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(54) IMPROVED HYDRAULIC ARRANGEMENT FOR A WORK MACHINE, CONTROL METHOD THEREOF, AND WORK MACHINE COMPRISING SUCH HYDRAULIC ARRANGEMENT

(57) A hydraulic arrangement (14, 214) for a work machine (1) comprising: a body (2) and a hydraulically actuated work implement (6); said hydraulic arrangement (14) comprises: pumping means (17) to suck hydraulic fluid from a tank (18) and to provide at outlet a pressurized flow of hydraulic fluid; one actuator (7) to operate the hydraulically actuated work implement (6); a hydraulic circuit (20) to put the source of hydraulic fluid (17) in communication with the hydraulic actuator (7); and a control valve arrangement (22) to selectively put the hydraulic circuit (20) in fluid communication with the hydraulic actuator (7); the hydraulic circuit (20) comprises: a first hydraulic line (21a) connecting the pumping means (17) with the actuator (7); a second hydraulic line (21c) connecting the tank (18) with the actuator (7); one hydraulic accumulator (26, 28) fluidly connected to the first hydraulic line (21a);
the hydraulic accumulator (26, 28) comprises a first chamber (31a) connected to the first hydraulic line (21a) and a second preload chamber (31b), opposite to the first chamber (31a), connected to pumping means (17).

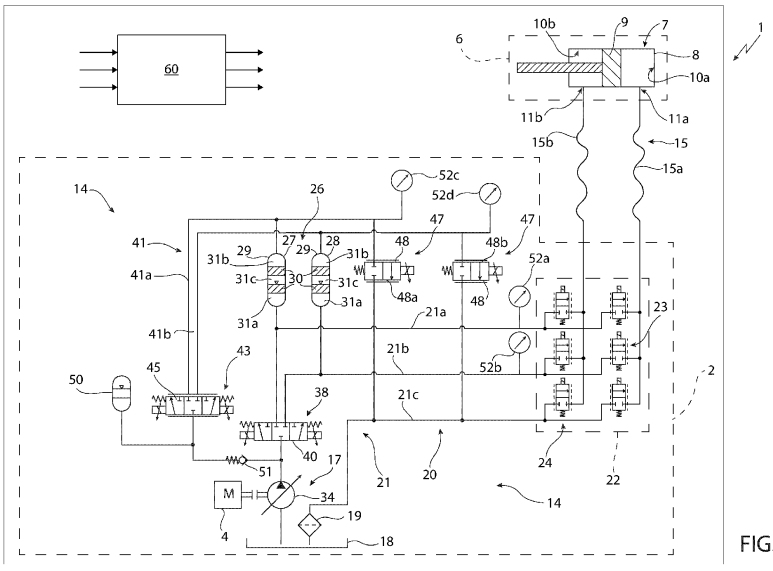

FIG. 2

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Description

TECHNICAL FIELD

[0001] The present invention relates to a hydraulic arrangement for a work machine, in particular for an earth-moving machine such as an excavator, a digger, a mechanical shovel or the like. The present invention further relates to the control method of such hydraulic arrangement and to a work machine comprising such hydraulic arrangement.

[0002] The present invention finds its preferred, although not exclusive, application in a hydraulic arrangement provided with a common pressure rails (CPR) configuration and adapted to control at least one hydraulic actuator of a hydraulically actuated arm of a work machine, in particular an excavator. Reference will be made to this application by way of the example below, without however losing in generality.

BACKGROUND OF THE INVENTION

[0003] As is known, work machines such as excavators, diggers, mechanical shovel or the like are provided with a hydraulically actuated work implement carried by a body of the work machine and configured to perform multiple earth-moving operations.

[0004] In particular, such hydraulic actuated work implement usually comprises: a boom rotatably carried by the body of the work machine; a stick or dipper or arm rotatably carried by the boom; a bucket or similar work attachment rotatably carried by the arm; and a plurality of hydraulic actuators adapted to rotate the boom, the arm, and the bucket with respect to their hinge points.

[0005] In addition, such work machines comprise a hydraulic system, which is configured to provide pressurized hydraulic fluid towards at least one of the aforementioned hydraulic actuators, in order to operate the latter.

[0006] Traditionally, such hydraulic system comprises a source of pressurized hydraulic fluid and directional proportional control valves configured to throttle the flow of hydraulic fluid provided to each hydraulic actuator, to control its operation. This allows a precise control of the operation of each hydraulic actuator, but unfortunately results in a great deal of hydraulic fluid routed back to tank, with the waste in energy that this entails.

[0007] To reduce waste of energy and allow some energy recovery, some manufacturer recently developed hydraulic systems including a hydraulic circuit provided with a common pressure rails (CPR) configuration, i.e. comprising a plurality of discrete pressure lines arranged in parallel to each other.

[0008] In addition, such hydraulic system comprises a set of logic on-off hydraulic valve configured to selectively fluidly connect the hydraulic actuator to a source of pressurized hydraulic fluid.

[0009] A simplified example of such hydraulic system is schematically represented in Figure 1 and is denoted as a whole with reference number 100.

[0010] Hydraulic system comprises a hydraulic pump 110, which are carried by an internal combustion engine 120 and are configured to suck hydraulic fluid from a tank 130 and to provide at outlet a pressured flow of such hydraulic fluid.

[0011] In addition, hydraulic system 100 comprises a hydraulic circuit 140, which fluidly connects pumping means 110 to at least one double-acting hydraulic cylinder 150, in order to feed to the same hydraulic cylinder 150 the hydraulic fluid provided at outlet. Hydraulic cylinder 150 may be, for instance, the boom actuator, the arm actuator or the bucket actuator of the aforementioned work machine.

[0012] More in detail, hydraulic circuit 140 includes three separate hydraulic lines or constant pressure rails 140a, 140b and 140c, which are arranged in parallel to each other and are adapted to form a high-pressure rail, a medium-pressure rail and a low-pressure rail respectively. Low-pressure rail 140c is fluidly connected to tank 130. Medium-pressure rail 140b and high-pressure rail 140a, on the other hand, are fluidly connected to the outlet of hydraulic pump 110.

[0013] In addition, hydraulic system 100 comprises a pair of hydraulic accumulators 160a and 160b fluidly connected respectively to high-pressure rail 140a and medium-pressure rail 140b, and a valve 170, which is operatively interposed between the outlet of hydraulic pump 110 and high- and medium-pressure rails 140a and 140b, and is configured to control the pressurized hydraulic fluid fed towards the same high- and medium-pressure rails 140a and 140b.

[0014] Although the above hydraulic system 100 allows to reduce waste of energy and allows some energy recovery by accumulating pressurized hydraulic fluid within the hydraulic accumulators 160a and 160b during operation of work machine, for instance during lowering of the hydraulically actuated work implement or during deceleration of the body, the same hydraulic architecture still poses several drawbacks and there is still plenty of room for improvements.

[0015] In particular, in the above-described hydraulic system 100, it is not possible to optimize in real-time and to quickly adapt the pressure of the hydraulic fluid within high- and medium-pressure rails 140a and 140b to the load demand at the hydraulic actuator 150, and therefore to minimize the throttling losses.

[0016] In view of the above, the need is felt to provide an improved hydraulic arrangement for a work machine able to overcome the aforementioned drawbacks.

[0017] Aim of the present invention is to satisfy the above-mentioned need in an optimized and cost-effective manner.

SUMMARY OF THE INVENTION

[0018] The aforementioned aims are reached by an hydraulic arrangement, by a work machine and by a

method as claimed in the appended set of claims.

BRIEF DESCRIPTION OF DRAWINGS

[0019] For a better understanding of the present invention, a preferred embodiment is described in the following, by way of a non-limiting example, with reference to the attached drawings, wherein:

- Figure 1 is a schematic illustration of a hydraulic system for a hydraulically actuated work implement of a work machine as known in the art;

- Figure 2, 3 are schematic illustrations of as many embodiments of a work machine realized according to the present invention, with parts removed for clarity.

DETAILED DESCRIPTION OF THE INVENTION

[0020] With reference to Figure 2, number 1 denotes, as a whole, a work machine, in particular an earth-moving machine such as an excavator, a digger, a mechanical shovel or the like.

[0021] Work machine 1 comprises a body 2 movable on the ground via ground engaging wheels or tracks (not illustrated).

[0022] In particular, body 2 preferably comprises: a lower frame or undercarriage (not illustrated), which carries the ground engaging wheels or tracks to allow motion of body 2 with respect to the ground; and an upper frame (not illustrated) or superstructure, which is carried in a rotatable manner by lower frame preferably about a rotation axis orthogonal to the advancing plane of work machine 1, i.e. orthogonal to the ground.

[0023] In addition, work machine preferably comprises an internal combustion engine 4, which is configured to provide torque to allow motion of the work machine 2, for instance by driving a hydraulic pump, which in turn is fluidly connected to hydraulic motors that drive in rotation the ground engaging wheels or tracks.

[0024] In addition, work machine 1 comprises a hydraulically actuated work implement 6, which is carried by body 2 and is configured to perform multiple earth moving operations, such as digging, handling earth or gravel, loading trucks and/or similar operations. In particular, work implement 6 is rotatably carried by the upper frame of work machine 1.

[0025] As known, the hydraulically actuated work implement 6 preferably comprises: a boom rotatably carried by the body 2; a stick or arm or dipper rotatably carried by the boom; and a bucket and/or other similar tools rotatably carried by the arm.

[0026] In addition, work machine 1 preferably comprises one or more hydraulic actuators 7, which are preferably carried by the hydraulically actuated work implement 6 and are configured to operate the hydraulically actuated work implement 6.

[0027] In particular, the one or more hydraulic actuators 7 may be configured to rotate the boom, the arm and/or the bucket with respect their corresponding hinge points.

[0028] More in detail, such a hydraulic actuator 7 preferably comprises a double-acting hydraulic cylinder, in particular a two-chamber double-acting hydraulic cylinder.

[0029] With reference to the exemplary embodiment illustrated in Figure 2, in particular, hydraulic actuator 7 preferably comprises a housing 8 which accommodates in a sliding and fluid tight manner a piston 9. The piston 9 defines within the housing 8 two opposite chamber 10a and 10b, which are adapted to contain pressurized hydraulic fluid and are configured to exert forces on the piston 9 opposite to each other.

[0030] In addition, housing 8 is preferably provided with two openings/ports 11a and 11b, which allow to put the respective chamber 10a and 10b in fluid communication with the outside.

[0031] With reference to a possible embodiment, hydraulic actuators 7 preferably comprise one or more boom actuators, configured to rotate the boom with respect to the body 2. Preferably, hydraulic actuators 7 comprise two boom actuators arranged on opposite sides of the boom.

[0032] Preferably, hydraulic actuators 7 further comprises at least one arm actuator (not illustrated), which is carried by the arm and is configured to rotate the arm with respect to the boom.

[0033] In addition, hydraulic actuators 7 preferably comprise also at least one bucket actuator (not illustrated), which is preferably carried by the arm and is configured to rotate the bucket with respect to the arm.

[0034] With reference to the preferred embodiment illustrated in Figure 2, work machine 1 further comprise a hydraulic arrangement 14, which is fluidly connected to hydraulic actuator 7 and is configured to actuate this latter, in order to operate said work implement accordingly.

[0035] In particular, hydraulic arrangement 14 is carried by body 2 and is adapted to be fluidly connected to hydraulic actuator 7 by means of hydraulic lines 15, in particular by means of flexible hydraulic hoses 15.

[0036] With reference to the exemplary embodiment illustrated in Figure 2, hydraulic lines 15 preferably comprises a line or hose 15a configured to be fluidly connected to opening 11a of hydraulic actuator 7 and a line or hose 15b configured to be fluidly connected to opening 11b of hydraulic actuator 7.

[0037] In addition, hydraulic arrangement 14 preferably comprises a source of pressurized hydraulic fluid 17, which is configured to provide at outlet a flow of pressurized hydraulic fluid.

[0038] More in detail, the source of pressurized hydraulic fluid preferably comprises pumping means 17, which are carried by internal combustion engine 4 and are configured to suck hydraulic fluid from a tank 18 and

to provide at outlet a pressurized flow of such hydraulic fluid.

[0039] With reference to the exemplary embodiment illustrated in Figure 2, hydraulic arrangement 14 further comprises a hydraulic circuit 20 which is adapted to put the outlet of the source of pressurized fluid, i.e. of pumping means 17 in fluid communication with the hydraulic actuator 7.

[0040] More in detail, the hydraulic circuit 20 is preferably provided with a common pressure rails (CPR) configuration, i.e. it comprises a plurality of separate hydraulic lines/ pipes/rails/conduits 21, which are arranged in parallel to each other and are each configured to be fluidly connected between the source of pressurized fluid and hydraulic actuator 7.

[0041] That is, all the hydraulic lines 21 of hydraulic circuit are selectively connectable to hydraulic actuator 7, in particular to both chambers 10a and 10b of hydraulic actuator 7.

[0042] In particular, according to the CPR configuration, hydraulic lines 21 of hydraulic circuit 20 are preferably configured to operate with a pressure setting which is constant and is different to each other, in order each to be able to provide pressurized hydraulic fluid to hydraulic actuator 7 with different pressure levels.

[0043] More in detail, hydraulic circuit 20 comprises at least two lines 21, which are arranged in parallel to each other and are adapted to fluidly connect the source of pressurized fluid with hydraulic actuator 7.

[0044] Preferably, the first one between the two lines 21 is connected to pumping means 17, while the second is preferably connected to tank 18.

[0045] Accordingly, in operation, the first one between lines 21 will define a high-pressure line and the other one between lines 21 will define a low-pressure line.

[0046] In particular, with reference to the example illustrated in Figure 2, hydraulic circuit comprises at least three lines 21a, 21b and 21c arranged in parallel to each other.

[0047] Lines 21a and 21b are preferably connected to the outlet of pumping means 17, while line 21c is preferably connected to tank 18 and preferably comprises filtering means 19.

[0048] With reference to the exemplary embodiment illustrated in Figure 2, hydraulic arrangement 4 further comprises a control valve arrangement 22, which is fluidly interposed between hydraulic circuit 20 and hydraulic actuator 7, and is configured to regulate the flow of pressurized hydraulic fluid fed toward the same hydraulic actuator 7.

[0049] More in detail, control valve arrangement 22 configured to selectively put at least the high-pressure line 21a and/or the low-pressure line 21c in fluid communication with chamber 10a and/or chamber 10b of hydraulic actuator 7.

[0050] In other words, in operation control valve arrangement 22 is configured to allow to selectively fluidly connect the chambers 10a and 10b of hydraulic actuator 7 with lines 21 of hydraulic circuit 20.

[0051] In addition, control valve arrangement 22 is preferably carried by body 2. Control valve arrangement 22 is preferably configured to be fluidly connected to hydraulic actuator 7 via hydraulic lines 15.

[0052] According to a possible embodiment, control valve arrangement 22 comprises a first valve set 23 configured to selectively put the lines of hydraulic circuit 20 in fluid communication with chamber 10a of hydraulic actuator 7 and a second valve set 24 configured to selectively put the lines of hydraulic circuit 20 in fluid communication with chamber 10a of hydraulic actuator 7.

[0053] More in detail, each valve set 23 or 24 may comprise as many valves as many lines 21 there are provided within hydraulic circuit 20.

[0054] For example, valves of first valve set 23 and of second valve set 24 may comprise solenoid-controlled two-way two-position valves, for instance solenoid-controlled two-way two-position on-off valves or solenoid-controlled two-way two-position proportional valves, which are operable independently to each other and are operable between an open position and a closed position, to selectively fluidly connect respective lines 21a, 21b or 21c with respective chambers 10a or 10b of hydraulic actuator 7.

[0055] With reference to the exemplary embodiment illustrated in Figure 2, hydraulic arrangement 14 further comprises at least one hydraulic accumulator 26, which is fluidly connected to hydraulic circuit 20, preferably upstream control valve arrangement 22.

[0056] More in detail, hydraulic accumulator 26 is preferably fluidly connected to the first one between lines 21, i.e. to the a high-pressure line 21a.

[0057] According to the exemplary embodiment illustrated in Figure 2, hydraulic arrangement preferably comprises a first hydraulic accumulator 27, in the following referred to as "high-pressure hydraulic accumulator 27" fluidly connected to high-pressure line 21a and a second hydraulic accumulator 28, in the following referred to as "medium-pressure hydraulic accumulator 28" fluidly connected to medium-pressure line 21b.

[0058] It is intended that according to the present invention, hydraulic arrangement 14 may comprise one hydraulic accumulator 26 for each hydraulic line 21 of hydraulic circuit 20, apart from low-pressure hydraulic line 21c, which may be not provided with a hydraulic accumulator 26.

[0059] The one or more hydraulic accumulators 26 preferably comprises housing 29, in particular a cylindrical housing 29, accommodating in a fluid tight and sliding manner at least one piston assembly or septum 30, which defines two opposing chambers 31a and 31b within housing 29 fluidly separated to each other.

[0060] In particular, first chamber 31a is preferably delimited between one end of housing 29 and piston assembly 30, in particular a first piston 30, and second chamber 31b is preferably delimited between a second end, opposite to the first, of housing 29 and the piston

assembly 30.

[0061] First chamber 31a is preferably fluidly connected to hydraulic circuit 20.

[0062] More in detail, according to the exemplary embodiment illustrated in Figure 2, first chamber 31a of high-pressure hydraulic accumulator 27 is preferably fluidly connected to high-pressure line 21a of hydraulic circuit 20, and first chamber 31a of medium-pressure hydraulic accumulator 28 is preferably fluidly connected to medium-pressure line 21b of hydraulic circuit 20.

[0063] Preferably, first chamber 31a of hydraulic accumulator 26, in particular of high-pressure hydraulic accumulators 27 and medium-pressure hydraulic accumulators 28, is preferably configured to contain pressurized hydraulic fluid, in particular oil.

[0064] Second chamber 31b of hydraulic accumulator 26, in particular of high-pressure hydraulic accumulators 27 and medium-pressure hydraulic accumulators 28, is preferably fluidly connected to the source of pressurized hydraulic fluid, i.e. to pumping means 17, in order to be charged with hydraulic fluid, preferably oil, and vary/regulate the preload of the same hydraulic accumulator 26.

[0065] More in detail, by varying the pressure within second chamber 31b of hydraulic accumulator 26, the pressure within first chamber 31a of the same hydraulic accumulator 26 will vary accordingly.

[0066] The technical effect associated to the variation of the pressure within chambers 31a and 31b of hydraulic accumulator 26 is related to the possibility of regulating the pressure within the line 21 fluidly connected to the same accumulator.

[0067] In particular, by varying the pressure within high-pressure hydraulic accumulators 27 and medium-pressure hydraulic accumulators 28, it is possible to regulate the pressure within high-pressure line 21a and medium-pressure line 21b respectively.

[0068] With reference to the exemplary embodiment illustrated in Figure 2, the one or more hydraulic accumulators 26, in particular high-pressure hydraulic accumulator 27 and medium-pressure hydraulic accumulator 28, preferably include double double-piston accumulators.

[0069] In other words, piston assembly 30 may comprise a pair of pistons or septa, which are arranged in a sliding and fluid tight manner within housing 29 and are spaced to each other. The two pistons of piston assembly 30 preferably defines within housing 29 a third chamber 31c fluidly separated from the two chambers 31a and 31b.

[0070] Third chamber 31c of hydraulic accumulator 26, in particular of high-pressure hydraulic accumulators 27 and medium-pressure hydraulic accumulators 28, is preferably configured to contain pressurized gas.

[0071] In addition, third chambers 31c of hydraulic accumulator 26, in particular of high-pressure hydraulic accumulators 27 and medium-pressure hydraulic accumulators 28, is preferably sealed and preferably contains pressurized gas at a predetermined pressure.

[0072] With reference to the exemplary embodiment illustrated in Figure 2, as far as the source of pressurized hydraulic fluid 17, i.e. pumping means 17, is concerned, it preferably comprises a hydraulic pump 34, which is preferably carried by internal combustion engine 4 in order to be driven in rotation.

[0073] Preferably, hydraulic pump 34 is variable displacement hydraulic pump.

[0074] In addition, the outlet of hydraulic pump 34 is fluidly connected at least to the first hydraulic line of hydraulic circuit 20 and to first chamber 31a of accumulator 26.

[0075] More in detail, with reference to the exemplary embodiment illustrated in Figure 2, the outlet of hydraulic pump 34 is preferably fluidly connected to high-pressure line 21a and medium pressure line 21c, and also to first chamber 31a of high-pressure hydraulic accumulator 27 and medium-pressure hydraulic accumulator 28.

[0076] In addition, hydraulic arrangement 14 preferably comprises valve means 38, which are operatively interposed between the source of pressurized hydraulic fluid 17 and the first hydraulic line of hydraulic circuit 20 and to first chamber 31a of accumulator 26.

[0077] Valve means 38 are configured to control the flow of hydraulic fluid provided at outlet the source of pressurized hydraulic fluid 17, i.e. by hydraulic pump 34, and flowing through the same first hydraulic line towards hydraulic accumulator 26.

[0078] More in detail, according to the example illustrated in Figure 2, valve means 38 are preferably fluidly interposed between the outlet of hydraulic pump 34 and high-pressure line 21a and medium pressure line 21c, and respectively also to first chamber 31a of high-pressure hydraulic accumulator 27 and medium-pressure hydraulic accumulator 28.

[0079] In addition, valve means 38 are preferably configured to selectively fluidly connect high-pressure line 21a and medium pressure line 21c to the outlet of hydraulic pump 34, in particular to alternatively fluidly connect one between high-pressure hydraulic line 21a and medium-pressure hydraulic line 21b to the outlet of hydraulic pump 34.

[0080] With reference to the exemplary embodiment illustrated in Figure 2, valve means 38 preferably comprises a three-way three-position hydraulic valve 40, in particular a solenoid controlled three-way three-position hydraulic valve 40.

[0081] The three openings of hydraulic valve 40 are preferably fluidly connected to the outlet of hydraulic pump 34, to high-pressure hydraulic line 21a and to medium-pressure hydraulic line 21b.

[0082] In the first position, hydraulic valve 40 is configured to put the outlet of hydraulic pump 34 in fluid communication with high-pressure hydraulic line 21a and to fluidly isolate medium-pressure hydraulic line 21b from hydraulic pump 34.

[0083] In the second position, hydraulic valve 40 is configured to put the outlet of hydraulic pump 34 in fluid

communication with medium-pressure hydraulic line 21b and to fluidly isolate high-pressure hydraulic line 21a from hydraulic pump 34.

[0084] In third position, hydraulic valve 40 is configured to fluidly separate its ports, i.e. to fluidly separate medium-pressure hydraulic line 21b and high-pressure hydraulic line 21a from the outlet of hydraulic pump 34.

[0085] With reference to the exemplary embodiment illustrated in Figure 2, in addition, hydraulic arrangement 14 further comprises at least one charging line 41 fluidly connecting the source of pressurized hydraulic fluid 17, i.e. pumping means 17, with the second chamber 31b of hydraulic accumulator 26, in order to allow to fed pressurized hydraulic fluid within second chamber 31b of hydraulic accumulator 26.

[0086] In particular, charging line 41 is preferably fluidly connected to the outlet of hydraulic pump 34.

[0087] More in detail, with reference to the exemplary embodiment illustrated in Figure 2, hydraulic arrangement 14 preferably comprises a first charging line 41a, in the following referred to as "high-pressure charging line 41a", fluidly connecting the source of pressurized hydraulic fluid 17 with the second chamber 31b of high-pressure hydraulic accumulator 27.

[0088] In addition, hydraulic arrangement 14 preferably comprises a second charging line 41b, in the following referred to as "medium-pressure charging line 41b", fluidly connecting the source of pressurized hydraulic fluid 17 with the second chamber 31b of medium-pressure hydraulic accumulator 28.

[0089] In addition, hydraulic arrangement 14 preferably comprises valve means 43, which are operatively interposed between the source of pressurized hydraulic fluid 17 and second chamber 31b of accumulator 26 along charging line 41, and are configured to control the flow of pressurized hydraulic fluid flowing through the same charging line 41 towards the respective hydraulic accumulator 26.

[0090] More in detail, according to the exemplary embodiment illustrated in Figure 2, valve means 43 are preferably fluidly interposed between the source of pressurized hydraulic fluid 17 and high- and medium-pressure charging lines 41a and 41b, and are configured to selectively fluidly connect these latter to the source of pressurized hydraulic fluid 17, in particular to alternatively fluidly connected one between high-pressure charging line 41a and medium-pressure charging line 41b to the source of pressurized hydraulic fluid 17.

[0091] In other words, downstream valve means 43, hydraulic line 41 preferably branches off in a high-pressure charging line 41a fluidly connected to the second chamber of high-pressure hydraulic accumulator 27 and in a medium-pressure charging line 41b fluidly connected to the second chamber of medium-pressure hydraulic accumulator 28.

[0092] With reference to the exemplary embodiment illustrated in Figure 2, valve means 43 preferably comprises a three-way three-position hydraulic valve 45, in particular a solenoid controlled three-way three-position hydraulic valve 45. Preferably, valve 45 is a proportional valve 45.

[0093] The three openings of hydraulic valve 45 are preferably fluidly connected to the source of pressurized hydraulic fluid 17, in particular to the outlet of hydraulic pump 34, to high-pressure charging line 41a and to medium-pressure charging line 41b.

[0094] In the first position, hydraulic valve 45 is configured to put the source of pressurized hydraulic fluid 17 in fluid communication with high-pressure charging line 41a and to fluidly isolate medium-pressure charging line 41b from the source of pressurized hydraulic fluid 17.

[0095] In the second position, hydraulic valve 45 is configured to put the source of pressurized hydraulic fluid 17 in fluid communication with medium-pressure charging line 41b and to fluidly isolate high-pressure charging line 41a from the source of pressurized hydraulic fluid 17.

[0096] In the third position, hydraulic valve 45 is configured to fluidly separate its ports, i.e. medium-pressure charging line 41b and high-pressure charging line 41a from the source of pressurized hydraulic fluid 17.

[0097] With reference to exemplary embodiment illustrated in Figure 2, charging line 41 and/or second chamber 31b of hydraulic accumulator 26, in particular of high-pressure hydraulic accumulator 27 and/or of medium-pressure hydraulic accumulator 28, is/are preferably selectively connectable to tank 18.

[0098] More in detail, charging line 41 is preferably selectively connectable to low-pressure line 21c.

[0099] In even more detail, high-pressure charging line 41a and medium-pressure charging line 41b are preferably selectively connectable to low-pressure line 21c.

[0100] In addition, hydraulic arrangement 14 preferably comprises valve means 47, which are operatively arranged along charging line 41, downstream hydraulic accumulator 26 and are configured to allow to selectively connect charging line 41 to tank 18, in particular to low-pressure line 21c.

[0101] With reference to the exemplary embodiment illustrated in Figure 2, valve means 47 preferably comprises a two-way two-position hydraulic valve 48, in particular a solenoid controlled two-way two-position hydraulic valve 48. Preferably, valve 48 is a proportional valve 48.

[0102] More in detail, valve means 48 preferably comprises a first hydraulic valve 48a arranged along high-pressure charging line 41a and a second hydraulic valve 48b arranged along medium-pressure charging line 41b, preferably downstream the respective high-pressure hydraulic accumulator 27 and medium-pressure hydraulic accumulator 28.

[0103] With reference to the exemplary embodiment illustrated in Figure 2, hydraulic arrangement 14 preferably further comprises at least one additional hydraulic accumulator 50, which is fluidly connected to charging line 41, preferably between the source of pressurized

hydraulic fluid 17, i.e. the outlet of hydraulic pump 34, and valve means 43.

[0104] In addition, hydraulic arrangement 14 preferably comprises a check valve 51 and/or other similar valve means fluidly interposed between the outlet of pumping means 34 and the hydraulic accumulator 50.

[0105] In particular, additional hydraulic accumulator 50 allows to fluidly decouple hydraulic pump 34 and the second chamber 31b of accumulator 26, in particular of high-pressure accumulator 27 and/or of medium-pressure accumulator 28.

[0106] Accordingly, during operation, the second chamber 31b of accumulator 26, in particular of high- and medium-pressure accumulator 28 and 27, may be charged with the pressurized hydraulic fluid stored within additional hydraulic accumulator 50. In addition, during operation, hydraulic pump 34 may be operated to charge additional hydraulic accumulator 50.

[0107] With reference to the exemplary embodiment illustrated in Figure 1, hydraulic arrangement 14 may be further provided with sensing means configured to measure the pressure of the hydraulic fluid present within hydraulic circuit 20.

[0108] More in detail, such sensing means may comprise pressure sensors 52a and 52b coupled at least to high- and medium- line 21a and 21b.

[0109] In addition, such sensor means may further comprise pressure sensor 52c and 52d coupled to high- and medium-pressure charging line 41a and 41b.

[0110] With reference to the exemplary embodiment illustrated in Figure 2, work machine 1 preferably further comprises an electronic control unit 60, which may be operatively connected to control valve arrangement 22, to valve means 38, 43 and/or 47, to pumping means 17 and is provided with elaboration means configured, in use, to control their operation.

[0111] In particular, electronic control unit 60 may be operatively connected to said sensor means and may be configured to control operation of control valve arrangement 22, valve means 38, 43 and/or 47, and/or pumping means 17 based on the data provided by said sensor means.

[0112] The operation of the above-described hydraulic arrangement 14 is the following.

[0113] Hydraulic pump 34 is controlled to provide at outlet a pressurized flow of hydraulic fluid and valve means 38 are controlled to selectively charge high-pressure line 21a and first chamber 31a of accumulator 27 so that the hydraulic fluid within high-pressure line 21a, i.e. high-pressure rail, reaches a predetermined level.

[0114] In addition, hydraulic pump 34 is controlled to provide at outlet a pressurized flow of hydraulic fluid and valve means 38 are controlled to selectively charge medium-pressure line 21b and first chamber 31a of medium-pressure accumulator 28, so that the hydraulic fluid within high-pressure line 21a, i.e. high-pressure rail, reaches a predetermined level.

[0115] At the same time, valve means 43 are controlled to charge the second chambers 31b of high- and medium-pressure accumulators 27 and 28, in order to control the preload of such hydraulic accumulators.

[0116] By controlling operation of hydraulic pump 34, valve means 43 and valve means 47, it is possible to control the pressure level within second chambers 31b of high- and medium-pressure accumulators 27 and 28, and accordingly within second chambers 31b of high- and medium-pressure accumulators 27 and 28 and high- and medium-pressure line 21a and 21b.

[0117] In view of the foregoing, the present invention is further directed to a method for controlling hydraulic arrangement 14.

[0118] The method comprises the following steps:

a) determining the pressure of the hydraulic fluid within the first line of the hydraulic circuit 20; and
b) controlling the operation of the source of pressurized hydraulic fluid 17 and of valve means 38, 43 and/or 47 so that the pressure within the first line of the hydraulic circuit 20 is within a predetermined interval.

[0119] More in detail, step a) preferably comprises the step of determining the pressure of the hydraulic fluid within the high- and medium-pressure line 21a and 21b.

[0120] In addition, step a) may further comprise the step of determining the pressure of the hydraulic fluid within charging line 41, in particular within high- and medium-pressure charging line 41a and 41b.

[0121] Steb b) in addition may comprise the step of controlling the displacement of main pumps 34 and/or the actuation of valve means 38, 43 and 47, so that the pressure of the hydraulic fluid within first chamber 31a and second chamber 31b of accumulator 36, in particular of high- and medium-pressure accumulator 27 and 28 is within a first and a second predetermined interval.

[0122] Preferably, the first predetermined interval is higher than the second predetermined interval.

[0123] In view of the foregoing, the advantages of a hydraulic arrangement 14 according to the present invention are considerable and apparent.

[0124] In particular, the provision of a double-chamber hydraulic accumulator 26 and of a dedicated charging line 41 allows, in use, to obtain a precise and fast control of the pressure levels within high-pressure line 21a and medium-pressure line 21b, in order to obtain a precise and fast response of the hydraulic circuit 20 to the actual flowrate and pressure demand required at hydraulic actuator 7.

[0125] In fact, the pressure levels within the same high-pressure line 21a and medium-pressure line 21b may be controlled also controlling the pressure of the hydraulic fluid stored within chambers 31b of hydraulic accumulators 26, which in turn is controlled by controlling valve means 43.

[0126] In addition, according to the proposed layout, it is possible to increase the number of hydraulic lines 21

within CPR hydraulic circuit 20 and the number of associated hydraulic accumulators 26 without necessarily increasing the number of hydraulic pumps 34. In fact, if properly sized, only one hydraulic pump 34 may be enough for four or more different hydraulic lines 21 within hydraulic circuit 20.

[0127] Lastly, the provision of the additional hydraulic accumulator 50 between the source of pressurized hydraulic fluid 17 and valve means 43, along charging line 41 allows to decouple the operation of hydraulic pump 34 from the operation of the hydraulic accumulators 26, in particular of high-pressure hydraulic accumulator 27 and medium-pressure hydraulic accumulator 28, arranged downstream the addition hydraulic accumulator 26.

[0128] This allows to operate the internal combustion engine 4 and the hydraulic pump 34 in their respective maximum efficiency intervals to charge the hydraulic accumulator 50, independently from the actual flow demand at the hydraulic actuators 7, thus allowing to reduce the overall fuel consumption of work machine 1.

[0129] It is clear that modifications can be made to the described hydraulic arrangement 14, which do not extend beyond the scope of protection defined by the claims.

[0130] In particular, the number of hydraulic lines 21 of hydraulic circuit 20 may be higher, for instance hydraulic circuit 20 may comprise four or more different hydraulic lines 21 arranged in parallel to each other.

[0131] Accordingly, also the number of hydraulic accumulators 26 may be different. In particular, hydraulic circuit may comprise as many hydraulic accumulators 26 as many different lines 21 there are provided within hydraulic circuit 20, apart from low-pressure line 21c which may not be provided with a hydraulic accumulator 26.

[0132] In addition, Figure 3 illustrates a hydraulic arrangement 214, which is similar to hydraulic arrangement 14 and whose corresponding parts will be denoted with the same reference numbers as hydraulic arrangement 14.

[0133] Hydraulic arrangement 214 distinguishes from hydraulic arrangement 14 in that charging line 41 is not connected to the outlet of hydraulic pump 34, and in that it further comprises a second hydraulic pump 234, referred also to as "charging pump 234", which is fluidly connected to charging line 41.

[0134] More in detail, charging pump 234 is preferably arranged in parallel to hydraulic pump 34.

[0135] In addition, charging pump 234 is preferably carried by internal combustion engine 4 and is adapted to suck hydraulic fluid from tank 18 and to provide at outlet a pressurized flow of hydraulic fluid, towards charging line 41.

[0136] Preferably, charging pump 234 is a variable displacement pump.

Claims

1. A hydraulic arrangement (14, 214) for a work machine (1) ;

said work machine (1) comprising: a body (2) movable on the ground by means of ground engaging means; and a hydraulically actuated work implement (6), which is rotatably carried by said body (2) and is configured to perform multiple earth moving operations;
said hydraulic arrangement (14) comprising:

- a source of pressurized hydraulic fluid (17), which is configured to suck hydraulic fluid from a tank (18) and to provide at outlet a pressurized flow of hydraulic fluid;
- at least one hydraulic actuator (7), which is configured to operate said hydraulically actuated work implement (6) ;
- a hydraulic circuit (20), which is configured to put said source of hydraulic fluid (17) in fluid communication with said hydraulic actuator (7); and
- a control valve arrangement (22), which is operatively interposed between said hydraulic circuit (20) and said hydraulic actuator (7) and is configured to selectively put said hydraulic circuit (20) in fluid communication with said hydraulic actuator (7); and

said hydraulic circuit (20) comprising:

- a first hydraulic line (21a), which fluidly connects said source of pressurized hydraulic fluid (17) with said hydraulic actuator (7);
- a second hydraulic line (21c), which is arranged in parallel to said first hydraulic line (21a) and fluidly connects said tank (18) with said hydraulic actuator (7); and
- at least a first hydraulic accumulator (26, 27), which is fluidly connected to said first hydraulic line (21a), upstream said control valve arrangement (22);

said first hydraulic accumulator (26, 27) comprising a housing (29) and a piston assembly (30), which is accommodated in a fluid-tight and slidable manner within said housing (29) and defines at least a first chamber (31a) and a second chamber (31b), opposite to said first chamber (31a);
the first chamber (31a) of said first hydraulic accumulator being fluidly connected to said first hydraulic line (21a);
the second chamber (31b) of said hydraulic accumulator (26, 27) being fluidly connected

to said source of hydraulic fluid (17) via a charging line (41, 41a), which is arranged in parallel to said hydraulic circuit (20).

2. Hydraulic arrangement according to claim 1, wherein said source of pressurized hydraulic fluid (17) comprises a first hydraulic pump (34) configured to be fluidly connected to said first hydraulic line (21a).

3. Hydraulic arrangement according to claim 1 or 2, further comprising first valve means (38), which are operatively interposed between said source of pressurized hydraulic fluid (17) and said first hydraulic line (21a), and are configured to control the flow of pressurized hydraulic fluid flowing towards said first chamber (31a) of said first hydraulic accumulator (26, 27).

4. Hydraulic arrangement according to claim 3, further comprising second valve means (43), which are operatively interposed between said source of pressurized hydraulic fluid (17) and the second chamber (31b) of said first hydraulic accumulator (26, 27), and are configured to control the flow of pressurized hydraulic fluid flowing towards said second chamber (31b) of said first hydraulic accumulator (26, 27).

5. Hydraulic arrangement according to claim 4, further comprising an additional hydraulic accumulator (50), which is fluidly connected to said charging line (41), between said source of pressurized hydraulic fluid (17) and said second valve means (43).

6. Hydraulic accumulator, according to claim 4 or 5, wherein said hydraulic circuit (20) further comprises:

- a third hydraulic line (21b), which fluidly connects said source of pressurized hydraulic fluid (17) with said hydraulic actuator (7) and is arranged in parallel to said first hydraulic line (21a); and
- a second hydraulic accumulator (26, 28), which is fluidly connected to said second hydraulic line (21b) upstream said control valve arrangement (22);

said second hydraulic accumulator (26, 28) comprising a housing (29) and a piston assembly (30), which is accommodated in a fluid-tight and slidable manner within said housing (29) and defines at least a first chamber (31a) and a second chamber (31b), opposite to said first chamber (31a); the first chamber (31a) of said second hydraulic accumulator (28) being fluidly connected to said second hydraulic line (21b) ; the second chamber (31b) of said second hydraulic accumulator (28) being fluidly connected to said source of pressurized hydraulic fluid (17) via said charging line (41, 41b) .

7. Hydraulic arrangement according to claim 6, wherein said charging line (41), downstream said second valve means (43) branches off in a first charging line (41a) fluidly connected to the second chamber of said first hydraulic accumulator (26, 28) and in a second charging line (41b) fluidly connected to the second chamber of said second hydraulic accumulator (26, 28).

8. Hydraulic arrangement according to claim 6 or 7, wherein the piston assembly (30) of said first hydraulic actuator (26, 28) and/or of said second hydraulic accumulator (26, 28) comprises a pair of pistons/septa, which are arranged in a sliding and fluid tight manner within said housing (29) and are spaced from each other, in order to define within said housing (29) a third chamber (31c), which is fluidly separated from said first chamber (31a) and said second (31b) and is configured to contain pressurized gas.

9. Hydraulic arrangement according to claim 6, 7 or 8, wherein said first valve means (38) and/or said second valve means (43) comprise a three-way three-position solenoid-controlled valve (40).

10. Hydraulic arrangement according to any of claims from 2 to 9, wherein said source of pressurized hydraulic fluid (17) comprises a second hydraulic pump (234), which is arranged in parallel to said first hydraulic pump (34) and is configured to be fluidly connected to said charging line (41).

11. A work machine (1) comprising: a body (2) movable on the ground by means of ground engaging means; a hydraulically actuated work implement (6), which is rotatably carried by said body (2) and is configured to perform multiple earth moving operations; and an hydraulic arrangement (14), which is realized according to any of the preceding claims.

12. A method for controlling a hydraulic arrangement (14, 214) realized according to any of claims from 4 to 10, the method comprising the following steps:

a) determining the pressure of the hydraulic fluid within said first hydraulic line (21a) of said hydraulic circuit (20); and
b) controlling the operation of source of hydraulic fluid (17), said first valve means (38) and/or said second valve means (43) according to the pressure determined in step a), in order to maintain the pressure of the hydraulic fluid within said first hydraulic line (21a) within a predetermined

interval.

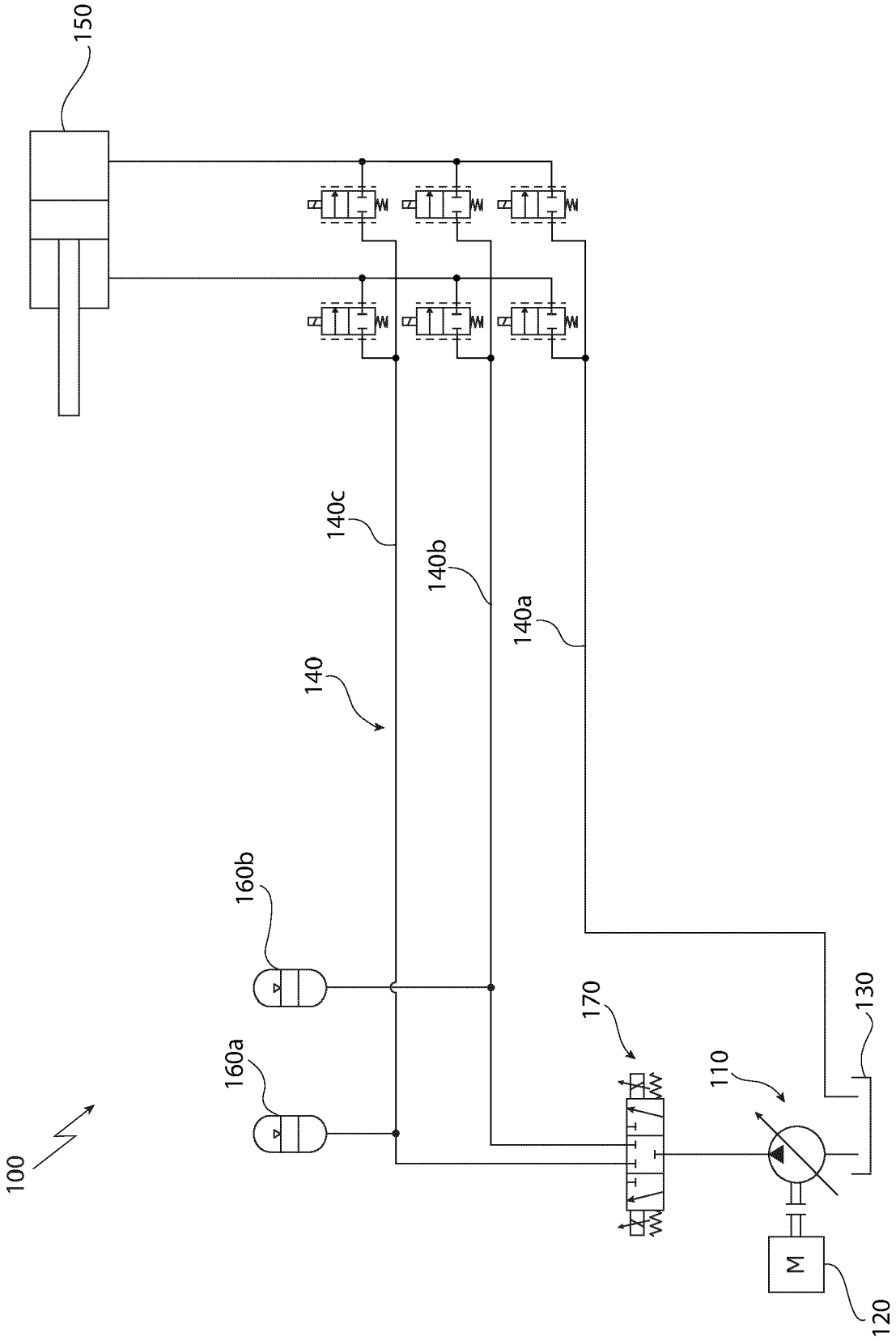

FIG. 1

FIG. 2

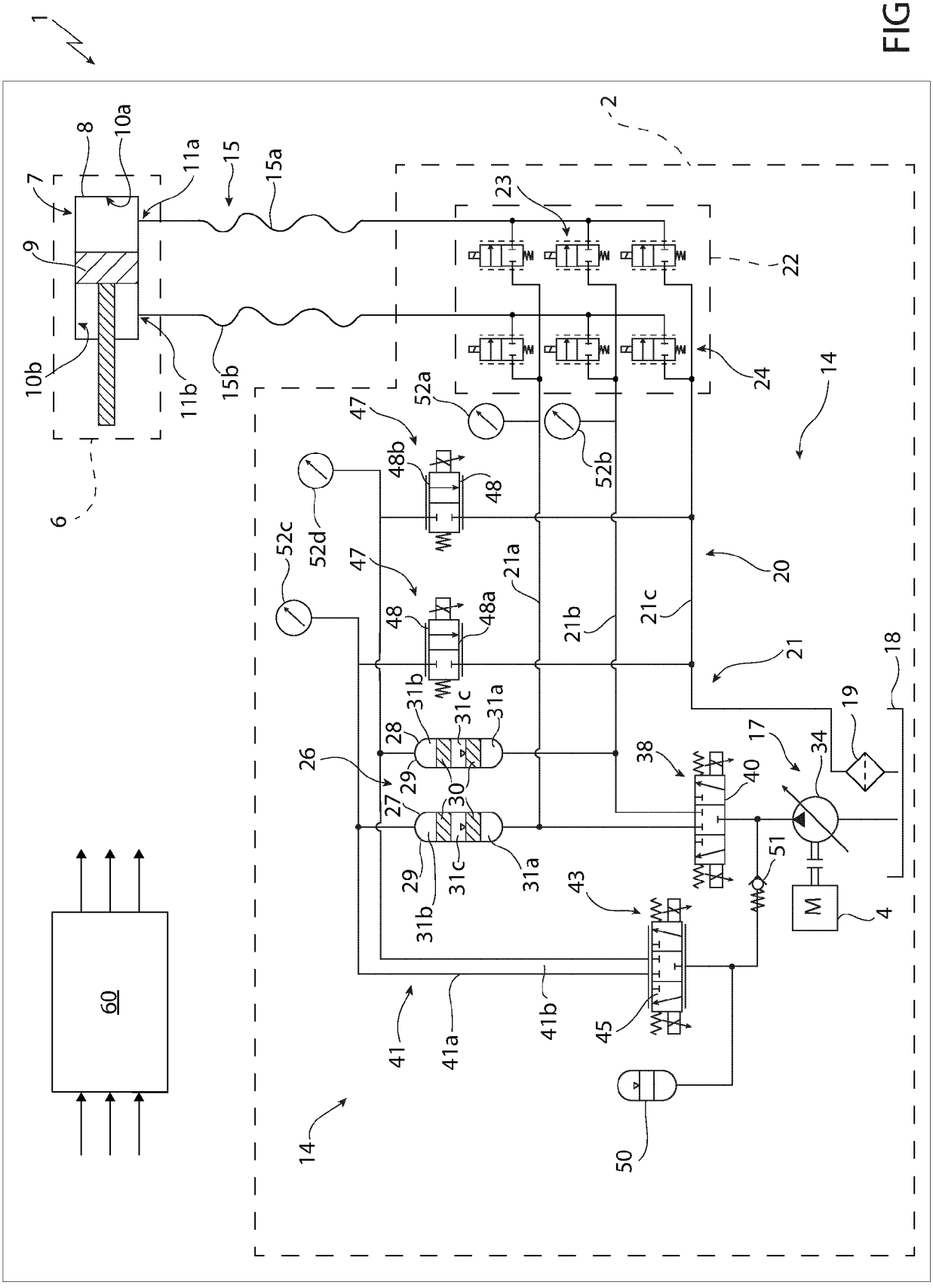
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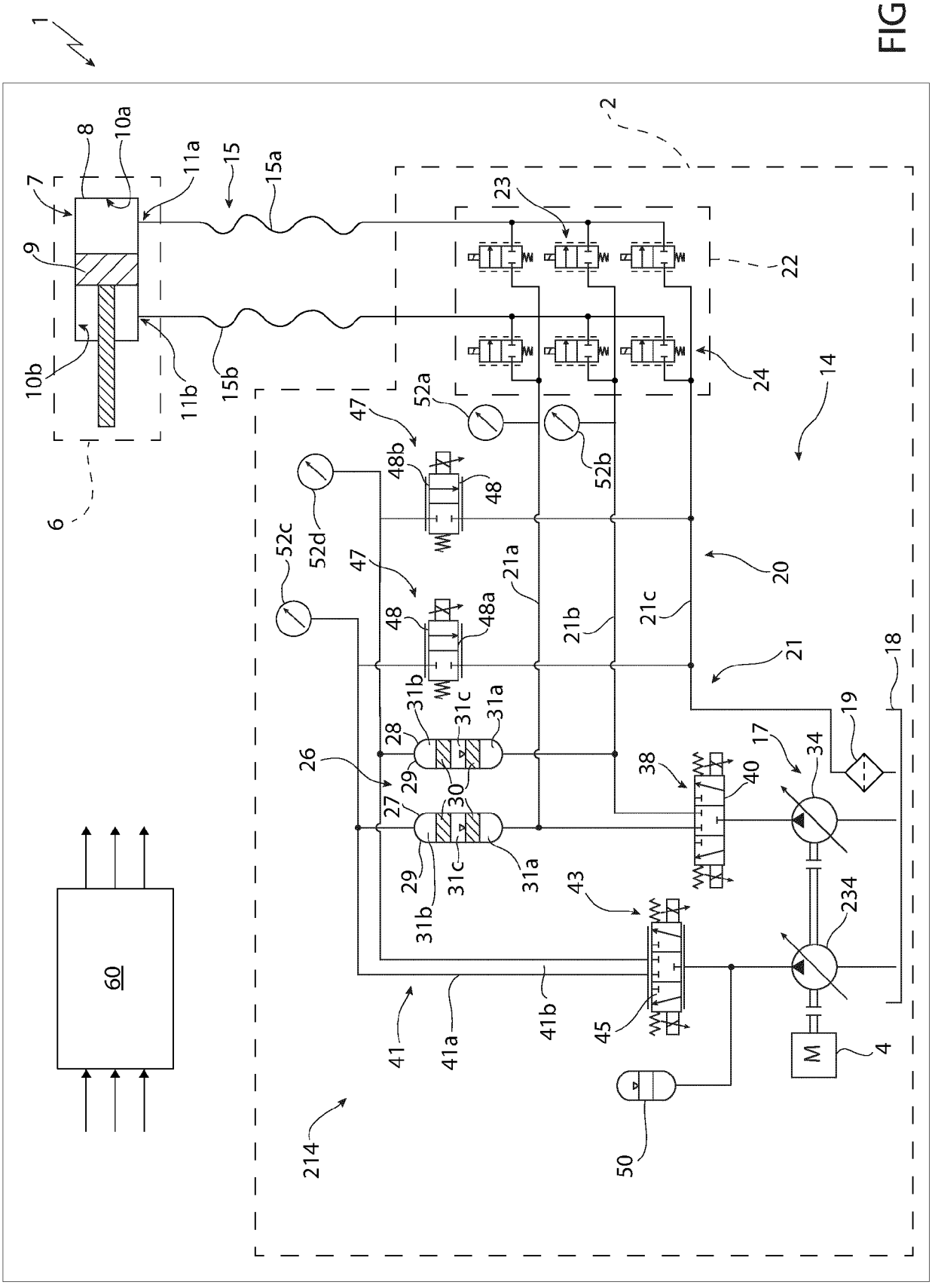
FIG. 3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EUROPEAN SEARCH REPORT

Application Number
EP 24 18 8145

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TECHNICAL FIELDS SEARCHED (IPC)

E02F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	13 November 2024	Dreyer, Christoph

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