

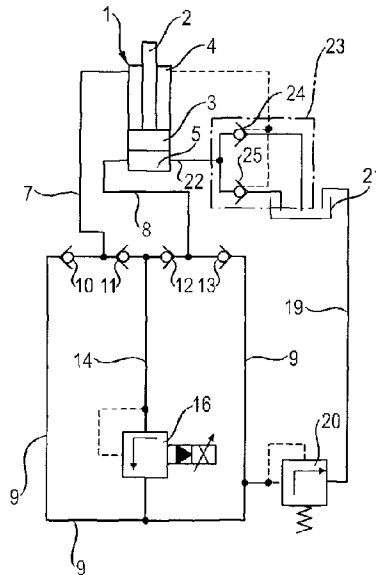


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(54) **Titre : SYSTEME D'ATTENUATION HYDRAULIQUE ET VEHICULE ARTICULE COMPORTANT UN TEL SYSTEME D'ATTENUATION**

(54) **Title: HYDRAULIC DAMPING SYSTEM AND ARTICULATED VEHICLE HAVING SUCH A DAMPING SYSTEM**



(57) **Abrégé/Abstract:**

A hydraulic damping system for damping pivoting movements of two vehicle parts which are at least indirectly connected to each other via a pivot joint has at least one damper configured as a double-acting hydraulic cylinder. Pressure and suction pressure chambers of this hydraulic cylinder are connected to each other via a proportional pressure relief valve. To provide a hydraulic damping system, the function of which is improved, wherein this can be produced with cost-effective means, the proportional pressure relief valve is to be configured as an electrically pilot-controlled inverse proportional pressure relief valve, with which a nominal pressure is adjustable in the de-energized state of a proportional solenoid or in a failure of the electromagnetic actuation in the damping system.

Abstract

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damper configured as a double-acting hydraulic cylinder. Pressure and suction
pressure chambers of this hydraulic cylinder are connected to each other via a
proportional pressure relief valve. To provide a hydraulic damping system, the
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HYDRAULIC DAMPING SYSTEM AND ARTICULATED VEHICLE HAVING SUCH A DAMPING SYSTEM

The invention relates to a hydraulic damping system for damping pivoting movements
5 of two vehicle parts connected to each other at least indirectly via a pivot joint, with at
least one damper configured as a double-acting hydraulic cylinder, the pressure and
suction pressure chambers of which are connected to each other via a proportional
pressure relief valve.

10 Furthermore, the invention relates to an articulated vehicle, in which two vehicle parts
are pivotally connected to each other at least indirectly via a pivot joint and are
brought together by means of at least one double-acting hydraulic cylinder of a
damping system, wherein a proportional pressure relief valve is arranged in a
damping line connecting pressure and suction pressure chambers of the at least one
15 hydraulic cylinder.

Articulated vehicles are motor vehicles, which are preferably configured as low-floor
articulated buses, wherein these have a front vehicle part and a rear vehicle part as
seen in the direction of travel. A turntable-like hinge arrangement is provided
20 between these, the arrangement allowing the reduction of the turning radius of the
corresponding motor vehicle articulation angle between the two vehicle parts and
thereby having a substantially vertical joint axle. In addition, in the context of the
coupling of the two vehicle parts, horizontally running joint axles may be provided,
around which these can execute movements that pitch with respect to each other.

25

A drive axle is usually provided for the drive of such articulated vehicles, the drive
axle being arranged as the last axle within the rear vehicle part and thus pushing the
entire articulated vehicle, including the front vehicle part, via the pivot joint. Without a
damping device arranged between the two vehicle parts, and which dampens their

movements with respect to each other, quickly executed jack-knife movements of the articulated vehicle could lead to its breaking loose. For this reason, a damping system is arranged between the articulated parts of the hinge arrangement that are brought together, the system having at least one double-acting hydraulic cylinder serving as a shock absorber. The flow of oil between the pressure chambers of this hydraulic cylinder is throttled to achieve a damping effect.

A hydraulic damping system, which is intended for an articulated vehicle, is known from EP 1 010 608 B1. In this case, a pivot joint with a damping system assigned thereto is provided for the damping of the rotational movement of a pivot joint between two vehicle parts of an articulated vehicle, for example, an articulated bus. The pivot joint has two joint members which are pivotally connected to each other by a joint axle. The one joint member may in this case be hinged directly on the one vehicle part, whereas the other joint member can be pivotally connected directly to the other vehicle part around a horizontally running axle to compensate for pitching movements. The hydraulic system is controllable, whereby an improved damping effect can be achieved when driving curves and driving straight ahead.

A parallel-connected mechanical pressure relief valve is to be provided between the suction and the pressure side of the damping arrangement in addition to a proportional pressure relief valve. These two pressure relief valves are selectively controlled via a multi-way valve configured as a 2/2-way valve in normal operation of the damping arrangement, the multi-way valve is located in its flow-through position, in which the proportional pressure relief valve is pressurized. In case of failure of the control or the function of the proportional pressure relief valve, i.e., in emergency operation, the electromagnetically activated multi-way valve is to be moved into a blocking position, so that the mechanical pressure relief valve arranged in a line branching before it is pressurized with pressure medium from one of the pressure chambers.

30

It is an object of the present invention to design a hydraulic damping system of the aforementioned type such that its function is improved and that it can be produced with cost-effective means.

- 5 Advantageous embodiments are given in the claims dependent on the claims 1 and 9, each of which taken alone or in combination with each other can represent an aspect of the invention.

Accordingly, a hydraulic damping system is provided for damping pivoting
10 movements of two vehicle parts connected to each other at least indirectly via a pivot joint, with at least one damper configured as a double-acting hydraulic cylinder. In this case, a double-acting can have a piston provided with two piston rods, wherein the respective ends of the piston rods facing away from the piston are at least indirectly connected to the vehicle parts. In the context of the hinge arrangement, a
15 gear wheel acting together with a gear rack may also be provided, the gear wheel being non-rotatably connected to the rotatable joint part. The gear rack receives the piston of the double-acting hydraulic cylinder.

Alternatively, however, two double-acting hydraulic cylinders, each having a piston
20 rod, may be provided, wherein the respective cylinder is connected to the one vehicle part and the piston rod is connected to a joint part of the other vehicle part. In this case, each piston-side pressure chamber of a hydraulic cylinder is connected to a piston rod-side pressure chamber of the other hydraulic cylinder.

25 The corresponding pressure and suction pressure chambers are connected to each other in both designs and arrangements of the hydraulic cylinder(s) or via a proportional pressure relief valve. This provides for a pressure build-up in the pressure chamber, displaced from the pressure medium, and for a damped pressure drop in the corresponding damper line with a pressure-dependent opening, so that
30 the movement of the piston(s) is/are damped.

In this case, the proportional pressure relief valve is configured as an electrically pilot-controlled inverse proportional pressure relief valve with which a nominal pressure is adjustable in the de-energized state of a proportional solenoid or in case of failure of the electromagnetic actuation in the damping system. This inverse proportional pressure relief valve thus has a function according to which the pressure decreases with rising electrical input signal, while this increases with decreasing input signal. For example, in case of failure of the input signal or a defect of the electromagnetic actuation, the nominal pressure can increase to the nominal pressure as a fail-safe function, which ensures safe emergency operation of the articulated vehicle. A sufficient damping behavior of the damping system is thus obtained in such defects, so that the articulated vehicle can continue its journey to a workshop.

In contrast, the damping system according to EP 1 010 608 B1 has a multi-way valve configured as a 2/2-way valve or 3/2-way valve, which in normal operation connects the respective pressure chamber, the volume of which decreases, exclusively to an electromagnetically actuated proportional pressure relief valve. In its second switching position, which corresponds to an emergency operation, the inflow to the electromagnetically actuated proportional pressure relief valve is blocked and an exclusive connection of the respective pressure chamber to a mechanically operated pressure relief valve arranged parallel or in series to the aforementioned proportional pressure relief valve is made. The latter is set to a certain minimum pressure, which should be in effect in emergency operation. This control of the damping system requires a total of three valves, which increases the construction effort. In addition, if the control of the damping system fails, unstable driving conditions of the vehicle, for example, rocking, can occur, despite emergency damping characteristics of the hydraulic system.

In a further embodiment of the invention, it is provided that a proportional pressure relief valve is connected in series with the inverse proportional pressure relief valve, and that in an emergency operation of the damping system, a hydraulic pressure in the respective pressure chamber can be achieved only via the inverse proportional pressure relief valve. The emergency damping pressure must be able to be lowered to a pressure level in case of failure of the electric control to ensure the steerability of the articulated vehicle. A reduced damping of the movements of the pivot joint is to be made possible in this operation of the vehicle.

For this reason, according to the invention, a proportional pressure relief valve, which is preferably actuated electromagnetically, is to be connected in series to the inverse proportional pressure relief valve. Both proportional pressure relief valves work logically in an "AND" combination, so that the respective set pressures are added together. This thus ensures that the required hydraulic pressure is achieved both in the event of failure of the on-board voltage as well as in the case of specification-based electrical control. The electrically controlled proportional pressure relief valve is in this case preferably pilot-controlled, depending on driving speed.

The inverse proportional pressure relief valve is also energized in normal driving operation, in such a way that it assumes an inverse control function based on the proportional pressure relief valve. Thus, when the control current is high, the normal proportional pressure relief valve is set to a high pressure and the inverse proportional pressure relief valve is set to a low pressure. At a low control current, the reverse pressure conditions are present. On the inlet side of the arrangement of the two proportional pressure relief valves, a pressure level is to be set by an addition of both pressures, which corresponds to the damping pressure required for the damping, which acts in the hydraulic cylinder in each of the two movement directions of the piston. But if the electrical control fails, then the normal proportional pressure relief valve enters a position in which only a very low pressure or no pressure is built up, while the likewise de-energized inverse proportional pressure relief valve sets an

emergency damping pressure. In this case, the inverse proportional pressure relief valve may be connected upstream of the proportional pressure relief valve.

It is also provided that the inverse proportional pressure relief valve has a pilot stage,
5 which is adjusted at a reduction or a failure of the control current in a blocking or throttling position and builds up a control pressure on a main piston of the inverse proportional pressure relief valve.

In a further embodiment of the invention, a pressure relief valve may be connected in
10 parallel to the inverse proportional pressure relief valve to limit the pressure in the pressure chambers and the forces acting on piston rods of the at least one hydraulic cylinder. In this case, this pressure relief valve serving as a safety valve should be set to a maximum allowable pressure of the damping system, which is specified by the buckling safety of the piston rods. Preferably, a factor of 3 buckling safety can be
15 considered in this case. For example, the electromagnetically controlled proportional pressure relief valve can have a range of the respective limiting pressure of 0-350 bar, wherein a maximum damping pressure of less than 200 bar results from the addition of these pressures to the respective pressures built up by the inverse proportional pressure relief valve. Preferably, the parallel-connected pressure relief
20 valve is set to an opening pressure of 200 bar.

Furthermore, a tank line receiving a counterbalance valve connected to a tank can be connected on the outlet side of a damping line receiving the inverse proportional
pressure relief valve and the proportional pressure relief valve therefrom. The
25 counterbalance valve establishes in the line sections, which are respectively connected to the increasing pressure chamber, a preload pressure, which leads to the pressure chamber being forcibly filled. This prevents cavitation, which could occur during rapid movements of the piston arranged in the hydraulic cylinder.

In addition, a subsequent feeding of pressure fluid in at least one of the pressure chambers can be achieved in that at least one of the pressure chambers is connected to an oil reservoir of a tank via at least one double check valve. In this case, the at least one double check valve can be actuated via a control line
5 connected to one of the pressure chambers in its open position. In pressure chambers which are configured cylindrical at a face side of the piston and hollow cylindrical at the other in the piston rod area, the control line can come out of the hollow cylindrical control chamber. The pressure generated by the proportional pressure relief valve is supplied to the double check valve, for example, via the
10 hollow cylindrical control chamber and the control line, so that this establishes a connection between the tank serving as equalizing tank and the cylindrical pressure chamber and an oil volume flow arrives in the pressure chamber.

Furthermore, the object also is achieved in a hydraulic damping system for damping
15 pivoting movements of two vehicle parts connected to each other at least indirectly via a pivot joint, with at least one damper configured as a double-acting hydraulic cylinder, the pressure and suction pressure chambers of which are connected to each other via a proportional pressure relief valve, so that at least one of the pressure chambers is connected to an oil reservoir of a tank via at least one double
20 check valve. A corresponding possibility for a feeding of pressure medium from an oil reservoir should therefore also be provided if an electromagnetically pilot-controlled proportional pressure relief valve is only arranged in the damper line. Also, in this case, a return line receiving a counterbalance valve connected to the tank can be connected on the outlet side of the proportional pressure relief valve. Also, cavitation
25 is prevented in the damping system by means of this counterbalance valve.

Finally, in an articulated vehicle in which two vehicle parts are at least indirectly pivotally connected to each other via a pivot joint and brought together by at least one double-acting hydraulic cylinder of a damping system, a proportional pressure

relief valve is to be arranged in a damping line connecting pressure and suction pressure chambers of the at least one hydraulic cylinder.

For further explanation of the invention, reference is made to the drawing, in which
5 embodiments are shown in simplified form. They show:

- Figure 1 shows a hydraulic circuit diagram of a damping system configured according to the invention having a double-acting hydraulic cylinder, a damper line receiving an inverse proportional pressure relief valve and
10 an electromagnetically actuated proportional pressure relief valve and a pressure relief valve connected parallel to the damper line,
- Figure 2 shows a second embodiment of a damping system in which the parallel-connected pressure relief valve is omitted and the double-acting
15 hydraulic cylinder has two piston rods,
- Figure 3 shows a third embodiment of a damping system in which it has two double-acting hydraulic cylinders,
- 20 Figure 4 shows a fourth embodiment of a damping system in which only one electromagnetically actuated proportional pressure relief valve is arranged in the damper line, wherein the damping system is connectable to an oil reservoir via a counterbalance valve and double
25 check valves,
- Figure 5 shows a fifth embodiment of a damping system which essentially corresponds to Figure 4, wherein but in accordance with the solution according to Figure 1, an inverse proportional pressure relief valve and an electromagnetically actuated proportional pressure relief valve are
30 arranged in the damper line,

Figure 6 shows a pivot joint arranged between two vehicle parts as a schematic representation, and

5 Figure 7 shows an inverse proportional pressure relief valve as a schematic representation in longitudinal section.

In Figures 1, 2, 4 and 5, 1 designates a double-acting hydraulic cylinder which has a piston 3 provided with a piston rod 2. The piston 3 is longitudinally displaceably
10 guided in a cylinder 4 and limited in this a cylindrical pressure chamber 5 and a hollow cylindrical pressure chamber 6. Pressure lines 7 and 8 lead from the pressure chambers 5 and 6 to a damping circuit 9, in which the targeted conducting and blocking of the pressure medium flow check valves 10, 11, 12 and 13 are arranged.

15 Furthermore, according to Figure 1, the damping circuit 9 is bridged by a damper line 14 which receives an inverse proportional pressure relief valve 15 and a proportional pressure relief valve 16 connected downstream of it. Both proportional pressure relief valves 15 and 16 are pilot-controlled via an electrical control current, wherein the corresponding control and control lines are not shown in detail. The proportional
20 pressure relief valve 16 provides for a pressure change in the respective pressure line 7 or 8, from which it is streamed, wherein this pressurization is changed proportionally to the electric current with which it is controlled. This electrical current in this case is preferably changed depending on the driving speed of an articulated
25 vehicle.

The inverse proportional pressure relief valve 15 is also energized in driving and thus influences the pressure in the pressure lines 7 and 8 together with the proportional pressure relief valve 16 downstream of this. These pressure changes by means of the two proportional pressure relief valves 15 and 16 will be discussed in more detail
30 below.

Via the check valves 11 and 12, the pressure lines 7 and 8 are connected to the damping circuit 9 such that a pressure medium displaced from these pressure chambers 5 or 6 enters the damper line 14. In contrast, the check valves 10 and 13 block a flow of the pressure medium in the damping circuit 9 in a direction away from the damper line 14. The pressure medium respectively displaced from one of the pressure chambers 5 or 6 is thus selectively fed to the damper line 14. Furthermore, a connecting line 17, which receives a pressure relief valve 18 serving as a safety valve, runs parallel to the damper line 14. In addition, a tank line 19 comes out of the damping circuit 9, the outlet side of the damper line 14, in which a counterbalance valve 20, which is also configured as a pressure relief valve, is arranged. This tank line 19 opens into an oil reservoir 21.

As can further be seen from Figure 1, the cylindrical pressure chamber 5 is in connection with the oil reservoir 21 via a feeding line 22, wherein a check valve unit 23 is located within the feeding line 22. This check valve unit 23 consists of two double check valves 24 and 25 which can be actuated via a control line 26 connected to the hollow cylindrical pressure chamber 6 in its open position. In addition, a pressure sensor designated with 27 is connected to the damping circuit 9 for monitoring the damping system.

The function of the damping system is the following:

During straight-ahead driving or curve driving of an articulated vehicle provided with a hinge arrangement, for example, according to Figure 6, pressure forces act on the piston rod 2 and thus on the piston 3, so that the pressure of the pressure fluid located in the pressure chambers 5 and 6 increases in a corresponding manner. If this pressure increase occurs, for example, in the pressure chamber 5, it is transmitted via the respective check valve 11 or 12 into the damping circuit 9 and is

thus initially applied to the inverse proportional pressure relief valve 15 via the damper line 14 and leads to its actuation depending on the amount of pressure. The pressure medium emerging from the inverse proportional pressure relief valve 15 passes in a second stage to the proportional pressure relief valve 16 downstream of this, which may be adjustable, for example, to a limiting pressure of 0-350 bar.

The term "proportional pressure relief valve" is generally understood as pressure valves that convert a variable input signal continuously into a hydraulic output signal. The pressure medium streaming out of the damper line 14 is thus finally led via the proportional pressure relief valve 16 under pressure drop into the other line section of the damping circuit, where it passes through the check valve 10 in the hollow cylindrical pressure chamber 6. In this case, the check valve 11 blocks this line section opposite of the line section of the damping circuit 9 under pressure. A portion of the pressure medium can flow via the counterbalance valve 20 into the oil reservoir 21, which is required, among other things, since the volumes of the pressure chambers 5 and 6 differ from each other due to different cross-sectional areas.

If, on the other hand, the piston 3 moves in the direction of the hollow cylindrical pressure chamber 6, then in this, i.e., thus on the side of the piston rod 2, a volume flow is generated which passes completely via the check valve 11 into the damper line 14. With a corresponding pressure increase to an electrically set limiting pressure, this volume flow first flows through the energized inverse proportional pressure relief valve 15 and then the proportional pressure relief valve 16 upon reaching the corresponding set limiting pressure, in order to then flow through the open check valve 13 and the pressure line 8 into the pressure chamber 5.

The pressure thereby generated by the proportional pressure relief valve 16 in the pressure chamber 6 is transmitted via the control line 26 to the double check valve

unit 23. This establishes a connection between the oil reservoir 21 and the pressure chamber 5, so that a missing oil volume can be compensated. So that this amount of oil can be fed from the oil reservoir 21, this is provided with a ventilation having a ventilation filter 28, via which a corresponding amount of air flows into the oil reservoir 21 or exits again from this.

The positive effect of this type of feeding is that the flow of oil into the pressure chamber 5 does not have to overcome the pressure difference of a spring-loaded check valve, but that it flows through the forced open check valves 24 and 25. Feeding would have to be otherwise overcome, i.e., when using a simple check valve which has no external actuation, the pressure difference in the check valve, which is proportionately added among others from the flow resistance and the preload pressure of the check valve spring. The flow resistance depends on the amount of the flowing oil volume flow and the viscosity of the hydraulic medium.

With increasing travel speed of the piston 3 and increasing viscosity, i.e., thus in particular with decreasing oil temperature, the pressure difference increases. When the pressure difference is higher than the atmospheric pressure in the oil reservoir, cavitation occurs. This can thus be effectively prevented by the invention. A corresponding feeding in the pressure chamber 6 via a controlled valve unit is not required, since this is always forcibly filled with the pressure set at the counterbalance valve 20.

The inverse proportional pressure relief valve 15 is configured such that it can set a nominal pressure in the de-energized state of a proportional solenoid provided in its pilot control unit or, in case of failure of the electromagnetic actuation, in the damping system. It has a function according to which the pressure generated in the respective pressure line 7 or 8 drops with an increasing electrical input signal,

whereas this increases with a decreasing input signal. Thus, the effect of the inverse proportional pressure relief valve 15 is opposite the proportional pressure relief valve 16 following this in the damper line 14.

5 According to the invention, it is now provided that these two proportional pressure relief valves 15 and 16 are coordinated with each other with respect to their pressure profiles so that a specific damping pressure can be set via this unit as a function of the respective driving conditions of the articulated vehicle. As is apparent from Figure 1, for example, the proportional pressure relief valve 16 should have a controllable
10 limiting pressure of 0-350 bar. In contrast, the inverse proportional pressure relief valve 15 will have a lowest value of the limiting pressure, which is predetermined in order to safely drive the articulated vehicle to the next workshop in the emergency operation of the damping system.

15 In normal operation of the damping device, however, as already explained, the respective limiting pressures of both proportional pressure relief valves 15 and 16 are to be added, so that in each case a predetermined amount of the limiting pressure is reached. Moreover, it is also possible to ensure both normal operation and emergency operation only by means of the inverse proportional pressure relief valve
20 15, thus without the additional proportional pressure relief valve 16, when the inverse proportional pressure relief valve 15 can be set to a very low pressure in normal operation, but in emergency mode, i.e., when it reaches a de-energized state through a defect, sets the nominal pressure to a higher nominal pressure as a fail-safe function.

25

In contrast to Figure 1, Figure 2 shows the double-acting hydraulic cylinder 1 in a design in which it has a further piston rod 2'. In addition, in this case, the damping system consists only of the damping circuit 9 and the damper line 14 with the inverse proportional pressure relief valve 15 and the proportional pressure relief valve 16. In

this case, therefore, both a connecting line having a further pressure relief valve and an oil reservoir having a tank line, a counterbalance valve and a device for feeding the pressure medium has been dispensed with. The double-acting hydraulic cylinder 1 has two pressure chambers 6 and 6', which are both configured
5 as a hollow cylinder.

As far as the damping circuit 9, the damper line 14 and the proportional pressure relief valves 15 and 16 are concerned, the arrangement according to Figure 3 essentially corresponds to the arrangement according to Figure 2, wherein in this
10 case, however, two double-acting hydraulic cylinders 1 and 1' are used. In this case, the pressure line 7 is connected to the cylindrical pressure chamber 5' of the hydraulic cylinder 1' and to the hollow cylindrical pressure chamber 6 of the hydraulic cylinder 1. Furthermore, the pressure chambers 6' and 5 are brought together and connected to the pressure line 8.

15 According to Figures 4 and 5, in accordance with Figure 1, a feeding device is associated with the pressure chamber 5, which contains the already explained oil reservoir, the check valve unit 23 and the control line 26. In addition, the tank line with the counterbalance valve 20 arranged therein comes out of the damper circuit 9.
20 In the embodiment according to Figure 4, only the electrically pilot-controlled proportional pressure relief valve 16 is arranged in the damper line 14. According to Figure 5, both the inverse proportional pressure relief valve 15 and the electrically pilot-controlled proportional pressure relief valve 16 are arranged in the damper line 14. In both cases, the connecting line having the pressure relief valve was dispensed
25 with.

Figure 6 shows a hinge arrangement 29 for an articulated vehicle (not shown in greater detail), which should preferably be configured as an articulated bus. This consists of a front vehicle part 30 and a rear vehicle part 31, which are connected to
30 each other via a pivot joint 32. Preferably, the articulated vehicle is driven by a drive

axle not shown, which is located in the rear vehicle part. The vehicle parts 30 and 31 are brought together via the double-acting hydraulic cylinders 1 and 1' of the above-described damping system such that they are stabilized during a straight-ahead driving or curve driving, i.e., can not break loose.

5

A possible embodiment of the inverse proportional pressure relief valve 15 is shown as a schematic representation of Figure 7. Accordingly, the proportional pressure relief valve 15 has a housing 33 in which a main valve 34 and a pilot stage 35 are arranged. The pilot stage 35 has an armature 36 and coils 37, wherein the armature
10 36 has a poppet valve body 38 which works with a valve seat 39 provided in the housing 33. The main valve 34 consists of a control piston 41 displaceably guided in the housing 33 and supported via a valve spring 40 in this. The control piston 41 is pressurized via a first connection 42 of the housing 33 with the pressure from one of the pressure chambers (see Figure 1; pressure chambers 5 or 6) and displaced
15 against the force of the valve spring 40 until the pressure medium passes over in a second connection 43, which should be connected to the damper line 14. Via the poppet valve body 38, on the back of which a hydraulic control pressure acts via a control line 44, the pressure to be limited can be adjusted continuously.

Reference numerals

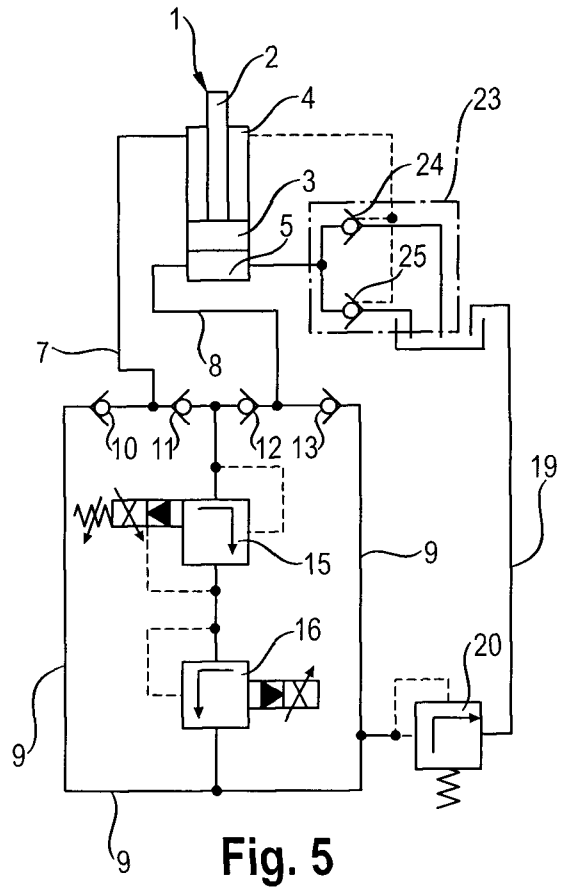
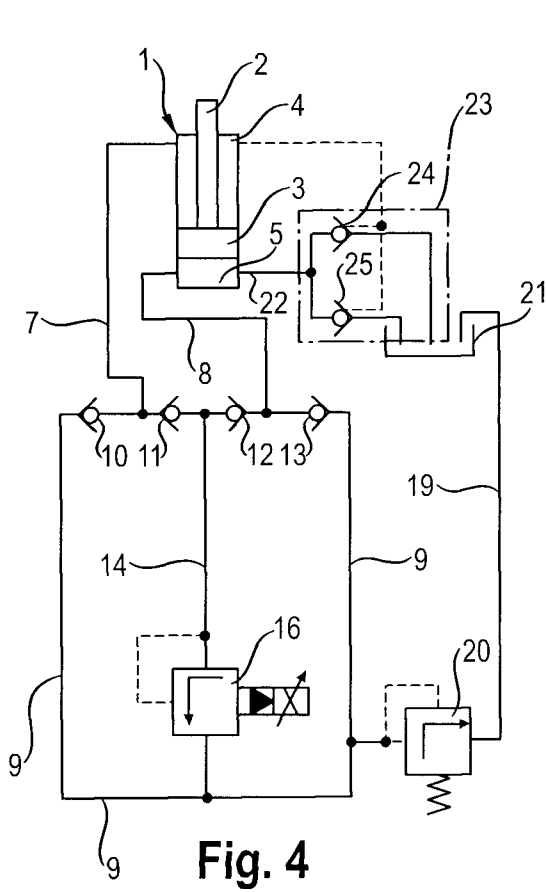
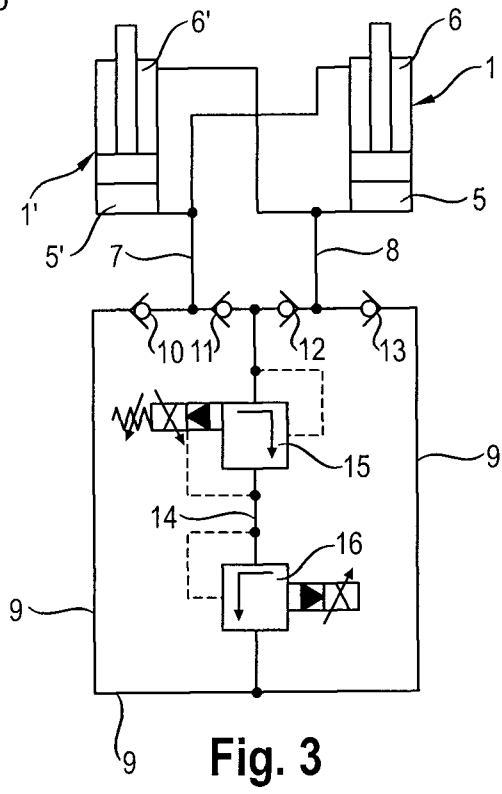
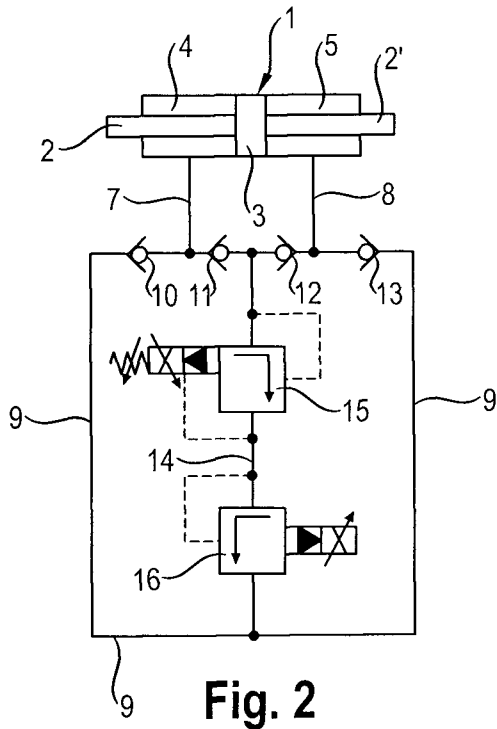
	1	double-acting hydraulic cylinder
5	1'	double-acting hydraulic cylinder
	2	piston rod
	2'	piston rod
	3	piston
	3	piston
10	4	cylinder
	4	cylinder
	5	cylindrical pressure chamber
	5	cylindrical pressure chamber
	6	hollow cylindrical pressure chamber
15	6	cylindrical pressure chamber
	7	pressure line
	8	pressure line
	9	damping circuit
	10	check valve
20	11	check valve
	12	check valve
	13	check valve
	14	damper line
	15	inverse proportional pressure relief valve
25	16	proportional pressure relief valve
	17	connection line
	18	pressure relief valve
	19	tank line
	20	counterbalance valve
30	21	oil reservoir
	22	feeding line

- 23 check valve unit
- 24 double check valve
- 25 double check valve
- 26 control line
- 5 27 pressure sensor
- 28 ventilation filter
- 29 hinge arrangement
- 30 front vehicle part
- 31 rear vehicle part
- 10 32 pivot joint
- 33 housing of 15
- 34 main valve of 15
- 35 pilot stage of 15
- 36 armature of 35
- 15 37 coils of 35
- 38 poppet valve body of 35
- 39 valve seat
- 40 valve spring of 34
- 41 control piston of 34
- 20 42 first connection of 15
- 43 second connection of 15
- 44 control line

Claims

1. A hydraulic damping system for damping pivoting movements of two vehicle parts
5 connected to each other at least indirectly via a pivot joint, with at least one
damper configured as a double-acting hydraulic cylinder, pressure chambers
connected to each other via an electrically pilot-controlled inverse proportional
pressure relief valve with which a nominal pressure can be set in a de-energized
state of a proportional solenoid or in an event of a failure of an electromagnetic
10 actuation in the hydraulic damping system.
2. The hydraulic damping system according to claim 1, wherein a proportional
pressure relief valve is connected in series with the inverse proportional pressure
relief valve, and in an emergency operation of the hydraulic damping system, a
15 hydraulic pressure in a respective one of the pressure chambers can be achieved
exclusively via the inverse proportional pressure relief valve.
3. The hydraulic damping system according to claim 2, wherein the inverse
proportional pressure relief valve is connected upstream of the proportional
20 pressure relief valve.
4. The hydraulic damping system according to claim 1, wherein a pilot stage of the
inverse proportional pressure relief valve is displaced with a reduction of a control
current in a blocking position and a control pressure builds up on a main piston of
25 the inverse proportional pressure relief valve.
5. The hydraulic damping system according to claim 1, wherein for limiting pressure
in the pressure chambers and forces acting on piston rods of the hydraulic
cylinder, a pressure relief valve is connected in parallel to the inverse proportional
30 pressure relief valve.

6. The hydraulic damping system according to claim 2, wherein a tank line receiving a counterbalance valve connected to an oil reservoir is connected on an outlet side of a damping line receiving the inverse proportional pressure relief valve and the proportional pressure relief valve therefrom.
- 5
7. The hydraulic damping system according to claim 1, wherein one of the pressure chambers is connectable to an oil reservoir via at least one double check valve.
8. The hydraulic damping system according to claim 7, wherein the at least one double check valve can be actuated via a control line connected to another of the pressure chambers in an open position of the another of the pressure chambers.
- 10
9. A hydraulic damping system for damping pivoting movements of two vehicle parts connected to each other at least indirectly via a pivot joint, with at least one damper configured as a double-acting hydraulic cylinder, pressure chambers connected to each other via a proportional pressure relief valve, wherein one of the pressure chambers is connectable to an oil reservoir via at least one double check valve.
- 15
10. The hydraulic damping system according to claim 9, wherein the at least one double check valve can be actuated via a control line connected to the pressure chamber in an open position of the another of the pressure chambers.
- 20
11. An articulated vehicle, in which two vehicle parts are at least indirectly pivotally connected to each other via a pivot joint and are brought together by means of at least one double-acting hydraulic cylinder of a hydraulic damping system according to any one of claims 1 to 10, wherein a proportional pressure relief valve is arranged in a damper line connecting the pressure chambers of the at least one hydraulic cylinder.
- 25



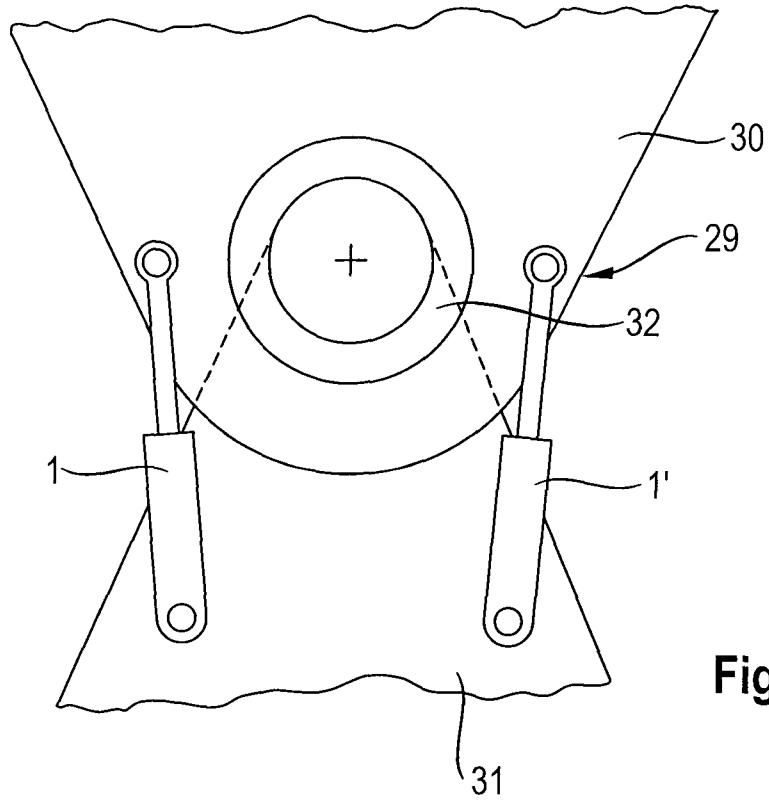


Fig. 6

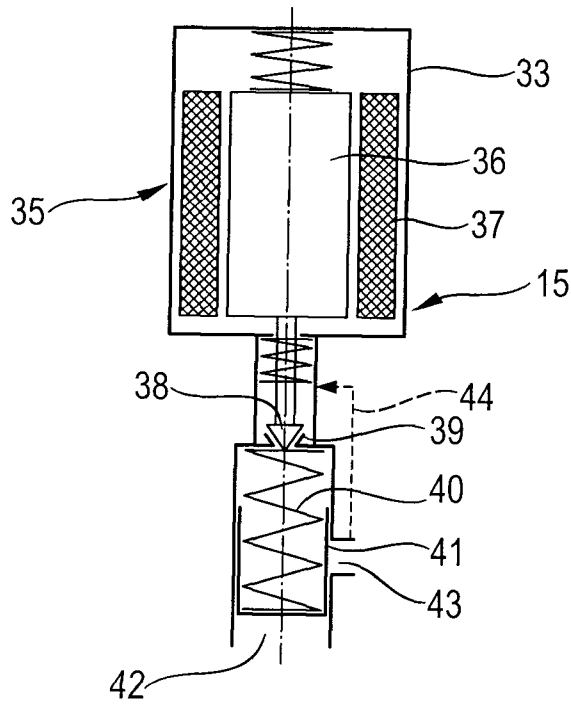


Fig. 7

