United States Patent Application Publication 20250257780
Kind Code A1
Publication Date August 14, 2025
Inventor(s) WOENARTA; Freddy

# DAMPING VALVE DEVICE FOR A SHOCK ABSORBER OF A MOTOR VEHICLE

## 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 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.

**Inventors:** **WOENARTA; Freddy (Braunschweig, DE)**

**Applicant:** **thyssenkrupp Bilstein GmbH** (Ennepetal, DE); **thyssenkrupp AG** (Essen, DE)

**Family ID:** **96499349**

**Assignee:** **thyssenkrupp Bilstein GmbH (Ennepetal, DE); thyssenkrupp AG (Essen, DE)**

**Appl. No.:** **19/046908**

**Filed:** **February 06, 2025**

## Foreign Application Priority Data

| | | |
|---|---|---|
| DE | 10 2024 103 604.4 | Feb. 08, 2024 |

## Publication Classification

**Int. Cl.:** **F16F9/18** (20060101); **F16F9/34** (20060101)

**U.S. Cl.:**

CPC **F16F9/185** (20130101); **F16F9/34** (20130101);

## Background/Summary

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 103 604.4, 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.

## Description

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 hydraulic circuit diagram of a damping valve device according to an exemplary embodiment.

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

[0011] FIG. **6** shows a schematic illustration of a hydraulic circuit diagram of a damping valve device according to an exemplary embodiment.

DETAILED DESCRIPTION

[0012] 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.

[0013] 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 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.

[0014] 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.

[0015] 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.

[0016] 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.

[0017] 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.

[0018] 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.

[0019] 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.

[0020] 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.

[0021] 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.

[0022] 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.

[0023] 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 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.

[0024] 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.

[0025] 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.

[0026] 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 second 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.
[0027] According to a first embodiment, one flow throttle is 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, and preferably fluidically connects the compression main control chamber to the pilot control chamber. In particular, the first flow passage extends centrally and in the axial direction through the main piston. The second flow passage is disposed, for example, in a positionally fixed housing part of the damping valve device and fluidically connects the traction main control chamber to the pilot control chamber. The main piston has, for example, a first piston region, which is adjoined in the axial direction by a second piston region with a smaller diameter than the first piston region. The first flow passage preferably extends exclusively through the first piston region of the main piston, in particular centrally and in the axial direction through the latter into 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.
[0028] According to a further embodiment, one check valve is in each case disposed on 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.
[0029] According to a further embodiment, the first flow passage and the second flow passage are in particular disposed completely separately from one another. As a result, directing separate flows is achieved in the traction phase and in the compression phase.
[0030] According to a further embodiment, the connecting duct for fluidically connecting the pilot control chamber to the pilot working chamber is formed in the main piston. The connecting duct extends in particular centrally and in the axial direction through the main piston, from the pilot control chamber into a 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.
[0031] According to a further embodiment, the sliding tappet in the closed position of the pilot valve 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. The pilot valve preferably comprises a sliding tappet which is disposed so as to be axially movable within the pilot working chamber. The sliding tappet by way of its end that faces away from the main valve preferably lies against the armature in

such a way that the movement of the armature and of the sliding tappet are mechanically coupled.

[0032] According to a further embodiment, the pilot valve has a pilot spring which is disposed in such a manner that the latter impinges the sliding tappet with an axial force acting in the direction of the armature, in particular in the opening direction of the pilot valve. The pilot spring preferably enables a fail-safe protection in 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 is designed as a spiral spring and lies against the main piston within a hollow-cylindrical region of the latter. By way of example, the pilot spring is supported on an annular step of the sliding tappet that points in the direction of the piston rod-distal working chamber.

[0033] According to a further embodiment, 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 spring force acting in the closing direction of the main valve. The spring element is preferably attached to the side of the main piston that faces away from the main valve seat. In particular, the spring element is disposed in such a manner that it impinges the main piston with a spring force acting in the direction of the valve seat. The spring element is designed, for example, as a spiral spring which bears against the internal face of a hollow-cylindrical region of the main piston, and is supported on an end face of the main piston that points in the direction of the drive region. The spring element by way of one end preferably lies against a positionally fixed housing part of the damping valve device.

[0034] According to a further embodiment, 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 formed as a step in the main piston. The main piston is preferably of stepped design and in particular has a first piston region which points in the direction of the piston rod-distal working region, and which by way of its external diameter preferably lies in a fluid-tight manner against a positionally fixed housing part of the damping valve device. The first piston region is preferably designed to be substantially cylindrical. The first piston region is adjoined in particular by a second cylindrical piston region which is disposed so as to be coaxial with the first piston region and preferably has a smaller diameter than the first piston region. Formed on the first piston region is preferably an annular, preferably circular disc-shaped, end face that points in the direction of the drive region. The end face is preferably designed as a closing face, in particular as a first closing face, of the main piston, and is in particular contiguous to the pilot control chamber, so that the hydraulic pressure prevalent in the pilot control chamber impinges the main piston, in particular the closing face of the main piston, with an axial force acting in the closing direction of the main valve.

[0035] Formed on the second piston region is preferably an annular end face that points in the direction of the drive region and is formed in particular as a second closing face of the main piston, in addition to the closing face described above. The second closing face is contiguous to the pilot working chamber, so that the hydraulic pressure prevalent in the pilot working chamber impinges the second closing face of the main piston with an axial force acting in the closing direction of the main valve. The entire closing face of the main piston therefore preferably comprises the first and the second closing face. In particular, the size and/or the position of the closing face of the main piston is the same for a tensile or compressive load of the vibration damper. The sliding tappet is preferably disposed and designed in such a manner that hydraulic fluid can flow through the connecting duct exclusively in one flow direction.

[0036] According to a further embodiment, the main piston has a traction opening face A.sub.Z which is directly contiguous to the traction main control chamber and has a compression opening face A.sub.D which is directly contiguous to the compression main control chamber, and wherein the ratio A.sub.Z/A.sub.D between the traction opening face A.sub.Z and the compression opening face A.sub.D is 1:1 to 5:1, in particular 2:1 to 4:1, preferably 3:1.

[0037] According to a further embodiment, the damping valve device has a first pilot outflow duct for fluidically connecting the pilot working chamber to the traction main control chamber, and a second pilot outflow duct for fluidically connecting the pilot working chamber to the compression main control chamber. As a result, a separate outflow of the hydraulic fluid from the pilot working chamber in the traction phase and the compression phase is made possible.
[0038] The first pilot outflow duct is preferably formed in a positionally fixed housing part of the vibration damper, and preferably extends from the pilot working chamber into the traction main control chamber. The first pilot outflow duct preferably has a check valve which is disposed in such a manner that a hydraulic flow is enabled from the pilot working chamber into the first fluid passage, in particular the piston rod-proximal working chamber and is prevented in the opposite direction. The first pilot outflow duct is disposed, for example, above the sliding tappet, in particular in the traction direction relative to the sliding tappet.
[0039] 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 formed in particular in the main piston and preferably extends axially through the latter, in particular through the first and the second piston region. The second pilot outflow duct preferably extends from the pilot working chamber into the compression main control chamber. The second pilot outflow duct preferably has 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 is prevented in the opposite direction.
[0040] 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.
[0041] According to a further embodiment, 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.
[0042] According to a further embodiment, a check valve is disposed on the bypass duct in such a manner that the bypass duct is able to be passed through by a flow of hydraulic fluid exclusively in one direction. The bypass duct preferably has a check valve which is disposed and designed in such a manner that it allows a hydraulic flow from the compression main control chamber into the traction main control chamber and prevents it in the opposite direction. In particular, a throttle element is disposed so as to be hydraulically connected in series with the check valve in the bypass duct. The damping valve device additionally has, for example, a further bypass duct which is preferably connected hydraulically in parallel with the bypass duct and in particular has a flow throttle. The further bypass duct is preferably able to be passed through by a flow of hydraulic fluid in the traction phase and the compression phase of the vibration damper.
[0043] According to a further embodiment, 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.

[0044] 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.

[0045] 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 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.

[0046] 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**.

[0047] 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.

[0048] 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.

[0049] 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 magnetic 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** preferably has a base and is designed to be open in particular in the direction of 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**.

[0050] 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 in the armature space **60**. 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**.

[0051] The hollow-cylindrical region of the pole tube **64** is adjoined in the axial direction and coaxially therewith by a pole tube element, conjointly forming the pole tube **64**, wherein 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.

[0052] 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 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 **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**. By way of example, the comfort valve housing **32** has a larger external diameter than 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.

[0053] 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**. 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**.

[0054] 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**.

[0055] 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. 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 within the housing part **80** and so as to be concentric with the latter. 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 centrally and in the axial direction through the main piston **76**. By way of example, the housing part **80** 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.

[0056] 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 as the gap described above, in particular the annular space, between the housing part **80** and the tube part **45**. 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*.

[0057] 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 preferably connected directly or indirectly to the tube part **45** and is disposed in a positionally fixed manner relative to the latter. 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**.

[0058] 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 **88** which is preferably formed hydraulically in parallel with the main flow duct **92**, as a bypass of the main valve **68**. By way of example, the bypass duct **88** extends from the compression main control chamber **82***a* to the traction main control chamber **82***b* and fluidically connects those to one another. The bypass duct **88** preferably has a check valve which is disposed and designed in such a manner that it allows a hydraulic flow from the pressure main control chamber **82***a* into the traction main control chamber **82***b* and prevents it in the opposite direction.

[0059] The main piston **76** is preferably of a stepped design and has, by way of example, a first piston region **113** that points in the direction of the piston rod-distal working region **24** and by way of its outer diameter lies against the housing part **80** in a fluid-tight manner. By way of example, the first piston region **113** is substantially cylindrical. The first piston region **113** is adjoined by a second cylindrical piston region **114** which is disposed so as to be coaxial with the first piston region **113** and has a smaller diameter than the first piston region **113**. An annular end face **46** that points in the direction of the drive region **48** is preferably formed on the main piston **76**, in particular on the first piston region **113**. The end face **46** serves as a closing face A.sub.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 closing face **46**, the housing part **80** and the main piston **76**, in particular the second region of the main piston **76**. The first flow passage **86***a* for connecting the compression main control chamber **82***a* preferably extends exclusively through the first region of the main piston **76**, in particular centrally and in the axial direction through said main piston into the pilot control chamber **84**. The first flow passage **86***a* preferably has a check valve which is disposed in such a manner that a hydraulic flow is enabled from the compression main control chamber **82***a* into the pilot control chamber **84** and is prevented in the opposite direction. The second flow passage **86***b* preferably likewise has a check valve which is disposed in such a manner that a hydraulic flow is enabled from the traction main control chamber **82***b* into the pilot control chamber **84** and is prevented in the opposite direction.

[0060] An annular end face A.sub.SP, that points in the direction of the drive region **48** is preferably formed on the main piston **76**, in particular on the second piston region **114**. The end face A.sub.SP serves, in addition to the closing face A.sub.S, as a further, in particular second, closing face A.sub.SP of the main piston **76** and 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.sub.SP of the main piston **76**, with an axial force acting in the closing direction of the main valve **68**.

[0061] Attached to that side of the main piston **76** that faces away from the main valve seat **90** is a spring element **94** which is disposed in such a manner that it impinges the main piston **76** with a

spring force acting in the direction of the valve seat **90**. The spring element **94** is, for example, a spiral spring which lies against the internal face of a hollow-cylindrical region of the housing part **80** and by way of one end is supported on the end face **46**, in particular the closing face A.sub.S, of the main piston **76**, said end face pointing in the direction of the drive region **48**. The spring element **94** by way of the other end is preferably supported on the housing part **80**. By way of example, the housing part has a groove in which the spring element **94** is disposed.
[0062] 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**. That region of the main piston **76** that points in the direction of the drive region **48** is, by way of example, designed to be hollow-cylindrical, wherein the interior of the hollow-cylindrical region preferably forms at least partially the pilot working chamber **100**. Preferably, the pilot working chamber **100** fluidically adjoins directly the connecting duct **98**.
[0063] 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** preferably lies against the armature **62**, in particular the armature rod **65**, so that the movement of the armature **62** and of the sliding tappet **102** is coupled at least during the movement of the armature **62** in the direction of the sliding tappet **102**. 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**. In particular, the sliding tappet **102** is guided axially by the main piston **76** and preferably lies, in particular in a fluid-tight manner, against the inner wall of the hollow-cylindrical region of the main piston **76**.
[0064] 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 larger cross section than the first region. The second region preferably extends over the entire cross section of the pilot working chamber **100**.
[0065] In the closed position, the sliding tappet **102** preferably lies against a first valve seat which is formed in the main piston **76**. The sliding tappet **102** of the pilot valve **70** preferably has at least one passage bore, or a plurality of passage bores **112**, which extends/extend in the axial direction through the sliding tappet **102** and forms/form a flow duct for hydraulic fluid through the sliding tappet **102**. The flow passages **112**, and in particular the pilot working chamber **100**, are preferably fluidically connected to the first fluid passage **39** and the second fluid passage **40**.
[0066] 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 direction of the armature **62**, in particular 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 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 preferably lies against the sliding tappet **102** and the main piston **76**. In particular, the pilot spring **108** is designed as a spiral spring and lies against the main piston **76** within the hollow-cylindrical region thereof. By way of example, the pilot spring **102** is supported on an annular step of the sliding tappet **102** that points in the direction of the piston rod-distal working chamber **24**.
[0067] 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.sub.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**.

[0068] 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 first fluid passage **39**, preferably to the piston rod-proximal working chamber **22**. The first pilot outflow duct **104***a* is formed by way of example in the housing part **80**, in particular in a housing element **106** fixedly connected thereto, and preferably extends from the pilot working chamber **100** into the traction main control chamber **82***b*. 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 first fluid passage **39** and is prevented in the opposite direction.

[0069] 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 second fluid passage **40**, preferably to the piston rod-distal working chamber **24**. The second pilot outflow duct **104***b* is formed by way of example in the main piston **76** and preferably extends axially through the latter, in particular through the first and the second piston region. The second pilot outflow duct **104***b* preferably extends from the pilot working chamber **100** into the compression main control chamber **82***a*. 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 second fluid passage **40** and is prevented in the opposite direction.

[0070] 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 through the passage bores **112** in the sliding tappet **102**, and by way of a first pilot outflow duct **104***a* disposed downstream of the passage bores **112** flows to the traction main control chamber **82***b*, in particular the second fluid passage **39**. A further sub-flow optionally flows through the bypass duct **88** which fluidically connects the compression main control chamber **82***a* to the traction main control chamber **82***b*. 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** and the bypass flow through the bypass duct **88**.
[0071] 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 is illustrated. The main piston **76** preferably has a traction opening face A.sub.Z and a compression opening face A.sub.D. The compression opening face A.sub.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.sub.Z is the face of the main piston **76** directly contiguous to the traction main control chamber **82***b*. The ratio (A.sub.Z/A.sub.D) between the traction opening face A.sub.Z and the compression opening face A.sub.D is, for example, 1:1 to 5:1, in particular 2:1 to 4:1, preferably 3:1.
[0072] FIG. **4** 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 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.sub.S of the main piston **76**, in particular as a function of the position of the sliding tappet **102** of the pilot valve **70**. The piston rod-distal working chamber **24** is preferably fluidically connected to the pilot valve **70** by way of the first flow passage **86***a*, for example by way of a flow throttle **96***a* and a check valve. The piston rod-proximal working chamber **22** is preferably fluidically connected to the pilot valve **70** by way of the second flow passage **86***b*, for example by way of a flow throttle **96***b* and a check valve.
[0073] FIG. **5** shows a further example of a hydraulic circuit diagram of a damping valve device **54**, which substantially corresponds to that of FIG. **4**, wherein a bypass duct **88** is additionally disposed between the piston rod-distal working chamber **24** and the piston rod-proximal working chamber **22**. By way of example, a throttle element and a check valve are disposed in the bypass duct **88** so as to be hydraulically connected to one another in series, so that a flow of hydraulic fluid is able to pass through the bypass duct **88** exclusively in one direction, specifically from the piston rod-distal working chamber **24** into the piston rod-proximal working chamber **22**. The bypass duct **88** is preferably disposed hydraulically in parallel with the pilot valve **70** and/or the main valve **68**.
[0074] FIG. **6** shows a further example of a hydraulic circuit diagram of a damping valve device **54**, which substantially corresponds to that of FIG. **4** or **5**, wherein the damping valve device **54** additionally has a further bypass duct **116** which is preferably connected hydraulically in parallel with the bypass duct **88** and in particular has a flow throttle. The further bypass duct **116** is preferably able to be passed through by a flow of hydraulic fluid in the traction phase and the compression phase of the vibration damper **10**.
LIST OF REFERENCE SIGNS
[0075] **10** Vibration damper [0076] **12** Outer tube [0077] **14** Inner tube [0078] **16** Compensation chamber [0079] **18** Working piston [0080] **20** Piston rod [0081] **22** First/piston rod-proximal working chamber [0082] **24** Second/piston rod-distal working chamber [0083] **26** Seal [0084] **28** Comfort valve [0085] **30** Comfort spring disc pack [0086] **32** Comfort valve housing [0087] **34** Closure pack [0088] **36** Base piece [0089] **38** Base valve [0090] **39** First fluid passage to the first working chamber **22** [0091] **40** Second fluid passage to the second working chamber **24** [0092] **42** Spring element [0093] **44** Housing upper part [0094] **45** Tube part [0095] **46** End face/closing face [0096] **48** Drive region [0097] **50** Valve region [0098] **52** Coil [0099] **54** Damping valve device [0100] **56** Cover portion [0101] **58** Magnetic separation [0102] **60** Armature space [0103] **62** Armature [0104] **64** Pole tube [0105] **65** Armature rod [0106] **68** Main valve [0107] **70** Pilot valve [0108] **72** Guide element [0109] **74** Bypass opening [0110] **76** Main piston [0111] **77** Spring assembly [0112] **78** Main working chamber [0113] **80** Housing part [0114] **82***a*,*b* Traction/compression main control chamber [0115] **84** Pilot control chamber [0116] **86***a*,*b* Flow

passage [0117] **88** Bypass duct [0118] **90** Main valve seat [0119] **92** Main flow duct [0120] **94** Spring element [0121] **96***a*,*b* Flow throttle [0122] **98** Connecting duct [0123] **100** Pilot working chamber [0124] **102** Sliding tappet [0125] **104***a* First pilot outflow duct [0126] **104***b* Second pilot outflow duct [0127] **106** Housing element [0128] **108** Pilot spring [0129] **110** Opening face of the sliding tappet [0130] **112** Passage bore [0131] **113** First piston region [0132] **114** Second piston region [0133] **116** Further bypass duct [0134] A.sub.S First closing face of the main piston **76** [0135] A.sub.D Compression opening face of the main piston **76** [0136] A.sub.Z Traction opening face of the main piston **76** [0137] A.sub.SP Second closing face of the main piston **76**

## Claims

**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 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.
**2**. The vibration damper according to claim 1, wherein one flow throttle is in each case disposed in the first flow passage and the second flow passage.
**3**. The vibration damper according to claim 1, wherein one check valve is in each case disposed on the first flow passage and the second flow passage so that hydraulic fluid is in each case able to flow exclusively in one direction through the first and the second flow passage.
**4**. The vibration damper according to claim 1, wherein the first flow passage and the second flow passage are disposed separately from one another.
**5**. 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 main piston.
**6**. The vibration damper according to claim 5, wherein the sliding tappet in the closed position of the pilot valve lies against the main piston in such a manner that said sliding tappet fluidically closes the connecting duct.
**7**. The vibration damper according to claim 1, wherein the pilot valve has a pilot spring which is disposed in such a manner that the latter impinges the sliding tappet with an axial force acting in the direction of the armature.
**8**. The vibration damper according to claim 1, wherein 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 spring force acting in the closing direction of the main valve.
**9**. The vibration damper according to claim 1, wherein 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 formed as a step in the main piston.
**10**. 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.

**11**. 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.

**12**. 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.

**13**. 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 traction main control chamber, and a second pilot outflow duct for fluidically connecting the pilot working chamber to the compression main control chamber.

**14**. 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.

**15**. The vibration damper according to claim 1, wherein the damping valve device comprises a bypass duct which is disposed in such a manner that the latter fluidically connects the compression main control chamber and the traction main control chamber to one another.

**16**. The vibration damper according to claim 15, wherein a check valve is disposed on the bypass duct in such a manner that the bypass duct is able to be passed through by a flow of hydraulic fluid exclusively in one direction.

**17**. The vibration damper according to claim 1, wherein 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.