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**Hinque**

(54) **NON-PNEUMATIC TIRE OR WHEEL WITH REINFORCED RUBBER SPOKES**

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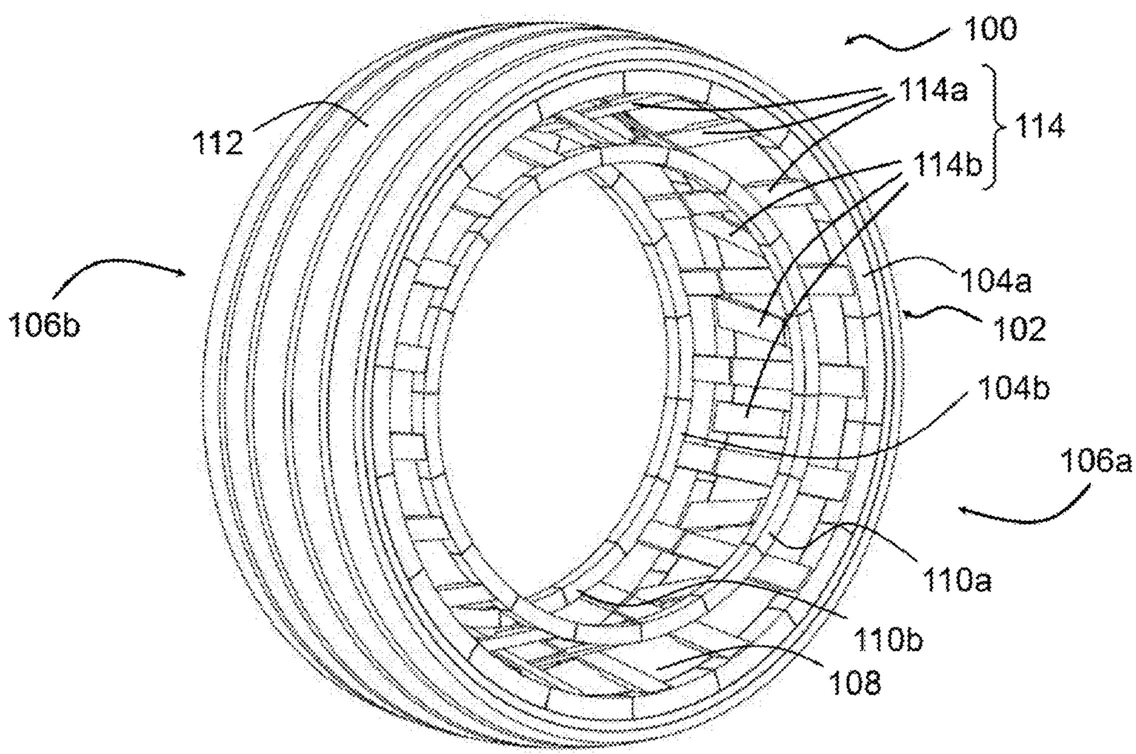
(57) **ABSTRACT**

The tire comprises an outer ring structure with a tread, the outer ring structure comprising a first support ring and a second support ring, the first and second support rings being substantially coaxial around the tire axis; an inner ring structure, the inner ring structure comprising a first base ring and a second base ring, the first and second base rings being substantially coaxial around the tire axis; and a connecting structure effective to transfer load from the inner ring structure to the outer ring structure, the connecting structure including first and second spokes made of reinforced rubber that connect the first and second support rings to the first and second base rings.



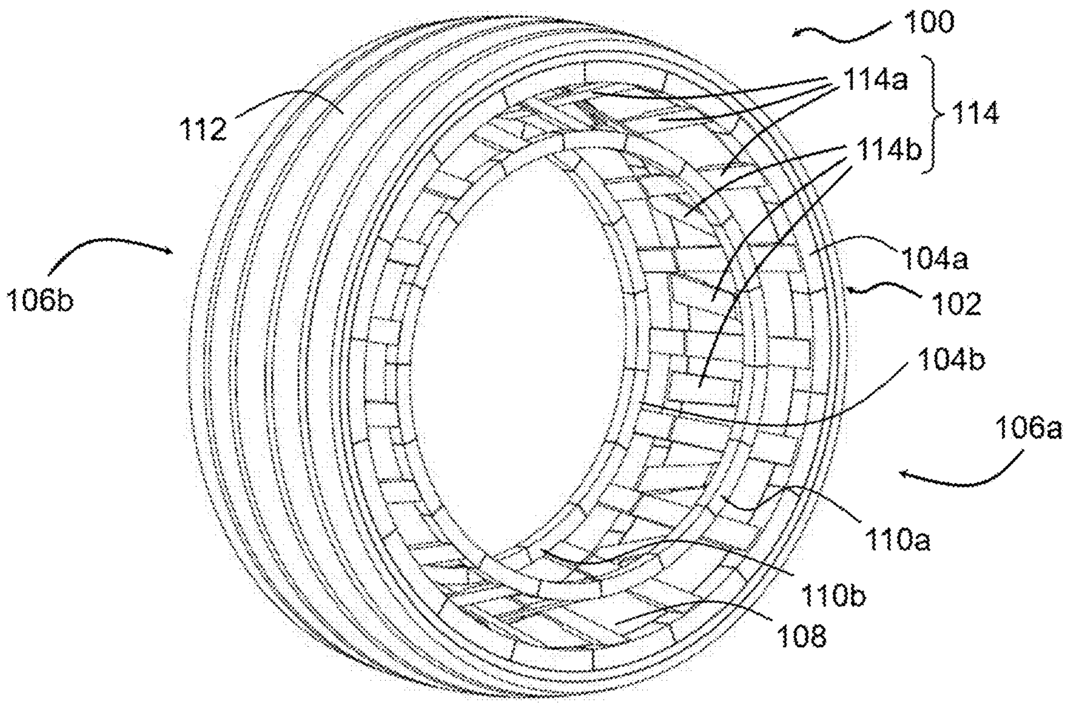



FIG. 1

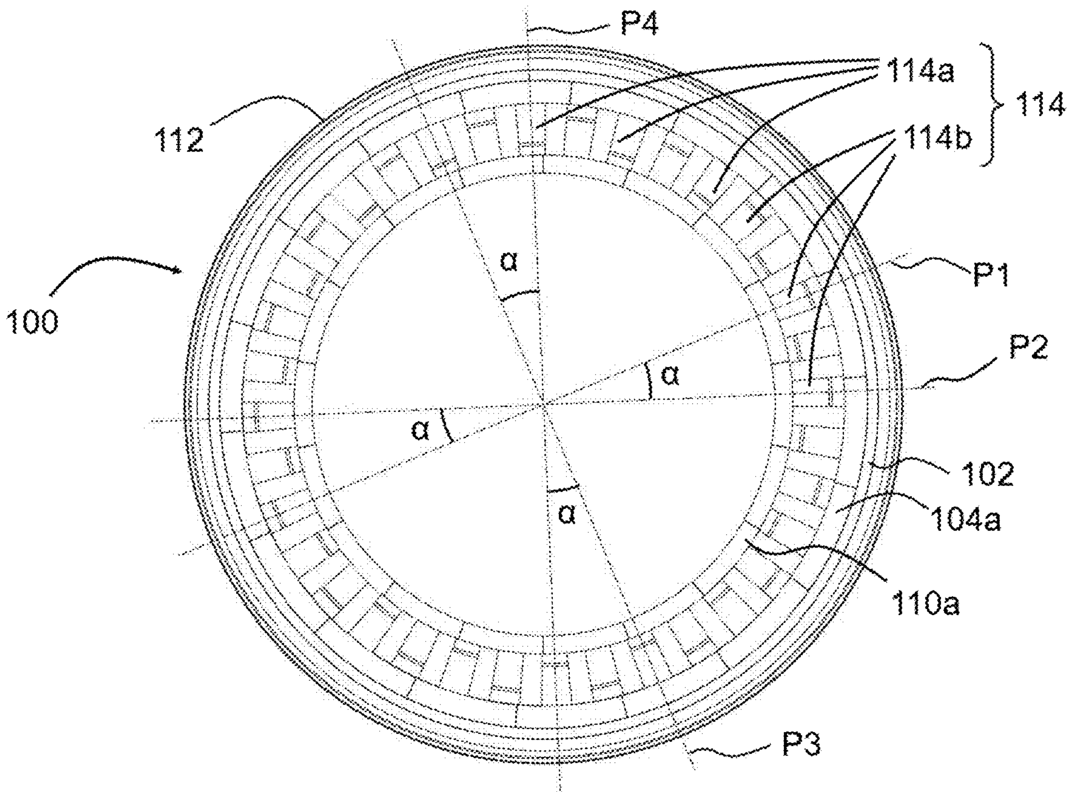



FIG. 2

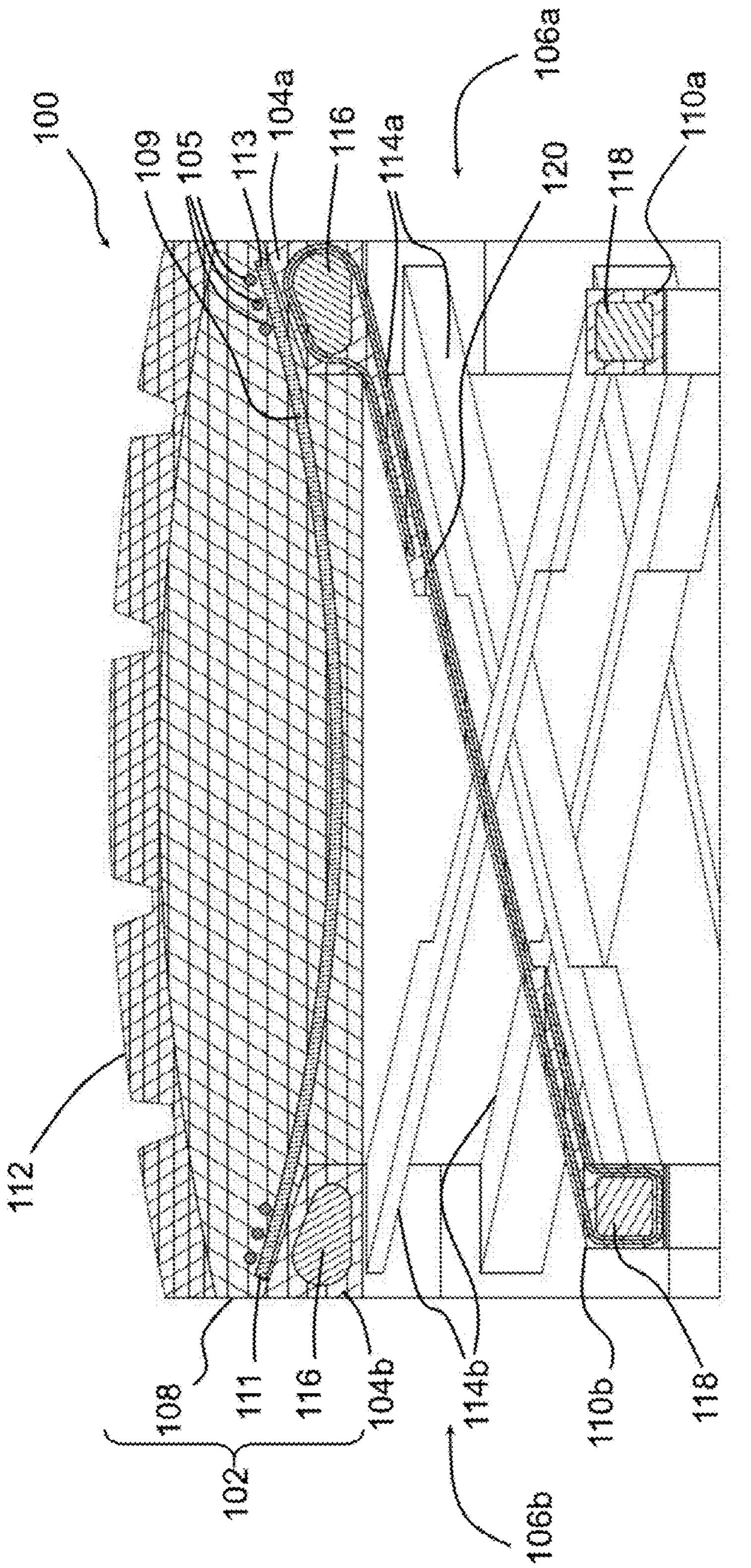

100
106a
109
105
113
104a
116
114a
120
118
110a
112
108
111
116
104b
114b
110b
118
102
106b

FIG. 3

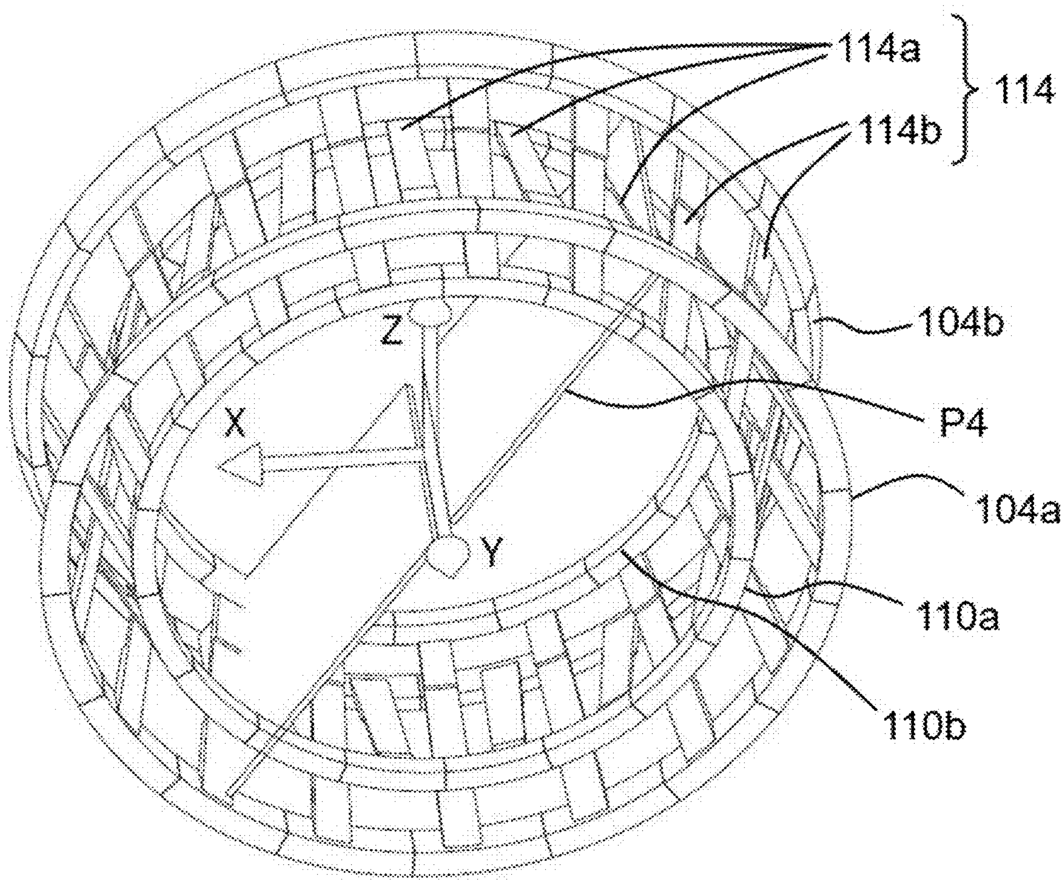



FIG. 4

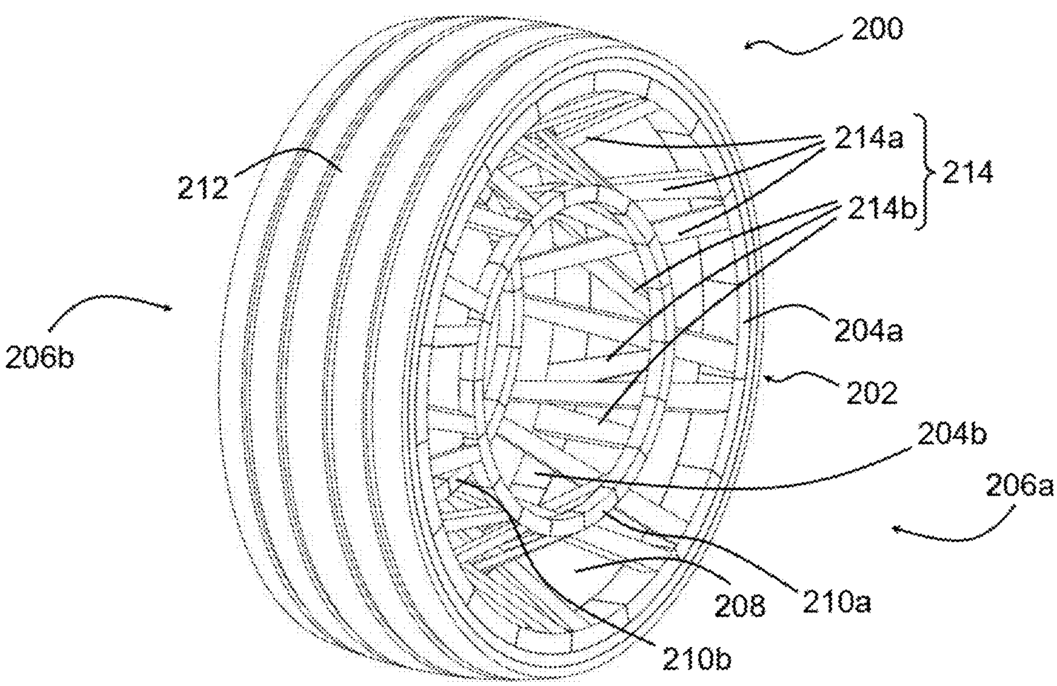



FIG. 5

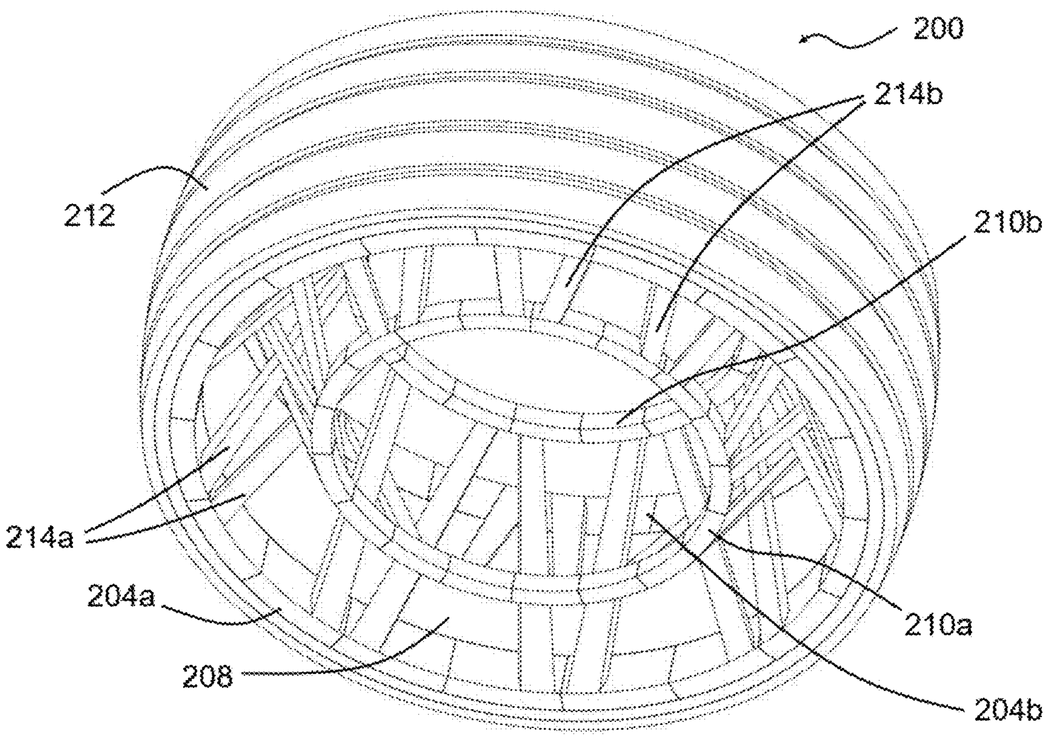



FIG. 6

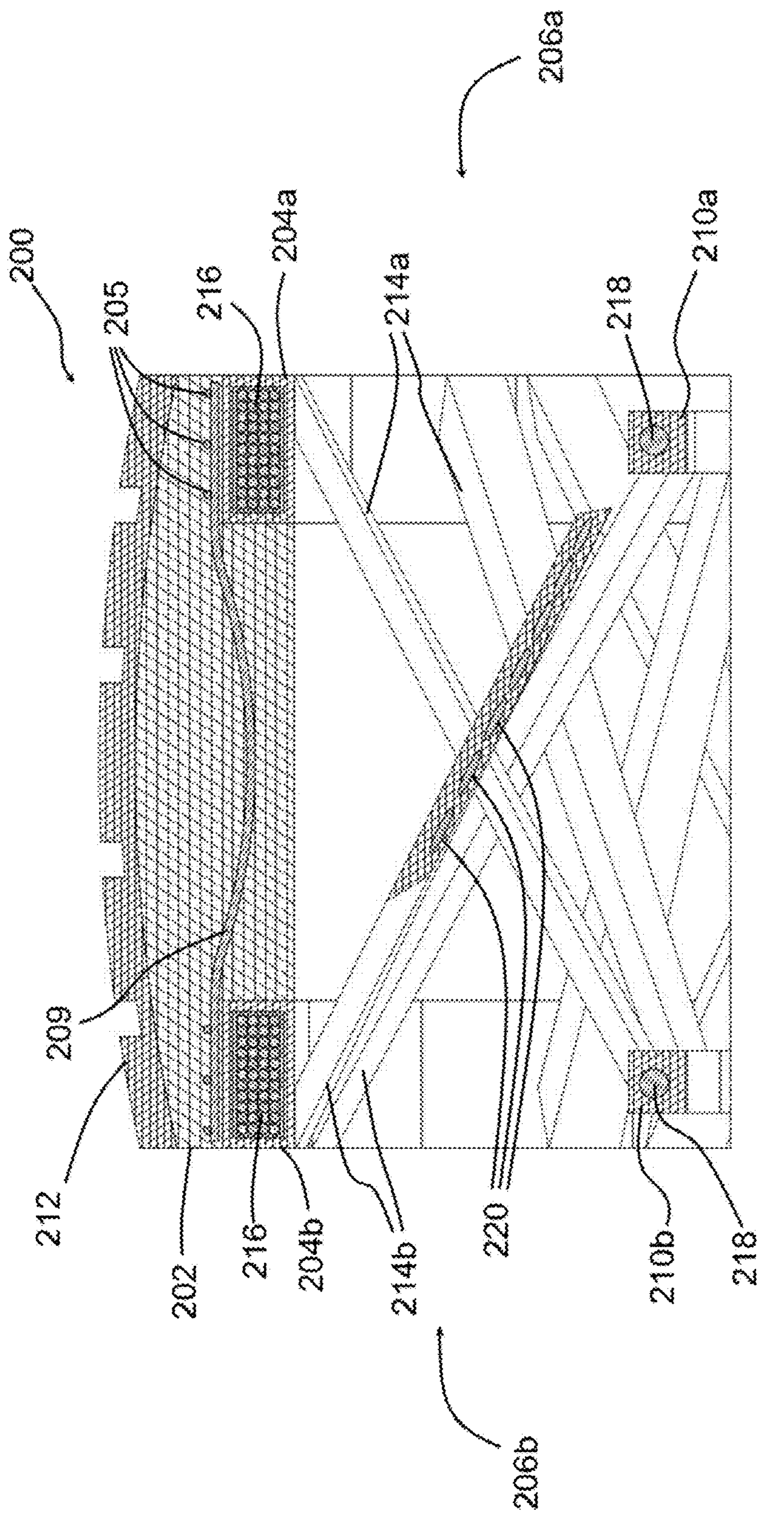

206a
200
205
216
204a
214a
218
210a
209
212
202
216
204b
214b
220
210b
218
206b

FIG. 7

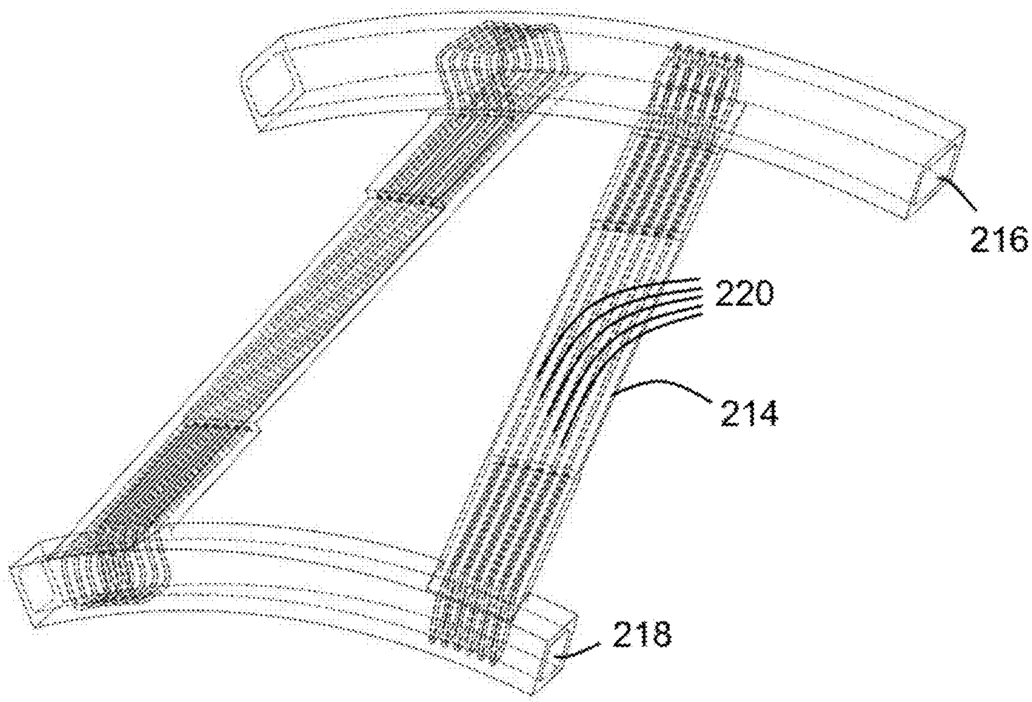



FIG. 8

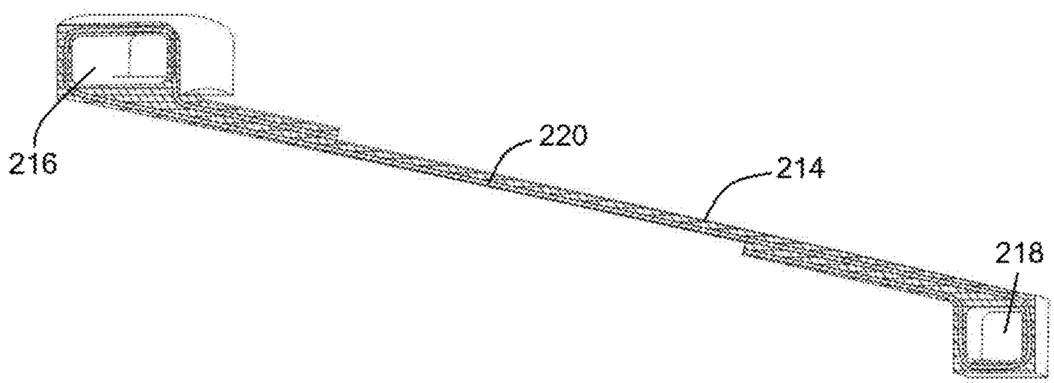



FIG. 9

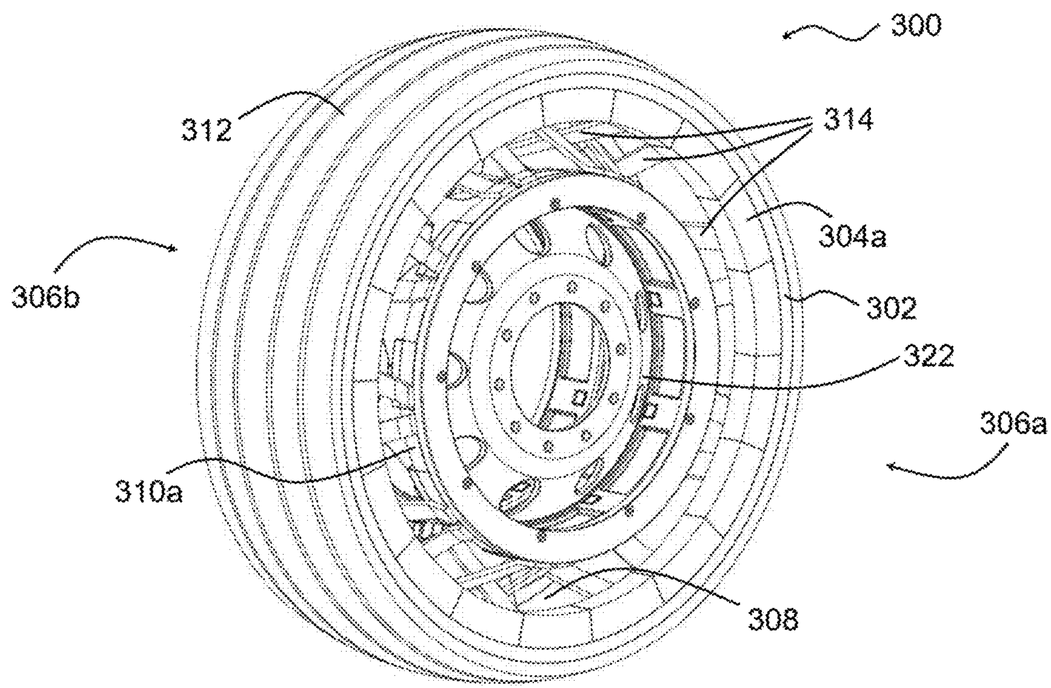



FIG. 10

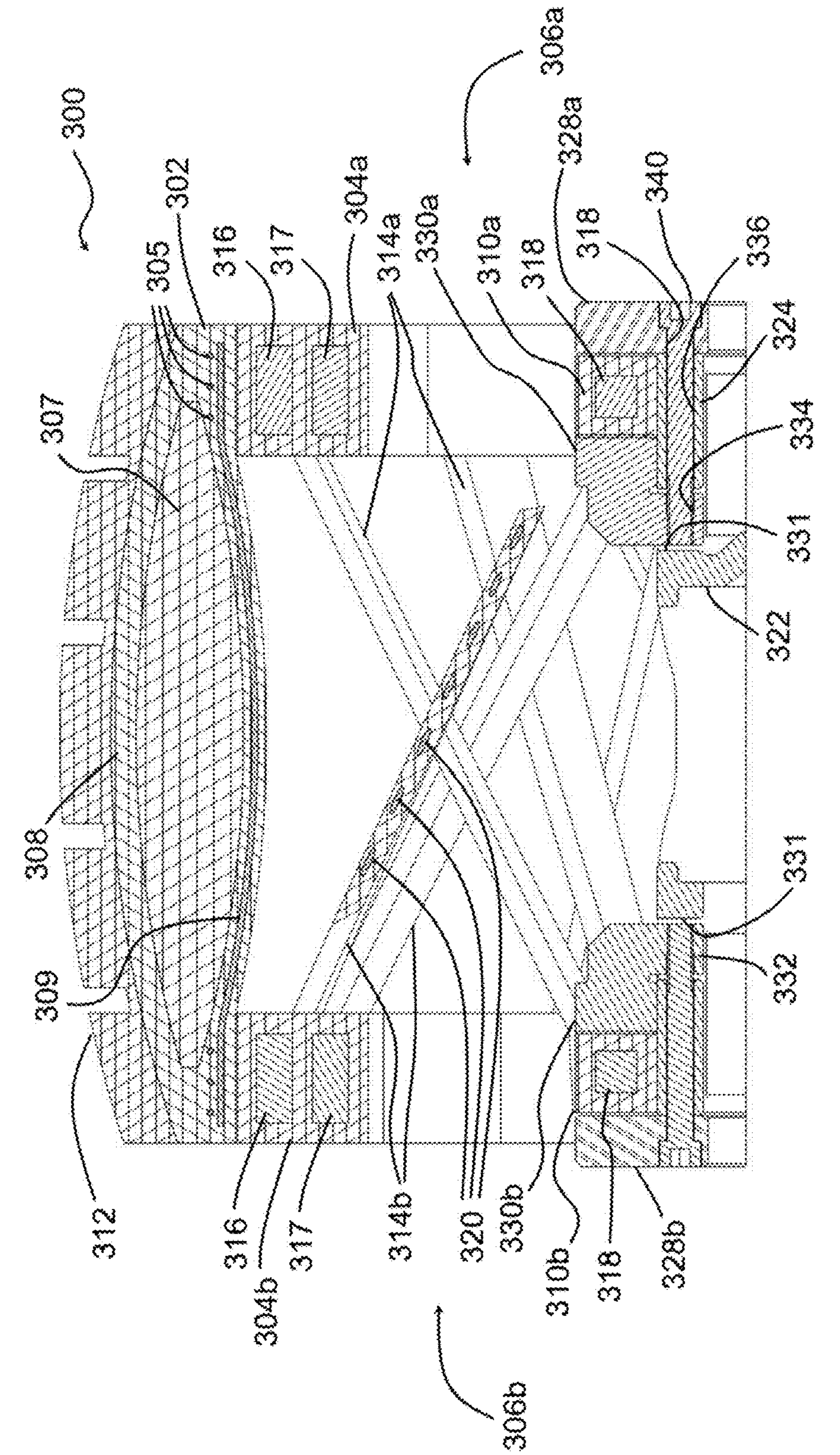

300
302
305
307
308
309
312
316
317
304a
304b
306a
306b
314a
314b
320
330a
330b
310a
310b
318
328a
328b
340
336
324
334
331
322
332

FIG. 11

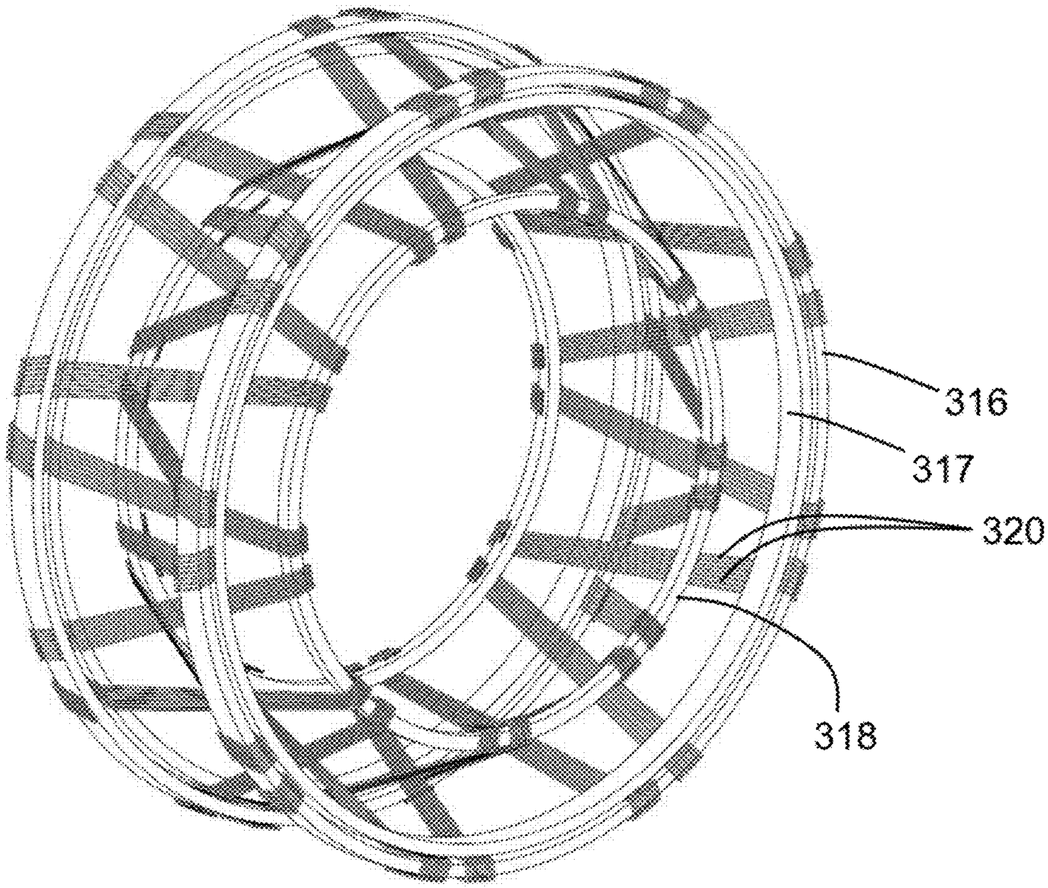



FIG. 12

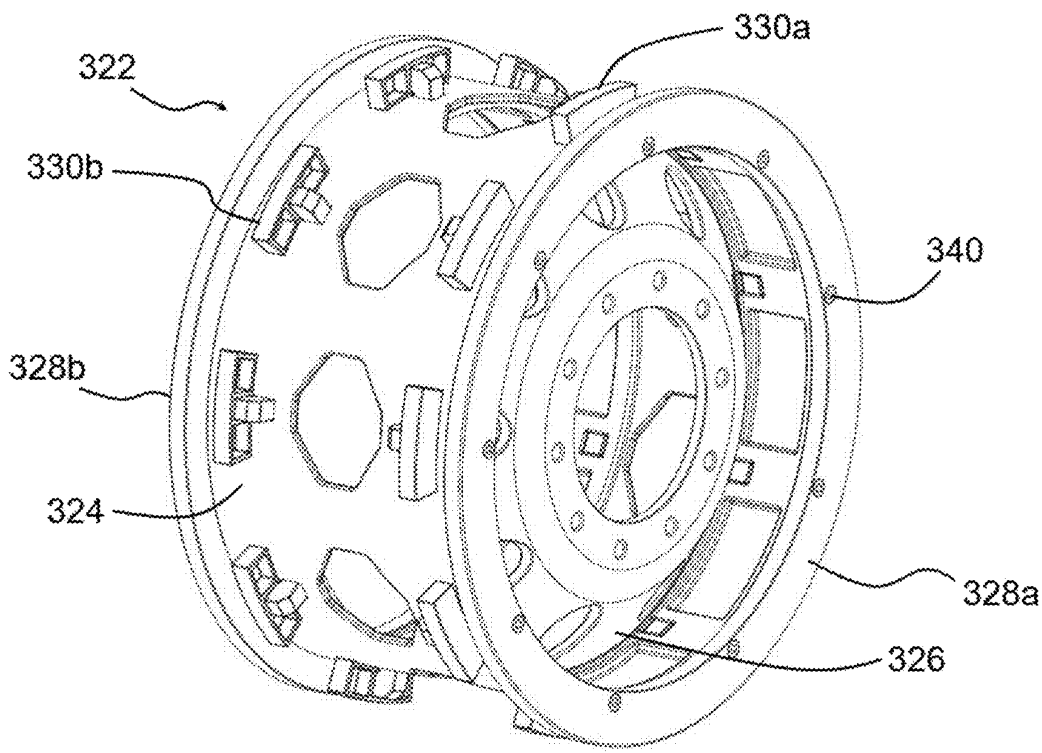



FIG. 13

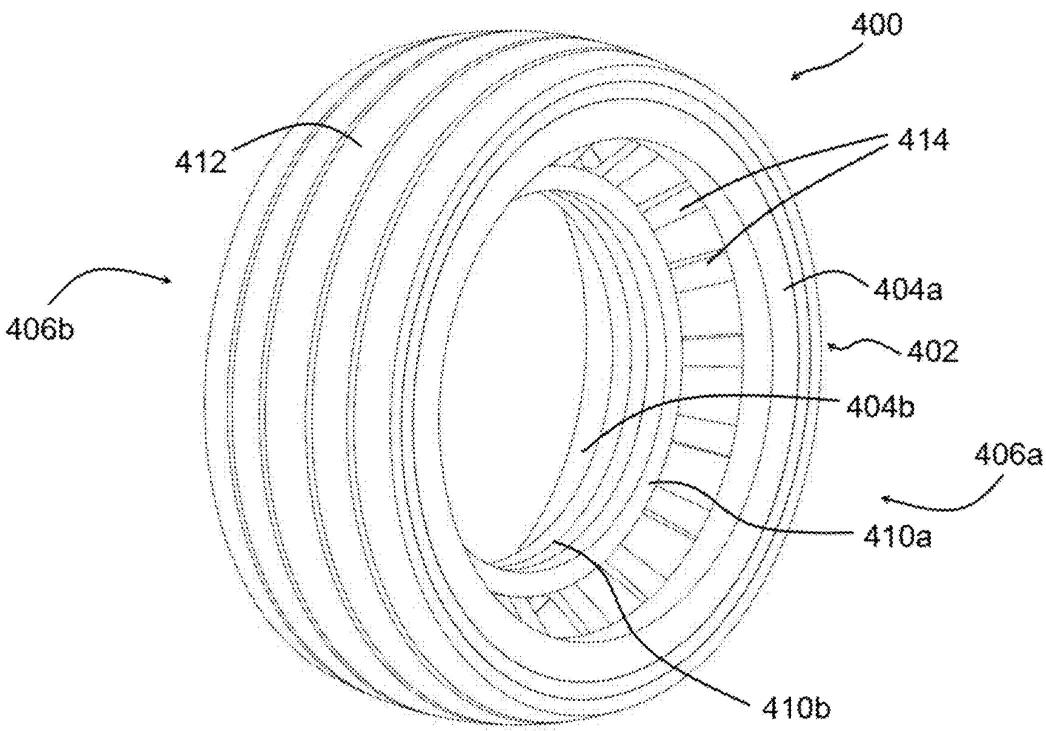



FIG. 14

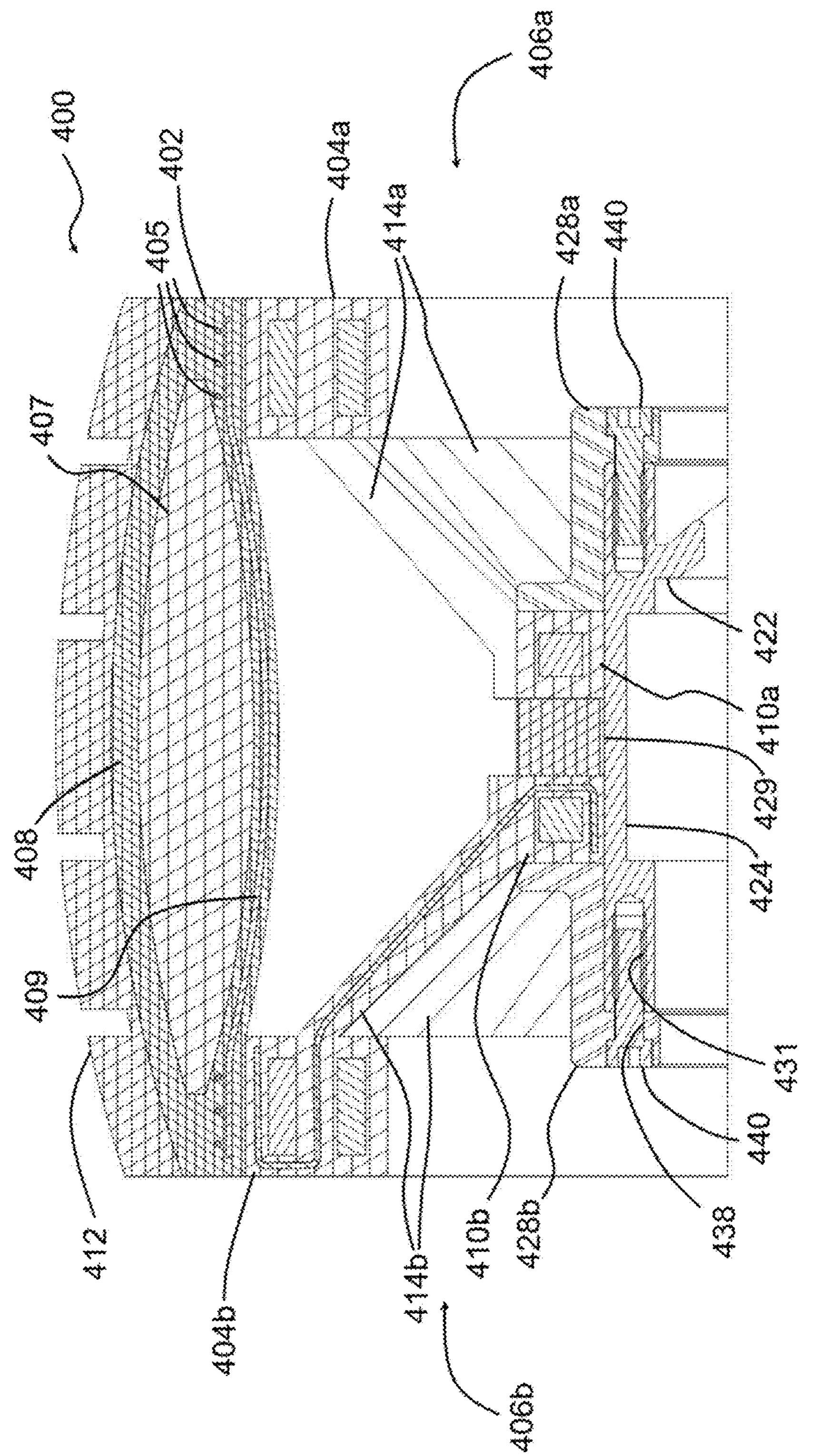

400
402
405
404a
406a
414a
428a
440
407
408
409
412
404b
414b
406b
410b
428b
438
440
431
424
429
410a
422

FIG. 15

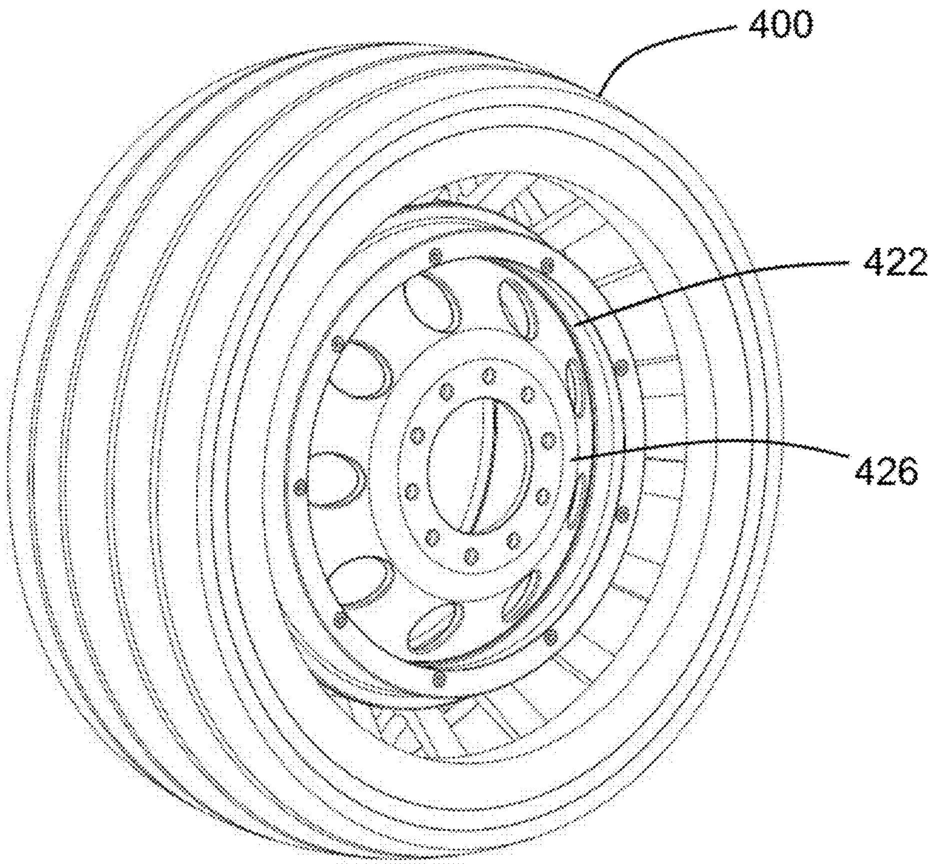



FIG. 16

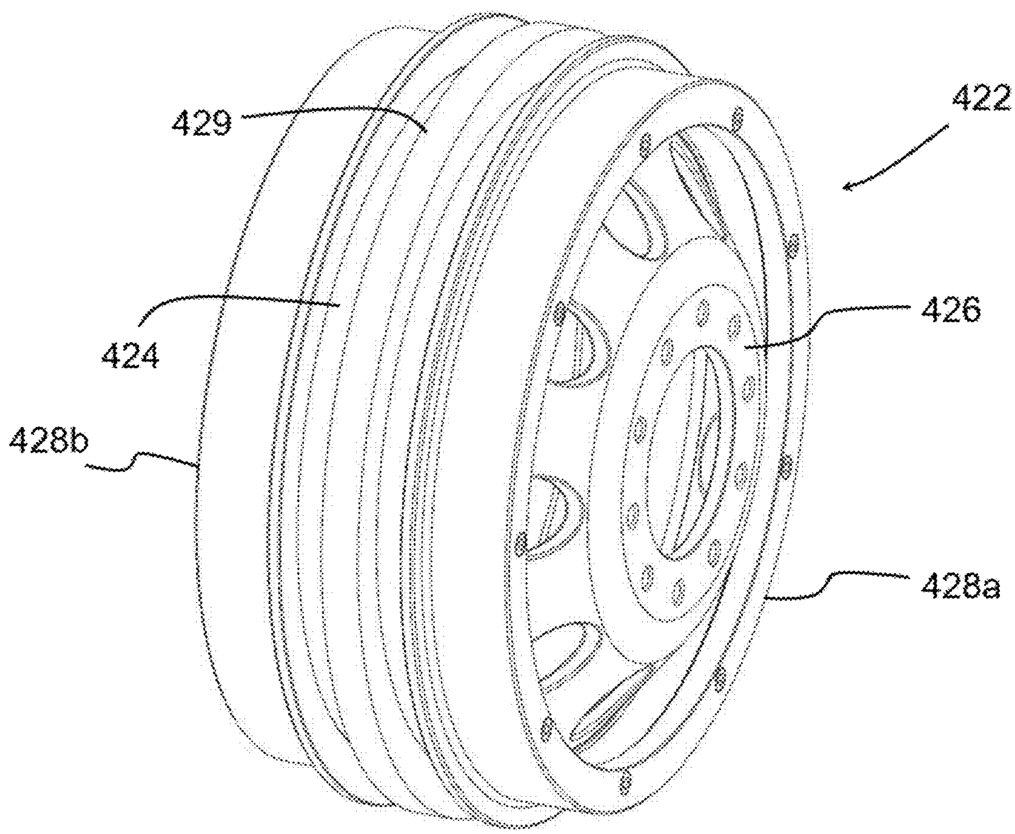



FIG. 17

## NON-PNEUMATIC TIRE OR WHEEL WITH REINFORCED RUBBER SPOKES

### BACKGROUND OF THE INVENTION

**[0001]** The present invention relates generally to a vehicle tire and, more particularly, to a non-pneumatic tire with support rings and spokes made of reinforced rubber. In a further aspect, the invention relates to a wheel comprising such a non-pneumatic tire.

**[0002]** The pneumatic tire has been the solution of choice for vehicular mobility for over a century and is still dominant on the tire market today. Pneumatic tires are efficient at carrying loads because all of their structure participates in carrying the load. Pneumatic tires are also desirable because they have low contact pressure, resulting in lower wear on roads due to the distribution of the load of the vehicle. Pneumatic tires also have low stiffness, which ensures a comfortable ride in a vehicle. The primary drawback to a pneumatic tire is that it requires compressed fluid (e.g., air or an inert gas). A conventional pneumatic tire is rendered useless after a complete loss of inflation pressure.

**[0003]** A tire designed to operate without inflation pressure may eliminate many of the problems and compromises associated with a pneumatic tire. Neither pressure maintenance nor pressure monitoring is required. Structurally supported tires such as solid tires or other elastomeric structures to date have not provided the levels of performance required from a conventional pneumatic tire. A structurally supported tire solution that delivers pneumatic tire-like performance would be a desirous improvement.

**[0004]** Non pneumatic tires are typically defined by their load carrying efficiency. So-called “bottom loaders” are essentially rigid structures that carry a majority of the load in the portion of the structure below the hub. “Top loaders” are designed so that all of the structure participates in carrying the load. Top loaders thus have a higher load carrying efficiency than bottom loaders, allowing a design that has less mass.

**[0005]** Non pneumatic tires, particularly those that are “top loaders” typically have a shear band. A shear band while allowing the tire to have higher load carrying efficiency, have the disadvantage of increased weight and decreased rolling resistance. Thus it is desired to have an improved nonpneumatic tire that omits a shearband and is useful for consumer or commercial truck applications.

### BRIEF DESCRIPTION OF THE DRAWINGS

**[0006]** The invention will be described by way of example and with reference to the accompanying drawings in which:

**[0007]** FIG. **1** is a perspective view of a non-pneumatic tire according to a first embodiment;

**[0008]** FIG. **2** is a side elevation view of the tire of FIG. **1**;

**[0009]** FIG. **3** is a partial radial cross-sectional view of the tire of FIG. **1**;

**[0010]** FIG. **4** is a perspective view of the radially outer support rings, the radially inner base rings, and the connecting structure of the tire of FIG. **1**;

**[0011]** FIG. **5** is a perspective view of a non-pneumatic tire according to a second embodiment;

**[0012]** FIG. **6** is another perspective view of the tire of FIG. **5**;

**[0013]** FIG. **7** is a partial radial cross-sectional view of the tire of FIG. **5**;

**[0014]** FIG. **8** is a perspective phantom view of a pair of spokes with their reinforcement;

**[0015]** FIG. **9** is a cross-sectional view of a spoke;

**[0016]** FIG. **10** is a perspective view of a wheel with a non-pneumatic tire according to a third embodiment;

**[0017]** FIG. **11** is a partial radial cross-sectional view of the wheel of FIG. **10**;

**[0018]** FIG. **12** is a perspective view of the reinforcement of the base rings, the spokes, and the support rings of the tire of FIG. **10**;

**[0019]** FIG. **13** is a perspective view of the rim of the wheel of FIG. **10**;

**[0020]** FIG. **14** is a perspective view of a non-pneumatic tire according to a fourth embodiment;

**[0021]** FIG. **15** is a partial radial cross-sectional view of the tire of FIG. **14** mounted on a rim;

**[0022]** FIG. **16** is a perspective view of a wheel formed by the tire of FIG. **14** and a rim; and

**[0023]** FIG. **17** is perspective view of the rim shown in FIGS. **15** and **16**.

### DETAILED DESCRIPTION OF THE INVENTION

**[0024]** FIGS. **1-4** illustrate a first embodiment of a non-pneumatic tire **100** which does not include a shear band. The tire **100** comprises an outer ring structure **102** with a first support ring **104*a*** on a first lateral side **106*a*** of the tire **100** and a second support ring **104*b*** on the second lateral side **106*b*** of the tire. The first and second support rings **104*a***, **104*b*** extend circumferentially around the tire axis, and are axially spaced apart from each other. The first and second support rings **104*a,b*** are preferably resilient, and made of steel, spring steel or composite material.

**[0025]** The outer ring structure **102** further comprises an annular support band **108** connecting to the first support ring **104*a*** and the second support ring **104*b***. The support band **108** maintains the first and second support rings **104*a***, **104*b*** in substantially coaxial, parallel positions. The support band **108** has a radially outer surface on which the tread is formed as a tread band **112**. The tread band **112** may include tread features such as, e.g., grooves, ribs, blocks, lugs, sipes, studs, etc. The support band includes a reinforcement layer **109** having a first end **111** that is secured to the first support ring **104*a*** and a second end **113** that is secured to the second support ring **104*b***. The support band distributes forces locally exerted on the tread **112** over a larger area and yields under pressure so as to contribute to formation of a contact patch between the tread **112** and the ground. The support band **108** further includes longitudinal reinforcement **105**, which wrap around each end of the annular reinforcement and function to secure the ends to the respective support ring **104*a,b***. The support band **108** functions to transmit the load of the tire to the support rings. The support band **108** can be in the form of a rubber band with optional reinforcements, or a metal band as a leaf spring.

**[0026]** The non-pneumatic tire **100** further comprises an inner ring structure including a first base ring **110*a*** on the first lateral side **106*a*** and a second base ring **110*b*** on the second lateral side **106*b***. The first and second base rings **110*a***, **110*b*** are connected to the outer ring structure by a connecting structure comprising spokes **114** made of reinforced rubber strips. The spokes **114** may be divided into two sets: a first spoke **114***a* that is secured to the first support ring **104***a* and extends from the first support ring to the second base ring **110***b*, and is secured to the second base ring **110***b*, and a second spoke **114***b* that is secured to the second support ring **104***b* and extend from the second support ring to the first base ring **110***a*, and is secured thereto. The support rings **104***a*, **104***b* receive the load exerted on the base rings **110***a*, **110***b* as tension in the spokes **114** and transfer this load to support band **108**, which, in turn, transfers the load to the ground, via the tread.

**[0027]** As shown in FIG. **3**, the first and second spokes **114***a*, **114***b* extend generally linearly and are slanted with respect to the tire axis. The spokes are arranged in an X-shaped configuration. The spokes of the first and second sets cross each other in a plane perpendicular to the tire axis located centrally between the support rings and the base rings. As best seen in FIGS. **2**-**4**, each spoke **114** extends substantially along a corresponding radial plane (i.e., a plane that contains the tire axis). In FIG. **2**, four such radial planes P**1**, P**2**, P**3** and P**4** are shown. In circumferential direction around the tire axis (axis Y in FIG. **4**), the first spokes **114***a* alternate with the second spokes **114***b*. In the illustrated embodiment, there are 36 spokes **114** in total, including 18 first spokes **114***a* and 18 second spokes **114***b*. The spokes are uniformly distributed in circumferential direction and the angular separation α between two neighboring first spokes **114***a* or between two neighboring second spokes **114***b* amounts to 20° (α=20°).

**[0028]** As best shown in FIG. **3**, the first spokes **114***a* span a truncated conical surface that is delimited in axial direction by the first support ring **104***a* and the second base ring **110***b*. Similarly, the second spokes **114***b* span a truncated conical surface that is delimited in axial direction by the second support ring **104***b* and the first base ring **110***a*. The conical surfaces intersect at the midplane between the support rings (or between the base rings).

**[0029]** As shown in FIG. **3**, each first spoke **114***a* is formed of strips of rubber with parallel reinforcement cords **120**, wherein the rubber strip has a first end wrapped around the first support ring **104***a* and a second end that is wrapped around the second base ring **110***b*. Each second spoke **114***b* is likewise formed of a rubber reinforced strip that has a first end wrapped about the second support ring **104***b* and a second end that is wrapped or secured to the first base ring **110***a*. The support rings **104***a*, **104***b* may each optionally comprise an inner core **116**. Each inner core **116** is made of rubber, metal, steel, spring steel or a composite material that is preferably encased in rubber. Also, the base rings **110***a*, **110***b* may optionally comprise respective cores **118** made of rubber, metal, steel, spring steel or a composite material that is preferably surrounded with rubber.

**[0030]** The spokes are preferably arranged such that the first spokes and second spokes cross each other in a X shaped configuration when viewed from the cross-section, and without intersecting each other. The first spokes may alternate with the second spokes in circumferential direction around the tire axis.

**[0031]** The first and second base rings may be axially movable one with respect to the other. Tension within the first and second spokes may be adjustable by axially moving the first and second base rings one with respect to the other.

**[0032]** In embodiments, the first and second spokes may have inclination angles between 10 and 60°, preferably between 15° and 50°, more preferably between 15° and 45°, with respect to the tire axis.

**[0033]** The tire **100** may be mounted on a rim shown in FIG. **13**. The rim may comprise a first axially inner abutment and a first axially outer abutment for securing the first base ring in a first axial position on the rim and a second axially inner abutment and a second axially outer abutment for securing the second base ring in a second axial position on the rim. The first and second spokes are pretensioned when the first and second base rings are secured in the first and second axial positions which result in the first and second base rings being pulled axially outwards. The rim may include a removable or fixed median ring providing the first and second axially inner abutments. The rim may include a disk for fixing the rim on an axle.

**[0034]** When the first spokes extend from the first support ring to the second base ring and the second spokes extend from the second support ring to the first base ring, the first and second base rings may be secured in the first and second axial positions against tension forces in the first and second spokes tending to move the first and second base rings axially closer together. The rim may further include a clamp to secure the first base ring between the first axially inner abutment and the first axially outer abutment, and a second clamp to secure the second base ring between the second axially inner abutment and the second axially outer abutment.

**[0035]** FIGS. **5** to **9** illustrate a second embodiment of a non-pneumatic tire **200** of the present invention. In this embodiment, the spokes are not coplanar, ie, extend in a radial plane as the first embodiment. The tire **200** of this embodiment like the first embodiment also includes an outer ring structure **202** with a first support ring **204***a* on the first lateral side **206***a* of the tire **200** and a second support ring **204***b* on the second lateral side **206***b* of the tire. The first and second support rings **204***a*, **204***b* extend circumferentially around the tire axis, one at an axial distance from the other. The outer ring structure **202** further comprises a support band **208** extending in the axial direction of the tire **200** and connecting the first support ring **204***a* with the second support ring **204***b*. The support band **208** maintains the first and second support rings **204***a*, **204***b* in substantially coaxial, parallel positions.

**[0036]** The support band **208** has a radially outer surface having a tread band **212**. The support band **208** includes an annular reinforcement **209** extending from the first support ring **204***a* to the second support ring **204***b*. The support band **108** further includes longitudinal reinforcement **205**. The support band distributes forces locally exerted on the tread **212** over a larger area and yields under pressure so as to contribute to formation of a contact patch between the tread **212** and the ground.

**[0037]** The tire **200** further comprises an inner ring structure including a first base ring **210***a* on the first lateral side **206***a* and a second base ring **210***b* on the second lateral side **206***b*. The first and second base rings **210***a*, **210***b* are connected to the outer ring structure by a connecting structure comprising spokes **214** made of reinforced rubber strips. The spokes **214** include a first spoke **214***a* that wraps around the first support ring **204***a* and extends to the second base ring **210***b* and is secured thereto, and a second spoke

**214***b* that extend from the second support ring **204***b* to the first base ring **210***a* (the "second spokes" in this embodiment).

**[0038]** The first and second spokes **214***a*, **214***b* extend generally linearly and are inclined with respect to the tire axis. The spokes are arranged in an X-shaped configuration when viewed from the cross-section. The spokes of the first and second sets cross each other in a plane perpendicular to the tire axis located centrally between the support rings and the base rings.

**[0039]** Unlike in the embodiment of FIGS. **1-4**, the spokes **214** do not follow radial planes. Each first spoke **214***a* is connected with the first support ring **204***a* at its first outer node and with the second base ring **210***b* at its first inner node. Each second spoke **214***b* is connected with the second support ring **204***b* at its second outer node and with the first base ring **210***a* at its second inner node. Each first spoke **214***a* has the first inner and first outer nodes thereof located in radial planes intersecting at an intersection angle. Likewise, each second spoke **214***b* has the second inner and second outer nodes thereof located in radial planes intersecting at an intersection angle. In the illustrated embodiment, the intersection angle is the same for all spokes **214**. The first spokes **214***a* are arranged in a first zigzag pattern generally extending around the truncated conical surface delimited by the first support ring **204***a* and the second base ring **210***b*, and the second spokes **214***b* are arranged in a second zigzag pattern generally extending around the truncated conical surface delimited by the second support ring **204***b* and the first base ring **210***a*. The first and second zigzag patterns may be staggered in circumferential direction such that the spokes do not interfere. The zigzag pattern of the first spokes thus defines a first mesh shaped overall as a first truncated conical surface delimited in axial direction by the first support ring **204***a* and the second base ring **210***b*. The zigzag pattern of the second spokes defines a second mesh shaped overall as a second truncated conical surface delimited in axial direction by the second support ring **204***b* and the first base ring **210***a*.

**[0040]** FIG. **7** shows a partial radial cross section of the tire of FIG. **5**. The support rings **204***a*, **204***b* comprise each a core **216** embedded in rubber. The core **216** is preferably formed of one or more steel cables, more preferably, one or more rows of 11 cable wires, wherein the cable wire is sized about 2 mm. Also, the base rings **210***a*, **210***b* comprise cores made of metal, steel cables that are preferably surrounded with rubber.

**[0041]** Referring to FIGS. **8** and **9**, each spoke **214** comprises a strip of reinforced rubber. One or more reinforcement cords **220** run lengthwise across the reinforced rubber strip. At the inner and outer node, the reinforced rubber strip is folded around the support ring and the base ring. The folded-around ends of the rubber strip are laid alongside the median portion of the strip that spans between the support ring and the base ring. The folding (wrapping around) is carried out with the green (uncured) reinforced rubber strips when the tire is built up in a multi-component vulcanization mold. When the tire is cured, adjacent rubber components are bonded together. This is the case, in particular, between in the areas of overlap of the folded-around ends and the median portions of the rubber strips. Strong, tension-resistant bonds are thereby formed between the spokes **214** and the support rings **204***a*, **204***b* as well as between the spokes **214** and the base rings **210***a*, **210***b*.

**[0042]** FIGS. **10-13** show an embodiment of wheel comprising a non-pneumatic tire **300** and a rim **322**. The arrangement of the spokes **314** of tire **300** is similar to that of tire **200** described hereinabove. The first spokes **314***a* form a first zigzag pattern and the second spokes **314***b* form a second zigzag pattern. The outer ring structure **302** includes a first support ring **304***a* on the first side **306***a* of the tire **300** and a second support ring **304***b* on the second side **306***b* of the tire. The first and second support rings **304***a*, **304***b* extend circumferentially around the tire axis, one at an axial distance from the other. The outer ring structure **302** further comprises a support band **308** extending in the circumferential direction of the tire **300** and connecting the first support ring **304***a* with the second support ring **304***b*. The support band **308** maintains the first and second support rings **304***a*, **304***b* in substantially coaxial, parallel positions.

**[0043]** The support band **308** has a radially outer surface on which the tread is formed as a tread band **312**. The tread band **312** may include tread features such as, e.g., grooves, ribs, blocks, lugs, sipes, studs, etc. The support band **308** includes a plurality of reinforcements **309** extending from the first support ring **304***a* to the second support ring **304***b*. The support band further includes one or more cushions **307** arranged between the reinforcement **309** and the tread band **312**. The cushions **307** distribute forces locally exerted on the tread **312** over a larger area and yield under pressure so as to contribute to formation of a contact patch between the tread **312** and the ground. The optional cushions are formed of foam or sponge rubber. The support band **308** further includes longitudinal reinforcement **305**.

**[0044]** The tire **300** further comprises an inner ring structure including a first base ring **310***a* on the first side **306***a* and a second base ring **310***b* on the second side **306***b*. The first and second spokes **314***a*, **314***b* extend generally linearly and are inclined with respect to the tire axis. The spokes are arranged in an X-shaped configuration. The first and second spokes cross each other in a plane perpendicular to the tire axis located centrally between the support rings and the base rings.

**[0045]** Each first spoke **314***a* is connected with the first support ring **304***a* and with the second base ring **310***b*. Each second spoke **314***b* is connected with the second support ring **304***b* and with the first base ring **310***a*. As shown in FIG. **12**, the first spokes **214***a* and the second spokes **314***b* are arranged in a first zigzag pattern and a second zigzag pattern. The first and second zigzag patterns are staggered in circumferential direction such that the first spokes **314***a* do not interfere with the second spokes **314***b*.

**[0046]** FIG. **11** shows a partial radial cross section of the wheel of FIG. **10**. The support rings **304***a*, **304***b* each comprise two metal cores **316**, **317** embedded in rubber. The base rings **310***a*, **310***b* comprise respective metal cores **318** surrounded with rubber. Each spoke comprises a strip of reinforced rubber. Reinforcement cords **320** run lengthwise across the reinforced rubber strip of each spoke. The reinforced rubber strip has a first end that is folded around the radially outward core **316** of the support ring, and a second end that is folded around the base ring.

**[0047]** FIG. **13** is a perspective view of the rim **322** of the wheel of FIG. **10**. The rim **322** comprises a circular cylindrical rim drum **324** and a disk **326** for mounting the rim to an axle. As can be seen in FIGS. **10** and **11**, the rim drum **324** supports the first and second base rings **310***a*, **310***b*. The rim **322** comprises a first lateral flange **328***a* arranged on the first side **306***a* of the wheel **300** and a second flange **328***b* arranged on the second side **306***b* thereof. The first and second flanges provide first and second axially outer abutment surfaces for the base rings **310***a*, **310***b*. First and second axially inner abutment surfaces are provided by a first and a second series of clamping jaws **330***a*, **330***b*.

**[0048]** The rim drum **324** comprises a first and a second series of openings **331** along first and the second flange. Each of these openings **331** is configured to accommodate the nut base **332** of a clamping jaw. The nut base **332** comprises an inside threaded hole **334** that is perpendicular to the insertion direction of the nut base **332**. When the nut base **332** is in place, the inside threaded hole **334** is in alignment with an axially oriented bore **336** in the rim drum **324**. The first and second flanges comprise corresponding bores **338** that are aligned with the bores **336** in the rim drum. The first and second base rings are clamped between the respective clamping jaws and flange with bolts **340**.

**[0049]** The axial extents of the openings **331** are somewhat greater than the axial extents of the base nuts **332**. When the bolts **340** are fastened, the clamping jaws **330***a*, **330***b* are moved axially outwards, pushing the first and second base rings **310***a*, **310***b* to axially more outward positions. This leads to pretension of the spokes **314**.

**[0050]** In the illustrated embodiment, both flanges **328***a* and **328***b* are removable. The tire may be slid on the rim **322** when the flanges **328***a*, **328***b* and the clamping jaws **330***a*, **330***b* are removed. When the tire is in place, the flanges and the clamping jaws are mounted and bolted.

**[0051]** FIGS. **14-17** show a non-pneumatic tire **400** according to a further embodiment. The non-pneumatic tire **400** comprises an outer ring structure **402** with a first support ring **404***a* on the first lateral side **406***a* of the tire **400** and a second support ring **404***b* on the second lateral side **406***b* of the tire. The first and second support rings **404***a*, **404***b* extend circumferentially around the tire axis, one at an axial distance from the other. The outer ring structure **402** further comprises a support band extending in the circumferential direction of the tire **400** and connecting the first support ring **404***a* with the second support ring **404***b*. The support band maintains the first and second support rings **404***a*, **404***b* in substantially coaxial, parallel positions.

**[0052]** The support band has a radially outer surface formed by a tread band **412**. The support band includes reinforcement **409** extending between the first and second support rings **404***a*, **404***b*. The support band further includes one or more cushions **407** arranged between the reinforcement **409** and the tread band **412**. The cushions **407** distribute forces locally exerted on the tread **412** over a larger area and yield under pressure so as to contribute to formation of a contact patch between the tread **412** and the ground. The support band further includes longitudinal reinforcement **405**.

**[0053]** The non-pneumatic tire **400** further comprises an inner ring structure including a first base ring **410***a* on the first lateral side **406***a* and a second base ring **410***b* on the second lateral side **406***b*. The first and second base rings **410***a*, **410***b* are connected to the outer ring structure by a connecting structure comprising spokes **414** made of reinforced rubber. The spokes **414** can be divided in two sets:

**[0054]** a first set comprising the spokes **414***a*, the "first spokes", that extend from the first support ring **404***a* to the first base ring **410***a*, and

**[0055]** a second set comprising the spokes **414***b*, the "second spokes", that extend from the second support ring **404***b* to the second base ring **410***b*.

**[0056]** The spokes **414** of the first and second sets are slanted with respect to the tire axis. The spokes **414** are arranged in a V-shaped configuration. In the illustrated embodiment, in circumferential direction around the tire axis, the spokes of the first set alternate with the spokes of the second set. However, since the spokes do not cross, the first and second spokes could also pairwise be arranged axially facing each other. In the illustrated embodiment, there are 36 spokes **414** in total, including 18 first spokes **414***a* and 18 second spokes **414***b*. The spokes are uniformly distributed in circumferential direction and the angular separation $\alpha$ between two neighboring first spokes **414***a* or between two neighboring second spokes **414***b* amounts to 20°.

**[0057]** As in the embodiment of FIGS. **1-4**, the spokes **414** follow radial planes. Each first spoke **414***a* has a first end connected with the first support ring **404***a* and a second end connected with the first base ring **410***a*. Each second spoke **414***b* is connected with the second support ring **404***b* at its first end and with the second base ring **410***b* at its second end.

**[0058]** FIG. **16** is a perspective view of the tire **400** mounted on a rim **422** and FIG. **17** shows the rim **422** without the tire. The rim **422** comprises a circular cylindrical rim drum **424** and a disk **426** for mounting the rim to an axle. As best seen in FIG. **15**, the rim drum **424** supports the first and second base rings **410***a*, **410***b*. The rim **422** comprises a first lateral flange **428***a* arranged on the first side **406***a* of the wheel and a second flange **428***b* arranged on the second side **406***b* thereof. The first and second flanges provide first and second axially outer abutment surfaces for the base rings **410***a*, **410***b*. First and second axially inner abutment surfaces are provided by a median rim ring **429**.

**[0059]** The rim drum **424** comprises a series of axially oriented inside threaded holes **431** distributed along the lateral circumferential edges of the rim drum **424**. The first and second flanges **428***a*, **428***b* comprise corresponding bores **438** that are aligned with the threaded holes **431** in the rim drum, such that the first and second flanges **428***a*, **428***b* may be fixed on the rim drum **424** by bolts **340**.

**[0060]** The first and second base rings are clamped between the respective clamping jaws and flange with bolts **340**.

**[0061]** In the illustrated embodiment, both flanges **428***a* and **428***b* are removable. The tire may be slid on the rim **422** when at least one of the flanges **428***a*, **428***b* is removed. The median rim ring **429** is arranged between the base rings **410***a*, **410***b* before the tire is placed on the rim drum **424**. The base rings **410***a*, **410***b* and the median rim ring **429** are then slid into abutment with one of the flanges **428***a* or **428***b*. Finally, the other flange is mounted, in such a way that the base rings **410***a*, **410***b* and the median rim ring **429** are clamped between the flanges **428***a*, **428***b*.

**[0062]** In any of the above-described embodiments, the cores of the support and base rings could be made from metal, e.g., steel, aluminum, etc., from reinforced rubber, from plastic, or from a composite material (e.g., reinforced rubber, fiber-reinforced plastic, etc.) The reinforcement of the rubber spokes, the support bands, etc. may be made of steel cords and/or cords formed from nylon fiber, polyester fiber, fiber glass, carbon fiber, aramid fiber, glass fiber, polyethylene fiber, polyethylene terephthalate fiber, or other reinforcement materials. Different reinforcement materials could be combined. It is worthwhile noting that a "cord" may include one or plural strands. The configuration of the tire structure, in particular the base rings, the spokes, the support rings and the support band, as well as the choice of materials may depend on the envisaged use of the tire and, in particular, the intended load-bearing capability.

**[0063]** Variations in the present invention are possible in light of the description of it provided herein. While certain representative embodiments and details have been shown for the purpose of illustrating the subject invention, it will be apparent to those skilled in this art that various changes and modifications can be made therein without departing from the scope of the subject invention. It is, therefore, to be understood that changes can be made in the particular embodiments described which will be within the full intended scope of the invention as defined by the following appended claims.

What is claimed is:

**1**. A non-pneumatic tire having a tire axis, a first side and a second side, the non-pneumatic tire comprising:

an outer ring structure with a tread extending circumferentially around the tire axis, the outer ring structure extending from the first side to the second side and comprising a first support ring on the first side and a second support ring on the second side, the first and second support rings being substantially coaxial around the tire axis;

an inner ring structure, the inner ring structure comprising a first base ring on the first side and a second base ring on the second side, the first and second base rings being substantially coaxial around the tire axis;

a connecting structure effective to transfer load from the inner ring structure to the outer ring structure, the connecting structure including first and second spokes made of reinforced rubber,

each of the first spokes extending from the first support ring to the second base ring, and being connected with the first support ring and with the second base rings, and

each of the second spokes extending from the second support ring to the first base ring, and being connected with the second support ring and with the first and second base rings,

wherein the first and second spokes are inclined with respect to the tire axis.

**2**. The non-pneumatic tire as claimed in claim **1**, wherein the first spokes alternate with the second spokes in circumferential direction around the tire axis.

**3**. The non-pneumatic tire as claimed in claim **1**, wherein the first and second base rings are axially movable one with respect to the other and wherein tension within the first and second spokes is adjustable by axially moving the first and second base rings one with respect to the other.

**4**. The non-pneumatic tire as claimed in claim **1**, wherein the first and second spokes have inclination angles between 10 and 60° with respect to the tire axis.

**5**. The non-pneumatic tire as claimed in claim **1**, wherein the first and second spokes extend along radial planes intersecting at the tire axis.

**6**. The non-pneumatic tire as claimed in claim **1**, wherein the outer ring structure comprises an annular support band extending from the first support ring to the second support ring.

**7**. The non-pneumatic tire of claim **6**, wherein the annular support band comprises one or more reinforcements, each reinforcement having a first lateral end secured to the first support ring and a second lateral end secured to the second support ring.

**8**. The non-pneumatic tire as claimed in claim **1**, wherein each one of the spokes comprises a reinforced rubber strip.

**9**. The nonpneumatic tire of claim **1** wherein the first and second support ring are resilient.

**10**. A vehicle wheel, the wheel having a wheel axis, a first side and a second side, the wheel comprising:

a rim coaxial with the wheel axis;

an outer ring structure with a tread extending circumferentially around the wheel axis, the outer ring structure comprising a first support ring on the first side and a second support ring on the second side, the first and second support rings being substantially coaxial around the tire axis;

an inner ring structure, the inner ring structure comprising a first base ring on the first side and a second base ring on the second side, the first and second base rings mounted on the rim;

a connecting structure effective to transfer load from the inner ring structure to the outer ring structure, the connecting structure including first and second spokes made of reinforced rubber,

each of the first spokes extending from the first support ring to one of the first and second base rings, and being connected with the first support ring and with the second base ring, and

each of the second spokes extending from the second support ring to the first base ring, and being connected with the second support ring and with the first base ring,

wherein the first and second spokes are inclined with respect to the wheel axis.

**11**. The vehicle wheel as claimed in claim **9**, wherein the rim comprises a first axially inner abutment and a first axially outer abutment for securing the first base ring in a first axial position on the rim and wherein the rim comprises a second axially inner abutment and a second axially outer abutment for securing the second base ring in a second axial position on the rim.

**12**. The vehicle wheel as claimed in claim **10**, wherein the first and second spokes are pretensioned when the first and second base rings are secured in the first and second axial positions.

**13**. The vehicle wheel as claimed in claim **10**, wherein the rim comprises a first flange arranged on the first lateral side and a second flange arranged on the second lateral side, at least one of the first and second flanges being removable, the first and second flange providing said first and second axially outer abutment surface.

**14**. The vehicle wheel as claimed in claim **10**, comprising first clamps that secure the first base ring between the first axially inner abutment and the first axially outer abutment and second clamps that secure the second base ring between the second axially inner abutment and the second axially outer abutment.

**15**. The vehicle wheel of claim **10**, wherein the outer ring structure comprises an annular support band extending from the first support ring to the second support ring.

**16**. The vehicle wheel of claim **10**, wherein the annular support band comprises an annular reinforcement having a first lateral end secured to the first support ring and a second lateral end secured to the second support ring.

**17**. The vehicle wheel of claim **10** wherein the first and second support ring are resilient.

**18**. A wheel having a wheel axis, a first lateral side and a second lateral side, the wheel comprising:

a rim coaxial with the wheel axis;

an annular tread ring including a support band, wherein the support band comprises one or more reinforcements having a first end secured to a first support ring and a second end secured to a second support ring, wherein the first and second support rings are substantially coaxial around the wheel axis, wherein the first and second support rings are resilient;

a first base ring on the first side and a second base ring on the second side, the first and second base rings being mounted on the rim;

and a connecting structure connecting the first and second support rings to a respective first and second base rings, and wherein the connecting structure is loaded in pretension when the first and second base rings are mounted to the rim.

**19**. The wheel of claim **18** wherein the connecting structure including a plurality of spokes connected to one of the support rings and extending to one of the first and second base rings and being connected thereto, wherein the spokes are loaded in pretension when mounted upon the rim.

**20**. The wheel of claim **18** wherein the one or more reinforcements extend in the axial direction.

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