



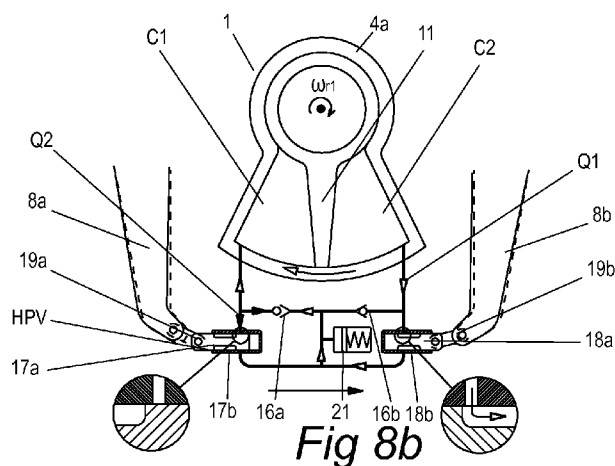
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- (71) **Applicant (for all designated States except US):** ÖHLINS RACING AB [SE/SE]; Box 722, S-194 27 Upplands Väsby (SE).
- (72) **Inventors; and**
- (75) **Inventors/Applicants (for US only):** SINTORN, Torkel [SE/SE]; Hallmans allé 1, Skarpö, S-185 91 Vaxholm (SE). NILSSON, Johan [SE/SE]; c/o Öhlins Racing AB, Box 722, S-194 27 Upplands Väsby (SE). GUSTAFSSON, Leif [SE/SE]; Snapphanev. 6, Saluboda, S-370 34 Holmsjö (SE). HANSEN, Thorleif [SE/SE]; c/o Öhlins Racing AB, Box 722, S-194 27 Upplands Väsby (SE). MATTISON, Joakim [SE/SE]; c/o Öhlins Racing AB, Box 722, S-194 27 Upplands Väsby (SE).
- (74) **Agent:** LOQVIST, Mathias; Awapatent AB, Box 45086, S-104 30 Stockholm (SE).

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(54) **Title:** STEERING DAMPER WITH ACTIVE ADJUSTMENT OF DAMPING CHARACTERISTICS

(57) **Abstract:** A device (1) is disclosed for in a vehicle adjusting the rotational damping of a steering device (2) such that the rotational damping varies depending on whether the rotational motion about a steering axis (SA) is caused by a force acting on the steering device (2) of the vehicle or a force acting on the part(s) (3) of the vehicle contacting the ground. The device comprises a steering damper (4) comprising a damping housing (4a) enclosing a main chamber which comprises hydraulic fluid and is partitioned into a first and a second damping chamber (C1, C2), for example by a delimiting part (11, 11') moveable in relation to the damping housing. The damping housing (4a) is fixed on an attaching part (5, 5') that couples together the part(s) (3) of the vehicle contacting the ground with the steering device (2). The present invention is characterized in that the flow of hydraulic fluid in the steering damper partly or wholly is adjusted by a main valve unit (HVU) that is coupled together with both the attaching part (5, 5') and the steering device (2). By means of this coupling the opening area (A1, A2) of the main valve unit is determined by a relative motion between the attaching part (5, 5') and the steering device (2) such that the flow of the hydraulic fluid in a direction from and to the respective damping chamber of the steering damper is controlled depending on the cause of the rotational movement. Furthermore, a steering device adapted to be arranged in a vehicle is disclosed.

STEERING DAMPER WITH ACTIVE ADJUSTMENT OF DAMPING CHARACTERISTICS

Technical field

The present invention relates to an adjustable steering damper intended to be used on a two or four-wheeled or any other vehicle having a steering device comprising a handlebar or a steering wheel rotatable about a steering axis. Preferably the vehicle is a motorcycle, a bicycle, a snowmobile or an ATV. The steering damper is mounted at the steering device and is also coupled together with the frame or chassis by means of an attaching device. The damper is composed of an outer housing in which a main chamber is arranged, the main chamber comprising hydraulic fluid. The main chamber is partitioned into two chambers, for example by means of a delimiting part that is either rotatable about a first end or laterally displaceable in the chamber. The flow of the hydraulic fluid between the chambers is adjusted by a main valve and enables an adjustable damping of the relative motion between the steering device and the frame/chassis.

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Background

A steering damper is mounted between the rotating handlebar or steering wheel of a vehicle and its fixed frame or chassis in order to damp shocks and violent movements that propagate from the front wheel(s) to the handlebar. When the steering damper is used on a motorcycle, the steering damper can also solve the problem of wobbling that may occur in a motorcycle at high speeds. Wobbling refers to the front wheel on the motorcycle beginning to oscillate about the steering axis with increasing amplitude. When the steering damper is used on a four-wheeled terrain vehicle, a so called ATV, the steering damper is primarily intended to damp the rapid steering movements caused by, for example, an asymmetric load on the wheels.

It has proven to be a problem to separate desired steering movements from undesired shocks caused by unevenness of the ground in a steering damper. In order to not create a delay in the steering movement when the driver turns the handlebar, it is desirable that this desired rotational movement

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is undamped. At the same time undesired rotational movements caused by shocks from the ground should be damped as much as possible to minimize the risk of the handlebar being stricken from the hands of the driver. Thus, it is desirable to provide a steering damper that actively adapts the damping on
5 basis of the cause of the movement.

In EP1248013 the problem is solved by a steering damper that by means of electronics senses and controls the damping on the handlebar depending on whether the movement is caused by the driver or the ground.

A steering damper that solves this problem by means of a principally
10 mechanical solution is not known. A device for controlling a rotational movement of a steering device and/or wheel arrangement relative a chassis of a vehicle is also not known.

Summary

15 It is with respect to the above considerations and others that the present invention has been made. The present invention seeks to mitigate, alleviate or eliminate one or more of the above-mentioned deficiencies and disadvantages singly or in combination. In particular, the inventor has realized that it would be desirable to achieve a device that enables separating the
20 damping of desired steering movements from undesired shocks caused by unevenness of the ground in a steering damper. The inventor has further realized that it would be desirable to achieve a device that enables separating the damping of desired steering movements from undesired shocks caused by unevenness of the ground in a steering damper in a manner that does not
25 require electronic components. Also, the inventors has also realized that a intentional limited relative movement of rotational movement of a steering device and/or wheel arrangement relative a chassis of a vehicle may be used to reliably control the rotational movement of a steering device and/or wheel arrangement relative the chassis of the vehicle. Thus, a build-in relative
30 movement or rotational movement about a steering axis enables a robust and reliable method of controlling a rotational movement of a steering device and/or wheel arrangement relative a chassis of a vehicle. The limited relative rotational movement also enables a more variable damping force, i.e. the

damping force may be accurately varied in response to the relative rotational movement.

It is also desirable that the damper obtains damping characteristics that is the same for different individuals. Furthermore, the final product should be
5 relatively inexpensive and uncomplicated to manufacture.

To achieve this, a device and a method having the features as defined in the independent claims are provided. Further advantageous embodiments of the present invention are defined in the dependent claims.

The present invention relates to a device for adjusting the rotational
10 damping of a steering device and/or a wheel arrangement in a vehicle such that the rotational damping varies depending on whether the rotational movement about a steering axis is caused by a force acting on the steering device of the vehicle or by a force acting on the wheel arrangement or the part(s) of the vehicle contacting the ground. By steering device it is referred to
15 the handlebar, steering wheel or the like of the vehicle, and by wheel arrangement or by parts of the vehicle contacting the ground it is referred to wheels, runners or similar arrangements that constitute the vehicle's points of contact against the ground. The present invention further relates to a steering device adapted to be arranged in a vehicle.

20 The devices and methods and steering device according to the present invention are for example intended to be used on a one, two, three or four-wheeled vehicle or any other vehicle having steering device rotatable about a steering axis for controlling the direction of the vehicle.

According to a first aspect of the present invention, there is provided a
25 device intended for a vehicle. The device comprises a steering device rotatable about a steering axis for adjusting the direction of the part(s) of the vehicle arranged for contacting ground, an attaching part that couples together the part(s) arranged for contacting ground with the steering device, and a steering damper. The attaching part rotates with the steering device
30 and with the damping housing of the steering damper that encloses a main damping chamber. The main damping chamber comprises hydraulic fluid and is partitioned into a first and a second damping chamber, wherein flow of hydraulic fluid between the damping chambers of the steering damper is

arranged to be adjusted by means of a main valve unit, mechanically coupled together with both the attaching part and the steering device, such as to adjust the rotational damping of the steering device. The amount of hydraulic fluid flowing through the main valve unit is determined by a relative movement
5 between the attaching part and the steering device.

According to a second aspect of the present invention, there is provided a device intended for a vehicle. The device comprises a steering device rotatable about a steering axis for adjusting the direction of the part(s) of the vehicle arranged for contacting ground, an attaching part that couples
10 together the part(s) arranged for contacting ground with the steering device, and a steering damper. The attaching part rotates with the steering device and with a delimiting part of the steering damper that partitions a main damping chamber which comprises hydraulic fluid into a first and a second damping chamber, wherein flow of hydraulic fluid between the damping
15 chambers of the steering damper is arranged to be adjusted by means of a main valve unit, mechanically coupled together with both the attaching part and the steering device, such as to adjust the rotational damping of the steering device. The amount of hydraulic fluid flowing through the main valve unit is determined by a relative movement between the attaching part and the
20 steering device. In other words, by means of the main valve unit being coupled together with both the attaching part and the steering device, an opening area of the main valve unit may be determined by a relative motion between the attaching part and the steering device such that the flow of the hydraulic fluid in a direction from and to the respective damping chamber of
25 the steering damper is controlled depending on the cause of the rotational movement. By such a configuration there may be enabled means for adjusting the rotational damping of a steering device in a vehicle, such that the rotational damping varies depending on whether the rotational movement about the steering axis is caused by a force acting on the steering device of
30 the vehicle or by a force acting on the part(s) of the vehicle contacting the ground. In other words, the device according to the first and second aspects of the present invention may enable separating the damping of desired steering movements from undesired shocks caused by unevenness of the

ground in a steering damper. This may be achieved by means of a substantially or completely mechanical arrangement. Thus, electronic components may not be required for achieving advantages of the present invention.

5 Thus, according to an aspect of the invention, there is provided a device intended for a vehicle comprising: a steering device rotatable about a steering axis for adjusting the direction of the part(s) of the vehicle arranged for contacting ground; a steering damper comprising a damping housing that encloses a main damping chamber which comprises hydraulic fluid and is
10 partitioned into a first damping chamber and a second damping chamber by a delimiting part that is arranged in the main damping chamber and movable with respect to the damping housing; an attaching part that couples together the part(s) arranged for contacting ground with the steering device and a steering damper, wherein the attaching part rotates with the steering device
15 and any one of the damping housing and the delimiting part; and a main valve unit (HVU) adapted to adjust a flow of hydraulic fluid between the damping chambers of the steering damper, said main valve unit (HVU) being mechanically coupled together with both the attaching part and the steering device, such as to adjust the rotational damping of the steering device, and
20 wherein the amount of hydraulic fluid flowing through the main valve unit (HVU) is determined by a relative movement between said attaching part and the steering device.

 According to a third aspect of the present invention, there is provided a steering damper adapted to be arranged in a vehicle comprising a steering
25 device rotatable about a steering axis for adjusting the direction of the part(s) of the vehicle arranged for contacting ground, and an attaching part that couples together the part(s) arranged for contacting ground with the steering device. The steering damper comprises a damping housing and a main damping chamber defined by the damping housing. The main damping
30 chamber comprises hydraulic fluid and is partitioned into a first and a second damping chamber. The steering device is mechanically connectable to the attaching part to enable rotation of the attaching part with the steering device and with the damping housing. A main valve unit is adapted to adjust a flow of

hydraulic fluid between the damping chambers such as to adjust the rotational damping of the steering device, wherein the main valve unit can be mechanically coupled together with both the attaching part and the steering device. The steering damper is configured such that a relative movement
5 between the attaching part and the steering device determines an amount of hydraulic fluid flowing through the main valve unit.

According to a fourth aspect of the present invention, there is provided a steering damper adapted to be arranged in a vehicle comprising a steering device rotatable about a steering axis for adjusting the direction of the part(s)
10 of the vehicle arranged for contacting ground, and an attaching part that couples together the part(s) arranged for contacting ground with the steering device. The steering damper comprises a damping housing and a main damping chamber defined by the damping housing. The main damping chamber comprises hydraulic fluid and is partitioned into a first and a second
15 damping chamber by a delimiting part. The steering device is mechanically connectable to the attaching part to enable rotation of the attaching part with the steering device and with the delimiting part. A main valve unit is adapted to adjust a flow of hydraulic fluid between the damping chambers such as to adjust the rotational damping of the steering device, wherein the main valve
20 unit can be mechanically coupled together with both the attaching part and the steering device. The steering damper is configured such that a relative movement between the attaching part and the steering device determines an amount of hydraulic fluid flowing through the main valve unit. In this manner, the amount of hydraulic fluid flowing through the main valve unit is determined
25 by a relative movement between the attaching part and the steering device. Thus, according to an aspect of the invention, there is provided a steering damper adapted to be arranged in a vehicle comprising a steering device rotatable about a steering axis (SA) for adjusting the direction of the part(s) of the vehicle arranged for contacting ground, and an attaching part that
30 couples together the part(s) arranged for contacting ground with the steering device, the steering damper comprising: a main damping chamber defined by a damping housing, said main damping chamber comprising hydraulic fluid and being partitioned into a first and a second damping chamber; wherein

said steering device is mechanically connectable to said attaching part to enable rotation of said attaching part with said steering device and with any one of said damping housing and said delimiting part, a main valve unit (HVU) is adapted to adjust a flow of hydraulic fluid between the damping chambers
5 such as to adjust the rotational damping of the steering device, wherein said main valve unit (HVU) can be mechanically coupled together with both the attaching part and the steering device, and wherein a relative movement between said attaching part and the steering device determines an amount of hydraulic fluid flowing through the main valve unit (HVU).

10 The main damping chamber being defined by the damping housing may for example refer to an arrangement wherein the damping housing encloses the main damping chamber.

The main valve unit may be arranged integral with the steering device.

By a configuration in accordance with the second, third and fourth
15 aspects of the present invention same or similar advantages as the advantages achieved by the device according to the first aspect may be achieved wholly or partly.

Advantageous exemplifying configurations for realizing the present invention are described in the following.

20 The steering device may be elastically coupled together with the attaching part. The relative movement between the attaching part and the steering device may according to one example occur only during a predetermined initial rotational movement of the steering device from a base position of the steering device.

25 It is understood that relative rotational movement between the attaching part and the steering device refers to relative movement about the steering axis or about another axis substantially in parallel to the steering axis. The main valve unit may comprise a first and a second main valve.

The device or the steering device may comprise a first main valve part
30 and a second main valve part arranged in the first main valve, and a third main valve part and a fourth main valve part arranged in the second main valve. The first main valve part may be coupled together with the steering device and the second main valve part may be coupled together with the

damping housing of the steering damper. The third main valve part may be coupled together with the steering device and the fourth main valve part may be coupled together with the damping housing of the steering damper. The first and the second, and the third and the fourth main valve parts,

- 5 respectively, may be moveable with respect to each other such that they form a first and a second variable opening area through which the hydraulic fluid can flow.

The opening area of the first main valve may decrease and the opening area of the second main valve may increase when the positions of
10 the first and the second, and the third and the fourth main valve parts, respectively, relatively each other are determined by a rotational motion in a first direction of the steering device or by a rotational motion in a second direction of the housing of the steering device.

The opening area of the first main valve may increase and the opening
15 area of the second main valve may decrease when the positions of the first and the second, and the third and the fourth main valve parts, respectively, relatively each other are determined by a rotational motion in a second direction of the steering device or by a rotational motion in a first direction of the housing of the steering device.

20 The opening area of the first main valve may increase and the opening area of the second main valve may decrease when the positions of the first and the second, and the third and the fourth main valve parts, respectively, relatively each other are determined by a rotational motion in a second direction of the steering device or by a rotational motion in a first direction of
25 the delimiting part of the steering damper.

The first and third main valve parts of the first and second main valve may move synchronously in relation to each other such that the opening area of the first main valve decreases substantially as much as the opening area of the second main valve increases, and vice versa.

30 The device or the steering device may comprise a first driver and a second driver, wherein the first main valve part may be coupled together with the steering device via the first driver and the third main valve part may be coupled together with the steering device via the second driver.

The first driver may be coupled together with the first main valve part by means of a first link and the second driver may be coupled together with the third main valve part by means of a second link, where the links are hinged in both ends.

- 5 The device or the steering device may comprise at least one spring element, wherein the first driver may be pressed against the first main valve part and the second driver may be pressed against the third main valve part by means of the at least one spring element.

- 10 The at least one spring element may be located between the first main valve part and the third main valve part such that the at least one spring element creates a pressing force acting on both valve parts.

- 15 The device may furthermore comprise a valve actuator being coupled together with the steering device for actuating the first and second main valves during relative movement between the steering device and the attaching part, thereby altering a first and a second variable opening area of the main valve. In other words, the valve actuator is moved in response to movement of the steering device when the valve actuator is coupled to the steering device. The valve actuator may refer to a pin, dowel, bolt or the like. The valve actuator may be coupled to the steering device by means of direct connection or may be coupled to the steering device via an intermediate element which may be attachment means arranged for clamping the steering device to the attaching part. The valve actuator may also refer to an extending portion of the steering device or an extending portion of the intermediate element being coupled to the steering device. Put differently, the valve actuator may be a mechanical element intended to affect the main valve unit upon relative movement between the steering device and the attaching part, i.e. when the steering device is turned or when the attaching part is rotated by force acting on the part(s) of the vehicle contacting the ground.

- 25 The device may furthermore comprise a valve actuator being coupled together with the attaching part for actuating the first and second main valves during relative movement between the steering device and the attaching part, thereby altering a first and a second variable opening area of the main valve.
- 30

In other words, the valve actuator is moved in response to movement of the attaching part when the valve actuator is coupled to the attaching part.

Put differently, the valve actuator may be a mechanical element intended to affect the main valve unit, in the sense that the hydraulic fluid
5 flowing through the main valve unit is affected, upon relative movement between the steering device and the attaching part, i.e. when the steering device is turned or when the attaching part is rotated by force acting on the part(s) of the vehicle contacting the ground.

The opening area of the first main valve may decrease and the
10 opening area of the second main valve may increase when the position of the valve actuator is determined by a rotational motion in a first direction of the steering device or by a rotational motion in a second direction of the attaching part. In other words, when the steering device is rotated in a first direction or when the attaching part is rotated in the opposite direction, the opening area
15 of the first valve may decrease and the opening area of the second valve may increase.

The opening area of the first main valve may increase and the opening area of the second main valve may decrease when the position of the valve actuator is determined by a rotational motion in a second direction of the
20 steering device or by a rotational motion in a first direction of the attaching part. In other words, when the steering device is rotated in a second direction or when the attaching part is rotated in the opposite direction, the opening area of the first valve may increase and the opening area of the second valve may decrease. The device or the steering device may comprise at least one
25 holding-up means arranged between the attaching part and the steering device, the at least one holding-up means being arranged to determine the magnitude of the initial rotational motion.

The steering device may be coupled together with the attaching part via a torsion bar for allowing relative rotational movement between the
30 steering device and the attaching part about a centre axis of the torsion bar. It is understood that torsion bar refers to a metal element being substantially elastically twistable and that acts as a spring. The torsion bar may be arranged in parallel to the steering axis.

The steering device may be coupled together with the attaching part via a silent block bush for allowing relative rotational movement between the steering device and the attaching part about a centre axis of the silent block bush. It is understood that silent block bush refers to a type of bush having an inner and an outer sleeve, which may be metallic, between which a bush which may be a rubber bush, is sandwiched.

The steering device may be coupled together with the attaching part via a bearing for allowing relative rotational movement between the steering device and the attaching part about a centre axis of the bearing. It is understood that bearing may refer to any type of bearing such as a ball bearing, roller bearing, sleeve bearing or a plain bearing for example.

The centre axis of the torsion bar, silent block bush or bearing may be arranged at a distance from the steering axis. In other words, the steering device rotates relative to the attaching part about the centre axis of the torsion bar, silent block bush or bearing which is arranged at a distance from the steering axis.

The device may furthermore comprise at least two mechanical stops for limiting said relative movement between the attaching part and the steering device. Hereby it may be possible to avoid excessive rotational movement between the steering device and the attaching part which otherwise could result in a damages to the torsion bar or the silent block bush. The two mechanical stops may refer to two mechanical elements such as two pins extending from the attaching part, thereby limiting the relative rotational movement. In other emodiments, the two mechanical stops may refer to mechanical devices involving at least two parts. The mechanical stops may interact with other portions of the attaching part or the steering device. The mechanical stops may refer to portions of an intermediate element such as attaching means for clamping the steering wheel to the attaching part.

The two mechanical stops may comprise at least one element slideably arranged in an opening between two surfaces portions thereof, such that the element is moveable between said surface portions in order to limit said relative movement to rotational movement. Hereby it may be possible to avoid damaging the torsion bar, the silent block bush or the bearing if for example

force is applied to the steering device in other directions than in the rotational direction. One such case may be during a motorcycle crash or during rough offroad driving. In one embodiment, an element is attached to one of the steering device and the attaching part and an opening is arranged in the other
5 one of the steering device and the attaching part, in which opening the element is slidably arranged. The opening may be a hole, a slot, an aperture or the like. The opening may have dimensions relative to the element to achieve a play such that slideable operation is achieved. The element may have geometric properties such that axial relative movement between the
10 steering device and the attaching part is limited. For example, the element may be shaped substantially as a bolt or screw, i.e. having a larger diameter in its one end. The attaching part may for example comprise a fork crown arranged at the front fork arrangement of a motorcycle.

The attaching part may comprise a cylindrical unit arranged around a
15 steering connecting rod through which the steering axis runs.

The attaching part may be divided into an upper and a lower cylindrical part coupled together by means of an elastic holding-up means which is arranged to determine the magnitude of the initial rotational motion.

The device or the steering device may comprise a delimiting part
20 arranged in the main damping chamber, which delimiting part is moveable with respect to the damping housing.

The steering damper may be a linear damping device in which the delimiting part is a piston attached to a piston rod for reciprocal movement within said damping chamber. The steering damper may be arranged at least
25 partly inside the attaching part for achieving a compact installation. The piston rod may be hollow in order to achieve hydraulic fluid flow passages to the damping chambers.

The steering damper may be a rotational damping device, in which the delimiting part is a wing attached to a lever for reciprocal movement within
30 said damping chamber. It is understood that lever refers to a mechanical element arranged for transferring rotational force to and from the wing. The rotational damping device may be of the type commonly referred to as a wing damper.

According to a fifth aspect of the present invention, there is provided a crown device adapted to be arranged in a vehicle comprising a steering device rotatable about a steering axis for adjusting the direction of the part(s) of the vehicle arranged for contacting ground. The crown device comprises

5 a steering damper, an attaching part and a main valve unit. The steering damper comprises a damping housing that encloses a main damping chamber which comprises hydraulic fluid and is partitioned into a first damping chamber and a second damping chamber by a delimiting part that is arranged in the main damping chamber and moveable with respect to the

10 damping housing. The attaching part is adapted to couple together the part(s) arranged for contacting ground with the steering device when the crown device is arranged in the vehicle. The attaching part is arranged to rotate with the steering device when the crown device is arranged in the vehicle. The main valve unit adapted to adjust a flow of hydraulic fluid between the

15 damping chambers of the steering damper when the crown device is arranged in the vehicle. The main valve unit is coupled together with both the attaching part and the steering device when the crown device is arranged in the vehicle such as to adjust the rotational damping of the steering device. The amount of hydraulic fluid flowing through the main valve unit is

20 determined by a relative movement between the attaching part and the steering device.

Thus, by allowing the steering device to move relative the attachment part, a relative movement is provided. Furthermore, by monitoring or measuring that relative movement between the steering device and the

25 attachment part, the rotational damping of a steering device is adjustable such that the rotational damping varies depending on whether the rotational movement about a steering axis is caused by a force acting on the steering device of the vehicle or by a force acting on the part(s) of the vehicle contacting the ground.

30 By a configuration in accordance with the fifth aspect of the present invention same or similar advantages as the advantages achieved by the device according to the first aspect may be achieved wholly or partly.

Advantageous exemplifying configurations for realizing the present invention are described in the following.

5 The crown device may comprise attachment means adapted to couple the steering device together with the attaching part when the crown device is arranged in the vehicle, wherein the attachment means is arranged to allow relative movement between the attaching part and the steering device when the crown device is arranged in the vehicle. In other words, the attachment means may be an intermediate element between the attaching part and the steering device allowing relative movement between the attaching part and the steering device. The relative movement may be realized between the attaching part and the attachment means, i.e. the steering device is fixed to the attachment means. Alternatively, the relative movement may be realized between the steering device and the attachment means, i.e. the attaching part is fixed to the attachment means.

15 The attachment means may be adapted to elastically couple the steering device together with the attaching part when the crown device is arranged in the vehicle, wherein the attachment means is arranged to elastically allow relative movement between the attaching part and the steering device when the crown device is arranged in the vehicle.

20 The main valve unit may be mechanically coupled together with both the attaching part and the steering device such as to adjust the rotational damping of the steering device. Hereby a mechanical crown device may be achieved which may not require electronics to achieve actuation of the main valve unit.

25 The crown device may furthermore comprise an electronic sensor adapted to measure said relative movement between the attaching part and the steering device. Hereby the relative movement is measured and the steering damper may be controlled in a customized manner by for example and electronic control unit (ECU). Using an electronic sensor may also be advantageous compared to a mechanical actuating mechanism from a friction perspective.

The electronic sensor may be selected from a group of sensors comprising a potentiometer, a hall effect sensor, and an optical sensor.

The electronic sensor may be arranged to measure the magnitude and the direction of the relative movement between the attaching part and the steering device when the crown device is arranged in the vehicle. This may be advantageous because the additional information provided by the
5 electronic sensor, i.e. magnitude and direction may be used to achieve improved control of the steering damper.

The main valve unit may be electrically actuated in response to a relative movement between the attaching part and the steering device measured by an electronic sensor. The main valve unit may comprise
10 actuation means, for example a solenoid or an electric motor, actuating at least one main valve of the main valve unit directly, thereby adjusting the flow of hydraulic fluid through the main valve unit. The main valve unit may comprise at least one pilot valve being actuated electrically using for example a solenoid. The pilot valve is used to control the main valve which in turn
15 adjusts the flow of hydraulic fluid through the main valve unit.

According to a sixth aspect of the present invention, there is provided a device for controlling rotational movement of a steering device and/or a thereto connected wheel arrangement about a steering axis relative a chassis of a vehicle. Thus, a device for controlling rotational movement of a steering
20 device about a steering axis relative a chassis of a vehicle or a device for for controlling rotational movement of a wheel arrangement about a steering axis relative a chassis of a vehicle. The steering device is mechanically connected to the wheel arrangement such that a limited relative rotational movement there between is allowed. In other words, the steering device and the wheel
25 arrangement are connected to each other such that they are rotatable relative each other within a limited rotational range. The device further comprises a main valve unit having a first valve member mechanically connectable to the steering device and a second valve member mechanically connectable to a wheel arrangement. The first valve member is arranged to interact with the
30 second valve member to adjust a flow passage area in response to the relative rotational movement in order to control the rotational movement of the steering device and/or the thereto connected wheel arrangement about the steering axis relative the chassis. In other words, when the first valve member

interacts with the second valve member, the flow passage area of a flow passage arranged in the main valve unit is adjusted in response to the relative rotational movement.

5 The device may further comprise a first element being connectable with the steering device, a second element being connectable to the wheel arrangement. The second element is mechanically coupled to the first element to allow the limited relative rotational movement. The first valve member is mechanically connected to the first element and the second valve member mechanically connected to the second element. In other words, a
10 limited relative rotational movement between the steering device and the wheel arrangement is allowed when the steering device is connected to the wheel arrangement via a first element and a second element.

The device may further comprise a damper unit having working chambers arranged in fluid communication with the main valve unit such that
15 a flow of damping fluid between the chambers is adjusted or restricted in response to the adjustment of the flow passage area. It is understood that the working chambers of the damper unit refers to the chambers formed by dividing the interior of a damper unit with a delimiting part. It is understood that the interior of a damper unit is adapted to be filled with a damping fluid. In
20 other words, the device may further comprise a damper unit, wherein the working chambers of the damper unit are fluidically coupled to or in fluid communication with the main valve unit such that a flow between the chambers passes through the adjustable flow passage area of the main valve unit.

25 The second element may be elastically coupled to the first element. Thereby, the limited relative rotational movement between the first and second element and thereby a limited relative rotational movement between the steering device and the wheel arrangement is achieved.

The device may further comprise elastic holding means being attached
30 between the first element and the second element for providing the elastic coupling.

The second element may be coupled to the first element via a torsion bar, a silent block bush or a bearing to allow a limited relative rotational

movement there between about a centre axis of the torsion bar, silent block bush or bearing.

The centre axis may be arranged at a distance from the steering axis. In other words, the first element (and the steering device) rotates relative to
5 the second element about the centre axis of the torsion bar, silent block bush or bearing which is arranged at a distance from the steering axis.

The device may further comprise at least two mechanical stops for limiting the relative movement. Hereby it may be possible to avoid excessive rotational movement between the first and second elements which otherwise
10 could result in a damages to the torsion bar or the silent block bush. The two mechanical stops may refer to two mechanical elements such as two pins extending from the second element, thereby limiting the relative rotational movement. In other emodiments, the two mechanical stops may refer to mechanical devices involving at least two parts. The mechanical stops may
15 interact with other portions of the first and/or second elements. The two mechanical stops may comprise at least one element slideably arranged in an opening between two surfaces portions thereof, such that the element is moveable between the surface portions in order to limit the relative movement to rotational movement. Hereby it may be possible to avoid damaging the
20 torsion bar, the silent block bush or the bearing if for example force is applied to the steering device in other directions than in the rotational direction. One such case may be during a motorcycle crash or during rough offroad driving.

The torsion bar may be arranged to be releasably connectable to the first element and the second element. Thereby a possibility is provided for a
25 vehicle user or a mechanic or the like to replace the torsion bar with another torsion bar with a different elasticity thereby adjusting the response time of the steering damping.

The first valve member may be arranged to interact with the second valve member to adjust an additional flow passage area in response to the
30 relative rotational movement in order to control the rotational movement of the steering device and/or the thereto connected wheel arrangement about the steering axis relative the chassis. In other words, when the first valve member interacts with the second valve member, the additional flow passage area of

an additional flow passage arranged in the main valve unit is adjusted in response to the relative rotational movement.

The device may further comprise an additional main valve unit having a third valve member mechanically connectable to the steering device and a fourth valve member mechanically connectable to the wheel arrangement, the third valve member being arranged to interact with the fourth valve member to adjust an additional flow passage area in response to the relative rotational movement in order to control the rotational movement of the steering device and/or the thereto connected wheel arrangement about the steering axis relative the chassis.

The working chambers may be in fluid communication with the main valve unit(s) such that a flow of damping fluid between the chambers is adjusted or restricted in response to the adjustment of the one additional flow passage area. In other words, the working chambers of the damper unit may be fluidically coupled to the main valve unit or units such that a flow between the chambers passes through the adjustable additional flow passage or additional adjustable flow passage area of the main valve unit.

The flow passage area may be arranged to adjust a flow of hydraulic fluid between the working chambers in a first direction, and the additional flow passage area may be arranged to adjust a flow of hydraulic fluid between the working chambers in a second direction, the second direction being opposite to the first direction.

The main valve unit may comprise adjustment means for adjusting the interaction between the first valve member and the second valve member.

The additional main valve unit may comprise adjustment means for adjusting the interaction between the third valve member and the fourth valve member.

The damper unit may be a hydraulic damper comprising a damping chamber and a delimiting part, the delimiting part dividing the damping chamber into two working chambers.

The damper unit may be a linear damper unit wherein the delimiting part is a piston.

The damper unit may be a rotational damper unit wherein the delimiting part is a wing element.

The damper unit may be integrated with the main valve unit.

According to a seventh aspect of the present invention, there is
5 provided a device for controlling rotational movement of a steering device and/or a thereto connected wheel arrangement about a steering axis relative a chassis of a vehicle, the steering device being mechanically connected to the wheel arrangement such that a limited relative rotational movement there between is allowed. The device comprises a main valve unit having a first
10 valve member mechanically connectable to the steering device and a second valve member mechanically connectable to a wheel arrangement, the first valve member being arranged to interact with the second valve member to adjust a flow passage area in response to the relative rotational movement in order to control the rotational movement of the steering device and/or the
15 thereto connected wheel arrangement about the steering axis relative the chassis. In other words, the device comprises a main valve unit having a first valve member mechanically connectable to the steering device and a second valve member mechanically connectable to a wheel arrangement, the first valve member being arranged to interact with the second valve member to
20 adjust a flow passage area of a flow passage in response to the relative rotational movement in order to control the rotational movement of the steering device and/or the thereto connected wheel arrangement about the steering axis relative the chassis. The device further comprises a first sensor device being able to be in operational communication with the steering device
25 and the wheel arrangement, the first sensor device being adapted to monitor a rotational position of the steering device relative the wheel arrangement when in operational communication with the steering device and the wheel arrangement.

The device may furthermore comprise a first element being
30 connectable with the steering device and a second element being connectable to the wheel arrangement. The second element is mechanically coupled to the first element to allow the limited relative rotational movement; and the first sensor device may be in operational communication with the first element and the second element. The first sensor device may be adapted to

monitor a rotational position of the steering device relative the wheel arrangement.

The device may furthermore comprise a second sensor device able to be in operational communication with the chassis and the first or second
5 element. The second sensor device may be adapted to monitor a rotational position of the steering device or the wheel arrangement relative the chassis.

The first sensor device may be adapted to monitor a rotational position of the steering device relative the wheel arrangement at least part of the limited relative rotational movement.

10 The first sensor device may be adapted to monitor a rotational position of the steering device relative the wheel arrangement throughout the whole of the limited relative rotational movement.

The device may further comprise an electrically controlled valve unit coupled to the sensor device(s), wherein the electrically controlled valve unit
15 is adapted to adjust a flow passage area in response to a signal from the sensor device(s) representing the rotational position.

The device may further comprise a damper unit in fluid communication with the electrically controlled valve unit, wherein the damper unit is adapted to control or damp a rotational movement of the steering device or the wheel
20 arrangement relative the chassis with a damping force adjusted in response to the adjustment of the flow passage area

The device may further comprise an electrically controlled damper unit adapted to control or damp a rotational movement of the steering device or the wheel arrangement relative the chassis, wherein the electrically controlled
25 damper unit is coupled to the sensor device(s) and is adapted to adjust its damping force in response to signal(s) from the sensor device(s) representing the rotational position(s) of the steering device.

The damper unit may be adapted to control or damp a rotational movement in one rotational direction.

30 The damper unit may be adapted to control or damp a rotational movement in both rotational directions.

The device may further comprise two electrically controlled valves coupled to the sensor device(s), wherein each of the electrically controlled

valves are adapted to adjust a flow passage area in response to a signal from the sensor device(s) representing the rotational position.

The device may further comprise a damper unit in fluid communication with the two electrically controlled valve units, wherein the damper unit is adapted to control or damp a rotational movement of the steering device or the wheel arrangement relative the chassis with a first damping force in one direction and a second damping force in a second and opposite direction, the first and second damping forces are adjusted in response to the adjustment of the flow passage areas.

The first sensor device may comprise a first member mechanically connectable with the first element or the steering device, wherein the first sensor device further comprises a second member mechanically connectable with the second element or the wheel arrangement, wherein the first valve member being arranged to interact with the second valve member in order to provide a signal representing the relative rotational position of the steering device and wheel arrangement.

The second sensor device may comprise a third member mechanically connectable with the first element or the steering device, wherein the second sensor device further comprises a fourth member mechanically connectable with the second element or the wheel arrangement, wherein the third member being arranged to interact with the fourth valve member in order to provide a signal representing the relative rotational position of the steering device and wheel arrangement.

The damper unit may be a hydraulic damper unit selected from a group comprising linear hydraulic damper and rotational damper.

The damper unit may be a magnetorheological damper or an electromechanical damper.

The sensor(s) may be selected from a group of sensor comprising: a potentiometer, a hall effect sensor and an optical sensor.

The second element or wheel arrangement may be elastically coupled to the first element or steering device.

The second element may be coupled to the first element via a torsion bar, a silent block bush or a bearing arrangement.

The electronically controlled valve unit and/or damper unit may be adjustable in response to at least one parameter selected from a group comprising vehicle speed, vehicle acceleration, vehicle braking, the rotational position(s) and rotational acceleration of the steering device and/or wheel arrangement relative each other or relative the chassis.

According to an eighth aspect of the present invention, there is provided a method of controlling rotational movement of a steering device and a thereto coupled wheel arrangement about a steering axis relative a chassis of a vehicle, the method comprising allowing a limited relative rotational movement between the steering device and the wheel arrangement, monitoring a rotational position parameter reflecting a rotational position of the steering device or the wheel arrangement relative the other rotational position parameter including a rotational position value (thus, monitoring a rotational position parameter reflecting a rotational position of the steering device relative the wheel arrangement or monitoring a rotational position parameter reflecting a rotational position of the wheel arrangement relative the steering device), performing a damping force analysis including a comparison of the rotational position value and reference rotational position value, and determining a specific damping force for controlling the rotational movement of the steering device and the thereto coupled wheel arrangement about a steering axis relative the chassis, the specific damping force value corresponding to a difference between the rotational position value and the reference rotational position value.

The method may further comprise providing a damping force signal representing the determined damping force to an electrically controlled valve unit, wherein the electrically controlled valve unit is adapted to adjust a flow passage area in response to the damping force signal.

The method may further comprise providing a damper unit in fluid communication with the electrically controlled valve unit, wherein the damper unit is adapted to control or damp a rotational movement of the steering device or the wheel arrangement relative the chassis with a damping force adjusted in response to the adjustment of the flow passage area.

The method may further comprise providing an electrically controlled damper unit adapted to control or damp a rotational movement of the steering device or the wheel arrangement relative the chassis, wherein the electrically controlled damper unit is coupled to the sensor device(s) and is adapted to
5 adjust its damping force in response to the damping force signal.

The damper unit may be adapted to control or damp a rotational movement in one rotational direction.

The damper unit may be adapted to control or damp a rotational movement in both rotational directions.

10 Further objects and advantages of the various embodiments of the present invention will be described below by means of exemplifying embodiments.

Brief description of the drawings

Exemplifying embodiments of the invention will be described below
15 with reference to the accompanying drawings, in which:

Fig. 1 is a view of a first embodiment of the present invention where the invention is arranged on a motorcycle;

Fig. 2 is a sectional view of one of the attachment means;

20 Figs. 3a and 3b show holding-up means arranged in the attachment means;

Fig. 4 is a sectional view through a first type of steering damper;

Fig. 5 is a sectional view through a second type of steering damper;

Fig. 6 shows the valve arrangement according to a first embodiment;

25 Fig. 7 shows the valve arrangement according to a second embodiment;

Fig. 8a shows the function of the steering damper when the vehicle is driven straight forward and no disturbances act on the steering means;

Fig. 8b shows the function of the steering damper when the driver actively steers to the right or when a disturbance acts on the steering means
30 from the left;

Fig. 8c shows the function of the steering damper when the driver actively steers to the left or when a disturbance acts on the steering means from the right;

Fig. 9 is a view of the steering damper according to the present invention arranged on a four-wheeled ATV; and

Fig. 10 is a sectional view of the steering damper mounted on an ATV.

Fig. 11 is a view of an embodiment of the device comprising a torsion
5 bar.

Fig. 12 is a sectional view of the steering damper in Fig. 11.

Fig. 13 is a view of an embodiment of the device comprising a linear steering damper.

Fig. 14 is a view of another embodiment of the device comprising a
10 linear steering damper.

Fig. 15 is a sectional view of a mechanically actuatable main valve unit.

Fig. 16 is a sectional view of a linear steering damper comprising pressure limiting valves.

Fig. 17 is a view of yet another embodiment of the device comprising a
15 linear steering damper.

Fig. 18 is a view of yet another embodiment of the device comprising a linear steering damper.

Fig. 19 is a view of yet another embodiment of the invention comprising an electronic sensor and an electrically controlled main valve unit.

Fig. 20a is a view of yet another embodiment of the invention comprising electronic sensors and an electrically controlled damper unit.

Fig. 20b is a view of yet another embodiment of the invention comprising electronic sensors and an electrically controlled damper unit.

Fig. 21a is a view of yet another embodiment of the invention comprising electronic sensors and an electrically controlled damper unit.

Fig. 21b is a view of yet another embodiment of the invention comprising electronic sensors and an electrically controlled damper unit.

Fig. 21c is a view of yet another embodiment of the invention comprising three electronic sensors and an electrically controlled damper
30 unit.

In the accompanying drawings, the same reference numerals denote the same or similar elements throughout the views.

Detailed description

The present invention will now be described more fully hereinafter with reference to the accompanying drawings, in which exemplifying embodiments of the invention are shown. This invention may, however, be embodied in
5 many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided by way of example so that this disclosure will convey the scope of the invention to those skilled in the art. Furthermore, like numbers refer to like or similar elements throughout.

- 10 Fig. 1 is a view of a first embodiment of the present invention where the invention is arranged on a vehicle in the form of a motorcycle having two parts 3 contacting the ground – one front wheel (not shown) coupled together with the chassis by means of a front fork having two fork legs 3a and a back wheel attached in the chassis by means of a swing arm (not shown).
- 15 According to the idea of the invention three wheels on this type of vehicle is also possible. The joining between the front fork legs 3a of the motorcycle and the motorcycle frame's front chassis 6 takes place by means of one or several attaching parts 5 which in this case have the shape of fork crowns 5a, 5b. The fork crowns 5a, 5b are rotatable about a steering axis SA centered in
20 a steering column 6 extending through both of the fork crowns 5a, 5b. The front wheel (not shown) of the motorcycle is located between the right fork leg and the symmetrically located left fork leg 3a so that rotation of front wheel, fork crowns 5a, 5b and fork legs 3a takes place about the steering axis SA. A steering device in the form of a handlebar 2 is attached in the upper fork
25 crown 5a by means of a first 7a and second 7b attachment means. The attachment means 7a, 7b comprise two parts; an upper 7a1, 7b1 and a lower 7a2, 7b2, between which the handlebar 2 is clamped.

- In addition to a handlebar, a steering wheel can also be used as steering device 2 for adjusting the direction of the vehicle's part(s) 3
30 contacting the ground. In Figs. 1 and 8a-8c the rotational movement of the steering device is shown by the arrows marked with ω_{r1} , ω_{r2} . When the vehicle is advanced straight forward, the steering device can be thought of to be in a base position in which the handlebar or the steering wheel is set such that the

vehicle's part(s) 3 contacting the ground are parallel with the direction of travel when no forces act on the wheel.

In Fig. 1 a steering damper 4 is mounted below the handlebar 2 between the attachment means 7a, 7b and attached to the upper 5a of the fork crowns 5. The steering damper 4 is coupled together with the lower part 7a2, 7b2 of the respective attachment means by means of a first and a second driver 11a, 11b. The steering damper 4 can also be mounted above the handlebar or at another position in proximity of the handlebar.

In Fig. 2 there is shown a sectional view of one of the attachment means 7a. Preferably both of the attachment means 7a, 7b are constructed in the same manner. A third attachment part 9a, 9b is arranged in the attaching part 5 which couples together the attachment means 7a, 7b and the attaching part 5. Between the lower attachments means part 7a2, 7b2 and the third attachment part 9a, 9b holding-up means 10a, 10b are arranged. These holding-up means 10a, 10b are constructed such that they are elastic in the direction of rotation such that the lower attachment means part 7a2, 7b2 can rotate with an initial rotational movement with respect to the third attachment part 9a, 9b. The third attachment part 9a, 9b can be omitted and then the lower attachment means part 7a2, 7b2 is instead elastically attached directly in the attaching part 5 via the holding up-means 10a, 10b. Drivers 8a, 8b are extending from the lower attachment part 7a2, 7b2, which drivers 8a, 8b may be made of the same material or be a separate unit attached in the lower attachment part.

The holding-up means 10a, 10b can also be constructed such that they are more elastic when rotated compared to when bent. The holding-up means 10a, 10b can in that case be arranged in the attachment means in the manner shown in Fig. 3a. The holding-up means in that case have a waist, meaning that the central portion of the holding-up means is tapered. The tapering preferably is radial symmetric around the whole holding-up means, Fig. 3a, or mainly in a lateral direction, Fig. 3b, such that the pliancy of the holding-up means depends on how the holding-up means are mounted in the attachment means 7a, 7b. Thus, the lower attachment means part 7a2, 7b2, with which the handlebar 2 is coupled together, can to a larger degree be moved

rotationally compared to horizontally with respect to the third attachment part 9a, 9b. In other words, the attachments means part 7a2, 7b2 and the third attachment part 9a, 9b may rotate in relation to each other within an initial rotational movement, but when the driver causes a force on the handlebar 2 in the direction of movement of the vehicle the coupling is mainly inelastic. Because the steering device 2 is elastically coupled together with the attaching part 5, rotation of the steering device 2 about the steering axis SA begins only after a predetermined initial rotational movement from the base position of the steering device has taken place.

10 A first and a second type of steering damper having an inner moveable delimiting part 11 are described in more detail in Figs. 4 and 5.

Fig. 4 is a sectional view through a first type of steering damper, a rotational steering damper, comprising an outer damping housing 4a enclosing a main damping chamber which comprises hydraulic fluid and is partitioned into two damping chambers C1, C2 by means of a delimiting part 11 in the form of a wing 11'. The wing 11' is rotatable about the steering axis SA at a first wing end. The main damping chamber may be arranged to be filled with hydraulic fluid. The hydraulic fluid preferably comprises oil, possibly comprising various additives. The outer surface of the wing end is rotating in a custom-made cut-out in the housing 4a and in the first wing end there is also attached a lever 12. The lever 12 rotates with the wing 11' in relation to the outer housing 4a and it is according to known techniques intended to couple together the steering damper 4, which rotates in relation to the steering device 2, with the frame/chassis 6 of the vehicle. By means of this fixture the movement of the attaching part 5 in the damping chamber mainly becomes related to the movement of the handlebar 2 and the wing 11' in relation to the frame 6 of the vehicle. It is also possible to attach the housing 4a of the steering damper in the chassis/frame 6 and couple together the wing 11' with the attaching part 5, which rotates in relation to the handlebar 2, and achieve the same function.

Fig. 5 shows a second type of steering damper, a linear steering damper, comprising an outer, cylindrically shaped housing 4a'' partitioned into two damping chambers C1, C2 by means of a delimiting part in the form of a

piston 11" attached to a piston rod 13. The piston rod 13 may either extend through the whole of the cylindrically shaped housing 4a" or be arranged on a side of the piston 11". The steering damper housing 4a" is coupled together with any of the attaching parts 5 rotating about the steering axis SA together
5 with the handlebar 2 and the piston bar 13 is coupled together with the chassis/frame 6, or vice versa.

In both embodiments in Figs. 4 and 5 the relative motion between the parts rotating about the steering axis SA and the chassis is damped by the delimiting part 11 moving in relation to the steering damper housing 4 and
10 pressing hydraulic fluid through one or several channels 14. The channel 14 is preferably arranged as a hole in the damping housing 4a and delimited by a valve arrangement 15.

The valve arrangement 15 is shown in detail in Fig. 6 and comprises at least one non-return valve 16, in this embodiment two non-return valves 16a,
15 16b, and a main valve unit HVU comprising one or several main valves 17, 18 mechanically coupled together with both the attaching part 5 and the steering device 2.

The first main valve comprises a first main valve part 17a and a second main valve part 17b. The first main valve part 17a is closely coupled together
20 with the steering device 2 via a first link 19a to the first driver 8a and the second main valve part 17b is closely coupled together with the attaching part 5 via the damping housing 4a of the steering damper. The second main valve comprises a third main valve part 18a and a fourth main valve part 18b. The third main valve part 18a is via a second link closely coupled together with the
25 steering device by means of the second driver 8b and the fourth main valve part 18b is closely coupled together with the attaching part 5 via the damping housing 4a of the steering damper as well. The first and the second 17a, 17b and the third and the fourth main valve parts 18a, 18b, respectively, move relatively to each other during the initial rotational movement. This creates a
30 first and a second variable opening area A1, A2 through which the hydraulic fluid can flow when a pressure difference between the damping chambers C1, C2 is present and when no disturbance acts in a direction that is reverse to the intentional rotational movement of the steering means. By means of

coordinated effect on the main valves' first and third valve parts 17a, 18a by respective adjustment devices, the opening area A1 of the first main valve 17 decreases while the opening area A2 of the second main valve 18 at the same time increases, and vice versa. An adjustment in the opening area
5 results in that control of the flow of hydraulic fluid from and to the respective damping chamber C1, C2 of the steering damper is enabled and eventually completely flowing freely or being brought to a stop when the initial rotation has been finished.

In Fig. 7 there is shown an alternative embodiment of the valve
10 arrangement 15. In this case the link 19a, 19b that couples together the drivers 8a, 8b and the first and the third main valve part 17a, 18a has been removed and replaced by one or several spring elements 22. The end of the first and the third main valve part 17a, 18a facing the respective driver 8a, 8b has a semispherical configuration in order to be able to accommodate certain
15 lateral movements. The spring element 22 is located between the first main valve part 17a and the third main valve part 18a so that the spring element creates a pressing force on both of the valve parts 17a, 18a and ensures that the first and the third main valve part 17a, 18a is pressed against the driver 8a, 8b with no play. Other than that, the valve arrangement in Fig. 7 is
20 substantially identical to the valve arrangement in Fig. 6.

In Figs. 8a-8c the function of the steering damper is described in more detail. In all of the figures the damping chambers C1, C2 are hydraulically coupled together by means of the damping channel 14 and the flow between the chambers is delimited by the main valves HPV, i.e. 17, 18, and blocked by
25 non-return valves 16a, 16b. The non-return valves 16a, 16b are positioned in series with the main valves in the damping channel 15 and prevent the flow in the respective flow direction Q1, Q2, which is determined by the rotational direction of the steering damper. According to a known construction, a pressurization reservoir 21 can be positioned in series with the main valves
30 and the non-return valves. The pressurization reservoir ensures that at least a base pressure always is present in the damping chambers C1, C2 and that volume changes in the hydraulic fluid can be absorbed. The pressurization reservoir 21 is located such that if there is a higher pressure in the

pressurization reservoir than in the damping chambers the reservoir 21 is always coupled together with respective damping chambers via the non-return valves 20a, 20b.

Fig. 8a shows the function of the steering damper when the vehicle is driven straight forward and no disturbances are acting on the steering means 2, that are neither caused by the driver nor the configuration of the ground. The moveable delimiting part 11 of the steering damper is located such that the damping chambers are basically equally large. The opening between the first and the second valve part is open and a flow of hydraulic fluid can run between the damping chambers C1, C2 via the main valves 17, 18.

Fig. 8b shows the function of the steering damper when the driver is actively steering to the right, i.e. in the first direction ω_{r1} . The damping housing 4a is turned with the handlebar 2 to the left in the figure in relation to the delimiting part 11 so that the volume of the second damping chamber C2 decreases. The possible initial rotation between the handlebar 2 and the attaching part 5 results in that the drivers 8a, 8b affect the main valves such that the first main valve 17 closes and the second main valve 18 opens. The hydraulic fluid flows between the damping chambers C2 and C1 in the direction Q1, also see the black/white arrow, via the channel 14 and through the completely open opening between the third and fourth main valve parts 18a, 18b of the second main valve 18. When a disturbance S1 that causes the wheel to turn to the left acts on the wheel, the flow Q2 of hydraulic fluid through the channel 14, also see the completely black arrow, is stopped both by the completely closed first main valve 17 and the first non-return valve 16a.

Fig. 8c shows the function of the steering damper when the driver is actively steering to the left or when a disturbance acts on the steering means from the right, i.e. in the second direction ω_{r2} . The damping housing 4a is turned with the handlebar 2 to the right in the figure in relation to the delimiting part 11 so that the volume of the first damping chamber C1 decreases. In this case, the initial rotation results in that the drivers 8a, 8b affect the main valves such that the second main valve 18 closes and the first main valve 17 opens. The hydraulic fluid flows between the damping

chambers C1 and C2 in the direction Q2, see also the completely black arrow, via the channel 14 and through the completely open opening between the first and second main valve parts 17a, 17b of the first main valve 17.

When a disturbance S2 that causes the wheel to turn to the right acts on the wheel, the flow Q1 of hydraulic fluid through the channel 14, also see the black/white arrow, is stopped both by the completely closed second main valve 18 and the second non-return valve 16b.

When the first and the second main valve 17, 18, respectively, is open, i.e. when the turning motion of the handlebar is caused by the driver, the hydraulic fluid basically flows freely between the damping chambers with no restriction and no damping of the steering motion takes place but the vehicle reacts just as quickly as if no steering damper were mounted. If a certain amount of damping is also desired when steering it may be achieved by an adjustment of the position of the first and second main valve parts 17a, 17b; 18a, 18b relatively each other. When shocks and impacts causes the wheel to be turned against the driver's will the motion of the handlebar is blocked or strongly damped in the undesired turning direction as the main valves 17, 18 in that direction are closed and the flow between the damping chambers is prevented.

Fig. 9 shows the location of the steering damper on a four-wheeled ATV. In this case the damping housing is fixed to an attaching part 5 in the form of a cylinder 5' arranged concentrically around the steering axis. The cylinder 5' is divided into an upper and a lower part 5a', 5b' coupled together by means of an elastic holding-up means 10. The upper cylinder part 5a' is coupled together with the steering device 2, and the lower cylinder part 5b' is coupled together with the wheels 3 via one or several wheel suspension parts. In this embodiment the steering damper 4 is mounted in the lower cylinder part 5b' but the steering damper can also be mounted in the upper cylinder part 5a'. The steering damper housing 4a is fixed to a flange 19 protruding from the cylinder part, and hence moves together with the lower cylinder part 5b'. In this case, the delimiting part 8 that is moveable in the damping housing is coupled together with the fixed chassis parts 6 of the

vehicle via the lever 12 so that the delimiting part 8 and the damping housing 4a move in relation to each other.

Of course, a linear steering damper such as the one shown in Fig. 5 can also be used in ATV applications.

- 5 Fig. 11 shows a view of an embodiment of the present invention suitable for use on for example a motorcycle. The attaching part 105 in this embodiment has the shape of a fork crown. The fork crown is of the triple clamp type which means that two front forks are attachable to the fork crown at either ends and a steering column is attachable in between said front forks.
- 10 The fork crown 105 is rotatable about a steering axis SA, coinciding with the axis of a steering column when attached thereto. A steering device in the form of a handlebar is attachable in the fork crown 105 by means of a first attachment means 107a and second attachment means 107b. The attachment means 107a, 107b comprise two parts; an upper 107a1, 107b1 and a lower 107a2, 107b2, between which a handlebar is clampable. The attachment means 107a, 107b are coupled together via bars 107c, 107d. The first bar, 107c is divided into two parts, 107c1, 107c2 between which a torsion bar 125 is disposed. The torsion bar 125 is attached in its upper end to the first bar 107c and in its lower end to the fork crown 105. In other
- 15 embodiments, a silent block bush or a bearing is used instead of the torsion bar. The attachment means 107a, 107b are attached to the fork crown 105 via two elements 126a, 126b. The elements are slidably arranged in openings in the fork crown between two end surfaces of the openings, i.e. the elements are slidably arranged between two end positions defined by these end
- 20 surfaces. The openings are larger in size relative to the elements, thereby allowing a slidable operation. In other embodiments, the elements are arranged in slots or holes in the fork crown. The elements are attached to the fork crown and the attaching part. Thereby, the attachment means are limited to rotational movement relative to the fork crown. On top of the fork crown
- 25 105 adjacent to the attachment means 107a, 107b, a main valve unit 115 is arranged. The torsion bar 125 may be arranged to be releasably connectable, mountable or replaceable, thus providing the possibility for a vehicle user or a mechanic or the like to replace the torsion bar with another torsion bar with
- 30

different characteristics such as different elasticity thereby adjusting the response time of the steering damping.

Fig. 12 shows a sectional view of the device in Fig. 11. The sectional view is shown along a cross section of the main valve unit 115 and the steering damper 104. The main valve unit 115 is arranged on top of the fork crown 105 and the steering damper 104 is arranged substantially in parallel with the main valve unit 115 mostly inside the fork crown 105, extending partly through the bottom of the fork crown. The main valve unit 115 comprises a first and a second valve unit 117, 118. A valve actuator 130, being coupled to the attachment means 107a, 107b via the bar 107d, extends into the main valve unit 115. The steering damper 104 is of the linear damping type comprising a piston 111 partitioning the interior of the damping housing 104a, i.e. the damping chamber, into two damping chambers C1 and C2. The piston 11 is attached to a piston rod 113 which extends through the steering damper 104. The piston rod 113 is attached in both ends to the fork crown. In other embodiments, the piston rod may be attached in one end only. Fig 13 shows a view from beneath of an embodiment of the present invention. The attaching part is in the form of a fork crown 105. The housing of the linear steering damper 104 is attached to the fork crown, and the piston rod 113 is coupled via a link bar 140 to the rotating link 127c which in turn is attachable to the frame of the vehicle when mounted thereto.

Fig 14 shows a view from beneath of an embodiment of the present invention. The attaching part is in the form of a fork crown 105. The housing of the linear steering damper 104 is coupled via a link bar 140 to the rotating link 127c which in turn is attachable to the frame of the vehicle via the links 127a, 127b when mounted thereto. The piston rod 113 extends through the steering damper 104, and the piston rod is attached in both ends to the fork crown 105. In another embodiment, at least one of the links 127a, 127b, 127c, 140 or 150 may be configured with a strength such that at least one of the links breaks if the damping force of the steering damper is higher than a predetermined value. Thereby, damages to the part(s) of the vehicle arranged for contacting ground or to the steering damper 104 may be avoided. The predetermined maximum value of the damping force may be exceeded during

for example an accident when high forces are applied to the part(s) arranged for contacting the ground. Another example when the maximum damping force may be exceeded is during malfunction of the valve unit which controls hydraulic fluid flow between the working chambers of the steering damper

5 104, i.e. when hydraulic fluid flow between the working chambers is essentially prevented. Furthermore, the damping characteristics may be adjusted by adjusting the ratios in the linkage, i.e. by varying the lengths and/or dimensions of the links 127a, 127b, 127c, 140 or 150.

Fig 15 shows a main valve unit 215 which may be used in embodiments such as exemplified in Fig 11 or 12. The main valve unit 215 comprises two main valves 217, 218 being actuatable by a valve actuator 230. Thus, the main valve unit 215 has a first valve member 230 and a second valve member 217, 218. Two valve adjustment means 224a, 224b are arranged at either end of the main valve unit, such that the damping characteristics of the main valves
15 217, 218 may be externally adjusted.

Fig 16 shows a sectional view of a steering damper 204. A piston 211 divides the damper volume into first and second working chambers C1 and C2. The piston 211 comprises through holes 229a, 229b and pressure limiting valves 223a, 223b arranged on either said of the piston such that the
20 pressure in the working chambers C1 and C2 is limited to a predetermined maximum value. The predetermined maximum value may be in the range of 30-100 bars. Thereby, the maximum damping force is limited in order to avoid damaging the part(s) of the vehicle arranged for contacting ground and the steering damper. The predetermined maximum value of the working chamber
25 pressure may be exceeded during for example an accident when high forces are applied to the part(s) arranged for contacting the ground. Another example when the predetermined maximum value of the pressure may be exceeded is during malfunction of the valve unit which controls hydraulic fluid flow between the working chambers of the steering damper 104, i.e. when
30 hydraulic fluid flow between the working chambers is essentially prevented. The pressure limiting valves 223a and 223b may be arranged to affect the damping characteristics of the steering damper at working chamber pressures lower than the predetermined maximum value. Thereby an additional degree

of freedom for customizing the damping characteristics during normal operation is achieved. The pressure limiting valves 223a and 223b may be of the disc-valve type. In yet another embodiment, the main valve 215, such as exemplified in Fig 15 comprises a pressure limiting valve coupled in parallel to the first and second valve units 217 and 218, i.e. between the working chambers C1 and C2 such that the pressure in the working chambers C1 and C2 is limited to a predetermined maximum value. The predetermined maximum value may be in the range of 30-100 bars.

Fig 17 shows a view from beneath of an embodiment of the present invention. The attaching part is in the form of a fork crown 205. The housing of the linear steering damper 204 is attached to the fork crown, and the piston rod 213 is coupled via a link bar 240 to the rotating link 227c which in turn is attachable to the frame of the vehicle when mounted thereto. The link bar 240 is attached to the piston rod with a bolt 228d and to the rotating link 227c with a bolt 228c. In other embodiments, the bolts 228c, 228d may be pins or studs. At least one of the bolts 228c, 228d have a reduced strength and be adapted to break if the damping force of the steering damper is higher than a predetermined value. Thereby, damages to the part(s) of the vehicle arranged for contacting ground and/or to the steering damper 204 may be avoided. The predetermined maximum value of the damping force may be exceeded during for example an accident when high forces are applied to the part(s) arranged for contacting the ground. Another example when the maximum damping force may be exceeded is during malfunction of the valve unit which controls hydraulic fluid flow between the working chambers of the steering damper 204, i.e. when hydraulic fluid flow between the working chambers is essentially prevented.

Furthermore, the characteristics of the damping of the rotational movement of the steering device and/or wheel arrangement relative the chassis of the vehicle may be adjusted by adjusting the ratios in the linkage, i.e. by varying the lengths and/or dimensions of the links 227c, 240.

Fig 18 shows a view from beneath of an embodiment of the present invention. The attaching part is in the form of a fork crown 205. The housing of the linear steering damper 204 is coupled via a link bar 240 to the rotating

link 227c which in turn is attachable to the frame of the vehicle via the links 227a, 227b when mounted thereto. The piston rod 213 extends through the steering damper 204, and the piston rod is attached in both ends to the fork crown 205. At least one of the bolts or pins 228a, 228b, 228c, 228d attaching the links 227a, 227b, 227c, 250 together with each other or with the steering damper have a reduced strength to break if the damping force of the steering damper is higher than a predetermined value. Thereby, damages to the part(s) of the vehicle arranged for contacting ground or to the steering damper 204 may be avoided. The predetermined maximum value of the damping force may be exceeded during for example an accident when high forces are applied to the part(s) arranged for contacting the ground. Another example when the maximum damping force may be exceeded is during malfunction of the valve unit which controls hydraulic fluid flow between the working chambers of the steering damper 204, i.e. when hydraulic fluid flow between the working chambers is essentially prevented.

Furthermore, the damping characteristics may be adjusted by adjusting the ratios in the linkage, i.e. by varying the lengths and/or dimensions of the links 227a, 227b, 227c, 250.

Fig 19 shows a view of yet another embodiment of the present invention. The second element 305 in this embodiment has the shape of a fork crown. However, it is understood that the second element may be of a different configuration or shape. The fork crown is of the triple clamp type which means that two front forks are attachable to the fork crown at either ends and a steering column is attachable in between said front forks. The fork crown 305 is rotatable about a steering axis SA, coinciding with the axis of a steering column when attached thereto. A steering device in the form of a handlebar is attachable in the fork crown 305 by means of a first element 307a and 307b. The first element 307a, 307b are attached to the fork crown 305 via two elastic members 310, such that a relative rotational movement is allowed between the first element and the fork crown. An electronic sensor in the form of a potentiometer 331 is coupled to the second element 305 and to the steering device 302 and is arranged for measuring relative rotation there between. In other embodiments, the electronic sensor 331 may be coupled to

the first and second elements, achieving the same technical effect, i.e. measuring relative rotation between the second element and the steering device. The electronic sensor may be a hall effect sensor or an optical sensor in other embodiments. The electronic sensor is electrically coupled to an ECU

5 360. The ECU is also electrically coupled to an electrically controlled main valve unit 315. The electrically controlled main valve unit 315 is hydraulically coupled to a steering damper 304 such that the flow of hydraulic fluid between the working chambers of the steering damper 304 may be controlled by the ECU in response to a signal from the electronic sensor 331 reflecting

10 relative movement between the first and second elements. The steering damper 304 is mechanically coupled to the fork crown 305 and to the chassis 306 of the vehicle such that rotational movement of the fork crown relative to the chassis of the vehicle may be damped. The steering damper 304 is a linear hydraulic damper comprising a piston and piston rod arrangement. In

15 other embodiments, the steering damper 304 may be a rotational wing damper. In yet other embodiments, the main valve unit may be coupled to the first element 307a, 307b or directly to the steering device 302. The electrically controlled main valve unit 315 may be arranged on top of the fork crown, underneath the fork crown or separately from the fork crown, for example on

20 the part(s) arranged for contacting the ground such as the front fork of a motorcycle or on the chassis of the vehicle. In yet another embodiment, the electrically controlled main valve unit 315 may be integrated with a steering damper which may be arranged underneath the fork crown. The electrically controlled main valve unit has a functional structure analogous to the

25 embodiment shown in Fig 8, except that the main valves are electrically controlled instead of being mechanically actuated. The main valves are controlled by pilot valves which are actuated by electrically controlled solenoids or other electrically controlled devices such as for example an electric motor. In other embodiments, the electrically controlled main valve

30 unit may comprise a main valve for adjusting the flow of hydraulic fluid between the working chambers which is directly actuated by actuating means such as for example a solenoid or an electric motor. In yet another embodiment, the electrically controlled main valve unit may comprise an

electromagnet for controlling the flow of a magnetorheological fluid through the main valve unit by means of a magnetic field. In such an embodiment,

Fig 20a shows a view of yet another embodiment of the present invention suitable for use on for example a motorcycle. The second element
5 305 in this embodiment has the shape of a fork crown. The fork crown is of the triple clamp type which means that two front forks are attachable to the fork crown at either ends and a steering column is attachable in between said front forks. The fork crown 305 is rotatable about a steering axis SA, coinciding with the axis of a steering column when attached thereto. A
10 steering device in the form of a handlebar is attachable to the fork crown 305 by means of a first element 307a and 307b. The first element 307a, 307b are attached to the fork crown 305 via two elastic members 310, such that a relative rotational movement is allowed between the first element and the fork crown. A first electronic sensor 331 is coupled to the first element and the
15 steering device and is arranged for measuring relative rotation there between. In other embodiments, the electronic sensor 331 may be coupled to the first and second elements, achieving the same technical effect, i.e. measuring relative rotation between the second element and the steering device. A second electronic sensor 332 is coupled to the fork crown 305 and to the
20 chassis 306 of the vehicle and is arranged for measuring relative rotation between the chassis of the vehicle and the fork crown. In this embodiment, the first and second electronic sensors are potentiometers. The electronic sensors may be Hall Effect sensors or optical sensors in other embodiments. The electronic sensors are electrically coupled to an ECU 360. The ECU is
25 also electrically coupled to an electrically controlled damper unit 304, such that the damping of the damper unit may be controlled by the ECU in response to signals from the electronic sensors 331, 332. The electrically controlled damper unit 304 is mechanically coupled to the fork crown 305 and to the chassis 306 of the vehicle such that rotational movement of the fork
30 crown relative to the chassis of the vehicle may be damped. In other embodiments, the electrically controlled damper unit may be coupled to the first element 307a, 307b or directly to the steering device 302. The electrically controlled damper unit 304 may be arranged on top of the fork crown,

underneath the fork crown or separately from the fork crown, for example on the part(s) arranged for contacting the ground such as the front fork of a motorcycle or on the chassis of the vehicle. The electrically controlled damper unit 304 is a linear hydraulic damper comprising a valve arrangement in its piston. The valve arrangement comprises a pilot valve which is electrically actuated using for example a solenoid. The pilot valve is used to control a main valve of the valve arrangement which in turn adjusts the flow of hydraulic fluid between the working chambers in the damper unit 304. Such a damper unit using an electrically controlled pilot valve is well known for the person skilled in the art, and is commonly referred to as a CES damper, and no further details regarding its construction will thus be given here. In other embodiments, the valve arrangement may comprise a main valve for adjusting the flow of hydraulic fluid between the working chambers which is directly actuated by actuating means such as for example a solenoid or an electric motor. In yet another embodiment, the electrically controlled damper unit may comprise a valve arrangement which is arranged radially outside the walls of the damping cylinder or axially above or below the working chambers of the damper unit. In yet another embodiment, the damper unit may be a magnetorheological damper being filled with a magnetorheological fluid, wherein the damping properties of the damper unit is electrically controlled by a magnetic field provided by an electromagnet for example. The electromagnet may be arranged in the piston of the damper unit such that the flow through the through-hole equipped piston may be electrically controlled. Such a magnetorheological damper unit is also well known for the person skilled in the art, and no further details regarding its construction will thus be given here. In yet another embodiment, the damper unit may be of the electromechanical type comprising at least one electric motor and means for transforming the rotational movement of the motor to axial movement such that the damping properties of the damper unit may be adjusted by electrically actuating the motor. Such an electromechanical damper unit is also well known for the person skilled in the art, and no further details regarding its construction will thus be given here. In yet another embodiment, the damper unit may be a friction damper which may comprise electrically actuatable

means for adjusting the abutment between the friction elements of the friction damper.

Fig 20b shows a view of an embodiment as shown in Fig 20a, except for that the second electronic sensor is coupled steering device 302 instead of
5 being coupled to the fork crown 305. In yet another embodiment, the second electronic sensor is coupled to the first element 307a, 307b and to the chassis of the vehicle 306.

Fig 21a shows a view of an embodiment of the present invention fitted on the front fork 403a, 403b of a motorcycle. The second element 405a, 405b
10 in this embodiment has the shape of cylindrical sleeves being attached to the front fork 403a, 403b. A steering device in the form of two separate handle-bars 402a, 402b is connectable to the second elements 405a, 405b via first elements 407a and 407b. The first and second elements are rotatable about a steering axis SA for adjusting the direction of a wheel being attached to the
15 front fork 403a, 403b. The first and second elements are coupled together by means of elastic elements 410a, 410b arranged there between to allow rotational movement between the first and second elements. The elastic elements 410a, 410b may be rubber bushes. In other embodiments, the second element 405a, 405b may be the front fork 403a, 403b itself, i.e. the
20 elastic elements 410a, 410b are arranged directly between the second element 405a, 405b and the front fork. Both of the handles 402a, 402b are connected to the front fork 403a, 403b using first and second elements with elastic elements there between. In other embodiments, one of the handles 402a, 402b may be unelastically coupled to the front fork, i.e. without an
25 elastic element. In other embodiments, other means for allowing a relative rotational movement between the first and second elements may be used such as for example a bearing. In such an embodiment, additional means are required to limit the relative rotational movement to a limited initial rotation. A first electronic sensor 431 is coupled to one of the front forks 403a and to
30 one of the second elements 405a and is arranged for measuring relative rotation there between. In another embodiment, first electronic sensor 431 may be coupled to one of the first elements 407a and to one of the second elements 405a. A second electronic sensor 432 is coupled to one of the first

elements 407a and to the chassis 406 of the vehicle and is arranged for measuring relative rotation between the chassis of the vehicle and the steering device 402a. The first and second electronic sensors are potentiometers. The electronic sensors may be Hall Effect sensors or optical sensors in other embodiments. The electronic sensors are electrically coupled to an ECU 360. The ECU is also electrically coupled to an electrically controlled damper unit 404, such that the damping of the damper unit may be controlled by the ECU in response to signals from the electronic sensors. The damper unit 404 is mechanically coupled to one of the first elements 407a and to a portion 406 of the vehicle chassis. In other embodiments, the electrically controlled damper unit 404 may be coupled to the other first element 407b which may be unelastically coupled to a fork leg 403b. In yet other embodiments, the electrically controlled damper unit 404 may be coupled to one of the fork holding elements 470a, 470b. In yet other embodiments, the damper unit 404 may be arranged underneath, on top of, or integrated in the upper fork holding element 470a.

Fig 21b shows a view of an embodiment as shown in Fig 21a, except for that the second electronic sensor 432 is coupled fork holding element 470a instead of being coupled to the first element 470a. In yet another embodiment, the second electronic sensor 432 is coupled to one of the second elements 405a, 405b and to the chassis of the vehicle 306.

Fig 21c shows a view of an embodiment as shown in Fig 21a, except for that a third electronic sensor 433 is used which is coupled to the first element 407b and to the front fork 403b. In another embodiment, the third electronic sensor 433 may be coupled to the first element 407b and to the second element 405b.

In conclusion, a device is disclosed for use in a vehicle for adjusting the rotational damping of a steering device such that the rotational damping varies depending on whether the rotational motion about a steering axis is caused by a force acting on the steering device of the vehicle or a force acting on the part(s) of the vehicle contacting the ground. The device comprises a steering damper comprising a damping housing enclosing a main chamber which comprises hydraulic fluid and is partitioned into a first

and a second damping chamber, for example by a delimiting part moveable in relation to the damping housing. The damping housing is fixed on an attaching part that couples together the part(s) of the vehicle contacting the ground with the steering device. The present invention is characterized in that

5 the flow of hydraulic fluid in the steering damper partly or wholly is adjusted by a main valve unit that is coupled together with both the attaching part and the steering device. By means of this coupling the opening area of the main valve unit is determined by a relative motion between the attaching part and the steering device such that the flow of the hydraulic fluid in a direction from

10 and to the respective damping chamber of the steering damper is controlled depending on the cause of the rotational movement.

Although exemplary embodiments of the present invention have been described herein, it should be apparent to those having ordinary skill in the art that a number of changes, modifications or alterations to the invention as

15 described herein may be made. Thus, the above description of the various embodiments of the present invention and the accompanying drawings are to be regarded as non-limiting examples of the invention and the scope of protection is defined by the appended claims. Any reference signs in the

claims should not be construed as limiting the scope.

Itemised list

Item 1. A device intended for a vehicle comprising; a steering device (2) rotatable about a steering axis (SA) for adjusting the direction of the part(s) (3) of the vehicle contacting the ground, an attaching part (5, 5') that couples together the part(s) (3) contacting the ground with the steering device (2) and a steering damper (4) adjusting the rotational damping of the steering device (2) wherein the attaching part (5, 5') rotates with the steering device (2) and with the damping housing (4a) of the steering damper (4) that encloses a main damping chamber which comprises hydraulic fluid and is partitioned into a first and a second damping chamber (C1, C2) by a delimiting part (11, 11') that is arranged in the main damping chamber and moveable with respect to the damping housing (4a),

characterized in that

the rotational damping, and thus also the flow of hydraulic fluid (Q1, Q2) between the damping chambers (C1, C2) of the steering damper (4), is arranged to be adjusted by means of a main valve unit (HVU) mechanically coupled together with both the attaching part (5, 5') and the steering device (2) and where the amount of hydraulic fluid flowing through the main valve unit (HVU) is determined by a relative movement between said attaching part (5, 5') and the steering device (2).

Item 2. A device according to item 1, **characterized in that** the steering device (2) is elastically coupled together with the attaching part (5, 5') and wherein the relative movement between the attaching part (5, 5') and the steering device (2) occurs only during a predetermined initial rotational movement of the steering device (2) from its base position.

Item 3. A device according to item 1 or 2, **characterized in that** the main valve unit (HVU) comprises a first (17) and a second main valve (18).

Item 4. A device according to item 3, **characterized in that** in the first main valve (17) there is arranged a first main valve part (17a) coupled

together with the steering device (2) and a second main valve part (17b) coupled together with the damping housing (4a) of the steering damper and in that in the second main valve (18) there is arranged a third main valve part (18a) coupled together with the steering device (2) and a fourth main valve part (18b) coupled together with the damping housing (4a) of the steering damper, wherein the first (17a) and the second (17b) and the third (18a) and the fourth (18b) main valve parts, respectively, are moveable with respect to each other such that they form a first and a second variable opening area (A1, A2) through which the hydraulic fluid can flow.

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Item 5. A device according to item 4, **characterized in that** the opening area (A1) of the first main valve (17) decreases and the opening area (A2) of the second main valve (18) increases when the positions of the first and the second (17a, 17b) and the third and the fourth (18a, 18b) main valve parts, respectively, relatively each other is determined by a rotational motion in a first direction (ω_{r1}) of the steering device (2) or by a rotational motion in a second direction (ω_{r2}) of the housing (4a) of the steering device and where the opening area (A1) of the first main valve (17) increases and the opening area (A2) of the second main valve (18) decreases when the positions of the first and the second (17a, 17b) and the third and the fourth (18a, 18b) main valve parts, respectively, relatively each other is determined by a rotational motion in a second direction (ω_{r2}) of the steering device (2) or by a rotational motion in a first direction (ω_{r1}) of the housing (4a) of the steering device.

25

Item 6. A device according to item 4 or 5, **characterized in that** the first and third main valve parts (17a, 18a) of the first (17) and second (18) main valve move synchronously in relation to each other such that the opening area (A1) of the first main valve decreases substantially as much as the opening area (A2) of the second main valve increases, and vice versa.

30

Item 7. A device according to item 4, 5 or 6, **characterized in that** the first main valve part (17a) is coupled together with the steering device (2) via

a first driver (8a) and the third main valve part (18a) is coupled together with the steering device (2) via a second driver (8b).

- Item 8. A device according to item 7, **characterized in that** the first driver (8a) is coupled together with the first main valve part (17a) by means of a first link (19a) and the second driver (8b) is coupled together with the third main valve part (18a) by means of a second link (19b), wherein the links (19a, 19b) are hinged in both ends.
- Item 9. A device according to item 7 or 8, **characterized in that** the first driver (8a) is pressed against the first main valve part (17a) and the second driver (8b) is pressed against the third main valve part (18a) by means of one or several spring elements (22).
- Item 10. A device according to item 9, **characterized in that** the spring element(s) is/are located between the first main valve part (17a) and the third main valve part (18a) and such that it/they creates a pressing force acting on both valve parts (17a, 18a).
- Item 11. A device according to any one the preceding items, **characterized in that** between the attaching part (5, 5') and the steering device (2) there is arranged one or several elastic holding-up means (10, 10a, 10b) arranged to determine the magnitude of the initial rotational motion (α).
- Item 12. A device according to any one the preceding items, **characterized in that** the attaching part (5) is a fork crown (5) arranged at the front fork arrangement of a motorcycle.
- Item 13. A device according to any one of items 1-10, **characterized in that** the attaching part (5) is a cylindrical unit (5') arranged around a steering connecting rod through which the steering axis (SA) runs.

Item 14. A device according to item 13, **characterized in that** the attaching part (5') is divided into an upper and a lower cylindrical part (5a', 5b') coupled together by means of an elastic holding-up means (10) which is arranged to determine the magnitude of the initial rotational motion (α).

Second itemised list

- v1. A device intended for a vehicle comprising; a steering device (2) rotatable about a steering axis (SA) for adjusting the direction of the part(s) (3) of the vehicle arranged for contacting ground, an attaching part (5, 5') that couples together the part(s) (3) arranged for contacting ground with the steering device (2) and a steering damper (4, 104), wherein the attaching part (5, 5', 105) rotates with the steering device (2) and with the damping housing (4a, 104a) of the steering damper (4, 104) that encloses a main damping chamber which comprises hydraulic fluid and is partitioned into a first and a second damping chamber (C1, C2), wherein a main valve unit (HVU) is adapted to adjust a flow of hydraulic fluid (Q1, Q2) between the damping chambers (C1, C2) of the steering damper (4, 104), said main valve unit (HVU) being mechanically coupled together with both the attaching part (5, 5', 105) and the steering device (2), such as to adjust the rotational damping of the steering device (2), and wherein the amount of hydraulic fluid flowing through the main valve unit (HVU) is determined by a relative movement between said attaching part (5, 5', 105) and the steering device (2).
- v2. A device intended for a vehicle comprising; a steering device (2) rotatable about a steering axis (SA) for adjusting the direction of the part(s) (3) of the vehicle arranged for contacting ground, an attaching part (5, 5', 105) that couples together the part(s) (3) arranged for contacting ground with the steering device (2) and a steering damper (4, 104), wherein the attaching part (5, 5', 105) rotates with the steering device (2) and with a delimiting part (11, 11', 11'', 111) of the steering damper (4, 104) that partitions a main damping chamber which comprises hydraulic fluid into a first and a second damping chamber (C1, C2), wherein a main valve unit (HVU) is adapted to adjust a flow of hydraulic fluid (Q1, Q2) between the damping chambers (C1, C2) of the steering damper (4, 104), said main valve unit (HVU) being mechanically coupled together with both the attaching part (5, 5', 105) and the steering device (2), such as to adjust the rotational damping of the steering device (2), and wherein the amount of hydraulic fluid flowing through the main valve unit

(HVV) is determined by a relative movement between said attaching part (5, 5', 105) and the steering device (2).

5 v3. A device according to item 1 or 2, wherein the steering device (2) is elastically coupled together with the attaching part (5, 5', 105).

10 v4. A device according to item 1 or 2, wherein the steering device (2) is elastically coupled together with the attaching part (5, 5', 105) and wherein the relative movement between the attaching part (5, 5', 105) and the steering device (2) occurs only during a predetermined initial rotational movement of the steering device (2) from a base position.

15 v5. A device according to any one of the preceding items, wherein the main valve unit (HVV) comprises a first (17, 117) and a second main valve (18, 118).

20 v6. A device according to item 5, further comprising a first main valve part (17a) and a second main valve part (17b) arranged in the first main valve (17), the first main valve part (17a) being coupled together with the steering device (2) the second main valve part (17b) being coupled together with the damping housing (4a) of the steering damper, the device further comprising a third main valve part (18a) and a fourth main valve part (18b) arranged in the second main valve (18), the third main valve part (18a) being coupled together with the steering device (2) and the fourth main valve part (18b) being coupled together with the damping housing (4a) of the steering damper, wherein the first (17a) and the second (17b) and the third (18a) and the fourth (18b) main valve parts, respectively, are moveable with respect to each other such that they form a first and a second variable opening area (A1, A2) through which the hydraulic fluid can flow.

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v7. A device according to item 6 as dependent on item 1, 3 or , wherein the opening area (A1) of the first main valve (17) decreases and the opening area (A2) of the second main valve (18) increases when the positions of the

first and the second (17a, 17b, 117a, 117b) and the third and the fourth (18a, 18b) main valve parts, respectively, relatively each other is determined by a rotational motion in a first direction (ω_{r1}) of the steering device (2) or by a rotational motion in a second direction (ω_{r2}) of the housing (4a) of the steering device, and where the opening area (A1) of the first main valve (17) increases and the opening area (A2) of the second main valve (18) decreases when the positions of the first and the second (17a, 17b) and the third and the fourth (18a, 18b) main valve parts, respectively, relatively each other is determined by a rotational motion in a second direction (ω_{r2}) of the steering device (2) or by a rotational motion in a first direction (ω_{r1}) of the housing (4a) of the steering device.

v8. A device according to item 6 as dependent on item 2, 3 or 4, wherein the opening area (A1) of the first main valve (17) decreases and the opening area (A2) of the second main valve (18) increases when the positions of the first and the second (17a, 17b) and the third and the fourth (18a, 18b) main valve parts, respectively, relatively each other is determined by a rotational motion in a first direction (ω_{r1}) of the steering device (2) or by a rotational motion in a second direction (ω_{r2}) of the delimiting part (11,111) of the steering damper, and where the opening area (A1) of the first main valve (17) increases and the opening area (A2) of the second main valve (18) decreases when the positions of the first and the second (17a, 17b) and the third and the fourth (18a, 18b) main valve parts, respectively, relatively each other is determined by a rotational motion in a second direction (ω_{r2}) of the steering device (2) or by a rotational motion in a first direction (ω_{r1}) of the delimiting part (11,111) of the steering damper.

v9. A device according to item 6, 7 or 8, wherein the first and third main valve parts (17a, 18a) of the first (17) and second (18) main valve move synchronously in relation to each other such that the opening area (A1) of the first main valve decreases substantially as much as the opening area (A2) of the second main valve increases, and vice versa.

v10. A device according to any one of the items 6-9, further comprising a first driver (8a) and a second driver (8b), wherein the first main valve part (17a) is coupled together with the steering device (2) via the first driver (8a) and the third main valve part (18a) is coupled together with the steering
5 device (2) via the second driver (8b).

v11. A device according to item 10 , wherein the first driver (8a) is coupled together with the first main valve part (17a) by means of a first link (19a) and the second driver (8b) is coupled together with the third main valve part (18a)
10 by means of a second link (19b), wherein the links (19a, 19b) are hinged in both ends.

v12. A device according to item 10 or 11 , further comprising at least one spring element (22), wherein the first driver (8a) is pressed against the first
15 main valve part (17a) and the second driver (8b) is pressed against the third main valve part (18a) by means said at least one spring element (22).

v13. A device according to item 12 , wherein the at least one spring element is located between the first main valve part (17a) and the third main valve part
20 (18a) and such that the at least one spring element creates a pressing force acting on both valve parts (17a, 18a).

v14. A device according to any one of the items 3-5, further comprising a valve actuator being coupled together with the steering device (2) for
25 actuating said first and second main valves (17, 18, 117, 118) during relative movement between said steering device (2) and said attaching part (5, 5', 105), thereby altering a first and a second variable opening area (A1, A2) of said main valve.

30 v15. A device according to any one of the items 3-5, further comprising a valve actuator being coupled together with the attaching part (5, 5', 105) for actuating said first and second main valves (17, 18) during relative movement between said steering device (2) and said attaching part (5, 5', 105), thereby

altering a first and a second variable opening area (A1, A2) of said main valve.

- 5 v16. A device according to item 14 or 15, wherein the opening area (A1) of the first main valve (17) decreases and the opening area (A2) of the second main valve (18) increases when the position of the valve actuator part is determined by a rotational motion in a first direction (ω_{r1}) of the steering device (2) or by a rotational motion in a second direction (ω_{r2}) of the attaching part (5, 5'), and where the opening area (A1) of the first main valve (17) increases and the opening area (A2) of the second main valve (18) decreases when the position of the valve actuator part is determined by a rotational motion in a second direction (ω_{r2}) of the steering device (2) or by a rotational motion in a first direction (ω_{r1}) of the attaching part (5, 5').
- 10
- 15 v17. A device according to any one the preceding items as dependent on item 3 or 4, further comprising at least one holding-up means (10, 10a, 10b) arranged between the attaching part (5, 5') and the steering device (2), the at least one elastic holding-up means (10, 10a, 10b) being arranged to determine the magnitude of the initial rotational motion (α).
- 20
- v18. A device according to any one of the items 1-16, wherein the steering device (2) is coupled together with the attaching part (5, 5') via a torsion bar for allowing relative rotational movement between said steering device and said attaching part about a centre axis of the torsion bar.
- 25
- v19. A device according to any one of the items 1-16, wherein the steering device (2) is coupled together with the attaching part (5, 5') via a silent block bush for allowing relative rotational movement between said steering device and said attaching part about a centre axis of the silent block bush.
- 30
- v20. A device according to any one of the items 1-16, wherein the steering device (2) is coupled together with the attaching part (5, 5') via a bearing for allowing relative rotational movement between said steering device and said attaching part about a centre axis of the bearing.

- v21. A device according to item 18, wherein said centre axis of the torsion bar is arranged at a distance from the steering axis (SA).
- 5 v22. A device according to item 18 or 19, further comprising at least two mechanical stops for limiting said relative movement between the attaching part (5, 5') and the steering device (2).
- 10 v23. A device according to item 20, wherein said two mechanical stops comprises at least one element slideably arranged in an opening between two surfaces portions thereof, such that the element is moveable between said surface portions in order to limit said relative movement to rotational movement.
- 15 v24. A device according to any one the preceding items, wherein the attaching part (5) comprises a fork crown (5) arranged at the front fork arrangement of a motorcycle.
- 20 v25. A device according to any one of items 1-15 , wherein the attaching part (5) comprises a cylindrical unit (5') arranged around a steering connecting rod through which the steering axis (SA) runs.
- 25 v26. . A device according to item 25 as dependent on item 3 or 4 , wherein the attaching part (5') is divided into an upper and a lower cylindrical part (5a', 5b') coupled together by means of an elastic holding-up means (10) which is arranged to determine the magnitude of the initial rotational motion (α).
- 30 v27. A device according to any one of the preceding items as dependent on item 1, further comprising a delimiting part (11, 11', 11'', 111) arranged in the main damping chamber and moveable with respect to the damping housing (4a).
- v28. A device according to any one of the preceding items, wherein said steering damper is a linear damping device, and wherein said delimiting part

(11) is a piston (111) attached to a piston rod (113) for reciprocal movement within said damping chamber.

5 v29. A device according to any one of the preceding items, wherein said steering damper is a rotational damping device, and wherein said delimiting part (11) is a wing (11', 11'') attached to a lever (12) for reciprocal movement within said damping chamber.

10 v30. A steering damper (4) adapted to be arranged in a vehicle comprising a steering device (2) rotatable about a steering axis (SA) for adjusting the direction of the part(s) (3) of the vehicle arranged for contacting ground, and an attaching part (5, 5') that couples together the part(s) (3) arranged for contacting ground with the steering device (2), the steering damper (4) comprising:

15 a damping housing (4a); and

a main damping chamber defined by said damping housing (4a), said main damping chamber comprising hydraulic fluid and being partitioned into a first and a second damping chamber (C1, C2);

20 wherein said steering device (2) is mechanically connectable to said attaching part (5, 5') to enable rotation of said attaching part (5, 5') with said steering device (2) and with said damping housing (4a), a main valve unit (HVU) is adapted to adjust a flow of hydraulic fluid (Q1, Q2) between the damping chambers (C1, C2) such as to adjust the rotational damping of the steering device (2), wherein said main valve unit (HVU) can be mechanically
25 coupled together with both the attaching part (5, 5') and the steering device (2), and wherein a relative movement between said attaching part (5, 5') and the steering device (2) determines an amount of hydraulic fluid flowing through the main valve unit (HVU).

30 v31. A steering damper (4) adapted to be arranged in a vehicle comprising a steering device (2) rotatable about a steering axis (SA) for adjusting the direction of the part(s) (3) of the vehicle arranged for contacting ground, and an attaching part (5, 5') that couples together the part(s) (3) arranged for

contacting ground with the steering device (2), the steering damper (4) comprising:

a damping housing (4a); and

5 a main damping chamber defined by said damping housing (4a), said main damping chamber comprising hydraulic fluid and being partitioned into a first and a second damping chamber (C1, C2) by a delimiting part (11, 11', 11'', 111)

wherein said steering device (2) is mechanically connectable to said attaching part (5, 5') to enable rotation of said attaching part (5, 5') with said steering device (2) and with said delimiting part (11, 11', 11'', 111) when the steering damper is arranged in a vehicle, a main valve unit (HVU) is adapted to adjust a flow of hydraulic fluid (Q1, Q2) between the damping chambers (C1, C2) such as to adjust the rotational damping of the steering device (2), wherein said main valve unit (HVU) can be mechanically coupled together
10 with both the attaching part (5, 5') and the steering device (2), and wherein a relative movement between said attaching part (5, 5') and the steering device (2) when the steering damper is arranged in a vehicle determines an amount of hydraulic fluid flowing through the main valve unit (HVU).

20 v32. A crown device adapted to be arranged in a vehicle comprising a steering device (2) rotatable about a steering axis (SA) for adjusting the direction of the part(s) (3) of the vehicle arranged for contacting ground, said device comprising:

- a steering damper (4) having a damping housing (4a, 4a'', 104a) that
25 encloses a main damping chamber which comprises hydraulic fluid and is partitioned into a first damping chamber (C1) and a second damping chamber (C2) by a delimiting part (11, 11', 11'', 111) that is arranged in the main damping chamber and moveable with respect to the damping housing (4a, 4a'', 104a);

30 - an attaching part (5, 5') adapted to couple together the part(s) (3) arranged for contacting ground with the steering device (2) when the crown device is arranged in the vehicle, wherein the attaching part (5, 5') is arranged

to rotate with the steering device (2) when the crown device is arranged in the vehicle; and

a main valve unit (HVU) adapted to adjust a flow of hydraulic fluid (Q1, Q2) between the damping chambers (C1, C2) of the steering damper (4)
5 when the crown device is arranged in the vehicle, said main valve unit (HVU) being coupled together with both the attaching part (5, 5') and the steering device (2) when the crown device is arranged in the vehicle such as to adjust the rotational damping of the steering device (2), and wherein the amount of hydraulic fluid flowing through the main valve unit (HVU) is determined by a
10 relative movement between said attaching part (5, 5') and the steering device (2).

v33. A device according to item 32, wherein said crown device further comprises attachment means adapted to couple the steering device together
15 with the attaching part when the crown device is arranged in the vehicle, wherein the attachment means is arranged to allow relative movement between said attaching part (5, 5') and the steering device (2) when the crown device is arranged in the vehicle.

20 v34. A device according to item 33, wherein said attachment means is adapted to elastically couple the steering device together with the attaching part when the crown device is arranged in the vehicle, wherein the attachment means is arranged to elastically allow relative movement between said attaching part (5, 5') and the steering device (2) when the crown device
25 is arranged in the vehicle.

v35. A device according to any one of the items 32-34, wherein said main valve unit (HVU) is mechanically coupled together with both the attaching part (5, 5') and the steering device (2) such as to adjust the
30 rotational damping of the steering device (2).

v36. A device according to any one of the items 32-34, wherein said crown device further comprises an electronic sensor adapted to measure said

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relative movement between the attaching part (5, 5') and the steering device (2).

5 v37. A device according to item 36, wherein said electronic sensor is selected from a group of sensor comprising:

- a potentiometer,
- a hall effect sensor, and
- an optical sensor.

10 v38. A device according to any one of the items 36-37, wherein said electronic sensor is arranged to measure the magnitude and the direction of the relative movement between the attaching part (5, 5') and the steering device (2) when the crown device is arranged in the vehicle.

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Claims

1. A device for controlling rotational movement of a steering device and/or a thereto connected wheel arrangement about a steering axis relative
5 a chassis of a vehicle, said steering device being mechanically connected to said wheel arrangement such that a limited relative rotational movement there between is allowed, said device comprising:
- a main valve unit having a first valve member mechanically connectable to said steering device and a second valve member
10 mechanically connectable to a wheel arrangement, said first valve member being arranged to interact with said second valve member to adjust a flow passage area in response to said relative rotational movement in order to control said rotational movement of said steering device and/or the thereto connected
15 wheel arrangement about said steering axis relative said chassis.
2. A device according to claim 1, said device further comprising:
- a first element (FE) being connectable with said steering device
(2);
 - 20 - a second element (SE) being connectable to said wheel arrangement, said second element being mechanically coupled to said first element to allow said limited relative rotational movement; and
 - wherein said first valve member is mechanically connected to
25 said first element and said second valve member mechanically connected to said second element.
3. A device according to claim 1 or 2, wherein said device further comprises a damper unit having working chambers in fluid
30 communication with said main valve unit such that a flow of damping fluid between said chambers is adjusted in response to said adjustment of said flow passage area.

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4. A device according to any one of claims 2-3, wherein said second element is elastically coupled to said first element.
5. A device according to claim 4, wherein said device further comprises elastic holding means being attached between said first element and said second element for providing said elastic coupling.
6. A device according to any one of the claims 2-4, wherein said second element is coupled to said first element via a torsion bar, a silent block bush or a bearing to allow a limited relative rotational movement there between about a centre axis thereof.
7. A device according to any one of the claims 6, wherein said centre axis is arranged at a distance from the steering axis (SA).
8. A device according to any one of claims 6 or 7, further comprising at least two mechanical stops for limiting said relative movement.
9. A device according to claim 8, wherein said two mechanical stops comprises at least one element slideably arranged in an opening between two surfaces portions thereof, such that the element is moveable between said surface portions in order to limit said relative movement to rotational movement.
10. A device according to any one of the claims 6 to 9, wherein said torsion bar is arranged to be releasably connectable to said first element and said second element.
11. A device according to any one of the preceding claims, wherein said first valve member is arranged to interact with said second valve member to adjust an additional flow passage area in response to said relative rotational movement in order to control said rotational movement of said steering device and/or the thereto connected wheel arrangement about said steering axis relative said chassis.

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- 12.A device according to any one of the claims 1 to 10, wherein said device further comprises an additional main valve unit having a third valve member mechanically connectable to said steering device and a fourth valve member mechanically connectable to said wheel arrangement, said third valve member being arranged to interact with said fourth valve member to adjust an additional flow passage area in response to said relative rotational movement in order to control said rotational movement of said steering device and/or the thereto connected wheel arrangement about said steering axis relative said chassis.
- 13.A device according to claim 11 or 12, wherein said working chambers are in fluid communication with said main valve unit(s) such that a flow of damping fluid between said chambers is adjusted in response to said adjustment of said one additional flow passage area.
- 14.A device according to claim 13, wherein said flow passage area is arranged to adjust a flow of hydraulic fluid between said working chambers in a first direction, and wherein said additional flow passage area is arranged to adjust a flow of hydraulic fluid between said working chambers in a second direction, said second direction being opposite to said first direction.
- 15.A device according to any one of the preceding claims, wherein said main valve unit comprises adjustment means for adjusting the interaction between said first valve member and said second valve member.
- 16.A device according to any one of the preceding claims, wherein said additional main valve unit comprises adjustment means for adjusting the interaction between said third valve member and said fourth valve member.

17. A device according to any one of the claims 3 to 16, wherein said damper unit is a hydraulic damper comprising a damping chamber and a delimiting part, said delimiting part dividing the damping chamber into two working chambers.
- 5
18. A device according to claim 17, wherein said damper unit is a linear damper unit wherein said delimiting part is a piston.
19. A device according to claim 17, wherein said damper unit is a rotational damper unit wherein said delimiting part is a wing element.
- 10
20. A device according to any one of the claims 3 to 19, wherein said damper unit is integrated with said main valve unit.
21. A device for controlling rotational movement of a steering device and/or a thereto connected wheel arrangement about a steering axis relative a chassis of a vehicle, said steering device being mechanically connected to said wheel arrangement such that a limited relative rotational movement there between is allowed, said device comprising:
- 15
- 20
- a main valve unit having a first valve member mechanically connectable to said steering device and a second valve member mechanically connectable to a wheel arrangement, said first valve member being arranged to interact with said second valve member to adjust a flow passage area in response to said
- 25
- relative rotational movement in order to control said rotational movement of said steering device and/or the thereto connected wheel arrangement about said steering axis relative said chassis.
 - a first sensor device being able to be in operational communication with said steering device and said wheel
- 30
- arrangement, said first sensor device being adapted to monitor a rotational position of said steering device relative said wheel arrangement when in operational communication with said steering device and said wheel arrangement.

- 22.A device according to claim 21, said device comprising
- a first element (FE) being connectable with said steering device (2);
 - a second element (SE) being connectable to said wheel arrangement, said second element being mechanically coupled to said first element to allow said limited relative rotational movement; and
 - wherein said first sensor device is in operational communication with said first element and said second element, said first sensor device being adapted to monitor a rotational position of said steering device relative said wheel arrangement.
- 23.Device according to claim 22, wherein said device further comprises
- a second sensor device able to be in operational communication with said chassis and said first or second element, said second sensor device being adapted to monitor a rotational position of said steering device or said wheel arrangement relative said chassis.
- 24.A device according to claim 22 or 23, wherein said first sensor device is adapted to monitor a rotational position of said steering device relative said wheel arrangement at least part of said limited relative rotational movement.
- 25.A device according to claim 22 or 23, wherein said first sensor device is adapted to monitor a rotational position of said steering device relative said wheel arrangement throughout the whole of said limited relative rotational movement.
- 26.A device according to any one of claims 22 to 25, wherein said device further comprises:
- an electrically controlled valve unit coupled to said sensor device(s), wherein said electrically controlled valve unit is adapted

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to adjust a flow passage area in response to a signal from said sensor device(s) representing said rotational position.

27.A device according to claim 26, wherein said device further comprises:

- 5 - a damper unit in fluid communication with said electrically controlled valve unit, wherein said damper unit is adapted to control a rotational movement of said steering device or said wheel arrangement relative said chassis with a damping force adjusted in response to said adjustment of said flow passage area

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28.A device according to any one of claims 22 to 25, wherein said device further comprises:

- an electrically controlled damper unit adapted to control (damp) a rotational movement of said steering device or said wheel arrangement
15 relative said chassis, wherein said electrically controlled damper unit is coupled to said sensor device(s) and is adapted to adjust its damping force in response to signal(s) from said sensor device(s) representing said rotational position(s) of said steering device.

20 29.A device according to claim 27 or 28, wherein said damper unit is adapted to control a rotational movement in one rotational direction.

 30.A device according to claim 27 or 28, wherein said damper unit is adapted to control (damp) a rotational movement in both rotational
25 directions.

31.A device according to any one of claims 22 to 25, wherein said device further comprises:

- two electrically controlled valves coupled to said sensor device(s),
30 wherein each of said electrically controlled valves are adapted to adjust a flow passage area in response to a signal from said sensor device(s) representing said rotational position.

32.A device according to claim 31, wherein said device further comprises:

- a damper unit in fluid communication with said two electrically controlled valve units, wherein said damper unit is adapted to control (damp) a rotational movement of said steering device or said wheel arrangement relative said chassis with a first damping force in one direction and a second damping force in a second and opposite direction, said first and second damping forces are adjusted in response to said adjustment of said flow passage areas.

33.A device according to any one of claims 22 to 32, wherein said first sensor device comprises a first member mechanically connectable with said first element or said steering device, and wherein said first sensor device further comprises a second member mechanically connectable with said second element or said wheel arrangement, wherein said first valve member being arranged to interact with said second valve member in order to provide a signal representing said relative rotational position of said steering device and wheel arrangement.

34.A device according to any one of claims 22 to 32, wherein said second sensor device comprises a third member mechanically connectable with said first element or said steering device, and wherein said second sensor device further comprises a fourth member mechanically connectable with said second element or said wheel arrangement, wherein said third member being arranged to interact with said fourth valve member in order to provide a signal representing said relative rotational position of said steering device and wheel arrangement.

35.A device according to any one of claims 27-28, wherein said damper unit is a hydraulic damper unit selected from a group comprising linear hydraulic damper and rotational damper.

36.A device according to claim 28, wherein said damper unit is a magnetorheological damper or an electromechanical damper.

37. A device according to any one of the preceding claims, wherein said sensor(s) is selected from a group of sensor comprising:
- a potentiometer,
 - 5 - a hall effect sensor, and
 - an optical sensor.
38. A device according to any one of the preceding claims, wherein said second element or wheel arrangement is elastically coupled to said first element or steering device.
- 10
39. A device according to any one of the preceding claims, wherein said second element is coupled to said first element via a torsion bar, a silent block bush or a bearing arrangement.
- 15
40. A device according to any one of the preceding claims, wherein said electronically controlled valve unit and/or damper unit are/is adjustable in response to at least one parameter selected from a group comprising vehicle speed, vehicle acceleration, vehicle braking, said rotational position(s) and rotational acceleration of said steering device and/or wheel arrangement relative each other or relative said chassis.
- 20
41. A method of controlling rotational movement of a steering device and a thereto coupled wheel arrangement about a steering axis relative a chassis of a vehicle, said method comprising
- 25
- Allowing a limited relative rotational movement between said steering device and said wheel arrangement;
 - Monitoring a rotational position parameter reflecting a rotational position of said steering device or said wheel arrangement relative the other, said rotational position parameter including a rotational position value;
 - 30 - Performing a damping force analysis including a comparison of said rotational position value and reference rotational position value; and

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- 5 - Determining a damping force for controlling said rotational movement of said steering device and said thereto coupled wheel arrangement about a steering axis relative said chassis, said damping force value corresponding to a difference between said rotational position value and said reference rotational position value.

42.A method according to claim 41, wherein said method further comprises

- 10 - Providing a damping force signal representing said determined damping force to an electrically controlled valve unit, wherein said electrically controlled valve unit is adapted to adjust a flow passage area in response to said damping force signal.

15 43.A method according to claim 42, wherein said method further comprises:

- Providing a damper unit in fluid communication with said electrically controlled valve unit, wherein said damper unit is adapted to control (damp) a rotational movement of said steering device or said wheel arrangement relative said chassis with a damping force adjusted in response to said adjustment of said flow passage area.
- 20

44.A method according to claim 41, wherein said method further comprises:

- 25 - providing an electrically controlled damper unit adapted to control a rotational movement of said steering device or said wheel arrangement relative said chassis, wherein said electrically controlled damper unit is coupled to said sensor device(s) and is adapted to adjust its damping force in response to said damping force signal.

- 30 45.A method according to any one of claims 42 to 44, wherein said damper unit is adapted to control a rotational movement in one rotational direction.

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46.A method according to any one of claims 42 to 44, wherein said damper unit is adapted to control a rotational movement in both rotational directions.

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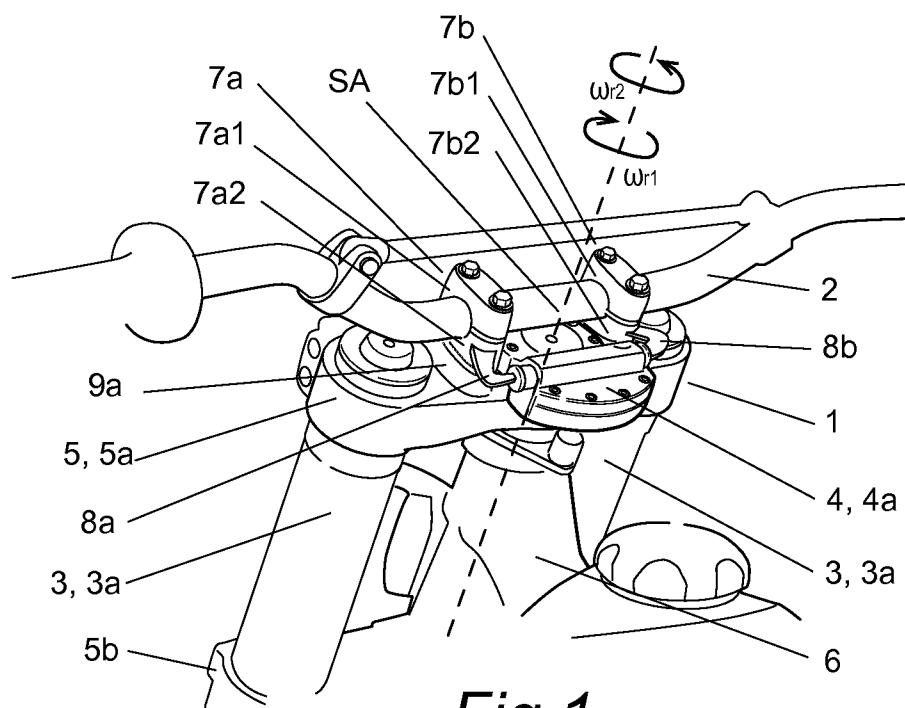


Fig 1

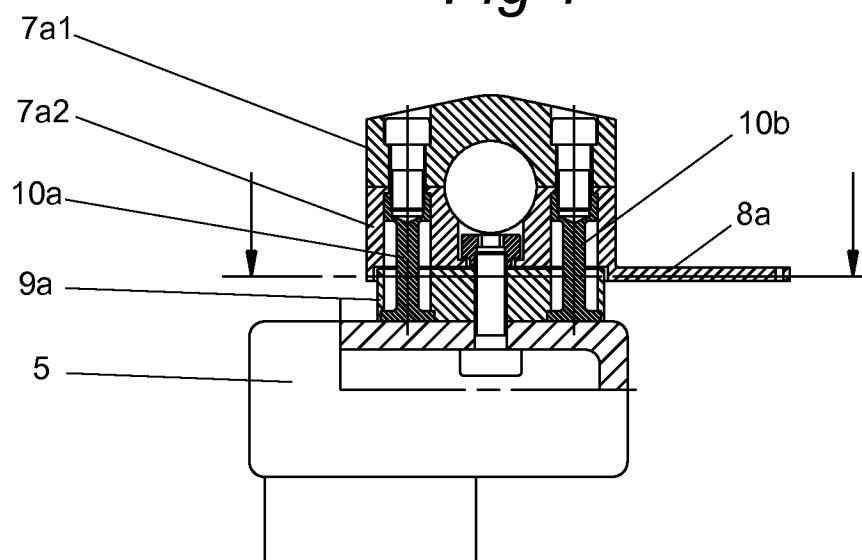


Fig 2

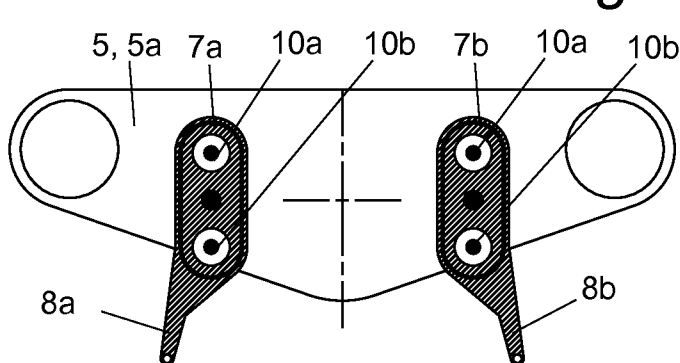


Fig 3a

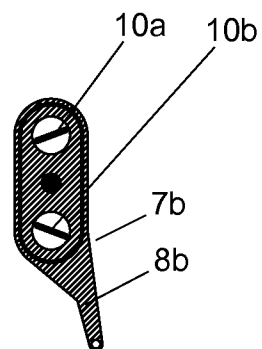


Fig 3b

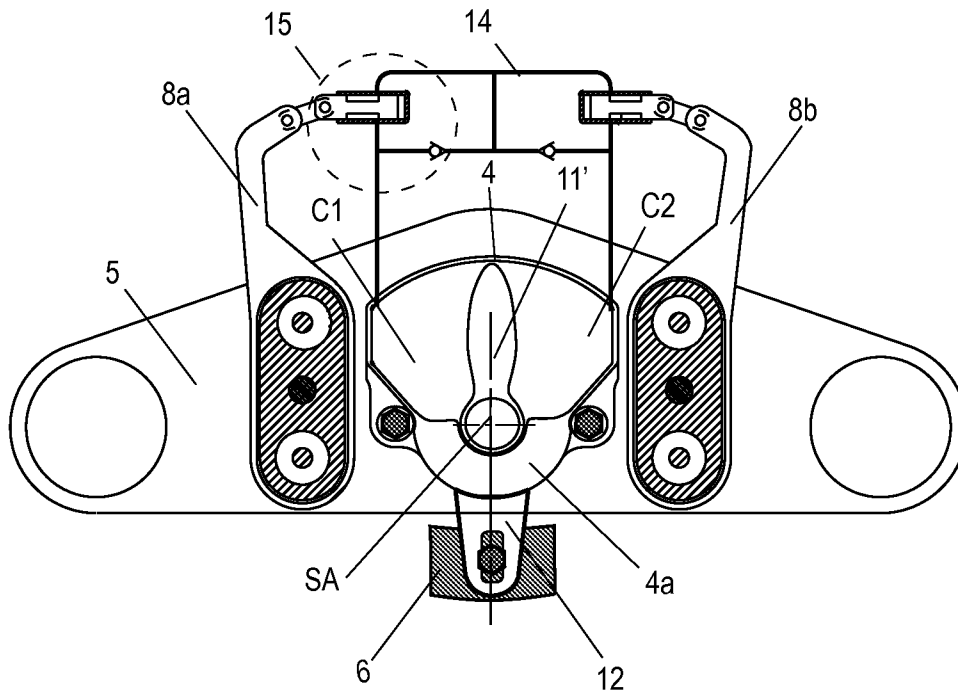


Fig 4

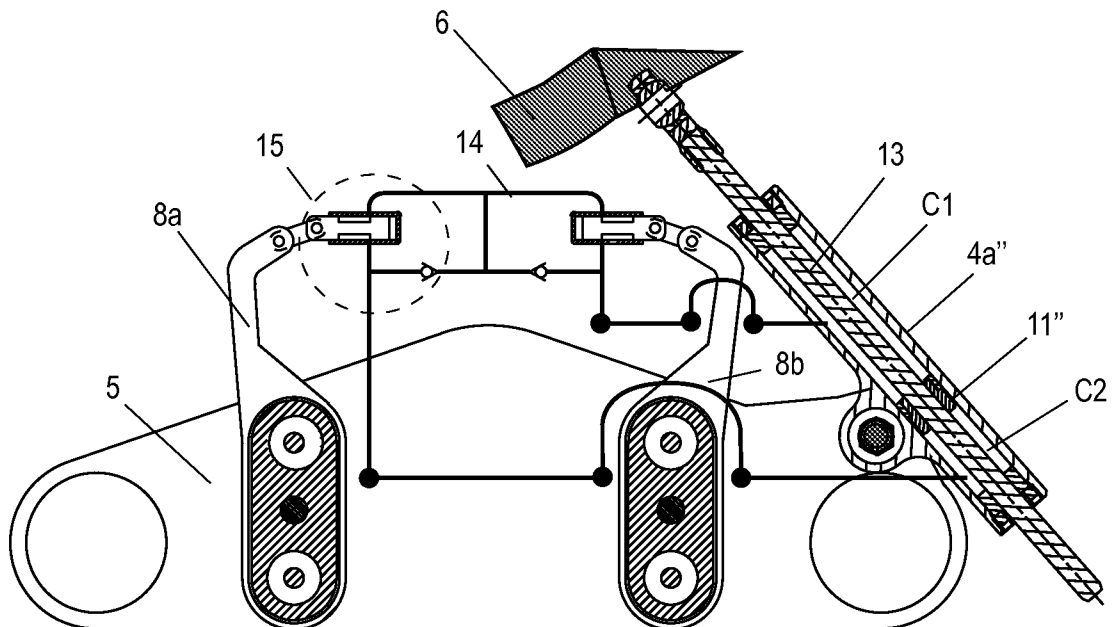


Fig 5

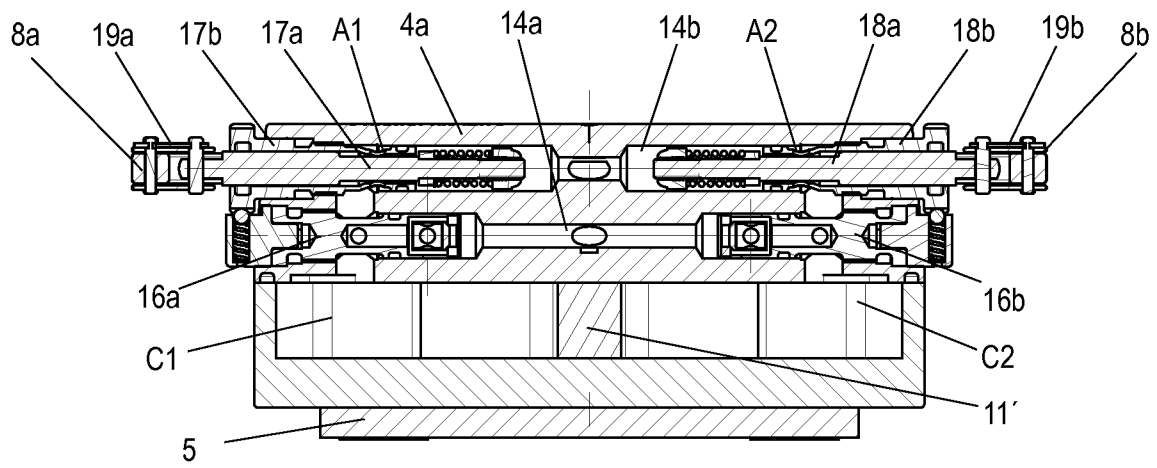


Fig 6

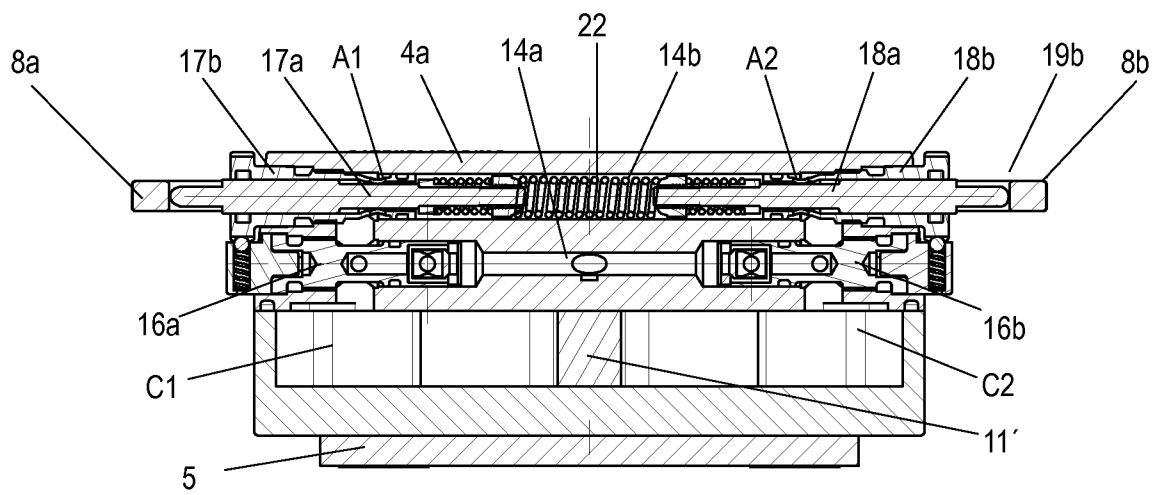


Fig 7

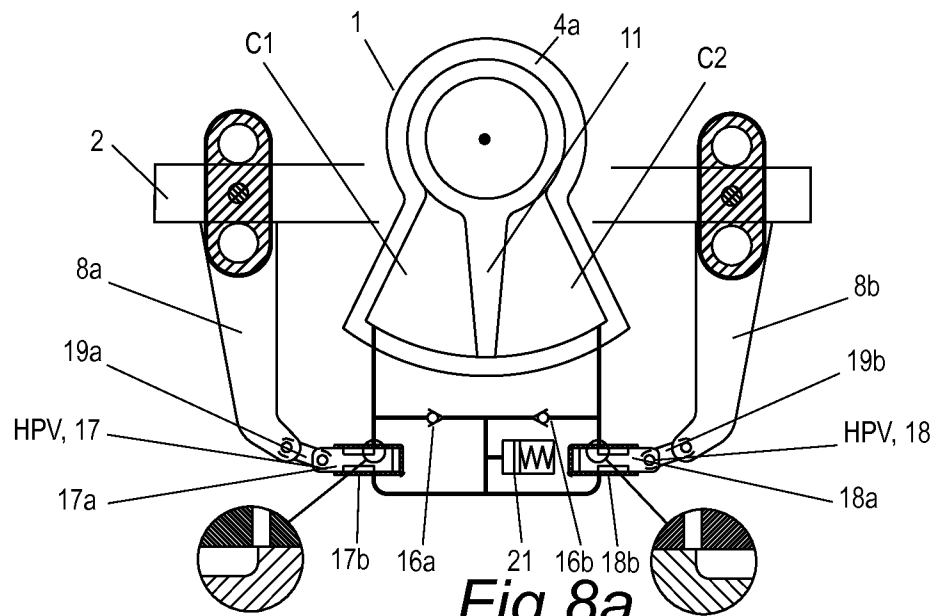


Fig 8a

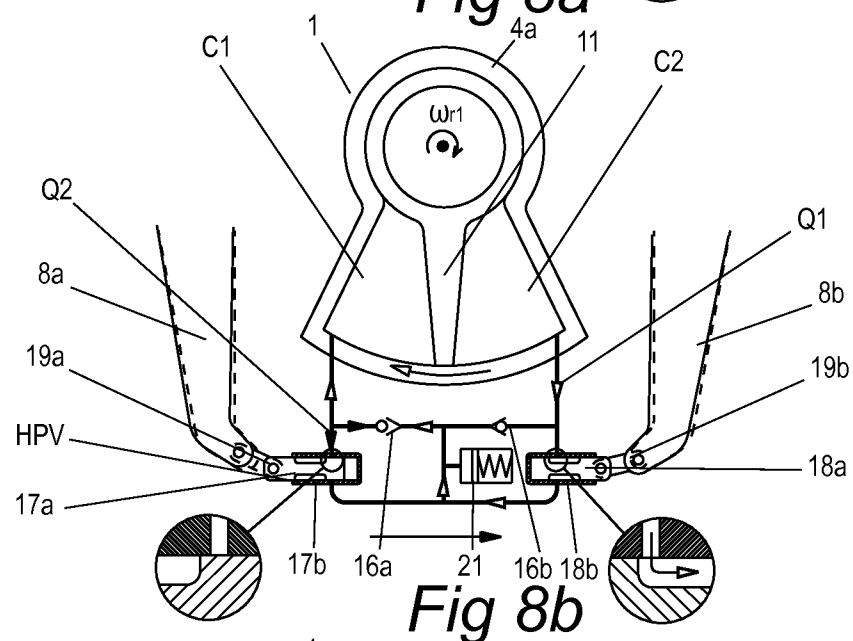


Fig 8b

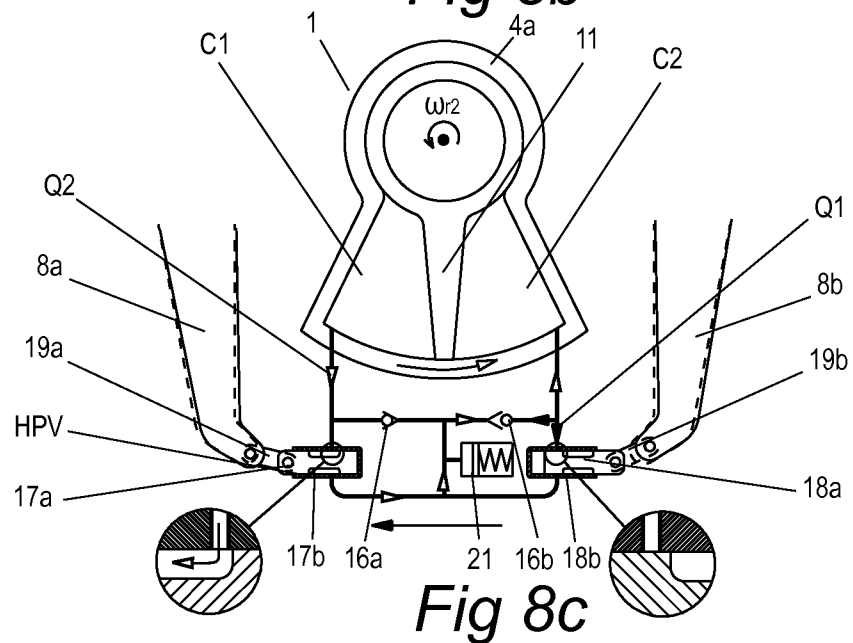


Fig 8c

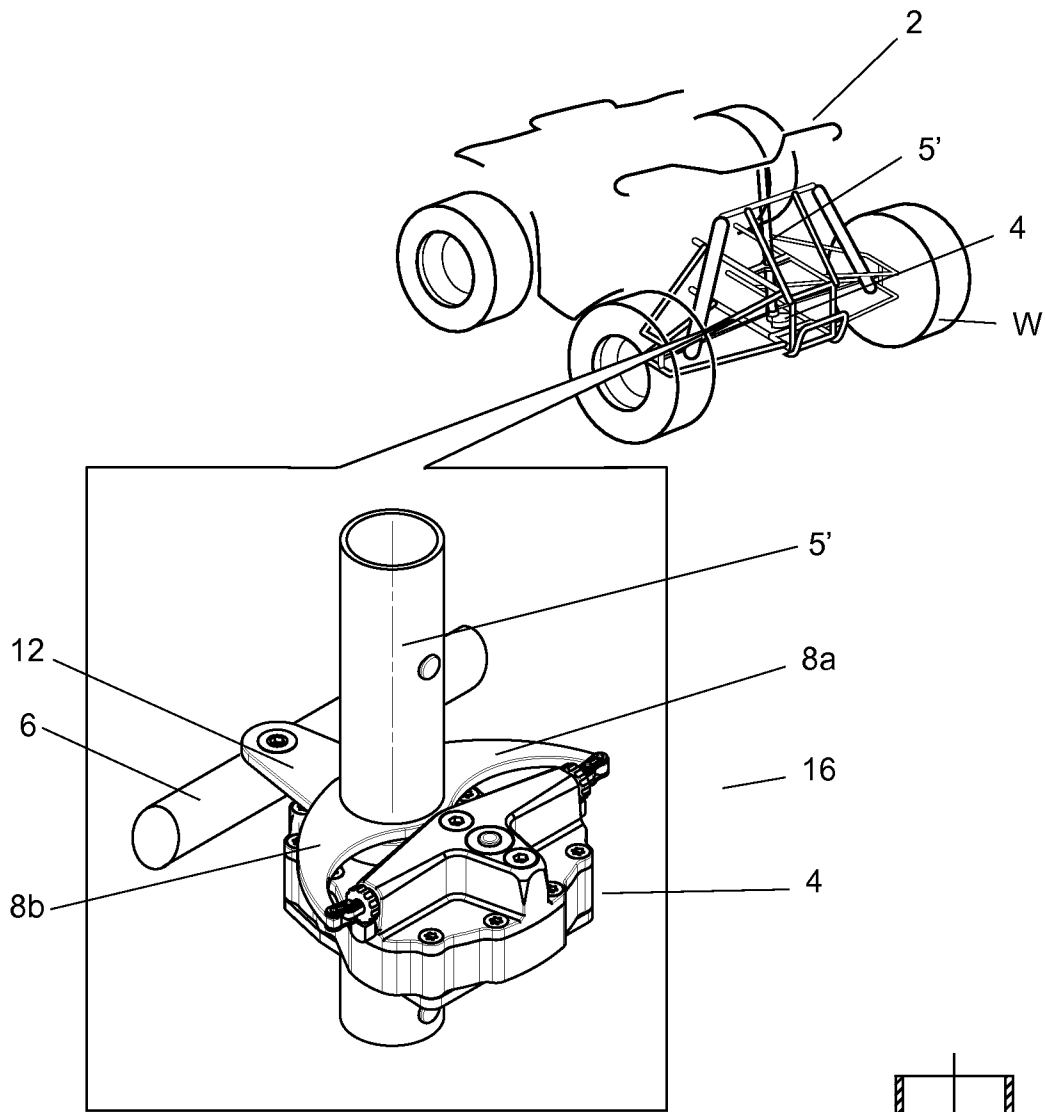


Fig 9

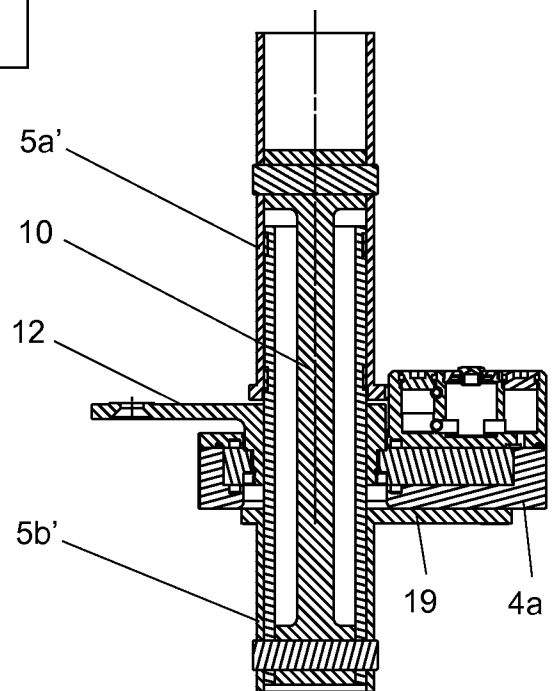
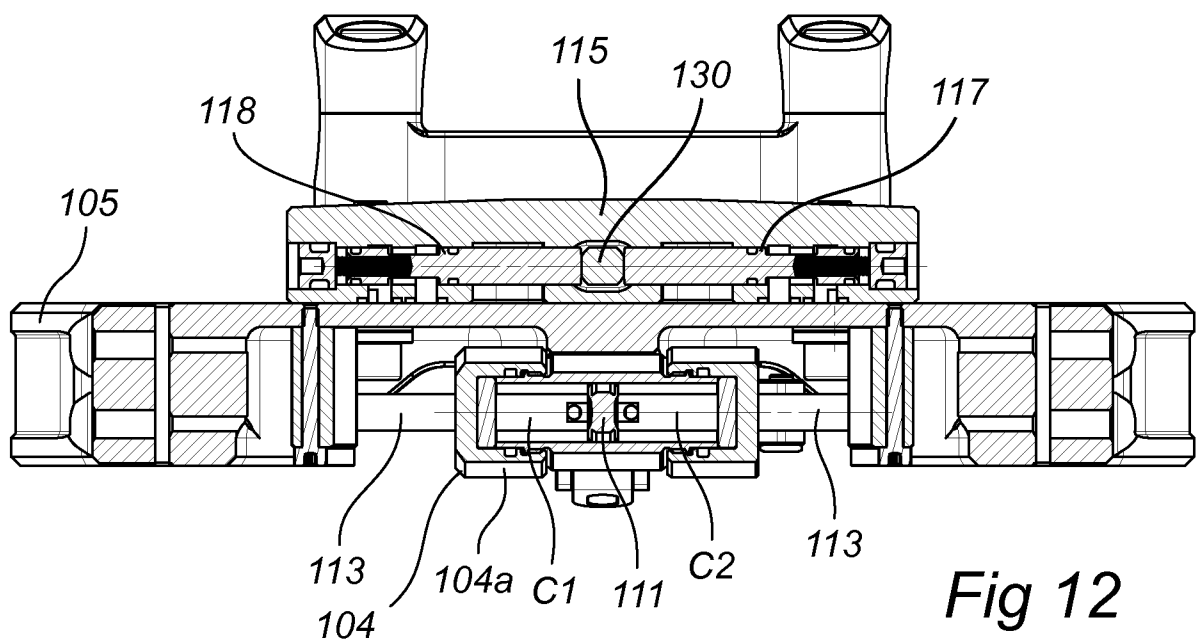
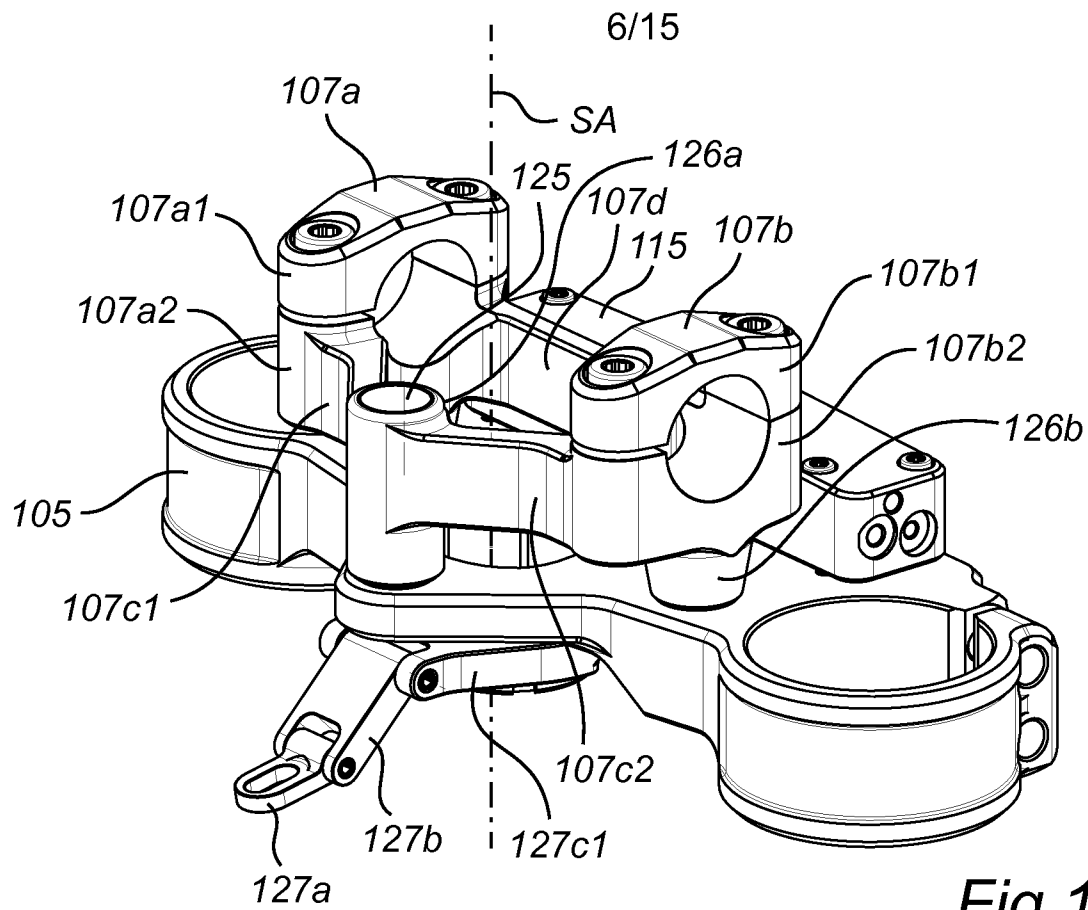


Fig 10



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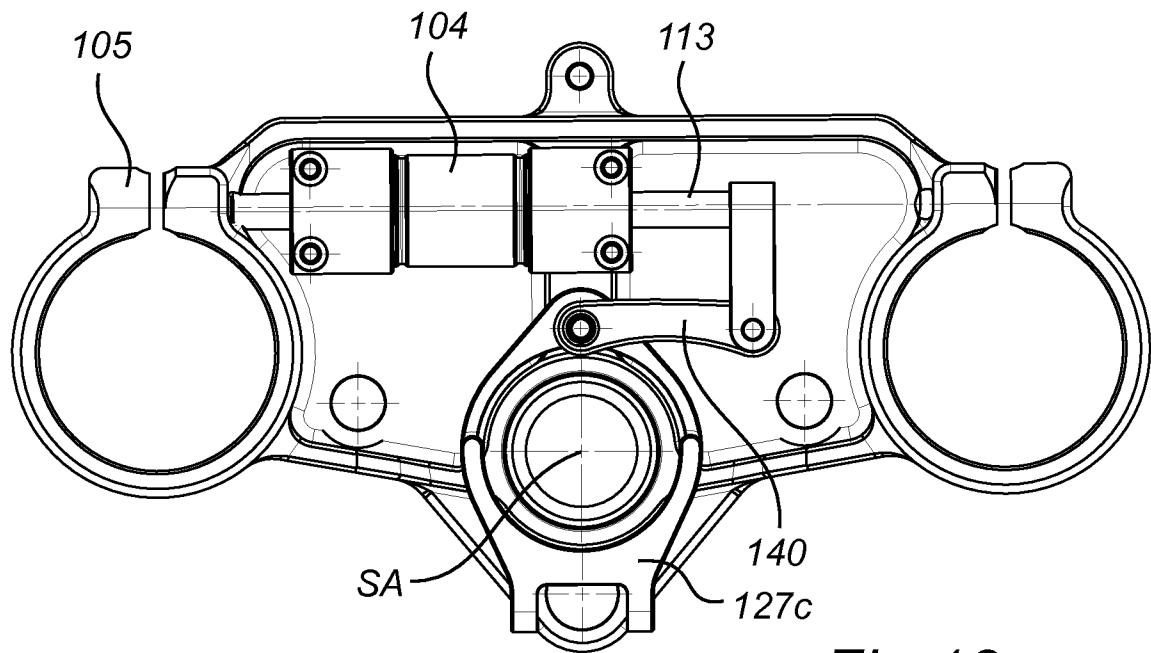


Fig 13

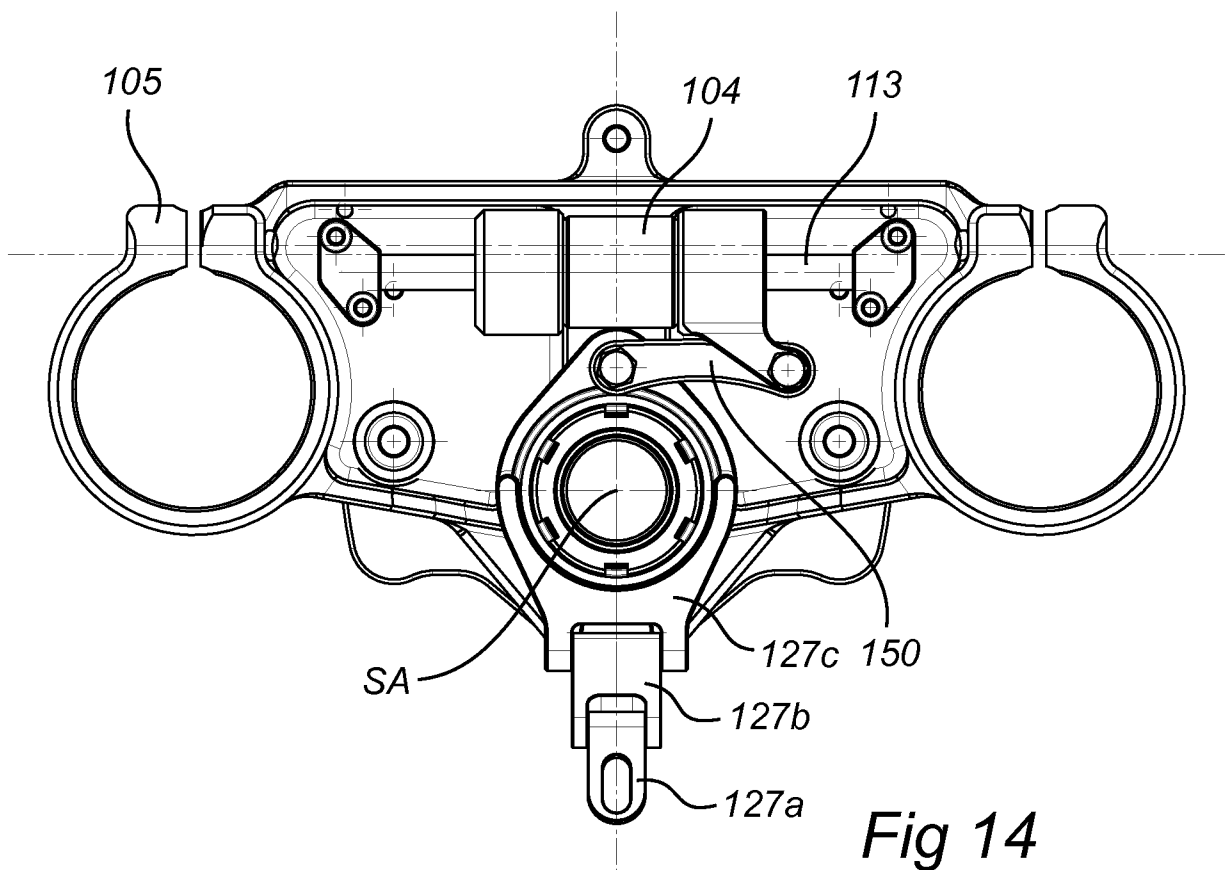


Fig 14

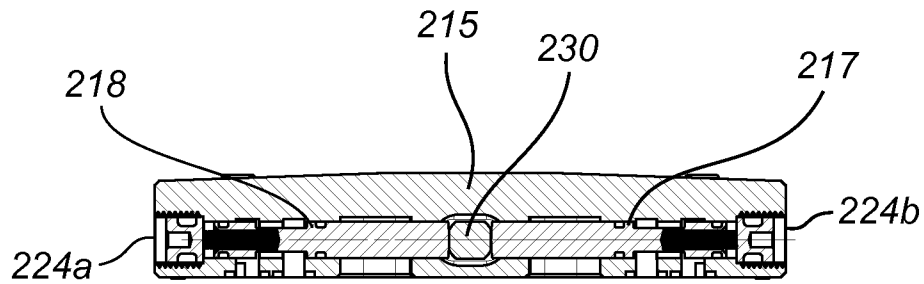


Fig 15

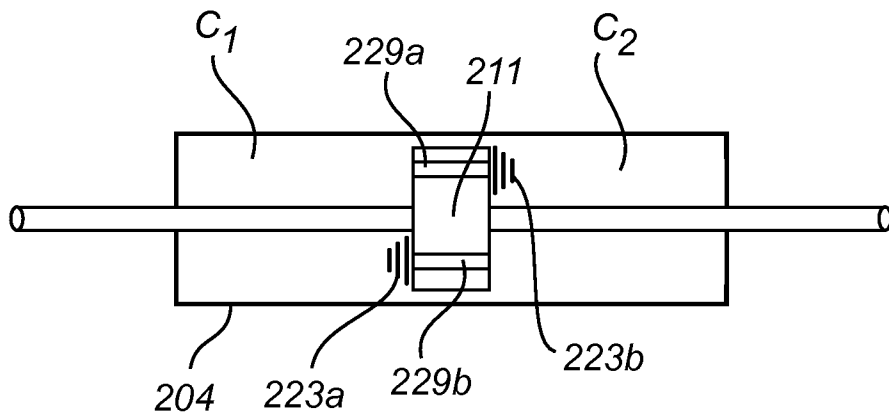


Fig 16

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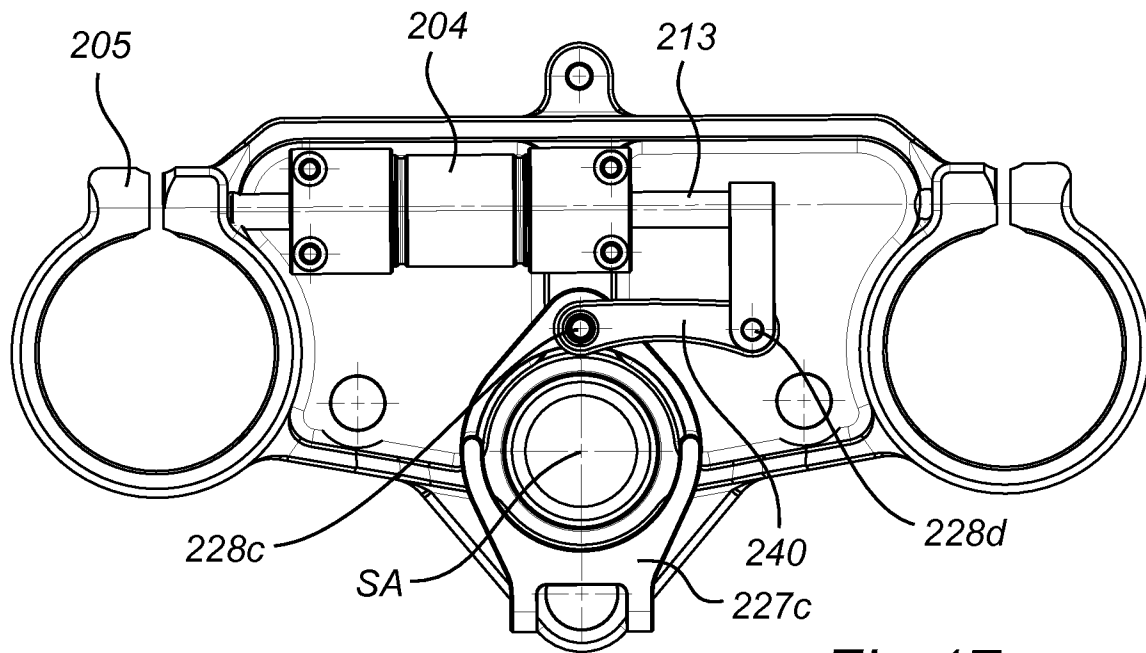


Fig 17

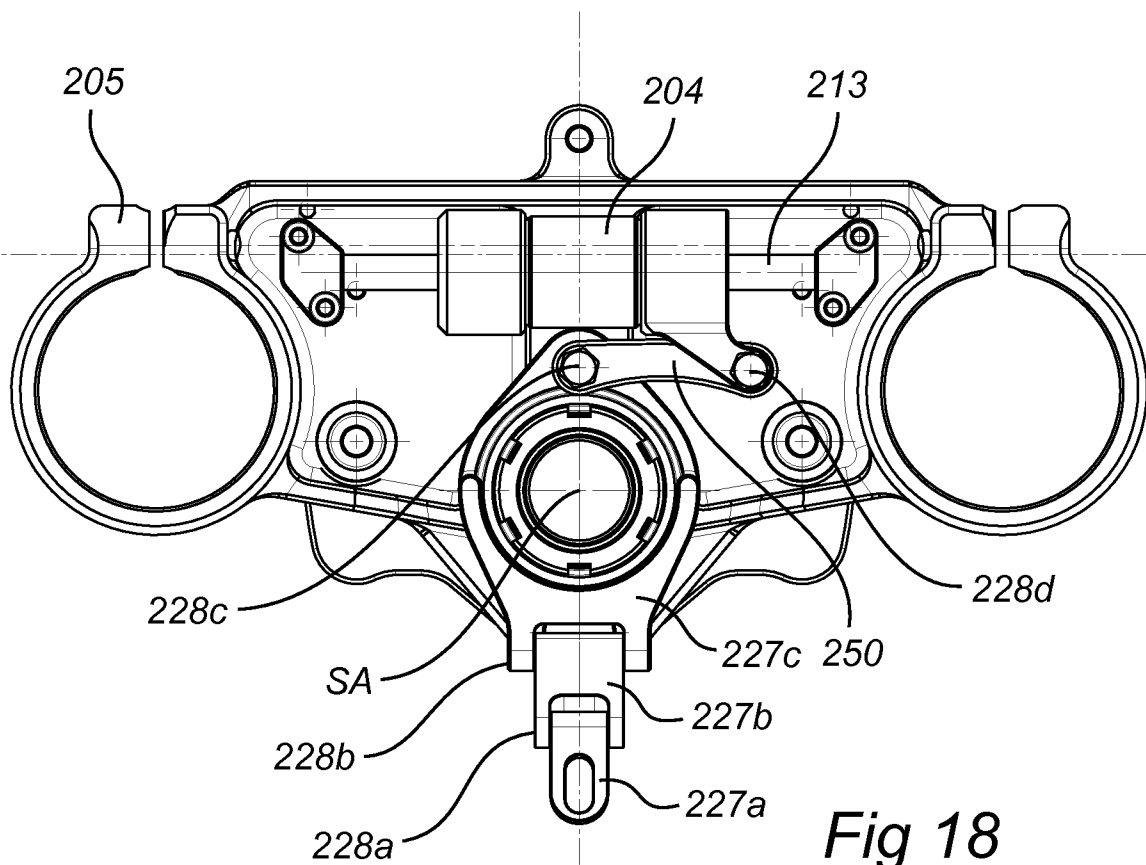
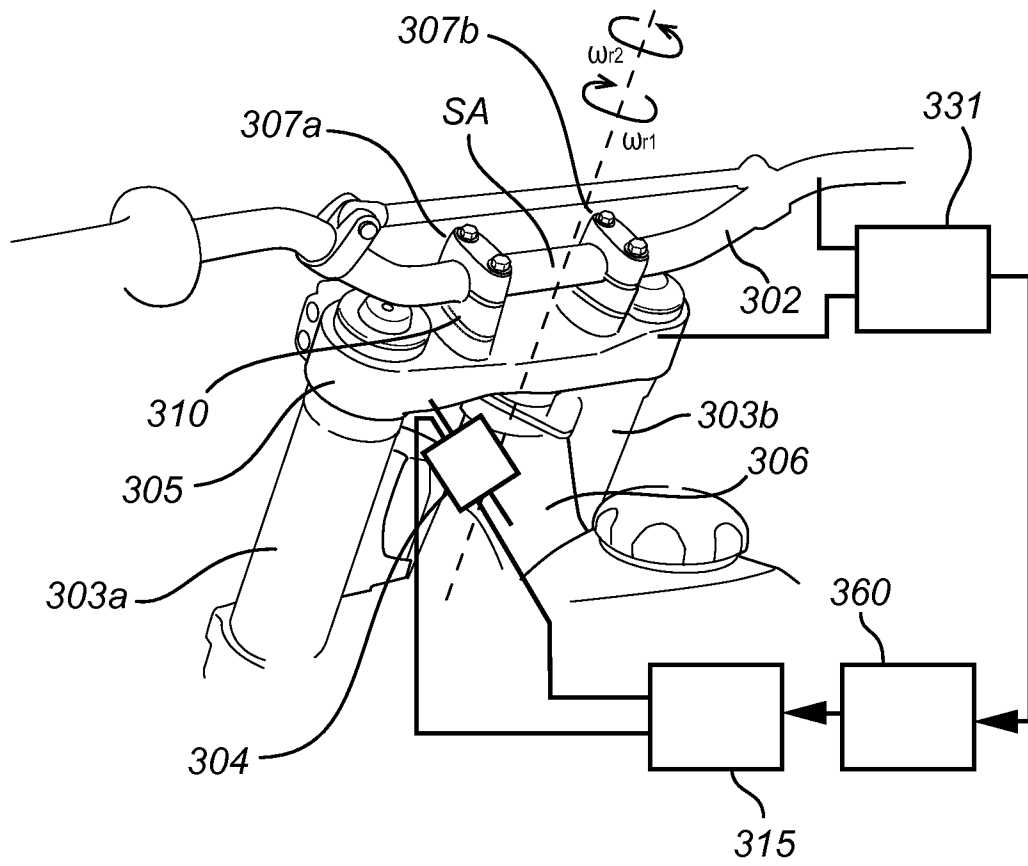
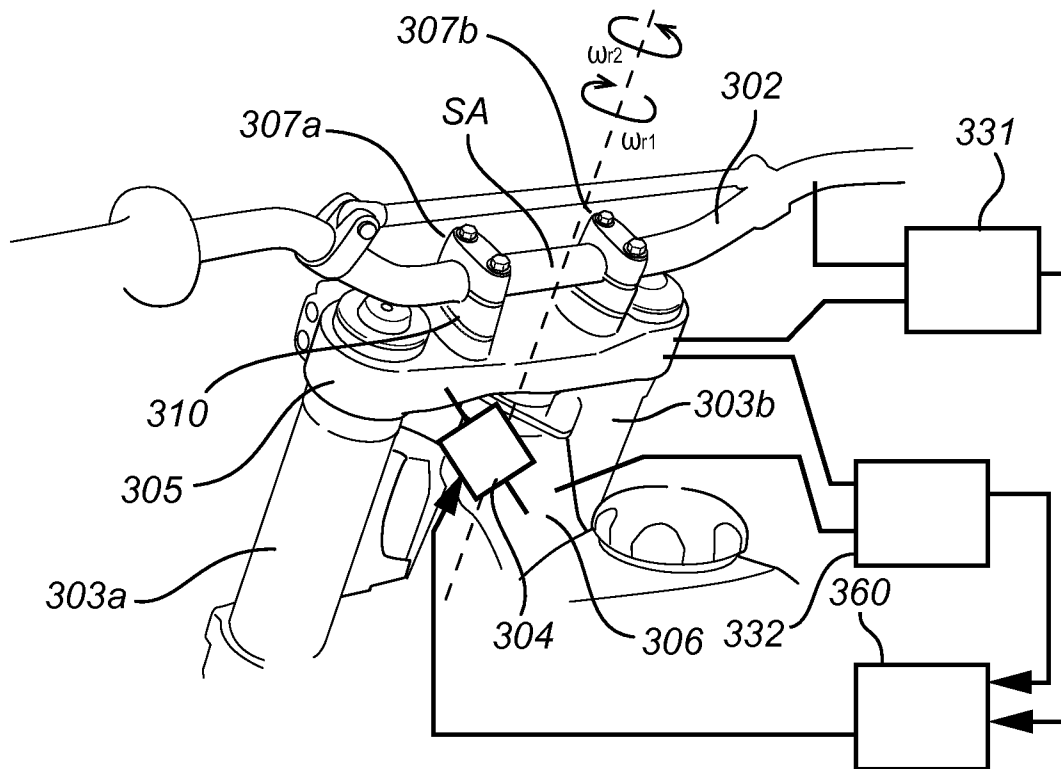
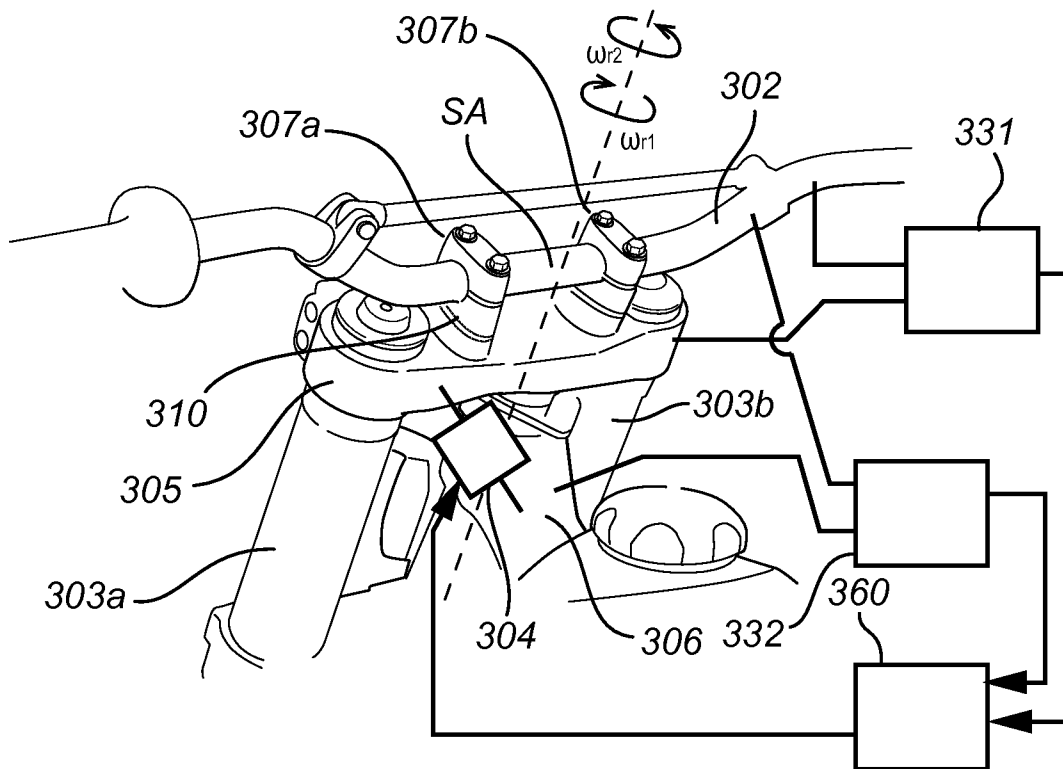


Fig 18

*Fig 19*

*Fig 20a*

*Fig 20b*

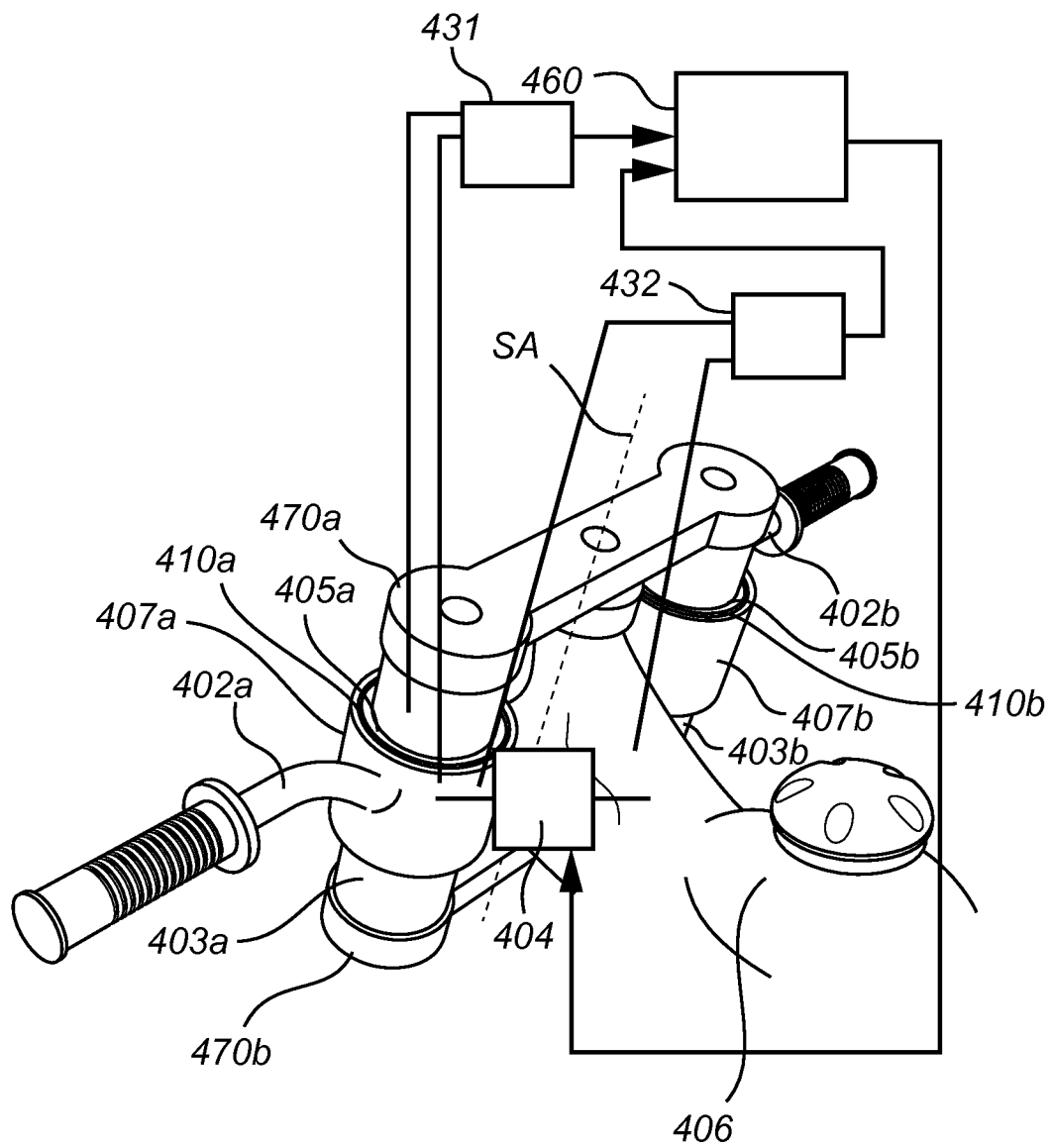


Fig 21a

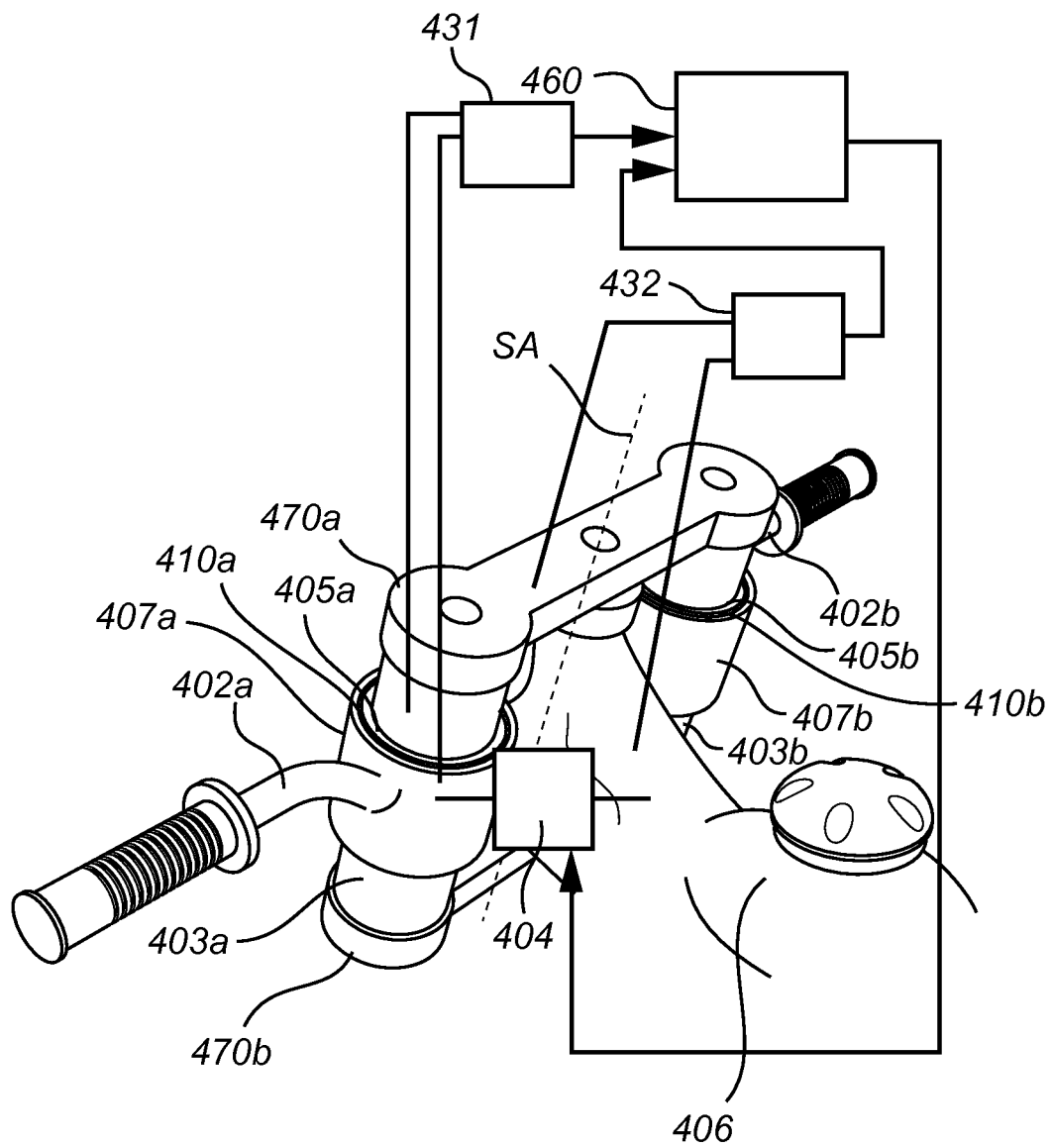


Fig 21b

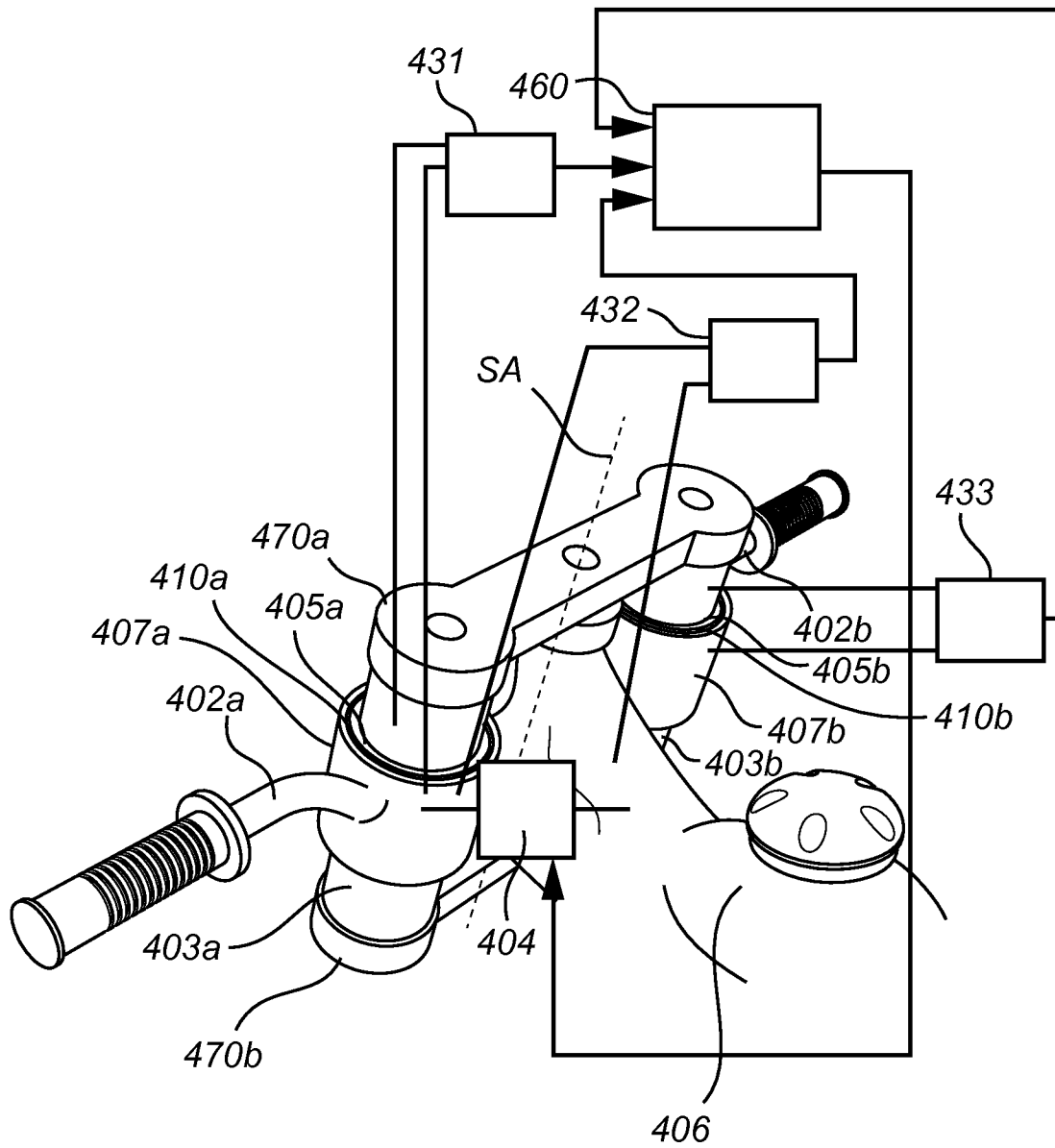


Fig 21c

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/057231

A. CLASSIFICATION OF SUBJECT MATTER
INV. B62K21/08 F16F9/14
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B62K F16F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 1 248 013 A2 (HONDA MOTOR CO LTD [JP]) 9 October 2002 (2002-10-09) abstract; figures 3,4	1,41
A	US 2004/211632 A1 (YAMADA SHINICHI [JP]) 28 October 2004 (2004-10-28) abstract; figures	1,41



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search

9 January 2012

Date of mailing of the international search report

20/01/2012

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Clasen, Martin

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2011/057231

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