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

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CPC ..... ***F16F 1/387*** (2013.01); ***F16F 1/3876*** (2013.01); *F16F 2230/0058* (2013.01); *F16F 2230/18* (2013.01)

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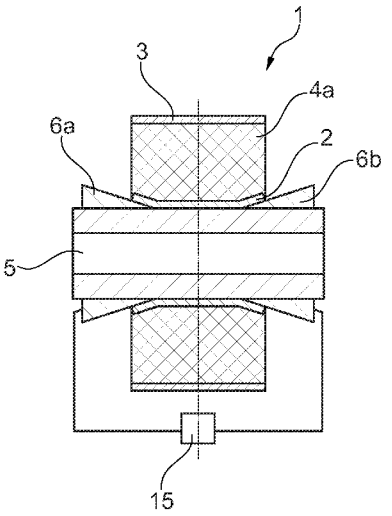
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(57) **ABSTRACT**

A bearing bush for a vehicle is disclosed. The bearing bush includes an inner ring, an outer ring, and an elastomer element between the inner and outer rings. An actuator is configured to cause an application of a force on the elastomer element in a radial direction against at least one of the inner ring and outer ring to alter the rigidity of the bearing bushing. This provides a system for mechanically altering the rigidity of the bearing bush, making the bearing bush switchable between at least two rigidity states.

**17 Claims, 3 Drawing Sheets**



(58) **Field of Classification Search**
USPC ..... 267/270, 279–283, 141.3, 141.6, 141.7, 267/292–294
See application file for complete search history.

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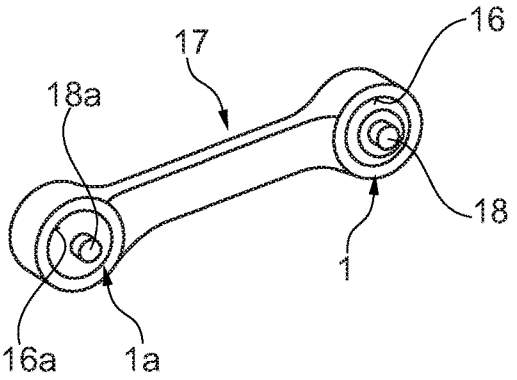



Fig. 1

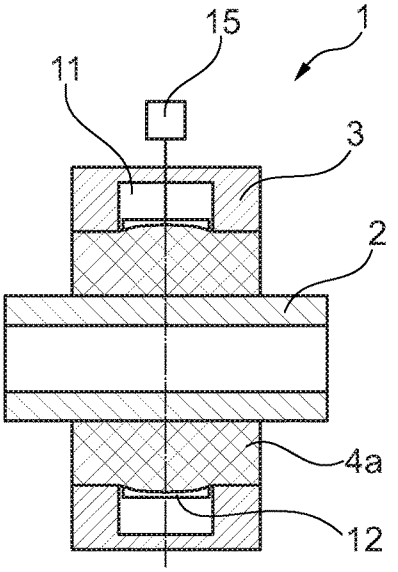



Fig. 2

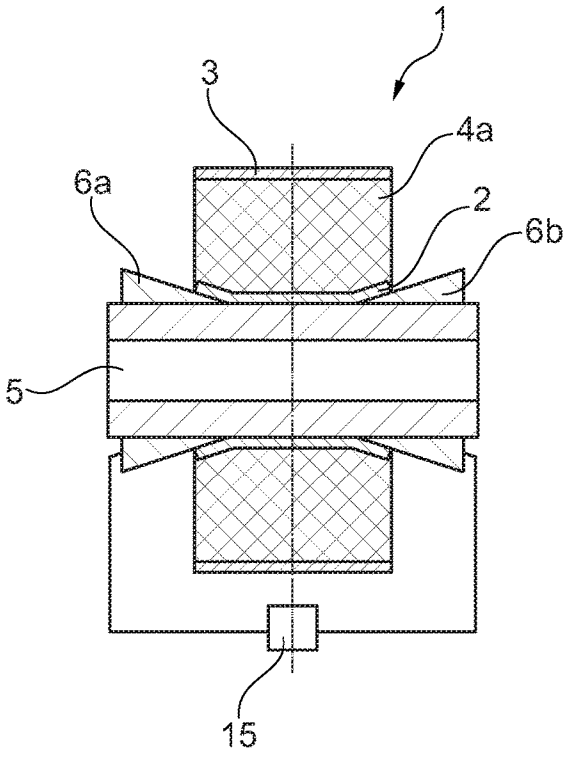



Fig. 3

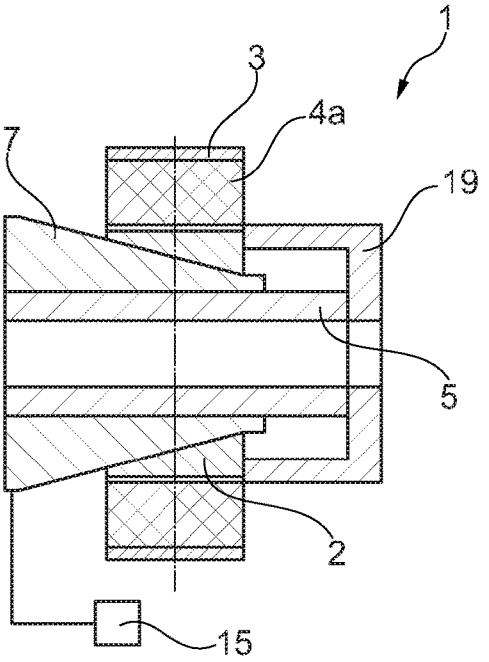



Fig. 4

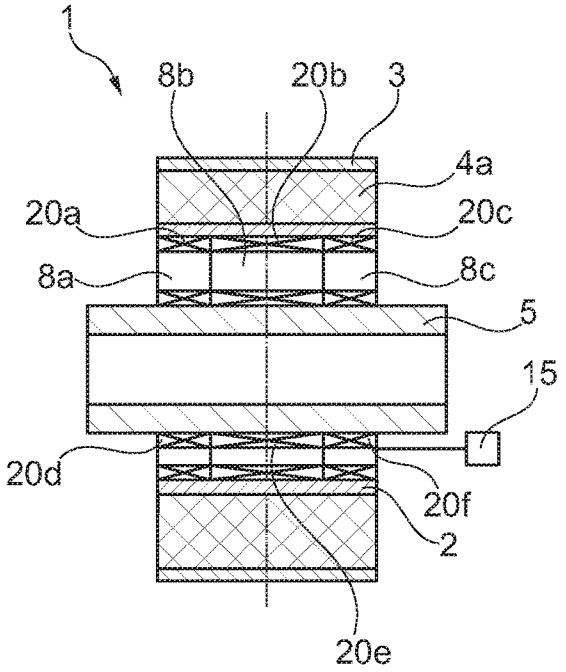



Fig. 5a

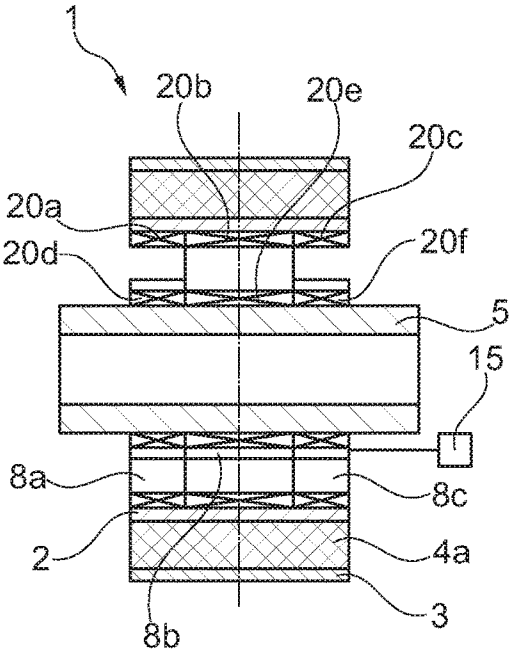



Fig. 5b

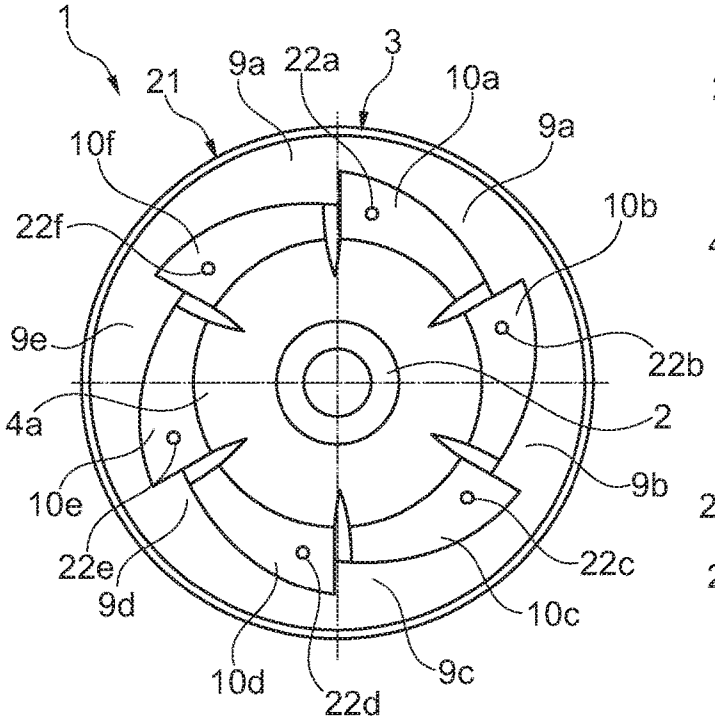



Fig. 6a

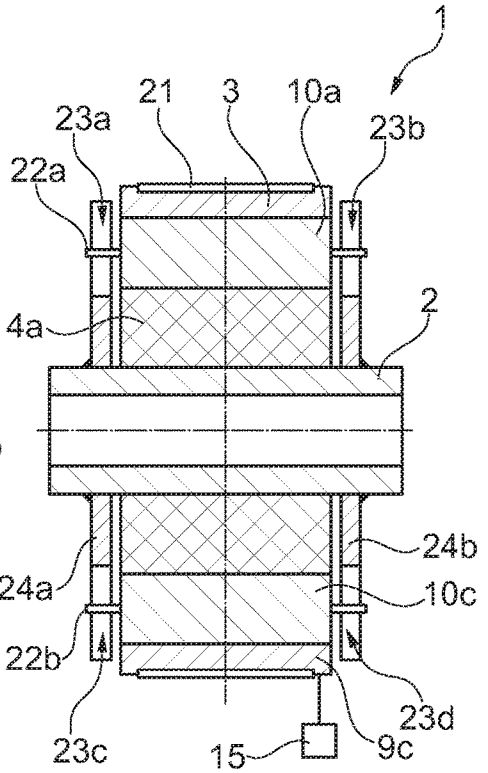



Fig. 6b

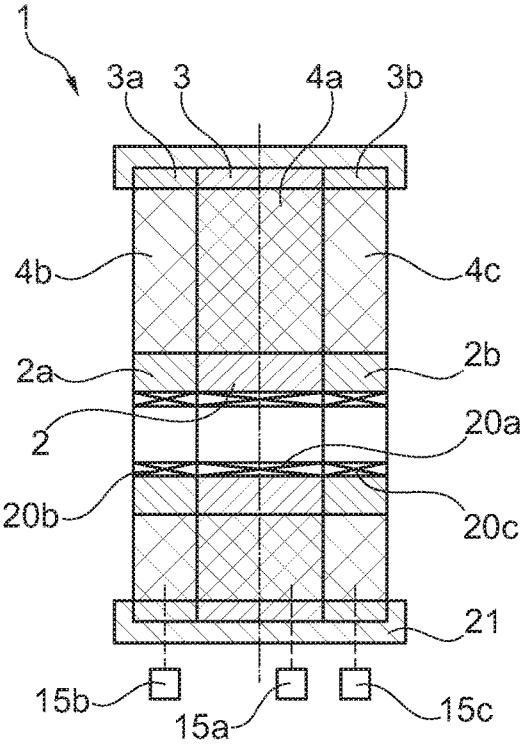



Fig. 7

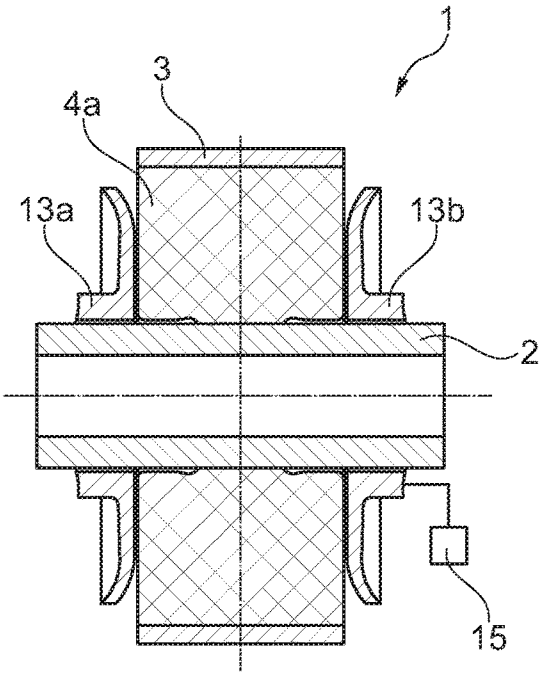



Fig. 8

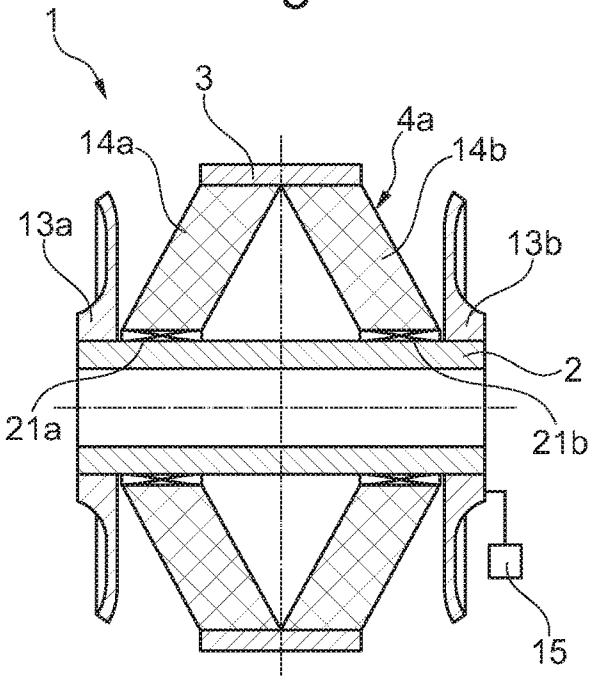



Fig. 9

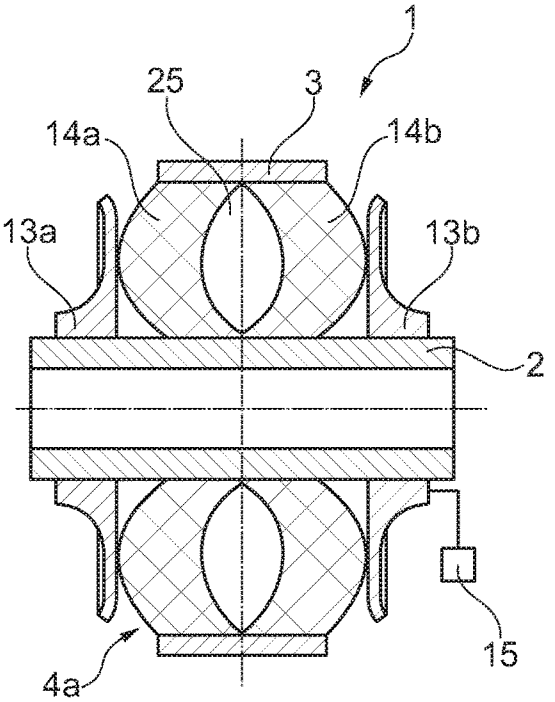



Fig. 10

# SWITCHABLE BEARING BUSH FOR A MOTOR VEHICLE

## CROSS-REFERENCE TO RELATED APPLICATIONS

This application is the U.S. National Phase of PCT/DE2016/200233 filed May 17, 2016, which claims priority to DE 102015215426.2 filed Aug. 13, 2015, the entire disclosures of which are incorporated by reference herein.

## TECHNICAL FIELD

This disclosure relates to a bearing bushing for a motor vehicle, comprising an inner ring and an outer ring, as well as an elastomer element disposed radially between the inner ring and the outer ring, wherein the bearing bushing can be switched between at least to rigidity states.

## BACKGROUND

The construction and the operating data of bearing bushings resulting therefrom that are used in a chassis of a motor vehicle have a strong impact on the driving and steering characteristics of the motor vehicle. Relatively minor modifications to a spring constant or rigidity of the bearing bushing can have significant effects on the vehicle characteristics, such as the under- and oversteering behavior as well as chassis noises, vibrations and operating resistances. Depending on the setting of the bearing bushing, the motor vehicle has a relatively "soft" or a relatively "hard" operating behavior.

Different bearing bushings in the chassis of a motor vehicle are known from the generally known prior art. On one hand, purely mechanical bearing bushings or rubber bearings are known, which have a defined rigidity. On the other hand, hydraulically dampened chassis bushings having a predefined or variable rigidity are known. Moreover, bearings with magnetorheological liquids or magnetorheological elastomers are known, wherein the rigidity can be varied via a magnetic field.

By way of example, DE 696 22 141 T2 discloses a method for the production and use of a suspension bushing with variable rigidity for controlling the relative movement between a suspension arm in a motor vehicle and a frame component of the motor vehicle. The suspension bushing has a variable rigidity, which is obtained in that a magnetorheological elastomer or gel is enclosed therein, the rigidity of which can be varied over a wide range by means of an adjustable magnetic field. The variably adjustable magnetic field is generated by means of an electromagnet structure, which is fully integrated in a suspension bushing structure as part of the structure.

The object of this disclosure is to create a bearing bushing for a motor vehicle, the rigidity of which can be mechanically adjusted, and thus is not based on a hydraulic or magnetorheological operating principle.

## SUMMARY

According to one embodiment, the bearing bushing is configured to introduce a preloading force into the elastomer element. In other words, through the introduction of a preloading force into the elastomer element, the rigidity of the bearing bushing is increased. Thus, the bearing bushing has a minimum rigidity in a first setting, wherein the elastomer element experiences a minimum preloading force, and thus exhibits a maximum deformation potential. On the other hand, the bearing bushing has a maximum rigidity in a second setting, wherein the elastomer element experiences a maximum preloading force, and exhibits a minimum deformation potential. Numerous switching settings may be possible between the first setting and the second setting, wherein the preloading force acting on the elastomer element can be adjusted in a variable manner.



## BRIEF DESCRIPTION OF THE DRAWINGS

Further measures for improvement shall be explained below in greater detail, together with the descriptions of exemplary embodiments based on the figures. Therein:

FIG. **1** shows a perspective illustration of a chassis connecting rod for a motor vehicle, wherein the chassis arm has a bearing bushing according to various embodiments described herein,

FIG. **2** shows a schematic sectional view, illustrating the construction of the bearing bushing according to a first exemplary embodiment,

FIG. **3** shows a schematic sectional view, illustrating the construction of the bearing bushing according to a second exemplary embodiment,

FIG. **4** shows a schematic sectional view, illustrating the construction of the bearing bushing according to a third exemplary embodiment,

FIG. **5***a* shows a schematic sectional view, illustration the construction of the bearing bushing according to a fourth exemplary embodiment, wherein the bearing bushing exhibits a low rigidity,

FIG. **5***b* shows a schematic sectional view of the bearing bushing according to FIG. **5***a*, wherein the bearing bushing exhibits a high rigidity,

FIG. **6***a* shows a schematic side view, illustrating the construction of the bearing bushing according to a fifth exemplary embodiment,

FIG. **6***b* shows a schematic sectional view of the bearing bushing according to FIG. **6***a*,

FIG. **7** shows a schematic sectional view, illustrating the construction of the bearing bushing according to a sixth exemplary embodiment,

FIG. **8** shows a schematic sectional view, illustrating the construction of the bearing bushing according to a seventh exemplary embodiment,

FIG. **9** shows a schematic sectional view, illustrating the construction of the bearing bushing according to an eighth exemplary embodiment, and

FIG. **10** shows a schematic sectional view, illustrating the construction of the bearing bushing according to a ninth exemplary embodiment.

## DETAILED DESCRIPTION OF THE DRAWINGS

According to FIG. **1**, a bearing bushing **1** is disposed in a borehole **16** provided for this in a chassis connecting rod **17**. The chassis connecting rod **17** is incorporated in a chassis—not shown here—of a motor vehicle—not shown here. A cross member—not shown here—of the motor vehicle is attached to a bolt **18** of the bearing bushing **1**. Furthermore, the chassis connecting rod **17** has a second borehole **16***a*, in which a mechanical, non-variable bearing bushing **1***a* is disposed. In other words, the bearing bushing **1***a* is in the form of a conventional rubber bearing. A wheel mount—not shown here—is disposed on a bolt **18***a* of the bearing bushing **1***a*.

According to an embodiment illustrated in FIG. **2**, the bearing bushing **1** has an inner ring **2** and an outer ring **3**, as well as a non-rotating elastomer element **4***a*, disposed radially between the inner ring **2** and the outer ring **3**. Furthermore, a circumferential groove **11** is formed on an inner circumferential surface of the outer ring **3**, in which an annular clamping element **12** is disposed. The diameter of the annular clamping element **12** can be reduced, in order to apply a preloading force to the elastomer element **4***a*. In other words, by reducing the diameter of the clamping element **12**, the preloading force to the elastomer element **4***a* is increased. An enlargement of the diameter of the clamping element **12** does not reduce the preloading force to the elastomer element **4***a*, but instead causes the elastomer element **4***a* to flow into the circumferential groove **11**, even when the bearing bushing **1** is subjected to a load, by means of which the rigidity of the bearing bushing **1** is further reduced. An actuator **15** acts on the annular clamping element **12** in order to change the diameter of the annular clamping element **12**.

According to an embodiment illustrated in FIG. **3**, the bearing bushing **1** has an inner ring **2** and an outer ring **3**, as well as a non-rotating elastomer element **4***a*, disposed radially between the inner ring **2** and the outer ring **3**. Furthermore, the inner ring **2** is disposed on a sleeve **5**. Moreover, a first and second axially moveable tapered ring **6***a*, **6***b* are disposed on the sleeve **5**, for introducing the preloading force into the elastomer element **4***a*. The respective tapered ring **6***a*, **6***b* lies, at least in part, radially between the inner ring **2** and the sleeve **5**. With an axial displacement of the two tapered rings **6***a*, **6***b* toward one another, the inner ring **2** experiences a radial expansion. For this, the inner ring **2** is designed such that it is radially elastic. In particular, the inner ring **2** has numerous recesses—not shown here—in order to obtain an elastic deformation. Moreover, the inner ring **2** has a particularly thin-walled design. For an axial displacement of the two tapered rings **6***a*, **6***b*, the two tapered rings **6***a*, **6***b* are connected to an actuator **15**.

According to an embodiment illustrated in FIG. **4**, the bearing bushing **1** has an inner ring **2** and an outer ring **3**, as well as a non-rotating elastomer element **4***a*, disposed radially between the inner ring **2** and the outer ring **3**. The inner ring **2** has a tapered design, and is disposed on a tapered sleeve **7**, such that it can be radially expanded. The tapered sleeve **7** is disposed on a sleeve **5** such that it can be displaced axially. Furthermore, a sleeve element **19** is supported axially on the inner ring **2**, in order to secure it axially, when the tapered sleeve **7** is displaced axially. An axial displacement of the tapered sleeve **7** thus results in a radial expansion of the inner ring **2**. For this, the inner ring **2** is formed such that it is radially elastic, and has numerous cavities—not shown here—distributed, in particular, over the entire circumferential surface. An expansion of the inner ring **2** results in a compression of the elastomer element **4***a* between the outer ring **3** and the inner ring **2**. As a result, the preloading force to the elastomer element **4***a* is increased, thus also increasing the rigidity of the bearing bushing **1**. An actuator **15** acts on the tapered sleeve **7** for an axial displacement of the tapered sleeve **7**.

According to an embodiment illustrated in FIGS. **5***a* and **5***b*, the bearing bushing **1** has an inner ring **2** and an outer ring **3**, as well as an elastomer element **4***a* disposed radially between the inner ring **2** and the outer ring **3**. Furthermore, three eccentric rings **8***a*, **8***b*, **8***c* are disposed radially between a sleeve **5** and the inner ring **2**, such that they can rotate via bearing elements **20***a*-**20***f*. The bearing elements **20***a*-**20***c* are disposed thereby on an inner circumferential surface of the inner ring **2**, and the bearing elements **20***d*-**20***f* are disposed on an outer circumferential surface of the sleeve **5**. When the two eccentric rings **8***a* and **8***c* are rotated in relation to the eccentric ring **8***b* disposed radially therebetween, a radial expansion of the inner ring **2** takes place. For this, the inner ring **2** is elastic and has numerous cavities—not shown here—distributed over the entire circumferential surface. An expansion of the inner ring **2** results in a radial compression of the elastomer element **4***a* toward one side, and thus in a direction-dependent increase in the preloading force to the elastomer element **4***a*. According to FIG. **5***a*, the bearing bushing **1** has a minimum rigidity in this first setting. The elastomer element **4***a* is not compressed by the eccentric rings **8***a*-**8***c* thereby. By way of comparison, in FIG. **5***b* the bearing bushing **1** is shown in the second setting. In accordance with the second setting, the bearing bushing **1** exhibits a maximum rigidity, wherein the elastomer element **4***a* experiences a maximum compression. Furthermore, the inner ring **2** assumes an oval shape in the second setting.

According to an embodiment illustrated in FIGS. **6***a* and **6***b*, the bearing bushing **1** has an inner ring **2** and an outer ring **3**, as well as an elastomer element **4***a* disposed radially between the inner ring **2** and the outer ring **3**. Furthermore, six tapered elements **10***a*-**10***f* are disposed between the elastomer element **4***a* and the outer ring **3**, which interact with respective ramps **9***a*-**9***f* on an inner circumferential surface of the outer ring **3**. When the tapered elements **10***a*-**10***f* interact with the respective ramps **9***a*-**9***f*, the respective tapered elements **10***a*-**10***f* move radially, due to a rotational movement of the outer ring **3**. The radial movement of the tapered elements **10***a*-**10***f* results in a compression of the axially slotted elastomer element **4***a*. In order to prevent a rotation of the tapered elements **10***a*-**10***f* on the elastomer element **4***a*, the tapered elements **10***a*-**10***f* may be vulcanized onto the elastomer element **4***a*, and also guided radially. For this, a respective bolt **22***a*-**22***f* is inserted through the respective tapered element **10***a*-**10***f*, wherein the respective bolt **22***a*-**22***f* is radially guided into a respective groove **23***a*-**23***g* on the washers **24***a*, **24***b* shown in FIG. **6***b*. In addition, the bolts **22***a*-**22***f* move exclusively in the radial direction. In order to implement a rotation of the outer ring **3** in relation to the inner ring **2**, the outer ring **3** has a sliding bearing bushing **21** on an outer circumferential surface, wherein the outer ring **3** is connected to an actuator **15**.

According to an embodiment illustrated in FIG. **7**, the bearing bushing **1** has an inner ring **2** and an outer ring **3**, as well as a non-rotating elastomer element **4***a* disposed radially between the inner ring **2** and the outer ring **3**. Furthermore, respective further inner rings **2***a*, **2***b* and outer rings **3***a*, **3***b*, as well as non-rotating elastomer elements **4***b*, **4***c* disposed radially between the respective inner rings **2***a*, **2***b* and the respective outer rings **3***a*, **3***b*, are disposed axially adjacent thereto. The three outer rings **3**, **3***a*, **3***b* are rotatably supported on a sliding bearing bushing **21**. Furthermore, the elastomer elements **4***a*-**4***c* have an eccentric design, and can rotate independently. A rotation of the elastomer elements **4***a*-**4***c* results in a radial compression of the respective elastomer elements **4***a*-**4***c*, and thus in a direction-dependent increase in the preloading force to the respective elastomer element **4***a*-**4***c*. In order to implement a direction-dependent increase in the preloading force to the respective elastomer element **4***a*-**4***c*, the elastomer element **4***a* may be rotated 90° clockwise, together with the non-rotating outer ring **3** disposed thereon and the non-rotating inner ring **2** disposed thereon, wherein the elastomer elements **4***b* and **4***c* are rotated 90° counter-clockwise, together with the respective outer ring **3***a*, **3***b* and the respective inner ring **2***a*, **2***b*. As a

result, the central axis is displaced upward, wherein it actively engages in the axle kinematics. The respective inner rings **2**, **2***a*, **2***b* are rotatably supported via respective bearing elements **20***a*-**20***c*. Furthermore, the respective elastomer elements **4***a*-**4***c* interact with respective actuators **15***a*-**15***c*.

According to an embodiment illustrated in FIG. **8**, the bearing bushing **1** has an inner ring **2** and an outer ring **3**, as well as a non-rotating elastomer element **4***a*, disposed radially between the inner ring **2** and the outer ring **3**. Furthermore, a first and a second washer **13***a*, **13***b* are disposed on the inner ring **2** such that they can move axially, wherein the two washers **13***a*, **13***b* can be displaced axially against the elastomer element **4***a* via an actuator **15**, in order to introduce the preloading force into the elastomer element **4***a*. In addition, the elastomer element **4***a* is axially compressed via the two washers **13***a*, **13***b*.

According to an embodiment illustrated in FIG. **9**, the bearing bushing **1** has an inner ring **2** and an outer ring **3**, as well as an elastomer element **4***a*, radially disposed between the inner ring **2** and the outer ring **3**. The elastomer element **4***a* has two legs **14***a* and **14***b*, which are axially spaced apart on an inner circumferential surface of the elastomer element **4***a* in a first setting—not shown here. The two legs **14***a*, **14***b* can be displaced axially on the inner ring **2** via a respective sliding bushing **21***a*, **21***b* disposed thereon. Moreover, an outer circumferential surface of the elastomer element **4***a* is non-rotatably disposed on the outer ring **3**. In order to change the rigidity of the bearing bushing **1**, two washers **13***a*, **13***b* are disposed on the inner ring **2** such that they can move axially, in order to axially compress the elastomer element **4***a*. The legs **14***a*, **14***b* are thus moved toward one another by an actuator **15**, by means of which the preloading force to the elastomer element **4***a* is increased. A change in the rigidity is also obtained by modifying the exposed, unloaded surfaces of the elastomer element **4***a*, where an expansion is possible. In the initial state, the elastomer element **4***a* has numerous unloaded surfaces, and is therefore relatively flexible. At its maximum rigidity, when the two legs **14***a*, **14***b* are in axial contact with one another, on one hand, and on the other hand, axially loaded by the two washers **13***a*, **13***b*, there are substantially no more exposed surfaces on the elastomer element **4***a*.

According to an embodiment illustrated in FIG. **10**, the bearing bushing **1** has an inner ring **2** and an outer ring **3**, as well as a non-rotating elastomer element **4***a*, disposed radially between the inner ring **2** and the outer ring **3**. The elastomer element **4***a* has two legs **14***a*, **14***b*, wherein the two legs **14***a*, **14***b* are bowed, such that the two legs **14***a*, **14***b* are at least in part axially spaced apart from one another. As a result, an axial, lens-shaped hollow space is formed between the two legs **14***a*, **14***b*. Furthermore, two washers **13***a*, **13***b* are disposed on the inner ring **2** such that they can move axially, wherein the two washers **13***a*, **13***b* can be displaced axially against the respective leg **14***a*, **14***b* in order to introduce the preloading force into the elastomer element **4***a*.

For this embodiment, an actuator acts on the two washers **13***a*, **13***b*. Here as well, a change in the rigidity is obtained, in the same manner as in FIG. **9**, by modifying the exposed, unloaded surfaces of the elastomer element **4***a* where an expansion is possible.

## LIST OF REFERENCE SYMBOLS

**1**, **1***a* bearing bushing
**2** inner ring
**3** outer ring
**4***a*-**4***c* elastomer element
**5** sleeve
**6***a*, **6***b* tapered ring
**7** tapered sleeve
**8***a*, **8***b* eccentric ring
**9***a*-**9***d* ramps
**10***a*, **10***b* tapered element
**11** groove
**12** clamping element
**13***a*, **13***b* washer
**14***a*, **14***b* leg
**15** actuator
**16**, **16***a* borehole
**17** chassis connecting rod
**18**, **18***a* bolt
**19** sleeve element
**20***a*-**20***f* bearing element
**21** sliding bearing bushing
**22***a*-**2***f* bolt
**23***a*-**23***d* groove
**24***a*, **24***b* washer
**25** hollow space

The invention claimed is:

**1**. A bearing bushing for a motor vehicle, comprising:
an inner ring;
an outer ring; and
an elastomer element disposed radially between the inner ring and the outer ring, wherein the bearing bushing can be switched between at least two rigidity states, and wherein the bearing bushing is configured to introduce a preloading force into the elastomer element;
wherein the inner ring is radially elastic, and is disposed on a sleeve via at least two eccentric rings, wherein the at least two eccentric rings are rotatably disposed between the inner ring and the sleeve in order to introduce the preloading force into the elastomer element.

**2**. The bearing bushing according to claim **1**, wherein the inner ring has a tapered and radially elastic design, wherein the sleeve can move axially, in order to introduce the preloading force into the elastomer element, and wherein the inner ring is axially fixed in place, at least at one side.

**3**. The bearing bushing according to claim **1**, wherein the outer ring has numerous ramps on an inner circumferential surface, wherein the respective ramps interact radially with a respective tapered element, non-rotatably disposed on the elastomer element.

**4**. The bearing bushing according to claim **1**, wherein the outer ring has a circumferential groove on an inner circumferential surface, wherein an annular clamping element is disposed in the groove, and wherein a diameter of the annular clamping element can be reduced, in order to introduce the preloading force into the elastomer element.

**5**. The bearing bushing according to claim **1**, wherein the elastomer element has an eccentric design, wherein at least one further eccentric elastomer element is disposed axially adjacent to the elastomer element, and wherein the elastomer element and the at least one further eccentric elastomer element can rotate independently of one another, in order to introduce the preloading force into at least the one elastomer element.

**6**. The bearing bushing according to claim **1**, wherein a first and second washer are disposed on the inner ring such that they can move axially, wherein the first and second washers can be displaced axially against the elastomer element in order to introduce the preloading force into the elastomer element.

7. The bearing bushing according to claim **6**, wherein the elastomer element has two legs which are at least in part spaced apart from one another.

8. The bearing bushing according to claim **1**, further comprising at least one actuator for changing the rigidity of the bearing bushing.

9. A bearing bushing for a vehicle, comprising:

an inner ring;

an outer ring;

an elastomer element disposed radially between the inner ring and the outer ring; and

an actuator configured to cause an application of a force on the elastomer element in a radial direction against at least one of the inner ring and outer ring to alter a rigidity of the bearing bushing;

wherein the outer ring includes an inner surface defining a circumferential groove, wherein the bearing bushing includes a clamp located in the circumferential groove, and wherein the actuator is configured to force the clamp radially inward to increase the rigidity of the bearing bushing.

10. The bearing bushing of claim **9**, further comprising an axially-displaceable ring coupled to the actuator and configured to displace along a central axis of the bearing bushing.

11. The bearing bushing of claim **10**, wherein the axially-displaceable ring is tapered such that axial displacement of the axially-displaceable ring causes radial compression of the elastomer element to increase the rigidity of the bearing bushing.

12. The bearing bushing of claim **11**, wherein the inner ring is disposed about a sleeve, and the inner ring is radially elastic such that the inner ring deforms radially as the axially-displaceable ring displaces along the central axis.

13. The bearing bushing of claim **10**, wherein the axially-displaceable ring is a washer abutting an axial side of the elastomer element, and axial displacement of the washer compresses the elastomer element in an axial direction.

14. The bearing bushing of claim **13**, further comprising a second ring abutting an opposite axial side of the elastomer element.

15. The bearing bushing of claim **10**, wherein the elastomer element includes two legs axially spaced apart and converging toward one another.

16. A bearing bushing for a motor vehicle, comprising:

an inner ring;

an outer ring; and

an elastomer element disposed radially between the inner ring and the outer ring, wherein the bearing bushing can be switched between at least two rigidity states, and wherein the bearing bushing is configured to introduce a preloading force into the elastomer element;

wherein the outer ring has numerous ramps on an inner circumferential surface, wherein the respective ramps interact radially with a respective tapered element, non-rotatably disposed on the elastomer element.

17. The bearing bushing of claim **16**, wherein the outer ring has a circumferential groove on an inner circumferential surface, wherein an annular clamping element is disposed in the groove, and wherein a diameter of the annular clamping element can be reduced, in order to introduce the preloading force into the elastomer element.

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