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(54) **HYDRAULIC CONTROL SYSTEM**

(57) The present invention relates to a hydraulic control system (100) of an actuation system to drive a working machine (98), wherein the said control system (100) comprises a first conduit and a second conduit (20, 30), wherein the said first conduit (20) comprises a first branch (21) and a second branch (22), wherein the said second conduit (30) comprises a first branch (31) and a second branch (32), wherein on the said first branch (21) of the said first conduit (20) there is a first check system (23) positioned, which is configured so as to prevent flow towards a first chamber (121) of a third cylinder (12) and to allow flow in the opposite direction, wherein on the said first branch (31) of the said second conduit (30) there is a second check system (33) positioned, which is configured so as to prevent flow towards a second chamber (122) of the said third cylinder (12) and to allow flow in

the opposite direction, wherein said hydraulic control system having a first valve (24) positioned parallel to the said first check system (23) and configured in such a way as to allow a flow of fluid from the said first conduit (20) to the said first chamber (121) of the said third cylinder (12) to be cut off completely, so that the said first chamber (121) of the said third cylinder (12) is hydraulically isolated from the said first conduit and **by the fact that** a second valve (34) is positioned parallel to the said second check system (33) and configured in such a way as to allow a flow of fluid from the said second conduit (30) to the said second chamber (122) of the said third cylinder (12) to be cut off completely, so that the said second chamber (122) of the said third cylinder (12) is hydraulically isolated from the said second conduit (30).

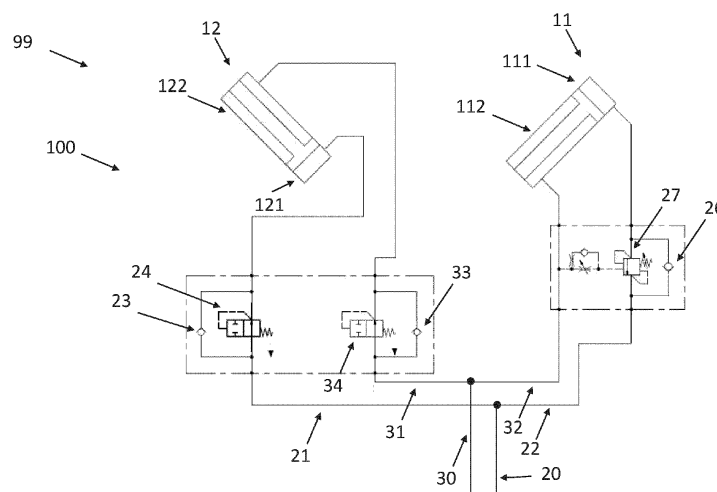


Fig. 3

Description

TECHNICAL FIELD

[0001] The present invention relates to a hydraulic control system for an actuation system to drive a working machine.

BACKGROUND

[0002] More commonly referred to as 'heavy machinery', working machines, such as telehandlers for example, are machines used in various industries to perform various lifting, handling, and loading operations.

[0003] A telehandler, also known as a telescopic manipulator or telescopic lift, is a working machine used in various industries such as construction, agriculture, and industry. A telehandler has a similar structure to a telescopic loader, but with some specific features. A telehandler has a stable chassis mounted on sturdy tires or tracks for mobility on various terrains. The main feature of a telehandler is the telescopic arm mounted on the front of the chassis. This arm can be telescopically extended and retracted to reach considerable heights and carry heavy loads. A fork or a lifting attachment is mounted at the end of the arm that serves to lift and transport materials such as pallets, concrete blocks, or loose loads. Some models may be equipped with additional accessories such as work platforms, lifting hooks, or winches, to render them suitable for a wide range of tasks.

[0004] An example of a telehandler is shown in Figure 1. As can be seen, the telehandler comprises a main body 3, which can be set in motion by means of a pair of front wheels 2 and rear wheels 1. A cabin 5 is positioned on the main body 3 which a user of the machine can enter and can control the said machine from therewithin. As shown in the figure, this machine comprises an actuation system for driving the telescopic mechanical arm 4. As can be seen in the figure, the mechanical arm 4 comprises a first and a second end portion. The first end portion is mechanically connected to the main body 3 while the second end portion is mechanically connected to a work element 6, which is not shown fully in the figure because this element may consist of any kind of element such as, as mentioned, a fork or a lifting attachment. In general, therefore, a work element means any element capable of moving a load. Movement of the arm is achieved by means of a first hydraulic cylinder 10, while movement of the work element 6 is achieved by means of a second hydraulic cylinder 11. There is also a third hydraulic cylinder 12, which is commonly known as a drive or compensation cylinder, which guarantees compensation of the position of the work element 6 due to movement of the mechanical arm 4, thereby preventing the load from falling.

[0005] The operation of the three hydraulic cylinders shown in Figure 1 will now be described in more detail, with reference to Figure 2. However, since the first hy-

draulic cylinder 10 can operate completely independently of the others, the description thereof will be omitted.

[0006] The hydraulic control system 100 shown in the figure is an integral part of an actuation system used to drive a working machine 98. The working machine 98 is composed of a main body 3, a mechanical arm 4, and a work element 6. The mechanical arm 4 has a first and a second end portion, where the first end portion is connected to the main body 3, while the second end portion is connected, directly or indirectly, to the work element 6. The term 'indirectly' means that there are mechanical elements included between the said mechanical arm 4 and the said work element. The term 'directly' means that these elements are connected together mechanically.

[0007] The actuation system shown in the figure includes the second hydraulic cylinder 11 which imparts movement to the work element 6. Furthermore, the actuation system comprises the third hydraulic cylinder 12 configured so as to impart movement to the said work element.

[0008] The control system 100 consists of two conduits: a first conduit and a second conduit 20, 30. The first conduit 20 has a first branch 21 connected to the first chamber 121 of the third cylinder 12, and a second branch 22 connected to the first chamber 111 of the second cylinder 11. The second conduit 30 has a first branch 31 connected to the second chamber 122 of the third cylinder 12, and a second branch 32 connected to the second chamber 112 of the second cylinder 11.

[0009] On the first branch 21 of the first conduit 20 there is a first check system 23 positioned, such as a one-way valve for example, which stops the flow towards the first chamber 121 of the third cylinder 12 and allows the flow in the opposite direction. On the first branch 31 of the second conduit 30 there is a second check system 33 positioned, such as a one-way valve for example, which stops the flow towards the second chamber 122 of the third cylinder 12 and allows the flow in the opposite direction.

[0010] In parallel to the said first check system 23, there is a first throttle 25 positioned, while a second throttle 35 is positioned in parallel to the said second check system. Both throttles are configured in such a way as to prevent cavitation inside the first and second chamber of the third hydraulic cylinder 12 respectively, thereby allowing the fluid contained inside the first and second conduit to enter the respective chambers in the event of movement of the third hydraulic cylinder 12 piston caused by the actuation generated by the first hydraulic cylinder 10 (not shown in the figure).

[0011] The operation of the two cylinders 11 and 12 will now be described.

[0012] In the event that only one movement of the second cylinder 11 is required, for example to tilt the work element 6, such as the forks, for example, the presence of the two check systems 23, 33 ensures the two chambers of the third hydraulic cylinder 12 are kept hydraulically separate, so as to allow actuation of the second

hydraulic cylinder 11 without affecting the positioning of the telescopic mechanical arm 4, whose movement could be caused by movement of the third cylinder 12 piston. Actuation of the third cylinder will therefore be achieved by means of the pressure present in the first and second conduit and the balancing valve 27, which causes a drain to open in the first chamber 111 into the tank.

[0013] In the event that there is an upward movement of the telescopic mechanical arm 4, and therefore an expansion of the first hydraulic cylinder 10 shown in Figure 1, the upward movement of the third hydraulic cylinder 12 will occur at the same time, which will therefore be driven, consequently increasing the volume of the first chamber 121 and reducing that of the second chamber 122. Indeed, what will happen is that the fluid contained inside the first branch 21 will flow through the throttle 25 and fill the first chamber 121. Due to the increase in volume of the first chamber 121, fluid will be released from the second chamber 122 and will flow through the check system 33 and reach the second chamber 112. Furthermore, the increase in pressure inside the conduit 32 caused by the release of fluid from the second chamber 122 will cause the opening of the balancing valve 27. Therefore, the opening of the balancing valve 27 will cause the second hydraulic cylinder 11 to be repositioned, thereby adjusting the inclination of the work element 6. In this way, an essentially constant inclination of the work element 6 can be maintained, even following movement of the telescopic mechanical arm 4.

[0014] Compensation will be achieved in an identical way if the telescopic mechanical arm 4 is lowered. Indeed, in that event, there will be an increase in the volume of the second chamber 122 (causing a fluid recall from the first branch 31 through the throttle 35) with the consequent release of fluid from the first chamber 121 through the first check system 23 towards the first chamber 11 and through the third check system 26, so as to compensate, at the work element 6, the variation in inclination that would occur due to the variation in the inclination of the telescopic mechanical arm 4.

[0015] However, a basic problem arises from the solution presented in the figure and described previously, which constitutes, as stated, the state of the art. Since the intention is to effectively prevent cavitation in the first and second chamber 121 and 122 of the third cylinder, in the event of larger hydraulic cylinders, the throttle 25 and 35 set screws must be enlarged considerably, so as to allow the desired amount of fluid to reach the respective chambers in the event of movement of the first hydraulic cylinder 10. However, an increase in the throttle 25 and 35 set screws also leads to an increase in the pressure in the two chambers 121 and 122 of the third hydraulic cylinder 12. The situation described becomes even more difficult if you wish to keep the second hydraulic cylinder 11 in a predetermined position, such as the end-of-stroke position for example, at which the first chamber 111 has a maximum volume and the second chamber 112 consequently has a minimum volume. In-

deed, to keep the second hydraulic cylinder 11 in an end-of-stroke position, the pressure in the first chamber 111 must be particularly high. This pressure will be achieved through the throttle 25 inside the first chamber 121, which will therefore influence, albeit slightly, the position of the telescopic mechanical arm 4. Therefore, movement of the telescopic mechanical arm 4 will work counter to the pressure present in the third hydraulic cylinder 12. Furthermore, in the event that, at a certain point one wishes to change the position of the second hydraulic cylinder 11 by actively moving the work element 6, for example if an end-of-stroke position is no longer required, the telescopic mechanical arm will jerk. This behaviour is unwanted as it involves unpredictable movement. Indeed, since an end-of-stroke position is no longer required, the conduit 20 will start draining and will therefore no longer be pressurised and the high pressure in the first chamber 121 will drop suddenly due to the release of the fluid through the first check system 23, thereby causing sudden changes in the position of the said arm.

[0016] Therefore, in light of the above, the present invention addresses the aforesaid problem by creating a method for adjusting the actuator cylinder that overcomes the drawbacks of the commonly known solutions and therefore guarantees particularly sophisticated initial control.

BRIEF DESCRIPTION OF THE FIGURES

[0017] The present invention will be described with reference to the appended figures, in which the same reference numbers and/or signs denote the same and/or similar and/or corresponding parts in the system.

Figure 1 shows a simplified diagram of a telehandler according to the state of the art;

Figure 2 shows a hydraulic control system for an actuation system to drive a working machine according to the state of the art;

Figure 3 shows a hydraulic control system for an actuation system to drive a working machine according to an embodiment of the present invention;

Figure 4 shows a hydraulic control system for an actuation system to drive a working machine according to a further embodiment of the present invention.

DETAILED DESCRIPTION

[0018] The present invention is described below with reference to particular embodiments, as illustrated in the appended drawings. However, the present invention is not limited to the particular embodiments described in the following detailed description and shown in the figures, rather the embodiments described merely exemplify various aspects of the present invention, the scope

of which is defined by the claims. Further modifications and variations of the present invention will be clear to persons skilled in the art.

[0019] In order not to unnecessarily repeat the description of elements which are very similar to those described in the introduction of the present patent application, the said elements will not be described again in the present description. Therefore, it is clear that all the elements described in Figures 3 and 4 which have the same reference numbers as those shown in Figure 2 also have the same configuration and function. Therefore, in the present patent application, the description of the elements provided in the introduction is likewise part of the description of the present patent application.

[0020] As shown in Figure 3, the first and second throttle are replaced by two other elements. In particular, a first valve 24 is positioned parallel to the said first check system 23, configured so as to allow complete cut-off of a flow of fluid from the said first conduit 20 to the said first chamber 121 of the said third cylinder 12, so that the said first chamber 121 of the said third cylinder 12 is hydraulically isolated from the said first conduit. Furthermore, a second valve 34 is positioned parallel to the said second check system 33, configured so as to allow complete cut-off of a flow of fluid from the said second conduit 30 to the said second chamber 122 of the said third cylinder 12, so that the said second chamber 122 of the said third cylinder 12 is hydraulically isolated from the said second conduit 30.

[0021] The first valve 24 is configured so as to cut off the passage of fluid from the said first conduit 20 to the said first chamber 121 of the said third cylinder 12 when the pressure at the said first chamber 121 exceeds a predetermined value, wherein the said pressure is preferably measured directly along the first branch 21 of the said first conduit 20, between the said first valve 24 and the said first chamber 121.

[0022] The second valve 34 is configured so as to cut off the passage of fluid from the said second conduit 30 to the said second chamber 122 of the said third cylinder 12 when the pressure at the said second chamber 122 exceeds a predetermined value, wherein the said pressure is preferably measured directly along the first branch 31 of the said second conduit 30, between the said second valve 34 and the said second chamber 122.

[0023] In the particular example shown in the figure, the first and second valve 24, 34, which - in the example shown in the figure - consist of two-position valves (preferably cartridge valves), comprise an elastic element, wherein the elasticity of the said elastic element is configured so as to determine the pressure in the said first or the said second chamber 121, 122 of the said third cylinder 12. In the example shown in Figure 3

[0024] The operating method for the hydraulic control system shown in Figure 3 will be presented in the following paragraphs.

[0025] As previously stated, with reference to Figure 1, in the event that only one movement of the second

cylinder 11 is required, for example to change the inclination of the work element 6, such as the forks, for example, the presence of the two check systems 23, 33 ensures the two chambers of the third hydraulic cylinder 12 are kept hydraulically separate, so as to allow actuation of the second hydraulic cylinder 11 without affecting the positioning of the telescopic mechanical arm 4, whose movement could be caused by movement of the third cylinder 12 piston.

[0026] In the event that there is an upward movement of the telescopic mechanical arm 4, and therefore an expansion of the first hydraulic cylinder 10 shown in Figure 1, the upward movement of the third hydraulic cylinder 12 will occur at the same time, which will therefore be driven, consequently increasing the volume of the first chamber 121 and reducing that of the first chamber. Similarly to the example described in the introduction of this patent application, it will therefore happen that the fluid contained within the first branch 21 will flow through the first valve 24, going on to fill the first chamber 121.

[0027] This is due to the fact that the pilot pressure of the first valve 24 caused by the pressure in the first chamber 121 will decrease and therefore the force of the spring will prevail, causing the first valve to open (essentially, the first valve 24 will be in the position shown in Figure 3).

[0028] Due to the increase in volume of the first chamber 121, fluid will be released from the second chamber 122 which will flow through the check system 33 and reach the second chamber 112. Furthermore, the increase in pressure inside the conduit 32 caused by the release of fluid from the second chamber 122 will cause the opening of the balancing valve 27. Therefore, the opening of the balancing valve 27 will cause the second hydraulic cylinder 11 to be reposition, thereby adjusting the inclination of the work element 6. In this way, an essentially constant inclination of the work element 6 can be maintained, even following movement of the telescopic mechanical arm 4.

[0029] However, as soon as an increase in pressure occurs in the first chamber 121 (for example due to a slowdown in the movement of the telescopic mechanical arm 4), the first valve 24 will close directly as there will be an increase in the pilot pressure. In this way, as described earlier, it will be the spring of the first valve 24 that determines the pressure that forms inside the first chamber. The system just described is particularly advantageous as it provides the possibility to prevent the formation of high pressures inside the first chamber 121 and at the same time preventing cavitation forming inside the said chamber. This is due to the fact that as soon as the pressure in the first chamber 121 drops, the valve will directly allow the passage of fluid (thereby preventing cavitation forming) and at the same time as soon as the pressure increases (and therefore there is no longer any risk of cavitation) the first valve 24 will directly cut off the passage of fluid, thereby preventing high pressures forming inside the first chamber.

[0030] Compensation will be achieved in an identical

way if the telescopic mechanical arm 4 is lowered. Indeed, in that event, there will be an increase in the volume of the second chamber 122, a fluid recall from the first branch 31 through the second valve 34 with the consequent release of fluid from the first chamber 121 through the first check system towards the first chamber 11 and through the third check system 26, so as to compensate, at the work element 6, the variation in inclination that would occur due to the variation in the inclination of the telescopic mechanical arm 4. The advantages are the same as described with reference to the first valve 24.

[0031] Figure 4 shows a hydraulic control system which is very similar to that shown in Figure 3. The only difference is that the first and second valve 24 and 34 respectively comprise a first and a second control conduit 241, 341 which allow valve opening to be controlled. This solution is technically simpler as it allows the oil to be kept on the spring side and therefore no special seals are required. Seals, however, are particularly important in the example shown in Figure 3. The first control conduit 241 exploits the pressure in the second chamber 122 of the third cylinder as its pilot pressure. The second control conduit 341, meanwhile, exploits the pressure in the first chamber 121 of the third cylinder 12 as its pilot pressure. Since operation is very similar to that shown in Figure 3 (the only difference is that, in addition to the force of the spring, there is also the pilot pressure in the opposite chamber), to prevent repetition, operation of the hydraulic control system will not be described again here.

[0032] In the present invention, 'hydraulic control system' 100 means all those hydraulic elements necessary for the hydraulic control of a hydraulic actuation system 99 comprising, for example, the hydraulic cylinders 10, 11, and 12. However, the present invention is not limited to the particular example described in the figures, wherein the hydraulic cylinders are the actuators of the hydraulic actuation system 99, but rather refers to any kind of hydraulic actuator. For this reason, the claims do not refer directly to the hydraulic cylinders but rather to the hydraulic control system 100 directly, which is precisely why this wording is entirely legitimate.

[0033] Although the present invention has been described with reference to the embodiments described above, it would be clear to a person skilled in the art that various modifications, variations and improvements can be made to the present invention based on the teaching described above and within the scope of the appended claims, without departing from the subject matter and falling outside the scope of protection of the invention.

[0034] For example, although in the present invention it has been described that this invention can be used on a telehandler, it is clear that this invention is not limited to use on this particular type of working machine but rather can be used on any kind of working machine comprising a main body, a mechanical arm, and a work element.

[0035] Lastly, aspects that are deemed known to any person skilled in the art have not been described, to avoid uselessly overshadowing the invention described.

[0036] Consequently, the invention is not limited to the embodiments described above but rather is only limited by the scope of protection of the appended claims.

Claims

1. Hydraulic control system (100) of an actuating system for actuating a working machine (98), said working machine (98) comprising a main body (3), a mechanical arm (4) and a work element (6), wherein said mechanical arm (4) comprises a first and a second end portion, wherein said mechanical arm (4) is connected at said first end portion to said main body (3) and wherein said second end portion is connected directly or indirectly to said work element (6), wherein said actuating system includes a first hydraulic cylinder (10) configured to allow a movement of said mechanical arm (4) relative to said main body (3) and a second hydraulic cylinder (11) configured to allow a movement of said working element (6), said actuating system further including a third hydraulic cylinder (12) configured to be entrained by the movement of said first hydraulic cylinder (10), wherein said control system (100) comprises a first conduit and a second conduit (20, 30), wherein said first conduit (20) includes a first branch (21) connected to a first chamber (121) of said third cylinder (12) and a second branch (22) connected to a first chamber (111) of said second cylinder (11), wherein said second conduit (30) includes a first branch (31) connected to a second chamber (122) of said third cylinder (12) and a second branch (32) connected to a second chamber (112) of said second cylinder (11), wherein on said first branch (21) of said first duct (20) is positioned a first check system (23) configured to prevent flow to said first chamber (121) of said third cylinder (12) and to allow flow in the opposite direction, wherein on said first branch (31) of said second duct (30) is positioned a second check system (33) configured to prevent flow to said second chamber (122) of said third cylinder (12) and to allow flow in the opposite direction; said hydraulic control system being **characterized in that** parallel to said first check system (23) is positioned a first valve (24) configured so as to allow to completely shut off a flow of fluid coming from said first duct (20) and directed to said first chamber (121) of said third cylinder (12), so that said first chamber (121) of said third cylinder (12) is hydraulically isolated from said first conduit, and **in that** parallel to said second check system (33) is positioned a second valve (34) configured to allow to completely shut off a flow of fluid coming from said second conduit (30) and directed to said second chamber (122) of said third cylinder (12), so that said second chamber (122) of said third cylinder (12) is hydraulically isolated from said second conduit (30).

2. Hydraulic control system (100) according to claim 1, wherein said first valve (24) is configured to close the passage of fluid from said first conduit (20) and directed to said first chamber (121) of said third cylinder (12) when a pressure at said first chamber (121) exceeds a predetermined value, wherein said pressure is preferably detected directly along the first branch (21) of said first conduit (20) between said first valve (24) and said first chamber (121). 5
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3. Hydraulic control system (100) according to any one of claims 1 or 2, wherein said second valve (34) is configured to close the passage of fluid from said second conduit (30) and directed to said second chamber (122) of said third cylinder (12) when a pressure at said second chamber (122) exceeds a predetermined value, wherein said pressure is preferably detected directly along the first branch (31) of said second conduit (30) between said second valve (34) and said second chamber (122). 15
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4. Hydraulic control system (100) according to any one of claims 1 to 3, wherein said first or said second valve (24, 34) comprises an elastic element, wherein the elasticity of said elastic element is configured to determine the pressure in said first or said second chamber (121, 122) of said third cylinder (12). 25
5. Hydraulic control system (100) according to any one of claims 1 to 4, wherein said first or said second valve (24, 34) is a two-position valve, preferably a two-position cartridge valve. 30
6. Actuating system (99) of a working machine, said system comprising a hydraulic control system (100) according to any one of claims 1 to 6, said actuating system further comprising said first, said second and said third hydraulic cylinders (10, 11, 12). 35
7. Working machine (98) comprising a main body (3), a mechanical arm (4) and a work element (6), wherein said mechanical arm (4) comprises a first and a second end portion, wherein said mechanical arm (4) is connected at said first end portion to said main body (3) and wherein said second end portion is connected directly or indirectly to said work element (6), wherein said working machine comprises an actuation system according to claim 6. 40
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8. Working machine according to claim 7, wherein said working machine is a telehandler. 50

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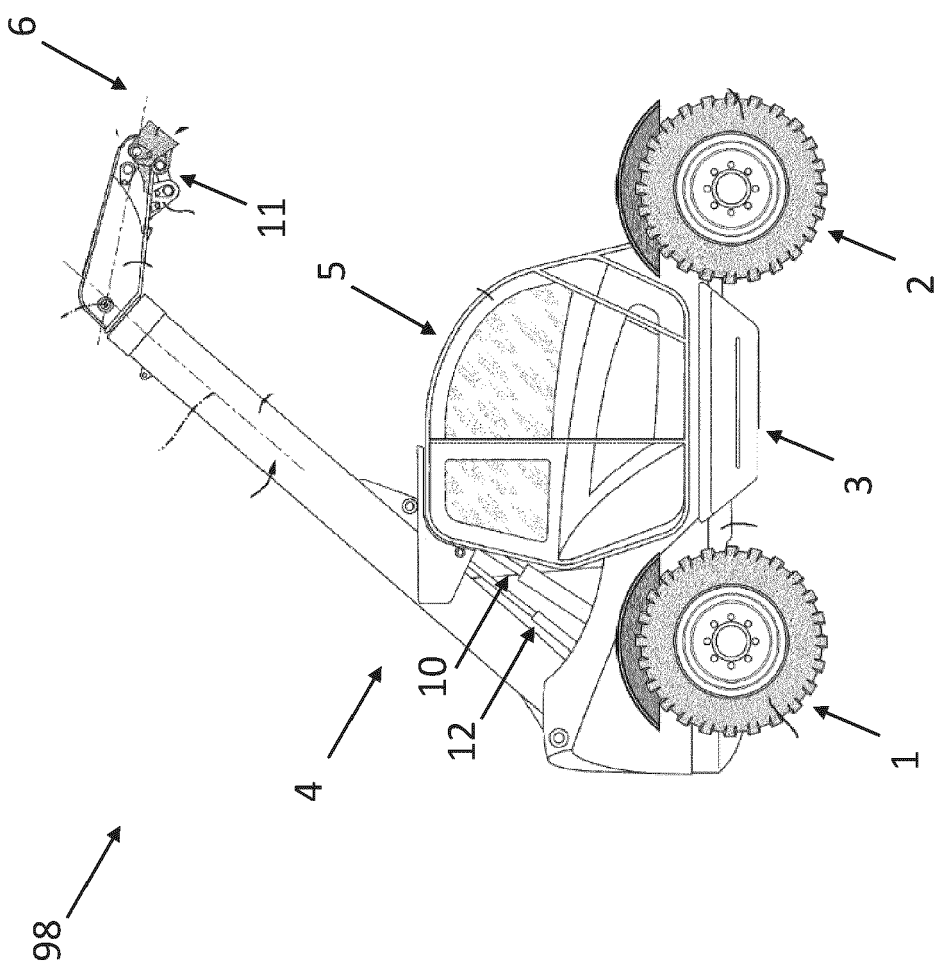


Fig. 1

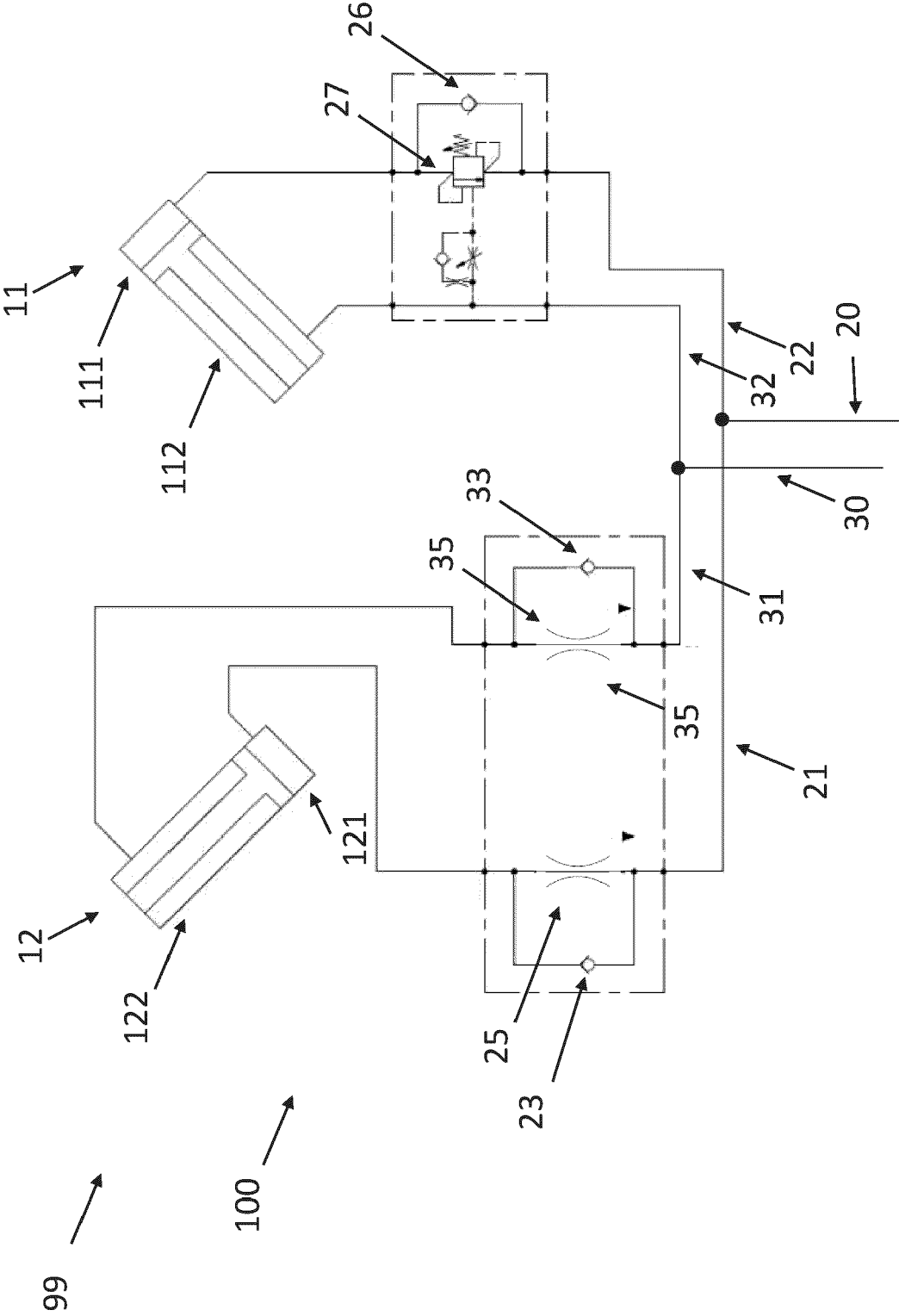


Fig. 2

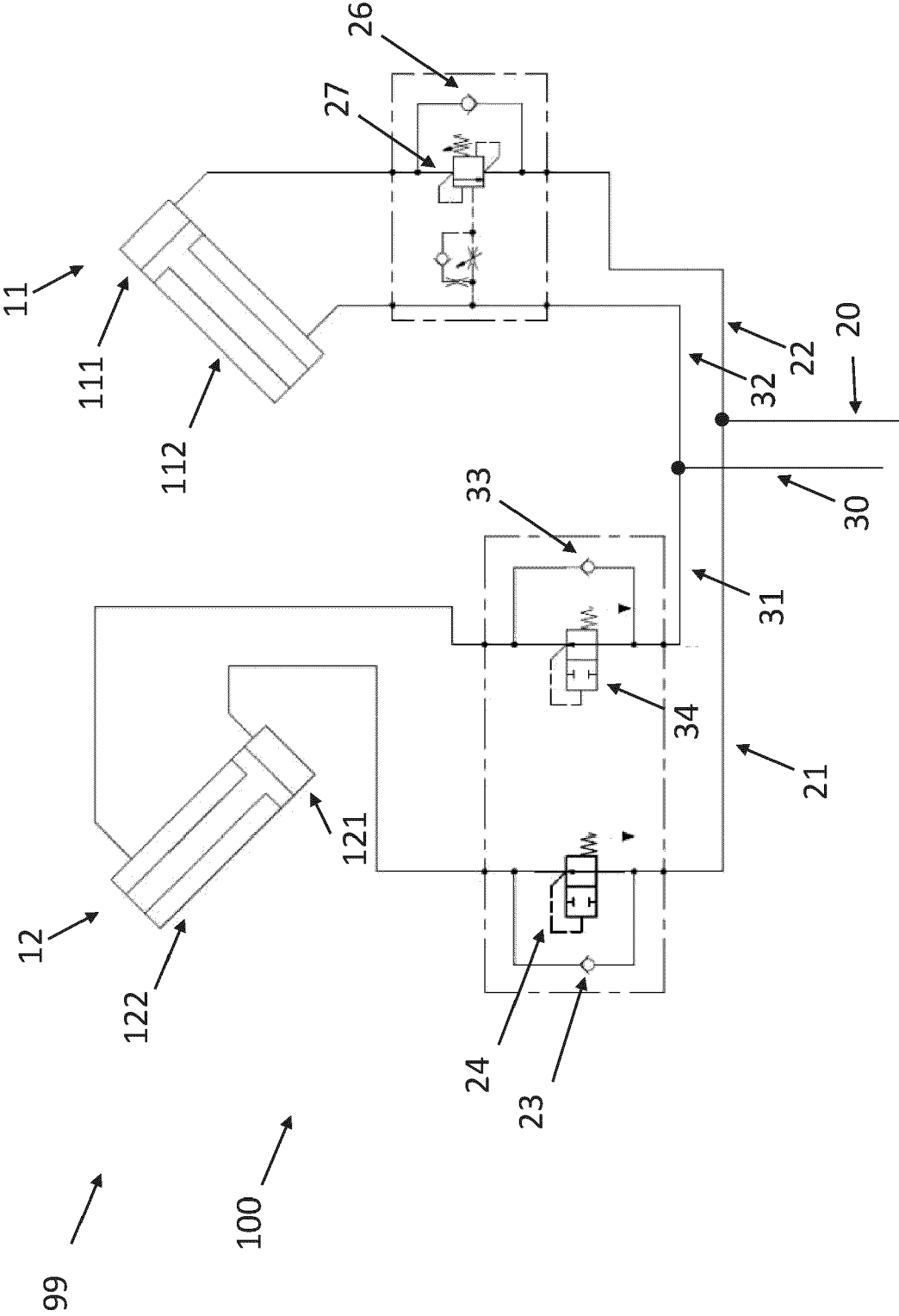


Fig. 3

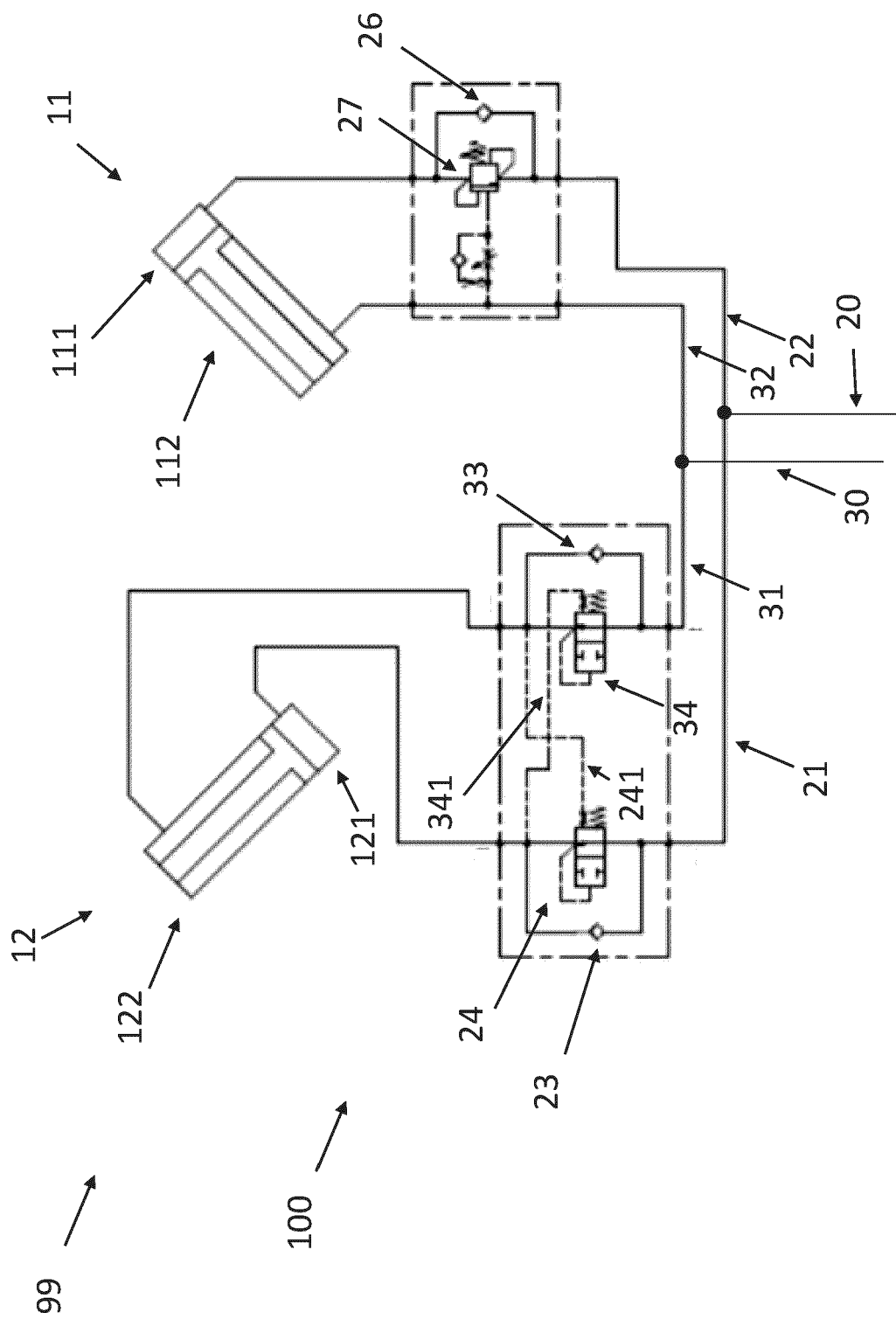


Fig. 4



EUROPEAN SEARCH REPORT

Application Number

EP 24 18 1314

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EPO FORM 1503 03.82 (P04C01)

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 11 339 041 B2 (CLARK EQUIPMENT CO [US]) 24 May 2022 (2022-05-24) * Summary section of Description * * Description of Figures 1 and 2 * * figures 1,2 * -----	1-8	INV. B66F9/22
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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 29 October 2024	Examiner Verheul, Omiros
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ON EUROPEAN PATENT APPLICATION NO.

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