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(54) TIRE PRESSURE CONTROL SYSTEM HAVING ROTARY FEEDTHROUGH

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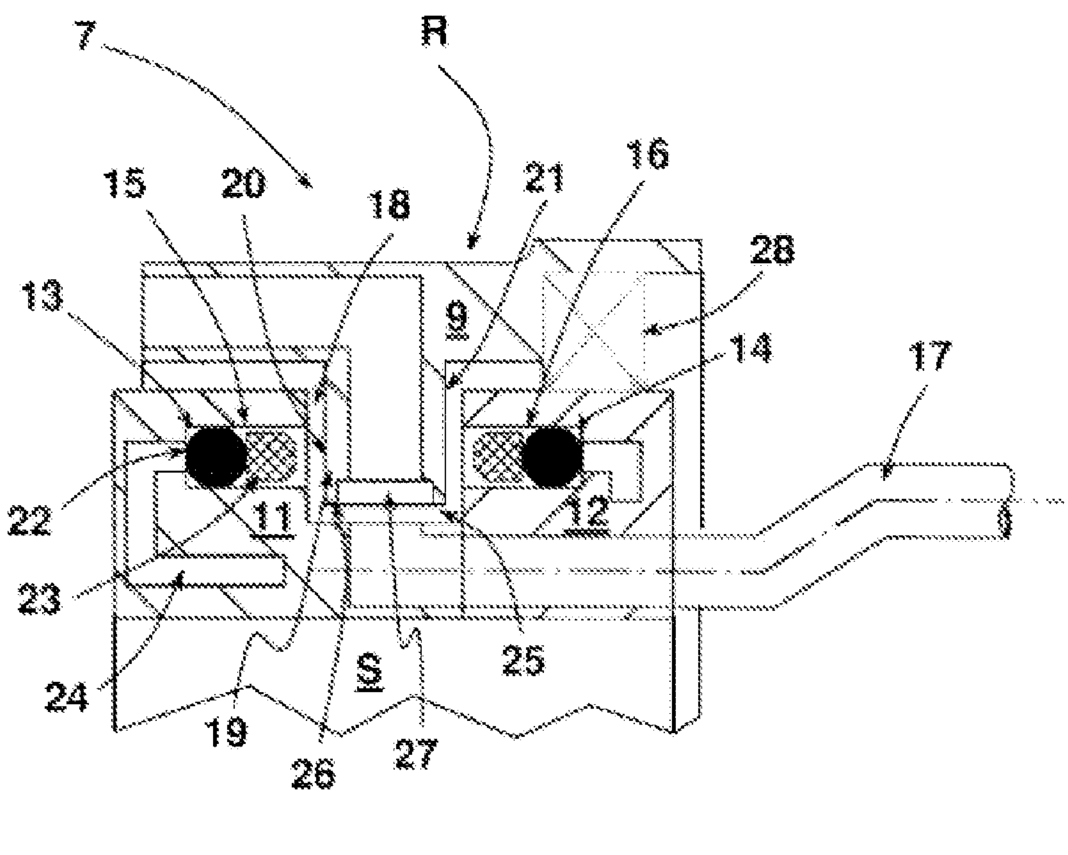
(57) **ABSTRACT**

The invention relates to a tire pressure control system for a motor vehicle, comprising a rotary feedthrough (**7**) having a stator and a rotor for transferring compressed air, fed from a compressed air source on the vehicle side to the rotor (R) designed for supporting a wheel. The rotary feedthrough (**7**) comprises an annular chamber (**25**) present between the rotor (R) and the stator (S) that can be sealed off by activatable seals (**15**, **16**). A stator side and a rotor side air channel (**8**, **17**) open into said chamber. The seals (**15**, **16**) that can be activated for the purpose of compressed air transfer are disposed spaced apart in an axial arrangement having the same or approximately the same spacing from the rotary axis of the rotor (R). According to the invention, either the seals (**15**, **16**) are designed for operating facing each other and an annular grove (**18**) present between the seals (**15**, **16**) and open to the rotor (R) in the radial direction engages in rotor flange (**19**). The seals (**15**, **16**) act against the opposite outer sides (**20**, **21**) thereof when activated, for the purpose of sealing off the annular chamber. According to an alternative embodiment, the seals are designed to operate facing away from each other and the seals are disposed on a stator flange engaging in an annular grove and, when activated, act for the purpose of sealing the annular chamber against the groove walls of the rotor side annular groove, which are situated opposite one another. The part of the annular grove (**18**) sealed off by the activated seals (**15**, **16**) in each case forms the annular chamber (**25**).



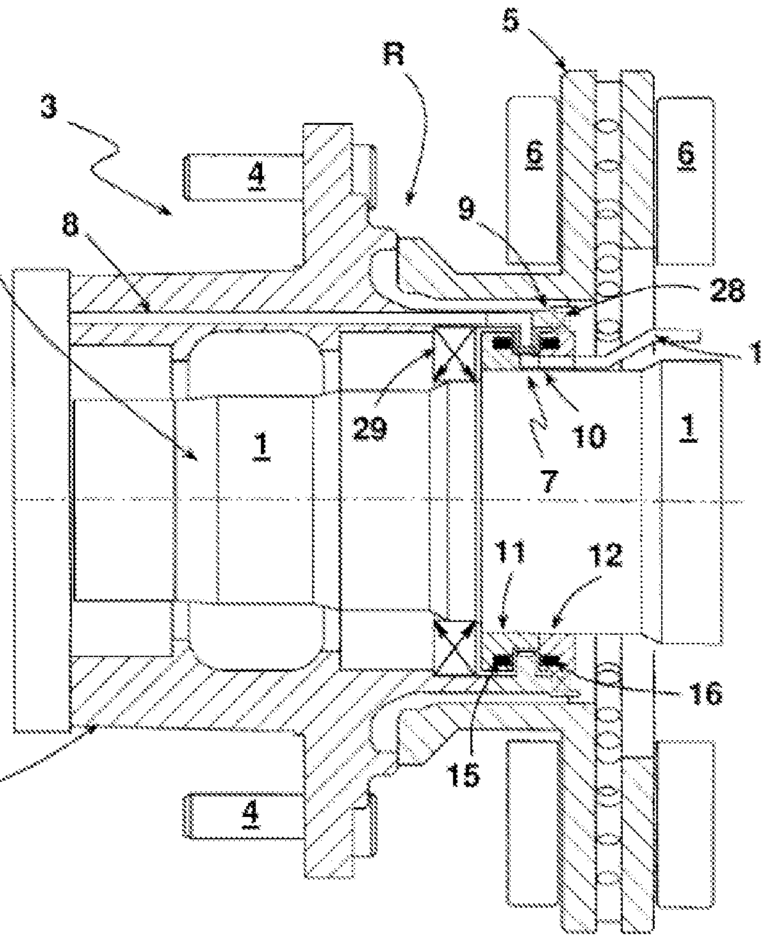

5
R
3
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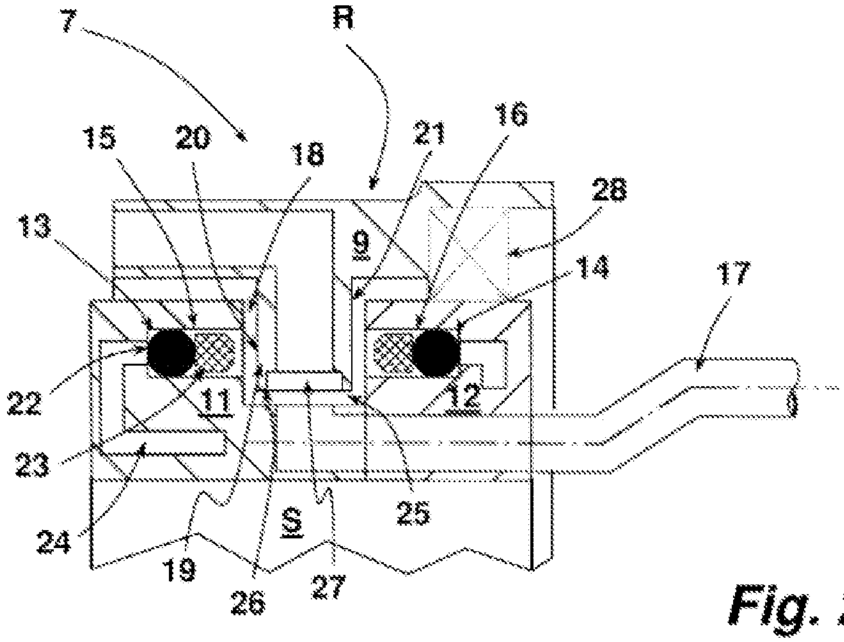
Fig. 1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27

Fig. 2

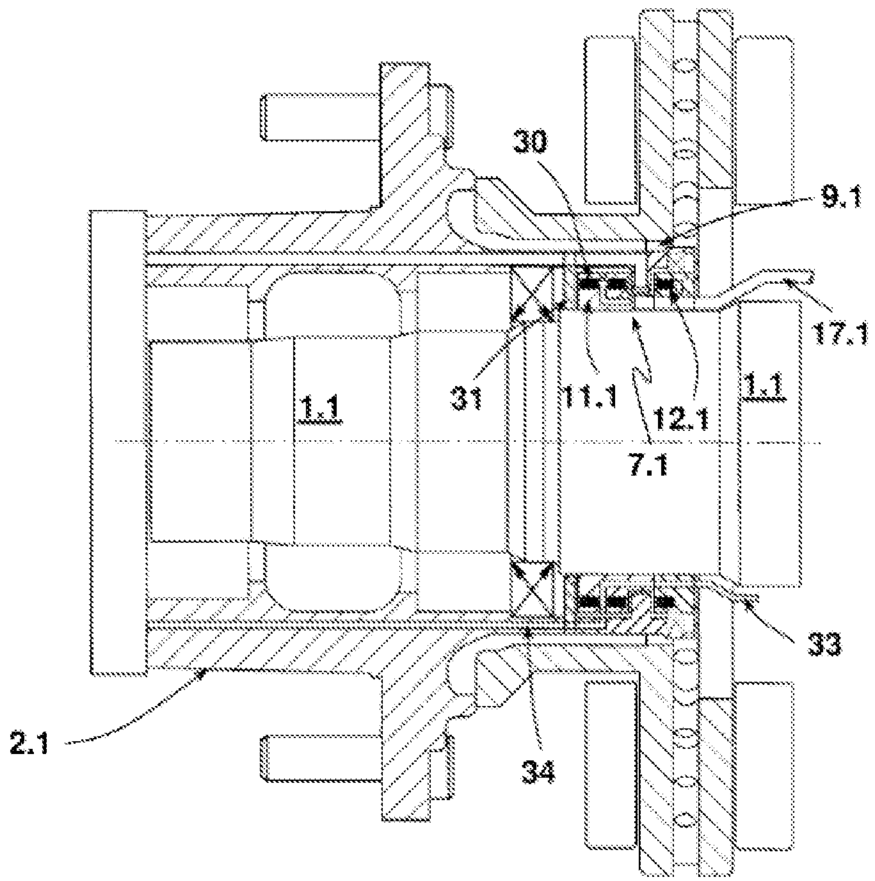
30
9.1
17.1
1.1
31
11.1
12.1
1.1
7.1
33
2.1
34

Fig. 3

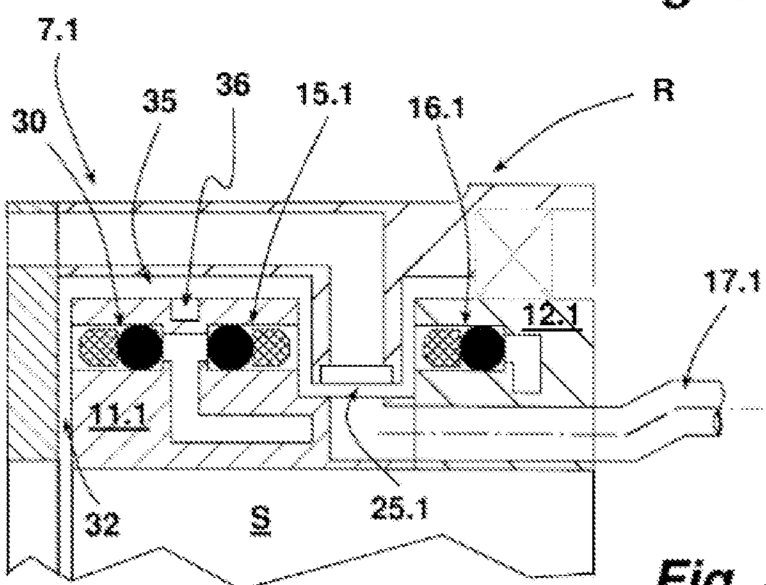
7.1
35
36
15.1
16.1
R
30
17.1
12.1
11.1
32
S
25.1

Fig. 4

TIRE PRESSURE CONTROL SYSTEM HAVING ROTARY FEEDTHROUGH

[0001] The invention relates to a tire pressure control system for a motor vehicle, comprising a rotary feedthrough having a stator and a rotor for transferring compressed air, fed from a compressed air source on the vehicle side to the rotor designed for supporting a wheel, rotary feedthrough which comprises an annular chamber present between the rotor and the stator that can be sealed off by activatable seals, into which both a stator side and a rotor side channel open. The invention further relates to a feedthrough for a tire pressure control system.

[0002] Tire pressure control systems are used in motor vehicles, in commercial vehicles for instance, such as trucks, tractors or earth moving machines, in order to be able to adapt the tire pressure present in the tire to different operating situations of the motor vehicle. An adaptation of the tire pressure occurs primarily as a function of the ground to be driven on and/or of the load. By way of the tire pressure, the footprint of the tire can be modified. In the case of a lower tire pressure, a tire has a larger footprint than with a higher tire pressure. For this reason, if the ground is soft, it is preferable to drive with a lower tire pressure and with a larger footprint than in the case of a consolidated road surface. The tire pressure can also be changed as a function of the given loading state.

[0003] Such tire pressure control systems comprise a rotary feedthrough in order to transfer compressed air from a vehicle side compressed air source to the rotatably mounted wheel, for the purpose of increasing the inner tire pressure. Such a rotary feedthrough comprises a stator arranged on the vehicle side and a rotor which is arranged on the wheel side and separated from said stator by a movement gap. The stator and the rotor are arranged axially with respect to each other and with respect to the rotary axis of the wheel. For the transfer of compressed air, the stator and the rotor have annular mutually opposite, with respect to the movement slit, and mutually facing open grooves or chambers which are sealed off by activatable seals, as described in EP 1 095 799 B1, during the compressed air transfer in order to form a compressed air transfer chamber. On the wheel side, an air duct leading to the rim of the wheel is arranged on the rotor of the rotary feedthrough. Said air duct passes through the rim in an opening, and it opens into the tire interior. Typically, a controllable valve is inserted in the wheel side air duct, valve which is opened for the process of the tire pressure regulation, and closed after the completion of the process. The pressurized air itself is provided by a compressor arranged on the vehicle side. Typically, the compressor that is present in any case in commercial vehicles for operating the braking system is used as compressor.

[0004] Increasingly, tire pressure control systems are also used in passenger cars. When such tire pressure control systems are used in passenger cars, the problems that arise are connected with the fact that, in contrast to commercial vehicles, there is hardly any installation space available in the area of the hub of the wheel for accommodating a rotary feedthrough. Tire pressure control installations are also used in passenger cars primarily with a view to providing in each case, as a function of the loading, an optimal tire pressure, in order to achieve as optimal as possible a rolling motion of the wheel in terms of resistance to rolling, the purpose of which is again to reduce the fuel consumption.

[0005] Although the tire pressure control system disclosed in EP 1 095 799 B1 can be used without problem in commercial vehicles, it is in fact not sufficiently compact in its structure so that it can be used in a passenger car. Moreover, in the case of rotors that turn at higher rotation speed in comparison to commercial motor vehicles, the seals applied against them undergo wear more rapidly due to the rotors being rotated at higher speed. Due to the friction-caused heating in the case of activated seals, it can sometimes be necessary to apply an appropriately high pressure for the purpose of sealing off the compressed air transfer chamber.

[0006] On the basis of the discussed prior art, the invention therefore is based on the problem of improving a tire pressure control system of the type mentioned at the start, in such a manner that it is not only suitable for being installed even under the tight installation conditions of a passenger car, but such that it also meets the requirements placed on such a rotary feedthrough in a passenger car.

[0007] According to the invention, this problem is solved by a tire pressure control system mentioned at the start and according to the preamble,

[0008] in which, for the purposes of a compressed air transfer, activatable seals are disposed in an axial arrangement having the same or approximately the same radial spacing from the rotary axis of the rotor, and

[0009] in which either the seals are designed to operate facing each other, and in which a rotor flange engages in an annular groove present between the seals and open to the rotor in the radial direction, against the opposite outer sides of which the seals act, for the purpose of sealing off the annular chamber,

[0010] or in which the seals are designed to operate facing away from each other, and the seals are disposed on a stator flange engaging in an annular groove of the rotor, and, when activated, act, for the purpose of sealing off the annular chamber, against the groove walls of the rotor side annular groove, which are situated opposite each other,

[0011] and the part of the annular groove which in each case is sealed off from the activated seals forms the annular chamber.

[0012] In this tire pressure control system, in contrast to the tire pressure control systems according to the prior art, the seals are positioned in an axial arrangement and not in a radial arrangement with respect to each other. This means that the seals have the same or at least approximately the same radial spacing from the rotary axis of the rotor. Thus, on each one of the two seals of such a seal pair, the sealing face of the rotor that works together with said sealing pair acts with the same rotary speed. Accordingly, the two seals are subjected to the same heating and to the same wear. The axial arrangement of the seals has the consequence that the rotary feedthrough, due to the small installation space in the radial direction that it requires, can be built in without problem even in motor vehicles having a small installation space in the area of the wheel or of the hub. Therefore, these tire pressure control systems and the associated rotary feedthroughs are particularly suitable for use in passenger cars.

[0013] For the formation of an annular chamber, into which the stator side and the rotor side air ducts open, and through which, when sealed off, the transfer of the compressed air from the stator to the rotor occurs, can be provided by two alternative designs. The designs differ in the alignment of the seals with regard to their direction of action and the resulting differences in the design of the rotary feedthrough. According to the first alternative, the seals are designed so that they operate facing each other. These seals act in an annular groove which is open in the radial direction toward the rotor. A rotor flange, whose parallel outer sides form the faces against which the seals, when activated, act, engages in this annular groove. In this design, the part of the annular groove which is sealed off by the activated seals forms the annular chamber, wherein the annular chamber is associated with the stator in this embodiment example. In this design, the seals, when activated, act on the rotor flange like the brake linings on the disk of a disk brake.

[0014] According to the second alternative, the seals are designed so they operate facing away from each other. These seals are located on a stator flange, which in turn engages in an annular groove of the rotor. The seals, when activated, act against the parallel walls of the rotor side annular groove. In this design as well, the annular chamber is the part of the annular groove closed off by the activated seals, annular groove which is associated with the rotor in this embodiment.

[0015] In both alternatives, the seals of a seal pair act on two mutually parallel faces of the rotor—in the first alternative design on the rotor flange, and in the second alternative design against the groove walls. Besides the small installation space required in the radial direction, this design has the advantage that the activation of the seals occurs neutrally with regard to a force introduction into the wheel bearing.

[0016] In the design of the described rotary feedthrough, it is particularly advantageous that without requiring a larger installation space in the radial direction, it is also possible to arrange two or more sealing arrangements located one after the other in the axial direction. This is required, for example, if the rotary feedthrough is to be designed with two or more channels, wherein, through one channel the compressed air is transferred for the inflation or deflating of the tire, and through the other channel the control compressed air for the actuation of an actuator arranged on the rotor side is transferred. Such a design can be implemented without problem even in the typically smaller available installation space in passenger cars. A two-channel rotary feedthrough can be produced with three seals. This can be achieved if one channel is designed according to the above described first alternative and the second channel according to the above described second alternative. This design can be implemented with only three seals, because the interior seal between the two outer seals separates the annular spaces of the two channels from each other.

[0017] Additional advantages and embodiments of the invention can be obtained from the following description of embodiment examples in reference to the appended drawings.

[0018] FIG. **1** shows a longitudinal section through the wheel hub of a passenger car with a rotary feedthrough according to a first embodiment of a tire pressure control system,

[0019] FIG. **2** shows a detail of the rotary feedthrough of the tire pressure control system of FIG. **1** in an enlarged representation,

[0020] FIG. **3** shows a longitudinal section through the wheel hub of a passenger car with a rotary feedthrough according to an additional embodiment of a tire pressure control system, and

[0021] FIG. **4** shows an enlarged representation of a detail of the rotary feedthrough of the tire pressure control system of FIG. **3**.

[0022] A motor vehicle, not represented in further detail for the rest, has a stub axle **1** which is connected to a drive shaft in a manner not represented in further detail, and on which a wheel hub **2** is rotatably mounted. A wheel seat **3** having several wheel bolts **4** arranged distributed over the circumference is located on the wheel hub **2**. A brake disk **5** is connected to the wheel hub **3** mounted rotatably opposite the stub axle **2**. The brake linings which work with the brake disk **5** are marked with the reference numeral **6** in FIG. **1**.

[0023] Opposite the stub axle **1** as stator S, the unit formed by the wheel hub **2** and the brake disk **5** thus forms a rotor R.

[0024] The motor vehicle is provided with a tire pressure control system. A rotary feedthrough **7** for transferring compressed air, which is provided by a compressed air source on the vehicle side, to the rotor R, is part of the tire pressure control system. To receive the transferred compressed air, the rotor R has an air channel **8** which is connected, in a manner not shown in further detail, to the interior of a tire mounted on a wheel arranged on the wheel seat **3**. The rotary feedthrough **7** comprises an annular body **9** having a design with T-shaped cross section and connected to the stub axle-side end of the wheel hub **2** of the rotor R, in a manner not represented in further detail, for example, by means of plug bolts, screws or the like. A stator ring **10** which sits rigidly on the outer side of the stub axle **1** is associated with the annular body **9** as a rotor part of the rotary feedthrough **7**. The stator ring **10** of the represented embodiment example consists of two individual annular bodies **11**, **12** in each of which a peripheral groove **13**, **14** is used to receive in each case one activatable annular seal **15**, **16**. The grooves **13**, **14** are located at the same radial spacing from the rotary axis of the rotor R. The annular seals **15**, **16** inserted therein operate in directions facing each other. The stator ring **10** is connected to an air channel **17** which is diagrammatically represented. The air channel **17** is the air channel on the vehicle side and thus the stator side through which the compressed air is fed during tire inflation. The air channel **17** is connected to a compressed air source which is not represented in further detail.

[0025] The rotary feedthrough **7** of FIG. **1** is shown again in an enlarged representation in FIG. **2**, separately without stub axle **1** and wheel hub **2**. The two annular bodies **11**, **12** of the stator ring **10** comprise a circumferential annular groove **18** which is open in the radial direction toward the annular body **9** on the rotor side. The circumferential grooves **13**, **14** for the seals **15**, **16** are introduced in the parts of the stator ring **10** which form the two mutually facing groove walls. A rotor flange **19**, as part of the rotor side annular body **9**, dips into the annular groove **18**. The two parallel outer sides **20**, **21** of the rotor flange **19**, which face away from each other, form the rotor faces against which the seals **15**, **16**, when activated, act.

[0026] The seals **15**, **16** are of identical design. Below, the seal **15** is described. The design of the seal **16** is the same. The seal **15** is arranged in the sealing groove **13** and it comprises, in the represented embodiment example, an adjusting ring **22** made of an elastomer material, which is sealed off in the radial direction and sits in the same groove. In the represented embodiment example, an O ring is used. In the direction toward the rotor flange **19**, a sliding ring **23** in the form of a Teflon ring in the represented embodiment example constitutes an additional part of the seal **15**. The sealing groove **13** is connected to a control line **24** which is connected, in a manner not shown in further detail, to a pneumatic control device. If the control line **24** is exposed to pressure, the adjusting ring **22** is moved from its position shown in FIG. **2**

in the direction of the rotor flange **19** and it pushes the sliding ring **23** against the outer side **20** of the rotor flange **19**. Since the sealing groove **14** is connected in parallel relative to the control line **24**, the two seals **15**, **16** are activated simultaneously. If the seals **15**, **16** are activated, the lower section of the annular groove **18**, which is directed toward the stator ring **10**, is sealed off. This part of the annular groove **18** forms an annular chamber **25**, through which the compressed air can be transferred from the stator ring **10** into the rotor body **9**. The air channel **17** opens in the radial direction into the annular chamber **25** in the represented embodiment example. The rotor side air channel **8** which, in the wheel hub **2** of the represented embodiment example of FIG. **1**, has an axial extension, continues into the rotor body **9** and it opens after bending also in the radial direction into the annular chamber **25**. A collecting channel **27** extending circumferentially is pierced into the front face **26** of the rotor flange **19**, which points into the annular groove **18**. Said collecting channel has a rectangular cross-sectional surface in the represented embodiment example. Due to the circumferential collecting channel **27**, the cross-sectional surface of the annular chamber **25** which is active for the purposes of the transfer of compressed air is enlarged.

[0027] Instead of providing two-part seals, as described above, it is also possible to use single piece seals. The latter can be materially homogeneous or they can be designed as composite rings, for example, with a material combination of the described embodiment example.

[0028] For the purpose of transferring compressed air from the stator ring **10** to the rotor side annular body **9**, the seals **15**, **16** are activated, as a result of which the annular chamber **25** is sealed off with respect to the remaining sections of the annular groove **18** and thus with respect to the environment. Subsequently, the pressurized air is transferred from the vehicle into the tires of the wheel. After the compressed air transfer has occurred, the seals **15**, **16** are deactivated, in particular by depressurizing the control line **24**. The seals **15**, **16**, with regard to the rotor flange, work like pliers, so that this does not lead to applying a load to the wheel bearing, as a result of the seals **15** or **16** being applied against the outer sides **20** or **21** due to the simultaneous and equal-force pressure application on the seals **15**, **16**. This is not inessential, since the control line **24** is definitely exposed to pressures of 3 bar or more in order to activate the seals **15**, **16**.

[0029] In order to prevent dirt from penetrating into the annular groove **18** from outside, the movement gap located between the rotor and the stator of the rotary feedthrough **7** is closed by corresponding dirt seals **28**, **29** (see FIG. **1**).

[0030] FIG. **3** shows a wheel bearing arrangement, as shown in principle in FIG. **1**, according to an additional embodiment of a rotary feedthrough of a tire pressure control system. The tire pressure control system of the embodiment example of FIG. **2** is designed with two channels. The first channel of the tire pressure control system operates as described above in reference to the embodiment example of FIG. **1**. The second channel is a control channel for actuating an actuator associated with the wheel. It is possible to use, for example, a valve that can be activated, through which, in the case of an appropriate actuation, air is let out of the tire interior. In FIGS. **3** and **4**, elements that are identical to those already described in regard to the embodiment example of FIGS. **1** and **2** bear the same reference numerals with the addition of "**0.1**" for the purpose of simplifying the representation.

[0031] In FIG. **3**, in the rotary feedthrough **7.1**, the compressed air transfer for inflating a tire with its stator side air channel **17.1** is shown above the rotary axis. In contrast to the design of the annular body **11**, the annular body **11.1** of the embodiment example of FIGS. **3** and **4**, supports, besides the seal **15.1**, an additional seal **30** which, relative to the seal **15.1**, is designed so that it operates facing away from the latter. For the collaboration with the seal **30**, a second rotor flange **31** is used, against whose side facing the annular body **11**, the seal **30**, when actuated, acts. Thus, the seals **15.1** and **30** are arranged in a stator flange which protrudes outward in the radial direction, and which dips in a circumferential annular groove **32** of the rotor body **9.1**. A control line **33** opens into this annular groove **32** in the radial direction outside of the seals **15**, **15.1**. To receive a pneumatic control signal, the wheel hub **2.1** has a control channel **34**. The latter leads to an actuator located on the wheel. The stator side control line **33** is connected to a pneumatic control device for controlling the actuator, in a manner which is not represented in further detail.

[0032] The rotary feedthrough **7.1** is represented again in an enlarged representation in FIG. **4**. If the seals **15.1** and **30** are activated, then they seal off the radially outer part of the annular groove **32**. This part of the annular groove **32** then forms the annular chamber **35** provided for the purposes of the transfer of compressed air. To increase the cross section of said annular chamber, a collecting channel **36** is produced in the radial outer side of the annular body **11.1**. As can be seen in FIG. **3**, the stator side control line **33** opens into said collecting channel, in particular in the radial direction. Similarly, the rotor side control channel **34** opens in the radial direction into the annular chamber **35** (see FIG. **3**).

[0033] The seals **16.1**, **15.1** and **30** of the rotary feedthrough **7** are connected parallel to a control line for the actuation of same. Therefore, the seals **16.1**, **15.1** and **30** act simultaneously on the rotor faces associated in each case with them, with the same application pressure in each case. Thus, pneumatic control signals and compressed air can be transferred simultaneously from the vehicle to the wheel, so that an effective tire pressure control with a tire pressure reduction and a tire pressure increase is possible.

[0034] It is apparent from the represented embodiment example that the seals **15**, **16** as well as **15.1**, **16.1** as well as **15.1** and **30**, which in each case act together in pairs, are in each case in an axial arrangement with respect to each other. They have the same radial spacing from the rotary axis of the wheel hub in each case. The described rotary feedthroughs clearly show that hardly any installation space is needed for the transfer of compressed air in the radial direction which is required for the tire pressure control.

[0035] The embodiment example of FIGS. **3** and **4** clearly shows that the seal **15.1** is used as an interior seal, located between the seals **16.1** and **30**, for sealing off the two annular chambers **35**, **25.1**, and thus has a dual use.

[0036] It should be understood that, in the case of a rotary feedthrough with more than two channels, the arrangement shown in the axial direction in the embodiment example of FIGS. **3** and **4** can be repeated.

[0037] The arrangement of the seals **15**, **16** or **15.1**, **16.1** and **30** at only a slight spacing from the outer side of the stub axle **1** or **1.1** additionally clarifies that they can be positioned at a site where the effective rotary speed of the rotor side sealing faces or of those sections against which the seals act is relatively low, in comparison with positions of the seals where they are arranged at a greater radial spacing from the rotary axis.

[0038] There are numerous additional designs embodying the invention available to the person skilled in the art, which do not go beyond the scope of the claims, and which do not need to be presented further in detail.

LIST OF REFERENCE NUMERALS

[0039] **1** Stub axle
[0040] **2** Wheel hub
[0041] **3** Wheel seat
[0042] **4** Wheel bolt
[0043] **5** Brake disk
[0044] **6** Brake lining
[0045] **7** Rotary feed through
[0046] **8** Air channel
[0047] **9** Annular body
[0048] **10** Stator ring
[0049] **11** Annular body
[0050] **12** Annular body
[0051] **13** Groove
[0052] **14** Groove
[0053] **15** Annular seal
[0054] **16** Annular seal
[0055] **17** Air channel
[0056] **18** Annular groove
[0057] **19** Rotor flange
[0058] **20** Outer side
[0059] **21** Outer side
[0060] **22** Adjusting ring
[0061] **23** Sliding ring
[0062] **24** Control line
[0063] **25** Annular chamber
[0064] **26** Front face
[0065] **27** Collecting channel
[0066] **28** Dirt seal
[0067] **29** Dirt seal
[0068] **30** Seal
[0069] **31** Rotor flange
[0070] **32** Annular groove
[0071] **33** Control line
[0072] **34** Control channel
[0073] **35** Annular chamber
[0074] **36** Collecting channel
[0075] R Rotor
[0076] S Stator

1. Tire pressure control system for a motor vehicle, comprising a rotary feedthrough (**7**, **7.1**) having a stator and a rotor for transferring compressed air, fed from a compressed air source on the vehicle side to the rotor (R) designed for supporting a wheel, rotary feedthrough (**7**, **7.1**) which comprises an annular chamber (**25**, **35**) present between the rotor (R) and the stator (S) that can be sealed off by activatable seals (**15**, **16**; **15.1**, **16.1**; **15.1**, **30**), into which both a stator side and a rotor side air channel (**8**, **17**; **17.1**) open, characterized in that

the seals (**15**, **16**; **15.1**, **16.1**; **15.1**, **30**) that can be activated for the purpose of compressed air transfer are disposed spaced apart in an axial arrangement having the same or approximately the same radial spacing from the rotary axis of the rotor (R), and in that either the seals (**15**, **16**; **15.1**, **16.1**) are designed for operating facing each other and in that an annular groove (**18**) present between the seals (**15**, **16**; **15.1**, **16.1**) and open to the rotor (R) in the radial direction engages a rotor flange (**19**), against the opposite outer sides (**20**, **21**) of which the seals (**15**, **16**; **15.1**, **16.1**), when activated, act, for the purpose of sealing off the annular chamber (**25**),

or in that the seals (**15.1**, **30**) are designed to operate facing away from each other, and the seals (**15.1**, **30**) are disposed on a stator flange engaging in an annular groove (**32**) of the rotor (R), and, when activated, act, for the purpose of sealing the annular chamber (**35**), against the groove walls of the rotor side annular groove (**32**), which are situated opposite one another,

and the part of the annular groove (**18**, **32**) which in each case is sealed off from the activated seals (**15**, **16**; **15.1**, **16.1**; **15.1**, **30**) forms the annular chamber (**25**, **35**).

2. Tire pressure control system according to claim **1**, characterized in that the air channels (**8**, **17**; **17.1**) open in the radial direction into the annular chamber (**25**, **35**).

3. Tire pressure control system according to claim **2**, characterized in that the rotor flange (**19**) comprises a peripheral collecting channel (**27**) which is directed toward the foot of the annular groove (**25**) of the stator (S), and into which the rotor side air channel (**8**) opens.

4. Tire pressure control system according to claim **3**, characterized in that the rotor side air channel (**8**) opens in the radial direction into the collecting channel (**27**).

5. Tire pressure control system according to one of claims **1-4**, characterized in that the rotor flange (**19**) is designed as an annular body designed with a T-shaped cross section and having an axially aligned air channel section.

6. Tire pressure control system according to one of claims **1-5**, characterized in that each activatable seal (**15**, **16**; **15.1**, **16.1**; **15.1**, **30**) comprises an adjusting ring (**22**) arranged with seal in an annular sealing groove (**13**, **14**) and a sliding ring (**23**) located before said adjusting ring in the direction of the outlet of the sealing groove (**13**, **14**).

7. Tire pressure control system according to one of claims **1-6**, characterized in that the rotary feedthrough (**7.1**) is designed to have two channels with one channel for transferring compressed air for tire inflation and with a second channel for transferring control air for actuating an actuator associated with the rotor (R).

8. Tire pressure control system according to claim **7**, characterized in that the channel of the rotary feedthrough (**7.1**) is designed for transferring compressed air to the rotor (R) for the purpose of tire inflation according to the first alternative of claim **1** and in that the channel provided for transferring the control air is designed according to the second alternative of claim **1**, wherein the rotary feedthrough (**7.1**) comprises, in an axial arrangement with respect to each other, two exterior seals (**15.1**, **16.1**, **30**) and one interior seal, interior seal (**15.1**) which, when activated, separates the annular chambers of the two channels from each other.

9. Rotary feedthrough for a tire pressure control system, characterized in that the feedthrough is designed according to one of claims **1-8**.

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