(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 4 325 068 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
21.02.2024 Bulletin 2024/08

(21) Application number: **23190030.9**

(22) Date of filing: **07.08.2023**

(51) International Patent Classification (IPC):
F15B 11/044 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
F15B 11/0445; F15B 11/044; F15B 2211/40515; F15B 2211/413; F15B 2211/41527; F15B 2211/426; F15B 2211/46; F15B 2211/50581; F15B 2211/526; F15B 2211/5753; F15B 2211/5756; F15B 2211/6313; F15B 2211/7053; F15B 2211/761; F15B 2211/851

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
KH MA MD TN

(30) Priority: **11.08.2022 IT 202200017223**

(71) Applicant: **Robert Bosch GmbH**
70442 Stuttgart (DE)

(72) Inventors:
- **Dotti, Francesco**
  40014 Crevalcore (IT)
- **Zaccarelli, Pierre Luigi**
  41126 Modena (IT)

(54) CONTROL SYSTEM FOR AN ACTUATOR CYLINDER

(57) The present invention relates to a Method for adjusting a control system for an actuator cylinder (10) of an operating machine, said actuator cylinder having a first and a second chamber (11, 12), a piston (13) separating said first chamber (11) from said second chamber (12), said system comprising a first feed conduit (20) of said first chamber (11) of said cylinder (10), a second feed conduit (21) of said second chamber (12) of said cylinder (10), wherein an increase in the volume of said second chamber (12) causes a load supported by said cylinder (10) to descend downwardly wherein said first feed conduit (20) and said second feed conduit (21) are connectable to a distribution valve (100) configured to control a feed operation and a discharge operation of said first feed conduit (20) and said second feed conduit (21), said control system comprising a retaining system (30) positioned along said first supply conduit (20) and configured to open a passage for a fluid coming from said distribution valve (100) and directed to said first chamber (11) if the pressure difference between the pressure of said fluid coming from said distribution valve (100) and the pressure in said first chamber (11) exceeds a first predetermined value, and wherein said retaining system (30) is configured to regulate the flow of fluid exiting said first chamber (11) and directed to said distribution valve (100) according to a signal provided to said retaining system (30); said method comprising the following steps:
a. Receiving an information corresponding to a request for descent of said load (C3);
b. Send to said restraint system (30) a signal for the descent of said load (C3);
c. Adjust said restraint system (30) so as to execute said descent of said load according to said signal received by said restraint system (30) in said step b.;
wherein said signal provided to said retaining system (30) during said step b. takes into consideration the weight of said load (C3) or a quantity dependent thereon so that the descent of said load (C3) meets at least one predetermined criterion.

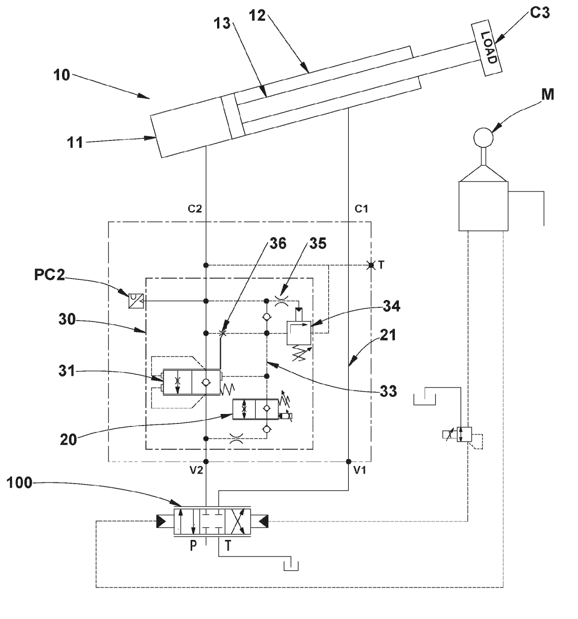

Fig.3

EP 4 325 068 A1

Description

TECHNICAL FIELD.

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

BACKGROUND

[0002] Control systems for hydraulic cylinders for moving the arms of machines such as telehandlers and cranes have evolved more and more over the years and require to fulfill an increasing number of functions. First, they require high safety so that in the event of a pipeline rupture, the system is able to control the actuator cylinder and stop it, preventing a possible load fall. Second, high stability of the system is required so that the user can ensure that he or she can control the system without generating sudden jerks, which could cause the user a sense of discomfort. In addition, last but not least, it is required that such systems be efficient in terms of consumption, so as to avoid waste such as throttling, and that the cost of implementing such systems be low in terms of price. In particular, such systems involve the use of hydraulic balancing valves or valves driven by an external line.

[0003] A first example of a control system for an actuator cylinder known from the state of the art is shown in Figure 1. Such a system shows a simple hydraulic balancing valve. Specifically, as shown in the figure, such a device includes a first conduit 2, arranged to connect a first chamber C1 of a cylinder C with a distributor D, a second conduit 3, arranged to connect a second chamber C2 of the cylinder C with the distributor D, a balancing valve 44, arranged along the first conduit 2, which is arranged to allow fluid flow from the distributor D to the first chamber C1 and to allow fluid flow from the first chamber C1 to the distributor D only when driven with a pilot pressure above a minimum value. Therefore, in order to allow cylinder movement, balancing valve 44 must be opened by a pressure signal from chamber C2 opposite to that which is to be controlled by the valve. In this way there is a balance of forces between the two chambers, and the valve opens in relation to this balance. This system causes the downward velocities of the arm to be very similar as the applied load changes. The higher the load C3, the less pressure it will take to open the valve; the thrust generated in the chamber opposite the controlled one will therefore be low. On the other hand, if the load is very low, the pressure to open the valve will increase, and consequently so will the thrust generated in the opposite chamber. In this way, the pressure in the cylinder chamber will always be averagely constant, so the rate of descent will also be constant.

[0004] However, such valves have limitations in terms of stability and response delay. Since the opening control is not adjustable, the valve undergoes abrupt opening, which tends to generate instability of movement. To remedy this problem, a damping device is inserted on the drive signal, but this generates pressure spikes in fast movements and an activation delay that, although tolerated, is a weakness of the system.

[0005] A second example of a control system for an actuator cylinder known from the state of the art, which describes an externally line-driven valve, is described in patent application EP 2 786 959 A1 and is depicted in Figure 2. As shown in the figure, such a device includes a first conduit 2, arranged to connect a first chamber C1 of a cylinder C with a distributor D, a second conduit 3, arranged to connect a second chamber C2 of the cylinder C with the distributor D, a control valve 4, arranged along the first conduit 2, which is arranged to allow fluid flow from the distributor D to the first chamber C1 and to allow ii fluid flow from the first chamber C1 to the distributor D only when supplied with a pilot pressure above a minimum value.

[0006] Such a device further comprises a third conduit 5, which connects the second conduit 3 with a section of the first conduit 2 between the control valve 4 and the control valve D, a shutoff valve 6, arranged along the third conduit 5, which is movable, on command, between an opening configuration, wherein it allows ii flow along the third conduit 5, and a closing configuration, wherein it prevents ii flow along the third conduit 5. Actuating valve 6 is configured to receive an open command only if control valve 4 is supplied with pilot pressure. In order to allow cylinder movement, control valve 4 must therefore be opened by a pressure signal from an external line P, usually connected to the line that controls the opening of the distributor. This system allows for movement control independent of the state of the cylinder, without having to push into the other chamber, since the movement will be by gravity. The advantages of such a system lie in the saving of power to obtain the same movement and in the possibility of obtaining very precise movements without any kind of intervention delay and pressure peaks on the line.

[0007] However, this type of valve has as a weak point the different speed of movement when the load varies and the possibility of triggering cavitation in the uncontrolled part of the cylinder. To overcome part of these problems (too high speeds at high loads and cavitation), pilot pressure limiting systems have been introduced. In addition, shutoff valve 6 was introduced, which, as described above, can prevent the formation of cavitation. With regard to low speeds at low loads, on the other hand, there are still some limitations on the use of such valves

[0008] Therefore, in light of the above, the present invention addresses the problem of realizing a control system for an actuator cylinder that can solve the above problems.

SUMMARY

[0009] The present invention relates to a control system according to the features listed in claim 1.

[0010] Such a configuration, i.e., the realization of a system capable of fully automatically limiting the rate of load descent based on a:

I. Magnitude of the load being lifted, and/or

II. Magnitude of the position of the load with respect to the operating machine lifting said load.

automatically allows the load descent speed to be checked and limited if a predetermined condition is not met. This thus makes it possible to solve the problem of lowering the load with the required speed while still respecting safety limits.

[0011] According to a particular embodiment of the present invention, in said step b. of claim 1 said weight of said load (C3) is calculated by means of a pressure sensed at said first chamber (11).

[0012] According to a particular embodiment of the present invention, said information corresponding to a descent request of said load is provided to said control system via an input device, preferably a joystick (M), and wherein in said step a. said descent request signal is received via said input device.

[0013] According to a particular embodiment of the present invention, said information corresponding to a request for descent of said load is detected by sensing a pressure or pressure change at said second chamber (12).

BRIEF DESCRIPTION OF THE FIGURES

[0014] The present invention will be described with reference to the attached figures wherein the same numbers and/or reference marks indicate the same and/or similar and/or corresponding parts of the system.

Figure 1 shows a hydraulic circuit diagram of a control system for an actuator cylinder comprising a simple hydraulic balancing valve according to the state of the art;

Figure 2 shows a hydraulic circuit diagram of a control system for an actuator cylinder with an externally line-driven valve according to the state of the art;

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

Figure 4a and Figure 4b show two similar hydraulic circuit diagrams of a control system for an actuator cylinder according to a second form of embodiment of the present invention;

Figure 5 shows a logic diagram of a method for adjusting a control system such as that shown in Figure 3 or Figure 4 according to a particular form of embodiment of the present invention;

Figure 6 shows a logic diagram of a method for limiting based on a weight of a load of a control system such as that shown in figure 3 or figure 4 according to a particular form of embodiment of the present invention;

Figure 7 shows a logic diagram of a method for limitation on the basis of a distance of a load from a main body of the machine of a control system such as that shown in figure 3 or figure 4 according to a particular form of embodiment of the present invention;

Figure 8 schematically shows an operating machine on which is usable method for adjusting a control system for an actuator cylinder according to the present invention.

DETAILED DESCRIPTION

[0015] In the following, the present invention is described by reference to particular forms of embodiment 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 forms of embodiment described simply 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 appear clear to the person skilled in the art.

[0016] As will be clear from the remainder of this description, Figures 3 and 4 show two examples where the present invention may be used. However, there are other examples of systems wherein this invention may be used. Therefore, it is clear that the present invention is not limited to the particular application examples shown in the figures.

[0017] Figure 3 shows a schematic of a control system for an actuator cylinder 10. Said cylinder 10 includes a first and a second chamber 11, 12 and a piston 13 separating said first chamber 11 from said second chamber 10. Said actuator cylinder is configured to allow direct or indirect displacement of a load C3. In fact, said actuator cylinder can be configured, as shown in figure 8, to move a mechanical arm such as the lifting arm 500 of a telescopic hoist 1000, which is configured so as to be able to move loads (it is clear, however, that the load can be represented by the weight of the mechanical arm itself, which is moved unloaded and does not require the presence of an external body).

[0018] As shown in Figure 8, the 1000 telehandler includes a main body 530 comprising wheels for moving the telehandler along the ground. Attached to said main body 530 is a lifting arm 500 which is mechanically connected to said main body and which, by means of the actuator cylinder 10 is movable relative to the main body 530. Said actuator cylinder 10 is configured to provide relative movement of said lifting arm 500 relative to said main body 530 along the arc of circumference 520. Further, the lifting arm 500, which in this particular case is a telescopic arm, can be telescopically extended, as shown by arrow 510 in the figure. A bucket or any element capable of moving a C3 load (such as, for example, simple mechanical forks) may be positioned at an end portion of said lifting arm.

[0019] It is clear, however, that the present invention is not limited to the application of a telescopic lift but of any operating machine comprising a main body and an arm mechanically connected to said main body, wherein the arm can be moved relative to the main body by means of said actuator cylinder 10.

[0020] Returning to Figure 3, the system includes a first feed conduit 20 of said first chamber 11 of said cylinder 10, a second feed conduit 21 of said second chamber 12 of said cylinder 10, wherein an increase in the volume of said second chamber 12 causes said load C3 supported by said cylinder 10 to descend downwardly. Said first feed conduit 20 and said second feed conduit 21 are connectable to a distribution valve 100 configured to control a feed operation and a discharge operation of said first feed conduit 20 and said second feed conduit 21.

[0021] Said control system includes a retaining system 30 positioned along said first supply conduit 20 and configured to open a passage for a fluid coming from said distribution valve 100 and directed to said first chamber 11 if the pressure difference between the pressure of said fluid coming from said distribution valve 100 and the pressure in said first chamber 11 exceeds a first predetermined value. This is due to the presence of the one-way valve shown in the right position of balancing valve 31.

[0022] In addition, the retaining system 30 is configured to regulate the flow of fluid leaving said first chamber 11 and directed to said distribution valve 100. This is due to the presence of the left position of balancing valve 31.

[0023] The adjustment of the positioning of the proportional balancing valve 31 is provided by the proportional solenoid valve 32, which allows the piloting pressure of the balancing valve 31 and thus its opening to be adjusted.

[0024] Specifically, in the phase before the lowering of load C3, the first chamber 11 will be under pressure. The same pressure will be present in the pilot line 33 of balancing valve 31, which receives the pressure from the first chamber 11 via restriction 36.

[0025] Proportional solenoid valve 32 allows the pilot pressure to be adjusted and thus to go to open and close balancing valve 31. In fact, in the particular example shown in the figure, proportional solenoid valve 32 is in the normally closed position. It will, when energized with a given current, begin to open and go to empty pilot port 33. This emptying of pilot port 33 will then go on to reduce the pressure in the first chamber 11 as the reconduition in pilot pressure will cause the balancing valve 31 to open and consequently empty the first chamber 11. It is clear that alternatively the electro-proportional valve could be of the normally open type and close if supplied with a given current (such a system, however, would be entirely dangerous since in the event of a power failure it would cause the load to drop).

[0026] Thus, the proportional solenoid valve 32 makes it possible to regulate the load drop. Such regulation is accomplished by means of an electronic control unit (shown symbolically with element 99 in Figure 8). This descent phase can alternatively begin as a result of the reception of a pressure signal in the second chamber 12 or as a result of a signal received from an input device, such as a common joystick M.

[0027] There is then a pressure-limiting valve 34 in the pilot conduit 33 that will empty the pilot conduit 33 if the pressure within it exceeds a predetermined value. Such emptying of pilot conduit 33 will then go on to reduce the pressure in the first chamber 11 as the reconduition in pilot pressure will cause balancing valve 31 to open and consequently empty the first chamber 11.

[0028] There is then a unidirectional valve 35 in the piloting port 33 to ensure fast emptying of the first chamber 11. However, such a valve 35 represents an entirely optional element.

[0029] According to a particular embodiment of the present invention, such a system comprises a pressure sensor PC2 configured to sense the pressure at said first chamber 11. Said pressure sensor indirectly enables measurement of the weight C3 supported by said actuator cylinder 10. According to further forms of embodiment said pressure sensor PC2 may be replaced by other means capable of deriving the weight of said load C3 or a quantity dependent thereon. For example, systems comprising force sensors positioned directly on the arm of the operating machine capable of detecting such a load or sensors positioned at the wheels of the operating machine are known from the state of the art.

[0030] Figure 4a and Figure 4b, on the other hand, show two different diagrams of a control system for an actuator cylinder 10 at which the control method according to the present invention (which will be described later) can be used.

[0031] To avoid redundancy, the description of elements completely analogous to those shown in figure 3 will be omitted here.

[0032] In contrast to the hydraulic scheme in Figure 3, the system in Figure 4a includes a balancing valve 37 positioned directly along the first conduit 20 whose pilot conduit is directly controlled by a proportional solenoid valve 38, which is configured to regulate the pilot pressure arriving at balancing valve 37. Specifically, valve 38 receives pressurized fluid from the second conduit 21 and as a result of a current signal received from an electronic control unit 99 will regulate the pressure in the piloting conduit thereby adjusting the opening of the first conduit 20, so as to regulate the downward phase of load

C3. In contrast to what is shown in figure 4a, in the system shown in figure 4b, valve 38 is positioned between the piloting conduit and an exhaust, thus allowing the piloting pressure to be adjusted by going to discharge the unwanted pressure to the exhaust. In the case where there is no demand to descend load C3, valve 38 will then go to zero pressure in the piloting conduit, thus going to discharge all pressure to a tank T. Differently, when descending load C3, following the reception of a current signal the valve will tend to increase the pressure in the piloting conduit going to decrease the amount of pressure discharged to tank T.

[0033] What the examples in Figures 3 and 4 have in common is that in both cases the electro-proportional valves go directly or indirectly to regulate an incoming pilot pressure to the balancing valve 31, 37.

[0034] Again there may be a PC2 pressure sensor entirely analogous to that shown in figure 3.

[0035] With reference to Figure 5, a method for regulating a control system for an actuator cylinder (such as the systems shown for example in Figures 3 and 4) will now be described according to a particular embodiment of the present invention.

[0036] Such a control method, as described above, can be used for both the control system in Figure 3 and those in Figure 4. However, there are other examples of systems wherein such an invention can be used. Therefore, it is clear that the present invention is not limited to the particular application examples shown in the figures but can be used in any system wherein down-step regulation of a C3 load by an electro-portional valve takes place.

[0037] In a first step 90 a pump P (as the pressure source) is connected to the valve 100, which is commanded to feed the port V1 of the valve and thus begin the descent phase. In fact, through the Joystick M signal or through a pressure sensor located at the second chamber 12 the control unit 99 will go to detect an opening command and the magnitude of this command will also preferably be detected. In fact, through the joystick, a user will be able to request a more or less rapid descent of the load C3.

[0038] Then, following the sending of the current signal by the control unit 99, there will be a current opening command for the electro-proportional valve 32 and 38 (in the respective hydraulic diagrams in Figures 3 and 4). This opening will put the first chamber 11 in communication with the discharge part of the distributor (line C2 - V2) in a progressive manner. The magnitude of the current signal will then allow the flow rate through the balancing valve 31, 37 to be adjusted: the higher this signal, the higher the flow rate will be.

[0039] It is particularly important to go to regulate the opening control of the electro-proportional valve. The purpose of the present invention is precisely to regulate the opening of the electro-proportional valve in such a way as to prevent sudden surges or accelerations during the downward phase. Until now, this purpose has been achieved by allowing extremely limited electro-proportional valve openings so as to go to limit the rate of descent of the load (i.e., by going to throttle the descent). However, this function was particularly disadvantageous in the case of extremely limited loads or even in the absence of loads in that it went too far in limiting the descent of the load.

[0040] To overcome this technical problem, the present invention developed a method of controlling the electro-proportional valve capable of providing the maximum possible rate of descent but at the same method of meeting predetermined criteria.

[0041] It is particularly important to go to adjust the opening command of the electro-proportional valve by going precisely to check the initial value of that current signal. In fact, it is clear that this is a progressive opening and that there will be a limit value above which the opening of the balancing valve 31, 37 will begin. To achieve this, in a second step 91 of the method preferably takes place the calculation of an initial value of said current signal before said balancing valve 31, 37 opens a flow of fluid along said first conduit 20 and thus to begin the descent of said load C3.

[0042] Said initial value of current is dependent on said load and in the case shown in Figures 3 and 4 will be directly proportional to the weight of said load C3. In fact, the higher the load the greater the pilot pressure required to open the balancing valve. It is clear that this reasoning applies only to the case wherein the electro-proportional valves are of the type shown in the figure, i.e., that in the case of no current signal they do not supply any pilot pressure to the balancing valve 31, 37 or supply in general less pilot pressure than is necessary to cause that valve to open. If, on the other hand, they were of the opposite type, that is, the particularly disadvantageous type that always requires a current signal to keep the balancing valve 31, 37 closed, there will be an initial value of current inversely proportional to the weight of said load C3. It is still valid in any case that the initial value of current is dependent on the weight of said load C3.

[0043] Therefore, in step 91 one will have gone to correct a reference function, for example, a simple reference curve, which has as its input a demand for the descent of the load and as its output a current signal to be supplied to the electro-proportional valve 32, 38, wherein such correction has been made on the basis of the weight of said load C3. However, this correction was made, in the case shown in the figure, only for an initial value of the current signal needed to start the descent because the greater the weight of the load, the greater will be the current signal needed to start the descent (in essence to open the balancing valve 31, 37.

[0044] In a third step the actual correction of the reference function takes place as it is corrected to adjust the opening according to the load. In particular,,ti the larger the load C3, the more a limitation of the rate of descent will be required and therefore a limitation of the maximum allowable opening of the balancing valve 31, 37 during descent. Similarly, in the case where the load C3 is located very far from the main body 530 of the operating machine 1000 there will be a particularly large moment generated by this load and it will therefore be necessary to limit the descent speed of the load so as to prevent undesirable effects. Therefore, both in the case where there is a large load and in the case where the distance between the load and the main body is large it will be necessary to reduce the rate of descent, which translated into "hydraulic" language means limiting the maximum flow rate passing through the balancing valve of the retaining system.

[0045] Therefore, as shown briefly in Figure 5 and in detail in Figures 6 and 7, respectively, two different types of corrections on this function are carried out in parallel. It is clear, however, to the branch expert that this function can also be used with only one of the two corrections made and it is in no way necessary for both corrections to be implemented.

[0046] Throughout this description for clarity we will refer to the first and second reference functions. However, it is clear that in both cases it is preferably the same input function from step 91 to which two different types of corrections are subjected thus going on to produce two different functions (precisely a corrected first reference function and a corrected second reference function)

[0047] The first reference function correction that will be described here is based on the weight of the load or a quantity dependent on it.

[0048] During such a correction, preliminary steps are initially taken to get all the necessary information to begin with the correction of the first reference function. Specifically, the following steps take place:

i. Receive 921 a set of prescalved parameters that will be explained in detail throughout this description;

ii. Detect 922 the magnitude of the load C3, preferably via the pressure signal from PC2 or alternatively via any system capable of detecting a quantity dependent on it (force sensors, tire pressure sensors, etc.);

iii. Detect 923 the magnitude of a command received from Joystick M;

iv. Receive 924 the first correct reference function in step 91.

[0049] A first received parameter is, for example, a function 925 describing a first correction factor. Such a first correction factor 925, as shown in the figure, is a function that describes a correction value depending on the load (in the particular case shown depending on the pressure in bar detected by sensor PC2).

[0050] Therefore, in step 925 this value of the first correction factor to be applied to the first reference function will be calculated. This value will preferably be inversely proportional to the magnitude of the load C3 since, as mentioned, as the load increases it will be preferable to have a decrease in the rate of load descent. Therefore, the value will be equal to 1 for extremely small load values and will decrease as load C3 increases.

[0051] In a subsequent step such first correction factor is applied, preferably by multiplication, to said first reference curve exclusively for values of said current signal corresponding to a fluid flow leaving said first chamber 11 and directed to said distribution valve 100 other than zero. Therefore, such correction will be made only for current values greater than the initial value calculated in step 91.

[0052] Therefore, as shown in the figure, starting from the first reference curve (shown with a solid line) a first correct reference function (shown with a dashed line) will have been obtained in this way to be used in the step for calculating the current signal that can then be sent to the electro proportional valve 32, 38. Specifically, as shown in the figure, giving as input the signal received from the Joystick will result in a current value I_P (between 400 and 500 mA), which will be precisely the signal required by the Joystick for the load to descend.

[0053] As shown in the figure, in a subsequent step 927 the single value of the signal I_P calculated in step 926 and corresponding to the request of Joystick M is reprocessed. In fact, as can be seen, the output current signal is not made to vary instantaneously from the initial value calculated in step 91 to the final I_P value calculated in step 926 but there is a ramp starting from that minimum value (in the case shown in the figure 400 mA) and is increased gradually until it reaches that value calculated 926 so as to avoid sudden acceleration. It will be preferable to use a delay parameter (in the case shown in the figure of 0.5 s) to define the magnitude of such a ramp: the higher such a parameter is, the milder the acceleration of such a load in the downward phase. Such a parameter will preferably also be dependent on the magnitude of the load C3.

[0054] Therefore, as an output from that function there will be a signal that can be sent to the retaining system 30 that varies over time in an initial phase until it then stabilizes once it reaches the final value corresponding to the value calculated in step 926.

[0055] As mentioned earlier, in parallel with that step 92, the correction of the second reference function based on the position of said load C3 also takes place, which will be described in detail below.

[0056] The second reference function correction that will be described here is based on the position of the load C3 or a quantity dependent on it. By position is preferably meant the distance between said load C3 and main body 530.

[0057] During such a correction, preliminary steps are initially taken in order to have all the necessary information to start with the correction of the first reference function. Specifically, the following steps take place:

i. Receive 931 a set of prescalved parameters that will be explained in detail throughout this description;

ii. Detect 932 the positioning of the load, preferably, in the particular example depicted in Figure 8, by means of a position sensor, which allows the extension 510 of the lifting arm 500 to be measured, and a sensor that allows the inclination of the same to be measured. However, very sophisticated systems are known from the state of the art that use accelerometers or alternatively more expensive sensors to be placed inside the displacement cylinders of the mechanical arms and that allow the position of the load C3 with respect to the main body 530 of the operating machine 100 to be determined in particular detail. Furthermore, in the case of an operating machine other than the telehandler, it is clear that it is necessary to determine the position of the C3 load differently;

iii. Detect 933 the magnitude of a command received from Joystick M;

iv. Receive 934 the first correct reference function in step 91.

[0058] For example, a first parameter received is a function 935 describing a second correction factor. Such a second correction factor 935, as shown in the figure, is a function that describes a correction value depending on the position of the load (in the particular case shown depending on the extension 510 in meters of the lifting arm 500).

[0059] Therefore, in step 935 such a value of the second correction factor will be calculated to be applied to the second reference function. This value will preferably be inversely proportional to the distance of the load C3 from the main body 530 of the operating machine 1000 since, as mentioned above, as the distance increases it will be preferable to have a decrease in the speed of descent of the load so as to prevent tipping or simply oscillation of the machine itself. Therefore, the value will be 1 for extremely small values of that distance and will decrease as that distance increases.

[0060] In a subsequent step said second correction factor is applied, preferably by multiplication, to said second reference curve exclusively for values of said current signal corresponding to a flow of fluid leaving said first chamber 11 and directed toward said distribution valve 100 other than zero. Therefore, such correction will be made only for current values greater than the initial value calculated in step 91.

[0061] Therefore, as shown in the figure, starting from the second reference curve (shown with a solid line) a second correct reference function (shown with a dashed line) will have been obtained in this way to be used in the step for calculating the current signal that can then be sent to the electro proportional valve 32, 38. Specifically, as shown in the figure, giving as input the signal received from the Joystick will result in a current value I_T (between 500 and 600 mA), which will be precisely the signal required by the Joystick for the load to descend.

[0062] As shown in the figure, in a subsequent step 937 the single value I_T of the signal calculated in step 936 and corresponding to the request of Joystick M is reprocessed. In fact, as can be seen, the output current signal is not made to vary instantaneously from the initial value calculated in step 91 to the final value calculated in step 936 but there is again a ramp starting from this minimum value (in the case shown in the figure 400 mA) and is gradually increased until it reaches this value calculated 936 so as to avoid sudden acceleration. It will be preferable to use a delay parameter (in the case shown in the figure of 0.5 s) to define the magnitude of this ramp: the higher this parameter is, the milder the acceleration of this load as it descends. This parameter will preferably be dependent on the magnitude (weight) of the load C3 or alternatively on the position of the load itself.

[0063] Therefore, as an output from this function there will be a signal that can be sent to the retaining system 30 that varies in time at an initial phase. This signal will then go on to stabilize once the final value corresponding to the value calculated in step 936 is reached.

[0064] Returning to Figure 5, the two current signals calculated in steps 92 and 93, respectively, will preferably be compared in step 94, and the minimum of the two values will be taken so that both quantities (weight and position) can be taken into account and both risks dependent on them can be effectively prevented.

[0065] Therefore, in the next step the minimum of the two values of the current signals calculated in 92 and 93 respectively will be sent to the restraint system 30 which will then adjust the descent of the load C3 based on the current signal received. Specifically, this current signal will be sent to the electro-proportional valve 32, 38, which will then go on to regulate the pilot pressure and the consequent descent of load C3.

[0066] Although the present invention has been described with reference to the forms of embodiment described above, it is clear to the person skilled in the art that various modifications, variations, and improvements of the present invention can be made in light of the teaching described above and within the scope of the appended claims, without departing from the subject matter and scope of protection of the invention.

[0067] For example, although with reference to Figure 8 it has been shown that the present invention can be used on a telescopic lift, it is clear that this invention can be used on any system capable of regulating the descent of a load by means of an electro proportional valve.

[0068] Finally, those areas that are believed to be known by those skilled in the art have not been described to avoid overshadowing the described invention unnecessarily.

[0069] 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. A method for adjusting a control system for an actuator cylinder (10) of an operating machine, said actuator cylinder having a first and a second chamber (11, 12), a piston (13) separating said first chamber (11) from said second chamber (12), said system comprising a first feed conduit (20) of said first chamber (11) of said cylinder (10), a second feed conduit (21) of said second chamber (12) of said cylinder (10), wherein an increase in the volume of said second chamber (12) causes a load (C3) supported by said cylinder (10) to descend downward, wherein said first feed conduit (20) and said second feed conduit (21) are connectable to a distribution valve (100) configured to control a feed operation and a discharge operation of said first feed conduit (20) and said second feed conduit (21), said control system comprising a retaining system (30) positioned along said first supply conduit (20) and configured to open a passageway for a fluid coming from said distribution valve (100) and directed to said first chamber (11) if the pressure difference between the pressure of said fluid coming from said distribution valve (100) and the pressure in said first chamber (11) exceeds a first predetermined value, and wherein said retaining system (30) is configured to regulate the flow of fluid exiting said first chamber (11) and directed to said distribution valve (100) based on a signal provided to said retaining system (30); said method comprising the following steps:

   a. Receive information corresponding to a request for the descent of said load (C3);
   b. Send to said retaining system (30) a signal for the descent of said load (C3);
   c. Adjust said retaining system (30) so as to execute said descent of said load according to said signal received by said retaining system (30) in said step b.;

   said method being **characterized by** the fact that said signal provided to said retaining system (30) during said step b. takes into account the weight of said load (C3) or a quantity dependent thereon so that the descent of said load (C3) satisfies at least one predetermined criterion, wherein said at least one predetermined criterion includes a maximum flow rate passing along said first feed conduit (20) through said retaining system (30) during said step of descent of said load (C3), so as to limit a rate of descent of said load (C3), wherein said maximum flow rate is adjusted by applying at least partially to a first reference function, which is a function having as its input said information corresponding to said request for descent of said load (C3) received in said step a. and as output a magnitude corresponding to a flow rate passing along said first supply conduit (20) during said descent phase, a first correction factor of said curve.

2. Method according to one claim 1, wherein said signal sent to said retaining system (30) in said step b. is a current signal on the basis of which the flow of fluid exiting said first chamber (11) and directed to said distribution valve (100) is regulated by means of the regulation of a pilot pressure, wherein the regulation of said retaining system (30) is carried out by means of the regulation of said current signal, which is supplied directly to an electro-proportional valve (32, 38) of said retaining system (30) so as to regulate said pilot pressure.

3. Method according to claim 2, wherein said electro-proportional valve (32, 38) is configured to regulate said pilot pressure of a balancing valve (31, 37) of said retaining system (30) positioned along said first conduit (20) based on said current signal, wherein said balancing valve (31, 37) is configured to open a passageway for a fluid coming from said distribution valve (100) and directed to said first chamber (11) if the pressure difference between the pressure of said fluid coming from said distribution valve (100) and the pressure in said first chamber (11) exceeds said first predetermined value, and wherein said balancing valve (31, 37) is configured to regulate the flow of fluid leaving said first chamber (11) and directed to said distribution valve (100) based on said piloting pressure.

4. Method according to claim 3, wherein said method further includes the following step:
   d. Detecting an initial value of said current signal before said balancing valve (31, 37) opens a flow of fluid along said first conduit (20) and thereby to initiate the descent of said load (C3), wherein said initial value of current is dependent on the weight of said load (C3) and preferably directly proportional to the weight of said load (C3).

5. Method according to any one of claims 1 to 4, wherein said first correction factor is inversely proportional to the weight of said load (C3) or a quantity dependent thereon.

6. A method according to any one of claims 1 to 5, wherein said signal provided to said retaining system (30) during said step b. further takes into account an information regarding a position of said load (C3) or a magnitude dependent thereon, wherein said maximum flow rate is adjusted by at least partially applying to a second reference function a second correction factor of said curve, wherein said second reference function is a function having as an input said information corresponding to said request for descent of said load (C3) received in said step a. and

as an output a quantity corresponding to a flow rate passing along said first supply conduit (20) during said descent step, wherein said second correction factor is preferably inversely proportional to a distance of said load (C3) from a main body (530) of said operating machine or to a quantity dependent thereon.

7. A method according to any one of claims 1 to 6, wherein said magnitude corresponding to said flow rate passing along said first supply conduit (20) is a value of said current signal, and wherein said maximum flow rate corresponds to a maximum flow rate value allowed during said descent phase.

8. Method according to claim 7, wherein said first and/or said second correction factor is applied, preferably by multiplication, to said first and/or said second reference function exclusively for values of said current signal corresponding to a flow of fluid exiting said first chamber (11) and directed to said distribution valve (100) other than zero.

9. A method according to any one of claims 1 to 8, wherein after correcting said first and/or said second reference function, a value of said current signal corresponding to said downward demand is calculated using said corrected first and/or said second reference function.

10. A method according to claim 9 when dependent on claim 6, wherein for each of said first and said second corrected reference functions said current signal corresponding to said downward demand is calculated, wherein in said step b. only one of said two calculated current signal values is sent to said retaining system (30), wherein said sent current signal value is a current signal value corresponding to a flow rate along said first conduit (20) which is the minimum of said two calculated current signal values.

11. A computing unit, preferably electronic control unit (99), containing means for performing a method according to any of the preceding claims.

12. A control system 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 comprising a first feed conduit (20) of said first chamber (11) of said cylinder (10), a second feed conduit (21) of said second chamber (12) of said cylinder (10), wherein an increase in the volume of said second chamber (12) is configured to cause a load supported by said cylinder (10) to descend downward, wherein said first feed conduit (20) and said second feed conduit (21) are connectable to a distribution valve (100) configured to control a feed operation and a discharge operation of said first feed conduit (20) and said second feed conduit (21), said control system comprising a retaining system (30) positioned along said first supply conduit (20) and configured to open a passageway for a fluid coming from said distribution valve (100) and directed to said first chamber (11) if the pressure difference between the pressure of said fluid coming from said distribution valve (100) and the pressure in said first chamber (11) exceeds a first predetermined value, and wherein said retaining system (30) is configured to regulate the flow of fluid exiting said first chamber (11) and directed to said distribution valve (100) based on a downward signal provided to said retaining system (30), wherein said control system comprises a computing unit according to claim 11.

13. Operating machine (1000) according to claim 19, wherein said operating machine (1000) comprises a main body (530) and a lifting arm (500) mechanically connected to said main body, wherein said actuator cylinder (10) is configured to provide relative movement of said lifting arm (500) relative to said main body (530).

14. A computer program comprising instructions which, when the program is executed by a computer, cause the computer to perform the steps of the method of any one of claims 1 to 10.

15. A computer-readable storage medium comprising instructions which, when executed by a computer, cause the computer to execute the method steps of any one of claims 1 to 10.

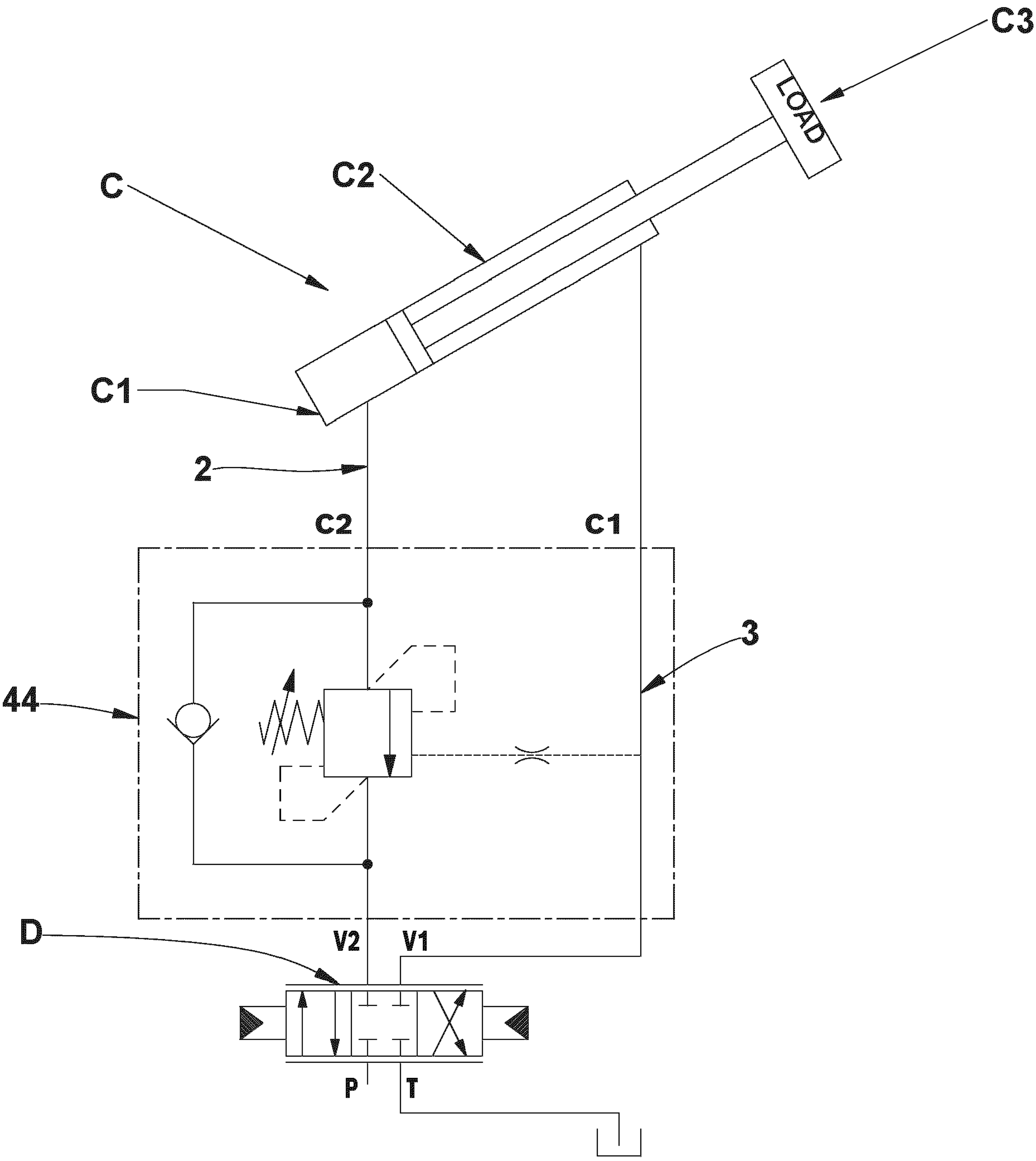

Fig.1

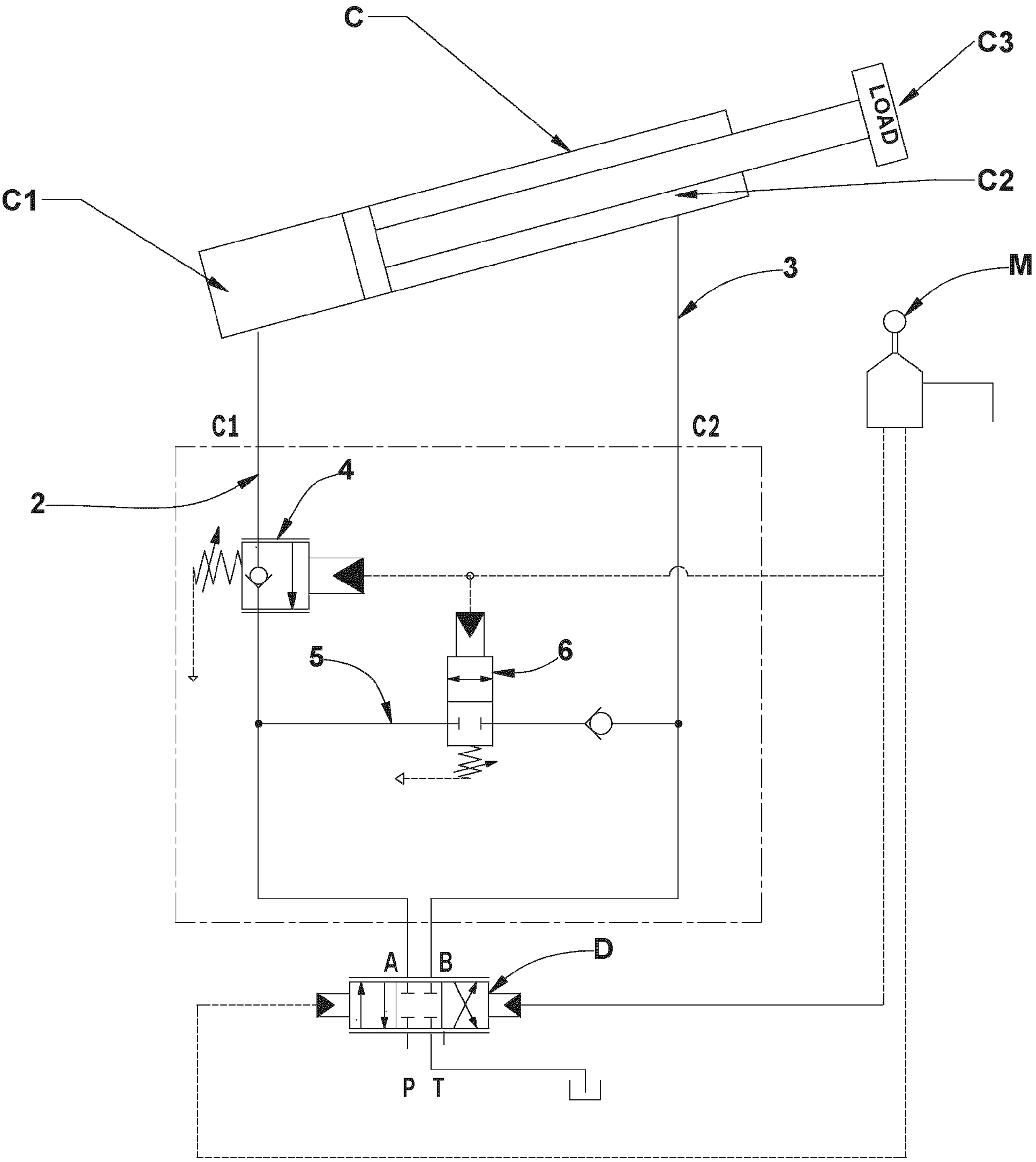

Fig.2

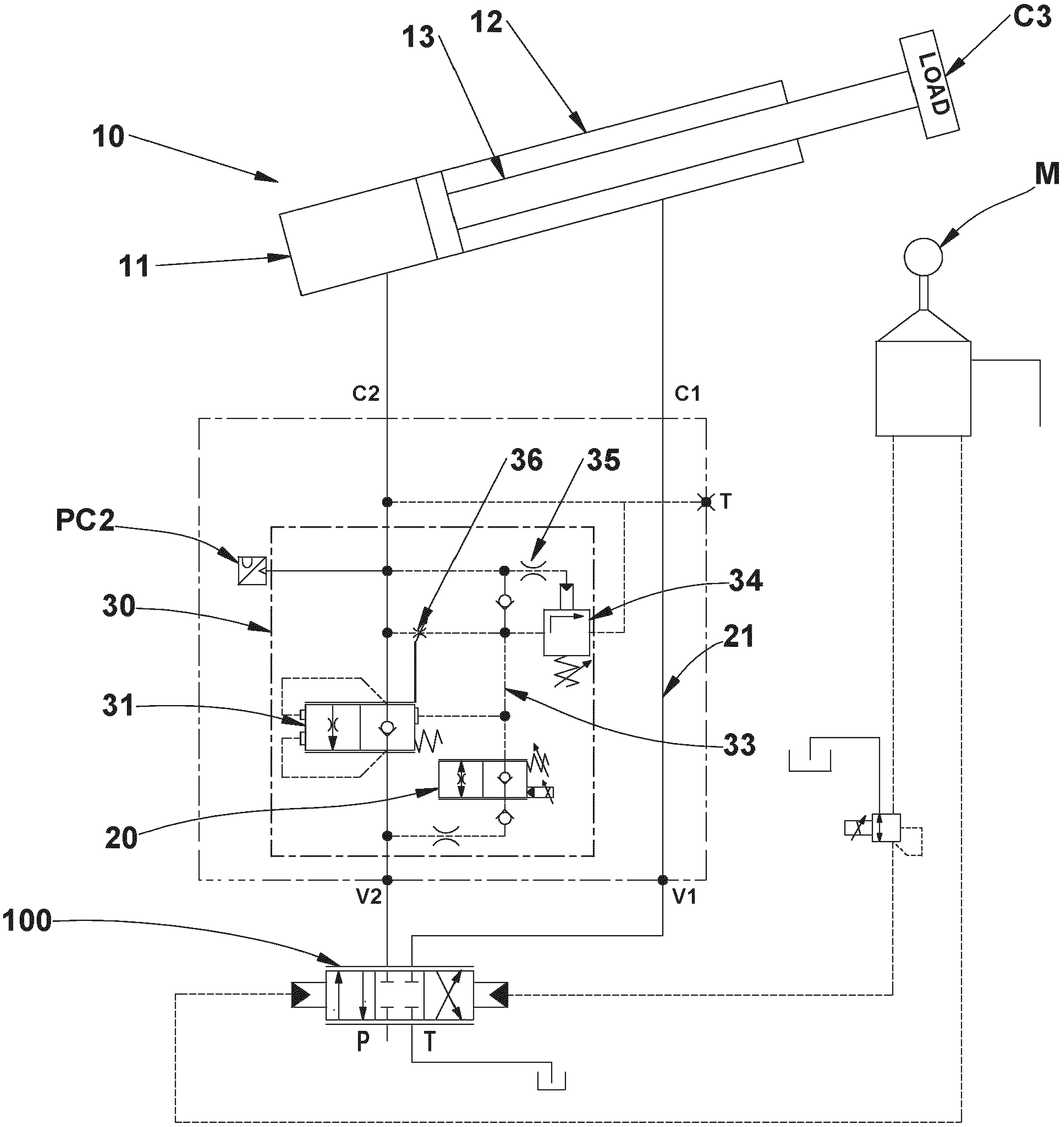

Fig.3

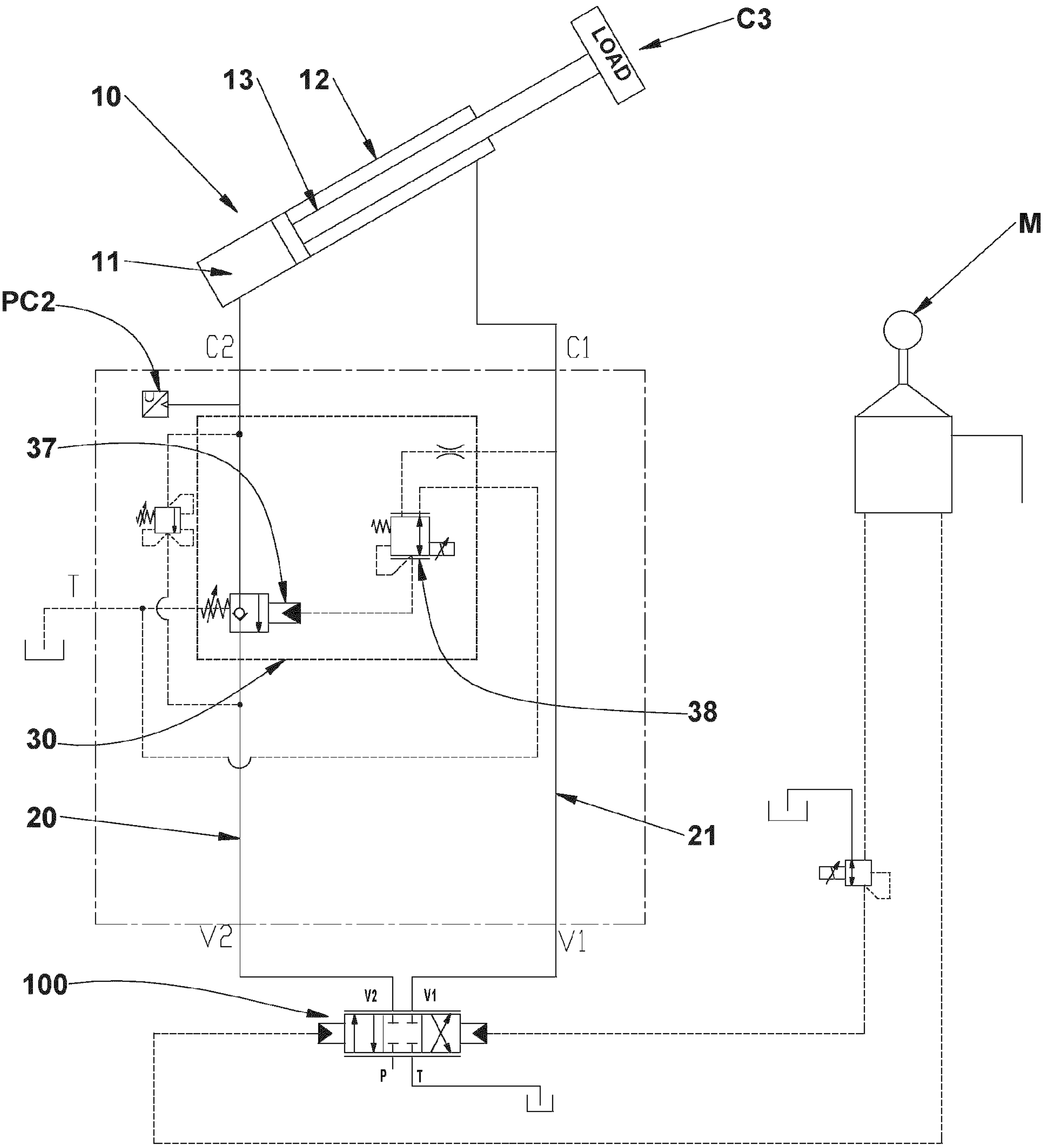

Fig.4a

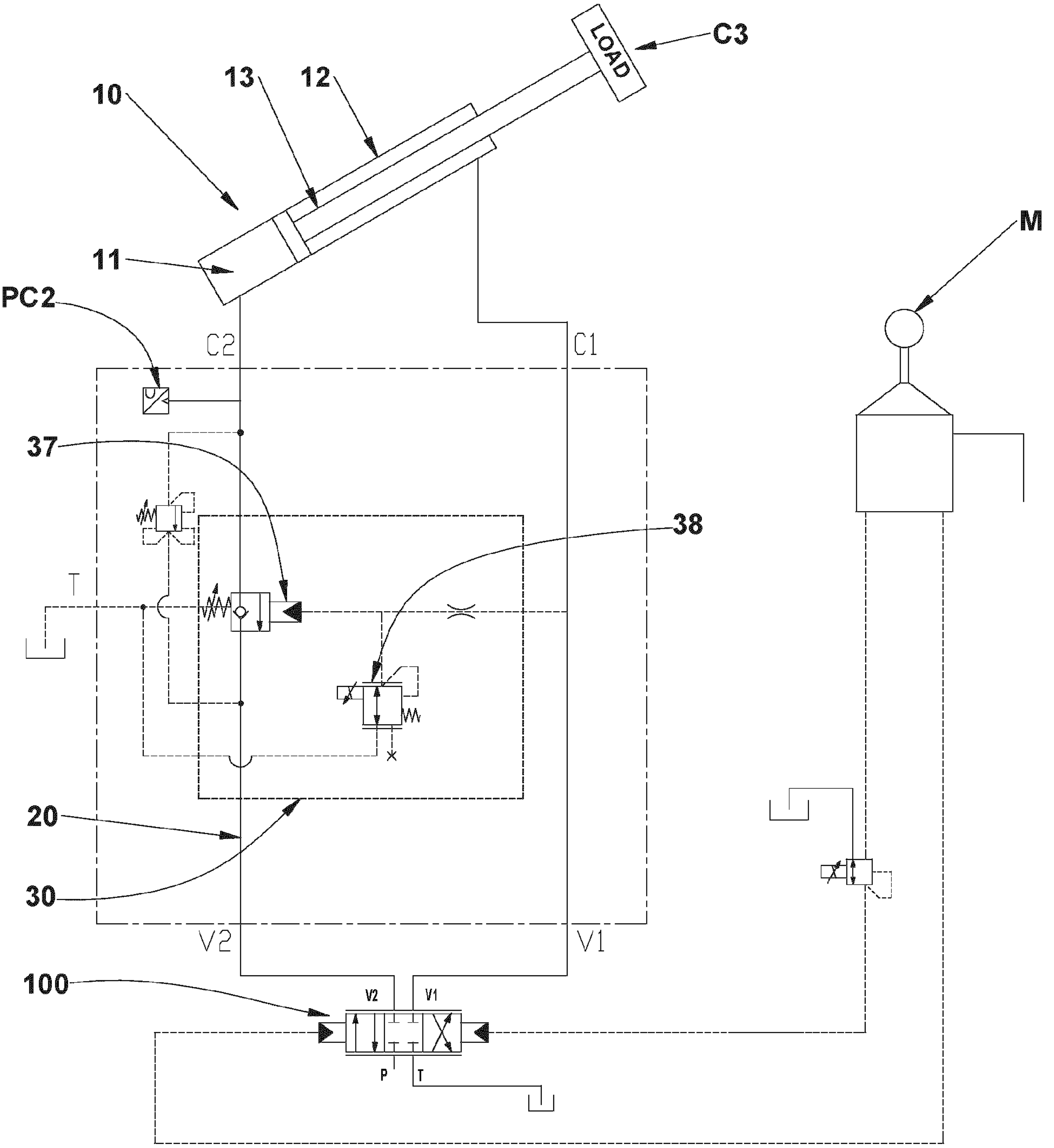

Fig.4b

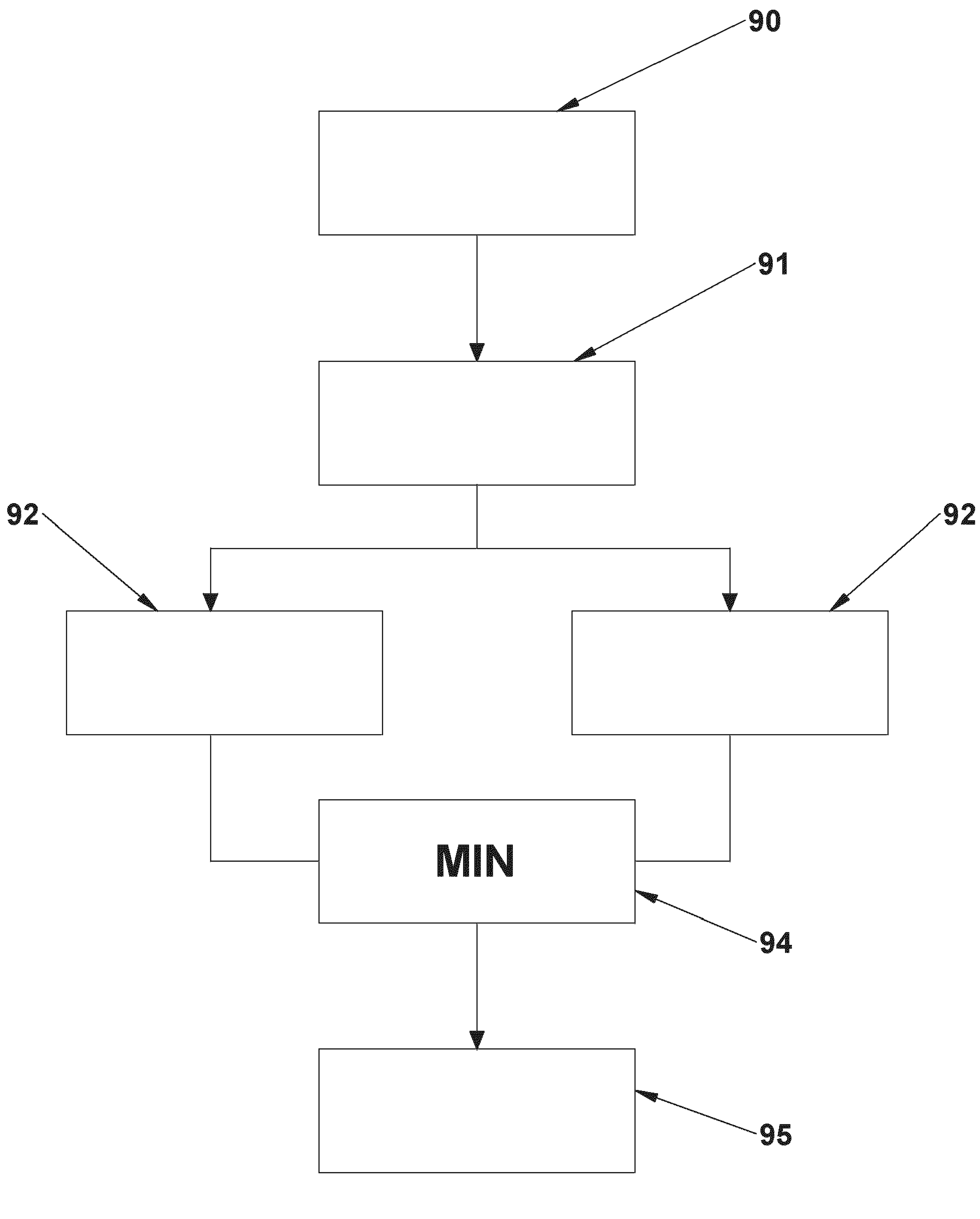

Fig.5

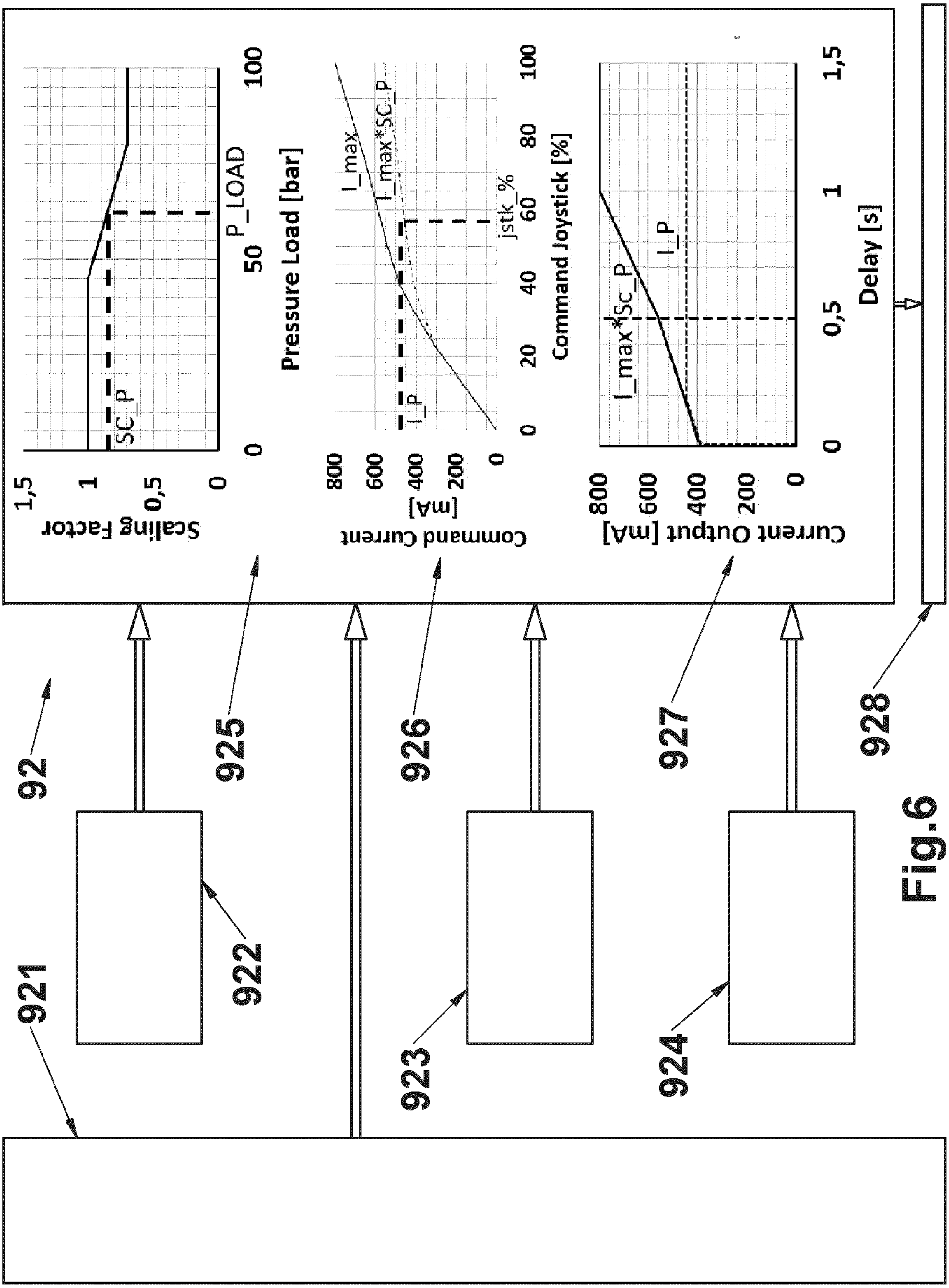
92
921
922
923
924
925
926
927
928
Scaling Factor
1,5
1
0,5
0
SC_P
P_LOAD
0
50
100
Pressure Load [bar]
Command Current [mA]
800
600
400
200
0
I_max
I_max*SC_P
I_P
jstk_%
0
20
40
60
80
100
Command Joystick [%]
Current Output [mA]
800
600
400
200
0
I_max*Sc_P
I_P
0
0,5
1
1,5
Delay [s]

Fig.6

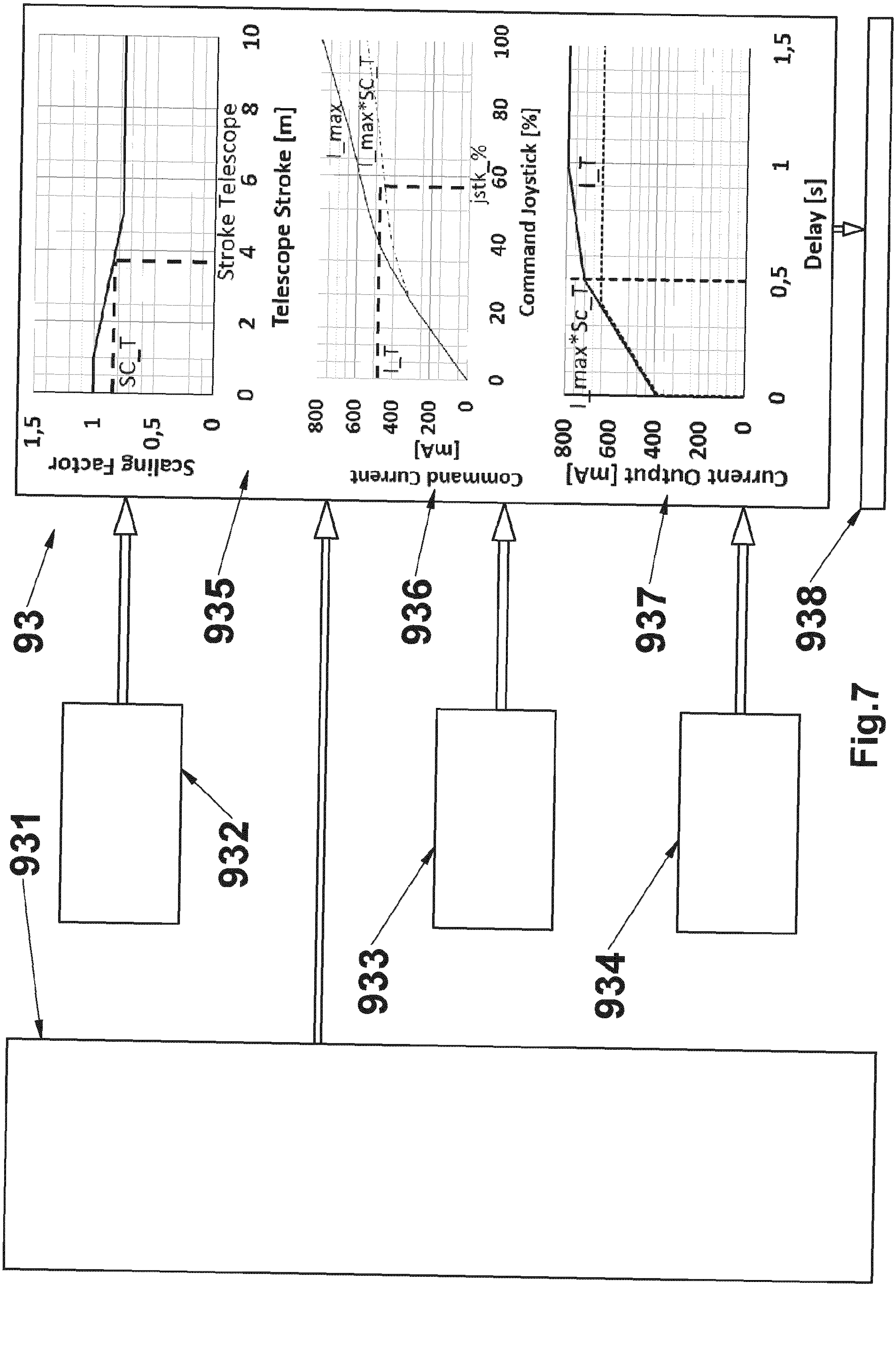
93
931
932
933
934
935
936
937
938
Scaling Factor
Stroke Telescope
Telescope Stroke [m]
SC_T
Command Current
[mA]
I_max
I_max*SC_T
I_T
jstk_%
Command Joystick [%]
Current Output [mA]
I_max*Sc_T
I_T
Delay [s]

Fig.7

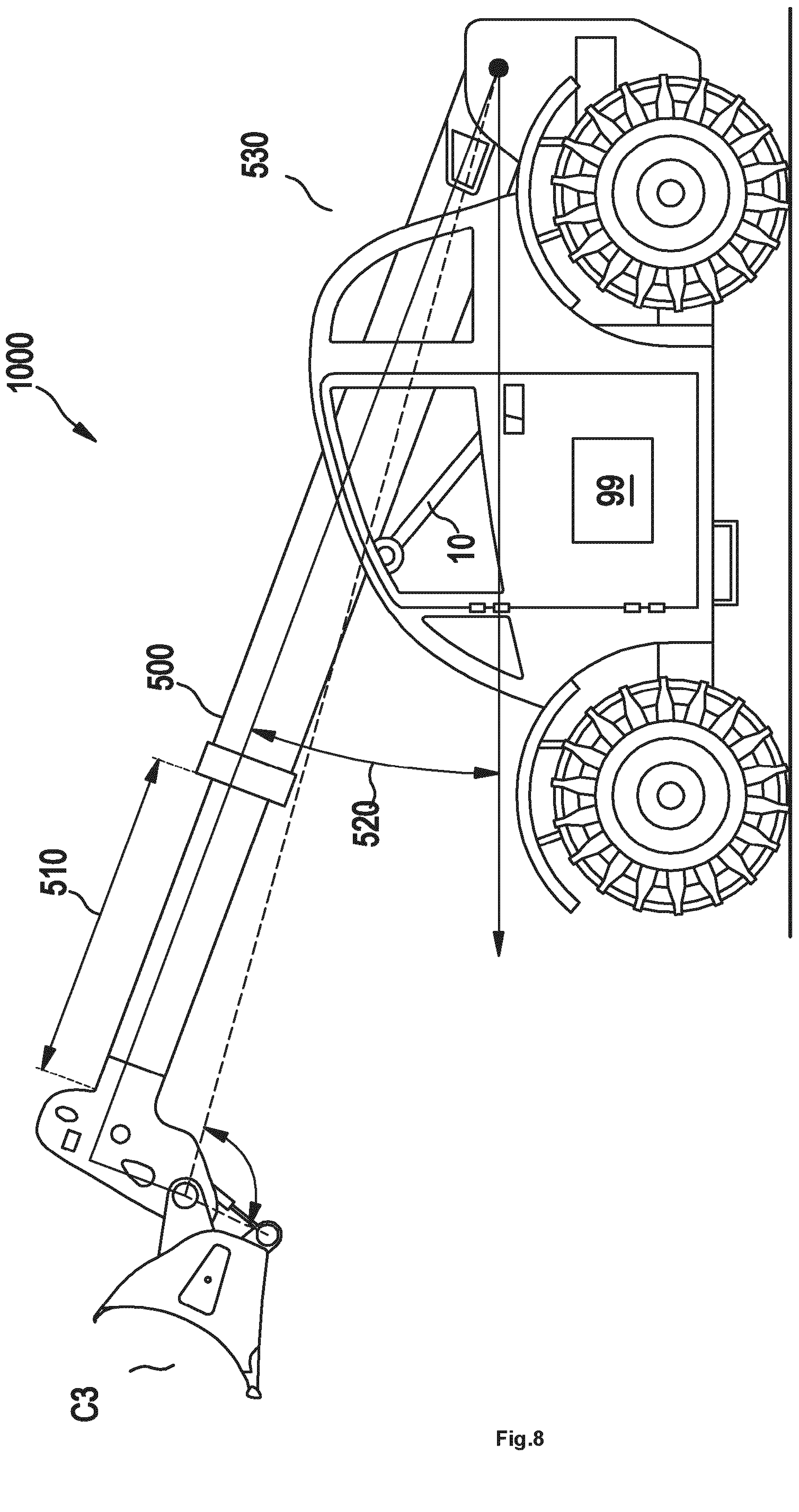

Fig.8

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 23 19 0030

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	JP H11 287206 A (KOBE STEEL LTD; YUTANI JUKO KK) 19 October 1999 (1999-10-19) * paragraphs [0033] - [0042] *	1-3,5-15 4	INV. F15B11/044
Y	JP 2000 255988 A (KOBELCO CONSTR MACHINERY LTD) 19 September 2000 (2000-09-19) * paragraphs [0062] - [0077]; figure 5 *	4	
A	US 11 225 981 B2 (CNH IND AMERICA LLC [US]) 18 January 2022 (2022-01-18) * column 2, line 34 - column 4, line 4 *	1	
A	US 10 794 510 B1 (PENA OSCAR [US] ET AL) 6 October 2020 (2020-10-06) * column 17, line 41 - column 20, line 58 *	1	
A	US 2013/298541 A1 (CARLIN JERRY FAYE [US] ET AL) 14 November 2013 (2013-11-14) * paragraphs [0051] - [0052] *	1	
			TECHNICAL FIELDS SEARCHED (IPC)
			F15B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	12 December 2023	Toffolo, Olivier

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

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 23 19 0030

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 The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

12-12-2023

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP H11287206 A	19-10-1999	NONE	
JP 2000255988 A	19-09-2000	JP 3536710 B2	14-06-2004
		JP 2000255988 A	19-09-2000
US 11225981 B2	18-01-2022	BR 112019022976 A2	19-05-2020
		EP 3619156 A1	11-03-2020
		ES 2891546 T3	28-01-2022
		US 2021156401 A1	27-05-2021
		WO 2018202659 A1	08-11-2018
US 10794510 B1	06-10-2020	NONE	
US 2013298541 A1	14-11-2013	CN 104379942 A	25-02-2015
		EP 2847469 A1	18-03-2015
		US 2013298541 A1	14-11-2013
		WO 2013169996 A1	14-11-2013

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- EP 2786959 A1 **[0005]**