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(54) **DAMPING VALVE DEVICE FOR A SHOCK ABSORBER OF A MOTOR VEHICLE**

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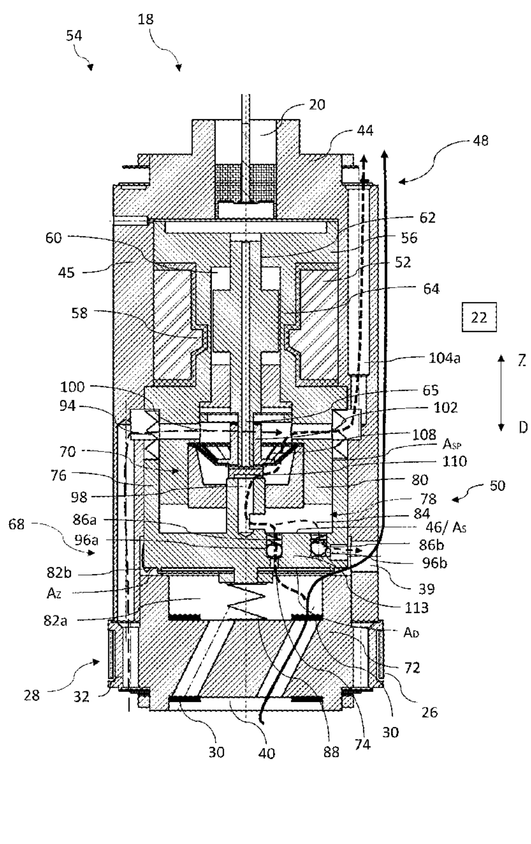
(57) **ABSTRACT**

A vibration damper of a motor vehicle comprises an outer tube and an inner tube which is disposed so as to be coaxial with the latter, and a working piston which is disposed so as to be axially movable within the inner tube and divides the interior of the inner tube into a piston rod-proximal working chamber and a piston rod-distal working chamber, a damping valve device which is disposed in the working piston, wherein the damping valve device has: a coil, an axially movable armature which is at least partially disposed within the coil, a main valve having a main piston which separates a compression main control chamber, a traction main control chamber and a pilot control chamber from one another, a pilot valve which is designed in such a manner that it is able to be passed through by a flow of hydraulic fluid in the traction phase and in the compression phase and has a pilot working chamber and a sliding tappet that is disposed in the pilot working chamber and is axially movable by means of the armature, and a connecting duct which is disposed between the pilot control chamber and the pilot working chamber and fluidically connects those to one another, wherein the main piston comprises a cylinder base region and a cylinder casing region which forms the radially outer face of the main piston.



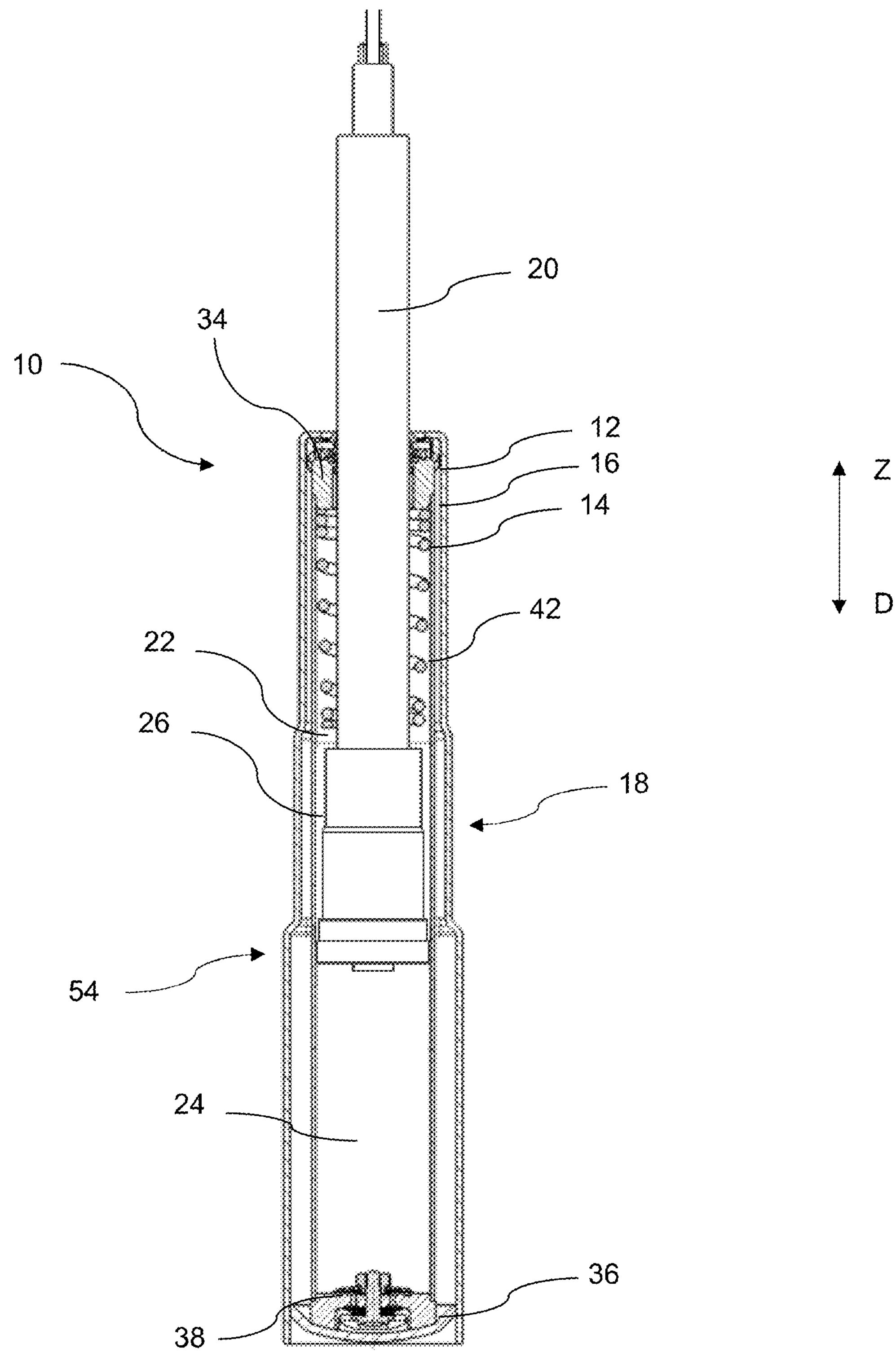


Fig. 1

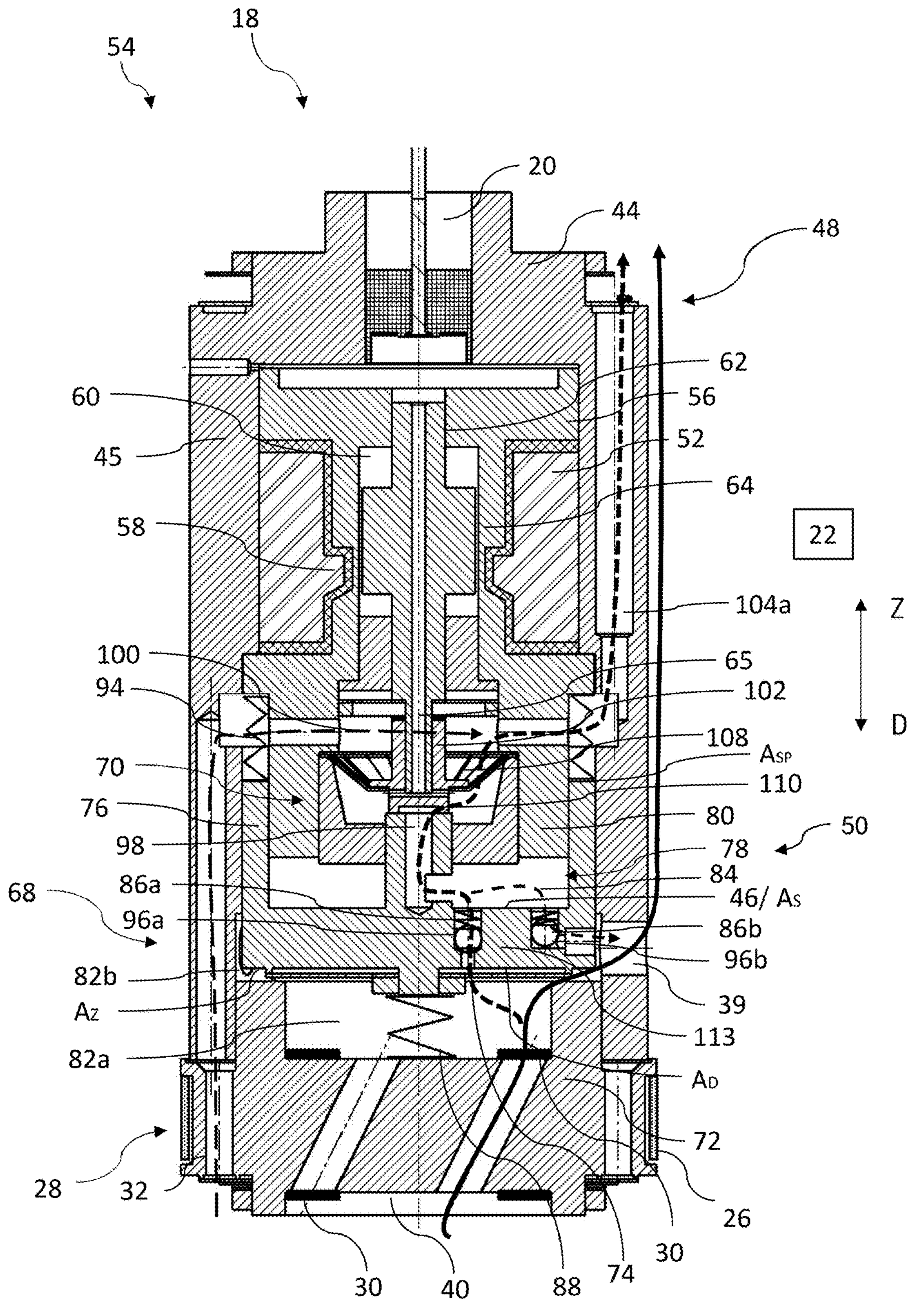

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Fig. 2

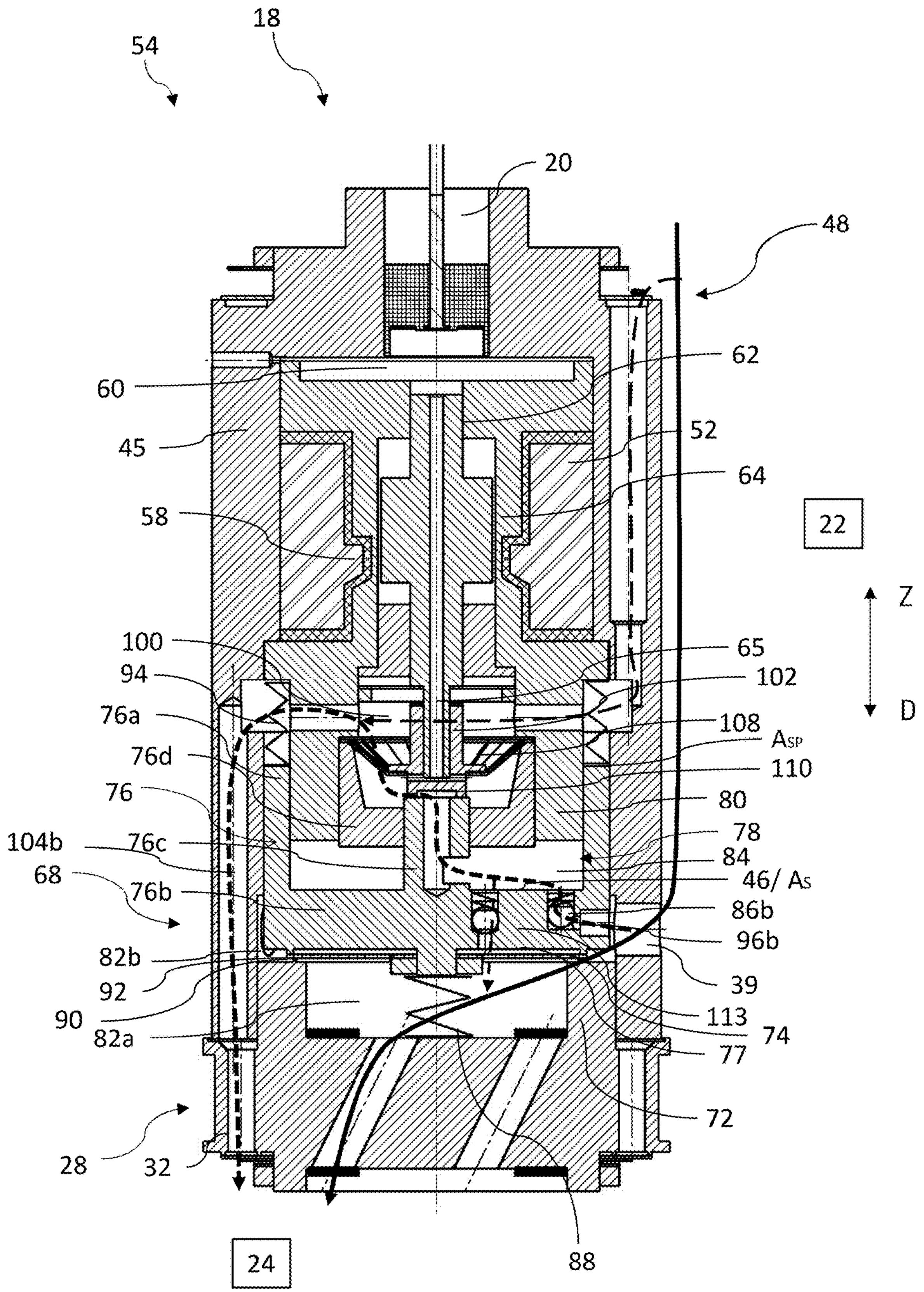
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Fig. 3

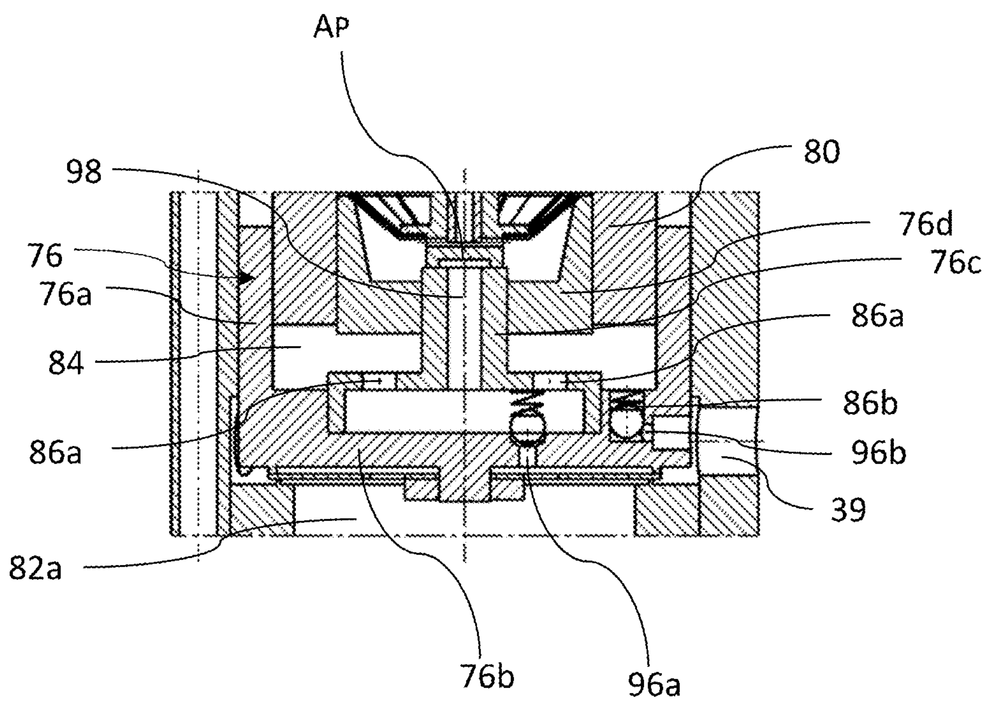

Fig. 4

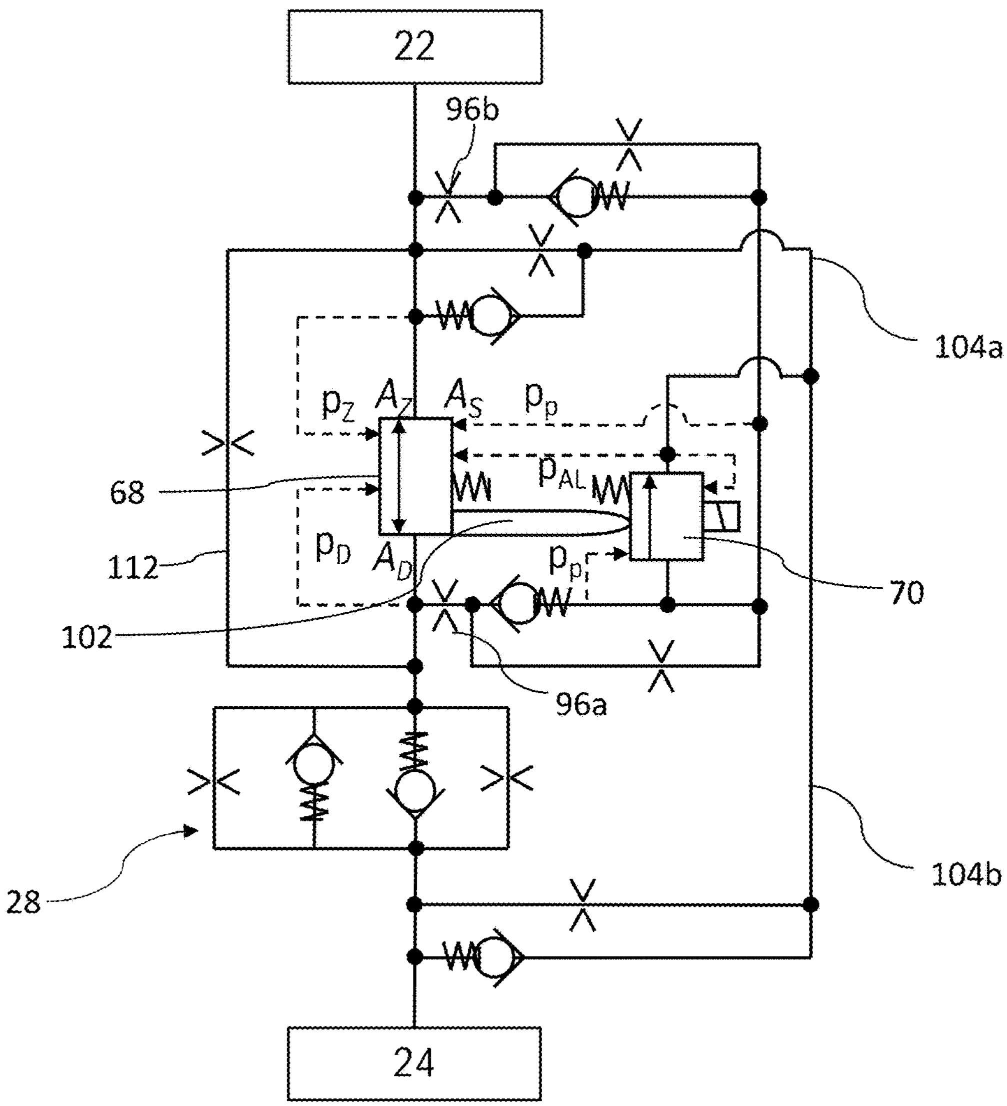

Fig. 5

DAMPING VALVE DEVICE FOR A SHOCK ABSORBER OF A MOTOR VEHICLE

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application is a U.S. Non-Provisional that claims priority to German Patent Application No. DE 10 2024 103 602.8, filed Feb. 8, 2024, the entire content of which is incorporated herein by reference.

FIELD

[0002] The present disclosure relates to a damping valve device for a shock absorber for motor vehicles, wherein the damping valve device has a main valve and a pilot valve.

BACKGROUND

[0003] Known from DE 10 2020 215 480 A1 is a vibration damper having a damping valve device, wherein the damping valve device has a pilot valve which is adjustable by way of a solenoid. An unstable behaviour of the damping valve may arise in particular in the dynamic operation of the vibration damper, when the main valve is opened and closed. Acoustic issues are additionally created during the switching procedure of the main valve. Furthermore, the damping valve devices are relatively large and therefore occupy a large installation space.

[0004] Thus a need exists to provide a damping valve device for a vibration damper, which is particularly space-saving and at the same time has a stable damping behaviour in the compression phase as well as in the traction phase, and is cost-effective in production.

BRIEF DESCRIPTION OF THE FIGURES

[0005] So that those skilled in the art to which the subject disclosure appertains will readily understand how to make and use the devices and methods of the subject disclosure without undue experimentation, preferred embodiments thereof will be described in detail herein below with reference to certain figures, wherein:

[0006] FIG. **1** shows a schematic illustration of a vibration damper according to an exemplary embodiment in a longitudinal sectional view.

[0007] FIG. **2** shows a schematic illustration of a damping valve device of a vibration damper according to an exemplary embodiment in the compression phase, in a longitudinal sectional view.

[0008] FIG. **3** shows a schematic illustration of a damping valve device of a vibration damper according to an exemplary embodiment in the traction phase, in a longitudinal sectional view.

[0009] FIG. **4** shows a schematic illustration of a section of a damping valve device according to a further exemplary embodiment.

[0010] FIG. **5** shows a schematic illustration of a hydraulic circuit diagram of a damping valve device according to an exemplary embodiment.

DETAILED DESCRIPTION

[0011] Although certain example methods and apparatus have been described herein, the scope of coverage of this patent is not limited thereto. On the contrary, this patent covers all methods, apparatus, and articles of manufacture fairly falling within the scope of the appended claims either literally or under the doctrine of equivalents. Moreover, those having ordinary skill in the art will understand that reciting "a" element or "an" element in the appended claims does not restrict those claims to articles, apparatuses, systems, methods, or the like having only one of that element, even where other elements in the same claim or different claims are preceded by "at least one" or similar language. Similarly, it should be understood that the steps of any method claims need not necessarily be performed in the order in which they are recited, unless so required by the context of the claims. In addition, all references to one skilled in the art shall be understood to refer to one having ordinary skill in the art.

[0012] According to a first aspect, a vibration damper of a motor vehicle comprises an outer tube and an inner tube which is disposed so as to be coaxial with the latter, and a working piston which is disposed so as to be axially movable within the inner tube and divides the interior of the inner tube into a piston rod-proximal working chamber and a piston rod-distal working chamber. The vibration damper also comprises a damping valve device which is disposed in the working piston, wherein the damping valve device has a coil and an axially movable armature which is at least partially disposed within the coil. The damping valve device also comprises a main valve having a main piston which fluidically separates a compression main control chamber, a traction main control chamber and a pilot control chamber from one another. The damping valve device moreover has a pilot valve which is designed and disposed in such a manner that it is able to be passed through by a flow of hydraulic fluid in the traction phase and in the compression phase and has a pilot working chamber and a sliding tappet that is disposed in the pilot working chamber and is axially movable by means of the armature. Furthermore, the damping valve device has a connecting duct which is disposed between the pilot control chamber and the pilot working chamber and fluidically connects those to one another. The main piston comprises a cylinder base region and a cylinder casing region which forms the radially outer face of the main piston.

[0013] The main piston is preferably designed to be hollow-cylindrical in shape. The cylinder base region is preferably formed on the end region of the main piston that points in the direction of the comfort valve. The cylinder casing region preferably adjoins the cylinder base region directly in the direction of the drive region. The external face of the cylinder casing region preferably forms the radially outer face of the main piston. The cylinder casing region preferably has a constant cross section. In particular, the cylinder casing region has a constant external diameter, so that a flat external face is preferably formed. The cylinder base region preferably has the main valve seat. The main piston preferably has a longitudinal section in the shape of a U or W. The cylinder casing region is in particular designed to be tubular. Such a design of the main piston increases the stability of the main piston when passed through by a flow in the traction or compression direction of the damping valve device. Tilting or twisting of the main piston during an axial movement is reliably minimized by such a geometry.

[0014] The damping valve device is, for example, a pressure control valve which can preferably be pilot-controlled. The main valve having the main piston is preferably designed for closing and opening the damping valve device, in particular the pressure control valve. The main piston is preferably axially movable by means of the armature and/or the hydraulic pressure prevalent in the pilot control chamber.

[0015] A damping valve device designed as a pilot-controlled pressure control valve, in addition to the main valve, preferably comprises a pilot valve having a pilot working chamber and a sliding tappet which is disposed in the pilot working chamber and is axially movable by means of the armature, and a connecting duct which is disposed between the pilot control chamber and the pilot working chamber and fluidically connects those to one another.

[0016] The damping valve device is disposed in a vibration damper for a motor vehicle, for example. The vibration damper is, for example, a single-tube vibration damper or a multi-tube vibration damper, by way of example a dual-tube vibration damper. The vibration damper comprises, for example, an outer tube which forms an external face, in particular a housing, of the vibration damper. An inner tube, which is also referred to as damper tube, is disposed within the outer tube so as to be coaxial with the latter. A compensation chamber, which is preferably at least partially filled with a hydraulic fluid, is formed between the outer tube and the inner tube. For example, the compensation chamber is partially filled with a gas.

[0017] A working piston which is connected to a piston rod is preferably disposed within the inner tube in such a manner that said working piston is movable within the inner tube, wherein the inner tube is preferably designed as a guide of the working piston. A damping valve device is disposed on the working piston, for example. The working piston divides the interior of the inner tube in particular into a first, piston rod-proximal, working chamber and a second, piston rod-distal, working chamber.

[0018] The vibration damper preferably has a closure pack which fluidically seals the interior of the outer tube on the piston rod-proximal side. The interior of the outer tube at the piston rod-distal end, opposite the closure pack, is preferably fluidically sealed by means of a base piece. A base valve, which is attached to the piston rod-distal end of the inner tube, is in particular disposed on the base piece.

[0019] The damping valve device comprises a preferably cylindrical damping valve housing which has a substantially tubular tube part and a housing upper part which is attached to the tube part or is formed so as to be integral to the latter. By way of example, the tube part has a connecting region which has one or a plurality of connection contacts for an electrical current supply of the damping valve device. The connection contacts for an electrical current supply are preferably connected to a drive unit.

[0020] The damping valve device preferably has a drive which is designed as a solenoid, in particular a coil having a plurality of windings made of a current-conducting wire. The coil is preferably disposed within a housing of the damping valve device and comprises, for example, a coil carrier on which the windings of the coil are wound. The coil preferably at least partially or completely encloses an armature space which extends centrally in the axial direction. An armature is preferably mounted so as to be axially movable within the armature space. The armature is preferably attached so as to be able to slide in the axial direction within the armature space and comprises, for example, a central armature rod that by way of example is of a tubular design and extends centrally in the axial direction through the armature space. The armature space is preferably delimited by an at least partially hollow-cylindrical pole tube, which preferably serves as a guide for the armature.

[0021] The damping valve device preferably comprises a main valve and a pilot valve. The pilot valve is preferably disposed in the flow direction behind the main valve, both in the compression phase as well as in the traction phase of the vibration damper. In particular, the damping valve device is able to be passed through by a flow of hydraulic fluid in both directions. The damping valve device disposed in the working piston preferably has exactly one main valve and/or exactly one pilot valve. A seal, in particular a sealing ring, which seals the working piston in a fluid-tight manner in relation to the damper tube, is attached to the working piston, for example. The working piston preferably comprises a first fluid passage to the piston rod-proximal working chamber. The damping valve device is preferably fluidically connected to the piston rod-proximal working chamber by way of the first fluid passage. By way of example, in a movement of the piston rod in the traction direction, the first fluid passage is designed as a fluid inlet to allow hydraulic fluid to enter the damping valve device, and in a movement of the piston rod in the compression direction, designed as a fluid outlet to allow hydraulic fluid to exit the damping valve device. The working piston preferably has a second fluid passage to the piston rod-distal working chamber, by way of which the damping valve device is preferably fluidically connected to the second, piston rod-distal, working chamber. In a movement of the piston rod in the compression direction, the second fluid passage is preferably designed as a fluid inlet to allow hydraulic fluid to enter an optional comfort valve and/or the main valve, and in a movement of the piston rod in the traction direction, designed as a fluid outlet to allow hydraulic fluid to exit the optional comfort valve and/or the main valve.

[0022] The main valve preferably comprises a main piston which is disposed so as to be axially movable within a main working chamber. The main valve optionally comprises a housing part which at least partially delimits the main working chamber and forms an axial guide for the main piston. The housing part is in particular formed in one piece with the pole tube, so that the pole tube preferably extends to the main piston and is in particular designed as an axial guide of the main piston. The main piston is preferably disposed in such a manner that it fluidically separates a compression main control chamber, a traction main control chamber and a pilot control chamber from one another. The main control chamber is understood to be the hydraulic space that is preferably directly contiguous to the main piston and preferably impinges the latter with a hydraulic force acting in the opening direction of the main valve. A main valve which is able to be passed through by a flow in the traction phase and in the compression phase preferably has a compression main control chamber which is designed and disposed in such a manner that the latter in the compression phase impinges the main piston with a hydraulic force acting in the opening direction, and has a traction main control chamber which is designed and disposed in such a manner that the latter in the traction phase impinges the main piston with a hydraulic force acting in the opening direction. The main valve preferably has a main valve seat, wherein, in an opened position of the main valve, a main flow duct is formed between the main piston and the main valve seat. The traction main control chamber and the compression main control chamber are preferably fluidically connected to one another by way of the main flow duct. The hydraulic pressure of the piston rod-distal working chamber is preferably applied in the compression main control chamber, wherein the hydraulic pressure of the piston rod-proximal working chamber is preferably applied in the traction main control chamber.

[0023] The main valve seat is preferably formed on a directing element which is attached in a positionally fixed manner within the damping device, wherein the main piston is movable relative to said directing element. A spring assembly, which in the closed position of the main valve lies against the main valve seat of the directing element, is in particular attached to the main piston. The spring assembly preferably comprises a plurality of, in particular two, spring discs which are coaxially disposed in relation to one another and preferable lie against one another. The spring disc of the spring assembly that points in the direction of the compression main control chamber preferably lies against the main valve seat and has in particular a bypass opening.

[0024] The pilot control chamber is understood to mean the hydraulic space which is preferably directly contiguous to the main piston and preferably impinges the latter with a hydraulic force acting in the closing direction of the main valve. The pilot control chamber is preferably disposed on the main piston so as to be opposite the traction main control chamber and the compression main control chamber. For example, the main piston is designed in such a manner that the end face of the main piston that faces the compression main control chamber or the traction main control chamber and is impinged with the hydraulic pressure of the compression main control chamber or the traction main control chamber is larger than the end face of the main piston that faces the pilot control chamber and is impinged with the hydraulic pressure of the pilot control chamber.

[0025] During operation of the damping valve device and during a movement of the piston rod in the compression direction, the hydraulic fluid preferably flows out of the piston rod-distal working chamber through the second fluid passage into the optional comfort valve, into the compression main control chamber, whereby the pressure in the compression main control chamber impinges the main piston with an opening force and is moved axially upward. In the process, the main piston is lifted from the main valve seat and the hydraulic fluid flows through the main flow duct to the traction main control chamber, in particular the first fluid passage, and subsequently into the piston rod-proximal working chamber. At the same time, in particular hydraulically parallel therewith, a partial flow of the hydraulic fluid flows through the pressure flow passage in the main piston to the pilot control chamber and impinges the main position with a closing force in the direction of the main valve seat. The closing force determines the opening width of the main valve, in particular the cross section of the main flow duct, which determines the damping force of the damping valve device. The pressure in the pilot control chamber is preferably set by the pilot valve, wherein the hydraulic fluid flows from the pilot control chamber through the connecting duct into the pilot working chamber which is released by the sliding tappet. The opening width, in particular the outflow cross section, of the connecting duct is preferably dependent on the axial position of the sliding tappet, which is set by means of the solenoid. In the closed position of the pilot valve, the sliding tappet preferably closes the connecting duct completely in such a way that the hydraulic pressure in the pilot control chamber increases to a maximum value and the main valve is closed in that the main piston is pressed onto the main valve seat. In an opened position of the pilot valve, the connecting duct is at least partially released by the sliding tappet.

[0026] According to a first embodiment, the main piston has a longitudinal section in the shape of a double U. In particular, the main piston has a longitudinal section in the shape of a W. The main piston is formed in one part or one piece, for example. The main piston is preferably designed to be rotationally symmetrical and in particular in two parts.

[0027] According to a further embodiment, the damping valve device has a damping valve housing, wherein the cylinder casing region by way of its external face lies, preferably in a fluid-tight manner, against the internal face of the damping valve housing. The external face is understood to mean the face that points radially outward, and the internal face is understood to mean the face that points radially inward. The damping valve housing preferably forms an axial guide of the main piston. In particular, the main piston lies against the internal face of the tube part of the damping valve housing. The radial external face preferably lies completely against the internal face of the damping valve housing. The contact due to the cylinder casing region lying against the internal face of the damping valve housing ensures a high degree of stability of the main piston during an axial movement, because the latter is guided on the radially outer face, a uniform introduction of force into the main piston taking place and twisting being reliably prevented in this way.

[0028] According to a further embodiment, the main piston has a central step which extends from the cylinder base region in the direction of the armature. The step is preferably disposed so as to be coaxial with the cylinder casing region, and has a smaller diameter than the cylinder casing region. Optionally, the step is designed as a component which is separate from the cylinder casing region and the cylinder base region, and is preferably fixedly connected to the cylinder base region. The step enables a central introduction of force into the main piston, and in this way ensures a particularly stable movement of the main piston.

[0029] For example, a support region which is designed as an axial guide of the central step and is disposed so as to be coaxial with the latter is fastened to the pole tube. The central step is preferably able to be moved axially relative to the support region. It is likewise conceivable that the main piston comprises the support region and the latter is fastened to the central step so as to be coaxial therewith. For example, the support region is designed as a component which is separate from the cylinder casing region, the cylinder base region and the step. The support region has in particular a longitudinal section in the shape of a U. The support region is preferably attached to the end of the step that points in the direction of the drive region. A spring element is preferably attached to the support region. The support region enables a spring element to be supported on the main piston, and offers a particularly compact construction mode of the main piston.

[0030] According to a further embodiment, the cylinder casing region has an annular end face which is contiguous to the pilot working chamber and is disposed in such a manner that the hydraulic pressure prevalent in the pilot working chamber impinges the end face of the main piston with an axial force acting in the closing direction of the main valve.

The end face preferably points in the direction of the drive region. The end face is preferably designed to be completely annular. The hydraulic pressure prevalent on the end face is, for example, the outflow pressure in the flow direction behind the sliding tappet. The introduction of force on the annular end face ensures stable guiding of the main piston in the axial direction, whereby little friction arises and twisting of the main piston is reliably prevented.

[0031] According to a further embodiment, a spring element is disposed on the end face of the cylinder casing region in such a manner that said spring element impinges the main piston with a spring force acting in the closing direction of the main valve. The spring element is, for example, a spiral spring, a plate spring and/or a spring disc. The spring element by way of its first end is preferably supported on the end face of the cylinder casing region, and by way of its other end on the pole tube and/or the damping valve housing. The spring element ensures an additional degree of stability of the main piston.

[0032] According to a further embodiment, the central step is designed as a separate component and is fastened to the cylinder base region. The cylinder base region and the cylinder casing region are preferably designed in one part or one piece as a common component. By way of example, the central step has a region which points in the direction of the cylinder base region and has a longitudinal section in the shape of a U. The central step is preferably fixedly connected to the cylinder base region, for example by a press-fit. By way of example, a hydraulic chamber is formed between the U-shaped region of the step and the cylinder base region, said hydraulic chamber by way of the flow passage formed in the step being fluidically connected to the pilot control chamber, and by way of the flow throttle being fluidically connected to the compression main control chamber. A separate design of the step enables the main piston to be easily and cost-effectively produced and assembled.

[0033] According to a further embodiment, the sliding tappet is fastened to the armature, in particular to the armature rod, and in the closed position of the pilot valve lies, in particular in a fluid-tight manner, against the end face of the central step. In the closed position of the pilot valve, the sliding tappet preferably lies against the main piston in such a manner that said sliding tappet fluidically closes the connecting duct. The armature and the sliding tappet are thus connected directly to one another in such a way that the solenoid acts directly on the preliminary stage and the main stage of the damping valve device, thus preferably implementing a sequential control. Furthermore, such a fastening causes reduced friction on the pilot valve because the tappet is guided by the armature rod.

[0034] According to a further embodiment, a pilot spring is disposed on the support region and on the sliding tappet in such a manner that said pilot spring impinges the sliding tappet with an axial force acting in the opening direction of the pilot valve. The pilot spring is preferably a plate spring, a spring disc or a spiral spring. The pilot spring preferably lies against the end face of the support region that points in the direction of the drive region. The pilot spring preferably enables a fail-safe protection for the event that the coil is unintentionally de-energized. The pilot spring preferably lies against the sliding tappet and the main piston. In particular, the pilot spring as a spiral spring lies within a hollow-cylindrical region of the main piston. Preferably, the pilot spring additionally ensures a reduced friction of the pilot valve because the sliding tappet is guided by the pilot spring.

[0035] According to a further embodiment, the damping valve device has a first pilot outflow duct for fluidically connecting the pilot working chamber to the piston rod-proximal working chamber, and a second pilot outflow duct for fluidically connecting the pilot working chamber to the piston rod-distal working chamber. A separate outflow of the hydraulic fluid from the pilot working chamber in the traction phase and the compression phase is enabled as a result.

[0036] The first pilot outflow duct is preferably formed in the damping valve housing of the vibration damper, and preferably extends from the pilot working chamber directly into the piston rod-proximal working chamber. The first pilot outflow duct preferably has a flow throttle and/or a check valve which is disposed in such a manner that a hydraulic flow is enabled from the pilot working chamber into the piston rod-proximal working chamber and prevented in the opposite direction. The first pilot outflow duct is formed within the damping valve housing, for example, preferably as an axial duct.

[0037] The second pilot outflow duct is preferably designed for fluidically connecting the pilot working chamber to the piston rod-distal working chamber. The second pilot outflow duct is in particular formed in the damping valve housing, and preferably extends axially through the latter. The second pilot outflow duct preferably extends from the pilot working chamber directly into the piston rod-distal working chamber. The second pilot outflow duct preferably has a flow throttle and/or a check valve which is disposed in such a manner that a hydraulic flow is enabled from the pilot working chamber into the piston rod-distal working chamber and prevented in the opposite direction.

[0038] According to a further embodiment, the pilot outflow ducts are designed as flow bypasses for at least partially bypassing the pilot valve and the main valve. The check valves of the pilot outflow ducts preferably have in each case at least one bypass opening.

[0039] According to a further embodiment, the compression main control chamber by way of a first flow passage, and the traction main control chamber by way of a second flow passage, are fluidically connected to the pilot control chamber. Providing a first and a second flow passage for connecting the main control chambers to the pilot control chamber ensures that the pilot valve is able to be passed through by a flow in the compression phase and in the traction phase of the vibration damper. The compression main control chamber and the traction main control chamber are in each case fluidically connected to the pilot control chamber.

[0040] One flow throttle is preferably in each case disposed in the first flow passage and the second flow passage. The first flow passage preferably extends at least partially or completely through the main piston, in particular through the cylinder base region, and preferably fluidically connects the compression main control chamber to the pilot control chamber. The second flow passage preferably likewise extends through the main piston, in particular through the cylinder base region, and fluidically connects the traction main control chamber to the pilot control chamber. A flow throttle in each flow passage permits a separate setting of the flow throttle in the traction phase and the compression phase.

[0041] One check valve is preferably in each case disposed in the first flow passage and the second flow passage so that hydraulic fluid is in each case able to flow through the first and the second flow passage exclusively in one direction. The first flow passage preferably has a check valve which is disposed in such a manner that a hydraulic flow is enabled from the traction main control chamber into the pilot control chamber and prevented in the opposite direction. The second flow passage preferably has a check valve which is disposed in such a manner that a hydraulic flow is enabled from the compression main control chamber into the pilot control chamber and prevented in the opposite direction. A check valve in each of the flow passages enables rectification of the hydraulic flows in the traction phase and the compression phase into the pilot control chamber so that the same pilot control chamber and the adjoining pilot valve can be used both in the traction phase and in the compression phase.

[0042] The first flow passage and the second flow passage are preferably disposed separately from one another. This ensures a separate configuration capability of the damping valve device in the traction phase and the compression phase. The spring assembly has in particular a bypass opening which is disposed so as to be co-aligned with the first flow passage.

[0043] According to a further embodiment, the connecting duct for fluidically connecting the pilot control chamber to the pilot working chamber is formed in the central step of the main piston. The connecting duct is preferably disposed exclusively in the step, and in particular not in the cylinder base region and/or the cylinder casing region. The connecting duct extends in particular centrally and in the axial direction through the main piston, from the pilot control chamber into the pilot working chamber. The connecting duct preferably forms the fluid inlet into the pilot valve. The pilot working chamber preferably fluidically adjoins the connecting duct directly. The connecting duct in the main piston preferably ensures a simple direct fluidic connection between the pilot control chamber and the pilot working chamber, wherein the hydraulic fluid flows axially in the direction of the armature through the pilot working chamber.

[0044] The sliding tappet in the closed position of the pilot valve preferably lies against the main piston in such a manner that said sliding tappet fluidically closes the connecting duct. The main piston preferably forms a pilot valve seat, the sliding tappet in the closed position of the pilot valve lying against said pilot valve seat. The sliding tappet lying against the main piston enables a sequence control, wherein the sliding tappet impinges the main piston directly with a closing force which is applied to the sliding tappet by way of the armature rod. As a result, a high operational reliability is achieved.

[0045] According to a further embodiment, the main piston has a traction opening face which is directly contiguous to the traction main control chamber and has a compression opening face which is directly contiguous to the compression main control chamber, and wherein the ratio between the traction opening face and the compression opening face is 1:1 to 5:1, in particular 2:1 to 4:1, preferably 3:1.

[0046] According to a further embodiment, the damping valve device comprises a comfort valve which in the compression phase and in the traction phase is able to be passed through by a flow of hydraulic fluid. In particular, the comfort valve comprises at least one comfort spring disc pack, which for example comprises at least one or a plurality of spring discs that lies/lie against a comfort valve seat. The comfort valve preferably has two spring disc packs, wherein one is designed for damping the hydraulic fluid during a movement of the piston rod in the traction direction, and the other spring disc pack is designed for damping the hydraulic fluid during a movement of the piston rod in the compression direction. The comfort valve is preferably fluidically connected directly to the piston rod-distal working chamber. The comfort valve preferably forms the end of the working piston that points in the direction of the base valve.

[0047] For example, the damping valve device has a spring element which is attached to the main piston in such a manner that said spring element impinges the main piston with a force acting in the opening direction of the main valve. The spring element is preferably attached to the side of the main piston that faces the comfort valve. The spring element is in particular designed as a spiral spring which is supported on a valve body of the comfort valve.

[0048] In particular, the main piston has a closing face which is contiguous to the pilot control chamber and is disposed in such a manner that the hydraulic pressure prevalent in the pilot control chamber impinges the closing face of the main piston with an axial force acting in the closing direction of the main valve, and wherein the closing face is designed as an annular face.

[0049] For example, the damping valve device comprises a bypass duct which is disposed in such a way that it fluidically connects the compression main control chamber and the traction main control chamber to one another. The bypass duct is preferably formed hydraulically in parallel with the main flow duct, as a bypass of the main valve. The bypass duct extends in particular from the compression main control chamber to the traction main control chamber and fluidically connects those to one another.

[0050] In particular, the sliding tappet has an opening face which in the closed position of the pilot valve lies at least partially against the main piston, and wherein the opening face has a clearance. The opening face is preferably formed on the end face of the sliding tappet that faces the connecting duct and is preferably disposed in such a manner that, in the closed position of the pilot valve, it completely closes the connecting duct. The opening face preferably has an, in particular central, clearance that points in the axial direction and which, by way of example, is conical. The clearance is designed to be, for example, cylindrical with a round, circular or angular cross section. The clearance preferably serves to increase the opening face and thus to set the opening pressure of the pilot valve.

[0051] FIG. **1** shows a vibration damper **10**, wherein the vibration damper **10** is a multi-tube vibration damper, by way of example a dual-tube vibration damper. The vibration damper **10** has an outer tube **12** which forms an external face in particular a housing, of the vibration damper **10**. An inner tube **14**, which can also be referred to as a damper tube is disposed within the outer tube **12** so as to be coaxial with the latter. Formed between the outer tube **12** and the inner tube **14** is a compensation chamber **16** which is preferably at least partially filled with a hydraulic fluid. For example, the compensation chamber **16** is partially filled with a gas.

[0052] A working piston **18**, which is connected to a piston rod **20**, is disposed within the inner tube **14** in such a manner that said working piston is movable within the inner tube **14**, wherein the inner tube **14** is preferably designed as a guide of the working piston **18**. The working piston **18** has a damping valve device **54**. The working piston **18** divides the interior of the inner tube **14** into a first working chamber **22**, which is disposed proximal to the piston rod, and a second working chamber **24**, which is disposed so as to be distal from the piston rod.

[0053] The interior of the outer tube **12** is fluidically sealed off on the piston rod side by means of a closure pack **34**. Opposite from the closure pack **34**, at the piston rod-distal end, the interior of the outer tube **12** is fluidically sealed off by means of a base piece **36**. By way of example, a base valve **38**, which is in particular attached to the piston rod-distal end of the inner tube **14**, is disposed on the base piece **36**. The base valve **38** is, for example, a check valve which is able to be passed through by a flow in both directions or only one direction. The second working chamber **24** is preferably fluidically connected to the compensation chamber **16** by way of the base valve **38**. The piston rod-proximal end of the inner tube **14** and of the outer tube **12** is preferably fastened to the closure pack **34**.

[0054] By way of example, the piston rod **20** has an optional traction stop, which is impinged with a spring force by way of a spring element **42** during a movement in the traction direction Z.

[0055] FIG. **2** shows an exemplary damping valve device **54** which is preferably disposed in the working piston **18** of the vibration damper **10**. The damping valve device **54** is designed, by way of example, as a pilot-controlled pressure control valve and comprises a preferably cylindrical damping valve housing which has, by way of example, a substantially tubular tube part **45** and has a housing upper part **44**, the latter being designed in one piece with the tube part **45**, for example. The piston rod **20** is preferably attached to the housing upper part **44**. The housing upper part **44** has, for example, a connection region (not illustrated) which has one or a plurality of connection contacts for an electrical power supply of the damping valve device **54**. The connection contacts for an electrical current supply are preferably connected to a drive unit.

[0056] By way of example, the damping valve device **54** has a drive region **48** and a valve region **50**. By way of example, the drive region **48** is disposed in the upper region of the damping valve device **54** that faces the piston rod **20**, and preferably substantially above the valve region **50**, in particular in the traction direction Z. The drive region **48** preferably comprises a drive in the form of a solenoid. The solenoid comprises a coil **52** having a plurality of windings made of a current-conducting wire. The coil **52** is preferably disposed within the tube part **45** and so as to be concentric with the latter. By way of example, the coil **52** lies against the inner wall of the tube part **45**. By way of example, a cover section **56** is disposed axially between the coil **52** and the housing upper part **44**. The coil **52** preferably lies against the cover portion **56** and is in particular fastened thereto. The cover portion **56** is formed for example from a metal, in particular a magnetizable material, preferably a material having a low magnetic resistance. The coil **52** comprises, for example, a coil carrier on which the windings of the coil are wound. The coil **52** encloses at least partially or completely an armature space **60** which extends centrally in the axial direction. An armature **62** is mounted so as to be axially movable within the armature space **60**. The armature **62** is preferably of a cylindrical design and has a diameter which is slightly smaller than the diameter of the armature space **60**, so that the armature **62** is preferably mounted so as to be able to slide in the axial direction. By way of example, the armature **62** comprises a central armature rod **65** which, by way of example, has a round cross section and extends centrally in the axial direction through the armature space **60**. The armature space **60** is preferably delimited by an at least partially hollow-cylindrical pole tube **64**. The pole tube **64** extends, by way of example, from the drive region **48** into the valve region **50**. The pole tube **64** is preferably made of a magnetizable or magnetic material and has, for example, a magnetic separation **58**.

[0057] The coil **52** is preferably designed and disposed in such a manner that, when impinged with a current, it forms a magnetic field which has magnetic field lines which preferably run substantially in the axial direction. The armature **62** is preferably made of a magnetizable or magnetic material and is movable in the axial direction, corresponding to the magnetic field formed by means of the coil **52**.

[0058] The pole tube **64** is formed in particular in multiple parts, integrally or in one part. The pole tube **64** has an upper tubular region with an in particular constant internal diameter, which is preferably formed as a hollow cylinder and extends, for example, from the cover portion **56** in the axial direction as far as beyond the armature **62**. The upper hollow-cylindrical region is adjoined in the axial direction by a lower region with an enlarged diameter, wherein the external face of the pole tube **64** preferably extends as far as the tube part **45** and at least partially lies against the latter and is sealed off in a fluid-tight manner in relation to the tube part **45** by means of, for example, a sealing element. The tube part **45** encloses at least partially or completely a valve region **50** in the axial and in the circumferential direction, said valve region being explained in more detail in one of the following paragraphs.

[0059] By way of example, the valve region **50** comprises a main valve **68** and a pilot valve **70**. Preferably, the damping valve device **54** disposed in the working piston **18** has exactly one main valve **68** and/or exactly one pilot valve **70**. Preferably, the main valve **68** and/or the pilot valve **70** are/is able to be passed through by a flow of hydraulic fluid during a movement of the piston rod **20** in the traction direction Z and in the compression direction D. Attached to the working piston **18** is preferably a seal **26**, for example a sealing ring, which seals the working piston **18** in a fluid-tight manner in relation to the damper tube **14**. The seal **26** preferably lies in a fluid-tight manner against the external face of the working piston **18** and against the internal face of the damper tube **14**. Furthermore, the damping valve device **54** optionally has a comfort valve **28**. The comfort valve **28** is preferably designed in such a way that it is able to be passed through by a flow of hydraulic fluid both in the compression direction D and in the traction direction Z. In particular, the comfort valve **28** comprises at least one comfort spring disc pack **30**, which for example comprises at least one or a plurality of spring discs that lies/lie against a comfort valve seat. The comfort valve **28** preferably has two spring disc packs, wherein one is designed for damping the hydraulic fluid during a movement of the piston rod **20** in the traction direction Z and the other spring disc pack is designed for damping the hydraulic fluid during a movement of the piston rod **20** in the compression direction D. The comfort valve **28** is preferably fluidically connected directly to the piston rod-distal working chamber **24**. Preferably, the comfort valve **28** is disposed in the piston rod-distal working chamber **24** and in particular forms the end of the working piston **18** that points in the direction of the base valve **36**. By way of example, the comfort valve **28** comprises a comfort valve housing **32** which is preferably formed separately from the tube part **45** and fixedly connected thereto or formed integrally with the tube part **45**. Preferably, the seal **26** is attached to the comfort valve housing **42** and connected thereto in a fluid-tight manner. The comfort valve housing **32** surrounds the comfort spring disc packs **30** preferably axially and circumferentially.

[0060] The working piston **18** comprises a first fluid passage **39** to the first working chamber **22**, wherein the first fluid passage **39** is formed by way of example in the tube part **45**, by way of example as a circular opening. The damping valve device **54** is preferably fluidically connected to the first, piston rod-proximal, working chamber **22** by way of the first fluid passage **39**. The first fluid passage **39** comprises, for example, a multiplicity of passage bores in the tube part **45**. By way of example, in a movement of the piston rod **20** in the traction direction Z, the first fluid passage **39** is formed as a fluid inlet for admitting hydraulic fluid into the damping valve device **54** and, in a movement of the piston rod in the compression direction D as a fluid outlet for discharging hydraulic fluid from the damping valve device **54**.

[0061] The working piston **18**, in particular the comfort valve **28**, preferably has a second fluid passage **40** to the second working chamber **24**, via which the damping valve device **54** is preferably fluidically connected to the second, piston rod-distal, working chamber **24**. By way of example, the second fluid passage **40** in a movement of the piston rod **20** in the compression direction D is formed as a fluid inlet for admitting hydraulic fluid into the comfort valve **28** and the main valve **68**, and in a movement of the piston rod in the traction direction Z as a fluid outlet for discharging hydraulic fluid from the comfort valve **28** and the main valve **68**.

[0062] During operation of the damping valve device **54**, in a piston rod movement in the traction direction Z, the hydraulic fluid preferably flows from the first fluid passage **39** into the main valve **68** and into the pilot valve **70**, and subsequently optionally through the comfort valve **28** and to the second fluid passage **40**. The main valve **68** comprises a main piston **76** which is disposed so as to be axially movable within a main working chamber **78**. By way of example, the main valve **68** also comprises a housing part **80** which at least partially delimits the main working chamber **78** and forms an axial guide for the main piston **76**. The housing part **80** is disposed, for example, within the tube part **45** and so as to be coaxial with the latter. By way of example, the housing part **80** is formed integrally with the pole tube **64**. A gap, in particular an annular space, is preferably formed between the housing part **80** and the tube part **45**. The main piston **76** is preferably disposed at least partially in the annular space between the housing part **80** and the tube part **45** and so as to be concentric with the latter.

[0063] The main piston **76** preferably divides the main working chamber **78** into a compression main control chamber **82*a***, a traction main control chamber **82*b*** and a pilot control chamber **84**. The main piston **76** has in particular a first flow passage **86*a***, which extends through the main piston **76** and forms a fluidic connection between the compression main control chamber **82*a*** and the pilot control chamber **84**. By way of example, the first flow passage **86*a*** extends in the axial direction through the main piston **76**.

[0064] By way of example, the main piston **76** has a second flow passage **86*b*** which forms a fluidic connection between the traction main control chamber **82*b*** and the pilot control chamber **84**. By way of example, the second flow passage **86*b*** is disposed at the same height as the first fluid passage **39**. The first and the second flow passage **86*a,b*** preferably each have a respective flow throttle **96*a,b***, in particular a cross-sectional constriction, and/or a check valve. The check valve in the first flow passage **86*a*** is preferably disposed in such a manner that it allows a flow from the compression main control chamber **82*a*** into the pilot control chamber **84**. The check valve in the second flow passage **86*b*** is preferably disposed in such a manner that it allows a flow from the traction main control chamber **82** into the pilot control chamber **84**.

[0065] The compression main control chamber **82*a*** is formed by way of example between the comfort valve **28** and the main piston **76**. The traction main control chamber **82*b*** is preferably formed, in particular as an annular space, on the fluid passage **39** to the first working chamber **22** and between the tube part **45** and the main piston **76**. The hydraulic pressure of the second, piston rod-distal, working chamber **24** is preferably prevalent in the compression main control chamber **82*a***, wherein the pressure of the first, piston rod-proximal, working chamber **22** is preferably prevalent in the traction main control chamber **82*b***.

[0066] A guide element **72** is preferably disposed in a positionally fixed manner in the damping valve device **54** between the main valve **68** and the comfort valve **28**. By way of example, the guide element **72** is of tubular design and serves for directing hydraulic fluid from the comfort valve **28** to the main valve **68**. By way of example, the guide element **72** forms at least partially the compression main control chamber **82*a***. The guide element **72** is optionally disposed in a positionally fixed manner formed in one piece with the valve body of the comfort valve **28**. A main valve seat **90** is preferably formed on the guide element **72**. Attached to the main piston **76** is, for example, a spring assembly **77** which in the closed position of the main valve **68** lies against the main valve seat **90** of the guide element **72**. The spring assembly **77** preferably comprises a plurality of, in particular two, spring discs which are disposed coaxially with respect to one another and preferably bear against one another. The spring disc of the spring assembly **77** that points in the direction of the compression main control chamber **82*a*** preferably lies against the main valve seat **90** and has, in particular, a bypass opening **74**. The bypass opening **74** in the spring assembly **77** is preferably disposed so as to be co-aligned with the first flow passage **86*a***.

[0067] In the opened position of the main valve **68**, in which the main piston **76** is moved away from the main valve seat **90** in the axial direction, the main piston **76** and the spring assembly **77** are lifted from the main valve seat **90** in such a way that a main flow duct **92** is formed between the main piston **76** and the main valve seat **90**. The main flow duct **92** forms a fluidic connection between the first and the second working chamber **22**, **24**. In particular, the main flow duct **92** forms a fluidic connection between the compression main control chamber **82*a*** and the traction main control chamber **82***b*. Optionally, the damping valve device **54** has a bypass duct which is preferably formed hydraulically in parallel with the main flow duct **92**, as a bypass of the main valve **68**.

[0068] The main piston **76** is preferably of a hollow-cylindrical design. By way of example, the main piston **76** has a cylinder base region **76***b* that points in the direction of the comfort valve **28** and an adjoining cylinder casing region **76***a* that points in the direction of the drive region **48**. By way of example, the cylinder casing region **76***a*, by way of its external face, lies, in particular in a fluid-tight manner, against the tube part **45**. The cylinder casing region **76***a*, by way of the internal face, lies, in particular in a fluid-tight manner, particularly on the housing part **80** of the pole tube **64**. The cylinder base region **76***b* preferably has the main valve seat **90** and the flow passages **86***a,b*. For example, the main piston **76** has a U-shaped or W-shaped longitudinal section. The main piston **76** preferably has a central step **76***c* which extends from the cylinder base region **76***b* in the direction of the armature rod **65** and is preferably disposed so as to be co-aligned, preferably coaxial, with the latter. The central step **76***c* is preferably disposed so as to be coaxial with the cylinder casing region **76***a*, and has in particular a round, preferably circular, cross section. By way of example, the step **76***c* has the connecting duct **98** which is designed as a central axial bore.

[0069] A support region **76***d* is attached to the central step **76***c* and is coaxial with the latter. The support region **76***d* preferably has a U-shaped longitudinal section having a central bore through which the central step **76***c* extends. The support region **76***d* is preferably fastened to the external face of the central step, for example by way of a press-fit or a threaded connection. The support region, by way of its external face, preferably lies, in particular in a fluid-tight manner, against the pole tube **64**, in particular the housing part **80**. It is likewise conceivable that the support region **76***d* is fastened to the housing part **80**, and preferably forms an axial guide of the central step **76***c*, wherein the central step **76***c* preferably lies in a fluid-tight manner against the support region **76***d*.

[0070] The cylinder casing region **76***a* of the main piston **76** preferably forms an annular end face A_{SP} which points in the direction of the drive region **48**. The end face A_{SP} serves as closing face of the main piston **76**. The cylinder base region **76***b* of the main piston **76** preferably has an annular face **46** which points in the direction of the drive region **48** and which likewise serves as a closing face A_S of the main piston **76** and adjoins the pilot control chamber **84**, such that the hydraulic pressure prevailing in the pilot control chamber **84** impinges the main piston **76**, in particular the closing face **46** of the main piston **76**, with an axial force acting in the closing direction of the main valve. The pilot control chamber **84** is preferably delimited by the main piston **76**, in particular the closing face **46**, the support region **76***d* and the cylinder casing region **76***a* and by the housing part **80**.

[0071] The end face A_{SP} is contiguous to the pilot working chamber **100** in such a way that the hydraulic pressure prevalent in the pilot working chamber **100** impinges the main piston **76**, in particular the closing face A_{SP} of the main piston **76**, with an axial force acting in the closing direction of the main valve **68**. A spring element which impinges the main piston **76** with a spring force acting in the closing direction is in particular attached to the end face A_{SP}. The spring element **94** is preferably supported on a step in the pole tube **64** and/or a step in the tube part **45**.

[0072] Attached to that side of the main piston **76** that points in the direction of the comfort valve is by way of example a further spring element **88** which is disposed in such a manner that it impinges the main piston **76** with a spring force acting in the opening direction. The spring element **94** is, for example, a spiral spring which lies against the valve body of the comfort valve **28** and the main piston **76**.

[0073] A connecting duct **98** which in particular extends centrally and in the axial direction from the pilot control chamber **84** through the main piston **76** into a pilot working chamber **100** is preferably formed in said main piston. Preferably, the connecting duct **98** forms the fluid inlet into the pilot valve **70**. Preferably, the pilot working chamber **100** fluidically adjoins directly the connecting duct **98**.

[0074] By way of example, the pilot valve **70** comprises a sliding tappet **102** which is disposed so as to be axially movable within the pilot working chamber **100**. The sliding tappet **102** by way of its end that faces away from the main valve **68** is preferably fastened on the armature **62**, in particular the armature rod **65**, so that the sliding tappet **102** moves with the armature **62**. In a closed position of the pilot valve **70**, the sliding tappet **102** preferably lies against the main piston **76** in such a way that the connecting duct **98** is completely closed by the sliding tappet **102**. In an opened position of the pilot valve **70**, the sliding tappet **102** is lifted from the main piston **76** in such a way that the connecting duct **98** is opened by the sliding tappet **102** and a fluid flow takes place between the pilot control chamber **84** of the main valve **68** and the pilot working chamber **100**. The sliding tappet **102** is preferably attached so as to be axially movable relative to the main piston **76**. The sliding tappet **102** preferably lies against the end face of the central step **76***c*.

[0075] By way of example, the sliding tappet **102** has a T-shaped longitudinal section, wherein the sliding tappet **102** has a first region that faces the connecting duct **98** and has a cross section which is larger than the cross section of the connecting duct **98**, and a second region that faces the armature **62** and has a smaller cross section than the first region.

[0076] In the closed position, the sliding tappet **102** preferably lies against a first valve seat which is formed in the main piston **76**. The pilot working chamber **100** is preferably fluidically connected to the first fluid passage **39** and the second fluid passage **40**. The pilot valve **70** preferably has a pilot spring **108** which is disposed in such a manner that it impinges the sliding tappet **102** with an axial force acting in the opening direction of the pilot valve **70**. The pilot spring **108** preferably serves as a fail-safe device for the event in which the coil **52** is de-energized, and is designed in such a manner that the hydraulic fluid flows out by way of the pilot outflow duct **104***a* and in particular a fail-safe valve disposed therein. The pilot spring **108** preferably lies against the sliding tappet **102** and the support region **76***d* of the main piston **76** or of the pole tube **80**. The leg regions of the U-shaped profile of the support region **76***d* form an annular end face on which a pilot spring **108** is preferably supported. By way of example, the pilot spring **108** is designed as a plate spring.

[0077] The sliding tappet **102** preferably has an opening face **110** which is formed on the first region of the sliding tappet that faces the connecting duct **98**, and is disposed in such a manner that it closes the connecting duct **98** in the closed position of the pilot valve **70**. The opening face **110** is likewise referred to as pilot opening face A_P, for example, and preferably has an in particular central clearance that points in the axial direction and is conical, by way of example. The clearance can be designed, for example, so as to be cylindrical, having a round, circular or angular cross section. The clearance preferably serves to enlarge the opening face and thus to set the opening pressure of the pilot valve **70**.

[0078] The pilot valve **70** preferably comprises a first pilot outflow duct **104***a* which is designed and disposed for fluidically connecting the pilot working chamber **100** to the piston rod-proximal working chamber **22**. The first pilot outflow duct **104***a* is formed by way of example in the tube part **45** and preferably extends from the pilot working chamber **100** directly into the piston rod-proximal working chamber **22**. The first pilot outflow duct **104***a* preferably has a check valve which is disposed in such a manner that a hydraulic flow is enabled from the pilot working chamber **100** into the piston rod-proximal working chamber **22** and is prevented in the opposite direction.

[0079] The pilot valve **70** preferably comprises a second pilot outflow duct **104***b* which is designed and disposed for fluidically connecting the pilot working chamber **100** to the piston rod-distal working chamber **24**. The second pilot outflow duct **104***b* is formed by way of example in the tube part **45** and preferably extends axially through the latter. The second pilot outflow duct **104***b* preferably extends from the pilot working chamber **100** directly into the piston rod-distal working chamber **24**. The second pilot outflow duct **104***b* preferably has a check valve which is disposed in such a manner that a hydraulic flow is enabled from the pilot working chamber **100** into the piston rod-distal working chamber **24** and is prevented in the opposite direction.

[0080] During operation of the damping valve device **54**, in a movement of the piston rod **20** in the compression direction D, the hydraulic fluid flows through the second fluid passage **40** into the optional comfort valve **28**, into the compression main control chamber **82***a*, whereby the pressure in the compression main control chamber **82***a* impinges the main piston **76** with an opening force and is moved axially upward. In the process, the main piston **76** is lifted from the main valve seat **90** and the hydraulic fluid flows through the main flow duct **92** to the traction main control chamber **82***b*, in particular the second fluid passage **39**. At the same time, a sub-flow of the hydraulic fluid flows through the first flow passage **86***a* in the main piston **76** to the pilot control chamber **84** and impinges the main piston **76** with a closing force acting in the direction of the main valve seat **90**. The closing force determines the opening width of the main valve **68**, in particular the cross section of the main flow duct **92**, which determines the damping force of the damping valve device **54**. The pressure in the pilot control chamber **84** is set by the pilot valve **70**, wherein the hydraulic fluid flows from the pilot control chamber **84** through the connecting duct **98** into the pilot working chamber **100** which is released by the sliding tappet **102**. The opening width of the connecting duct **98** is dependent on the axial position of the sliding tappet **102**, which is set, in particular predefined, by means of a solenoid **54**. In the closed position of the pilot valve **70**, the sliding tappet **102** preferably closes the connecting duct **98** completely, so that the hydraulic pressure in the pilot control chamber **84** increases to a maximum value and the main valve **68** is closed and preferably impinged with a force acting in the closing direction, the main piston **76** thereby being pressed onto the main valve seat **90**. In an opened position of the pilot valve **70**, the connecting duct **98** is at least partially released by the sliding tappet **102**, so that a hydraulic flow flows by way of a first pilot outflow duct **104***a* to the piston rod-proximal working chamber **22**. The fluid flow during a movement of the piston rod **20** in the compression direction D is schematically illustrated by the arrows in FIG. **2**, whereby the solid line represents the main flow through the main valve **68** and the dashed line represents the pilot flow through the pilot valve **70**.

[0081] FIG. **3** shows the damping valve device **54** of FIG. **2**, wherein the fluid flow during a movement of the piston rod in the traction direction Z is illustrated. The main piston **76** preferably has a traction opening face A_Z and a compression opening face A_D. The compression opening face A_D is the face of the main piston **76** directly contiguous to the compression main control chamber **82***a*, wherein the traction opening face A_Z is the face of the main piston **76** directly contiguous to the traction main control chamber **82***b*. The ratio (A_Z/A_D) between the traction opening face A_Z and the compression opening face A_D is, for example, 1:1 to 5:1, in particular 2:1 to 4:1, preferably 3:1.

[0082] FIG. **4** shows a detailed illustration of the main piston **76**, wherein the vibration damper corresponds substantially to the vibration damper described with reference to FIGS. **1** to **3**, but with the difference that the central step **76***c* is designed separately from the cylinder casing region **76***a* and the cylinder base region **76***b*. By way of example, the step **76***c* has a region with a U-shaped longitudinal section that points in the direction of the cylinder base region **76***b*. The central step **76***c* is preferably fixedly connected to the cylinder base region **76***a*, for example by way of a press-fit. By way of example, a hydraulic chamber which by way of the flow passage **86***a* formed in the step is fluidically connected to the pilot control chamber **84**, and by way of the flow throttle **96***a* is fluidically connected to the compression main control chamber **82***a*, is formed between the U-shaped region of the step **76***c* and the cylinder base region **76***a*.

[0083] FIG. **5** shows a hydraulic circuit diagram of a damping valve device **54**, wherein the solid lines represent the main volume flow and the dashed lines represent the pilot flow. The hydraulic circuit diagram is merely by way of example and serves to simplify the hydraulic correlations of FIGS. **1** to **3** for improved understanding. The working chambers **22**, **24** of the vibration damper **54** are fluidically connected to one another by way of the main volumetric flow flowing through the main valve **68** of the damping valve device **54**. The pilot valve **70** is preferably hydraulically connected in parallel with the main valve **68**. In particular, the pilot valve **70** is designed in such a manner that it sets the hydraulic pressure acting on the closing face A_S of the main piston **76**, in particular as a function of the position of the sliding tappet **102**, in particular as a function of the force of the pilot valve **70** that has been introduced by the sliding tappet. By way of example, the pilot outflow ducts **104***a,b* have in each case one check valve and one throttle, the latter being designed as a bypass opening in the check valve, for example. In this way, the pilot outflow ducts **104***a,b* are optionally designed as flow bypasses for at least partially bypassing the pilot valve **70** and the main valve **68**.

By way of example, the check valves have in each case one bypass opening in the flow passages **86***a,b*.

[0084] The hydraulic circuit diagram of FIG. **5** shows by way of example that the damping valve **54** optionally has a bypass duct **112** which is, for example, attached to the main valve set **90** and forms a bypass of the main valve **68**.

[0085] Furthermore illustrated in the hydraulic circuit diagram are the hydraulic pressure P_Z in the traction phase Z, the hydraulic pressure PD in the compression phase D, the pilot control pressure P_P and the outflow pressure P_{AL}.

LIST OF REFERENCE SIGNS

[0086] **10** Vibration damper
[0087] **12** Outer tube
[0088] **14** Inner tube
[0089] **16** Compensation chamber
[0090] **18** Working piston
[0091] **20** Piston rod
[0092] **22** First/piston rod-proximal working chamber
[0093] **24** Second/piston rod-distal working chamber
[0094] **26** Seal
[0095] **28** Comfort valve
[0096] **30** Comfort spring disc pack
[0097] **32** Comfort valve housing
[0098] **34** Closure pack
[0099] **36** Base piece
[0100] **38** Base valve
[0101] **39** First fluid passage to the first working chamber **22**
[0102] **40** Second fluid passage to the second working chamber **24**
[0103] **42** Spring element
[0104] **44** Housing upper part
[0105] **45** Tube part
[0106] **46** End face/closing face
[0107] **48** Drive region
[0108] **50** Valve region
[0109] **52** Coil
[0110] **54** Damping valve device
[0111] **56** Cover portion
[0112] **58** Magnetic separation
[0113] **60** Armature space
[0114] **62** Armature
[0115] **64** Pole tube
[0116] **65** Armature rod
[0117] **68** Main valve
[0118] **70** Pilot valve
[0119] **72** Guide element
[0120] **74** Bypass opening
[0121] **76** Main piston
[0122] **76***a* Cylinder casing region
[0123] **76***b* Cylinder base region
[0124] **76***c* Central step
[0125] **76***d* Support region
[0126] **77** Spring assembly
[0127] **78** Main working chamber
[0128] **80** Housing part
[0129] **82***a,b* Traction/compression main control chamber
[0130] **84** Pilot control chamber
[0131] **86***a,b* Flow passage
[0132] **88** Spring element
[0133] **90** Main valve seat
[0134] **92** Main flow duct
[0135] **94** Spring element
[0136] **96***a,b* Flow throttle
[0137] **98** Connecting duct
[0138] **100** Pilot working chamber
[0139] **102** Sliding tappet
[0140] **104***a* First pilot outflow duct
[0141] **104***b* Second pilot outflow duct
[0142] **106** Housing element
[0143] **108** Pilot spring
[0144] **110** Opening face of the sliding tappet
[0145] **112** Bypass duct
[0146] A_S First closing face of the main piston **76**
[0147] A_D Compression opening face of the main piston **76**
[0148] A_Z Traction opening face of the main piston **76**
[0149] A_{SP} Second closing face of the main piston **76**
[0150] A_P Pilot opening face

1. A vibration damper of a motor vehicle, comprising:
an outer tube and an inner tube which is disposed so as to be coaxial with the outer tube;
a working piston which is disposed so as to be axially movable within the inner tube and divides the interior of the inner tube into a piston rod-proximal working chamber and a piston rod-distal working chamber; and
a damping valve device which is disposed in the working piston, wherein the damping valve device includes:
a coil;
an axially movable armature which is at least partially disposed within the coil;
a main valve having a main piston which separates a compression main control chamber, a traction main control chamber and a pilot control chamber from one another;
a pilot valve which is designed in such a manner that it is able to be passed through by a flow of hydraulic fluid in the traction phase and in the compression phase and has a pilot working chamber and a sliding tappet that is disposed in the pilot working chamber and is axially movable by the armature; and
a connecting duct which is disposed between the pilot control chamber and the pilot working chamber and fluidically connects those to one another;
wherein the main piston comprises a cylinder base region and a cylinder casing region which forms the radially outer face of the main piston.

2. The vibration damper according to claim **1**, wherein the main piston has a longitudinal section in the shape of a double U.

3. The vibration damper according to claim **1**, wherein the damping valve device has a damping valve housing, and wherein the cylinder casing region by way of its external face lies against the internal face of the damping valve housing.

4. The vibration damper according to claim **1**, wherein the main piston has a central step which extends from the cylinder base region in the direction of the armature.

5. The vibration damper according to claim **4**, wherein the central step is designed as a separate component and is fastened to the cylinder base region.

6. The vibration damper according to claim **4**, wherein the sliding tappet is fastened to the armature and in the closed position of the pilot valve lies against the end face of the central step.

7. The vibration damper according to claim **1**, wherein the cylinder casing region has an annular end face which is contiguous to the pilot working chamber and is disposed in such a manner that the hydraulic pressure prevalent in the pilot working chamber impinges the end face of the main piston with an axial force acting the closing direction of the main valve.

8. The vibration damper according to claim **7**, wherein a spring element is disposed on the end face of the cylinder casing region in such a manner that said spring element impinges the main piston with a spring force acting in the closing direction of the main valve.

9. The vibration damper according to claim **7**, wherein a pilot spring is disposed on a support region and on the sliding tappet in such a manner that said pilot spring impinges the sliding tappet with an axial force acting the opening direction of the pilot valve.

10. The vibration damper according to claim **1**, wherein the damping valve device has a first pilot outflow duct for fluidically connecting the pilot working chamber to the piston rod-proximal working chamber, and a second pilot outflow duct for fluidically connecting the pilot working chamber to the piston rod-distal working chamber.

11. The vibration damper according to claim **10**, wherein the pilot outflow ducts are designed as flow bypasses for at least partially bypassing the pilot valve and the main valve.

12. (canceled)

13. The vibration damper according to claim **1**, wherein the connecting duct for fluidically connecting the pilot control chamber to the pilot working chamber is formed in the central step of the main piston.

14. The vibration damper according to claim **1**, wherein the main piston has a traction opening face which is directly contiguous to the traction main control chamber and has a compression opening face which is directly contiguous to the compression main control chamber, and wherein the ratio between the traction opening face and the compression opening face is 1:1 to 5:1.

15. The vibration damper according to claim **1**, wherein the main piston has a traction opening face which is directly contiguous to the traction main control chamber and has a compression opening face which is directly contiguous to the compression main control chamber, and wherein the ratio between the traction opening face and the compression opening face is 2:1 to 4:1.

16. The vibration damper according to claim **1**, wherein the main piston has a traction opening face which is directly contiguous to the traction main control chamber and has a compression opening face which is directly contiguous to the compression main control chamber, and wherein the ratio between the traction opening face and the compression opening face is 3:1.

17. The vibration damper according to claim **1**, wherein the damping valve device comprises a comfort valve which in the compression phase and in the traction phase is able to be passed through by a flow of hydraulic fluid.

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