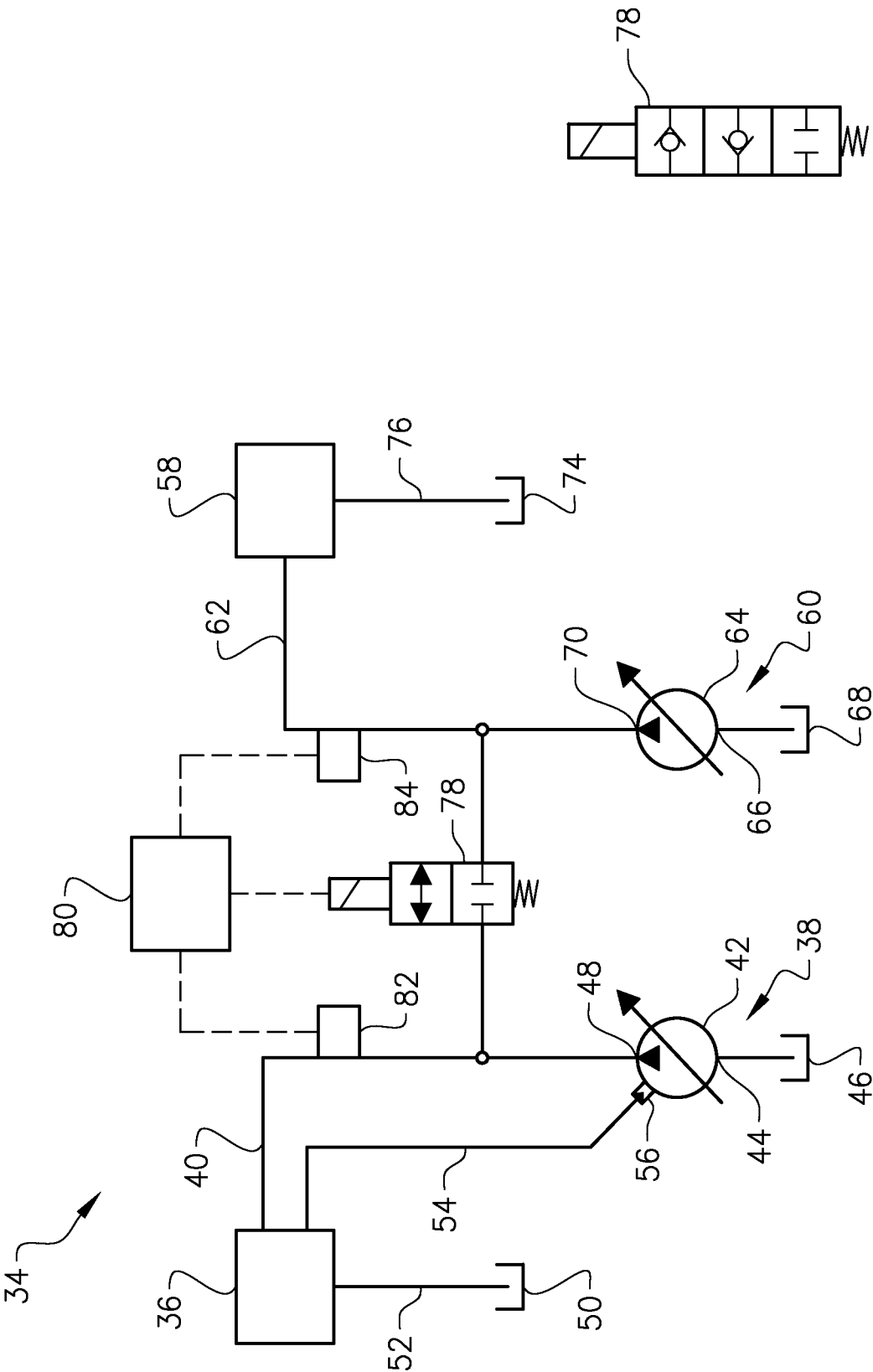


FIG. 2

FIG. 3

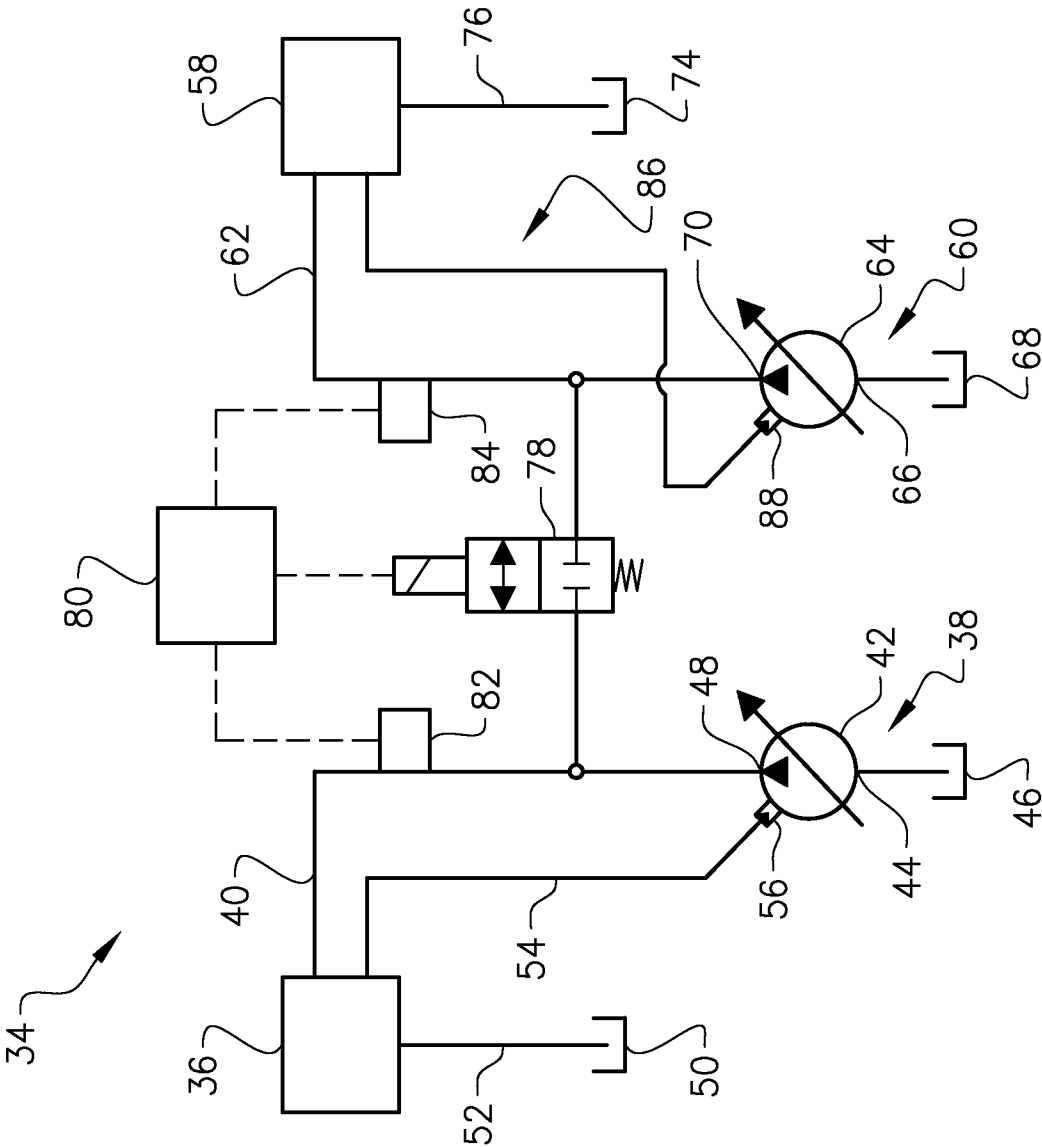


FIG. 4

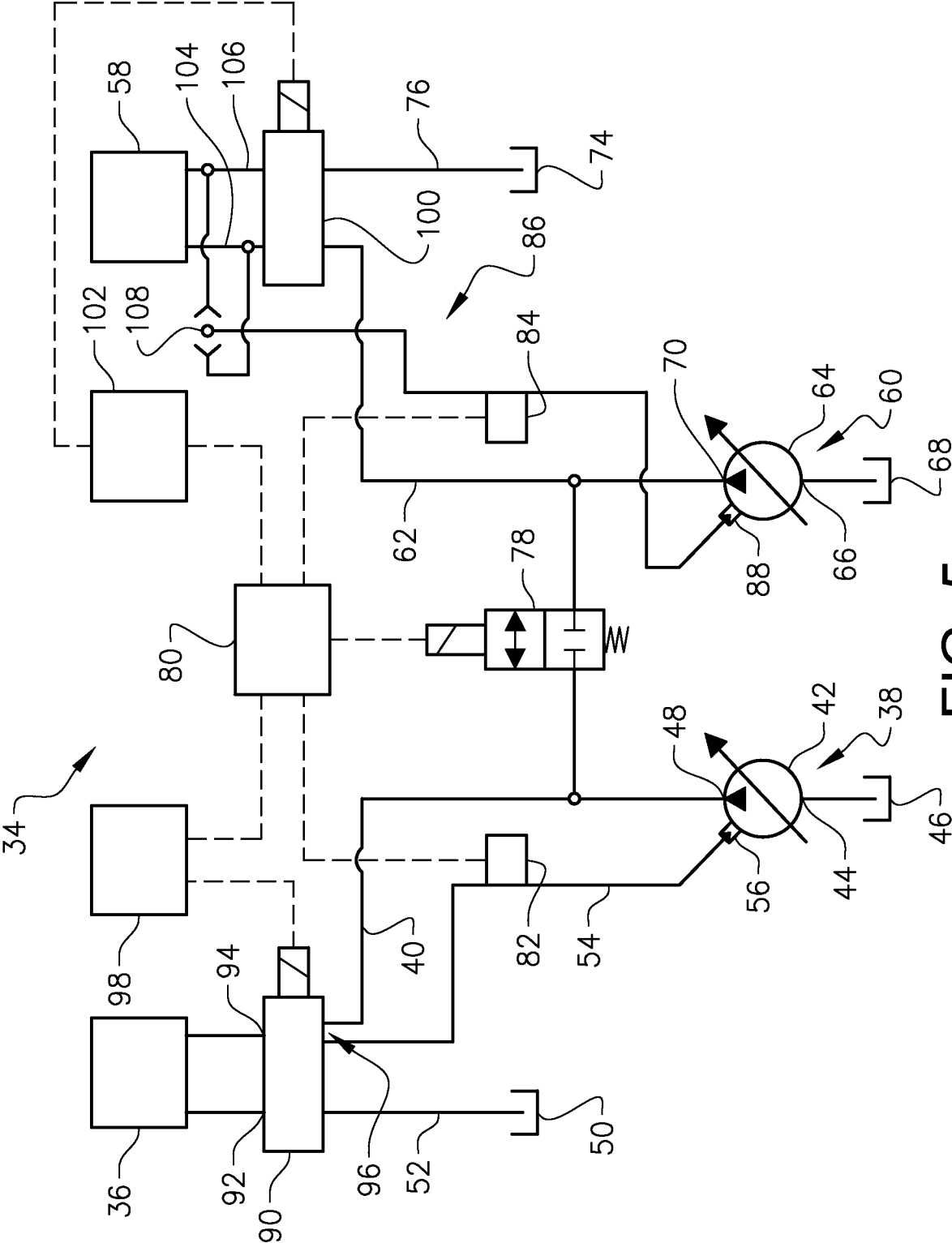


FIG. 5

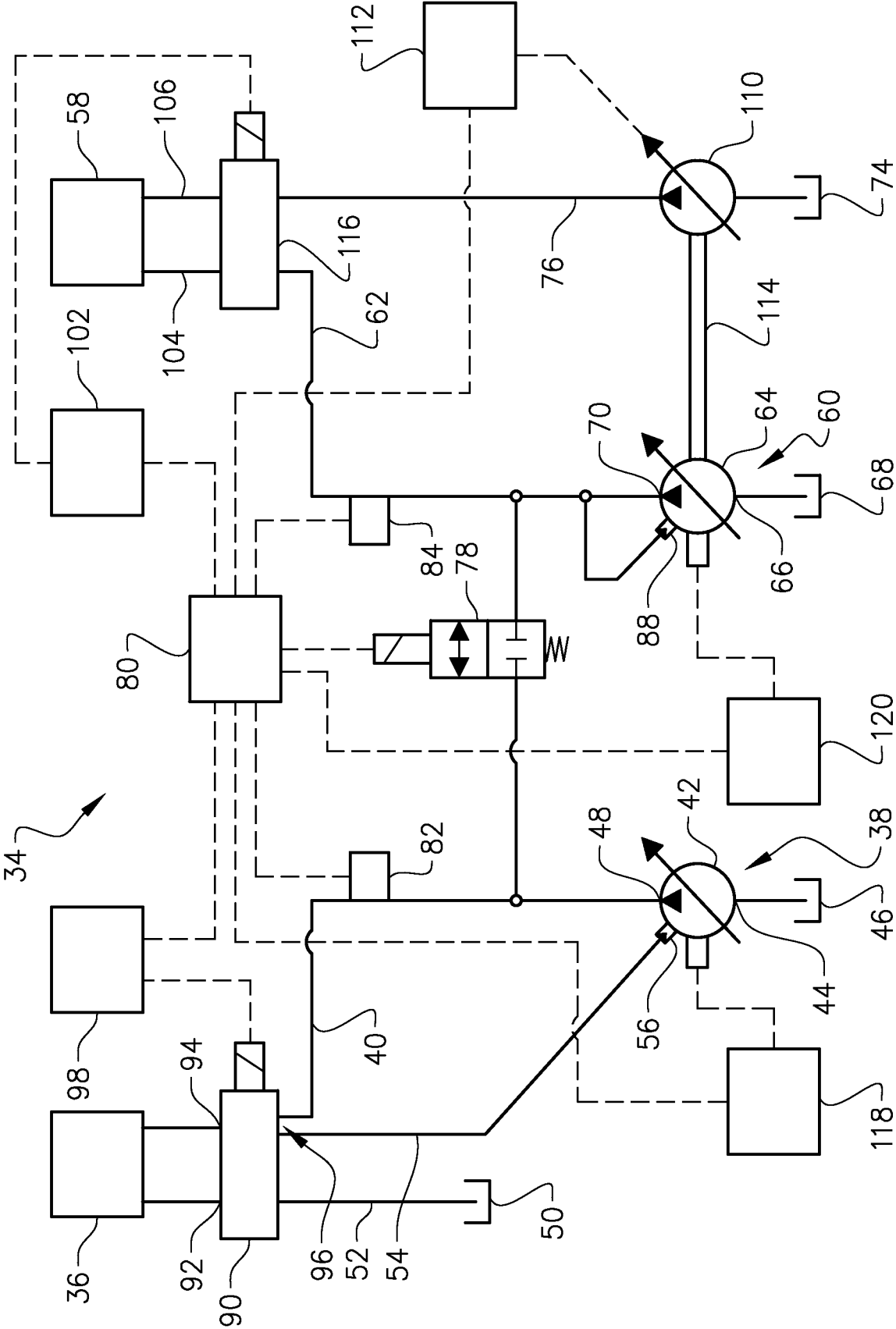


FIG. 6

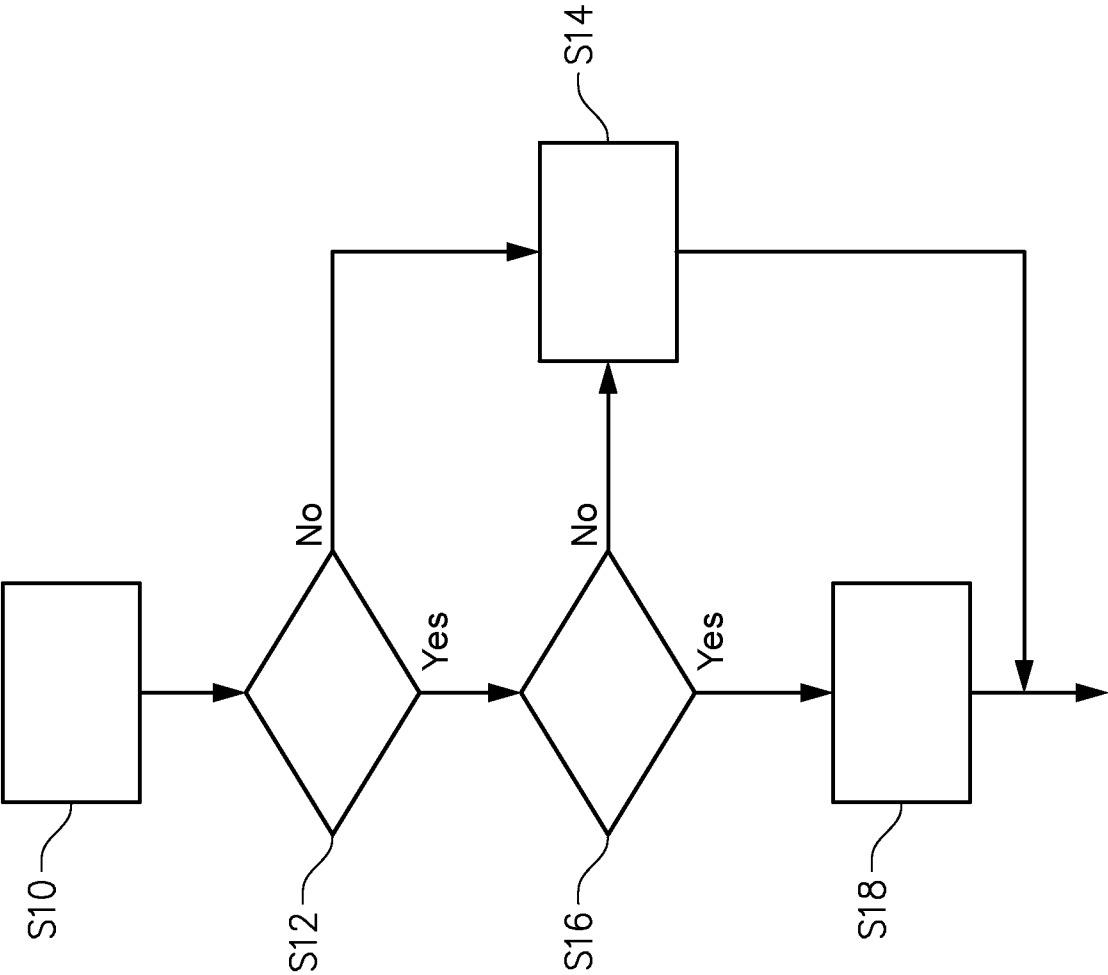


FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2016/050472

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: E02F, F15B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE, DK, FI, NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, PAJ, WPI data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5485724 A1 (NOZAWA YUSAKU ET AL), 23 January 1996 (1996-01-23); abstract; column 3, line 29 - line 36; column 6, line 60 - column 7, line 6; column 7, line 65 - column 8, line 12; figure 1 --	1-47
A	US 4768339 A1 (AOYAGI YUKIO ET AL), 6 September 1988 (1988-09-06); abstract; column 5, line 33 - line 44; column 10, line 48 - line 58; figure 7 --	1-47
A	DE 10134747 A1 (LIEBHERR MACHINES BULLE S A), 13 February 2003 (2003-02-13); abstract; figure 1; claims 1,8 --	1-47



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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INTERNATIONAL SEARCH REPORT

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A	US 20150377258 A1 (TAKAHASHI KIWAMU ET AL), 31 December 2015 (2015-12-31); abstract; figure 1; claim 1 -- -----	1-47

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F15B 11/16 (2006.01)

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