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(54) **A VALVE UNIT, PARTICULARLY FOR CONTROLLING AN ARTICULATED ARM HAVING A TOOL**

(57) Described herein is a valve unit (VU) and a corresponding hydraulic system configured for driving an articulated arm equipped with a tool. The valve unit enables implementation of a function of self-levelling of the tool in a purely hydraulic way.

FIG. 1

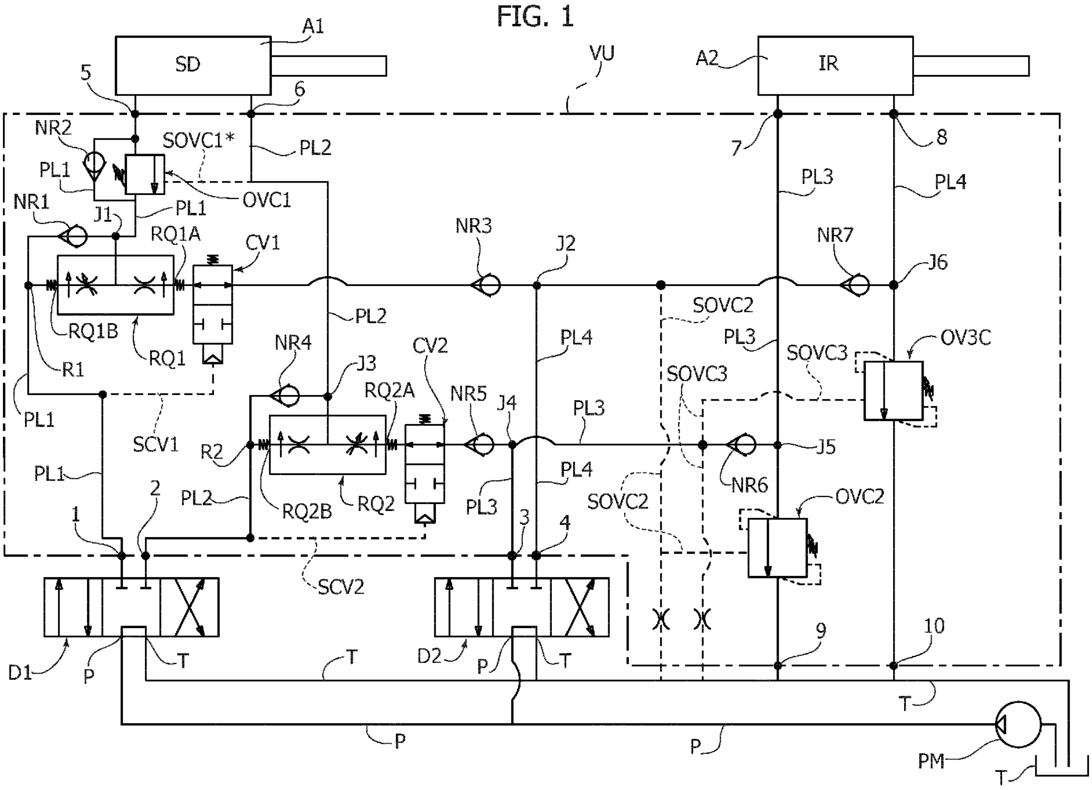

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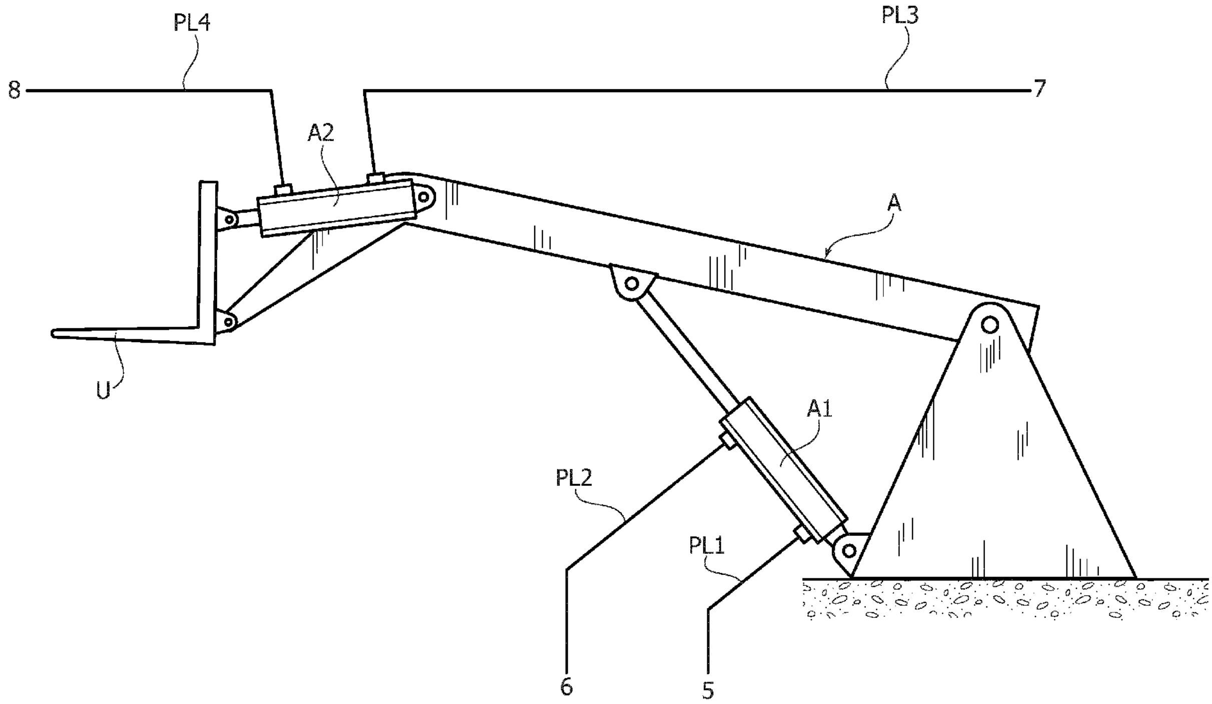
FIG. 1A



Description

Field of the invention

[0001] The present invention relates to valve units and hydraulic systems, in particular for control of articulated arms or booms that carry a tool, typically an end tool.

[0002] In greater detail, the invention has been developed with specific reference to applications where the tool requires a self-levelling action to maintain a constant attitude with respect to the ground as the position of the articulated arm varies.

Description of the prior art and general technical problem

[0003] The reference technological background of the invention forming the subject of the present disclosure is represented by devices that enable implementation of the so-called self-levelling function on a tool that is being carried - typically in an end position - by an articulated arm, in order to maintain the tool with a constant attitude with respect to the ground to prevent any unbalancing of the load or, in the case of aerial work platforms, of the operator who is present on the platform.

[0004] Currently, the prior art has provided a solution to the problem with two completely distinct modes, namely:

- a "mechanical" mode, where the articulated arm includes a first actuator that governs the raising and lowering movement of the arm and a second actuator that varies the position of the end tool with respect to the articulated arm, where the self-levelling function is obtained by means of an articulated mechanism that applies corrections of position to the end tool during the raising or lowering movement of the articulated arm; and
- a "hydraulic" mode, where the flow of working fluid that is sent towards the active chamber of the actuator that moves the articulated arm (raising/lowering actuator) is deviated in a calibrated way towards the actuator that governs the tool of the articulated arm so as to compensate for the variations of attitude due to the raising or lowering movement of the articulated arm itself; an example of this solution appears in the document No. US 4,683,802.

[0005] Both of the aforesaid modes present some problems that up to now remain unsolved; namely:

- the mechanical solution inevitably leads to an undue complication of the equipment, with an increase in the cost for production or retrofitting, as well as of the maintenance costs; furthermore, the mechanical solutions are intrinsically less adaptable to a wide range of different uses in so far as they must be devised specifically for a given user device;
- the hydraulic solution referred to in the document No. US 4,683,802 entails a considerable technical drawback due to the fact that, in order to exert the action of compensation on the actuator that governs the tool of the articulated arm, a flow divider has to be used that sends a priority share of the flow supplied by the pump to the actuator that governs raising and lowering of the articulated arm (main actuator in a raising/lowering manoeuvre, with respect to which the self-levelling action is applied), and a secondary share of flow to the actuator that governs the user device for attitude compensation.

[0006] This, however, results in a reduction of flow to the actuator that carries out the main movement, i.e., the movement of raising/lowering of the load, which is not acceptable for a plurality of applications, namely in the cases where it is necessary to retrofit the circuit on already existing vehicles or platforms. In the case where the solution of US 4,683,802 were to be implemented, it would no longer be possible to respect the requisites of performance (raising speed, for example) imposed on the raising/lowering actuator of the articulated arm, without carrying out massive interventions on the system, such as replacement of the pump and of the prime mover that drives the latter.

Object of the invention

[0007] The object of the present invention is to solve the technical problems mentioned above.

[0008] In particular, the object of the present invention is to provide a valve unit and a hydraulic system for control of an articulated arm and to make available a self-levelling function for the tool that is connected to the articulated arm that will be adaptable to a wide range of applications and will enable performance of the articulated arm to be maintained unaltered with respect to a condition where the latter is driven in a traditional way, i.e., without a self-levelling function.

Summary of the invention

[0009] The object of the present invention is achieved by a hydraulic valve unit and a hydraulic system that present the characteristics forming the subject of the ensuing claims, which constitute an integral part of the technical teaching provided herein in relation to the invention.

[0010] In particular, the object of the invention is achieved by a valve unit comprising:

- a first working port and a second working port, which are configured for connection to a first hydraulic distributor;
- a third working port and a fourth working port, which are configured for connection to a second hydraulic distributor;
- a fifth working port and a sixth working port, which are configured for connection to a respective fluid

chamber of a first hydraulic actuator that can be driven by means of the first hydraulic distributor; and
- a seventh working port and an eighth working port, which are configured for connection to a respective chamber of a second hydraulic actuator that can be driven by means of the second hydraulic distributor,

wherein:

- a first power line connects said first working port to said fifth working port;
- a second power line connects said second working port to said sixth working port;
- a third power line connects said third working port to said seventh working port; and
- a fourth power line connects said fourth working port to said eighth working port,

wherein the valve unit moreover includes:

- a first flow regulating valve including an inlet port connected to said first power line at a first circuit node in fluid communication with said fifth working port and a first outlet port connected to said fourth power line at a second circuit node; and
- a second flow regulating valve including an inlet port connected to said second power line at a third circuit node in fluid communication with said sixth working port and a first outlet port connected to said third power line at a fourth circuit node.

[0011] The object of the invention is moreover achieved by a hydraulic system according to Claim 10.

Brief description of drawings

[0012]

- Figure 1 is a representation of a hydraulic circuit according to a first embodiment of the invention;
- Figure 1A is a schematic representation of an articulated arm to which the hydraulic system according to the invention can be applied;
- Figure 2 is a circuit representation of a second embodiment of the hydraulic circuit according to the invention;
- Figures 3A-3D illustrate variants of circuit components that can be used in the valve unit according to the invention;
- Figures 4 and 6 illustrate embodiments of a hydraulic system according to the invention; and
- Figure 5 illustrates a preferred embodiment of an electrical circuit for control of parts of the system of Figures 4, 6.

Detailed description of preferred embodiments of the invention

[0013] The reference VU in Figure 1 denotes as a whole a valve unit according to a first embodiment of the invention.

[0014] The valve unit VU comprises a first working port 1 and a second working port 2, which are configured for hydraulic connection to a first hydraulic distributor D1.

[0015] The circuit VU includes a third working port 3 and a fourth working port 4, which are configured for hydraulic connection to a second hydraulic distributor identified by the reference D2. Each of the distributors D1, D2 is here schematically illustrated as a distributor with four ports (two upstream/source ports, two downstream/user-device ports) and three positions. The position on the left is a so-called parallel-flow position, the position on the right is a so-called cross-flow position, whilst the (centre) resting position is a closed-centre position for the ports 1 and 2 (and likewise for the ports 3 and 4) and a bypass-centre for the upstream ports.

[0016] Upstream of each of the two distributors D1 and D2, which are connected in hydraulic parallel to one another, there converge a supply line P and a return line T, the former receiving working fluid from a hydraulic pump PM and the latter returning working fluid to a tank T.

[0017] The reference numbers 5 and 6 designate, respectively, a fifth working port and a sixth working port of the valve unit VU, which are configured for connection to a respective fluid chamber of a first hydraulic actuator A1, in particular a linear actuator that can be driven by means of the distributor D1. In particular, the port 5 is connected to a fluid chamber (plunger side) that, when supplied, causes extraction of the stem of the actuator, whereas the port 6 is connected to a fluid chamber (stem side) that, when supplied, brings about retraction of the stem of the actuator.

[0018] The reference numbers 7 and 8 designate, respectively, a seventh working port and an eighth working port of the valve unit VU, which are configured for connection to a respective fluid chamber of a second hydraulic actuator A2 that can be driven by said second hydraulic distributor D2. In particular, the actuator A2 is again a linear actuator, and the port 7 is connected to a fluid chamber (plunger side) that, when supplied, brings about extraction of the stem of the actuator, whereas the port 8 is connected to a fluid chamber (stem side) that, when supplied, brings about retraction of the stem of the actuator A2.

[0019] Figure 1A is a schematic illustration of an articulated arm A, the (raising/lowering) movement of which is controlled by means of the actuator A1, which has a first end hinged to a fixed platform and a second end hinged to the arm A. A tool U (for example, a pair of forks) is set at the end of the arm A and is connected thereto in an articulated way. The movement of the joint, and hence the movement of the tool U with respect to the arm A, is governed by means of the actuator A2, which has a first end hinged to the arm A and a second end hinged to the tool U in a point that creates a lever arm with respect to the articulation between the tool and the arm A (pitching movement of the tool). The reference numbers that are identical to the ones already adopted previously designate the same components that have already been described.

[0020] Thanks to the connection in parallel of the distributors D1 and D2, the two actuators A1 and A2 can be driven each independently of the other, when this becomes necessary.

[0021] A first power line PL1 connects the first working port 1 to the fifth working port 5, while a second power line PL2 connects the second working port 2 to the sixth working port 6. On the side of the distributor D2, a third power line PL3 connects the third working port 3 to the seventh working port 7, while a fourth power line PL4 connects the fourth working port 4 to the eighth working port 8.

[0022] The term "power line" used herein (with reference to the lines PL1, PL2, PL3, PL4) is borrowed from the terminology commonly used in the sector of hydraulics and pneumatics and indicates a hydraulic power line, which is configured for transfer of flow of working fluid (at a respective pressure) in the hydraulic circuit. The term "power line" is - as per convention - applied to distinguish this type of hydraulic line from so-called (hydraulic) "pilot lines", which serve only to carry a signal (generally a pressure signal) for operating/piloting components of the hydraulic circuit. As such, pilot lines do not generally have a function of transferring flow (on the other hand, the amount of fluid that is in a pilot line is very low as compared to the amount flowing in a power line), but merely have a function of transferring the (pressure) signal onto surfaces of influence of driving actuators or of moving elements of valves.

[0023] The valve unit VU referred to above moreover includes a first flow regulating valve RQ1 and a second flow regulating valve RQ2, which are preferably identical. The first flow regulating valve RQ1 includes an inlet port connected to the aforesaid first power line PL1 at a first circuit node J1, and moreover includes a first outlet port RQ1A connected to said fourth power line at a second circuit node J2. In the preferred embodiment here considered, the flow regulating valve RQ1 is a flow divider, and thus includes a second outlet port RQ1B, which is connected to the power line PL1 at a circuit node R1 upstream of the node J1 ("upstream" being understood with respect to the direction of reading of the circuit diagram, proceeding from the port 1 to the port 5; during operation, the direction of flow may in actual fact vary).

[0024] It should be borne in mind, however, that other flow regulating valves may be used, for example a flow regulating valve with two ports, with a pressure-limiting valve connected in derivation, or else a flow regulating valve with three ports. The flow divider, as is known, splits the flow of incoming fluid into a priority flow that passes through the port RQ1A and an excess flow that passes through the port RQ1B and returns to the node R1. Located upstream of the node J1, and in particular in a position such as to be downstream of the node R1 ("upstream" and "downstream" being understood as explained previously), the latter constituting the connection of the port RQ1B to the line PL1, is a first check valve NR1 designed to enable a flow of working fluid only towards the node J1. A second check valve NR2 is, instead, set on the line PL1 between the circuit node J1 and the fifth working port 5 and is designed to enable a flow of working fluid only towards the port 5.

[0025] Moreover set in parallel with the check valve NR2 is a first overcentre valve OVC1. The valve OVC1 is normally in a closed position and is driven into opening by the pressure that is exerted upon the working port 5 and by the pressure that is exerted upon the working port 6, in the latter case by means of a signal SOVC1*. It should be noted that the valve NR2 may form part of a single hydraulic component with the valve OVC1. The signal SOVC1* enables optimal control of opening of the overcentre valve OVC1; i.e., it enables control of opening thereof when there is effectively a supply of working fluid from the line P to the port 6 by way of the line PL2, and not under the action of a static load on the articulated arm that pressurises the chamber, plunger side (port 5).

[0026] A first cut-off valve CV1 is set between the first outlet port RQ1A of the valve RQ1 and the node J2. Furthermore, set between the cut-off valve CV1 and the node J2 is a third check valve NR3 designed to enable a flow of working fluid only towards the node J2.

[0027] The cut-off valve CV1 is preferably a valve with two ports and two positions (open/closed) with a two-way open position, where the resting position shown in Figure 1 is a free-flow position (open position), whereas the second operative position is a position with flow shut off (closed position).

[0028] The valve CV1 is driven in closing, i.e., into the second operative position, by a pilot line SCV1, which transfers to the moving element of the valve CV1 a pressure signal corresponding to the pressure in the power line PL1, in particular on the working port 1.

[0029] In a way similar to the valve RQ1 on the line PL1, the valve RQ2 includes an inlet port connected to the second power line PL2 at a third circuit node J3, which is in fluid communication with the working port 6 and is set downstream of the working port 2 ("downstream" being understood as indicated above). The valve RQ2 moreover includes a first outlet port RQ2A, which is connected to the third power line PL3 at a fourth circuit node J4, where the node J4 is located downstream of the working port 3 ("downstream" being understood as indicated above). In the light of what has been described previously, preferably in the embodiment illustrated herein the valve RQ2 is provided as a flow divider and thus includes a second outlet port RQ2B, which is connected to the power line PL2 at a circuit node R2 that is located upstream of the circuit node J3, between the working port 2 and the circuit node J3 itself ("upstream" being understood as indicated above).

[0030] Furthermore, set between the working port 2 and the circuit node J3 is a fourth check valve NR4, which is moreover positioned downstream of the circuit node R2 ("downstream" being understood as indicated above), the latter constituting the connection of the port RQ2B to the line PL2 so as to be comprised between the nodes R2 and J3. The valve NR4 is configured for enabling a flow of fluid only towards the node J3.

[0031] A second cut-off valve CV2 is set between the first outlet port RQ2A of the valve RQ2 and the circuit node J4, and has characteristics identical to the valve CV1: a first operative position of rest with (two-way) free flow (open position), illustrated in the figure, and a second operative position of work with the flow shut off (hence, it is a valve with two ports and two positions).

[0032] The valve CV2 is driven in closing, i.e., into the second operative position, by means of a pilot signal SCV2 that transfers onto a surface of influence of the moving element of the valve CV2 a pressure signal corresponding to the pressure in the line PL2, in particular at the working port 2.

[0033] Furthermore, preferably, a fifth check valve NR5 is set between the first outlet port RQ2A and the circuit node J4, and preferably between the valve CV2 and the node J4, and is configured for enabling a flow of working fluid only towards the node J4.

[0034] Moreover set along the third power line PL3 are the components referred to in what follows. A sixth check valve NR6 is set between the circuit node J4 and a fifth circuit node J5, which is directly in view of the working port 7. The valve NR6 is configured for enabling a flow of working fluid only towards the circuit node J5.

[0035] Starting from the circuit node J5, and again in direct connection with the port 7, is a hydraulic return line, set along which is a second overcentre valve OVC2, set upstream of which is the node J5 ("upstream" and "downstream" are here understood with reference to the only direction of flow of the working fluid through the overcentre valve) and set downstream of which is a ninth working port 9, which connects up directly to the discharge line T.

[0036] On the line PL4, set downstream of the circuit node J2 ("downstream" being understood with reference to the only direction of flow allowed by the valve NR3) is a seventh check valve NR7, which is configured for enabling a flow of working fluid only towards a sixth circuit node J6, which is set immediately downstream of the valve NR7 ("downstream" being understood with reference to the only direction of flow allowed by the valve NR3). Starting from the node J6 is a return line, set along which is a third overcentre valve OVC3, which connects up directly to a tenth working port 10, which is in turn connected to the discharge line T. The line PL4 moreover supplies a pilot signal SOVC2, which drives the overcentre valve 2 in opening, and is moreover connected to the discharge line T by means of a choke, which decouples the pressure level of the pilot signal SOVC2 from the pressure level that is exerted upon the discharge line T.

[0037] Likewise, the power line PL3 supplies a pilot signal SOVC3 for the valve OVC3, which drives the overcentre valve OVC3 in opening and is also connected to the discharge via interposition of a choke that decouples the pressure level of the pilot signal SOVC2 from the pressure level in the discharge line T. The signals SOVC2 and SOVC3 are received immediately downstream of the nodes J2 and J4, respectively.

[0038] Operation of the valve unit VU, and in general of the hydraulic system that enables control of the articulated arm according to the invention, is described in what follows.

[0039] The actuators A1 and A2 can be driven separately by means of the distributors D1 and D2 for governing the movements of raising and lowering of the articulated arm - actuator A1 - and the positive and negative movements of pitching of the tool, i.e., the positive or negative variations in attitude of the tool that is carried by the articulated arm - actuator A2.

[0040] Furthermore, each driving action imparted on the actuator A1 via driving of the distributor D1 results in a compensatory driving action on the actuator A2 performed by the valve unit VU in order to keep the attitude of the tool of the articulated arm constant with respect to the ground, preventing any variations thereof.

[0041] The manoeuvres of raising (parallel-flow position of the distributor D1) and lowering (cross-flow position of the distributor D1) of the articulated arm will be described separately so that it will be possible to appreciate how the action of compensation takes place.

[0042] By switching the distributor D1 into the parallel-flow position and by not imparting any driving action on the distributor D2, the port 1 is connected to the line P, and hence receives the working fluid directly from the pump PM. The pressurized working fluid then enters the power line PL1, traverses the node R1, the check valve NR1, which allows a direction of flow only towards the node J1 (and towards the port 5), and the node J1, and then passes beyond the overcentre valve OVC1 thanks to the check valve NR2, and directly reaches the port 5 and the chamber of the actuator A1, which, when supplied, brings about extraction of the stem.

[0043] At the same time, the valve CV1 is switched into a closed position by means of the pilot signal SCV1, which reads the pressure of the working fluid in the power line PL1 (in particular, on the port 1), so that no part of the flow that traverses the line PL1 is diverted by the flow divider RQ1 towards the node J2 and towards the line PL4.

[0044] This constitutes a fundamental difference with respect to the document No. US 4,683,802 since, as is evident, the actuator A1 that governs the movement of raising and lowering is managed by the valve unit VU effectively as a priority user, in the sense that all the flow processed by the pump PM is immediately made available to the actuator, without being diverted towards the actuator A2, contrary to what occurs in the aforementioned U.S. document where the flow passes though the flow divider. In this case, on account of closing of the cut-off valve CV1, the flow of working fluid that passes through the valve NR1 does not enter the inlet port of the divider RQ1 since this would constitute a path with a hydraulic resistance that prevails over the hydraulic resistance presented by the next valve NR2.

[0045] At the same time, as the flow of working fluid passes through the port 5, the port 6 receives a flow of working fluid in the opposite direction, which enters the line PL2 and proceeds towards the circuit node J3, and corresponds to the working fluid discharged by the opposite chamber of the actuator A1, i.e., the chamber coming under which is the port 6.

[0046] From the node J3 the path towards the inlet port of the flow divider RQ2 is obligate in so far as the check valve NR4 does not allow the working fluid to pass through the rest of the line PL2 with the current direction of flow.

[0047] Furthermore, given that the line PL2 is connected to the discharge, the pilot signal SCV2 is inactive, and the cut-off valve CV2 remains in an open position. The flow divider RQ2 consequently directs a priority share of the flow received from the chamber of the actuator A1 that is decreasing in volume (the chamber coming under which is the port 6) towards the line PL3, with passage through the port RQ2A. It is thus evident how the flow of working fluid that performs the action of compensation is supplied, not by drawing off part of the flow that is to carry out the main operation, i.e., that is to reach the actuator A1 (movements of raising/lowering - raising in this case), but rather by re-use of the flow of fluid discharged by the actuator A1 itself, which would otherwise be simply re-directed to the discharge.

[0048] A secondary share of flow is, instead, emptied off through the port RQ2B and sent directly to the discharge through the line PL2.

[0049] After passing through the port RQ2A, the working fluid traverses the cut-off valve CV2 (which remains in an open position given that the pilot signal SCV2 reads and transfers thereto a pressure equal to the discharge pressure) and traverses the check valve NR5 to reach the node J4.

[0050] From here, given that the distributor D2 is in the centre position, the only direction possible for the working fluid is the power line PL3 downstream of the node J4, then the check valve NR6, and from there the node J5 and the working port 7, from which the working fluid enters the chamber (plunger side) of the actuator A2, to achieve a compensation in the direction of extraction of the stem.

[0051] With reference to Figure 1A, this corresponds to a counterclockwise rotation of the end tool, which ensures that the orientation parallel to the ground will be maintained. The overcentre valve OVC2 remains in a closed position so that the fluid that enters the node J5 cannot be sent directly to the discharge (it should be noted, in fact, that the driving signal SOVC2 reads the pressure signal from the line PL4, this signal being, however, substantially equal to the tank pressure in so far as the valves NR3 and CV1 isolate the node J2 from the line PL1 and the valve NR7 does not enable the fluid discharged from the port 8 to contribute to definition of the signal SOVC2).

[0052] Instead, the fluid at output from the port 8 can only be sent towards the overcentre valve OVC3, which enables control of the pulling action exerted upon the end tool during the action of compensation.

[0053] The overcentre valve OVC3 preferably has a calibration pressure of 200 bar and, once again preferably, is sized so as to have a driving ratio of 1:3 in order to ensure a more regular operation of the actuator A2 under the pulling load. In particular, the typical volume displacement of the actuator A2 and the section of the corresponding plunger are in general such that, under the most statistically frequent loads, the pressure in the discharge chamber rises considerably when the load is a pulling load (the area of the plunger is relatively small so that the chamber pressure is relatively high). With an overcentre valve that opens at low pressure - the driving ratio is a ratio between the opening pressure and the calibration pressure/maximum pressure of the overcentre valve - opening occurs in a sharp and jerky way. The intervention carried out on the valve OVC 3 is typically that of adopting a stiffer pre-loading spring so as to increase the driving ratio according to the definition given above (if the reciprocal is used, the driving ratio is decreased).

[0054] From the valve OVC3 the fluid that is discharged by the actuator A2 and is received by the port 8 reaches the discharge T directly through the port 10, without passing through the distributor D2.

[0055] This constitutes another advantage of the present invention since, as will be appreciated, the discharge of flow during the action of compensation is independent of the distributors D1 and D2 that may already be present on the vehicle that carries the articulated arm, thus rendering the valve unit VU a natural candidate for retrofitting on already existing vehicles.

[0056] As regards the manoeuvre of lowering of the articulated arm illustrated in Figure 1A, this corresponds to the position of cross flows of the distributor D1, where the port 2 is connected to the line P while the port 1 is connected to the discharge T. As described previously, the working fluid processed by the pump PM is sent into the line PL2 through the port 2, traverses the junction R2 and the valve NR4, and reaches the node J3. From the node J3, the working fluid proceeds directly towards the port 6 and towards the chamber of the actuator A1, which, when supplied, causes retraction of the stem, while the fluid is substantially prevented from passing through the flow divider RQ2.

[0057] This happens because, given that the line PL2 is pressurized, the pilot signal SCV2 causes switching of the cut-off valve CV2 into a closed position and consequently closes the outlet of the flow divider at the port

RQ2A. Also in this case, it will be appreciated that all the flow processed by the pump PM is sent directly to the actuator A1, without part thereof being diverted towards the actuator A2.

[0058] The share that is sent to the actuator A2 is, as in the previous case, supplied by the chamber of the actuator A1 that is emptying, namely, the chamber that comes under the port 5. From here, the working fluid discharged first traverses the overcentre valve OVC1, necessary for control of the pulling load acting to bring about lowering of the articulated arm, and then passes through the line PL1 until it reaches the node J1.

[0059] The working fluid is then prevented from proceeding through the valve NR1 and is consequently forced to enter the flow divider RQ1. From here, a priority share of flow is sent towards the port RQ1A and through the valve CV1, which, given the connection of the line PL1 to the discharge, has the pilot signal SCV1 inactive, and hence remains in an open position.

[0060] Once the valve CV1 has been traversed, the priority flow of working fluid traverses the valve NR3, then the node J2, and from this the valve NR7, the node J6, and the port 8, and enters the chamber (stem side) of the actuator A2, which thus retracts the stem.

[0061] As in the previous case, the closed-centre position of the distributor D2 prevents the flow of working fluid through the node J2 from being split, whilst the absence of pilot signal SOVC3 keeps the overcentre valve OVC3 in a closed position. Furthermore, the valve NR5 isolates the stretch of line PL3 upstream of the valve NR6 in such a way that the signal SOVC3 can only represent the pressure on the discharge line T.

[0062] The flow of working fluid at output from the port 7 is then sent through the overcentre valve OVC2 (passage beyond the valve NR6 is rendered impossible since the latter blocks the flow at output from the node J5), which controls a possible pulling action of the load. Then, the fluid is directly discharged into the tank through the port 9, again irrespective of the position of the distributor D2.

[0063] The overcentre valve OVC2 preferably has a calibration pressure of 200 bar, and, once again preferably, is sized so as to have a driving ratio 1:8 or 1:10 (in general from 1:8 to 1:10) in such a way that also with a pilot signal of low intensity (low pressure) the valve can be opened. The same applies to the valve OVC 1: calibration pressure preferably equal to 200 bar, and driving ratio of 1:8 or 1:10 (in general from 1:8 to 1:10).

[0064] In the case of the valve OVC 1, the pressure that is exerted upon the port 6 during lowering of the actuator is typically low on account of the marked pulling action due to the load that is exerted upon the actuator A1. If the driving ratio were higher, the valve OVC1 would not manage to open if not under impulsive actions (but at this point it would be an opening due to exceeding of the calibration pressure/maximum pressure).

[0065] For the valve OVC2, during normal operation controlled by the distributor D2, it regulates the flow at the discharge of the chamber leading to the port 7, the pilot signal coming from the port 8. Since the load in this case is a purely resistant load and not a pulling load, the valve OVC2 must open for low pressures in order to prevent any useless dissipation of energy (in brief, the resistant action of the overcentre valve OVC2 must not add to the resistance already offered by the load). Also on the hypothesis of pulling loads in the direction that causes retraction of the stem of the actuator A2, the opening pressure must in any case be low to prevent any blocking of the actuator itself (the pulling actions during retraction are physiologically of a modest degree, considering operation of the actuator A2).

[0066] During the manoeuvres of compensation, the valve OVC2 is piloted by a pressure signal that is linked to the pressure that is exerted upon the port RQ1A: in that point, the pressure could be relatively low on account of the marked pressure drop induced by the overcentre valve OVC1 so that the pilot pressure could, in the final analysis, be relatively low.

[0067] Figure 2 illustrates a different embodiment of the hydraulic system according to the invention, where accessory functional assemblies are provided, and where the unit VU is equipped, not only with the basic configuration that has already been described, but also with further valves to provide some accessory functions.

[0068] The reference numbers that are identical to the ones already adopted previously designate the same components that have already been described.

[0069] From the standpoint of the system, the accessory components include:

- an accumulation assembly ACC comprising a manually controlled tap TP, which governs fluid communication between the working port 5 (and hence the chamber of the actuator A1, plunger side, that carries out extraction of the stem, when supplied) and a pressurized-nitrogen accumulator NA; the accumulation assembly ACC has the function of damping the oscillations of pressure due to raising of the articulated arm, as well as the oscillations due to the oscillatory movement of the arm when the vehicle is travelling along rough roads, preventing troublesome vibrations in the cab for the person driving the vehicle that carries the articulated arm;
- a flowrate-limiter assembly QLIM, which includes a set of sensors, which read the pressure on the port 5, and a by-pass valve, which is installed so that it bridges the branches P and T immediately downstream of the pump PM and is normally in a closed position; the set of sensors includes a pressure switch PS piloted by a hydraulic pilot signal SPS, which reads the pressure on the port 5 and transfers it; the pressure switch is configured for switching once a pressure threshold is exceeded so as to generate a signal T*, which in turn causes switching of the valve S3 downstream of the pump PM into an open position, thus reducing the flow in the circuit;

and

- a flow-deviation unit UTX, which includes a set of deviating distributors UT1, UT2, UT3 which are connected in series along the power lines PL3 and PL4; each one is built as a distributor with six ports (two upstream and four downstream) and two positions; in particular, each distributor includes two upstream ports and four downstream ports, where the terms "upstream" and "downstream" here refer to a concordant direction of flow along the lines 3 and 4 that originates from the distributor D2.

[0070] The two upstream ports in the first operative position (resting position, illustrated in the figure) of each of the distributors UT1, UT2, UT3, are connected to the upstream ports of the next distributor, thus substantially obtaining a continuity in the lines PL3 and PL4 that is functionally equivalent to the condition of Figure 1.

[0071] The second operative position of each of the distributors, which can be activated by means of an electrical signal PA, PB, PC, enables the ports 3 and 4 to be set in communication, respectively, with the ports A and B of users UT1, UT2, UT3, denoted by the same references as the distributors, where each port A, B is associated to a prefix that consists of a U followed by the progressive number of each user.

[0072] In this way, during normal operation (the unit UTX does not intervene during compensation), when the distributor D2 is governed so as to drive the actuator A2 it is possible to deviate the drive onto any one of the actuators UT1, UT2, UT3 according to the need.

[0073] The valve unit VU is enriched, instead, with a fast-filling module FF, which facilitates filling of the chamber of the actuator A1 that will first be involved in a phenomenon of discharge of working fluid after a prolonged stoppage of the system, in particular a discharge to complete an action of compensation on the actuator A2.

[0074] It may in fact happen that, after a prolonged layoff, even in the presence of all the check valves in the circuit, the working fluid leaks and partially empties the chambers of the actuator A1. Since it is always the chamber of the actuator A1 that discharges fluid to supply the working flowrate for the action of compensation on the actuator A2, it is evident that this chamber must always be completely full to guarantee timely compensation.

[0075] It is thus essential that, at the moment of supply of the opposite chamber of the actuator A1 (which has no need of facilitated filling in so far as it is directly supplied by the pump PM), it is necessary to re-integrate the amount of fluid that has leaked via fast filling of the chamber that is about to discharge the fluid.

[0076] The fast-filling assembly FF includes a third cut-off valve CV3 and a fourth cut-off valve CV4, which bridge the power lines PL1 and PL2. The cut-off valve CV3 is combined to an eighth check valve NR8 set in series to it on the side of the line PL2, whereas the valve CV4 is set in series to a ninth check valve NR9 set on the side of the line PL1.

[0077] The valve NR8 enables a flow of working fluid only from the line PL1 towards the line PL2 (after the fluid has passed through the valve CV3), whereas the valve NR9 enables a flow of working fluid only from the line PL2 towards the line PL1 (after the fluid has passed through the valve CV4).

[0078] During an arm-raising manoeuvre, where it is necessary to carry out fast filling of the chamber that comes under the port 6, the working fluid that enters the line PL1 is blocked by the valve NR9 but can pass through the valve CV3 and the valve NR8, then traversing the line PL2, to enter the chamber (stem side) directly through the port 6 (the working fluid does not enter the flow divider in so far as it is a path with higher hydraulic resistance). The valve CV4 is at the same time forced to close by the pressure exerted upon the line PL1. Once filling of the chamber (stem side) is through, the pressure that is set up on the port 6 drives the valve CV3 into closing (signal SCV3), isolating the ports of the series of valves CV3 and NR8 and enabling movement of the working fluid in a way identical to what has been described previously. In this connection, closing of the valve CV4 prevents in any case any passage of fluid towards the valve NR9, avoiding a hydraulic short-circuit (a phenomenon already in itself generally prevented by the fact that the pressure that is present in the line PL1 and that keeps the valve NR9 in a closed position is higher than the pressure that is present in the line PL2).

[0079] Likewise, in an arm-lowering manoeuvre - where the chamber to be filled fast is the one, plunger side, coming under which is the port 5 - the working fluid that enters the line PL2 traverses the valve CV4 and the valve NR9, going directly to the working port 5 through the valve NR1 (the flow divider RQ1 is not traversed in so far as it constitutes a path with higher hydraulic resistance, while the overcentre valve OVC1 does not allow passage in the direction that goes towards the port 5).

[0080] The valve CV3 is at the same time driven into closing by the pressure that is present in the line PL2. Once filling of the chamber, plunger side, is completed, the pressure that is set up on the port 5 drives the valve CV4 into closing (signal SCV4), isolating the ports of the series of valves CV4 and NR9 and enabling movement of the working fluid in a way identical to what has been described previously. In this connection, closing of the valve CV3 in any case prevents any passage of fluid towards the valve NR8, avoiding hydraulic short-circuit (a phenomenon already in itself generally prevented by the fact that the pressure that is present in the line PL1 and that keeps the valve NR9 in a closed position is higher than the pressure that is present in the line PL2).

[0081] On the basis of the foregoing description, the person skilled in the branch will hence certainly appreciate how a valve unit VU and the hydraulic system according to the invention enable an easy solution to the problems left unsolved by the prior art. In particular, the problem of reduction of performance of the actuator that governs the articulated arm is solved by the fact that there takes place a direct supply of the expanding chamber of the actuator A1, without passing through flow-splitting valves or flow regulating valves. In this way, the performance of the actuator A1 can be kept constant as compared to the case where it is controlled only by the distributor D1, without requiring replacement of the pump PM.

[0082] The person skilled in the branch will likewise appreciate how the valve unit VU possesses interfaces for connection to the other components of the hydraulic system that adapt completely to the most common hydraulic schemes of already existing vehicles, thus rendering it a natural candidate for on-vehicle retrofitting.

[0083] Furthermore, the valve unit VU is intrinsically suited to retrofitting or implementation on a vast range of different vehicles and on a vast range of different tools. In particular, the element that determines the behaviour of the valve unit VU, in particular as regards the action of compensation, is the flow regulating valve RQ1, RQ2. In the embodiment described herein, where the valves RQ1 and RQ2 are built as flow dividers, it is sufficient to vary calibration of the flow dividers themselves to vary splitting of the flow at inlet through the nodes J1 and J3 in order to vary the degree of the action of compensation. Since it is not indispensable to use flow dividers for achieving the desired effect, but the same result could be achieved by a flow regulating valve with two ports (for example, a variable choke), connected in derivation to which is a pressure-limiting valve, or again a flow regulating valve with three ports, it is sufficient to vary accordingly the calibration of each of these three valves in order to obtain a flow sent to the actuator A2 that is commensurate with the requirements.

[0084] Of course, the details of construction and the embodiments may vary widely with respect to what has been described and illustrated herein, without thereby departing from the scope of the present invention, as defined by the annexed claims.

[0085] For instance, Figure 3 illustrates some possible variants of the flow regulating valve RQ1/RQ2 that can be used in a valve unit according to the invention. The references adopted that are identical to the ones already used in the description designate the same power ports. Appearing in brackets are the references that apply to the valve RQ2.

[0086] Figure 3A illustrates a flow regulating valve RQ1/RQ2 obtained as distributor with three ports and two positions, electrically driven as a function of the pressure that is present in the line PL1, designated by p(PL1) (for the other branch of the circuit, the line is PL2 and the pressure is p(PL2)). The resting position corresponds to the same type of hydraulic connection implemented in the flow divider referred to in the diagrams of Figures 1 and 2, whereas the resulting position following upon electrical driving (switching) of the valve corresponds to a position where the port RQ1A (or RQ2A) is isolated, whereas the inlet port is in fluid communication with the port RQ2B. It should be noted that, in the case of use of the valve of Figure 3A, the cut-off valves CV1 and CV2 are no longer necessary in so far as their function is automatically performed at the moment of switching of the valve RQ1/RQ2.

[0087] Figure 3B illustrates a variant of the valve RQ1/RQ2 of Figure 3A, where the position resulting from electrical control of the valve envisages isolation of all three working ports. For the rest, the description already presented for Figure 3A applies.

[0088] Figure 3C illustrates a valve RQ1/RQ2 obtained with an ensemble of a flow regulating valve with two ports R2W, connected to which, upstream and in derivation, is a pressure-limiting valve VL. The flow regulating valve with two ports R2W includes a choke with variable section set in series with, and upstream of, a normally open valve, the moving element of which is driven into closing by the pressure upstream of the choke and into opening by the pressure downstream of the choke. The moving element is moreover kept in an open position by means of an elastic element, to which there corresponds an equivalent calibration pressure that enables regulation of the value of flowrate of fluid discharged by the valve R2W. For this reason, provided upstream of the valve R2W is the inlet port of the valve RQ1/RQ2 (where the node J1/J3 is located), whereas provided downstream of the valve R2W is the port RQ1A/RQ2A.

[0089] The port RQ1B/RQ2B is, instead, provided downstream of the pressure-limiting valve VL, which in this way is configured for disposing of the flow of working fluid that cannot be disposed of through the valve R2W.

[0090] Finally, Figure 3D illustrates a valve RQ1/RQ2 obtained by means of a flow regulating valve with three ports. The latter valve includes a choke with variable section (this being understood as component as such or as functional equivalent) connected to the inlet port of the valve RQ1/RQ2. Set in derivation upstream of the choke and downstream of the inlet port is a normally closed valve R3, the moving element of which is driven into opening by the pressure upstream of the choke (the pilot signal is preferably picked up also upstream of the derivation of the valve R3), whereas it is driven into closing by means of an elastic element and a pressure signal, which is picked up downstream of the choke with variable section. Provided downstream of the choke with variable section is the port RQ1A/RQ2A, whereas provided downstream of the valve R3 is the port RQ1B/RQ2B.

[0091] In both variants of Figures 3C and 3D, it is moreover preferable to combine the valves RQ1/RQ2 represented therein with the cut-off valves CV1 and CV", but it is also possible, if the construction of the valve so allows, to envisage an electrical driving of the section of the choke with variable section that will cause closing thereof at the moment of supply of the line PL1 for the valve RQ1 and the line PL2 for the valve RQ2.

[0092] With reference to Figures 4, 5, and 6, described in what follows are further variants and/or embodiments of a hydraulic system according to the invention, here in particular based upon the valve unit VU of Figure 2. The reference numbers that are identical to the ones adopted previously designate the same components that have already been described.

[0093] The hydraulic system as illustrated in Figures 4 and 6 includes the valve unit VU of Figure 2, and differs from the scheme illustrated therein only as regards the structure and connections of the flow-deviation unit UTX.

[0094] With reference to Figure 4, the flow-deviation unit is designated by the reference UTX1, and is split into in two sections, a first section UTX1D and a second section UTX1U (this applies also to the next Figure 6). The section UTX1D is connected in a position upstream of the valve unit VU, and in particular in a position hydraulically in series between the distributor D1 and the ports 1 and 2 (hence in series to the power lines PL1 and PL2). The section UTX1D includes the distributor UT1, which, as has already been described previously, takes the form of a distributor with six ports (two upstream and four downstream, where the terms "upstream" and "downstream" here refer to a concordant direction of flow through the lines 1 and 2 that originates from the distributor D1) and two positions. The upstream ports of the distributor UT1 are connected to the downstream ports of the distributor D1, whereas the downstream ports of the distributor UT1 are connected/connectable in pairs to the ports 1 and 2 of the valve unit VU (and to the power lines PL1, PL2, respectively) and to the power lines U1A, U1B leading to the chambers of the actuator UT1, which governs a hydraulic tool/user of a vehicle on which the hydraulic system with the unit VU is installed.

[0095] The power lines U1A, U1B moreover lead to the section UTX1U. In this regard, the section UTX1U is connected in parallel to the valve unit VU via the distributor UT1, the lines U1A, U1B of which constitute power lines for the connection in series of the two distributors UT2, UT3. As has already been described, these are operatively associated to respective users UT2, UT3, denoted by the same references as the distributors, and can be governed by means of a signal PB, PC, respectively. Appearing in brackets in Figure 4 (the same applies to Figure 6) are the interfaces of the series of distributors UT2, UT3. The section UTX1D is in view of the upstream ports of the distributor UT2, whereas the user UT1 is in view of the downstream port of the distributor UT3.

[0096] The distributor UT1 moreover includes two operative positions, in particular a first operative position (at rest) corresponding to the active position of Figure 4, and a second operative position corresponding to the inactive position of Figure 4.

[0097] In the first operative position, a fluid communication is provided between the downstream port of the distributor D1 and the ports 1 and 2 of the valve unit VU. The two further downstream ports of the distributor UT1 are not involved in passage of fluid (closed condition). This is an operative position that provides a bypass of the distributor UT1, where the working fluid that passes within the distributor UT1 does not govern the corresponding user UT1. The valve unit VU substantially operates as if the distributor UT1 were absent.

[0098] The second operative position of the distributor UT1, which can be activated by means of an electrical signal P1 (Figure 5) that governs the solenoid (or other kind of electrical or electromagnetic actuator) PA enables setting-up of a fluid communication between the downstream port of the distributor D1 and the power lines U1A, U1B, deviating the flow of working fluid that is processed by the distributor D1 entirely into the flow-deviation unit UTX1, i.e., supplying the user UT1 and the distributors UT2, UT3.

[0099] Each of the aforesaid distributors has a structure similar to that of the distributor UT1 and includes two upstream ports and four downstream ports. It should be noted that the definition "upstream" and "downstream" here also imposes the sequence of the distributors: UT1 is set upstream of UT2, which is in turn set upstream of UT3. The user UT1 is set downstream of all the series of distributors UT1-UT2-UT3. In the first operative position, the two upstream ports of each distributor UT2, UT3 are connected to a first pair of downstream ports so as to provide a bypass for the distributor itself. In other words, the working fluid passes within the distributor UT2, UT3, without controlling the corresponding user UT2, UT3. This is the position illustrated in Figure 4. The two further downstream ports of the distributors UT2, UT3 are not involved in the passage of fluid (closed condition).

[0100] In the second operative position, each distributor UT2, UT3 deviates the flow of working fluid reaching it towards the corresponding user UT2, UT3, excluding the user set downstream (in this way, in the light of what has been described, driving of UT2 by means of the electrical signal PB excludes the users UT1 and UT3, whereas driving of UT3 excludes the user UT1).

[0101] In this way, during normal operation (the unit UTX1 does not intervene during compensation), when the distributor D1 is governed so as to drive the actuator A1, it is possible to deviate the aforesaid drive onto any one of the actuators UT1, UT2, UT3 according to the need. If just the distributor UT1 is active, then the drive will be deviated onto the user/actuator UT1. If also the distributor UT2 is active, then the drive will be deviated onto the user/actuator UT2. If, instead, the distributors UT1 and UT3 are both active, the drive will be deviated onto the user/actuator UT3.

[0102] Driving is effected via an electrical circuit EC, a preferred embodiment of which is illustrated in Figure 5.

[0103] The electrical circuit EC illustrated in Figure 5 develops between a power line PW (preferably at 12 V) and a ground line GND (at 0 V). Upstream of the line PW, a fuse MF (preferably a 20-A fuse) is provided for protecting the electrical network between the nodes A and B.

[0104] There now follows a description of the components of the circuit and the corresponding connections to the two lines PW and GND.

[0105] Set along the line PW are circuit nodes B, B', D, D', F, F'.

[0106] Set along the line GND are circuit nodes C, C', E, E', G, G'.

[0107] Connected in series between the nodes B and C (the order followed in the ensuing description goes from the line PW to the line GND) are a first relay RL1, in particular an electromagnet K1* thereof, and a first push-button switch P1. Connected, instead, in series between the nodes B', C' are a switch K1, which functionally forms part of the relay RL1 and is governed by means of the electromagnet K1*, a first diode D1, and the solenoid PA, which governs the distributor UT1. It should be noted that the relay RL1 may be replaced by a similar component (including an electronic one) that performs the same function.

[0108] Connected in series between the nodes D and E (again, the order followed in the ensuing description goes from the line PW to the line GND) are a second relay RL2, in particular an electromagnet K2* thereof, and a second push-button switch P2. Connected, instead, in series between the nodes D', E' are a switch K2 that functionally forms part of the relay RL2 and is governed by means of the electromagnet K2*, and the solenoid PB that governs the distributor UT2. A second diode D2 is, instead, connected to the switch K2 in derivation with respect to the solenoid PB. In other words, a terminal of the solenoid PB is connected to the line GND, whereas another terminal of the solenoid PB is connected upstream of the diode D2 (for the diodes described herein, the references "upstream" and "downstream" are dictated by the direction allowed for the current), i.e., to one terminal of the switch K2. As mentioned above, the relay RL2 may be replaced by a similar component (including an electronic one) performing the same function.

[0109] Connected in series between the nodes F and G (once again, the order followed in the ensuing description goes from the line PW to the line GND) are a third relay RL3, in particular an electromagnet K3* thereof, and a third push-button switch P3. Connected, instead, in series between the nodes D', E' are a switch K3 that functionally forms part of the relay RL3 and is governed by means of the electromagnet K3* and the solenoid PC that governs the distributor UT3. A third diode D3 is, instead, connected to the switch K3 in derivation with respect to the solenoid PC. In other words, a terminal of the solenoid PC is connected to the line GND, whereas another terminal of the solenoid PC is connected upstream of the diode D3 (once again, for the diodes described here, the references "upstream" and "downstream" are dictated by the direction allowed for the current), i.e., to a terminal of the switch K3. As mentioned above, the relay RL3 may be replaced by a similar component (including an electronic one) performing the same function.

[0110] A push-button P1 connects the node B to the node C, exciting the relay K1. Once the signal has traversed the diode D1, it energises the solenoid PA responsible for control of the distributor UT1 connected to the cylinder bearing the same reference.

[0111] A push-button P2 connects the node D to the node E, exciting the relay K2; the signal energises the solenoid PB responsible for control of the distributor UT2 connected to the cylinder bearing the same reference, and simultaneously the diode D2 through which the signal passes energises the solenoid PA.

[0112] A push-button P3 connects the node F to the node G, exciting the relay K3; the signal energises the solenoid PC responsible for control of the distributor UT3 connected to the cylinder bearing the same reference, and simultaneously the diode D3 through which the signal passes energises the solenoid PA.

[0113] The downstream terminals the diodes D2, D3 are moreover all connected to the downstream terminal of the diode D1 in the circuit node EJ, which constitutes a derivation in the electrical series between the nodes B' and C'. In particular, thanks to the node EJ a parallel is formed between the connections in series of the switches K1, K2, K3 and the respective diodes D1, D2, D3.

[0114] By means of the circuit of Figure 5, the functions described below can hence be controlled.

[0115] The push-button switches PI, P2, P3 correspond to physical commands that can be governed by the operator/driver of the vehicle. Pressure applied on each of the push-buttons PI, P2, P3 brings about supply of the respective solenoid - PA, PB, PC - and switching of the corresponding distributor UT1, UT2, UT3 into the second operative position.

[0116] For instance, pressure applied on the push-button P1 energises the relay RL1 (supplying the electromagnet K1*) and closes the switch K1, supplying the diode D1 and the solenoid PA. This deviates the flow that is to reach the valve unit VU towards the section UTX1U and the user UT1 in accordance with the diagram of Figure 4.

[0117] It should be noted that pressing of the push-button P1 does not produce any effect on the solenoids PB, PC: the presence of the diodes D2, D3 prevents circulation of the current towards the other solenoids, and on the other hand the modalities of connection between the various components rule out the possibility of supplying the relays RL2, RL3 by simply pressing the push-button P1.

[0118] Instead, pressing of one of the push-buttons P2 or P3 causes at the same time supply of the corresponding solenoid PB, PC and supply of the solenoid PA. In fact, pressing of the push-button P2 causes excitation of the relay RL2, with closing of the switch K2. This supplies the solenoid PB directly, while the diode D2 enables passage of current towards the solenoid PA, since it is set electrically upstream of the solenoid itself (again, since it is a diode, the terms "upstream" and "downstream" are unequivocal).

[0119] Supply of the solenoid PA causes switching of the distributor UT1 into the second operative position, with deviation of flow towards the section UTX1U; however, pressing of the push-button P2 with the solenoid PB supplied likewise causes switching of the distributor

UT2 into the second operative position, with deviation of the flow towards the user UT2 and exclusion of the users UT1, UT3.

[0120] Finally, pressing of the push-button P3 causes excitation of the relay RL3, with closing of the switch K3. This supplies the solenoid PC directly, while the diode D3 enables passage of current towards the solenoid PA, since it is set electrically upstream of the solenoid itself (once again, since it is a diode, the terms "upstream" and "downstream" are unequivocal).

[0121] Supply of the solenoid PA causes the distributor UT1 to switch into the second operative position, with deviation of flow towards the section UTX1U. However, pressing of the push-button P3 with supply of the solenoid PC also causes the distributor UT3 to switch into the second operative position, with deviation of the flow towards the user UT3 and exclusion of the users UT1, UT2.

[0122] Finally, it should be noted that the ensembles of push-button switch and corresponding relay can be replaced by a single switch (which in this case must be able to operate at high amperage; in the embodiment illustrated here, the push-button switches PI, P2, P3 are shielded by interposition of the corresponding relays) set upstream of the corresponding diode. With reference to the diagram of Figure 5, all the reader has to do is to imagine that the branches B-C, D-E, F-G are eliminated and the switches K1, K2, K3 are replaced by switches that are controlled from outside, whereas in the circuit EC the switches K1, K2, K3 are controlled indirectly by means of the push-buttons PI, P2, P3 and corresponding electromagnets K1*, K2*, K3*.

[0123] The person skilled in the branch will hence appreciate how, thanks to the electrical circuit EC of Figure 5 and the hydraulic system of Figure 4, it is possible to carry out two simultaneous manoeuvres, i.e., use of UT1 or UT2 or UT3 simultaneously with the actuator A2, since the latter remains completely independent, being controlled just by the distributor D2 during normal operation.

[0124] The prearrangement of a flow-deviation unit obtained as in Figure 4 enables reduction of the number of fast-connection pipes for coupling and uncoupling the machine and the tools that are to be mounted on the arm controlled by the actuator A1.

[0125] This guarantees a considerable economic saving in terms of pipes and couplings and a simplification of the circuit.

[0126] With this solution it is possible to equip the system with just one additional solenoid valve (UT1) and the corresponding electrical wiring. The section UTX1U can be supplied subsequently as optional equipment, without having to modify the original system in any way.

[0127] Finally, with reference to Figure 6, this represents a further embodiment of the hydraulic system according to the invention. This embodiment is once again based upon the unit VU of Figure 2 and is conceptually configured as a variant of the system of Figure 4. The reference numbers identical to the ones adopted previously designate the same components that have already been described.

[0128] At the circuit level, the solution of Figure 6 differs from the solution of Figure 4 only in that the section UTX1D of the flow-deviation unit UTX1 is installed between the distributor D2 and the ports 3, 4.

[0129] The section UTX1D is here connected in a position upstream of the valve unit VU and in particular in a position hydraulically in series between the distributor D2 and the ports 3 and 4 (hence in series to the power lines PL3 and PL4). The section UTX1D includes the distributor UT1, which, as has already been described previously, is built as a distributor with six ports (two upstream and four downstream, where the terms "upstream" and "downstream" here refer to a concordant direction of flow through the lines 3 and 4 that originate from the distributor D2) and two positions. The upstream ports of the distributor UT1 are connected to the downstream port of the distributor D2, whereas the downstream ports of the distributor UT1 are connected, or can be connected, in pairs to the ports 3 and 4 of the valve unit VU (and to the power lines PL3, PL4, respectively) and to the power lines U1A, U1B leading to the chambers of the actuator UT1 that governs a hydraulic tool/ user of a vehicle on which the unit VU is installed.

[0130] The power lines U1A, U1B moreover lead to the section UTX1U, which is built in exactly the same way as what is illustrated in Figure 4.

[0131] The solenoids PA, PB, PC of the unit UTX1 of Figure 6 are governed by means of the electrical circuit EC of Figure 5. In this connection, while preserving the logic of driving of the users UT1, UT2, UT3, the different location of the distributor UT1 makes it possible to carry out two simultaneous manoeuvres, i.e., use of UT1 or UT2 or UT3 simultaneously with the actuator A1 (instead of the actuator A2, as was the case, instead, for the embodiment of Figure 4). For the rest the same benefits described above apply.

Claims

1. A valve unit (VU) comprising:

- a first working port (1) and a second working port (2), which are configured for connection to a first hydraulic distributor (D1);
- a third working port (3) and a fourth working port (4), which are configured for connection to a second hydraulic distributor (D2);
- a fifth working port (5) and a sixth working port (6), which are configured for connection to a respective fluid chamber of a first hydraulic actuator (A1) that can be driven by means of the first hydraulic distributor (D1); and
- a seventh working port (7) and an eighth working port (8), which are configured for connection to a respective chamber of a second hydraulic actuator (A2) that can be driven by means of the

second hydraulic distributor (D2);

wherein:

- a first power line (PL1) connects said first working port (1) to said fifth working port (5);
- a second power line (PL2) connects said second working port (2) to said sixth working port (6);
- a third power line (PL3) connects said third working port (3) to said seventh working port (7); and
- a fourth power line (PL4) connects said fourth working port (4) to said eighth working port (8),

wherein the valve unit (VU) moreover includes:

- a first flow regulating valve (RQ1) including an inlet port, which is connected to said first power line (PL1) at a first circuit node (J1) and is in fluid communication with said fifth working port (5), and a first outlet port (RQ1A), connected to said fourth power line (PL4) at a second circuit node (J2); and
- a second flow regulating valve (RQ2) including an inlet port, which is connected to said second power line (PL2) at a third circuit node (J3) and is in fluid communication with said sixth working port (6), and a first outlet port (RQ2A), connected to said third power line (PL3) at a fourth circuit node (J4).

2. The valve unit (VU) according to Claim 1, further including:

- a first cut-off valve (CV1), set between the first outlet port (RQ1A) of the first flow regulating valve (RQ1) and the second circuit node (J2); and
- a second cut-off valve (CV2), set between the first outlet port (RQ2A) of the second flow regulating valve (RQ2) and said fourth circuit node (J4),

wherein:

- the first cut-off valve (CV1) can be driven as a function of a pressure signal (SCV1) in the first power line (PL1) so as to be switched into a closed position when, during operation, pressurized working fluid is supplied from the first working port (1) to the fifth working port (5) through said first power line (PL1); and
- the second cut-off valve (CV2) can be driven as a function of a pressure signal (SCV2) in the second power line (PL2) so as to be switched into a closed position when, during operation, pressurized working fluid is supplied from the second working port (2) to the sixth working port (6) through said second power line (PL2).

3. The valve unit (VU) according to Claim 1 or Claim 2, wherein:

- the first flow regulating valve (RQ1) is configured, during operation, for deviating, through the first outlet port (RQ1A) and towards said eighth working port (8), at least part of the flow of working fluid entering the respective inlet port and coming from the fifth working port (5).

4. The valve unit (VU) according to Claim 3, wherein the second flow regulating valve (RQ2) is configured, during operation, for deviating, through the first outlet port (RQ2A) and towards said seventh working port (7), at least part of the flow of working fluid entering the respective inlet port and coming from the sixth working port (6).

5. The valve unit (VU) according to any one of Claims 1 to 4, wherein each of said first and second flow regulating valves (RQ1, RQ2) is a flow divider further including a second outlet port (RQ1B, RQ2B) connected, respectively, to said first power line (PL1) and to said second power line (PL2).

6. The valve unit (VU) according to Claim 5, wherein a first check valve (NR1) is set between said first circuit node (J1) and a connection (R1) of said second outlet port (RQ1B) of the first flow regulating valve (RQ1) to said first power line (PL1), said first check valve (NR1) being configured for enabling a flow of working fluid only towards said first circuit node (J1), and wherein a second check valve (NR2) is set between said first circuit node (J1) and said fifth working port (5) and is connected in parallel with a first overcentre valve (OVC1).

7. The valve unit (VU) according to Claim 6, wherein a third check valve (NR3) is set between said first cut-off valve (CV1) and said second circuit node (J2), said third check valve (NR3) being configured for enabling a flow of working fluid only towards said second circuit node (J2).

8. The valve unit (VU) according to Claim 5 or Claim 7, wherein a fourth check valve (NR4) is set between a connection (R2) of said second outlet port (RQ2B) of the second flow regulating valve (RQ2) to said second power line (PL2) and said third circuit node (J3), said fourth check valve (NR4) being configured for enabling a flow of working fluid only towards said third circuit node (J3), wherein a fifth check valve (NR5) is moreover set between said second cut-off valve (CV2) and said fourth circuit node (J4) and is configured for enabling a flow of working fluid only towards said fourth circuit node (J4).

9. The valve unit (VU) according to any one of the preceding claims, wherein:

- set on said third power line (PL3), in derivation with respect to a fifth circuit node (J5), is a second overcentre valve (OVC2) in fluid communication with a ninth working port (9) configured for discharge connection; and
- set on said fourth power line (PL4), in derivation with respect to a sixth circuit node (J6), is a third overcentre valve (OVC3) configured for connection with a tenth working port (10) configured for discharge connection,

wherein moreover:

- a sixth check valve (NR6) is set between said fourth circuit node (J4) and said fifth circuit node (J5) and is configured for enabling a flow of working fluid only towards said fifth circuit node (J5); and
- a seventh check valve (NR7) is set between said second circuit node (J2) and said sixth circuit node (J6) and is configured for enabling a flow of working fluid only towards said sixth circuit node (J6).

10. A hydraulic system for control of an articulated arm equipped with a tool, the system including:

- a valve unit (VU) according to any one of Claims 1 to 9;
- a first hydraulic actuator (A1) configured for moving the articulated arm;
- a second hydraulic actuator (A2) configured for moving the tool with respect to the articulated arm;
- a first hydraulic distributor (D1) for control of said first actuator (A1); and
- a second hydraulic distributor (D2) for control of said second actuator (A2),

wherein:

- said first hydraulic distributor (D1) is connected to said first and second working ports (1, 2);
- said second hydraulic distributor (D2) is connected to said third and fourth working ports (3, 4);
- said first hydraulic actuator (A1) includes a first chamber connected to said fifth working port (5) and a second chamber connected to said sixth working port (6); and
- said second hydraulic actuator (A2) includes a first chamber connected to said seventh working port (7) and a second chamber connected to said eighth working port (8).

11. The hydraulic system according to Claim 10, including a flow-deviation unit (UTX, UTX1) configured for deviating a flow of fluid that is to reach said valve unit (VU) towards a plurality of fluid-using devices (UT1, UT2, UT3).

12. The hydraulic system according to Claim 11, wherein said flow-deviation unit (UTX1) includes a first distributor (UT1) connected in series between said first hydraulic distributor (D1) and the pair of first and second working ports (1, 2) of said valve unit (VU).

13. The hydraulic system according to Claim 11, wherein said flow-deviation unit (UTX1) includes a first distributor (UT1) connected in series between said second hydraulic distributor (D2) and the pair of third and fourth working ports (3, 4) of said valve unit (VU).

14. The hydraulic system according to Claim 12 or Claim 13, wherein the flow-deviation unit (UTX1) includes a second distributor (UT2) and a third distributor (UT3), which are connected in series to said first distributor (UT1) of the flow-deviation unit, wherein each distributor (UT1, UT2, UT3) of the flow-deviation unit (UTX1) includes:

- two upstream ports and four downstream port;
- a first operative position where the two upstream ports are in fluid communication with a first pair of downstream port for providing a bypass of the distributor (UT1, UT2, UT3); and
- a second operative position where the two upstream ports are in fluid communication with a second pair of downstream port for providing a deviation of flow towards a corresponding fluid-using device (UT1, UT2, UT3) connected to said distributor (UT1, UT2, UT3).

15. The hydraulic system according to Claim 14, including an electrical circuit (EC) configured for governing the distributors of said flow-deviation unit, wherein:

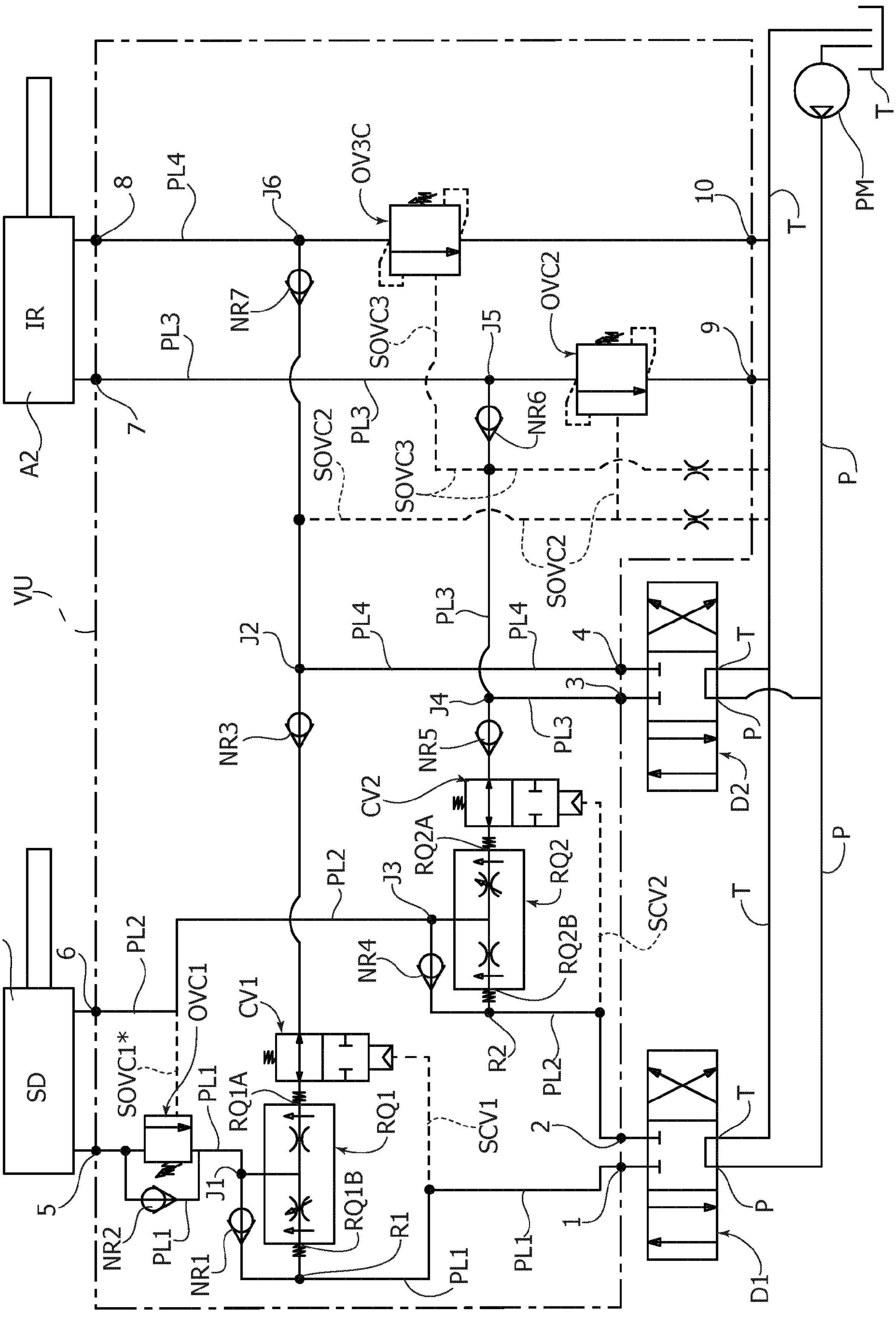
- the first distributor (UT1) of the flow-deviation unit (UTX1) is set upstream of the hydraulic series including the further second and third distributors (UT2, UT3) of the flow-deviation unit (UTX1, UTX1U);
- a first solenoid (PA) of said first distributor (UT1) of the flow-deviation unit (UTX1) can be supplied by means of a switch (PI, RL1) electrically connected in series upstream of a first diode (D1), said first diode being in turn connected in series upstream of said first solenoid (PA);
- a second solenoid (PB) of said second distributor (UT2) of the flow-deviation unit (UTX1) is connected in series to a second switch (P2,

RL2), and a second diode (D2) is connected in derivation between said second switch (P2, RL2) and said second solenoid (PB); and

- a third solenoid (PC) of said third distributor (UT3) of the flow-deviation unit (UTX1) is connected in series to a third switch (P3, RL3), and a third diode (D3) is connected in derivation between said third switch (P3, RL3) and said third solenoid (PC),

wherein moreover an electrical derivation (EJ) set between said first solenoid (PA) and said first diode (D1) is connected to said second diode (D2) and said third diode (D3), and
in such a way that, during operation, closing of the first switch supplies only said first solenoid (PA), whereas closing of either said second switch (P2) or said third switch (P3) supplies the corresponding second solenoid (PB) or third solenoid (PC) and said first solenoid (PA).

FIG. 1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PL4
J1
J2
J3
J4
J5
J6
NR1
NR2
NR3
NR4
NR5
NR6
NR7
OVC1
SOVC1*
OVC2
SOVC2
OV3C
SOVC3
CV1
CV2
SCV1
SCV2
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RQ2
RQ2A
RQ2B
R1
R2
D1
D2
P
T
PM

FIG. 1A

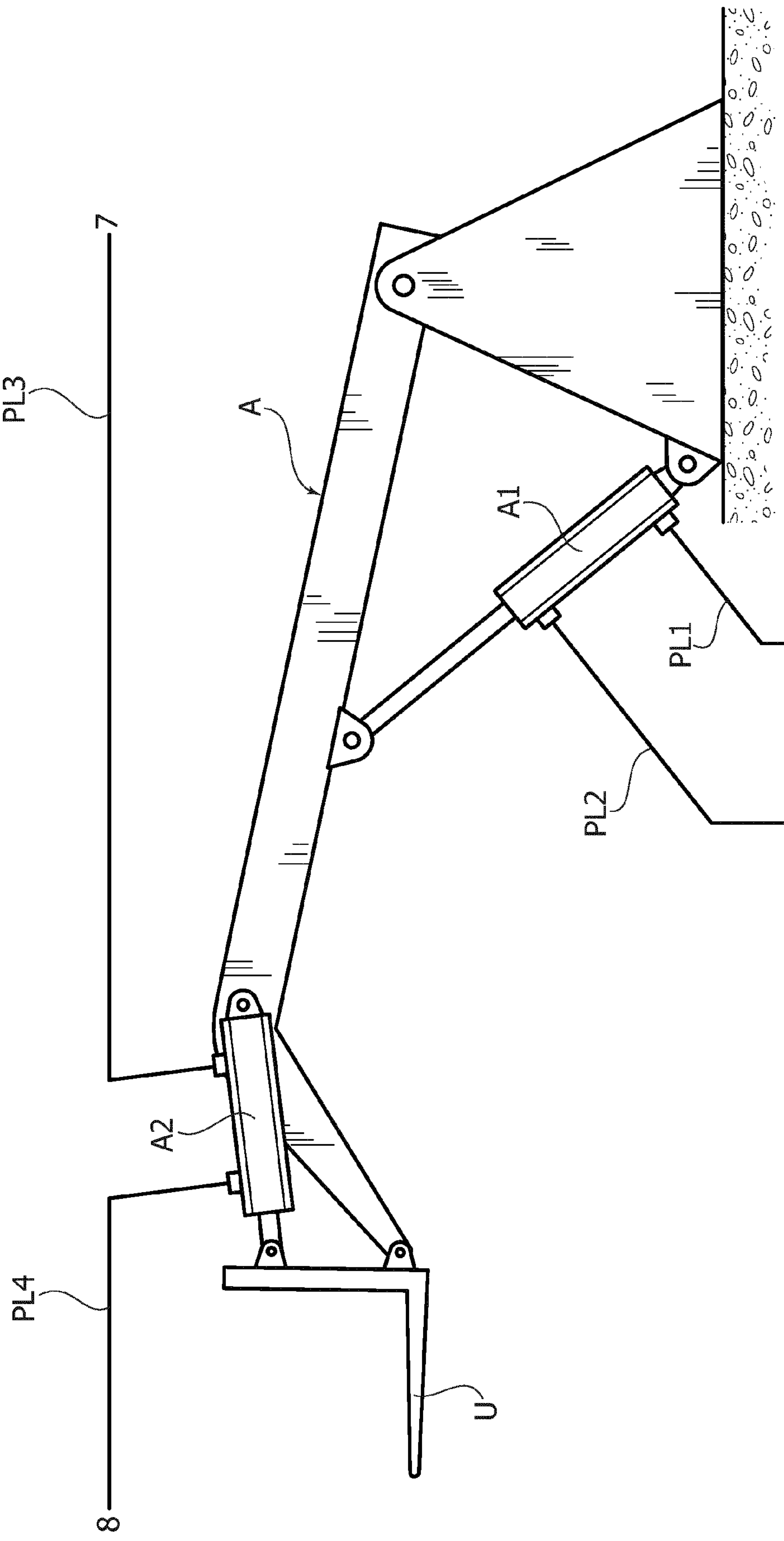
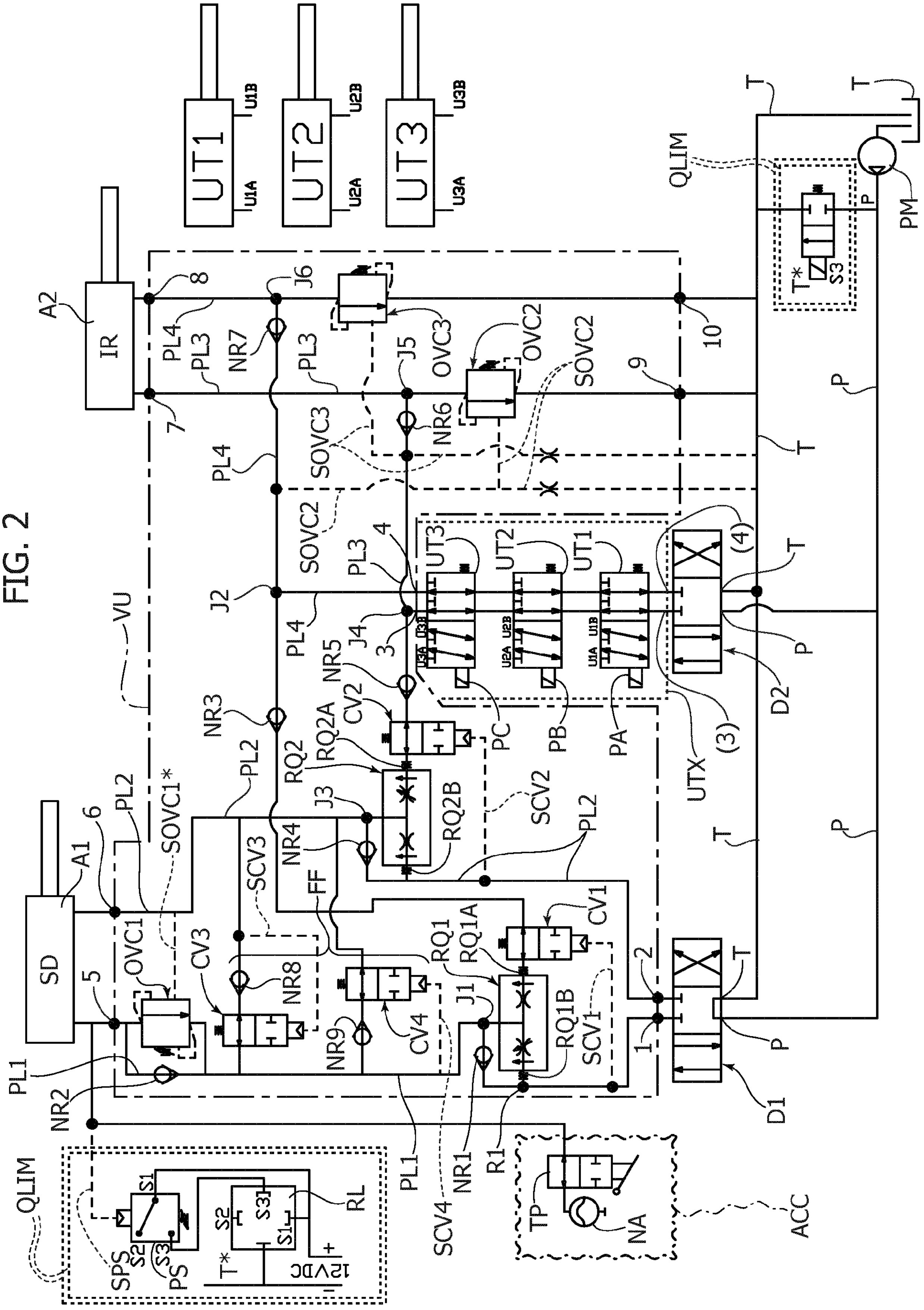


FIG. 2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PA
PB
PC
UTX
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ACC
PM
T
P

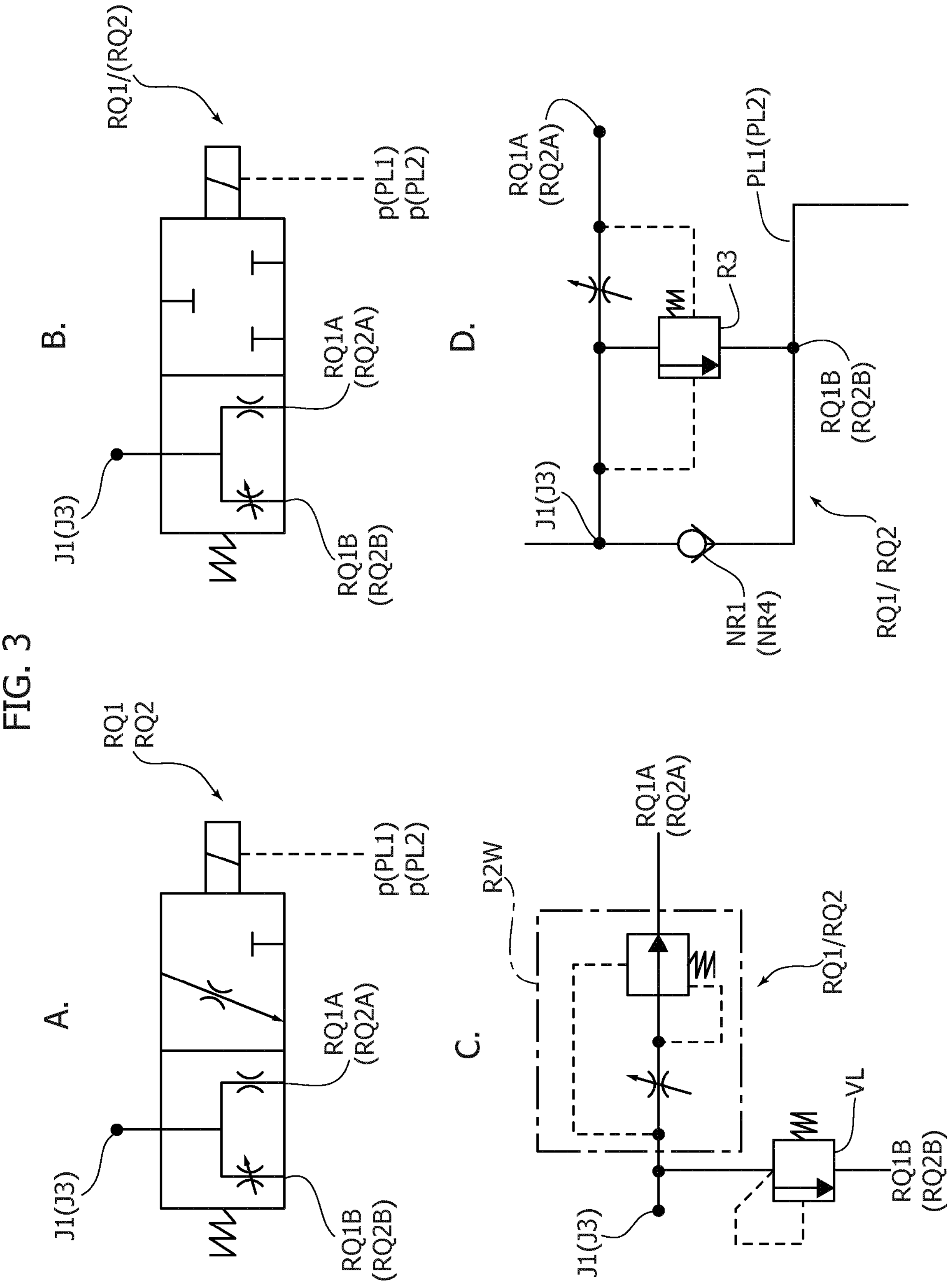
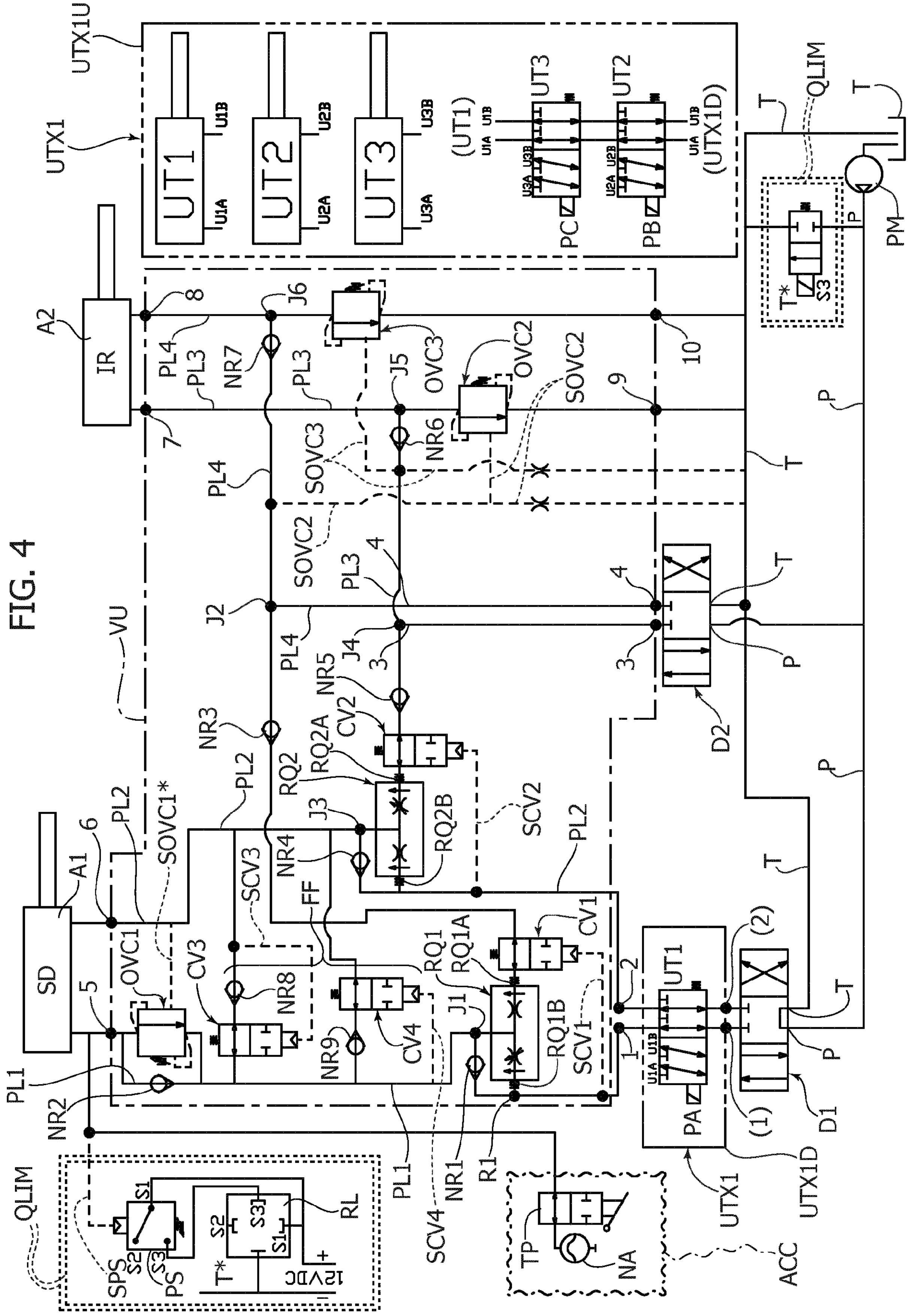

A.
B.
C.
D.
RQ1
RQ2
RQ1/(RQ2)
p(PL1)
p(PL2)
J1(J3)
RQ1A
(RQ2A)
RQ1B
(RQ2B)
R2W
RQ1/RQ2
VL
R3
PL1(PL2)
NR1
(NR4)
RQ1/ RQ2

FIG. 3

FIG. 4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(UTX1D)
PC
PB
A2
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8
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9
10
J6
J5
J4
J3
J2
J1
NR1
NR2
NR3
NR4
NR5
NR6
NR7
NR8
NR9
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OVC2
OVC3
SOVC1*
SOVC2
SOVC3
PL1
PL2
PL3
PL4
VU
QLIM
T*
S1
S2
S3
T
P
PM
D1
D2
SD
A1
5
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CV1
CV2
CV3
CV4
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SCV3
SCV4
RQ1
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RQ1B
RQ2
RQ2A
RQ2B
FF
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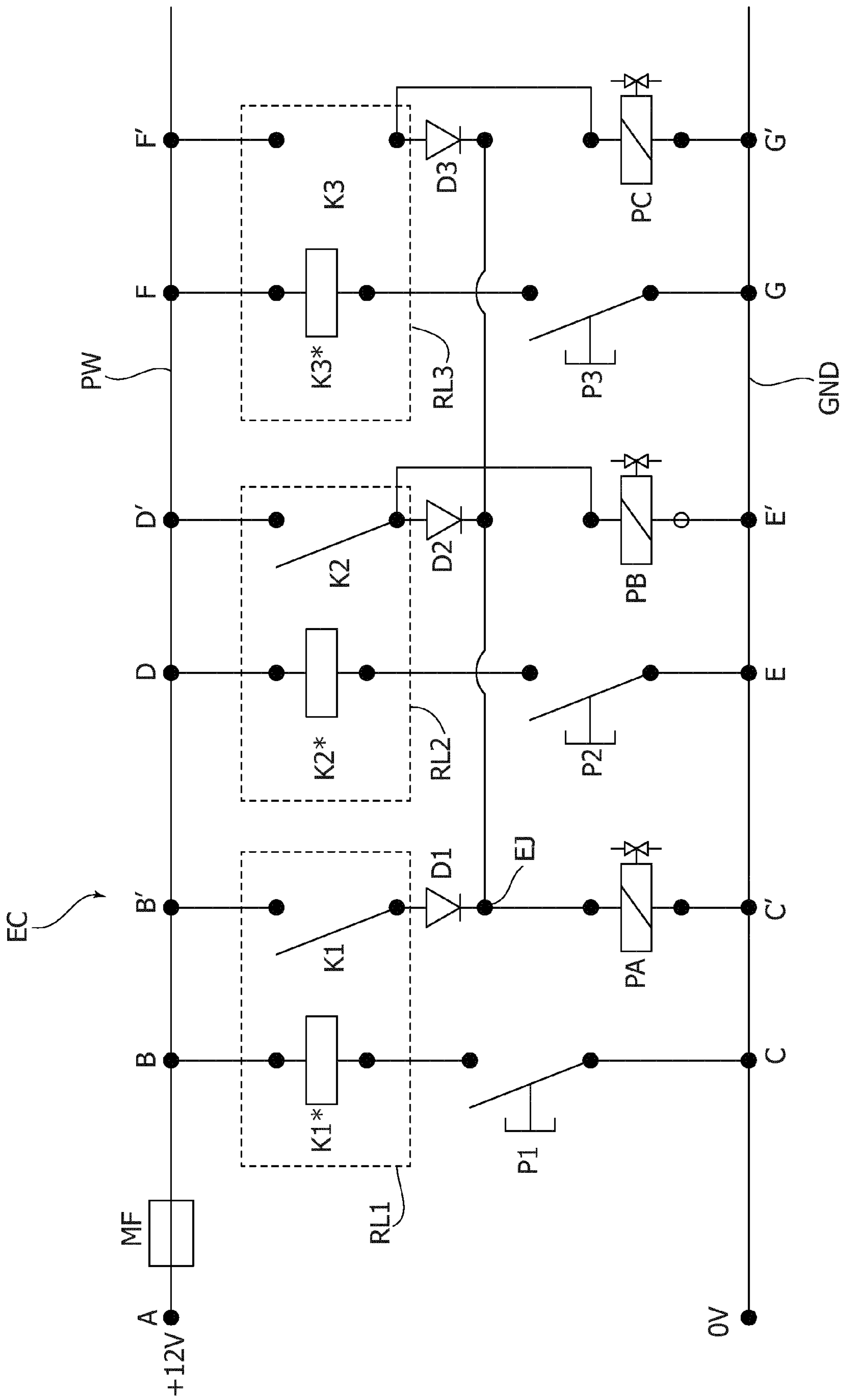
FIG. 5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D2
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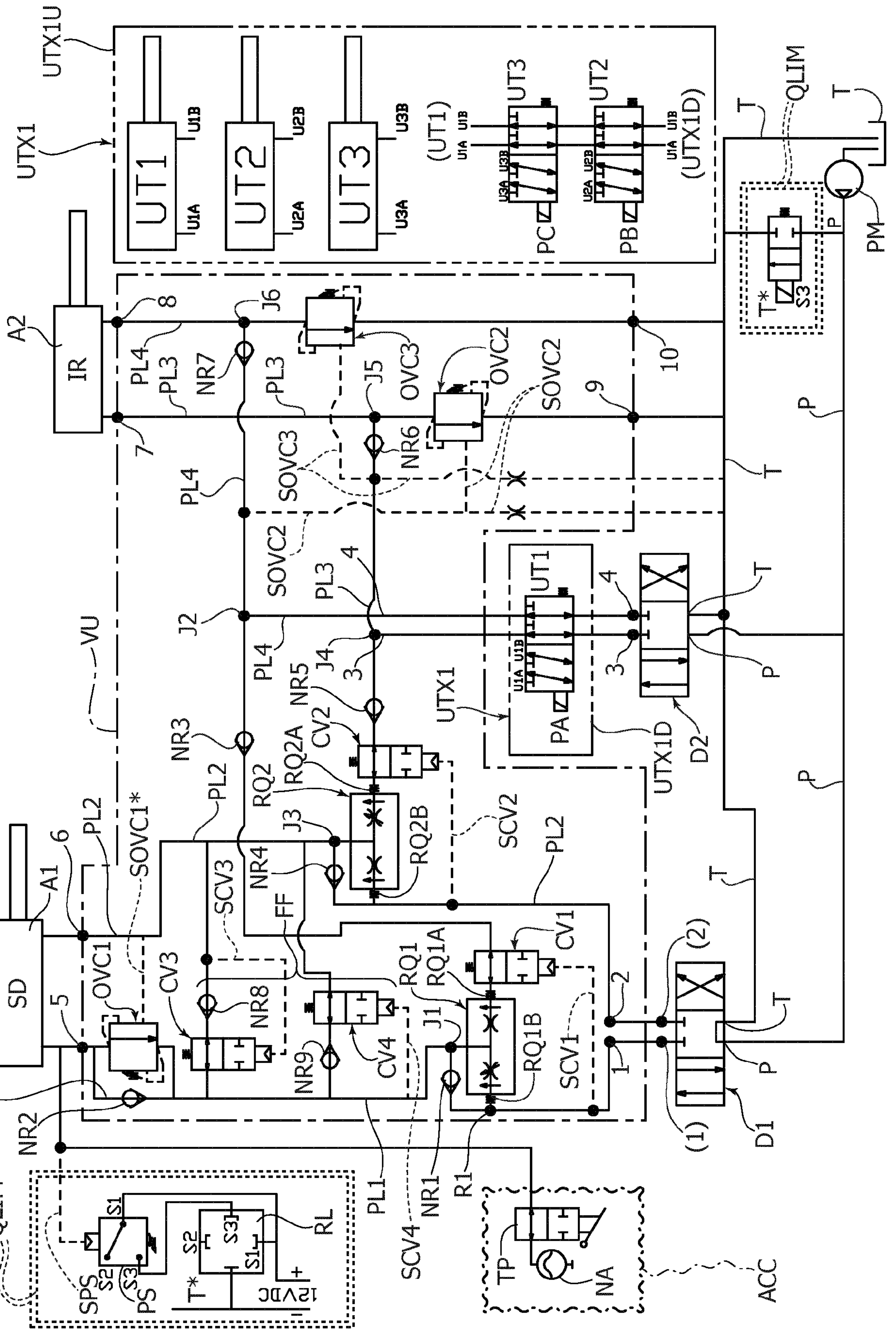
FIG. 6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PC
PB
A2
IR
8
7
J6
PL4
PL3
NR7
OVC3
OVC2
SOVC2
SOVC3
J5
NR6
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10
T
QLIM
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S3
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PM
VU
J2
J4
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3
NR5
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TP
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EUROPEAN SEARCH REPORT

Application Number
EP 17 20 5561

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			E02F B66F F15B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	22 May 2018	Ferrien, Yann

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22-05-2018

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