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(54) **CONTROL SYSTEM FOR AN ACTUATOR CYLINDER OF A CRANE**

(57) The present invention regards a control system (1000) for an actuator cylinder (10) having a first and a second chamber (11, 12), a piston (13) separating said first chamber (11) from said second chamber (12), said system (1000) comprising: a first supply conduit (20) of said first chamber (11) of said cylinder (10); a second supply conduit (21, 22) of said second chamber (12) of said cylinder (10); wherein said first supply conduit (20) and said second supply conduit (21, 22) are connectable to a distribution valve (100) configured to control a feed operation and a discharge operation of said first supply conduit (20) and said second supply conduit (21, 22); a first check system (30) positioned along said second supply conduit (21) and configured to open a passage for a fluid coming from said distribution valve (100) and directed towards said second chamber (12) if the pressure difference between the pressure of said fluid coming from said distribution valve (100) and the pressure in said second chamber (12) exceeds a first predetermined value, and wherein said first check system (30) is connected to said first supply conduit (20) by means of a first pilot conduit (201), wherein said first check system (30) is configured to open a passage for a fluid coming from said second chamber (12) and directed to said distribution valve (100) when the pressure in said first pilot conduit (201) at said first check system (30) reaches a first predetermined value; said second supply conduit (21) comprises a primary branch (21) along which said first check system (30) is positioned, and a secondary branch (22) parallel to said primary branch (21) and along which a second check system (40, 50) is positioned, wherein said second check system (40, 50) is configured to allow to open a passage for a fluid coming from said distribution valve

(100) and directed towards said second chamber (12) along said secondary branch (22) if the pressure difference between the pressure of said fluid coming from said distribution valve (100) and the pressure in said second chamber (12) exceeds a second predetermined value, wherein said first and said second check systems (30, 40, 50) are dimensioned in such a way that a maximum fluid flow which can pass through said second check system (40, 50) is at least twice as large as a maximum fluid flow which can pass through said first check system (30).

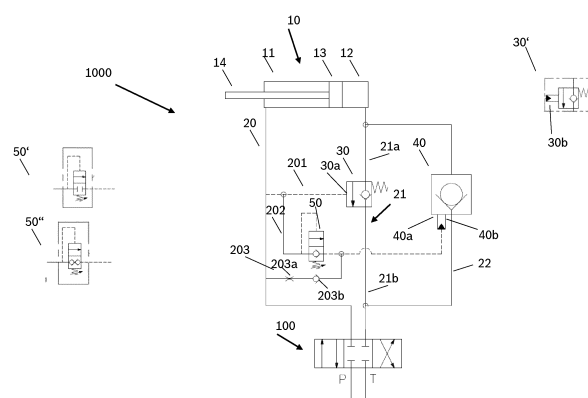


FIG. 2

Description

TECHNICAL SCOPE

[0001] The present invention relates to the field of a control system for controlling an actuator cylinder in a hydraulic application and in particular an actuator cylinder of a crane.

BACKGROUND

[0002] Control systems for actuator cylinders have evolved more and more over the years and require to satisfy an increasing number of functions. Firstly, they require a high level of safety so that, in the event of a pipe breakage, the system is able to control the actuator cylinder and stop it, preventing the load from falling. Secondly, a high level of system stability is required to ensure that the user can control the system without sudden jerks, which could cause the user discomfort. Last but not least, it is required that such systems are efficient in terms of consumption, so as to avoid waste such as bottlenecks, and that the costs of implementing such systems are low in terms of price.

[0003] An example of a control system for a crane actuator cylinder known from the state of the art is shown in figure 1 and will be briefly described below. During the ascent phase, for example when the crane is lifting a load, the cylinder bottom is controlled during the ascent phase from 1 to 2 by opening valve 5.

[0004] During the control and sustaining phase, the pressure source in 1 does not act on valve 5. Therefore, valve 5, due to the spring-induced force, prevents the hydraulic fluid from passing through it. The function of valve 6 is to prevent pressure peaks from inducing very high pressures in branch 2.

[0005] During the control phase of the descent, the fluid under pressure in 3, via valve 7, drives the control valve 5. The cylinder, on re-entry, causes a pressure increase in 2 which, if not controlled, could cause a sudden acceleration. To prevent such an acceleration during descent, it is preferable to insert a restriction in branch 1, thus creating a pressure increase in branch 1, downstream of valve 5, thus slowing down and controlling the descent of the pressurized fluid.

[0006] The two main disadvantages of a system such as that shown in figure 1 are that valve 5 always tends to close again, thus sacrificing the fluid-dynamic efficiency of the system. In addition, valve 5 must also always be sized according to the flow rate of the machine.

[0007] Therefore, in view of the foregoing, the present invention addresses the problem of realising a control system for an actuator cylinder, preferably of an actuator cylinder of a crane, capable of solving the problems listed above.

SUMMARY

[0008] The present invention relates to a control system according to the features listed in claim 1.

[0009] Such a configuration, i.e. the positioning of two check systems having staggered openings in the downstream phase, has as an advantage the use of a rather small valve (the balancing valve 30), which allows to perform the initial control phase preventing jumps due to pressure differences between the upstream and downstream branches. Subsequently, most of the fluid is exchanged using a one-way valve, which is of very simple construction and easily adjustable.

BRIEF DESCRIPTION OF THE FIGURES

[0010] The present invention will be described with reference to the appended figures in which the same numbers and/or reference signs indicate the same and/or similar and/or corresponding parts of the system.

Figure 1 schematically shows a control system for an actuator cylinder of a crane according to the state of the art;

Figure 2 shows a hydraulic circuit diagram of a control system for an actuator cylinder according to an embodiment of the present invention;

Figure 3 shows a hydraulic circuit diagram of a control system for an actuator cylinder according to a further embodiment of the present invention;

Figure 4 shows a comparative example of two hydraulic circuit diagrams of two different control systems for an actuator cylinder according to two embodiments of the present invention;

Figure 5 shows a hydraulic circuit diagram of a control system for an actuator cylinder according to a further embodiment of the present invention.

Figure 6 shows a hydraulic circuit diagram of a control system for an actuator cylinder according to a further embodiment of the present invention.

DETAILED DESCRIPTION

[0011] In the following, the present invention is described with reference to particular embodiments as illustrated in the accompanying drawing plates. However, the present invention is not limited to the particular forms of embodiment described in the following detailed description and depicted in the figures, but rather the described forms of embodiment merely exemplify the 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 the person

skilled in the art.

[0012] Figure 2 shows a control system 1000 for an actuator cylinder 10 having a first chamber 11 and a second chamber 12, a piston 13 separating the first chamber 11 from the second chamber 12 and a piston rod 14 connected to the piston 13.

[0013] The control system 1000 of the present invention is controlled by a distribution valve 100. Said distribution valve 100 comprises three positions which will be described in the course of the present description

[0014] The system 1000 comprises a first supply conduit 20 of the first chamber 11 of the cylinder 10 and a second supply conduit 21, 22 of the second chamber 12 of the cylinder 10.

[0015] The distribution valve 100 is connected to the first supply conduit 20 and the second supply conduit 21, 22 and is configured to alternately supply one between the first supply conduit 20 and the second supply conduit 21, 22 and discharge the other between the first supply conduit 20 and the second supply conduit 21, 22.

[0016] In particular, in the left position of figure 2 the distribution valve 100 connects the pressure source P to the first supply conduit 20 and, at the same time, connects the second supply conduit 21, 22 to a tank T. Conversely, in the right position of figure 2 the distribution valve 100 connects the pressure source P to the second supply conduit 21, 22 and, at the same time, connects the second supply conduit 20 to a tank T.

[0017] Between the first and second positions described above there is a third position in which the distribution valve 100 closes a connection between the pressure source P and the tank T with the supply ducts. Alternatively, in the middle position there could be a connection "Y", i.e. both the first supply conduit 20 and the second supply conduit 21, 22 are connected with the tank T.

[0018] The distribution valve 100 comprises an asymmetrical spool (not shown) configured in such a way that it is possible to start connecting the first supply conduit 20 with the pressure source P (left position of figure 2) while the connection between the supply conduit 21, 22 and the tank T is still closed. The advantage of this feature will become clear in the following description.

[0019] The second supply conduit comprises a primary branch 21 along which a first check valve 30 is positioned, which acts as a pressurisation control valve, and a secondary branch 22 parallel to the primary branch 21 along which a check valve 40 is positioned. In the case shown in figure 2, the first check system 30 consists of a balancing valve 30, 30' whose characteristics are described in the following paragraph.

[0020] The balancing valve 30 is configured to open a passage for a fluid coming from the distribution valve 100 and directed towards the second chamber 12 if the pressure difference between the pressure in P (i.e. on the pressure acting on the basis of the first check valve 30) and the pressure in the second chamber 12 exceeds a first predetermined value. The balancing valve 30 in-

cludes a pilot port 30 connected to the first supply conduit 20 by means of a first pilot conduit 201. In particular, the balancing valve 30 is configured to open a passage for a fluid coming from the second chamber 12 and directed towards the distribution valve 100 when the pressure at the pilot port 30a reaches a first predetermined value.

[0021] Preferably, as shown in Figure 5, the first pilot conduit 201 may comprise a restriction 201a, which allows the amount of fluid entering the first pilot conduit 201 to be reduced and to create a pressure difference between the first supply port 20 and the first pilot port 201 itself.

[0022] The check valve 40, which is positioned on the secondary branch 22, is configured to open a passage for a fluid coming from the distribution valve 100 and directed towards the second chamber 12 if the pressure difference between the pressure in P (i.e. on the pressure acting on the base of the check valve 40) and the pressure in the second chamber 12 exceeds a second predetermined value. The values of the first and second predetermined values may be chosen as desired. For example, the two valves may be set to open simultaneously or one after the other.

[0023] The check valve 40 includes a pilot port 40a connected to the first supply conduit 20, and as shown, also to the first pilot conduit 201, by means of a second pilot conduit 202. The check valve 40 is configured to open a passage for a fluid coming from the second chamber 12 and directed towards the distribution valve 100 when the pilot port 40a is pressurised.

[0024] Further, the balancing valve 30 and the check valve 40 are sized such that the maximum fluid flow that can pass through the check valve 40 is at least twice as large as the maximum fluid flow that can pass through the balancing valve 30, preferably at least three times as large, more preferably at least four times as large, even more preferably at least five times as large, even more preferably at least six times as large. It is clear that in any of the embodiments of the present invention the check valve 40 (in particular the check valve system 40) may be replaced by a plurality of check valves. However, it is important that the sum of the flow rates of the plurality of valves is at least twice the maximum flow rate of the balancing valve 30.

[0025] Furthermore, as shown in figure 2, both the pilot port 30a of the balancing valve 30 and the pilot port 40a of the check valve 40 may each comprise a piston 30b, 40b which is configured to amplify the pilot pressure at the pilot port 30a, 40a, so as to facilitate the opening of the valves.

[0026] A two-way two-position control valve 50 is positioned along the second pilot conduit 202 to control the pilot flow to the check valve 40.

[0027] Figures 2 and 3 show two alternative embodiments of the control valve 50.

[0028] With reference to figure 2, a first embodiment of the control valve 50 will first be presented. Subsequently, with reference to figure 3 a second form of embodiment

of the control valve 50 will be presented.

[0029] As shown in figure 2, in a first embodiment, when the pressure in the second pilot conduit 202 is less than a second threshold value, the control valve 50 closes a fluid passage to the pilot port 40a of the check valve 40. Conversely, when the pressure in the second pilot conduit 202 is greater than the second threshold value, the control valve 50 opens a fluid passage to the pilot port 40a of the check valve 40. As shown in figure 2, and in particular in the left portion of said figure, the control valve 50 may be either perfectly tight 50', or with a slight leakage.

[0030] As instead shown in figure 3, the control valve 50 is connected to a first portion 21a of the second supply conduit 21 included between the second chamber 12 and the balancing valve 30 and to a second portion 21b of the second supply conduit 21 included between the balancing valve 30 and the distribution valve 100.

[0031] When the pressure difference between the first portion 21a and the second portion 21b of the primary branch of the second supply conduit 21 is greater than a third predetermined value, the control valve 50 is configured to close a passage of fluid to the pilot port 40a of the check valve 40. On the other hand, when the pressure difference between the first portion 21a and the second portion 21b of the second supply conduit 21, 22 is less than the third predetermined value the control valve 50 is configured to open a fluid passage to the pilot port 40a of the check valve 40.

[0032] As shown in the comparative example of figure 4, the positioning in series of the control valve 50 and the check valve 40 (representing the second check valve system 40), for both the example of figure 2 and the example of figure 3, acts as a balancing valve, analogous to the balancing valve 30 described above. Hence, alternatively, the check valve 40 and the balancing valve 30 may be replaced by a balancing valve 40', shown in the figure, having larger dimensions than the balancing valve 30 so as to allow a large part of the flow between the second chamber 12 and the distribution valve 100 to pass through it.

[0033] The system 1000 further comprises a first drainage conduit 203 configured to connect a portion of the second pilot conduit 202 between the control valve 50 and the check valve 40 with the first supply conduit 20. By means of a check valve 203b and a restriction 203a said first drainage conduit 203 is configured to allow fluid to be released to the first supply conduit 20 in the event that the pressure difference between the pressure at said portion of the second pilot conduit 202 and the pressure in the first supply conduit 20 exceeds a predetermined value, and also so as to prevent reverse flow. The first drainage conduit 203 thus allows an overpressure generated in the area between the control valve 50 and the check valve 40 to be discharged to the first supply conduit 20.

[0034] The system 1000, as shown in Figure 5, may further comprise a second drainage conduit 204 that con-

nects a portion of the second pilot conduit 202 between the first pilot conduit 201 and the control valve 50 to the second supply conduit 21, 22. A drain valve 205 is positioned along said second drainage conduit 204 and is configured to drain fluid through it until the balancing valve 30 is fully open. This arrangement will then allow the opening of balancing valve 30 to be dampened by draining fluid through drain valve 205, thereby allowing a gradual opening of balancing valve 30. This function is fully described in the applicant's Italian patent application number 10 2018 000002172.

[0035] This solution of the drain valve 205 could be particularly useful, in case the dimensions of the balancing valve 30 require it. For example, in the event that the dimensions of the balancing valve 30 cause the direct flow from the second chamber 12 to the distribution valve 100 to cause a forward jerk of the actuator cylinder 10, such a drain valve 205 would make it possible to diminish this undesirable effect.

[0036] As mentioned, the above-described control system can preferably be used as a control system for controlling an actuator cylinder in a hydraulic application and in particular an actuator cylinder of a crane. Therefore, the present invention can be used in a crane comprising such a control system.

[0037] In the following paragraphs, the method of operation of the control system 1000 of figure 2 will be described in detail. The method described below may be used as a method of operation of the control system 1000 in a crane.

[0038] In the present invention, the control of the actuator cylinder 10 is by means of the distribution valve 100. Therefore, by going to operate the distribution valve 100, the positioning of the actuator cylinder 10 will be controlled.

[0039] During the ascent phase, for example in the case of lifting of a load by the crane, the control of the cylinder bottom 10 takes place by bringing the distribution valve 100 to the position on the right of figure 2, thus connecting the pressure source P with the second supply conduit 21, 22 and at the same time connecting the first supply conduit 20 with the outlet T, for example with an external tank. Thanks to the pressure of the pressure source P, both the balancing valve 30 and the non-return valve 40 will open and give a thrust to the piston 13 which will cause an expansion of the second chamber 12. The fluid contained within the second chamber 12 will then be conveyed through the distribution valve 100 to the tank T.

[0040] During the control and sustaining phase, the distribution valve 100 will be brought to the central position shown in figure 2, so neither the first supply conduit 20 nor the second supply conduits 21, 22 are connected with the pressure source P and, thanks to the force of the internal spring of the balancing valve 30 and the check valve 40, a flow of fluid through them is prevented.

[0041] It is precisely during the descent control phase that the advantages of the control system 1000 according

to the present invention are obtained.

[0042] In this respect, the displacement of the distribution valve 100 towards the left position of figure 1, thanks to the presence of the asymmetrical coil, allows to start supplying fluid under pressure to the first supply conduit 20 while the connection between the second supply conduit 21, 22 and the tank T is still closed.

[0043] The inlet pressure of the first supply conduit 20 will be applied to the balancing valve 30 by means of the first pilot conduit 201 at the pilot port 30a. Once a certain predetermined pressure has been reached, the balancing valve 30 will open so as to open a passage for the fluid coming from the second chamber 12 and directed towards the distribution valve 100. However, since there is not yet a connection between the second supply conduit 21, 22 and the tank T, the balancing valve 30 will allow the pressure upstream and downstream of the balancing valve 30 to be equalized so as to prevent a possible "hopping" of the cylinder 10. This pressure difference is due to a possible leakage of the distribution valve 100 or to the load induced on the cylinder 10.

[0044] Subsequently, with a further increase in pressure, the control valve 50 will open the section of the second pilot conduit 202 between the control valve 50 and the check valve 30 and therefore the check valve 40 will also be opened accordingly.

[0045] This subsequent opening of the valves 30, 40 is due to the fact that, as described above, the setting of the control valve 50 causes the pressure of the first supply conduit 20 to be transferred initially to the balancing valve 30 which will progressively open and only after a certain pressure has been reached, thanks to the opening of the control valve 50, will it be transferred to the check valve 40, which will open.

[0046] This opening of the balancing valve 30 makes it possible to equalise the pressure upstream and downstream of it, so as to prevent leaps.

[0047] After the pressure upstream and downstream of the two valves 30, 40 has been equalized, the distribution valve 100 will create the connection between the second supply conduit 21, 22 and the tank T in such a way as to be able to discharge the fluid contained inside the second chamber 12 towards the tank T.

[0048] Furthermore, since the balancing valve 30 and the check valve 40 are dimensioned in such a way that the maximum fluid flow which can pass through the check valve 40 is greater than the maximum flow passing through the balancing valve 30, it will be the case that most of the flow will pass through the check valve 40.

[0049] As could have been guessed from the above description, the present configuration of the control system 1000 has as an advantage the use of a rather small valve (the balancing valve 30), which allows to carry out the initial control phase which prevents jumps due to pressure differences between the branches upstream and downstream of the same. Subsequently, most of the fluid is exchanged using a one-way valve, which is of very simple construction and easily calibrated. Control

of the cylinder is, as mentioned above, delegated to the full distributor.

[0050] The control system 1000 of figure 3 is completely analogous to the one described above. The only difference is the mode of opening of the control valve 50 which, in this particular case, is controlled by the pressure in the two portions 21a and 21b of the primary branch 21 of the second supply line. In fact, when the pressure difference between the two portions 21a and 21b is less than a third predetermined value, that is, when the balancing valve 30 has gone to reduce said pressure difference, the control valve 50 will go to open the second pilot conduit 202. When, on the other hand, said pressure difference is greater than said third predetermined value, the control valve will close the connection and therefore the check valve will be closed. This solution may, for example, be useful in the event of a rupture of the portion 21b of the second supply conduit 21. In fact, the sudden drop in pressure of said portion due to the rupture of the conduit will allow to close the check valve 40 and to safely descend with only the balancing valve.

[0051] Although the present invention has been described with reference to the embodiments described above, it is clear to the person skilled in the art that it is possible to carry out various modifications, variations and improvements of the present invention in the light of the teaching described above and within the scope of the appended claims, without departing from the object and scope of protection of the invention.

[0052] A control system 1000 for an actuator cylinder 10 according to a further embodiment of the present invention is shown in figure 6.

[0053] Elements similar to those described with reference to the other embodiments will not be described in detail so as to avoid excessive redundancy.

[0054] The distribution valve 100 again comprises an asymmetric spool (not shown) configured in such a way that it is possible to start connecting the first supply conduit 20 with the pressure source P (left position of figure 2) while the connection between the supply conduit 21, 22 and the reservoir T is still closed. The advantage of this feature will become clear in the following description.

[0055] The second supply conduit comprises a primary branch 21 along which a first non-return system 30 is positioned and a secondary branch 22 parallel to the primary branch 21 along which a non-return valve 40 is positioned. The first check system is completely analogous to that described with reference to the other embodiments.

[0056] The check valve 40, which is positioned on the secondary branch 22, is configured to open a passage for a fluid coming from the distribution valve 100 and directed towards the second chamber 12 if the pressure difference between the pressure in P (i.e. on the pressure acting on the base of the check valve 40) and the pressure in the second chamber 12 exceeds a second predetermined value. In this embodiment, the values of the first and second predetermined values may be chosen as de-

sired. For example, the two valves may be set to open simultaneously or one after the other.

[0057] The check valve 40 includes a pilot port 40a connected to the primary branch 21 and by means of a second pilot port 211. The check valve 40 is configured to open a passage for a fluid coming from the second chamber 12 and directed towards the distribution valve 100 when the pilot port 40a is subjected to pressure, in particular when the pressure at the pilot port 40a reaches a second threshold value.

[0058] In this embodiment, the first opening threshold value of the balancing valve 30 may be chosen as desired and may be greater than, less than or equal to the second opening threshold value of the check valve 40. The reason for this is that the operations of the two valves are independent of each other. For example, check valve 40 can open at a pressure of just under 10 bar, while balancing valve 30 can open at a pressure of, for example, between 5 and 10 bar.

[0059] Furthermore, also in this case, the balancing valve 30 and the check valve 40 are dimensioned in such a way that the maximum fluid flow that can pass through the check valve 40 is at least twice as high as the maximum fluid flow passing through the balancing valve 30, preferably at least three times as high, more preferably at least four times as high, even more preferably at least five times as high, even more preferably at least six times as high.

[0060] Furthermore, both the pilot port 30a of the balancing valve 30 and the pilot port 40a of the check valve 40 may each comprise a piston 30b, 40b which is configured to amplify the pilot pressure at the pilot port 30a, 40a, so as to facilitate the opening of the valves.

[0061] A restriction 212 is also positioned along the primary branch 21 of the second supply conduit. In particular, the second pilot conduit 211 is connected to the primary branch 21 of the second supply conduit at an intermediate position between the bottleneck 212 and the second chamber 12. This allows, in the phase of descent of the load, to be able to create a pressure downstream of the balancing valve 30 in such a way as to guarantee the opening of the check valve (from which substantially all the fluid contained in the second chamber 12 passes).

[0062] In a particular embodiment, the restriction 212 may also be omitted since the opening of the check valve 40 via the second pilot conduit 211 may be ensured by the asymmetrical spool of the distributor 100 (which has been described above)

[0063] The system 1000 further comprises a pressure relief valve 99 positioned along a channel connecting the first supply conduit 20 to the second supply conduit, and configured to open a connection between the first supply conduit and second supply conduit if the pressure in either supply conduit exceeds a predetermined value. The pressure relief valve can open at pressures between 280 and 380 bar, for example.

[0064] In the following paragraphs, the method of op-

eration of the control system 1000 of figure 2 will be described in detail. The method described below may be used as a method of operation of the control system 1000 in a crane.

[0065] In the present invention, the control of the actuator cylinder 10 is by means of the timing valve 100. Therefore, by actuating the distribution valve 100, the positioning of the actuator cylinder 10 will be controlled.

[0066] During the ascent phase, for example in the case of lifting of a load by the crane, the control of the cylinder bottom 10 takes place by bringing the distribution valve 100 to the position on the right of figure 2, thus connecting the pressure source P with the second supply conduit 21, 22 and at the same time connecting the first supply conduit 20 with the outlet T, for example with an external tank. Thanks to the pressure of the pressure source P, both the balancing valve 30 and the non-return valve 40 will open and give a thrust to the piston 13 which will cause an expansion of the second chamber 12. The fluid contained within the second chamber 12 will then be conveyed through the distribution valve 100 to the tank T.

[0067] During the control and sustaining phase, the distribution valve 100 will be brought to the central position shown in figure 2, so neither the first supply conduit 20 nor the second supply conduits 21, 22 are connected with the pressure source P and, thanks to the force of the internal spring of the balancing valve 30 and the check valve 40, a flow of fluid through them is prevented.

[0068] It is precisely during the descent control phase that the advantages of the control system 1000 according to the present invention are obtained.

[0069] In this respect, in the case of using a distribution valve with an asymmetrical spool, the displacement of the distribution valve 100 towards the left position of figure 1, allows to start supplying fluid under pressure to the first supply conduit 20 while the connection between the second supply conduit 21, 22 and the tank T is still closed.

[0070] The inlet pressure of the first supply conduit 20 will be applied to the balancing valve 30 by means of the first pilot conduit 201 at the pilot port 30a. Once a certain predetermined pressure has been reached, the balancing valve 30 will open so as to open a passage for the fluid coming from the second chamber 12 and directed towards the distribution valve 100. However, since there is not yet a connection between the second supply conduit 21, 22 and the tank T, the balancing valve 30 will allow the pressure upstream and downstream of the balancing valve 30 to be equalized so as to prevent a possible "hopping" of the cylinder 10. This pressure difference is due to a possible leakage of the distribution valve 100 or to the load induced on the cylinder 10.

[0071] Thanks to this pressure increase, the opening of the check valve 40 can take place by means of the second pilot line 211. As mentioned above, the task of allowing the opening of the check valve 40 can alternatively be performed by the asymmetry of the distribution

valve 100 (as described in the previous paragraph) or by the presence of the restriction 212. It is clear that in a preferred embodiment such as that shown in the figure, both the asymmetry of the spool of the distribution valve 100 and the bottleneck 212 may be present.

[0072] In the case of an asymmetrical spool, after the pressure upstream and downstream of the two valves 30, 40 has been equalized, the distribution valve 100 will create the connection between the second supply conduit 21, 22 and the tank T so as to be able to discharge the fluid contained inside the second chamber 12 towards the tank T.

[0073] Furthermore, since the balancing valve 30 and the check valve 40 are sized in such a way that the maximum fluid flow that can pass through the check valve 40 is greater than the maximum fluid flow passing through the balancing valve 30, it will be the case that most of the flow will pass through the check valve 40.

[0074] As could have been guessed from the above description, the present configuration of the control system 1000 has as an advantage the use of a rather small valve (the balancing valve 30), which allows to carry out the initial phase which prevents jumps due to pressure differences between the branches upstream and downstream of the same. Subsequently, most of the fluid is exchanged using a one-way valve, which is of very simple construction and easily calibrated. The control of the cylinder is, as mentioned above, left to the full distributor.

[0075] For example, although the present invention has been described with particular reference to a crane, the present invention can be applied in any other field where hydraulic control is required in moving a load. For example, in operating machines.

[0076] Finally, those areas considered to be known to those skilled in the art have not been described in order to avoid overshadowing the described invention unnecessarily.

[0077] Accordingly, the invention is not limited to the forms of embodiment described above, but is only limited by the scope of protection of the appended claims.

Claims

1. Control system (1000) for an actuator cylinder (10) having a first and a second chamber (11, 12), a piston (13) separating said first chamber (11) from said second chamber (12), said system (1000) comprising:

a first supply conduit (20) of said first chamber (11) of said cylinder (10);

a second supply conduit (21, 22) of said second chamber (12) of said cylinder (10);

wherein said first supply conduit (20) and said second supply conduit (21, 22) are connectable to a distribution valve (100) configured to control a feed operation and a discharge operation of said first supply conduit (20) and said second

supply conduit (21, 22);

a first check system (30) positioned along said second supply conduit (21) and configured to open a passage for a fluid coming from said distribution valve (100) and directed towards said second chamber (12) if the pressure difference between the pressure of said fluid coming from said distribution valve (100) and the pressure in said second chamber (12) exceeds a first predetermined value, and wherein said first check system (30) is connected to said first supply conduit (20) by means of a first pilot conduit (201), wherein said first check system (30) is configured to open a passage for a fluid coming from said second chamber (12) and directed to said distribution valve (100) when the pressure in said first pilot conduit (201) at said first check system (30) reaches a first threshold value; said second supply conduit (21, 22) comprises a primary branch (21) along which said first check system (30) is positioned, and a secondary branch (22) parallel to said primary branch (21) and along which a second check system (40, 50) is positioned,

wherein said second check system (40, 50) is configured to allow to open a passage for a fluid coming from said distribution valve (100) and directed towards said second chamber (12) along said secondary branch (22) if the pressure difference between the pressure of said fluid coming from said distribution valve (100) and the pressure in said second chamber (12) exceeds a second predetermined value, wherein said first and said second check systems (30, 40, 50) are dimensioned in such a way that a maximum fluid flow which can pass through said second check system (40, 50) is at least twice as large as a maximum fluid flow which can pass through said first check system (30).

2. System (1000) according to claim 1, wherein said first check valve (30) comprises a balancing valve (30) comprising a pilot port (30a), said balancing valve (30) being configured to allow or block a passage for a fluid coming from said second chamber (12) and directed towards said distribution valve (100) by means of the pressure at said first pilot conduit (201), wherein said pilot port (30a) preferably comprises a piston (30b) which is configured to amplify the pilot pressure at said pilot port (30a).
3. System (1000) according to any one of claims 1 or 2, wherein said second check system (40, 50) comprises a check valve (40) comprising a pilot port (40a), wherein said check valve (40) is configured to open a passage for a fluid coming from said second chamber (12) and directed towards said distri-

bution valve (100) when said pilot port (40a) is subjected to pressure, wherein said pilot port (40a) preferably comprises a piston (40b) which is configured to amplify the pilot pressure at said pilot port (40a).

4. System (1000) according to any one of claims 1 to 3, wherein said second check system (40, 50) is connected to said first supply conduit (20), and preferably to said first pilot conduit (201), by means of a second pilot conduit (202), and wherein said second check system (40, 50) is configured to open a passage for a fluid coming from said second chamber (12) and directed to said distribution valve (100) when the pressure in said second pilot conduit (202) at said second check system (40, 50) reaches a second threshold value greater than said first threshold value.
5. System (1000) according to claim 4, wherein said second check system (40, 50) further comprises a control valve (50), preferably a two-way two positions, positioned along said second pilot conduit (202), wherein in a first position, when the pressure in said second pilot conduit (202) is less than a second threshold value, said control valve (50) closes a fluid passage to said pilot port (40a) of said check system (40), wherein when the pressure in said second pilot conduit (202) is greater than said second threshold value, said control valve (50) opens a fluid passage to said pilot port (40a) of said check valve (40).
6. System (1000) according to claim 4, wherein said second check system (40, 50) further comprises a control valve (50), preferably a two-way two-position valve, positioned along said second pilot conduit (202), wherein said control valve (50) is connected to a first portion (21a) of said primary branch (21) of said second supply conduit comprised between said second chamber (12) and said first check system (30), and to a second portion (21b) of said primary branch (21) of said second supply conduit comprised between said first check system (30) and said distribution valve (100), wherein when the pressure difference between said first portion (21a) and said second portion (21b) of said second supply conduit (21) is greater than a third predetermined value said control valve (50) is configured to close a fluid passage to said pilot port (40a) of said check valve (40), wherein when the pressure difference between said first portion (21a) and said second portion (21b) of said second supply conduit (21) is less than said third predetermined value said control valve (50) is configured to open a fluid passage to said pilot port (40a) of said check valve (40).
7. System (1000) according to any one of claims 5 or 6, wherein said system (1000) further comprises a

first drainage conduit (203) configured to connect a portion of said second pilot conduit (202) between said control valve (50) and said check valve (40) with said first supply conduit (20), wherein said first drainage conduit (203) is configured to allow fluid to be released to said first supply conduit (30) in the event that the pressure difference between the pressure at said portion of said second pilot conduit (202) and the pressure of said first supply conduit (20) exceeds a predetermined value, and so as to prevent reverse flow.

8. System (1000) according to any one of claims 5 or 7, wherein said system (1000) further comprises a second drainage conduit (204) connecting a portion of said second pilot conduit (202) between said first pilot conduit (201) and said control valve (50) to said primary branch (21) of said second supply conduit, wherein a drain valve (205) is positioned along said second drainage conduit (204) and is configured to drain fluid through it until said first check valve (30) is fully open.
9. System (1000) according to any of claims 1 to 3, wherein said second check system (40) is connected to said primary branch (21) of said second supply conduit (21, 22) by means of said second pilot conduit (211), and wherein said second check system (40) is configured to open a passage for a fluid coming from said second chamber (12) and directed towards said distribution valve (100) when the pressure in said second pilot conduit (211) at said second check system (40) reaches a second threshold value.
10. System (1000) according to any one of claims 1 to 3 or according to claim 9, wherein said control system (1000) further comprises a first restriction (212), said restriction (212) being positioned along said primary branch (21) of said second supply conduit (21, 22), wherein said second pilot conduit is connected to said primary branch (21) of said second supply conduit (21, 22) at an intermediate position between said first restriction (212) and said second chamber (12).
11. System (1000) according to claim 10, wherein said system (1000) further comprises a pressure relief valve (99) positioned along a channel connecting said first supply conduit (20) to said second supply conduit (21, 22) and configured to open a connection between said first conduit and said second supply conduit if the pressure in one between said first and said second supply conduits exceeds a predetermined value.
12. System (1000) according to any one of claims 1 to 11, wherein said system (1000) comprises said distribution valve (100), said distribution valve (100)

comprising an asymmetrical spool so as to allow to start the supply of said first supply conduit (20) while the discharge from said second supply conduit (21, 22) is still closed.

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- 13.** A crane comprising a control system (1000) for an actuator cylinder (10) according to any one of claims 1 to 12, wherein said actuator cylinder is configured to provide movement of a load suspended from said crane.

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- 14.** Use of a system (1000) according to any one of claims 1 to 12 in a crane.

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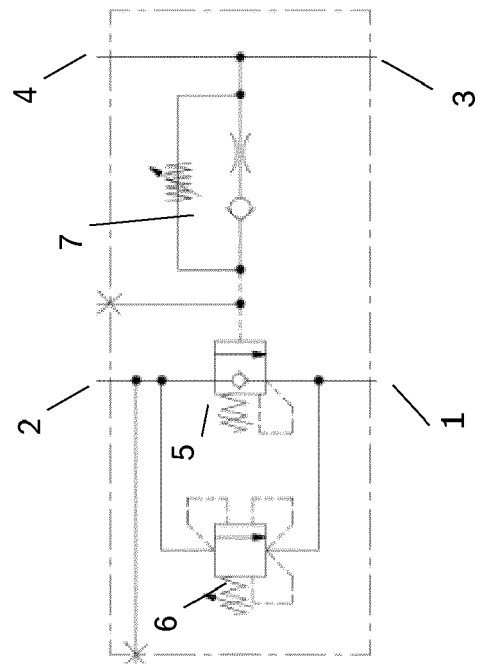


FIG. 1

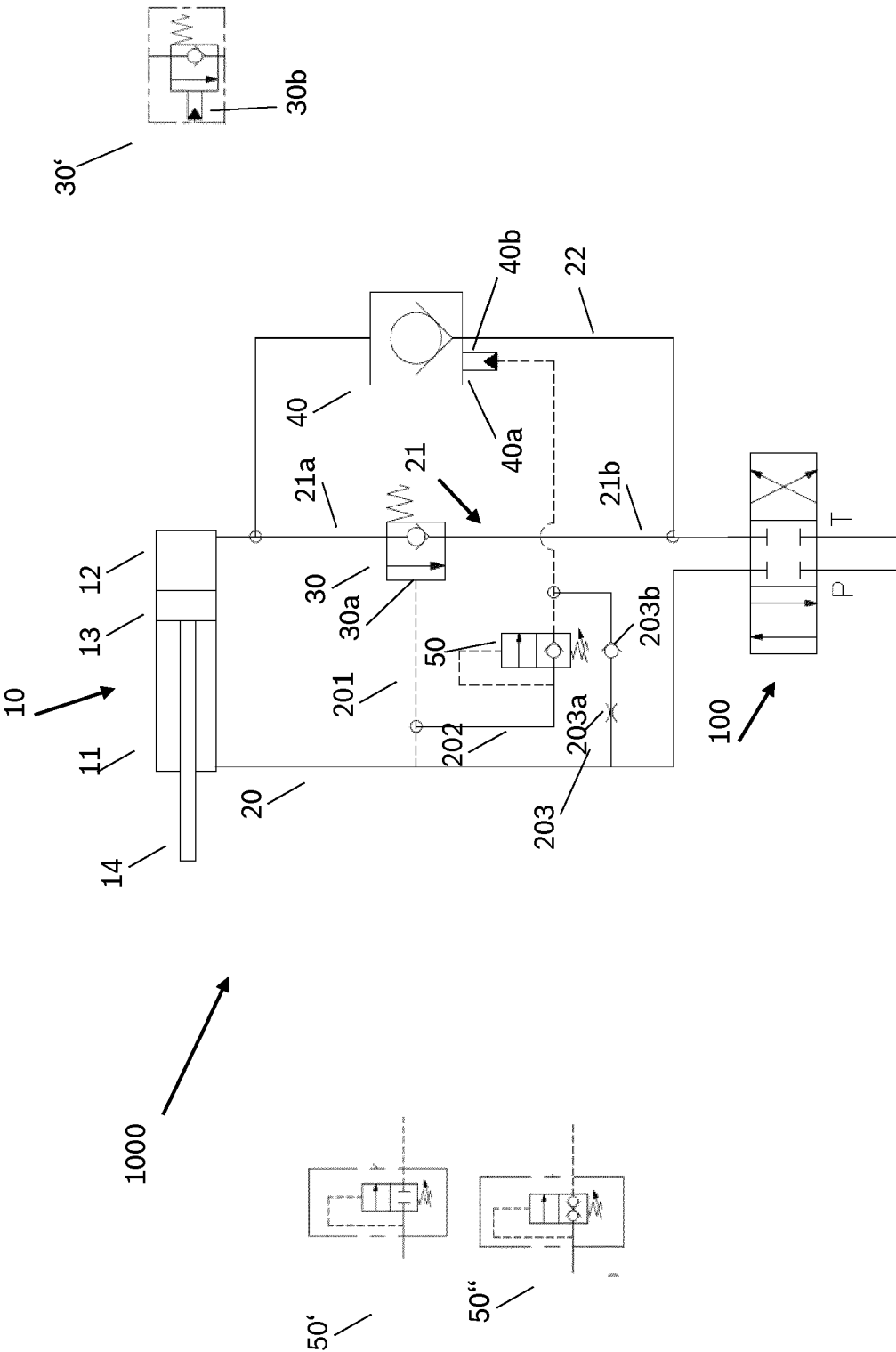


FIG. 2

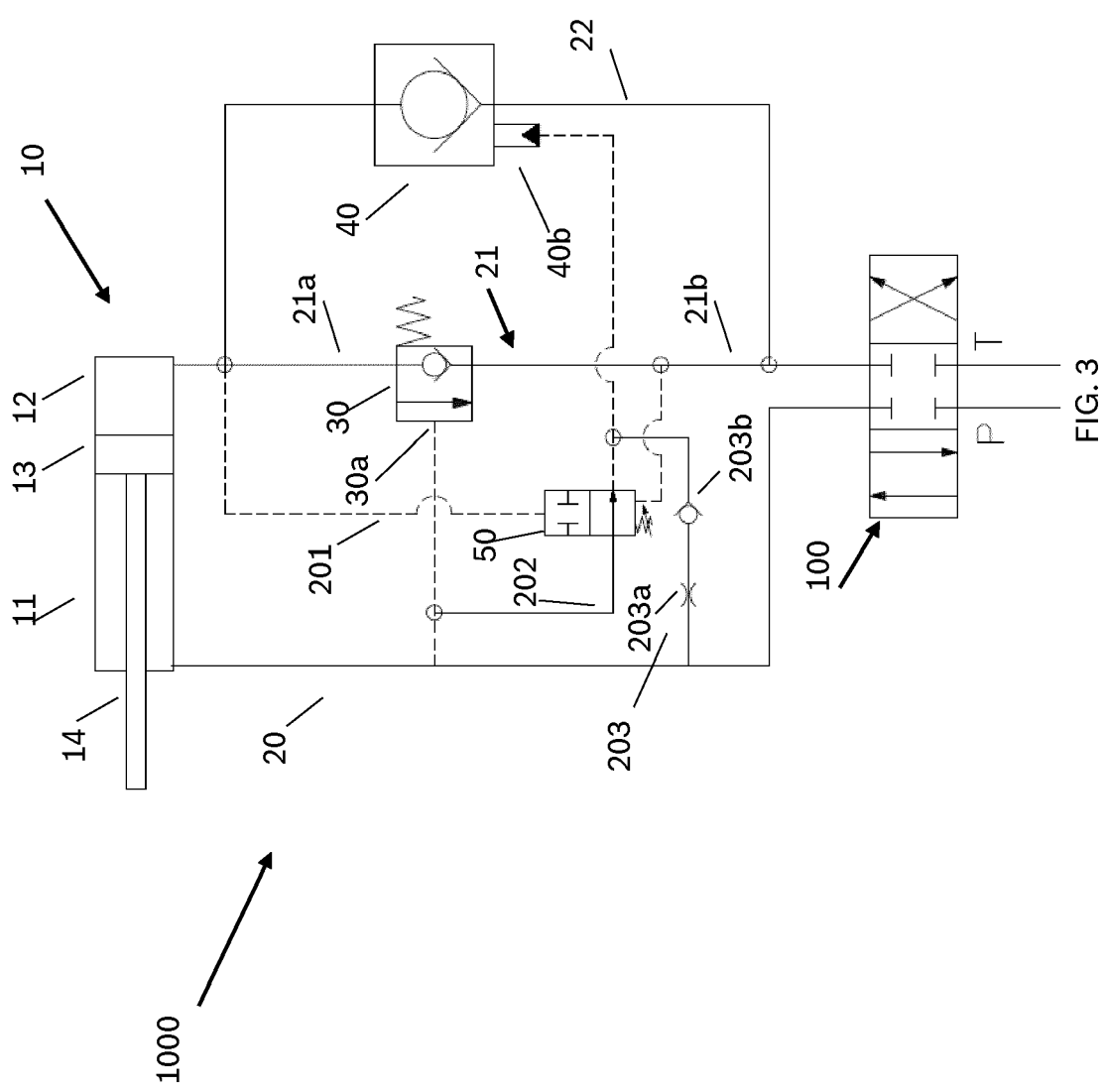


FIG. 3

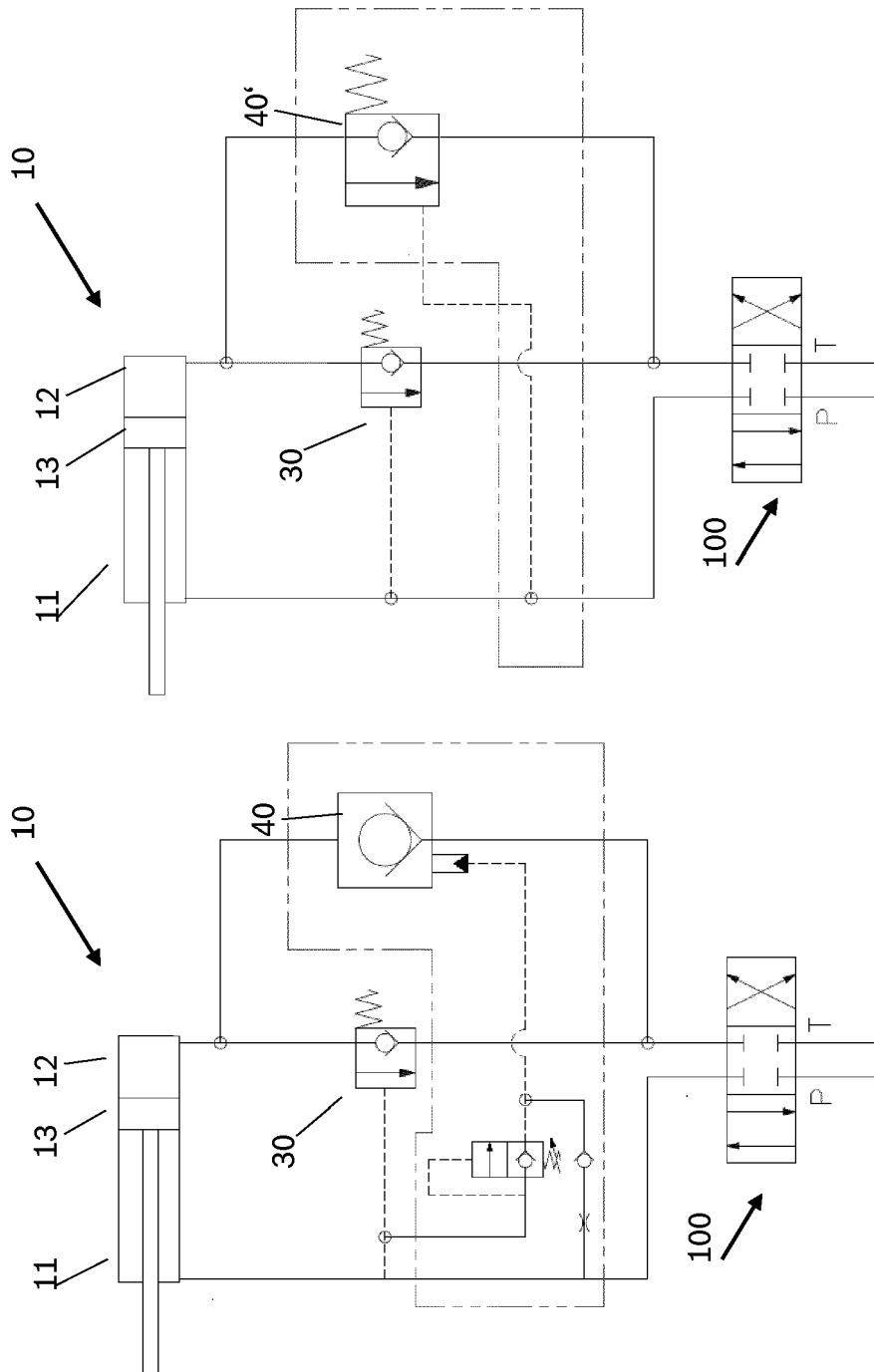


FIG. 4

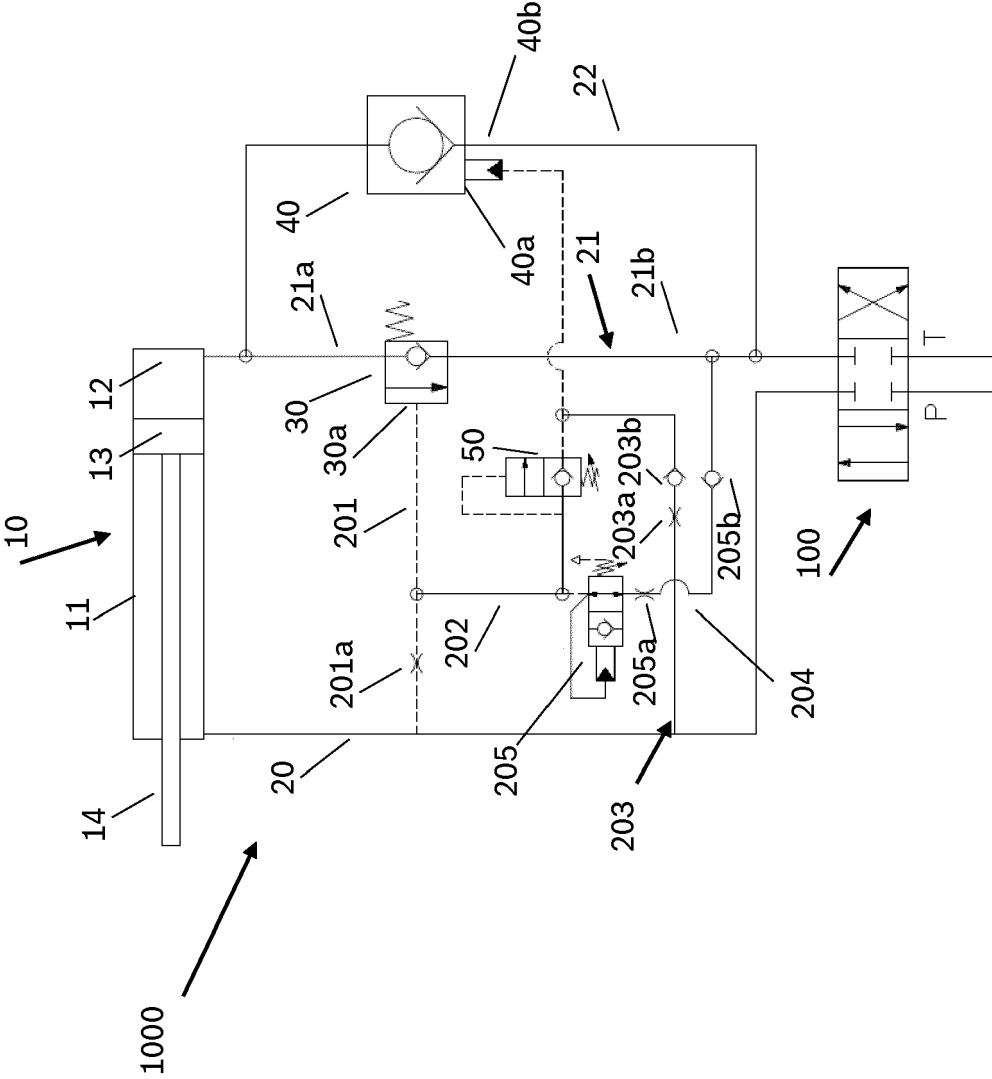


FIG. 5

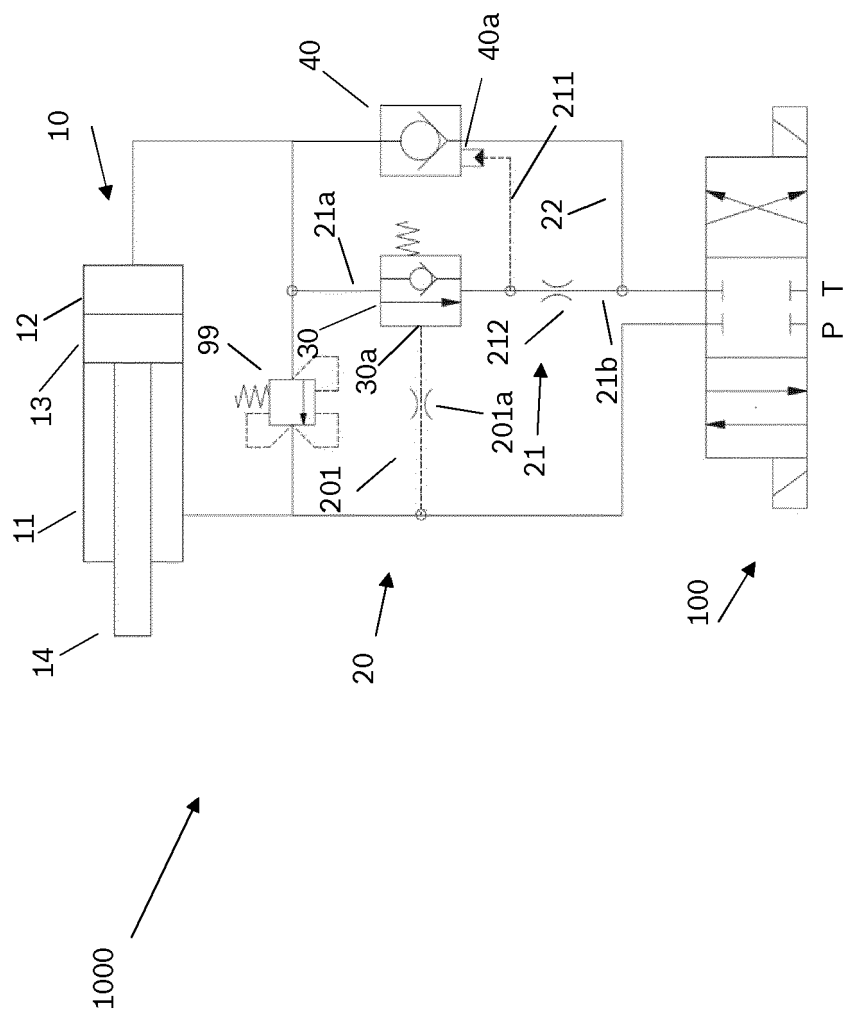


FIG. 6



EUROPEAN SEARCH REPORT

Application Number
EP 21 15 5350

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			F15B E02F B66F
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 16 June 2021	Examiner Díaz Antuña, Elena
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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16-06-2021

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