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(54) **A method of controlling a control cylinder, as well as an agricultural machine for applying said method**

(57) A method of controlling a control cylinder (1), preferably constituted by a hydraulic control cylinder, provided with a housing accommodating a piston (3) with a piston rod (4), said piston dividing the housing into at least a first (5) and a second chamber (6), while a fluid, such as e.g. oil, can be supplied to or discharged from the first and second chamber via apertures (7,9) in the housing, characterized in that, when the piston has been moved in the housing over a predetermined distance and in a predetermined direction, there are activated first closing means (11) that close a shut-off valve (12), so that the amount of fluid between the piston and the shut-off valve at that side of the piston that is opposite to the direction of movement of the piston, remains constant or almost constant, after which the piston is still further moved in the housing over a distance X, X being greater than zero.

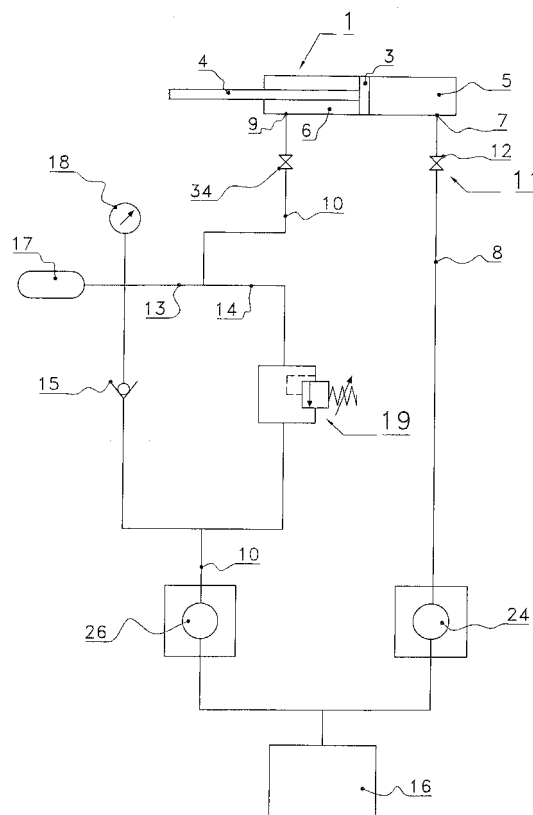


FIG. 1

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Description

[0001] The invention relates to a method of controlling a control cylinder, preferably constituted by a hydraulic control cylinder, provided with a housing accommodating a piston with a piston rod, said piston dividing the housing into at least a first and a second chamber, while a fluid, such as e.g. oil, can be supplied to or discharged from the first and second chamber via apertures in the housing.

[0002] Such a method of controlling a control cylinder is generally known.

[0003] It is an object of the invention to obtain a method in which the control cylinder is optimally used for certain purposes.

[0004] According to the invention, this is achieved in that, when the piston has been moved in the housing over a predetermined distance and in a predetermined direction, there are activated first closing means that close a shut-off valve, so that the amount of fluid between the piston and the shut-off valve at that side of the piston that is opposite to the direction of movement of the piston, remains constant or almost constant, after which the piston is still further moved in the housing over a distance X in the direction of movement, X being greater than zero. During the time when the piston is moved over a distance X, fluid is not supplied to and discharged from one chamber. In most cases there is applied a partial vacuum to the relevant chamber. When such a control cylinder is disposed e.g. in an agricultural machine, such as e.g. a mowing machine, the piston of the relevant control cylinder can freely be moved over a distance X, which is advantageous for example when the control cylinder is used for bringing the machine from the transport position into the working position and the control cylinder can thus follow irregularities in the field without being blocked. According to a further inventive feature, the method also comprises first closing means that are activated automatically. In the example of the mowing machine this has the advantage that the operator on the tractor needs not to decide himself on the activation of the closing means. Because the moment of activating the first closing means may vary with the machine used, the method also includes that the automatic activation of the first closing means is adjustable. According to again another method of the invention, it is also possible to determine, with the aid of registration means, the moment when the first closing means have to be activated. It is also possible to alert the operator, by means of acoustic or optical signals, that the first closing means have to be activated or are being activated. Using the above-mentioned method it is possible to create an absolute or almost absolute stop point for the piston when a non-compressible or hardly compressible fluid is applied and when the piston is moved in a second direction, opposite to the first direction of movement, while the first shut-off valve remains closed and as a result thereof the piston can be moved maximally over

the distance X. When a compressible fluid, such as air or an other gas, is applied, there is indeed created a stop, but, depending on the force exercised on the piston and the piston rod, the distance over which the piston can maximally be moved may be greater than the distance X. According to a further inventive feature, the method also includes that, after the first closing means have been activated, via a first non-return valve, pressure is built up by the fluid in that chamber of the housing that is not in connection with the first shut-off valve, which chamber will be called hereinafter the second chamber, until a value has been reached that is greater than or equal to the opening pressure of second closing means that are in connection with the second chamber, after which the pressure built up in the second chamber flows away along the second closing means until a value has been reached that is lower than that of the opening pressure of the second closing means. In this manner it is possible to give the piston with the piston rod one adjustable force in the first direction of movement. In the situation that the control cylinder is disposed in a mowing machine, it is thus possible, by applying the above-mentioned method, to adjust the pressure with which the cutter bar bears on the ground during operation of the machine. It will be obvious that adjustment of the ground pressure with other machines, in particular agricultural machines, is possible as well. According to again another inventive feature, the method also includes that, during building up of the pressure in the second chamber, pressure is applied by the fluid to an accumulator that is in connection with the second chamber. Using an accumulator has the advantage that unexpected forces that are exercised on the piston and the piston rod can be absorbed in the accumulator while the pressure in the entire system is maintained. According to a further inventive feature, the method also includes that, after the first closing means have been deactivated, the piston is moved in the second direction of movement over a greater distance than the distance X. By the deactivation of the first closing means the blocking in the control cylinder of the piston is removed. According to again another aspect of the invention, the method also includes that the deactivation of the first closing means takes place manually or automatically. According to an inventive feature, the automatic deactivation of the first closing means can be controlled directly or indirectly by the movement of the piston in the housing. In the situation that the control cylinder is applied in a mowing machine or an other agricultural implement, after the deactivation of the first closing means it is thus possible to bring the machine e.g. from the working position into the transport position. According to a further inventive feature it is also possible that, after the first closing means have been deactivated, fluid is supplied to the first chamber and fluid flows from the second chamber, the flow velocity of the fluid being determined by flow control means that determine the outflow velocity from the second chamber. In this manner it is prevented that a vacuum is cre-

ated in the first chamber due to the fact that the piston, e.g. under the influence of a heavy load, is moved too quickly in the direction of the second chamber. According to again another inventive feature, the outflow velocity of the fluid from the second chamber is adjustable.

[0005] The invention also relates to an agricultural machine, adapted for applying the method as described above and provided with at least one working member which, by means of a control cylinder comprising two chambers with a fluid, separated by a movable piston, can be brought into a first transport position corresponding with a first piston position in which a first chamber contains a first amount of fluid, or into one or more working positions each corresponding with a further piston position in which the first chamber contains a further amount of fluid that is larger than the first amount, characterized in that the machine is provided with means that are adapted, when the working member is in one of the working positions, for automatically controlling the amount of fluid in the first chamber in such a manner that the working member cannot reach the transport position. According to a further inventive feature, the means keep the amount of fluid in the first chamber almost constant.

[0006] The invention further also relates to an agricultural machine provided with a control cylinder and provided with a housing accommodating a piston with a piston rod, said piston dividing the housing into at least a first and a second chamber, and with first closing means with a first shut-off valve, said agricultural machine being adapted for applying the method as described above. According to an inventive feature, the first shut-off valve is designed as a non-return valve or a multistage cock or a slide valve or a valve. It will be obvious that in that case the multistage cock produces the same effect as the non-return valve. According to again another inventive feature, the first shut-off valve may be designed as a cock. According to again another aspect of the invention, the agricultural machine comprises second closing means as described in the above-mentioned method. According to a further inventive feature, the second closing means comprise at least one non-return valve. According to again another inventive feature, the second closing means may have a non-return valve or a cock or a slide valve with a controllable opening pressure. However, it will be obvious that the second closing means may also comprise other multistage cocks or slide valves or valves known per se with the aid of which the same effect is obtained. According to again another inventive feature, the second chamber is connected with an accumulator. According to a further aspect of the invention, the second closing means comprise a multistage cock or a slide valve or a valve that is adapted for making the fluid flow from the second chamber in a certain position of the cock. According to a further inventive feature, the multistage cock is in connection with a throttle valve and/or is included in a smaller line than the line that is in connection with the first

chamber. According to another aspect of the invention, the aforementioned registration means comprise a mechanical switch. According to another inventive feature, the aforementioned registration means may also comprise a clinometer. In a preferred embodiment of the invention, the control cylinder is designed as a hydraulic control cylinder. The above-mentioned method and control cylinder can in particular be applied with a mowing machine to be coupled to the three-point lifting hitch of a tractor.

[0007] The method of controlling the control cylinder, and the agricultural machine adapted for applying the method for the control cylinder will now be explained in further detail with reference to the accompanying figures in which:

Figure 1 is a first embodiment of a control diagram for a control cylinder according to the invention;

Figure 2 is a second embodiment of a control diagram for a control cylinder, in which the control cylinder is shown in a first position corresponding with the transport position when the control cylinder is disposed in a mowing machine;

Figure 3 shows the working position of the control cylinder according to Figure 1 when it is applied to the mowing machine;

Figure 4 is a third embodiment of a control diagram for a control cylinder, showing the control cylinder in a first position corresponding with the transport position when the control cylinder is applied to a mowing machine;

Figure 5 shows the working position of the control cylinder according to Figure 4 when it is applied to the mowing machine, and

Figure 6 is a front view of the mowing machine, the control cylinder according to Figures 2 to 5 being included therein.

[0008] Figure 1 shows a control diagram for controlling a control cylinder 1, preferably constituted by a hydraulic control cylinder, provided with a housing 2 accommodating a piston 3 with a piston rod 4. The piston 3 divides the housing into a first chamber 5 and a second chamber 6. Via a first aperture 7 and via a first line 8 coming from a (non-shown) source, a fluid can be brought into the first chamber 5 or flow away therefrom. Via a second aperture 9 and a second line 10 the fluid can flow respectively into and from the second chamber 6. In the first line 8 there are included first closing means 11 comprising in the present embodiment a shut-off valve 12 that is designed as a cock. However, it will be obvious that instead of a cock it is also possible to apply an other type of shut-off valve, such as e.g. a slide valve or a valve having the same function. The second line 10 splits up into a third line 13 and a fourth line 14 which join later to form the second line 10. In the third line 13 there is included a first non-return valve 15 allowing the fluid to pass from a source 16 in the direction of the sec-

ond chamber 6. To the third line 13 between the first non-return valve 15 and the second chamber 6 there is further connected an accumulator with a manometer 18. In the fourth line 14 there are included second closing means 19 along which the fluid can only flow from the chamber 6 to the source 16. The second closing means 19 are preferably designed as closing means with a controllable opening pressure. In the present embodiment the second closing means 19 are constituted by a non-return valve with controllable opening pressure. As shown in Figure 6, the control cylinder 1 can e.g. be applied to a mowing machine 20 with a cutter bar 27 as shown in Figure 6. From the source 16 fluid can be supplied to respectively discharged from the first line 8 and the second line 10 by means of third closing means 26.

[0009] Figure 2 and Figure 3 show a second embodiment of a control cylinder 1 with a control diagram related thereto in which parts corresponding with those of the first embodiment are indicated by the same reference numerals. In the second embodiment the first closing means 11 comprise a slide valve 21 as shown in Figure 2. In the present embodiment the slide valve 21 is constituted by a 6/2-valve that is mechanically controllable against spring pressure. However, it will be obvious that instead of the valve 21 shown it will also be possible to realize the same control with the aid of cocks or other shut-off valves or valves known per se. The first closing means 11 further comprise a shut-off valve 12 included in the first line 8 and designed as a non-return valve. Via the non-return valve 12 the fluid can flow back from the first chamber 5 to the source 16. As shown in Figures 2 and 3, there is provided between the first closing means 11 and the source 16 a fifth line 22 in which a throttle valve 23 is included. Figure 2 shows the first closing means 11 in the deactivated position, while Figure 3 shows the first closing means 11 in the activated position.

[0010] As shown in Figures 2 and 3, by means of a first closing element 24 that is connected to the first line 8, a fluid can be supplied to or discharged from the source 16. By means of a second closing element 25 it is possible in an analogous manner to supply or discharge the fluid from the source 16 through the fifth line 22, while by means of a third closing element 26 it is also possible to supply and discharge the fluid from the source 16 through the second line 10. In the case that the control cylinder 1 is applied to an agricultural machine, it is possible to design the first and second closing element 24, 25 as a double-acting valve and the third closing element 26 as a single-acting valve. In the embodiment of Figure 1 the same closing elements are applied as in the second embodiment, however with this distinction that to the first line 8 only one first closing element 24 is connected. The function of the control cylinder 1 of the second embodiment will now be explained in further detail with reference to Figure 6 in which the control cylinder 1 is included in a mowing machine 20 provided with a cutter bar 27 and being able to be cou-

pled with a (non-shown) tractor by means of a coupling trestle 28. By means of the control cylinder 1 the cutter bar 27 is pivotable from a transport position indicated by the reference numeral 29 to a working position indicated by the reference numeral 30. In the transport position 29 the cutter bar 27 encloses an angle of approximately 120° with the horizontal. The transport position 29 shown in Figure 6 corresponds with the position shown in Figure 2 of the piston 3 and the first and second closing means 11, 19. For the purpose of bringing the machine into the working position 30 the second closing element 25 is controlled, so that the fluid flows from the first line 8 into the first chamber 5 and the piston 3 is moved to the right. The fluid present in the chamber 6 can flow away to the source 16 via the aperture 9 and the second line 10 and the fifth line 22 with the throttle valve 23 included therein. It will be obvious that in that situation the second closing element 25 must be opened. During moving the cutter bar 27 to the working position 30, there is exercised a force on a roll element 31 of the first closing means 11 by a curve disc 32 shown in Figure 6 on the shut-off valve 12, so that the latter remains against spring pressure in the position shown in Figure 2. At the moment when the cutter bar 27 assumes an intermediate position that is indicated by the reference numeral 33 in Figure 6, the roll element 31 comes loose from the curve disc 32, so that the spring belonging to the shut-off valve 12 activates the shut-off valve and the latter assumes the position shown in Figure 3. However, it will be obvious that it is also possible to choose another way of mechanical control of the shut-off valve 12. During switching of the first closing means 11 the cutter bar 27 is located approximately at an angle of 20° with the horizontal. The throttle valve 23 ensures that, before the control means 11 are activated, it is prevented that a vacuum is created in the first chamber 5 as a result of the fact that the weight of the cutter bar 27 pulls the piston rod 4 with a rather great force. After the first closing means 11 have been activated, fluid cannot flow into or from the chamber 5 and the first line 8, because this is prevented by the non-return valve 12. However, under the influence of the weight of the cutter bar 27 the piston 3 will be moved over a distance X to the right until the cutter bar 27 bears on the ground in the working position 30. It will be obvious that a partial vacuum is then applied to the first chamber 5. By controlling the third closing element 26 fluid is subsequently brought into the second chamber 6 via the second line 10. The operator has to ensure that the cutter bar 27 is only raised over a small height, in any case not higher than the intermediate position 33. In this manner pressure is applied to the accumulator 17. By subsequently opening the third closing element 26 and bringing it into the so-called floating position, the fluid flows back via the second closing means 19, until the pressure set by said second closing means 19 has been reached. When this pressure has been reached, the second closing means 19 automatically close the fourth line 14. Also via

the third line 13 it is impossible for fluid to flow back to the source 16, because the first non-return valve 15 is included in said line. In this manner it is possible to set the maximum pressure with which the cutter bar 27 bears on the ground. At the moment when the cutter bar 27 has to be taken temporarily from the working position 30, e.g. upon turning of the mowing machine 20 with the tractor at the end of a working run, the third closing element 26 is controlled again, so that the second chamber 6 is filled with fluid from the source 16. During raising of the cutter bar 27 the first and second closing element 24 and 25 remain closed. It will be obvious that the piston 3 is then allowed to move maximally over a distance X to the left, as the vacuum applied earlier to the first chamber 5 is then removed, and the piston 3 is stopped by the fluid present in the chamber 5. In this manner there is formed a stop created by the fluid for the movement of the cutter bar 27. After the cutter bar 27 with the tractor has turned, it is possible to lower it again by controlling the third closing element 26, in such a manner that the fluid can flow from the second chamber 6 to the source 16. The fluid will then flow until the pressure set by the second closing means 19 has been reached. If it is desired to bring the machine into the transport position 29, the blockage created by the fluid has to be removed, which is possible by opening the first closing element 24, so that the fluid can flow from the first chamber 5 to the source 16 as shown in Figure 2. For the purpose of transporting the cutter bar 27 safely in the transport position 29, there is included in the second line 10 a third shut-off valve 34 which is preferably controlled manually and which prevents fluid from flowing from the second chamber 6, which would enable the cutter bar 27 to pivot from the transport position 29 into the working position 30. The embodiment shown in Figure 1 functions generally in the same manner as the second embodiment, but in the first embodiment the first closing means are closed automatically and have to be reopened manually for pivoting the machine from the working position 30 or from the intermediate position 33 to the transport position 29.

[0011] Figure 3 and Figure 4 show a third embodiment of a control cylinder 1 with a control diagram related thereto, in which parts corresponding to those of the first and the second embodiment are indicated by the same reference numerals. The third embodiment only differs from the second embodiment in that the slide valve 21 is a 6/2-valve which is mechanically controllable against spring pressure and which, in the position shown in Figure 4, interconnects the line 10 and also connects the line 10 with the line 22. Said valve also interconnects the line 8 and connects the line 8 with the line in which the non-return valve 12 is included. The slide valve 21 applied in the third embodiment has relative to the second embodiment the advantage that, if the stop of the piston 3 is only reached after the distance over which the piston 3 has moved in the housing 2 is greater than the distance X, the control cylinder 1 can still be control-

led by means of the third closing element 26, which is not possible in the second embodiment in which the control cylinder 1 can exclusively be controlled by means of the second closing element 25. In particular when at the end of a working run the cutter bar 27 has to be raised temporarily for a short while and has to be brought short thereafter into the working position 30, this can be achieved in the third embodiment by exclusively controlling the third closing means 26. It will be obvious that this offers considerable advantages for the control and that mistakes in controlling the control cylinder 1 are minimized, irrespective of the fact whether the slide valve 21 is activated or deactivated (switched).

Claims

1. A method of controlling a control cylinder, preferably constituted by a hydraulic control cylinder, provided with a housing accommodating a piston with a piston rod, said piston dividing the housing into at least a first and a second chamber, while a fluid, such as e.g. oil, can be supplied to or discharged from the first and second chamber via apertures in the housing, **characterized in that**, when the piston has been moved in the housing over a predetermined distance and in a predetermined direction, there are activated first closing means that close a shut-off valve, so that the amount of fluid between the piston and the shut-off valve at that side of the piston that is opposite to the direction of movement of the piston, remains constant or almost constant, after which the piston is still further moved in the housing over a distance X in the direction of movement, X being greater than zero.
2. A method as claimed in claim 1, **characterized in that** the first closing means are activated automatically.
3. A method as claimed in claim 2, **characterized in that** the moment of automatically activating the first closing means is adjustable.
4. A method as claimed in claim 1 or 2, **characterized in that** the moment when the first closing means have to be activated is determined with the aid of registration means.
5. A method as claimed in any one of the preceding claims, **characterized in that**, when the piston is moved in a second direction, opposite to the first direction of movement, the first shut-off valve remains closed and as a result thereof the piston can be moved maximally over the distance X.
6. A method as claimed in any one of the preceding claims, **characterized in that**, after the first closing

means have been activated, via a first non-return valve, pressure is built up by the fluid **in that** chamber of the housing that is not in connection with the first shut-off valve, which chamber will be called hereinafter the second chamber, until a value has been reached that is greater than or equal to the opening pressure of second closing means that are in connection with the second chamber, after which the pressure built up in the second chamber flows away along the second closing means until a value has been reached that is lower than that of the opening pressure of the second closing means.

7. A method as claimed in claim 6, **characterized in that**, during building up of the pressure in the second chamber, pressure is applied by the fluid to an accumulator that is in connection with the second chamber.
8. A method as claimed in any one of the preceding claims, **characterized in that**, after the first closing means have been deactivated, the piston is moved in the second direction of movement over a greater distance than the distance X.
9. A method as claimed in claim 8, **characterized in that** the deactivation of the first closing means takes place manually.
10. A method as claimed in any one of claims 1 to 8, **characterized in that** the deactivation of the first closing means takes place automatically.
11. A method as claimed in claim 10, **characterized in that** the deactivation of the first closing means is controlled directly or indirectly by the movement of the piston in the housing.
12. A method as claimed in any one of claims 8 to 11, **characterized in that**, after the first closing means have been deactivated, fluid is supplied to the first chamber and fluid flows from the second chamber, the flow velocity of the fluid being determined by flow control means that determine the outflow velocity from the second chamber.
13. A method as claimed in claim 12, **characterized in that** the outflow velocity of the fluid from the second chamber is adjustable.
14. An agricultural machine, adapted for applying the method as described in any one of claims 1 to 13, provided with at least one working member which, by means of a control cylinder (1) comprising two chambers (5, 6) with a fluid, separated by a movable piston (3), can be brought into a first transport position corresponding with a first piston position in which a first chamber (5) contains a first amount of

fluid, or into one or more working positions each corresponding with a further piston position in which the first chamber (5) contains a further amount of fluid that is larger than the first amount, **characterized in that** the machine is provided with means that are adapted, when the working member is in one of the working positions, for automatically controlling the amount of fluid in the first chamber (5) in such a manner that the working member cannot reach the transport position.

15. An agricultural machine as claimed in claim 14, **characterized in that** the means keep the amount of fluid in the first chamber almost constant.
16. An agricultural machine provided with a control cylinder and provided with a housing (2) accommodating a piston (3) with a piston rod (4), said piston (3) dividing the housing (2) into at least a first (5) and a second chamber (6), and with first closing means (11) with a first shut-off valve (12), said agricultural machine being adapted for applying the method as claimed in any one of claims 1 to 13.
17. An agricultural machine as claimed in claim 16, **characterized in that** the first shut-off valve (12) is designed as a non-return valve or a multistage cock or a slide valve or a valve.
18. An agricultural machine as claimed in claim 16, **characterized in that** the first shut-off valve (12) is designed as a cock or a slide valve or a valve as shown in Figures 2 to 5 with reference numeral 21.
19. An agricultural machine as claimed in any one of claims 12 to 18, **characterized in that** the agricultural machine is provided with second closing means (19) as described in any one of claims 4 to 12.
20. An agricultural machine as claimed in claim 19, **characterized in that** the second closing means (19) comprise at least one non-return valve.
21. An agricultural machine as claimed in claim 19 or 20, **characterized in that** the second closing means (19) have a non-return valve or a cock or a slide valve with a controllable opening pressure.
22. An agricultural machine as claimed in any one of claims 16 to 21, **characterized in that** the second chamber (6) is connected with an accumulator (17).
23. An agricultural machine as claimed in any one of claims 16 to 22, **characterized in that** the second closing means (19) comprise a multistage cock that is adapted for making the fluid flow from the second chamber (6) in a certain position of the cock.

24. An agricultural machine as claimed in claim 23, **characterized in that** the multistage cock or slide valve or valve (21) is in connection with a throttle valve (23) and/or is included in a smaller line (22) than the line that is in connection with the first chamber (5). 5
25. An agricultural machine as claimed in any one of claims 16 to 24, **characterized in that** the registration means comprise a mechanical switch (31; 32). 10
26. An agricultural machine as claimed in any one of claims 16 to 24, **characterized in that** the registration means comprise a clinometer. 15
27. An agricultural machine as claimed in any one of claims 14 to 26, **characterized in that** the control cylinder (1) is constituted by a hydraulic cylinder. 20
28. An agricultural machine as claimed in any one of claims 14 to 27, **characterized in that** the machine is constituted by a mowing machine (20). 25

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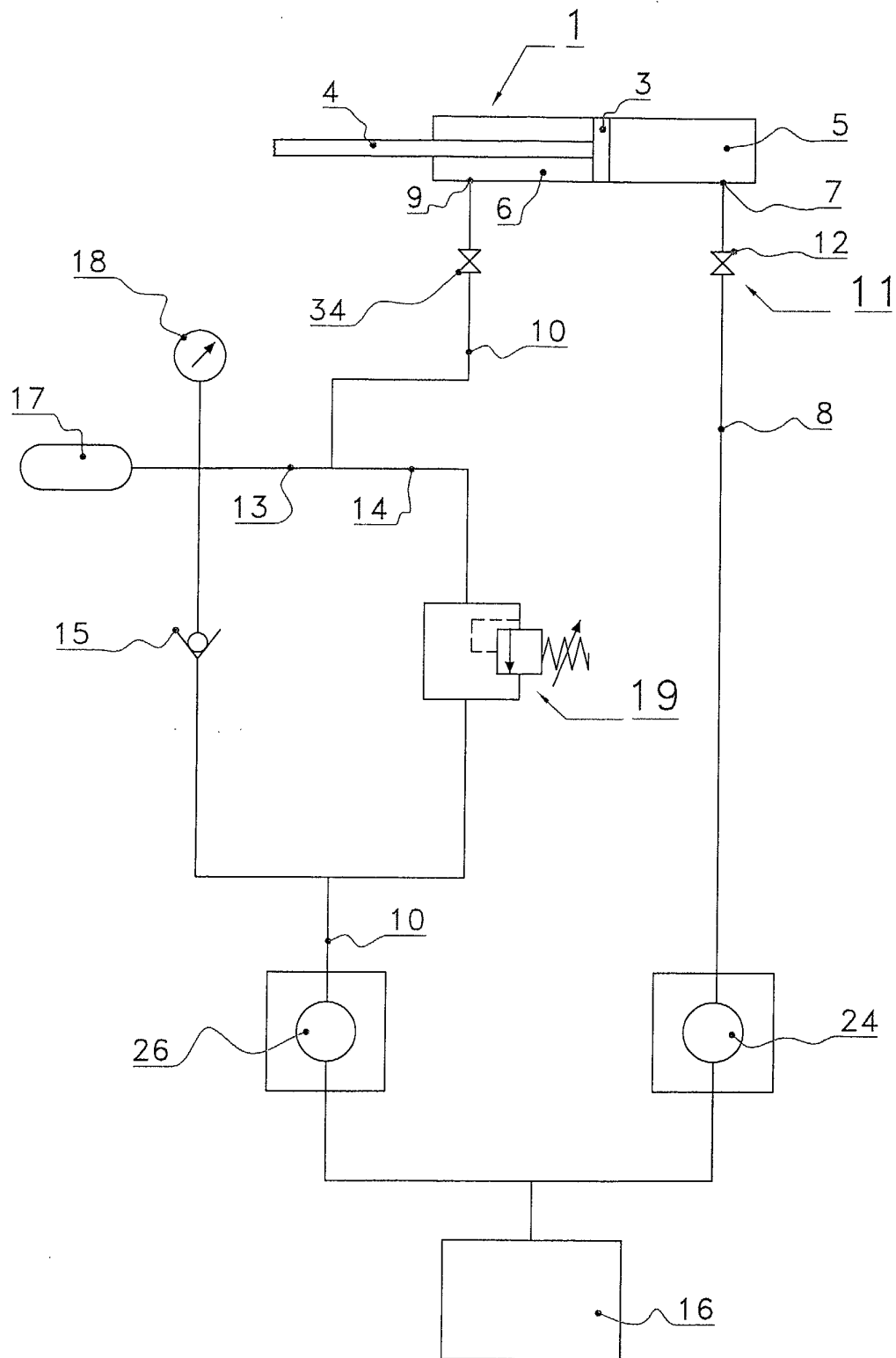


FIG. 1

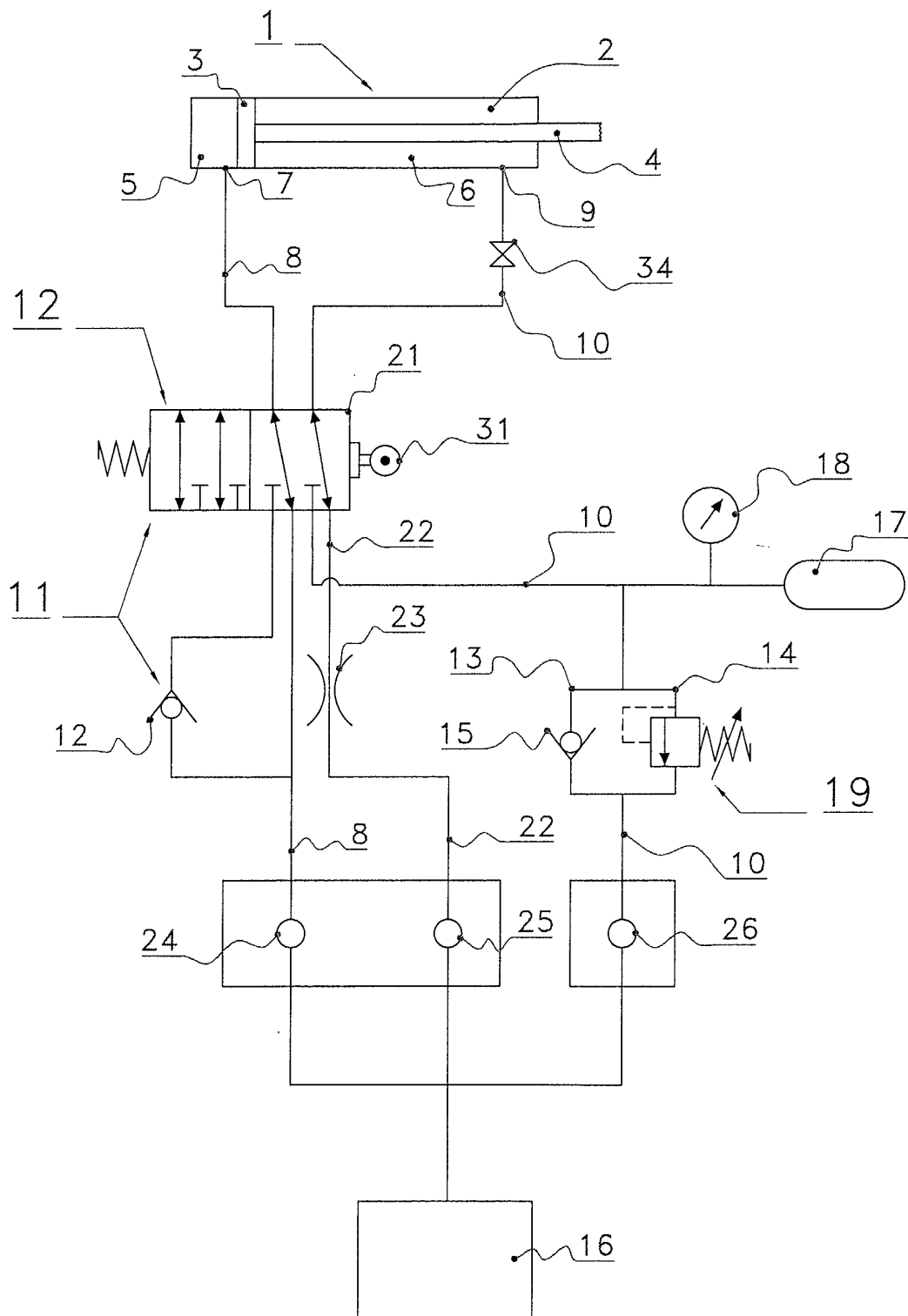


FIG. 2

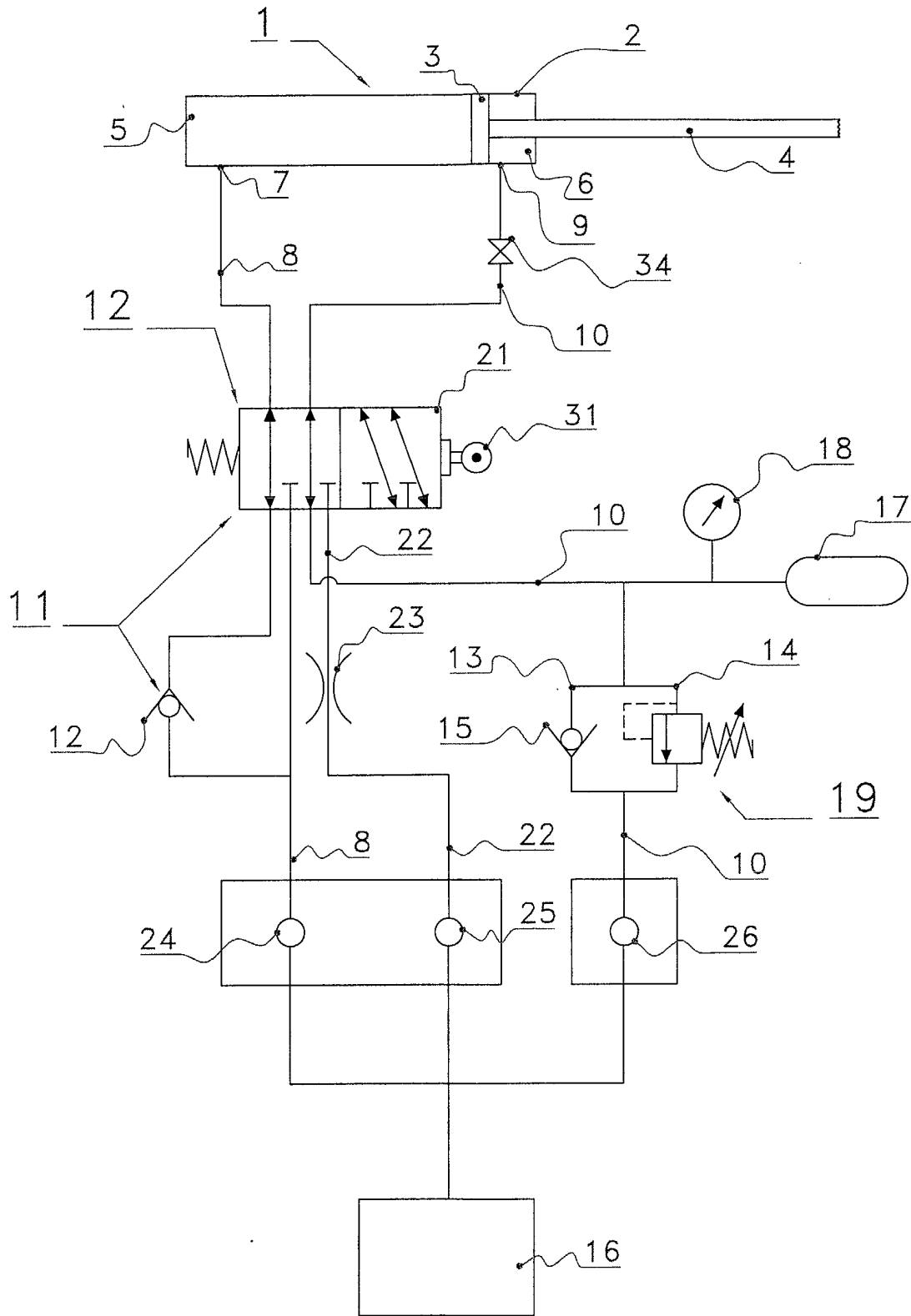


FIG. 3

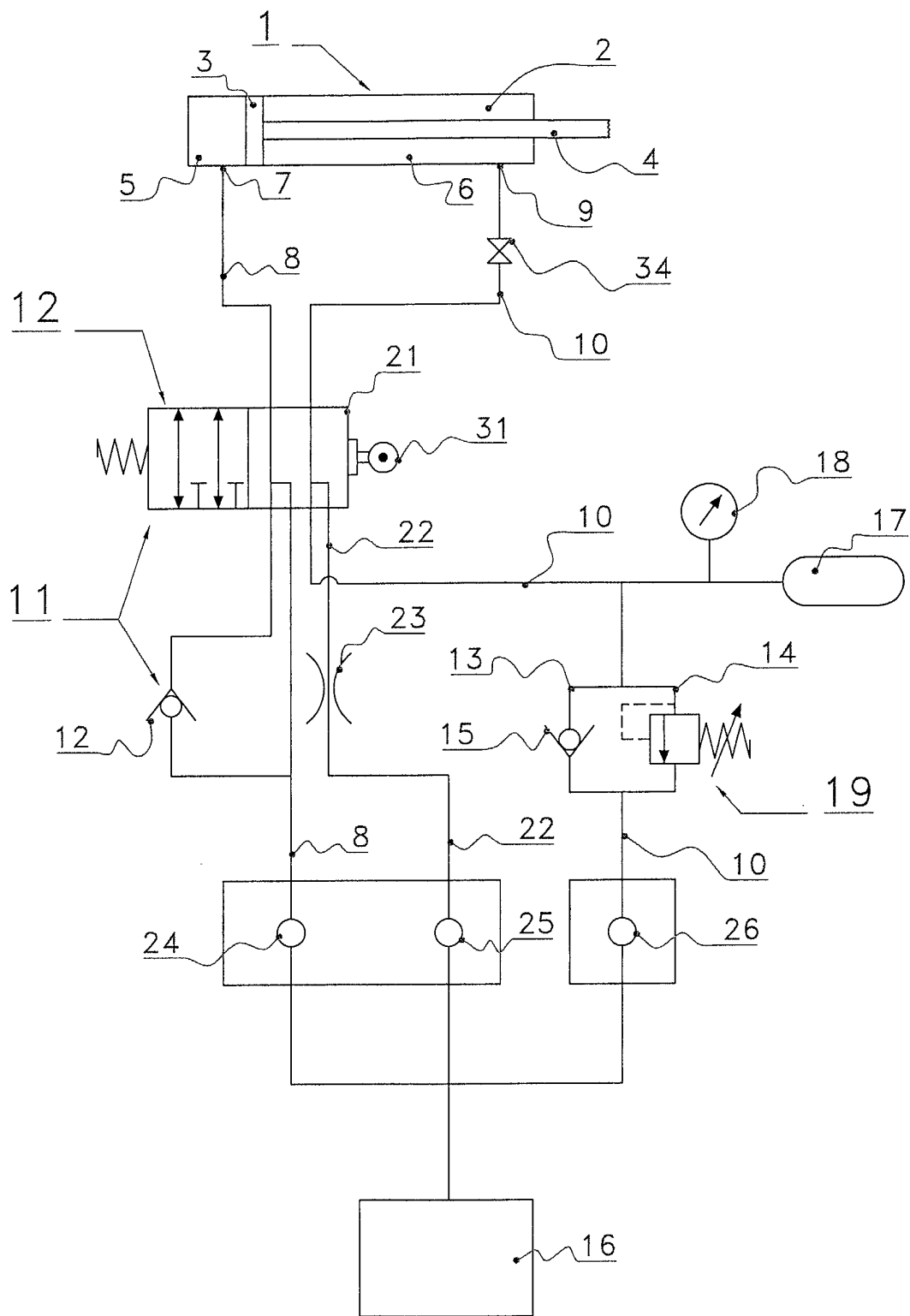


FIG. 4

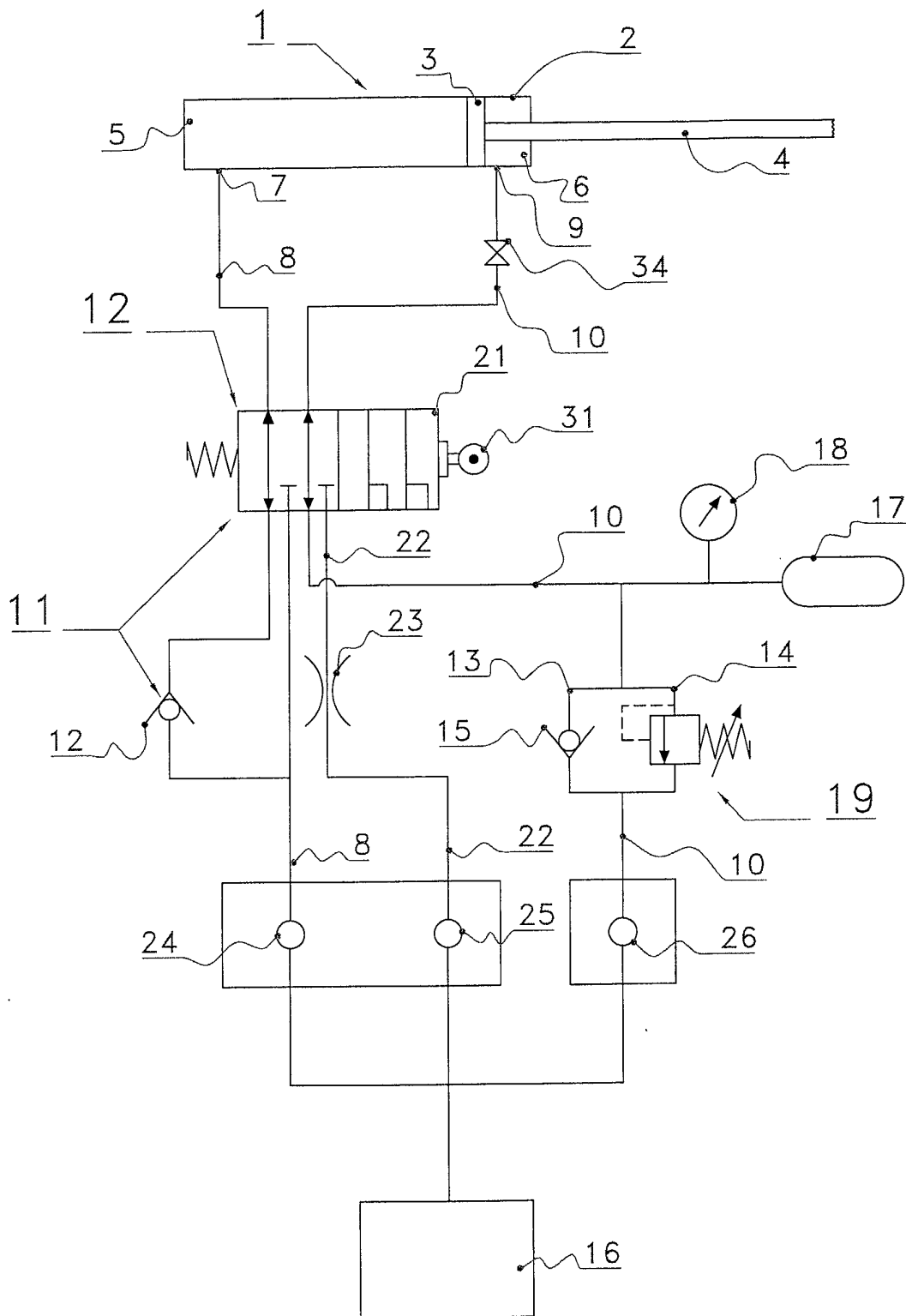


FIG. 5

