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(54) Title: PNEUMATIC TIRE WITH NON-ANNULAR PROTECTIVE SHEET FOR BEAD AREA AND METHODS FOR USE WITH WHEEL HAVING GAP IN RIM-FLANGE

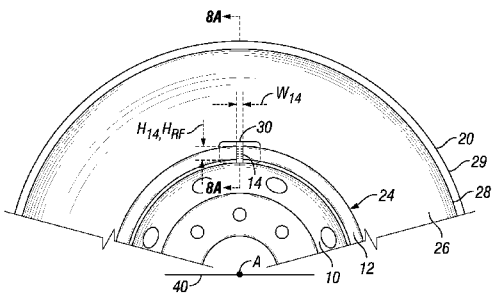

FIG. 7

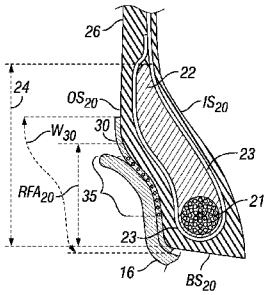

FIG. 8A

(57) Abstract: Embodiments of the invention include a pneumatic tire (20) and a method of installing a pneumatic tire (20) onto a wheel (10) having a gap (14) along a rim-flange (12, 16) thereof. Particular embodiments of the method include providing a wheel (10) having a central barrel (18) and a pair rim-flanges (12, 16), where at least one of the rim- flanges (12, 16) has a gap (14). A pneumatic tire (20) is also provided, and which includes a protective sheet (30) arranged along an external side of a bead area (24) of the tire (20) at a location where the tire (20) will be arranged adjacent a gap (14) in a rim-flange (12, 16) of a wheel (10), the protective sheet (30) being non-annular and including a plurality of elongate reinforcements (34) arranged within an elastomeric matrix (32) within a thickness of the protective sheet (30). The method further includes mounting the tire (20) onto the wheel (10) such that the protective sheet (30) spans a width of the gap (14) of the rim-flange (12, 16).

WO 2017/116408 A1

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PNEUMATIC TIRE WITH NON-ANNULAR PROTECTIVE SHEET FOR BEAD AREA AND METHODS FOR USE WITH WHEEL HAVING GAP IN RIM-FLANGE

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] This invention relates generally to pneumatic tires, and methods for using pneumatic tires with wheels.

Description of the Related Art

[0002] Pneumatic tires may be mounted on a variety of different wheels. Wheels generally include a central barrel and a pair of rim-flanges spaced axially along the central barrel and between which a tire is installed. Certain wheels, such as multi-piece wheels, can have a gap along a rim-flange that can decrease the life of the tire. The gap is also referred to as a void or spacing. A gap is generated by opposing ends of a rim-flange, the opposing ends forming terminal ends of a discontinuous ring, the ring extending annularly from one terminal end to the other terminal end. The terminal ends are closely spaced to form the ring, but are spaced apart to form a gap in the ring. The rim-flange is attached to a central barrel of the wheel after the tire has been installed upon the central barrel for the purpose of constraining the tire on the central barrel and complete installation of the tire on the wheel. Multi-piece wheels can form a two-piece wheel, where one of the pair of rim-flanges is a single annular component separable from the wheel, or a three-piece wheel, where one of the pair of rim-flanges comprises two annular components each being separable from the wheel.

[0003] Presently, to protect the tire from the gap and the opposing terminal ends forming the gap in the rim-flange, scrap rubber, such as used tire tubes, are arranged between the gap and the tire during tire installation. During tire use, however, tire life is impacted as the scrap rubber migrates into the gap from its installed arrangement between the rim-flange and the tire.

[0004] Accordingly, there is a need to improve tire durability when using multi-piece wheels.

SUMMARY OF THE INVENTION

[0005] Embodiments of the present invention include a non-annular protective sheet for use along a bead area of a pneumatic tire, a pneumatic tire employing at least one non-annular protective sheet, a method of using the pneumatic tire with a multi-piece wheel, and a method for forming the pneumatic tire. In particular embodiments, the method of

installing a tire onto a wheel having a gap along a rim-flange thereof includes providing a wheel having a central barrel and a pair rim-flanges extending radially outward from the central barrel, where at least one of the rim-flanges has a gap. The method further includes providing a pneumatic tire, the tire having a pair of beads, a pair of sidewalls, and a central portion arranged between the pair of sidewalls and including a tire tread having an outer, ground-engaging side, the pair of beads each arranged in a bead area of the tire, each bead area forming an inner-radial portion of the tire from which one of the pair of sidewalls extend radially outward to the central portion, each pair of beads with each associated bead area and pair of sidewalls being spaced apart axially along a rotational axis of the tire, and a protective sheet arranged along an external side of one of the bead areas of the tire at a location where the tire will be arranged adjacent the gap in one rim-flange of the pair of rim-flanges, the protective sheet being non-annular and including a plurality of elongate reinforcements arranged within an elastomeric matrix within a thickness of the protective sheet. The method also includes mounting the tire onto the wheel such that the protective sheet spans a width of the gap of the one of the pair of rim-flanges.

[0006] Embodiments of the pneumatic tire include a pair of beads, a pair of sidewalls, and a central portion arranged between the pair of sidewalls and including a tire tread having an outer, ground-engaging side. The pair of beads are each arranged in a bead area of the tire, each bead area forming an inner-radial portion of the tire from which one of the pair of sidewalls extend radially outward to the central portion. Each pair of beads with each associated bead area and pair of sidewalls are spaced apart axially along a rotational axis of the tire. The pneumatic tire also includes a protective sheet arranged along an external side of one of the bead areas of the tire at a location where the tire will be arranged adjacent to a gap in one rim-flange of the pair of rim-flanges, the protective sheet being non-annular and including a plurality of elongate reinforcements arranged within an elastomeric matrix within a thickness of the protective sheet.

[0007] The foregoing and other objects, features and advantages of the invention will be apparent from the following more detailed descriptions of particular embodiments of the invention, as illustrated in the accompanying drawing wherein like reference numbers represent like parts of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. **1** is a perspective view of an exemplary two-piece multi-piece wheel having a gap in a rim-flange.

[0009] FIG. **2** is a perspective view of the multi-piece wheel of FIG. **1**.

[0010] FIG. **3** is a sectional view of an exemplary three-piece multi-piece wheel with a tire mounted thereon, the tire having a protective sheet in accordance with an embodiment of the invention.

[0011] FIG. **4** is a top view of a non-annular protective sheet for use in a bead area of a tire, in accordance with an embodiment of the invention.

[0012] FIG. **5A** is a sectional view of the protective sheet of FIG. **2** taken along line **5-5**.

[0013] FIG. **5B** is sectional view showing an alternative embodiment of the protective sheet of FIG. **5A**.

[0014] FIG. **6** is a side view of a tire having the protective sheet of FIG. **4** arranged along a bead area of the tire, in accordance with an embodiment of the invention.

[0015] FIG. **7** is a side view of the tire of FIG. **6** installed on the multi-piece wheel of FIG. **1**.

[0016] FIG. **8A** is a sectional view of the tire of FIG. **7**, taken along line **8A-8A**.

[0017] FIG. **8B** is a sectional view of the tire of FIG. **8A** additionally including an annular chafer (protective bead area) ply arranged along the bead area.

DETAILED DESCRIPTION OF THE INVENTION

[0018] Embodiments of the present invention comprise non-annular protective sheets for use along a bead area of a pneumatic tire, pneumatic tires employing at least one non-annular protective sheet, methods of using the pneumatic tire with a multi-piece wheel, and methods for forming the pneumatic tire. By use of the non-annular protective sheet and pneumatic tires employing one or more of said protective sheets, improved tire life is achieved when using the pneumatic tires with a wheel having a gap in a rim-flange thereof. Additionally, when using a non-annular protective sheet on a tire, the currently employed annular bead area protective ply may not only be eliminated.

[0019] With regard to a method of installing a tire onto a wheel having a gap along a rim-flange thereof, particular embodiments of said method include providing a wheel having a central barrel and a pair rim-flanges extending radially outward from the central

barrel, where at least one of the rim-flanges has a gap. Wheels upon which pneumatic tires are mounted generally include a central barrel and a pair of rim-flanges spaced axially along the central barrel and between which a tire is installed. Each rim-flange extends radially outward from the central barrel by a radial height. As noted previously, certain wheels can have a gap along one or both pairs of rim-flanges. The gap is also referred to as a void or spacing. For example, multi-piece wheels include this gap arranged along one rim-flanges, the rim-flange being separable from the wheel and positionable between installed and uninstalled arrangements. In such instances, the gap is generated by opposing ends of the separable rim-flange, the opposing ends forming terminal ends of a discontinuous ring, the ring extending annularly from one terminal end to the other terminal end. The terminal ends are closely spaced to form the ring, but are spaced apart to form a gap in the ring. It is noted that the span of the gap can vary between wheel manufactures. For example, in certain instances, the width (span) of the gap annularly along the ring is as much as 20 millimeters (mm), and in certain variations, ranges from 5 mm to 20 mm. It is appreciated that the gap may be even greater than 20 mm. The gap also has a radial height, which may be equal to or less than a radial height of the rim-flange. The rim-flange is installed along a central barrel of the wheel after the tire has been installed upon the central barrel for the purpose of constraining the tire on the central barrel and complete installation of the tire on the wheel. Multi-piece wheels can form a two-piece wheel, where one of the pair of rim-flanges is a single annular component separable from the wheel, or a three-piece wheel, where one of the pair of rim-flanges comprises two ring components each being separable from the wheel, where at least one of the two ring components has a gap. In certain instances, for the three-piece wheel, one of the two ring components is a lock ring that has a gap and the other ring is a continuous ring without a gap.

[0020] With regard to a method of installing a tire onto a wheel having a gap along a rim-flange thereof, particular embodiments of said method include providing a pneumatic tire. The tire includes a pair of beads, a pair of sidewalls, and a central portion arranged between the pair of sidewalls and including a tire tread having an outer, ground-engaging side. The pair of annular beads are spaced apart in an axial direction of the tire, where a radial center of each annular bead is arranged along a common axis, namely, the rotational axis of the tire. Each bead may form any bead used in the art of forming pneumatic tires or known to one of ordinary skill in the art, or any obvious variation thereof. For example, a bead may be formed of one or more rubber-coated metal wires wound one or more

revolutions to form a ring having a cross-section formed of a plurality of wires. When using the term "rubber" herein, "rubber" connotes any natural or synthetic rubber or rubber blend. A bead filler is commonly placed atop (that is, on the radially outer side of) each bead, the bead filler being made of any suitable material known within the industry, such as, an elastomeric or rubber material. One or more body plies may also be arranged to extend downward from a central portion of the tire to partially wrap around the bead. More specifically, a body ply extends radially inward from the central portion and along a sidewall to an axially-inner side of the bead and then to a location below a radially inward side, or bottom side, of the bead. From the bottom side of the bead, the body ply extends radially outward along an external side of the tire to a terminal location along the tire sidewall. Each bead of the pair of beads is arranged in a bead area of the tire, where each bead area forms an inner-radial portion of the tire from which one of the pair of sidewalls extend radially outward to the central portion. The bead area is generally a portion of the tire within which a bead is arranged. More specifically, a bead area as used herein is defined to extend radially outward from the innermost radial location of the tire (also referred to as the bottom side of the bead area), located adjacent to and radially inward from a tire bead, and to the top of a bead filler arranged atop the bead within a thickness of the tire. Located along an external side of the bead area is a rim-flange area configured to be arranged adjacent to a rim-flange of a wheel upon which the tire is mounted. The rim-flange area as used herein is defined to extend radially outward from the innermost radial location of the tire, located adjacent to and radially inward from a tire bead, and to the top of an area configured for adjacent arrangement to a rim-flange of a wheel, the area extending to the radial height of the rim-flange. In being adjacently arranged to a rim-flange of a wheel, it is appreciated that the entire rim-flange may not be adjacently arranged to the tire, as a portion of the rim-flange may extend outwardly from the tire (such as, from the top of the rim-flange area of the tire), where this outwardly extending portion of the rim-flange is not necessarily arranged adjacent to the tire. Described differently, in particular embodiments, the rim-flange area is an area of the tire that a portion of the rim-flange will engage or contact the tire when the tire is mounted on the wheel and/or during tire/wheel operation. In certain tires, the rim-flange area is particularly contoured to receive a rim-flange of a wheel. The external side of the bead area includes the area of the tire along which a wheel rim-flange is intended to be adjacently arranged, the external bead area being arranged axially outward from the associated bead. The central portion is annular and forms the portion of the tire arranged between a pair of tire

sidewalls. The central portion includes a tire tread having an outer, ground-engaging side, and may include a belt extending annularly around the tire and comprising one or more belt plies. The belt plies each comprise a sheet of elastomeric material reinforced with elongate reinforcements, such as cord or cable.

[0021] The tire also includes a protective sheet arranged along an external side of one of the bead areas of the tire at a location where the tire will be arranged adjacent the gap on one of the pair of rim-flanges. The protective sheet is non-annular, meaning it does not extend completely around the tire. Instead, it is sized and shaped for local application to the location of the bead area to be adjacently-aligned with the gap of a rim-flange, that is, in other words, within the rim-flange area of the tire at a location to be arranged adjacent to the gap within the rim-flange. It is appreciated that the protective sheet is at least sized to span the width of the gap but without extending substantially around the tire, and in particular embodiments, having a length not greater than (that is, equal to or less than) 15%, 10%, 5%, or 3% around the tire. The width of the gap extends in an annular direction of the wheel. In more specific embodiments, the arrangement of reinforcements within the non-annular protective sheet is sized to at least span the width of the gap. For example, in certain embodiments, the arrangement of reinforcements spans a length of no more than 60 mm and a width of 55 mm or less or 25 to 55 mm. While the reinforcements may be as long as the sheet length, in particular variations, the reinforcements are shorter than the length of the non-annular protective sheet. For example, in particular instances, the length of the reinforcements are up to 80% or 66% of the length of the non-annular protective sheet. In certain exemplary embodiments, the non-annular protective sheet has a length equal to or less than of 90 mm or 75 mm. The protective sheet also has a width extending in a widthwise direction perpendicular to both the length and thickness of the protective sheet, each of the length, width, and thickness extending in directions perpendicular to one another. In particular embodiments, the protective sheet width partially or fully spans the radial height of the gap. As for the widthwise span of the arrangement of reinforcements, the width of the reinforcement arrangement may be less than, equal to, or greater than the radial height of the rim-flange area of the bead area of the tire and/or the radial height of the gap in the rim-flange, and may be equal to or less than the width of the non-annular protective sheet. In certain instances, for example, the width of the reinforcement arrangement is up to 80% or 66% the width of the non-annular protective sheet. In certain exemplary embodiments, the non-annular protective sheet has a width equal to or less than 83 mm or 69 mm. In an

exemplary embodiment, a non-annular protective sheet having a length of 75 mm with reinforcements having a length of 60 mm and a width of 45 mm with the arrangement of reinforcements spanning a width of 30 mm is used with a tire characterized as having a bead area having a circumference of approximately 1600 mm, although this sized protective sheet may be used on tires greater or lesser in size. It is appreciated that the length of all reinforcements within a non-annular protective sheet may all be the same length or one or more of the plurality of reinforcements may be of different lengths. As to coverage area, in certain exemplary embodiments, the non-annular protective sheet is sized to cover an area not greater than 7,500 square millimeters (mm^2), such as where, for example, the protective sheet length is 90 mm and the width is 83 mm. It is appreciated that the protective sheet may form any shape, so long as it is sized as described herein. For example, in certain exemplar embodiments, the protective sheet forms a rectangle or an oval. In certain instances, the length of the protective sheet extends in a direction perpendicular to a radial direction of the tire while the width of the protective sheet extends in the radial direction of the tire, or vice versa in other instances.

[0022] The protective sheet is formed and arranged to locally protect the tire from the gap and the structure forming the gap in a rim-flange. To achieve this purpose, the protective sheet is formed of an elastomeric material, such as rubber, and reinforced with a plurality of elongate reinforcements arranged within a thickness of the protective sheet. Stated differently, the plurality of elongate reinforcements are arranged within an elastomeric matrix within a thickness of the protective sheet. Any suitable elongate reinforcement may be employed. In certain exemplary embodiments, the elongate reinforcements are made of steel, and may take the form of wire or cable. In other exemplary embodiments, the elongate reinforcements are made of aramid, and may take the form of a strand or cord. Additionally, the elongate reinforcement may comprise any reinforcement arranged within any tire reinforcement ply, such as a body ply or belt ply reinforcement. For example, in certain embodiments, the strongest ply used in a particular tire construction is used to form the non-annular protective sheet. Exemplary arrangements of reinforcements include arranging reinforcements in a spaced-apart, parallel arrangement, where the reinforcements are spaced apart, centerline to centerline, from 1.4 mm to 2.5 mm, where the reinforcements have a diameter upwards of 0.3 mm, such that elastomeric material fills the 0.5 mm to 1.5 mm between the reinforcements. In other variations, the reinforcements have diameters up to 0.7 mm to 1.3 mm, where elastomeric material fills up to 0.5 mm to 1.5 mm between adjacent,

spaced-apart reinforcements. In arranging the reinforcements within the protective sheet, the reinforcements may be molded within a thickness of elastomeric material or may be coated with elastomeric material forming the thickness of the protective sheet. In other instances, the plurality of reinforcements are arranged within a one or more plies each including one or more reinforcements arranged within an elastomeric matrix. The one or more plies may form the non-annular protective sheet, or may be arranged with one or more sheets of elastomeric material. For example, in certain variations, one or more reinforced plies are arranged between a pair of elastomeric sheets (which may or may not include any other reinforcements). In one variation, the reinforced ply is 1.2 mm thick and each of a pair of elastomeric sheets arranged an opposing sides of the reinforced ply are 0.5 mm thick to provide a non-annular protective sheet having a thickness of 2.2 mm. In other variations, the thickness of the non-annular protective sheet is up to 4 mm.

[0023] It is appreciated that the plurality of elongate reinforcements may be arranged in any desired arrangement within the protective sheet. In particular exemplary embodiments, the plurality of elongate reinforcements are arranged parallel to each other, to form an array of elongate reinforcements. Other arrangements are contemplated, such as where the plurality of elongate reinforcements are arranged to provide a cross-woven arrangement. Cross-woven may form an over and under woven pattern, where reinforcements alternate overtop and below other reinforcements in a woven arrangement, or may simply provide an overlay of one or more reinforcements over other reinforcements. For example, the cross-woven arrangement of reinforcements utilize aramid.

[0024] It is also appreciated that the protective sheet may include one or more identifiers, such as colored and/or raised or sunken text, symbols, or images, or any combination thereof, to indicate placement, use, or orientation of the protective sheet relative a tire or a wheel. Any such identifiers may also be used to identify the location of the reinforcements within the protective sheet, to ensure proper arrangement of the reinforcements relative a gap on a wheel rim-flange. The one or more identifiers maybe formed and arranged in any sufficient manner, such as, for example, by printing onto the protective sheet, molding with the protective sheet, or affixing to the protective sheet with an adhesive.

[0025] The protective sheet may be applied to the tire and installed in uncured or cured forms. In particular embodiments, the protective sheet is installed on the tire during a tire assembly process and before the tire is cured. In such instances, the protective sheet

forms a portion of an original tire. Typically, the protective sheet is uncured at the time of installation, and is later cured with the tire during a vulcanization process. In other embodiments, the protective sheet is installed on a cured tire, that is, after the tire has been cured. In such instances, the protective sheet forms an accessory attachment on an original tire. Furthermore, in such instances, the protective sheet may applied in a precured form or uncured form, and in either case applied using a bonding agent, such as an adhesive or bonding rubber. When applied in an uncured form, it may be subsequently cured using a vulcanization process while attached to the cured tire.

[0026] Particular embodiments of the methods for installing a tire onto a wheel having a gap along a rim-flange thereof includes a step of mounting the tire onto the wheel such that the protective sheet spans (extends across) a width of the gap of one rim-flange of the pair of rim-flanges. In more specific instances, the plurality of elongate reinforcements, or the arrangement of reinforcements, are arranged to span (extend across) the width of the gap. For example, in certain instances, the plurality of elongate reinforcements are arranged to extend lengthwise across the gap. It is appreciated that the tire may be installed on the multi-piece wheel in accordance with any known manner or obvious variation thereof, so long as the protective sheet or reinforcements within said sheet are arranged to span the width of a gap along the separable rim-flange. Optionally, the protective sheet and/or the arrangement of elongate reinforcements within the sheet are also arranged to partially or fully span a radial height of the gap arranged within a rim-flange area of the tire. It is appreciated that the protective sheet may be arranged in any desired configuration relative to the wheel. For example, in certain embodiments, the tire is mounted onto the wheel such that the plurality of elongate reinforcements are arranged to extend in a direction substantially parallel to a line extending through and perpendicular to the rotational axis of the tire. Stated differently, each, or one or more, elongate reinforcements of the protective sheet are arranged perpendicular to a radius extending from the rotational axis A or tangent to a circle for which the rotational axis is the origin. In other variations, the non-annular protective sheet may be arranged such that the reinforcements are oriented at any other angle relative to the radial direction of the tire or wheel.

[0027] As noted previously, in certain embodiments, where a pneumatic tire employs a protective sheet within the bead area of the tire, the tire is free of an annular reinforced bead area ply. By use of the protective sheet, tires commonly including an annular reinforced bead area ply arranged along the external side of each bead area may eliminate use

of said annular reinforced bead area ply when employing the use of the protective sheet. The annular reinforced bead area ply is arranged along the bead area and extends radially outward from a first terminal end arranged adjacent the bead and to a second terminal end arranged radially outward from the first terminal end. The second terminal end may be located along the external portion of the bead area or of the sidewall. An annular reinforced bead area ply is commonly referred to as a chafer ply.

[0028] Particular embodiments of the tire treads and methods discussed above will now be described in further detail below in association with the figures filed herewith exemplifying the present invention in association with particular embodiments of the tires.

[0029] With reference to FIGS. **1** and **2**, an exemplary multi-piece wheel **10** is shown, the wheel being a two-piece wheel. Wheel **10** includes a pair of rim-flanges **12**, **16**. Rim-flange **16** is fixed while rim-flange **12** is separable from the wheel **10**, and more specifically, from central barrel **18**. This is more clearly shown in FIG. **2**, where a separable rim-flange **12** is shown in association with a central barrel **18**. Each rim-flange **12**, **16** has a radial height $\mathbf{H_{RF}}$. Rim flange height $\mathbf{H_{RF}}$ extends radially outward from the central barrel **18**, or more generally from a location where the tire sits on the wheel. As best shown in FIG. **1**, rim-flange **12** includes opposing terminal ends $\mathbf{E_{12}}$ that are closely spaced apart to form a gap **14**, which extends the full radial height $\mathbf{H_{RF}}$ of the rim-flange (at least locally). In FIG. **3**, a three-piece wheel **110** is shown in association with a pneumatic tire **20**, where the separable rim-flange **112** comprises two (first and second) ring components **112A**, **112B**, which are annular or substantially annular. Separable rim-flange **112** also includes a gap (not shown) similar to the gap **14** shown in FIG. **2**, but which is formed solely by second ring component **112B**, such that the resulting gap is limited to the radial height of second ring component **112B** and not the full effective radial height $\mathbf{H_{RF}}$ of rim-flange **112**. An opposing rim-flange **116** (fixed/non-removable) and central barrel **118** are also shown. As discussed previously, other wheel designs may be employed.

[0030] In FIGS. **4** and **5A**, an exemplary protective sheet **30** is shown, which is non-annular and rectangular in shape, having a length $\mathbf{L_{30}}$ greater than its width $\mathbf{W_{30}}$ and thickness $\mathbf{T_{30}}$. Exemplarily lengths and widths have been described previously above, any of which may be employed with sheet **30**. Protective sheet **30** includes a plurality of elongate reinforcements **34** arranged within elastomeric material forming an elastomeric matrix **32**. The plurality of elongate reinforcements **34** can be said to form an arrangement of reinforcements **35**. In the embodiment shown, the arrangement has a length $\mathbf{L_{35}}$ and a width

W_{35}. The elastomeric matrix in any embodiment may be formed of one or more elastomers, and may be homogeneous or heterogeneous, and may be molded and/or formed of layers. The plurality of elongate reinforcements **34** are each arranged to extend in a lengthwise direction of the protective sheet **30** and parallel to each other in an array. The plurality of elongate reinforcements **34** are spaced apart by a spacing distance S_{30}, which is uniform in the embodiment shown but may be non-uniform in other variations. Exemplary spacings are discussed previously above. The reinforcements are shown to be arranged entirely within the thickness T_{20}, but may be arranged partially within the thickness and along an exterior surface of the protective sheet in other variations of any protective sheet. With reference to another exemplary embodiment in FIG. **5B**, the plurality of elongate reinforcements **134** are arranged within an elastomeric matrix **132** to form of a ply of reinforced elastomeric material **131**, which may comprise any reinforced ply used to form any other component within a tire, for example, where the ply **131** is arranged between a pair of elastomeric plies **136** to form the non-annular protective sheet. Width W_{130} of the protective sheet and width W_{135} of the arrangement of reinforcements are also shown for reference.

[0031] In application, any protective sheet contemplated herein is arranged on the external side of the bead area of a tire. In the exemplary embodiment shown in FIGS. **6** and **8A**, the protective sheet **30** of FIGS. **4** and **5** is shown arranged along tire **20**, and more specifically along an external side OS_{20} of bead area **24**. Interior side IS_{20} is arranged along the interior of the tire. With specific reference to FIG. **8A**, bead area **24** includes a bead **21** and a bead filler **22** arranged atop the bead and extending radially outward toward a sidewall **26** and away from a rotational axis **A** of the tire, where, with reference to FIG. **6**, a tire sidewall **26** extends radially outward from the associated bead area and to an annular, central portion **28** of the tire, which includes a tire tread **29**. A body ply **23** is also shown extending downward/inward from the central portion of the tire to partially wrap around the bead **21**. Specifically, the body ply **23** extends radially inward along a sidewall **26** to an axially-inner side IS_{20} of the bead and then to a location below a radially inward side, or bottom side, of the bead. From the bottom side of the bead, the body ply **23** extends radially outward along an external side OS_{20} of the tire to a terminal location along the tire sidewall **26**. In the embodiment shown, bead area **24** extends radially outward from the innermost radial location of the tire, or bottom side BS_{20}, located adjacent to and radially inward from a tire bead, and to the top of bead filler **22** arranged atop bead **21**. Located within the bead area **24** is a rim-flange area RFA_{20}, which is an area of the tire configured to be arranged adjacent to, and/or

configured to receive a rim-flange of a wheel when the tire is mounted on the wheel. The rim-flange area **RFA$_{20}$** extends radially outward from the innermost radial location of the tire **BS$_{20}$**, located adjacent to and radially inward from a tire bead **21**, and to the top of an area configured for adjacent arrangement next to a rim-flange of a wheel, the area extending to the radial height of the rim-flange of the wheel. With specific reference to FIG. **8A**, it is noted that the protective sheet **30** is arranged in bead area **24** and within rim-flange area **RFA$_{20}$**, and has a width **W$_{30}$** extending radially outward from bottom side **BS$_{20}$** to span the height of rim-flange area **RFA$_{20}$**. The protective sheet width **W$_{30}$** spans a full height of the rim-flange area **RFA$_{20}$** and therefore spans the rim-flange gap height **W$_{14}$** (not shown, but see FIG. **7**), while the arrangement **35** of elongate reinforcements partially spans the height of rim-flange area **RFA$_{20}$** and the rim-flange gap height **H$_{14}$** of wheel **10**. With reference to the embodiment of FIG. **3**, a width **W$_{30}$** of protective sheet **30** spans a height of the rim-flange area **RFA$_{20}$** and therefore spans the rim-flange gap height **W$_{14}$** (not shown, but see FIG. **7**), while the arrangement **35** of elongate reinforcements also fully spans the height of rim-flange area **RFA$_{20}$** and the gap arranged in rim-flange ring **112B** of wheel **10**. As noted previously, in certain embodiments, the pneumatic tire is free of an annular reinforced bead area ply that is otherwise commonly incorporated into an pneumatic tire. In the exemplary embodiment of FIG. **8A**, the tire is free of an annular reinforced bead area ply. To the contrary, with reference to an exemplary embodiment in FIG. **8B**, pneumatic tire **20** includes an annular reinforced bead area ply **25**, which has a width **W$_{25}$** extending radially outward from the rim-flange area (see **RFA$_{20}$** in FIG. **8A**).

[0032] In mounting any pneumatic tire having a non-annular protective sheet as contemplated herein, the protective sheet is aligned with the gap on a rim-flange such that the protective sheet spans the width of the gap. In an exemplary embodiment shown in FIG. **7**, the tire **20** of FIG. **6** is arranged along the wheel **10** of FIG. **1**, where non-annular protective sheet **30** is aligned with gap **14** in separable rim-flange **12**. The non-annular protective sheet **30** is arranged such that the plurality of elongate reinforcements **34** arranged in the sheet extend across (span) gap **14**, and more specifically, across a width **W$_{14}$** of gap **14**. Also, in association with FIGS. **8A** and **8B**, the width of the arrangement **35** of reinforcements **34** extends partially along the height **H$_{14}$** of gap **14**. By further example, with reference to the embodiment of FIG. **3**, a width **W$_{30}$** of protective sheet **30** spans a height of the rim-flange area **RFA$_{20}$** and therefore spans the rim-flange gap height **W$_{14}$** (not shown, but see FIG. **7**), while the arrangement **35** of elongate reinforcements also fully spans the height of rim-flange

area **RFA_{20}** and the gap arranged in rim-flange ring **112B** of wheel **10**. It is noted that the arrangement **35** of reinforcements extends beyond the height of the gap arranged in rim-flange ring **112B** and substantially the full height of the rim-flange **112**, such that in other variations, the arrangement of reinforcements may extend less than the height of rim-flange **112** when spanning the substantial full height of a gap in rim-flange ring **112B**. It is noted that tire **20** is mounted onto wheel **10** such that each elongate reinforcement of the plurality of elongate reinforcements **34** in the protective sheet **30** are arranged to extend in a direction substantially parallel to a line **40** extending through and perpendicular to the rotational axis **A** of the tire. In other words, one or more elongate reinforcements of the protective sheet are arranged perpendicular to a radius extending from the rotational axis **A** or tangent to a circle for which the rotational axis is the origin.

[0033] In spanning or extending any full width or height, the protective sheet or the arrangement of reinforcements arranged therein may extend up to or beyond the full width or height, and in extending up to the full width or height may substantially span or extend up to the full or partial height, where substantially connotes a difference of up to 5 percent or to up to 10 percent from the full width or height, or the full dimension of any other dimension referenced herein.

[0034] It is appreciated that the pneumatic tire as described in association with any embodiment or variation may be assembled and formed using any known method(s) or apparatus(es). In particular embodiments, where the non-annular protective sheet is applied to an uncured pneumatic tire (also referred to as a green tire) and cured with the tire, any such pneumatic tire is formed by:

- arranging a pair of annular beads spaced apart in an axial direction of an uncured tire assembly;
- arranging one or more body plies within other tire components within the uncured tire assembly, each one or more body plies comprising a sheet of elastomeric material reinforced with elongate reinforcements;
- arranging a cured or uncured non-annular protective sheet as contemplated herein along an external side of a bead area of the uncured tire assembly;
- curing the uncured tire assembly to form a pneumatic tire having a protective sheet arranged along an external side of the bead area as contemplated herein.

It is appreciated that the protective sheet may be formed during assembly of the uncured tire assembly at a tire building machine, or after being assembled at a tire building machine but prior to curing.

[0035] The terms "comprising," "including," and "having," as used in the claims and specification herein, shall be considered as indicating an open group that may include other elements not specified. The terms "a," "an," and the singular forms of words shall be taken to include the plural form of the same words, such that the terms mean that one or more of something is provided. The terms "at least one" and "one or more" are used interchangeably. The term "single" shall be used to indicate that one and only one of something is intended. Similarly, other specific integer values, such as "two," are used when a specific number of things is intended. The terms "preferably," "preferred," "prefer," "optionally," "may," and similar terms are used to indicate that an item, condition or step being referred to is an optional (i.e., not required) feature of the invention. Ranges that are described as being "between a and b" are inclusive of the values for "a" and "b" unless otherwise specified.

[0001] While this invention has been described with reference to particular embodiments thereof, it shall be understood that such description is by way of illustration only and should not be construed as limiting the scope of the claimed invention. Accordingly, the scope and content of the invention are to be defined only by the terms of the following claims. Furthermore, it is understood that the features of any specific embodiment discussed herein may be combined with one or more features of any one or more embodiments otherwise discussed or contemplated herein unless otherwise stated.

CLAIMS

What is claimed is:

1. A method of installing a tire onto a wheel having a gap along a rim-flange thereof, the method comprising:

providing a wheel having a central barrel and a pair rim-flanges extending radially outward from the central barrel, where at least one of the rim-flanges has a gap;

providing a pneumatic tire, the tire having a pair of beads, a pair of sidewalls, and a central portion arranged between the pair of sidewalls and including a tire tread having an outer, ground-engaging side, the pair of beads each arranged in a bead area of the tire, each bead area forming an inner-radial portion of the tire from which one of the pair of sidewalls extend radially outward to the central portion, each pair of beads with each associated bead area and pair of sidewalls being spaced apart axially along a rotational axis of the tire, and a protective sheet arranged along an external side of one of the bead areas of the tire at a location where the tire will be arranged adjacent the gap in one rim-flange of the pair of rim-flanges, the protective sheet being non-annular and including a plurality of elongate reinforcements arranged within an elastomeric matrix within a thickness of the protective sheet;

mounting the tire onto the wheel such that the protective sheet spans a width of the gap of the one of the pair of rim-flanges.

2. The method of claim 1, where the elastomeric material is rubber.

3. The method of any one of claims 1 and 2, where the plurality of elongate reinforcements are formed of steel or aramid.

4. The method of any one of claims 1 to 3, where the tire is mounted onto the wheel such that the plurality of elongate reinforcements are arranged to extend in a direction substantially parallel to a line extending through and perpendicular to the rotational axis of the tire.

5. The method of any one of claims 1 to 4, where the protective sheet is rectangular or forms an oval.

6. The method of any one of claims 1 to 5, where the protective sheet is installed on the tire during a tire assembly process and before the tire is cured.

7. The method of any one of claims 1 to 6, where the protective sheet is affixed to the tire after the tire has been cured.

8. The method of any one of claims 1 to 7, where the tire is free of any annular reinforced bead area ply arranged along the external side of each bead area, the annular reinforced bead area ply configured to extend radially outward from a first terminal end arranged adjacent the bead and to a second terminal end arranged radially outward from the first terminal end.

9. The method of any one of claims 1 to 8, where for the protective sheet, the plurality of elongate reinforcements are arranged to extend lengthwise across the width of the gap.

10. The method of any one of claims 1 to 9, where the plurality of reinforcements span a length of 75 mm or less and a width of 55 mm or less.

11. The method of any one of claims 1 to 10, where the wheel is a two-piece or three-piece wheel, and the gap is formed by opposing terminal ends of the associated rim-flange.

12. A pneumatic tire comprising:

a pair of beads,

a pair of sidewalls, and

a central portion arranged between the pair of sidewalls and including a tire tread having an outer, ground-engaging side,

the pair of beads each arranged in a bead area of the tire, each bead area forming an inner-radial portion of the tire from which one of the pair of sidewalls extend radially outward to the central portion,

each pair of beads with each associated bead area and pair of sidewalls being spaced apart axially along a rotational axis of the tire, and

a protective sheet arranged along an external side of one of the bead areas of the tire at a location where the tire will be arranged adjacent to a gap in one rim-flange of the pair of rim-flanges, the protective sheet being non-annular and including a plurality of elongate reinforcements arranged within an elastomeric matrix within a thickness of the protective sheet.

13. The pneumatic tire of claim 12, where the elastomeric material is rubber.

14. The pneumatic tire of any one of claims 12 to 13, where the plurality of elongate reinforcements are formed of steel or aramid.

15. The pneumatic tire of any one of claims 12 to 14, where the protective sheet is rectangular or forms an oval.

16. The pneumatic tire of any one of claims 12 to 15, where the protective sheet forms a portion of an original tire.

17. The pneumatic tire of any one of claims 12 to 15, where the protective sheet is an accessory attachment to an original tire.

18. The pneumatic tire of any one of claims 12 to 17, where the tire is free of any annular reinforced bead area ply arranged along the external side of each bead area, the reinforced bead area ply extending radially outward from a first terminal end arranged adjacent the bead and to a second terminal end arranged along the associated (adjacent) sidewall.

19. The pneumatic tire of any one of claims 12 to 18, where for the protective sheet, the plurality of elongate reinforcements are arranged to extend lengthwise across the width of the gap.

20. The pneumatic tire of any one of claims 12 to 19, where the plurality of reinforcements span a length of 75 mm or less and a width of 55 mm or less.

21. The pneumatic tire of any one of claims 12 to 20, where a second protective sheet is arranged along an external side of the other of the bead areas of the tire at a location where the tire will be arranged adjacent a gap of the other of the pair of rim-flanges, the second protective sheet being non-annular, where the second protective sheet is provided as the protective sheet described in of any one of claims 12 to 20.

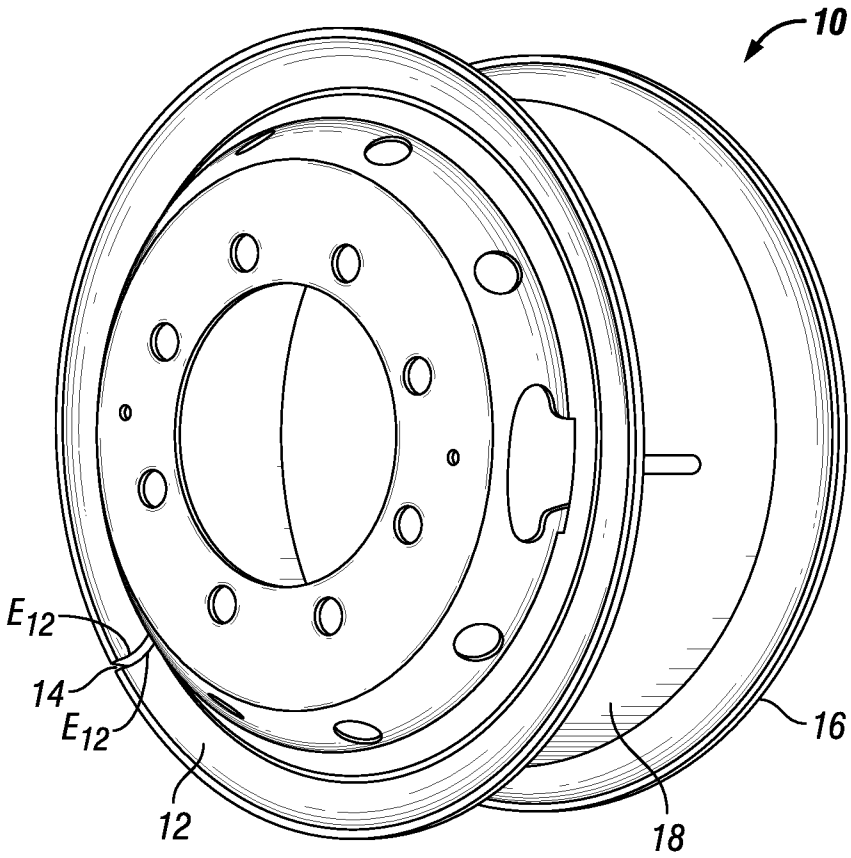

FIG. 1

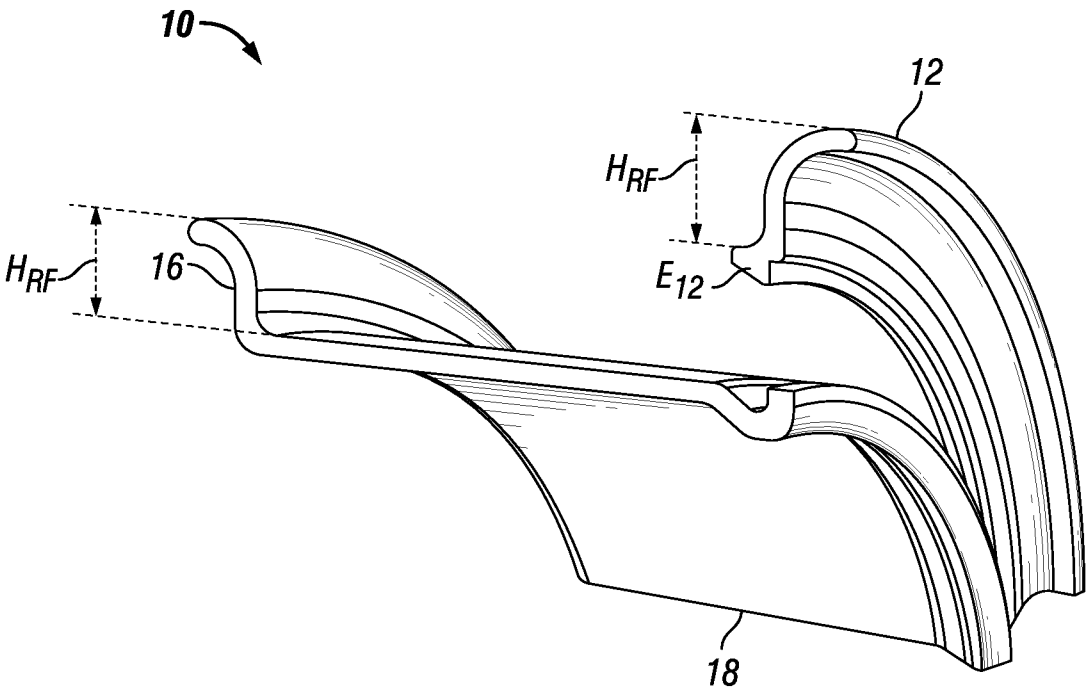

FIG. 2

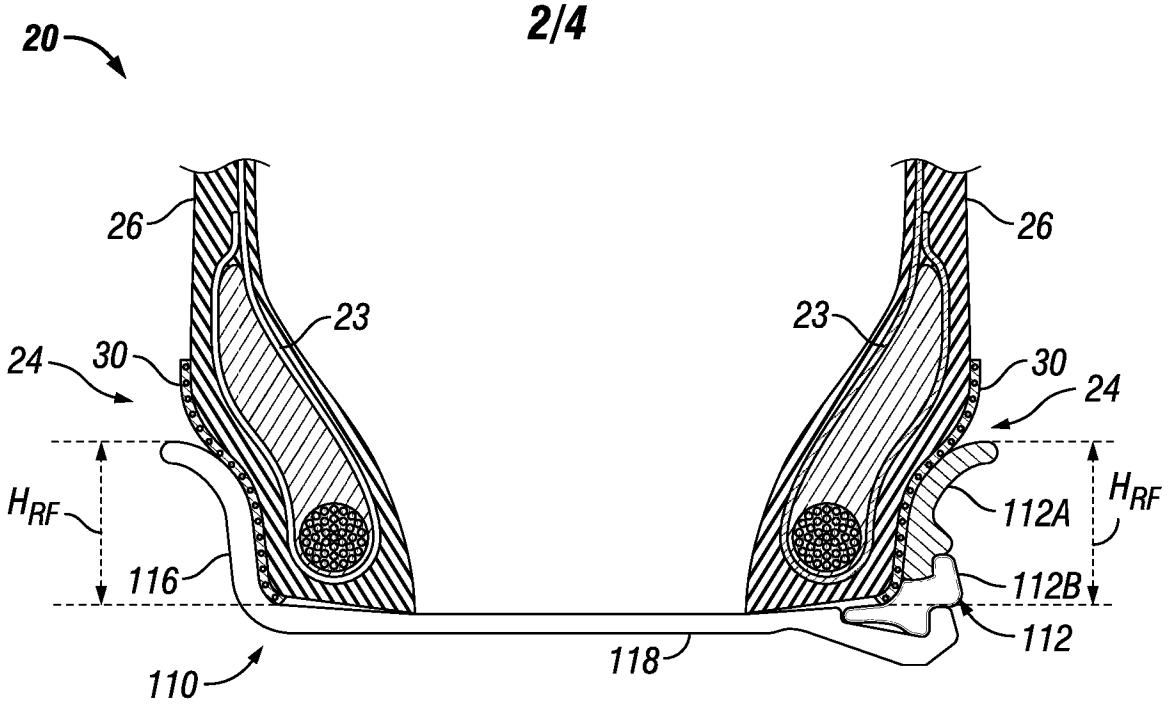
20
26
23
24
30
H_{RF}
116
110
118
112A
112B
112

FIG. 3

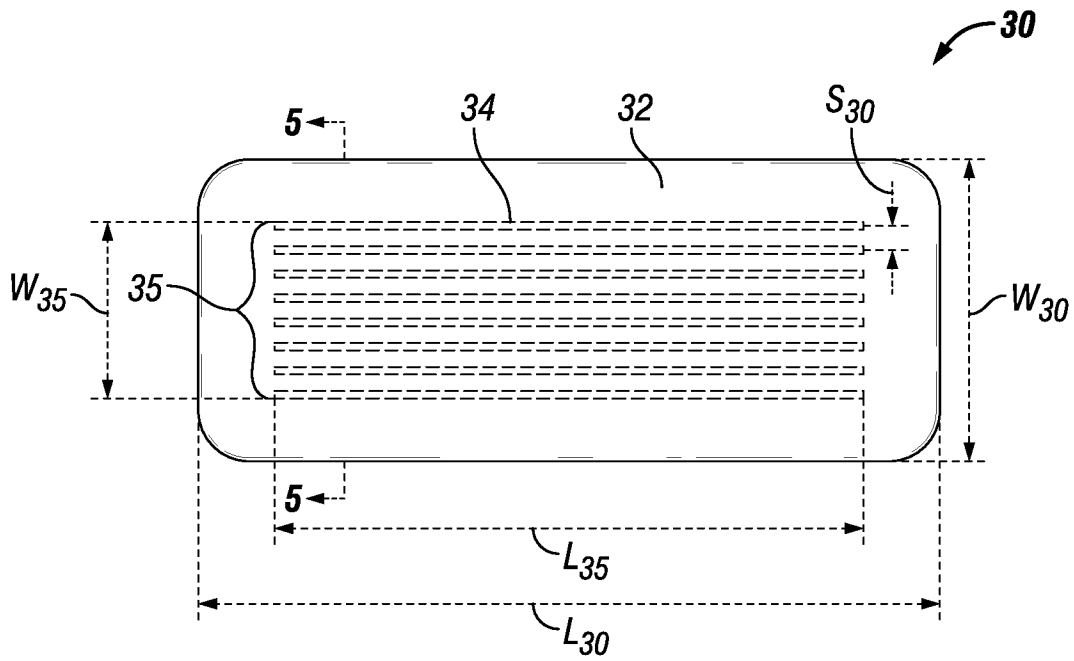
30
5
34
32
S_{30}
W_{35}
35
W_{30}
L_{35}
L_{30}

FIG. 4

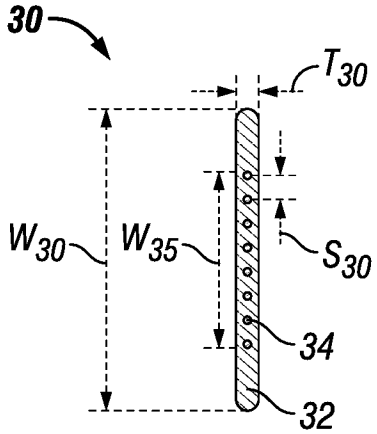

FIG. 5A

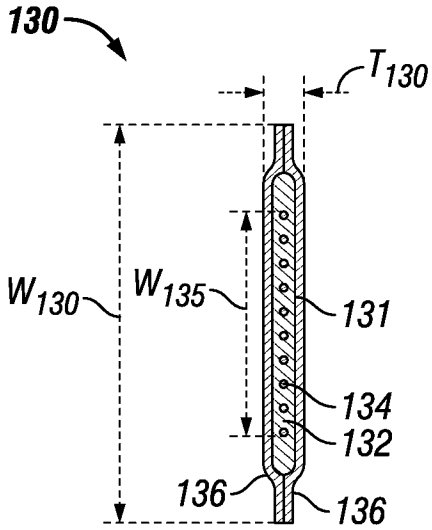

FIG. 5B

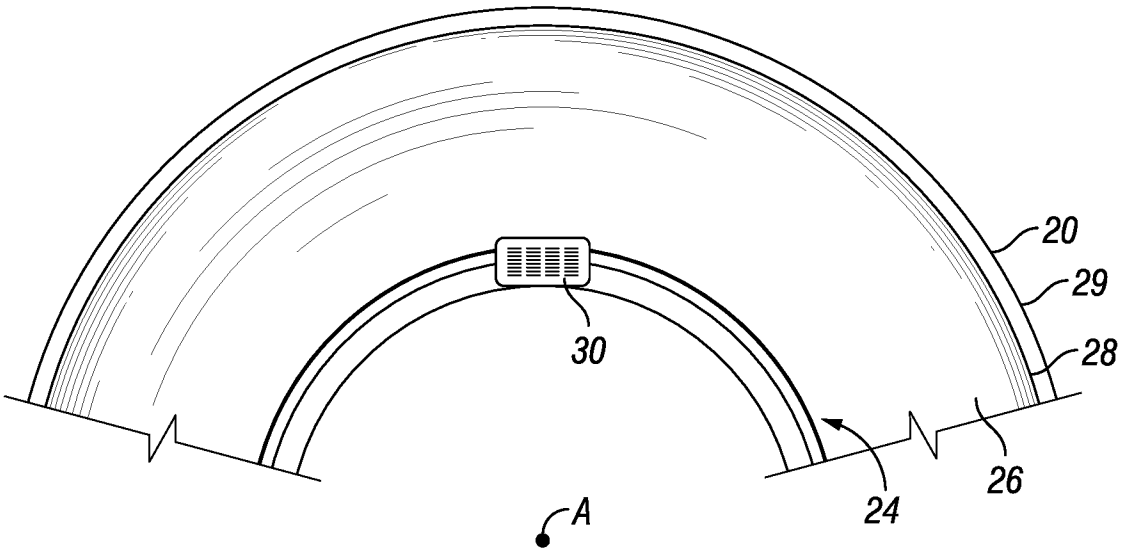

FIG. 6

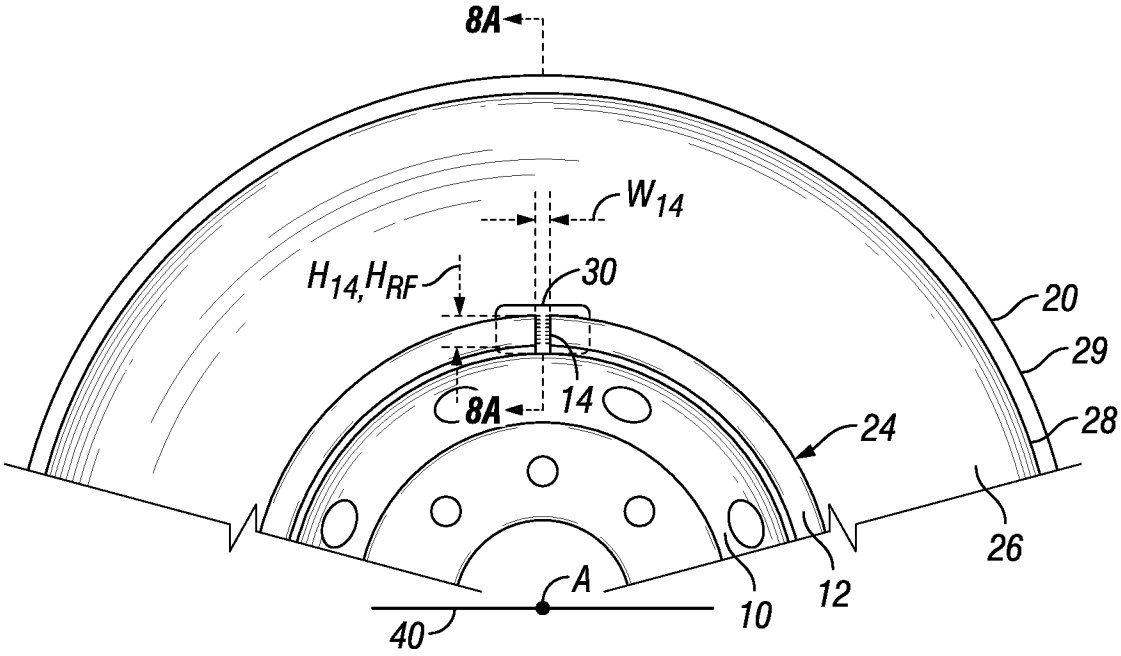

FIG. 7

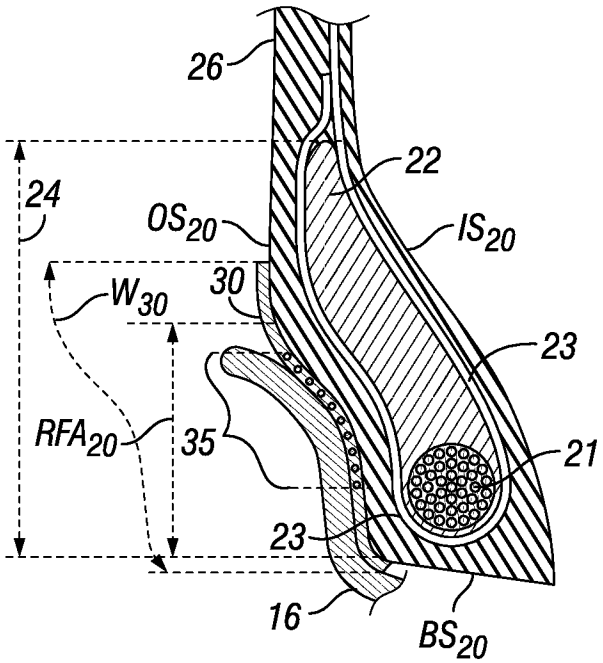

FIG. 8A

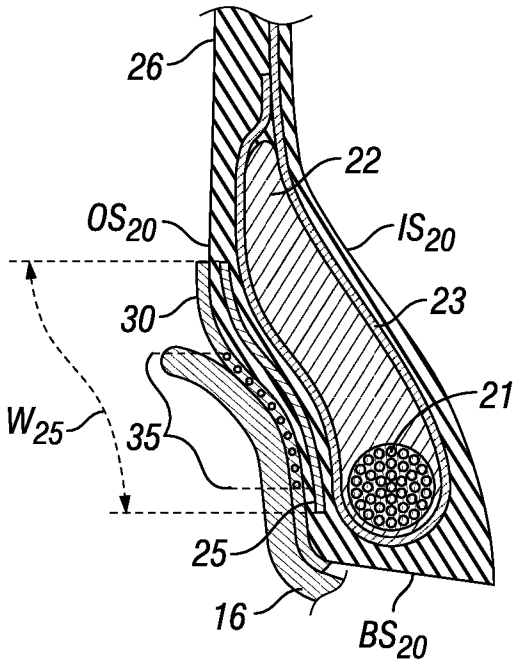

FIG. 8B

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2015/067785

A. CLASSIFICATION OF SUBJECT MATTER
INV. B60C15/06 B60C9/00 B60B25/06 B60B25/04
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B60C B60B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 3 419 061 A (RYUICHI MORIKAWA ET AL) 31 December 1968 (1968-12-31) the whole document	1,12
A	EP 0 114 994 A2 (CONTINENTAL GUMMI WERKE AG [DE]) 8 August 1984 (1984-08-08) the whole document	1,12
A	US 3 009 501 A (PAUL LEMMERZ) 21 November 1961 (1961-11-21) the whole document	1,12
A	GB 809 575 A (FIRESTONE TIRE & RUBBER CO) 25 February 1959 (1959-02-25) the whole document	1,12
A	US 3 608 607 A (GERBETH GERHART L) 28 September 1971 (1971-09-28) the whole document	1,12

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 September 2016	04/10/2016

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Jung, Wolfgang

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2015/067785

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