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(54) **SWITCHABLE BEARING BUSHING FOR A MOTOR VEHICLE**

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See application file for complete search history.

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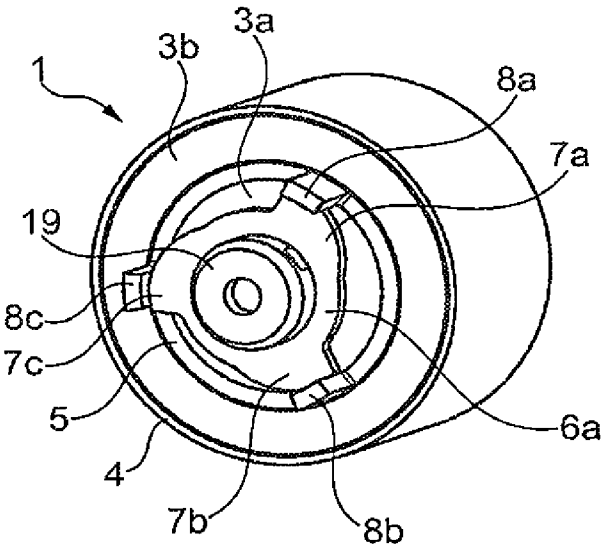
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(57) **ABSTRACT**

A bearing bushing, for example, for a motor vehicle. The bearing bushing is switchable between a first and a second stiffness stage. The bearing bushing has a first elastomer ring, which is arranged rotationally fixedly on an outer circumferential surface of an inner ring, and a second elastomer ring, which is arranged rotationally fixedly on an inner circumferential surface of an outer ring. Radially between the two elastomer rings, an intermediate ring makes contact in a rotationally fixed manner with the two elastomer rings. To change in stiffness of the bearing bushing, the first elastomer ring can be bridged by the intermediate ring and at least one blocking ring which is arranged on the bearing bushing at an end side.

**16 Claims, 2 Drawing Sheets**



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| *F16H 19/08* | (2006.01) |

(52) **U.S. Cl.**

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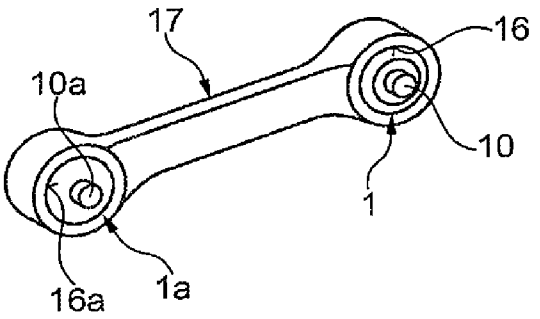



Fig. 1

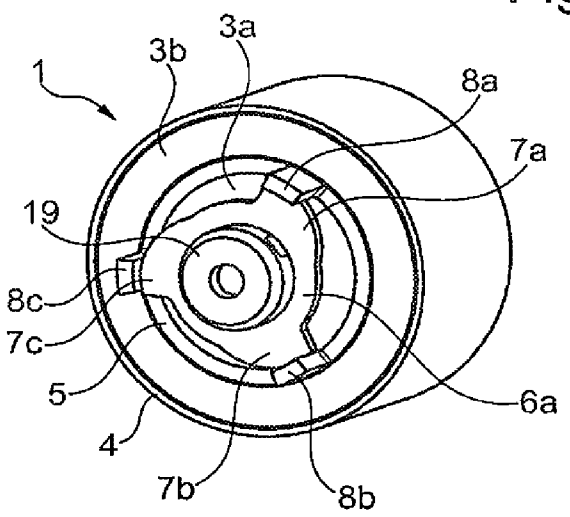



Fig. 2a

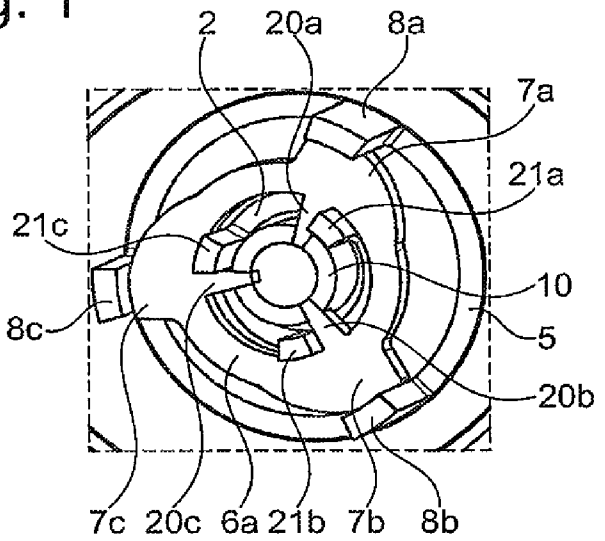



Fig. 2b

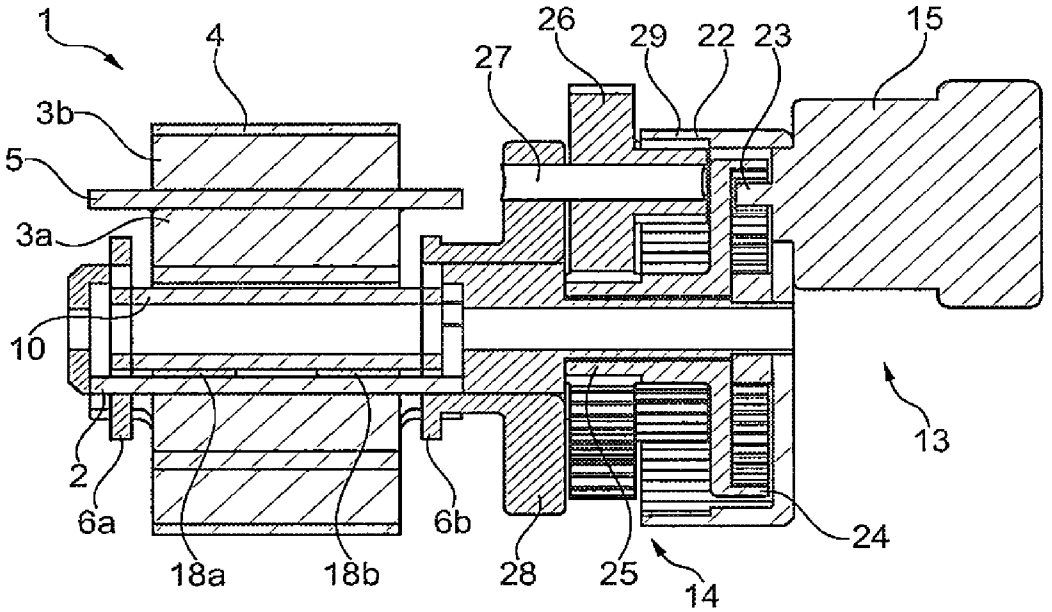



Fig. 3

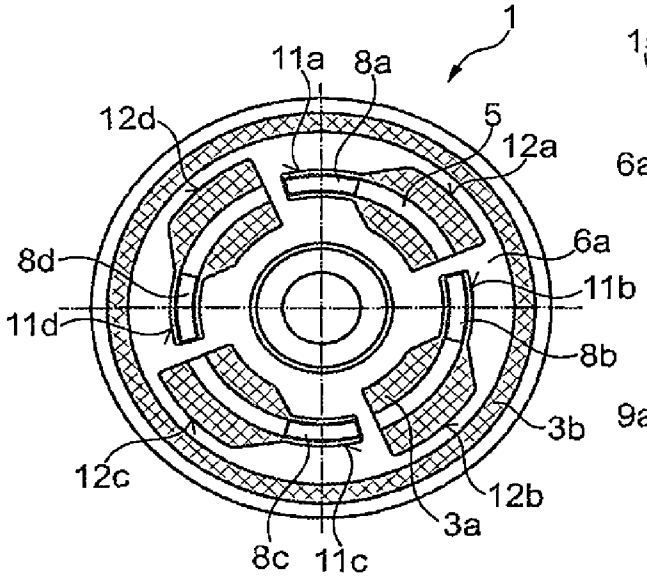



Fig. 4a

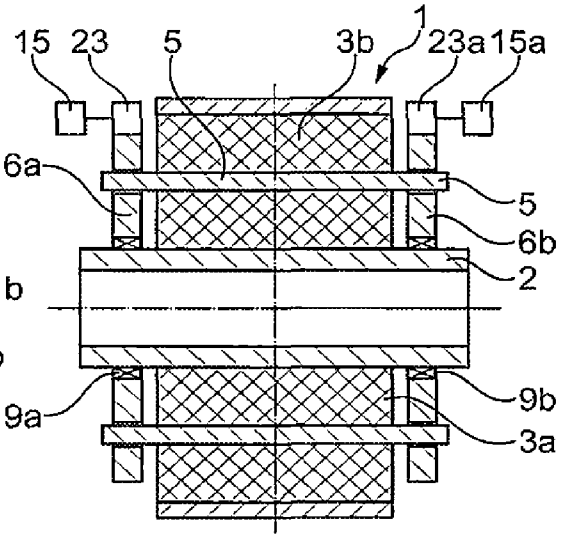



Fig. 4b

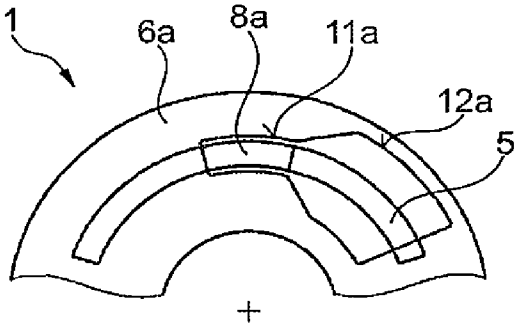



Fig. 5a

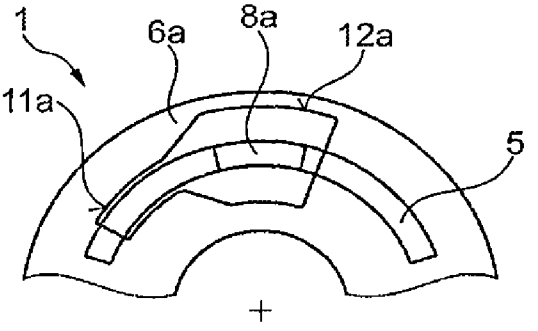



Fig. 5b

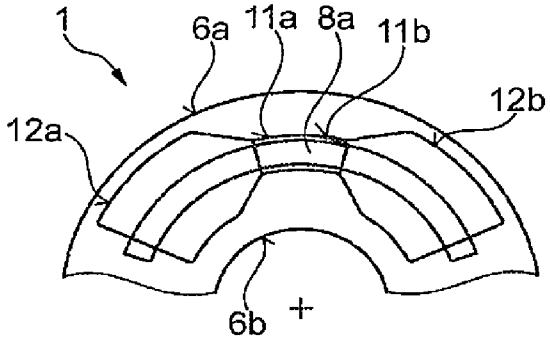



Fig. 6a

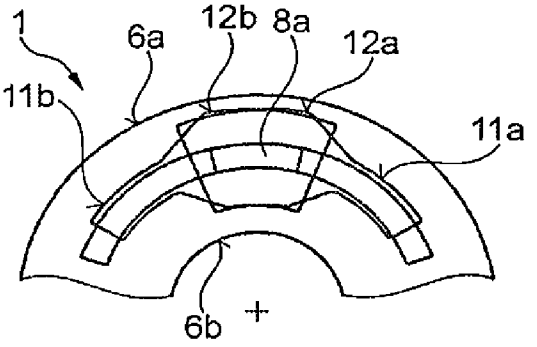



Fig. 6b

# SWITCHABLE BEARING BUSHING FOR A MOTOR VEHICLE

## CROSS-REFERENCE TO RELATED APPLICATIONS

This application is the U.S. National Phase of PCT Appln. No. PCT/DE2016/200230 filed May 17, 2016, which claims priority to DE 102015214860.2 filed Aug. 4, 2015, the entire disclosures of which are incorporated by reference herein.

## TECHNICAL FIELD

The disclosure relates to a bearing bushing for a motor vehicle, wherein the bearing bushing is switchable between a first and a second stiffness stage.

## BACKGROUND

The structure and the resulting operational data of bearing bushings that are used in a chassis of a motor vehicle can have a very great influence on the driving and steering characteristics of the motor vehicle. Relatively minor changes to a spring constant or stiffness of the bearing bushings can have considerable effects on the vehicle characteristics, such as for example the understeer or oversteer characteristics and chassis noises, vibrations and running harshness. Depending on the setting of the bearing bushing, the motor vehicle has a relatively "soft" or relatively "hard" running characteristic.

The generally known prior art has disclosed various bearing bushings in the chassis region of a motor vehicle. Firstly, purely mechanical bearing bushings or rubber bearings are known which have a defined stiffness. Furthermore, hydraulically damped chassis bushings with fixed or variable stiffness are known. Furthermore, bearings with magnetorheological liquids or magnetorheological elastomers are known, wherein the stiffness can be varied by means of a magnetic field.

For example, DE 696 22 141 T2 discloses a method for producing and using a suspension bushing with variable stiffness for controlling the relative movement between a suspension link in a motor vehicle and a frame component of the motor vehicle. The suspension bushing has a variable stiffness, which is realized by virtue of the fact that there is an enclosed magnetorheological elastomer or gel, the stiffness of which is variably adjustable over a wide range, specifically by means of a controllable magnetic field. The variable controllable magnetic field is generated by means of an electromagnetic structure which is completely integrated, as part of the structure, into a suspension bushing structure.

The problem addressed by the present disclosure includes providing a bearing bushing for a motor vehicle, the stiffness of which bearing bushing is mechanically adjustable and is thus not based on a hydraulic or magnetorheological operating principle.

## SUMMARY

According to the disclosure, the bearing bushing has a first elastomer ring, which is arranged rotationally fixedly on an outer circumferential surface of an inner ring, and a second elastomer ring, which is arranged rotationally fixedly on an inner circumferential surface of an outer ring, wherein, radially between the two elastomer rings, an intermediate ring makes contact in a rotationally fixed manner with the two elastomer rings, wherein furthermore, for the change in stiffness of the bearing bushing, the first elastomer ring can be bridged by the intermediate ring and at least one blocking ring which is arranged on the bearing bushing at an end side. In other words, a change between a first and a second stiffness stage occurs by virtue of the fact that the intermediate ring comes into contact with the at least one blocking ring and thereby bridges the first elastomer ring arranged between the intermediate ring and the inner ring. The stiffness of the bearing bushing is consequently increased.

The at least one blocking ring preferably has at least three support elements for radially accommodating a respective axially formed lug of the intermediate ring. Here, the at least three lugs are formed axially on an end face of the intermediate ring. In a first switching position of the at least one blocking ring, the respective lugs come into contact with the respective support elements of the at least one blocking ring. In other words, the intermediate ring, and thus also the second elastomer ring and the outer ring connected rotationally fixedly thereto, are supported on the at least one blocking ring via the lugs and the support elements. In this way, the first elastomer ring is bridged, whereby the stiffness of the bearing bushing is relatively high. In a second switching position of the at least one blocking ring, the respective lugs are at least radially movable, wherein the respective lugs do not come into contact with the respective support elements of the at least one blocking ring element. In other words, the intermediate ring, and thus also the second elastomer ring and the outer ring connected rotationally fixedly thereto, are supported on the inner ring via the first elastomer ring. By the series connection of the two elastomer rings, a relatively soft damping action is realized, wherein the bearing bushing has a relatively low stiffness.

In one embodiment, the at least one blocking ring is mounted rotatably on the inner ring by means of a bearing element. The bearing element is preferably in the form of a plain bearing bushing or rolling bearing. Consequently, in the first switching position of the bearing bushing, the force flow runs from the outer ring into the second elastomer ring, and via the intermediate ring and the at least one blocking ring into the inner ring.

In a further embodiment, the at least one blocking ring is connected rotationally fixedly to a bolt which is mounted rotatably on the inner ring. In particular, the bolt is mounted rotatably on an inner circumferential surface of the inner ring. For this purpose, at least one bearing element is arranged between the inner ring and the bolt. Consequently, in the first switching position of the bearing bushing, the force flow runs from the outer ring into the second elastomer ring, and via the intermediate ring and the at least one blocking ring into the bolt.

It is particularly preferable for at least one blocking ring to be provided for each of the two end faces of the bearing bushing. Thus, in the first switching position, the intermediate ring is supported radially on two blocking rings, wherein a first blocking ring is arranged axially on a first end face of the bearing bushing, and wherein a second blocking ring is arranged axially on a second end face of the bearing bushing. In particular, the two blocking rings are axially spaced apart from the respective end face of the bearing bushing and thus do not come into contact therewith.

In a further embodiment, the at least one blocking ring has a respective first and second aperture for each lug, which apertures are connected to one another, wherein the respective first aperture is of substantially complementary form with respect to the respective lug, and wherein the respective second aperture is at least radially larger than the respective first aperture. Consequently, the respective first and second

aperture form a coherent aperture in which the respective lug is movable during a rotation of the blocking ring in a circumferential direction. In other words, for the change in stiffness of the bearing bushing, the at least one blocking ring is rotated such that the respective lug passes out of the first aperture into the second aperture. In the respective first aperture, the respective lug comes into contact with the blocking ring radially when the bearing bushing is subjected to load. By contrast, in the respective second aperture, the respective lug is movable both radially and axially, and does not come into contact with the blocking ring, when the bearing bushing is subjected to load. Consequently, in the first switching position, the at least one blocking ring realizes at least a partial blockage of the freedom of movement of the intermediate ring, and thus a stiffening of the bearing bushing.

It is advantageous for two blocking rings to be arranged axially adjacent to one another on an end face of the bearing bushing. In particular, for the change in stiffness of the bearing bushing, the two blocking rings are rotatable relative to one another. For this purpose, the two apertures in the respective blocking ring are arranged oppositely. Thus, a change in stiffness of the bearing bushing is realized by a rotation of the first blocking ring in a first direction of rotation and a rotation of the second blocking ring in a second direction of rotation.

The disclosure encompasses the technical teaching whereby, for the change in stiffness of the bearing bushing, the at least one blocking ring is rotatable, by an actuator connected at least indirectly thereto, relative to the intermediate ring. The blocking ring preferably has a toothing on an outer circumferential surface, which toothing meshes with a pinion shaft of the actuator. It is furthermore preferable for the actuator to be connected to the at least one blocking ring via a gearing arrangement. Here, the gearing arrangement is arranged axially on the bearing bushing. It is furthermore preferable for the actuator to comprise an electric motor.

## BRIEF DESCRIPTION OF THE DRAWINGS

Further measures which improve the disclosure will be presented in more detail below together with the description of embodiments of the disclosure on the basis of the figures. In the figures:

FIG. **1** is a perspective illustration of a chassis link for a motor vehicle, wherein the chassis link has a bearing bushing according to an embodiment of the disclosure,

FIG. **2***a* is a perspective illustration of the bearing bushing according to the disclosure as per a first exemplary embodiment,

FIG. **2***b* is a perspective detail illustration of the bearing bushing according to the disclosure from FIG. **2***a*,

FIG. **3** is a schematic sectional illustration for illustrating the construction of the bearing bushing according to the disclosure from FIG. **2***a* together with gearing arrangement and actuator,

FIG. **4***a* shows a schematic side view of the bearing bushing according to the disclosure as per a second exemplary embodiment,

FIG. **4***b* is a schematic sectional illustration of the bearing bushing according to the disclosure from FIG. **4***a*,

FIG. **5***a* is a schematic detail illustration of the bearing bushing according to the disclosure in a first switching position,

FIG. **5***b* is a schematic detail illustration of the bearing bushing according to the disclosure in a second switching position,

FIG. **6***a* is a schematic detail illustration of the bearing bushing according to the disclosure with two axially mutually adjacently arranged blocking rings in a first switching position, and

FIG. **6***b* is a schematic detail illustration of the bearing bushing according to the disclosure with two axially mutually adjacently arranged blocking rings in a second switching position.

## DETAILED DESCRIPTION

In FIG. **1**, a bearing bushing according to the disclosure is arranged in a bore **16**, provided for the purpose, on a chassis link **17**. The chassis link **17** is installed in a chassis (not illustrated here) of a motor vehicle (not illustrated here). An axle support (not illustrated here) of the motor vehicle is fastened to a bolt **10** of the bearing bushing **1**. Furthermore, the chassis link **17** has a further bore **16***a* in which there is arranged a mechanical, non-switchable bearing bushing **1***a*. In other words, the bearing bushing **1***a* is designed as a conventional rubber bearing. A wheel support (not illustrated here) is arranged on a bolt **10***a* of the bearing bushing **1***a*.

As per FIG. **2***a*, a bearing bushing **1** according to the disclosure has a first and a second elastomer ring **3***a*, **3***b*. The first elastomer ring **3***a* is arranged rotationally fixedly on an inner ring **2** illustrated in FIG. **2***b*. By contrast, the second elastomer ring **3***b* is arranged radially between an intermediate ring **5** and an outer ring **4**. Furthermore, the intermediate ring **5** makes contact with the first elastomer element **3***a* radially. Furthermore, a blocking ring **6***a* is arranged on the bearing bushing **1** at an end side, which blocking ring has three support elements **7***a*-**7***c* for radially accommodating a respective axially formed lug **8***a*-**8***c* of the intermediate ring **5**. The blocking ring **6***a* is secured axially by a covering element **19** arranged axially thereon. For the change in stiffness of the bearing bushing **1**, the first elastomer ring **3***a* can be bridged via the intermediate ring **5** and the blocking ring **6***a*. For this purpose, as illustrated in FIG. **2***a*, the intermediate ring **5** comes into contact with the blocking ring **6***a* radially via the three lugs **8***a*-**8***c*. In this illustrated switching position of the blocking ring **6***a*, the bearing bushing **1** has a relatively high stiffness.

FIG. **2***b* is a detail illustration of FIG. **2***a*, with the covering element **19** not being illustrated. As per FIG. **2***b*, the bolt **10** is arranged within the inner ring **2**. Here, the bolt **10** is connected rotationally fixedly to the blocking ring **6***a*, wherein three radially formed elements **20***a*-**20***c* on the blocking ring **6***a* are connected in positively locking fashion to the bolt **10**. Furthermore, the inner ring **2** has three axially formed elements **21***a*-**21***c* for positively locking connection to the covering element **19**. Furthermore, during a rotation of the blocking ring **6***a*, the axially formed elements **21***a*-**21***c* on the inner ring **2** are provided as stop surfaces for the radially formed elements **20***a*-**20***c* on the blocking ring **6***a*, and thus, in the respective switching position, position the support elements **7***a*-**7***c* on the blocking ring **6***a* relative to the lugs **8***a*-**8***c* on the intermediate ring **5**.

As per FIG. **3**, the bearing bushing **1** according to the disclosure from FIG. **2***a* has an actuator **13** which is connected to the blocking ring **6***b* via a gearing arrangement **14**. Consequently, in each case one blocking ring **6***a*, **6***b* is provided for each of the two end faces of the bearing bushing **1**. Furthermore, the blocking ring **6***b* is connected rotationally fixedly to the blocking ring **6***a* via the bolt **10**. The bolt **10** is mounted rotatably on the inner ring **2** by means of two plain bearing bushings **18***a*, **18***b*. For the

change in stiffness of the bearing bushing **1**, the two blocking rings **6***a*, **6***b* are rotated, via the gearing arrangement **14**, by an electric motor **15** of the actuator **13**. The electric motor **15** is arranged axially on a housing **22** of the gearing arrangement **14**. The electric motor **15** drives the gearing arrangement **14** via a pinion shaft **23**. For this purpose, the pinion shaft **23** meshes with an internal gear **24**, wherein the internal gear **24** is formed integrally with a sun gear **25**. Furthermore, the sun gear **25** meshes with a stepped planetary gear set **26**, which is connected to the blocking ring **6***b* via a bolt **27**. For this purpose, the blocking ring **6***b* has a section of flange-like form, which is simultaneously a planet carrier **28**. Furthermore, the stepped planetary gear set **26** also meshes with an internal gear **29** which is formed in the housing **22** and which is fixed so as to be stationary. The first elastomer ring **3***a* is arranged rotationally fixedly radially between the inner ring **2** and the intermediate ring **5**. Furthermore, the second elastomer ring **3***b* is arranged rotationally fixedly radially between the intermediate ring **5** and the outer ring **4**. The outer ring **4** is of sleeve-like form and is pressed into a bore (not illustrated here) of a chassis link (not illustrated here).

As per FIGS. **4***a* and **4***b*, in each case one blocking ring **6***a*, **6***b* is provided for each of the two end faces of the bearing bushing **1**. The intermediate ring **5** has in each case four axially formed lugs **8***a*-**8***d* to both axial sides, of which however only four lugs **8***a*-**8***d* are illustrated owing to the side-on illustration of the bearing bushing **1**. The two blocking rings **6***a*, **6***b* are of identical form. Each blocking ring **6***a* has a respective first and second aperture **11***a*-**11***d*, **12***a*-**12***d* for each lug **8***a*-**8***d*, which apertures are connected to one another, wherein the respective first aperture **11***a*-**11***d* is of substantially complementary form with respect to the respective lug **8***a*-**8***d*. In other words, the respective lug **8***a*-**8***d* has only minimal play in the respective first aperture **11***a*-**11***d*, such that, when the bearing bushing **1** is subjected to load, the first elastomer ring **3***a* is bridged by means of the intermediate ring **5** and the two blocking rings **6***a*, **6***b*. Furthermore, the respective second aperture **12***a*-**12***d* is formed so as to be more than twice as large as the first aperture **11***a*-**11***d*, such that, when the bearing bushing **1** is subjected to load, a substantially radial displacement of the intermediate ring **5** is permitted, and thus an exertion of load on both elastomer rings **3***a*, **3***b* is realized.

As per FIG. **4***b*, the respective blocking ring **6***a*, **6***b* is rotatable by a respective electric motor **15**, **15***a* with respective pinion shaft **23**, **23***a*. For this purpose, the respective blocking ring **6***a*, **6***b* is mounted rotatably on the inner ring **2** by a respective bearing element **9***a*, **9***b*.

FIGS. **5***a* and **5***b* show a partially illustrated switchable bearing bushing **1** according to the disclosure, which is switchable between a first and a second stiffness stage, wherein FIG. **5***b* illustrates a relatively low stiffness stage and FIG. **5***a* illustrates a relatively high stiffness stage of the switchable bearing bushing **1**. The relatively high stiffness stage is realized in that, when the bearing bushing **1** is subjected to load, the lug **8***a* of the intermediate ring **5** makes contact in the first aperture **11***a* of the blocking ring **6***a*. The relatively low stiffness stage is realized in that, when the bearing bushing **1** is subjected to load, the lug **8***a* is freely movable in the second aperture **12***a*.

As per FIGS. **6***a* and **6***b*, two blocking rings **6***a*, **6***b* are arranged axially adjacent to one another on an end face of the bearing bushing **1**. For the change in stiffness of the bearing bushing **1**, the two blocking rings **6***a*, **6***b* are rotatable relative to one another. For this purpose, the two apertures **11***a*, **12***a* and **11***b*, **12***b* in the respective blocking ring **6***a*, **6***b* are arranged oppositely. FIG. **6***b* illustrates a relatively low stiffness stage, and FIG. **6***a* illustrates a relatively high stiffness stage of the switchable bearing bushing **1**. A change in stiffness of the bearing bushing **1** from the position illustrated in FIG. **6***a* into the position illustrated in FIG. **6***b* is realized by means of a rotation of the first blocking ring **6***a* clockwise and a rotation of the second blocking ring **6***b* counterclockwise. The embodiment of the bearing bushing **1** with two axially mutually adjacently arranged blocking rings **6***a*, **6***b* offers the advantage in particular that the lug **8***a* is blocked in a circumferential direction and radially in the respective first aperture **11***a*, **11***b* of the two blocking rings **6***a*, **6***b*.

It is pointed out that the respective blocking rings **6***a*, **6***b* have been illustrated in transparent form in FIGS. **5***a*, **5***b*, **6***a* and **6***b*.

## LIST OF REFERENCE DESIGNATIONS

**1** Bearing bushing
**2** Inner ring
**3***a*, **3***b* Elastomer ring
**4** Outer ring
**5** Intermediate ring
**6***a*, **6***b* Blocking ring
**7***a*-**7***d* Support elements
**8***a*-**8***d* Lug
**9***a*, **9***b* Bearing element
**10** Bolt
**11***a*-**11***d* First aperture
**12***a*-**12***d* Second aperture
**13** Actuator
**14** Gearing arrangement
**15**, **15***a* Electric motor
**16**, **16***a* Bore
**17** Chassis link
**18**, **18***a* Bolt
**19** Covering element
**20***a*-**20***c* Axially formed element
**21***a*-**21***c* Radially formed element
**22** Housing
**23**, **23***a* Pinion shaft
**24** Internal gear
**25** Sun gear
**26** Stepped planetary gear set
**27** Bolt
**28** Planet carrier
**29** Internal gear

The invention claimed is:

**1**. A bearing bushing for a motor vehicle, comprising:

a bearing bushing that is configured to be switchable between a first and a second stiffness stage;

the bearing bushing having a first elastomer ring, which is arranged rotationally fixedly on an outer circumferential surface of an inner ring, and a second elastomer ring, which is arranged rotationally fixedly on an inner circumferential surface of an outer ring; and

wherein, radially between the two elastomer rings, an intermediate ring makes contact in a rotationally fixed manner with the two elastomer rings, wherein furthermore, for the switch in stiffness of the bearing bushing, the first elastomer ring can be bridged by the intermediate ring and at least one blocking ring which is arranged on the bearing bushing at an end side;

wherein the at least one blocking ring has at least three support elements that each radially accommodate an axially formed lug of the intermediate ring;

wherein the at least one blocking ring has a first and a second aperture for each lug, which apertures are connected to one another, wherein the first aperture is of substantially complementary form with respect to the lug, and wherein the second aperture is at least radially larger than the first aperture.

**2**. The bearing bushing as claimed in claim **1**, wherein the at least one blocking ring is mounted rotatably on the inner ring by a bearing element.

**3**. The bearing bushing as claimed in claim **1**, wherein the at least one blocking ring is connected rotationally fixedly to a bolt which is mounted rotatably on the inner ring.

**4**. The bearing bushing as claimed in claim **1**, wherein the at least one blocking ring is provided for each of two end faces of the bearing bushing.

**5**. The bearing bushing as claimed in claim **4**, wherein the at least one blocking ring includes two blocking rings arranged axially adjacent to one another on at least one of the two end faces of the bearing bushing.

**6**. The bearing bushing as claimed in claim **1**, wherein, for the switch in stiffness of the bearing bushing, the at least one blocking ring is rotatable, by an actuator connected at least indirectly thereto, relative to the intermediate ring.

**7**. The bearing bushing as claimed in claim **6**, wherein the actuator is connected to the at least one blocking ring via a gearing arrangement.

**8**. The bearing bushing as claimed in claim **6**, wherein the actuator comprises an electric motor.

**9**. A bearing bushing, comprising:

a bearing bushing configured to be switchable between a first stiffness and a second stiffness, the first stiffness being different from the second stiffness;

a first elastomer ring arranged rotationally fixedly on an outer circumferential surface of an inner ring;

a second elastomer ring arranged rotationally fixedly on an inner circumferential surface of an outer ring; and

an intermediate ring radially between the two elastomer rings, the intermediate ring making contact in a rotationally fixed manner with the first and second elastomer rings;

wherein to switch between the first and second stiffness, the first elastomer ring is configured to be bridged by the intermediate ring and at least one blocking ring which is arranged on the bearing bushing at an end side

wherein the at least one blocking ring has at least three support elements that each radially accommodate an axially formed lug of the intermediate ring;

wherein the at least one blocking ring has a first and a second aperture for each lug, which apertures are connected to one another, wherein the first aperture is of substantially complementary form with respect to the lug, and wherein the second aperture is at least radially larger than the first aperture.

**10**. The bearing bushing as claimed in claim **9**, wherein the at least one blocking ring is mounted rotatably on the inner ring by a bearing element.

**11**. The bearing bushing as claimed in claim **9**, wherein the at least one blocking ring is connected rotationally fixedly to a bolt which is mounted rotatably on the inner ring.

**12**. The bearing bushing as claimed in claim **9**, wherein at least one blocking ring is provided for each of two end faces of the bearing bushing.

**13**. The bearing bushing as claimed in claim **9**, wherein the at least one blocking ring includes two blocking rings arranged axially adjacent to one another on an end face of the bearing bushing.

**14**. The bearing bushing as claimed in claim **9**, wherein, for the switch in stiffness of the bearing bushing, the at least one blocking ring is rotatable, by an actuator connected at least indirectly thereto, relative to the intermediate ring.

**15**. The bearing bushing as claimed in claim **14**, wherein the actuator is connected to the at least one blocking ring via a gearing arrangement.

**16**. The bearing bushing as claimed in claim **14**, wherein the actuator comprises an electric motor.

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