US 20190263211A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2019/0263211 A1**

**ROSENFELD et al.** (43) **Pub. Date: Aug. 29, 2019**

(54) **ACTIVE WHEEL SUSPENSION ELEMENT**

(71) Applicant: **SCHAEFFLER TECHNOLOGIES AG & CO. KG**, Herzogenaurach (DE)

(72) Inventors: **Jochen ROSENFELD**, Erlangen (DE); **Kilian MARSING**, Hetzles (DE); **Klaus-Peter KOENEKE**, Oberreichenbach (DE); **Hartmut KREHMER**, Erlangen (DE); **Harald HOCHMUTH**, Hagenbuechach (DE)

(73) Assignee: **SCHAEFFLER TECHNOLOGIES AG & CO. KG**, Herzogenaurach (DE)

(21) Appl. No.: **16/318,433**

(22) PCT Filed: **Jun. 20, 2017**

(86) PCT No.: **PCT/DE2017/100516**

§ 371 (c)(1),
(2) Date: **Jan. 17, 2019**

(30) **Foreign Application Priority Data**

Jul. 22, 2016 (DE) ..... 102016213424.8

**Publication Classification**

(51) **Int. Cl.**

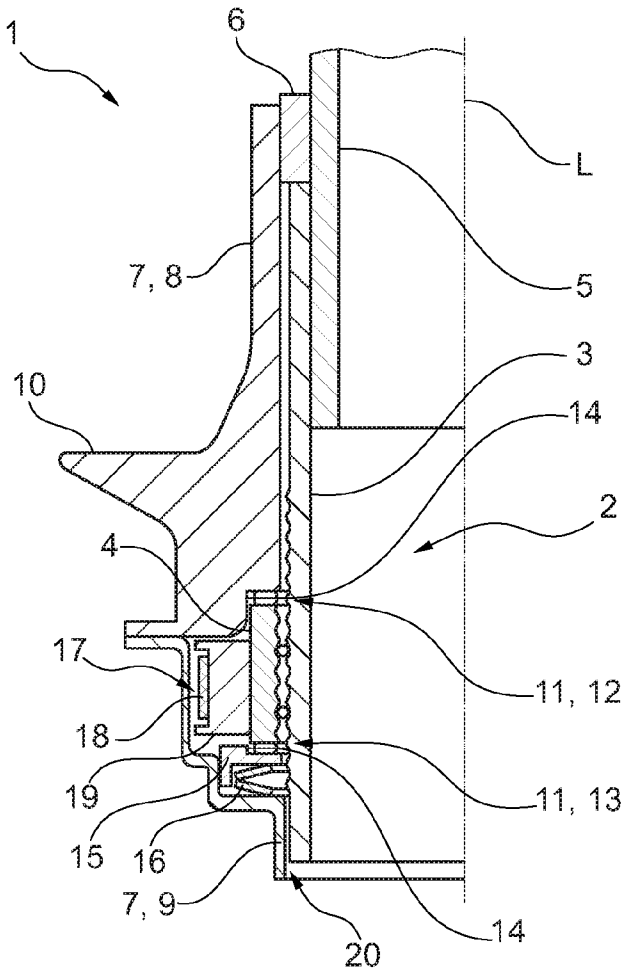
| | |
|---|---|
| ***B60G 17/02*** | (2006.01) |
| ***F16C 19/10*** | (2006.01) |
| ***F16C 19/30*** | (2006.01) |
| ***F16C 25/08*** | (2006.01) |
| ***F16H 25/22*** | (2006.01) |

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

CPC ..... ***B60G 17/021*** (2013.01); ***F16C 19/10*** (2013.01); ***F16C 19/305*** (2013.01); ***F16C 25/083*** (2013.01); ***F16H 25/2204*** (2013.01); *F16C 2326/05* (2013.01); *B60G 2202/42* (2013.01); *B60G 2204/418* (2013.01); *B60G 2204/419* (2013.01); *B60G 2500/30* (2013.01); *B60G 2202/32* (2013.01)

(57) **ABSTRACT**

An active wheel suspension element has a ball screw drive having a screw drive with a threaded spindle and a spindle nut which is mounted in a housing via an axial bearing. The axial bearing is formed as a rolling bearing, whose rolling element rolls directly on the spindle nut.



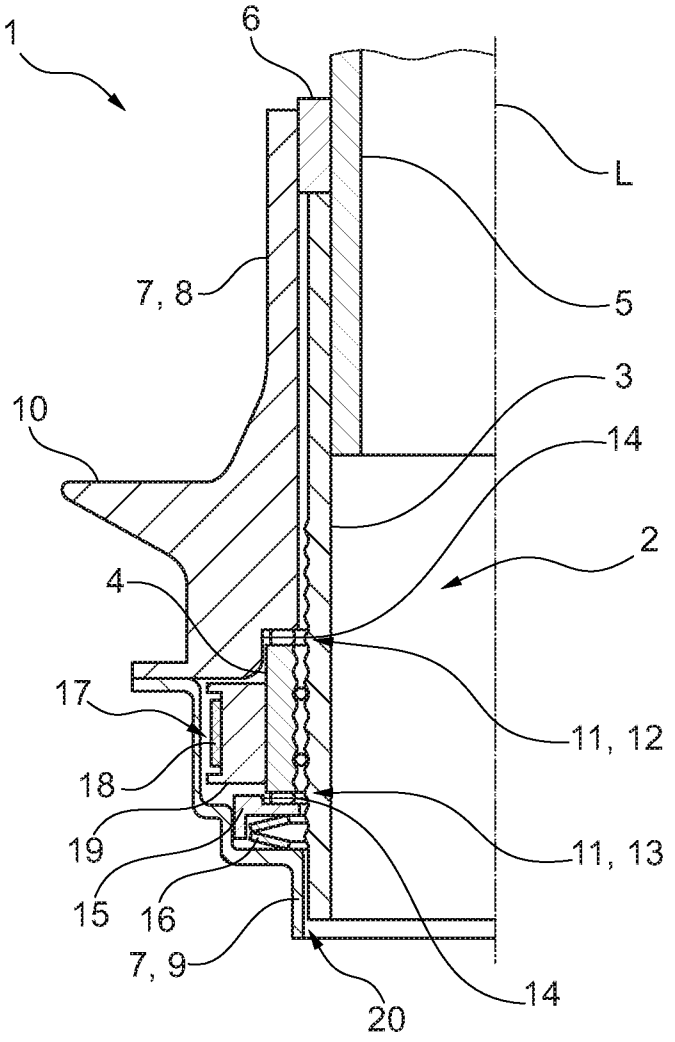



Fig. 1

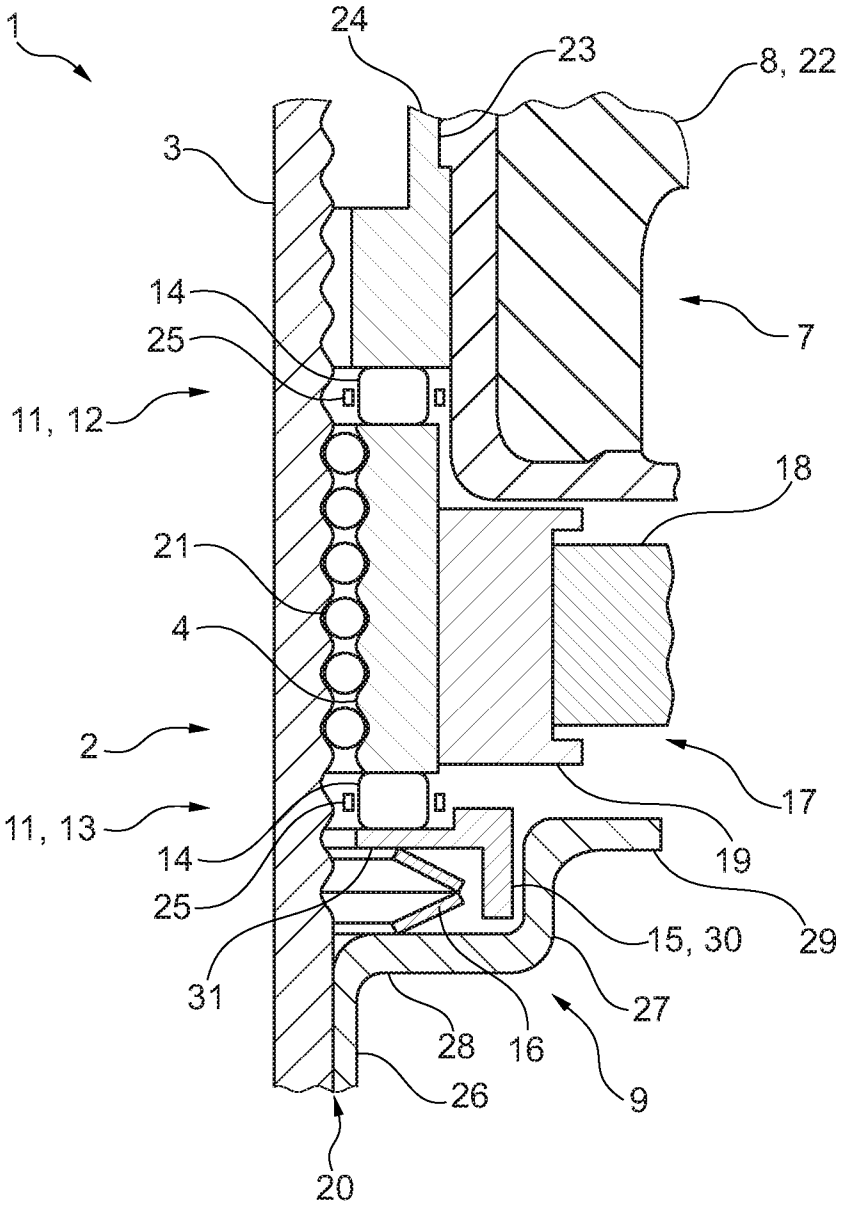

1
24
23
8, 22
3
14
25
7
11, 12
18
21
4
2
17
11, 13
19
14
25
29
15, 30
31
27
28
16
9
26
20

Fig. 2

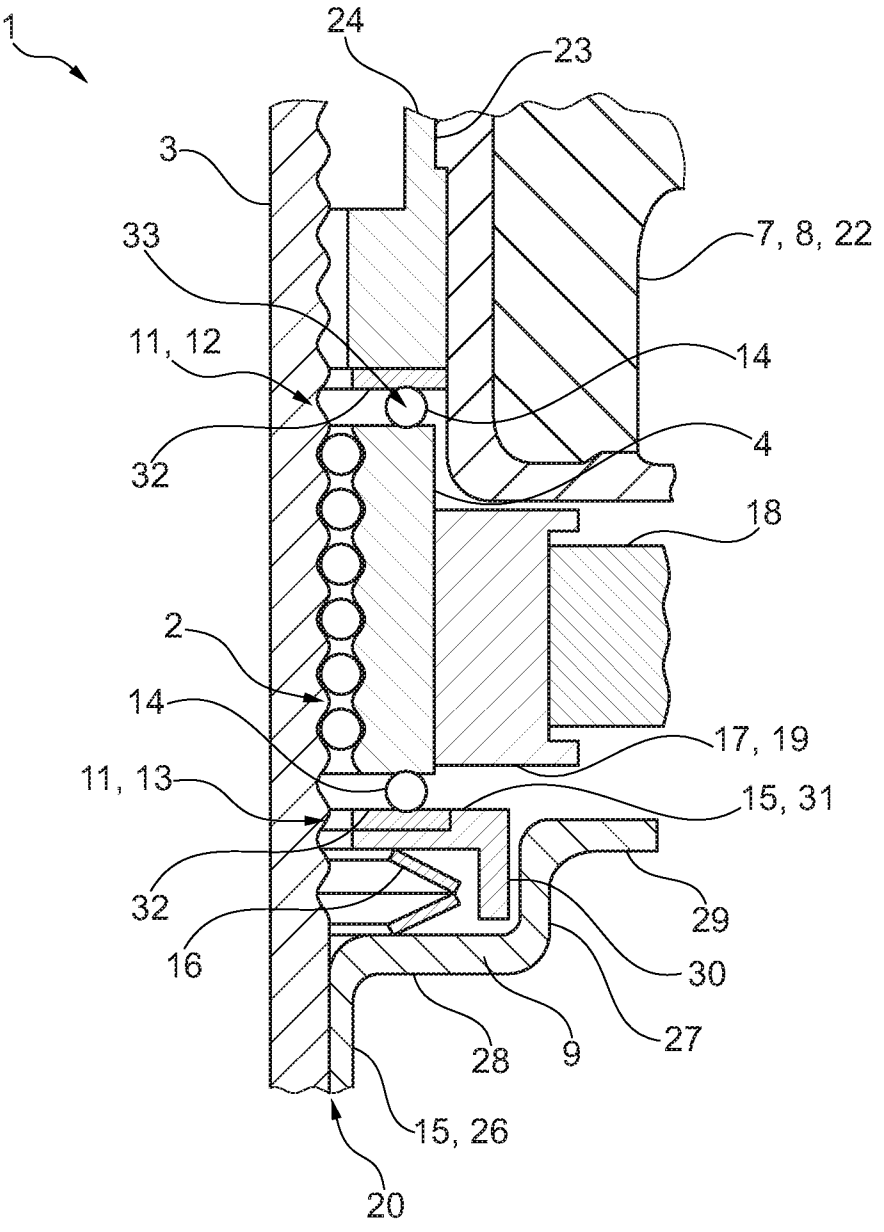

1
24
23
3
7, 8, 22
33
11, 12
14
4
32
18
2
14
17, 19
11, 13
15, 31
32
29
16
30
27
28
9
15, 26
20

Fig. 3

# ACTIVE WHEEL SUSPENSION ELEMENT

## CROSS-REFERENCE TO RELATED APPLICATIONS

**[0001]** This application is the U.S. National Phase of PCT/DE2017/100516 filed Jun. 20, 2017, which claims priority to DE 102016213424.8 filed Jul. 22, 2016, the entire disclosures of which are incorporated by reference herein.

## TECHNICAL FIELD

**[0002]** The disclosure relates to a suitable active wheel suspension element for a chassis of a motor vehicle.

## BACKGROUND

**[0003]** An active wheel suspension element for the adjustable spring suspension of a wheel of a motor vehicle is known from the DE 10 2013 222 648 A1. Two mounting elements of the known wheel suspension element are provided for its mounting to an element that is supporting the structure of the vehicle on the one hand and to an element that is supporting the wheel on the other hand. A suspension spring is braced between one of these mounting elements and an adjustable spring seat. The adjusting of the spring seat is possible via a linear actuator, which includes a rotation motor and a transmission. The transmission of the known wheel suspension element may refer to a ball screw drive or to a planetary roller screw drive.

**[0004]** Further examples of adjustable suspension elements are disclosed in the documents DE 10 2007 026 606 A1, DE 10 2007 025 468 A1 and EP 1 479 542 A2.

## SUMMARY

**[0005]** This disclosure is based on an objective to develop an active wheel suspension element in comparison to the mentioned prior art with respect to a particularly compact and at the same time sturdy design.

**[0006]** This objective is achieved via a wheel suspension element featuring the characteristics disclosed below.

**[0007]** The wheel suspension element is designed as an active wheel suspension element, which works in association with a screw drive that comprises a threaded spindle and a spindle nut. The spindle nut is hereby mounted in such a way within a housing of the wheel suspension element via an axial bearing that it can be rotated, but not shifted. The axial bearing of the spindle nut is designed as a rolling bearing, wherein the rolling elements, e.g. the balls, rolls or needles roll directly on the spindle nut. The spindle nut itself thus provides at least one rolling track for the rolling elements of the axial bearing. A rolling track for the respective rolling elements of the axial bearing i can be formed at each end face of the spindle nut.

**[0008]** In the case that the screw drive is designed as a ball screw drive or the like that is functioning with rolling elements, such as rollers, various types of tracks for the rolling element, in particular tracks of the axial bearing on the one hand and on the other hand tracks of the spindle drive, are formed via the spindle nut. By well-known heat treatment methods it is possible to achieve suitable characteristics of the spindle nut for the rolling bearings. The formation of the tracks of the axial rolling bearings directly via the spindle nut favors the compact structure of the wheel suspension element both in radial as well as in axial direction.

**[0009]** According to one possible embodiment, the axial bearing of the wheel suspension element includes an axial ring that can be variably positioned in relation to the housing. The variable positioning can be provided e.g. via an adjustability of the axial ring via a thread or via intermediate plates of varying thickness, e.g. shims, that can be inserted selectively. In any case, the axial ring represents a bearing ring of one of the two axial rolling bearings, which together form the axial bearing of the wheel suspension element.

**[0010]** In a particularly embodiment, the axial ring is spring-loaded in relation to the housing, wherein the spring-loading extends in axial direction. For the spring-loaded support of the axial ring at the housing, e.g. a plate spring or an arrangement of several plate springs is suitable. The rolling elements, in particular the rolls or needles, of the axial rolling bearing can either roll directly on the axial ring that is mounted in a spring-loaded manner in the housing, or it can roll via an insertion of an axial bearing disk. In both cases, the axial ring can be designed as an L-section ring, which can be supported towards the radial outside by forming a plain bearing at the housing. Due to the angled cross-section of the axial ring, e.g. L-section ring, a support of the spring arrangement, in particular of the plate spring arrangement, is provided in an embodiment, which exerts a force in axial direction onto the L-section ring, in radial direction towards the outside. A cylindrical section, e.g. a sleeve section of the L-section ring is hereby placed around the spring arrangement in a ring-shaped manner. On the other hand, axial forces are transferred between the spring arrangement and a disc section of the L-section ring which is adjacent to the sleeve section. When the spring arrangement is compressed to its maximum, the L-section ring can function as a blocking protection, so that a remaining spring path of the spring arrangement will be retained, e.g. that it does hit on the block.

**[0011]** The force transmission between the spring arrangement and the disk section of the L-section ring can be carried out in a ring-shaped area according to this embodiment, whose diameter deviates from the partial circle of the axial rolling bearing by less than half of the width of the rolling elements of this axial bearing when measured in radial direction of the screw drive. This means that an imagined cylinder that runs concentrically towards the center axis of the screw drive, which is places in the center through this ring-shaped area, in which the spring arrangement exerts an axial force onto the L-section ring, intersects the rolling elements of the axial bearing, which comprises the L-section ring on the one hand and the spindle nut as bearing ring on the other side.

**[0012]** The spindle nut can be basically driven via an electrical direct drive or via a transmission, e.g. a gear transmission or a continuously variable transmission. The driving of the spindle nut can e.g. be carried out via a belt drive that is designed as a reduction gear unit. To accomplish this, a belt pulley, which is located around the spindle nut or which is directly formed by the spindle nut that is positioned within the housing of the wheel suspension element, protrudes in one embodiment both the spring-loaded axial ring as well as the spring arrangement that is provided for its spring-loading in radial direction, with reference to the longitudinal axis of the screw drive.

**[0013]** The housing or a part that is solidly connected to the housing of the wheel suspension element also forms in one embodiment a seat for a helical spring, which functions

as a suspension spring. The active wheel suspension element is suitable for passenger vehicles as well as for trucks and other vehicles, e.g. for construction machines. Suspensions of different vehicles can comprise a varying number of active wheel suspension elements. It is for example possible that two active wheel suspension elements are provided at one single axis of the vehicle. In like manner it is possible that each vehicle axis is equipped with active wheel suspension elements.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0014]** In the following, several design embodiments are explained in more detail via a drawing. It is shown:

**[0015]** FIG. **1** partially a first design example of an active wheel suspension element,

**[0016]** FIG. **2** details of the wheel suspension element according to FIG. **1**,

**[0017]** FIG. **3** details of an alternative wheel suspension element in a depiction that is analog to FIG. **2**.

## DETAILED DESCRIPTION OF THE DRAWINGS

**[0018]** The following explanations refer to both design examples, if not stated otherwise. Corresponding parts or those which are principally functioning in the same way in all figures are identified with the same reference signs.

**[0019]** The wheel suspension element that is in general identified with the reference sign **1** refers to an active element of a vehicle suspension, in particular that of a passenger vehicle.

**[0020]** The wheel suspension element **1** comprises a screw drive **2**, e.g. a ball screw drive, with a threaded spindle **3** and a spindle nut **4**. An adapter element **5** is solidly connected to the threaded spindle **3**. The longitudinal axis of the screw drive **2** and thus of the entire wheel suspension element **1** is identified with L. The details of the wheel suspension elements **1** that are outlined in FIGS. **2** and **3** are respectively located on the right side of the longitudinal axis L that is not shown in these depictions.

**[0021]** By the plain bearing element **6**, which can be seen in FIG. **1**, the arrangement of spindle nut **4** and adapter element **5** can be shifted in relation to a housing **7** of the wheel suspension element **1**. A locking device, which prevents the twisting of spindle nut **4** in relation to housing **7**, is not depicted in the figures.

**[0022]** Housing **7** is composed of an upper housing portion **8** and a lower housing portion **9**. The upper housing portion **8** provides a seat area **10** for a not depicted helical spring. In comparison to the upper housing portion **8**, the lower housing portion **9** is designed with essentially thinner walls. The reference "upper" and "lower" housing portion **8**, **9** are chosen for describing a distinguishing between the housing portions **8**, **9** and do not imply any statement regarding their installation position within the motor vehicle.

**[0023]** An axial bearing **11** is located within housing **7** mainly in the area of the lower housing portion **9**, which is made as a metal sheet element, and it serves as the bearing for the spindle nut **4** within housing **7**. The axial bearing **11** is composed by an upper axial bearing **12** and a lower axial bearing **13**, wherein also in this case the reference "upper" and "lower" is merely referring to the arrangement in the figures, which does not mandatorily correspond to the arrangement within the motor vehicle.

**[0024]** As rolling elements **14** of the axial bearings **12**, **13**, rolls are provided in the design example according to FIGS. **1** and **2**, and balls for the design example according to FIG. **3**. In like manner, it is possible to combine different bearing construction types, in particular ball bearings, rolling bearings and needle bearings for the bearing of spindle nut **4** within one individual wheel suspension element **1**.

**[0025]** In all cases, the rolling elements **14** of the axial bearing **11** roll directly on the surface of spindle nut **4**. In the design example according to FIGS. **1** and **2**, the axial bearing **11** does not feature any guiding function in radial direction, whereas the axial bearing **11** according to FIG. **3** assumes in addition to its main function, e.g. the axial bearing function, also a bearing function in radial direction.

**[0026]** In each one of the design examples outlined in FIGS. **1** to **3**, the lower axial ring **13** includes an axial ring **15**, which is designed as an L-section ring. Axial ring **15** is spring-loaded via two plate springs **16** that are set one behind the other. The plate springs **16** are located in a ring-shaped space featuring an almost rectangular cross-section, which is limited on two sides via the axial ring **15** and on the other two sides via the lower housing portion **9** as well as via the threaded spindle **3**. The spring deflection of the plate springs **16** is dimensioned in such a way, that the two axial bearings **12**, **13** are operating under tension in each operating mode of the wheel suspension element **1**.

**[0027]** Spindle nut **4**, which is located in axial direction, e.g. in longitudinal direction of the longitudinal axis L, between the spring-loaded axial ring **15** and the upper housing portion **8**, is driven via a belt drive **17**. A belt is hereby marked with **18**, and a belt pulley, which is rotationally connected to as well as enclosing spindle nut **4**, is marked with **19**. Along with spindle nut **4**, belt drive **17** is located axially between the plain bearing **6**, which is arranged in the upper portion in the arrangement according to FIG. **1**, and an optional plain bearing **20**, which is arranged in the lower portion in the arrangement according to FIG. **1** as well as in the arrangement according to FIG. **3**, which can—in deviation to the simplified depiction—also reach around a separate, ring-shaped plain bearing element. In the embodiment according to the FIGS. **1** and **2**, the axial bearing **11**, via which spindle nut **4** is mounted between the two housing portions **8**, **9**, is carrying out a pure axial bearing function, while the radial bearing is being carried out via plain bearing **6** as well as by plain bearing **20**. In this case, a radial bearing of spindle nut **4** is provided exclusively via the bearing elements **21**, in particular balls, of screw drive **2**. A ball return system within screw drive **2** is not depicted.

**[0028]** The upper housing portion **8** is designed with multiple parts both in the design example according to the FIGS. **1** and **2** as well as in the design example according to FIG. **3**. In detail, an outer housing portion **22**, an intermediate housing portion **23**, as well as an inner housing portion **24** can be seen, wherein the rolling elements **14**, e.g. the rollers, roll directly on the inner housing portion **24** in the case of FIG. **2**. Cages **25** are furthermore indicated in FIG. **2**, which guide the rolling elements **14** within the axial bearings **12**, **13**.

**[0029]** In the design example according to the FIGS. **1** and **2**, the design of the lower housing portion **9** corresponds to the design according to FIG. **3**. The lower housing portion **9** is designed in a stepped manner, wherein an inner cylindrical section **26**, which is located on the side of the plate

springs **16** that is facing away from the axial bearing **11**, provides a bearing component of the plain bearing **20**. A middle cylindrical section **27**, which is also an integral component of the lower housing portion **9**, is connected to the inner cylindrical section **26** via an inner disc section **28**. The inner disc section **28** is located within a normal plane with reference to the longitudinal axis L and is arranged parallel to the axial ring **15**, wherein one of the disc springs **16** contacts the inner disc section **28** and the other disc spring **16** contacts the axial ring **15** within a respectively ring-shaped area. The two ring-shaped areas are located within an imagined cylinder that is aligned concentrically with regards to the longitudinal axis L, which intersects the rolling elements **14** of both axial bearings **12**, **13**.

**[0030]** The cylindrical inner surface of the central cylindrical section **27** provides a limit stop for the axial ring **15** in radial direction. A cylindrical sleeve section of the axial ring **15**, which is marked with **30**, can be slightly shifted in relation to the central cylindrical section **27** of the lower housing portion **9**. The sleeve section **30** represents one of the side surfaces of the substantially rectangular cross-section of the ring-shaped space in which the arrangement of the disc springs **16** is located. A disc section of the axial ring **15**, which is marked with **31**, adjoins the sleeve section **30** in radial direction towards the inside, which forms a further side surface of the before-mentioned ring-shaped space, which is rectangular in cross-section. A plane that is running through the disc section **31** intersects an outer disc section, that is marked with **29**, in the arrangements according to FIGS. **1** to **3**, which is a component of the lower housing portion **9**.

**[0031]** In contrast to the design example according to the FIGS. **1** and **2**, the axial bearings **12**, **13** of the wheel suspension element **1** according to FIG. **3** is not designed as a rolling bearing, but as an axial ball bearing. Just like the rolling elements **14**, which are designed as rollers in the case of the FIGS. **1** and **2**, the ball-shaped rolling elements **14** of the axial bearing **11** according to FIG. **3** roll directly on the end faces of spindle nut **4**. For this purpose, ball tracks **33** are located within both end faces of spindle nut **4**. On the opposite sides of the axial bearing **12**, **13**, that is on the side of the inner housing portion **24** or on the side of the axial ring **15**, the rolling elements **14**, in particular the balls, of the wheel suspension element **1** according to FIG. **3** roll on a respectively separate axial bearing disc **32**. In contrast to the configuration according to FIG. **4**, it is also possible to implement construction types, in which a separate axial bearing disc **32** is only provided on one of the end faces of axial bearing **11**. In like manner, it is possible to implement modifications of the design example according to FIGS. **1** and **2**, in which the rolling elements **14**, in particular the rollers, do not roll directly on the inner housing portion **24** as well as on the disc section **31** of axial ring **15**, but at least in one case on a separate bearing disc.

LIST OF REFERENCE SIGNS

**[0032]** **1** Wheel suspension element
**[0033]** **2** Screw drive
**[0034]** **3** Threaded spindle
**[0035]** **4** Spindle nut
**[0036]** **5** Adapter element
**[0037]** **6** Plain bearing element
**[0038]** **7** Housing
**[0039]** **8** Upper housing portion
**[0040]** **9** Lower housing portion
**[0041]** **10** Seat area
**[0042]** **11** Axial bearing
**[0043]** **12** Upper axial bearing
**[0044]** **13** Lower axial bearing
**[0045]** **14** Rolling bearing
**[0046]** **15** Axial ring
**[0047]** **16** Plate spring
**[0048]** **17** Transmission, belt drive
**[0049]** **18** Belt
**[0050]** **19** Belt pulley
**[0051]** **20** Plain bearing
**[0052]** **21** Rolling element of the screw drive
**[0053]** **22** Outer housing portion
**[0054]** **23** Intermediate housing portion
**[0055]** **24** Inner housing portion
**[0056]** **25** Cage
**[0057]** **26** Inner cylindrical section
**[0058]** **27** Middle cylindrical section
**[0059]** **28** Inner disc section
**[0060]** **29** Outer disc section
**[0061]** **30** Sleeve section
**[0062]** **31** Disc section
**[0063]** **32** Axial bearing disc
**[0064]** **33** Ball track
**[0065]** L Longitudinal axis

**1**. An active wheel suspension element comprising:

a screw drive which includes a threaded spindle and a spindle nut which is mounted in a housing via an axial bearing, wherein the axial bearing is a rolling bearing with rolling elements that roll directly on the spindle nut.

**2**. The active wheel suspension element according to claim **1**, wherein the axial bearing has an axial ring positioned in a variable way within the housing.

**3**. The active wheel suspension element according to claim **2**, wherein the axial ring is spring-loaded in relation to the housing.

**4**. The active wheel suspension element according to claim **3**, wherein the axial ring is mounted in a spring-loaded manner in the housing at least via a plate spring.

**5**. The active wheel suspension element according to claim **2**, wherein the rolling elements roll directly on the axial ring.

**6**. The active wheel suspension element according to claim **2**, wherein the axial ring is designed as an L-section ring, which is supported in radial direction by forming a plain bearing at the housing.

**7**. The active wheel suspension element according to claim **1**, wherein a belt-drive transmission is provided to drive the spindle nut.

**8**. The active wheel suspension element according to claim **1**, wherein rollers or needles are provided as the rolling elements of the axial bearing.

**9**. The active wheel suspension element according to claim **1**, wherein balls are provided as the rolling elements of the axial bearing.

**10**. The active wheel suspension element according to claim **1**, wherein the screw drive is designed as ball screw drive.

**11**. An active wheel suspension element comprising:
a housing;
a screw drive extending along a longitudinal axis and configured to rotate relative to the housing, the screw drive including:
a threaded spindle having threads extending along the longitudinal axis, and
a spindle nut radially spaced from the threaded spindle and having a pair of radially-extending surfaces, the spindle nut rotatably coupled to the housing via a rolling bearing having rolling elements that directly contact and roll directly on the spindle nut.

**12**. The active wheel suspension element of claim **11**, wherein the axial bearing has an axial ring extending about the longitudinal axis and variably positioned within the housing.

**13**. The active wheel suspension element of claim **12**, wherein the axial ring is spring-loaded against the housing.

**14**. The active wheel suspension element of claim **13**, wherein at least one of the rolling elements directly contacts and rotates on a radially-extending surface of the axial ring.

**15**. The active wheel suspension element of claim **11**, wherein at least one of the rolling elements directly contacts and rolls direction on a radially-extending surface of the housing.

* * * * *