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(54) **Title**: IMPROVED PNEUMATIC TIRE WITH SEGMENTED BODY PLY

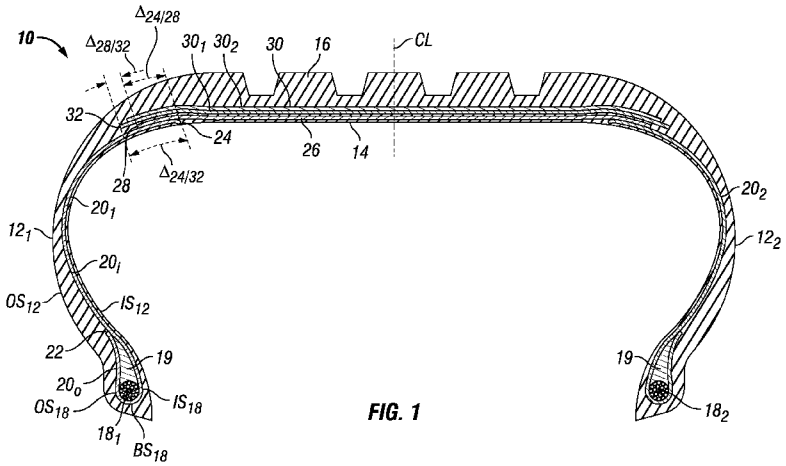


FIG. 1

(57) **Abstract**: Pneumatic tire including one or more segmented body plies. The segmented body ply forms a first side body ply 20_1 and a second side body ply 20_2 arranged within a thickness of the tire. The first side body ply extends from an outer terminal end 22 of the first side body ply radially inward along an axially-outer side portion of the first sidewall portion 12_1 to an outer side of the first bead 18_1, and around a bottom of the first bead to an inner side of the first bead, and radially outward along an axially-inner side portion of the first sidewall portion to an inner terminal end 24 of the first side body ply. The second side body ply extends in a similar fashion along a second sidewall and relative a second bead. A further aspect comprises a method of forming said tire.

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IMPROVED PNEUMATIC TIRE WITH SEGMENTED BODY PLY

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] This invention relates generally to pneumatic tires, and methods for forming pneumatic tires.

Description of the Related Art

[0002] Pneumatic tires are known to have at least one body ply and a pair of annular beads spaced apart along a rotational axis of the tire, the at least one body ply extending lengthwise in an annular direction around the tire, and extending across a width of the tire by wrapping partially around a first bead of the pair of beads, then extending to the second bead of the pair of beads, and then partially around the second bead within the thickness of the tire. The wraps at each of the beads are commonly referred to as body ply turn-ups, there the terminal end of the body ply for each turn-up is commonly referred to as a turn-up ending. The body ply turn-ups are employed to anchor the body ply in association with the beads to provide structural integrity by allowing the body ply to properly operate under tension within the tire. This body ply is continuous along its length, except for any splice in the body ply length, should a splice be present, and is continuous along its width. In addition to the body ply, a pneumatic tire may also include a bead filler arranged atop each bead, a chafer wrap extending at least partially around the bead (with or without any bead filler), and/or a sidewall stiffening ply arranged along each sidewall, commonly at or near the body ply turn-up. The chafer wrap and sidewall stiffening ply are generally formed of a material different from the material used to form the body ply. For example, the chafer ply is commonly formed of a square-woven fabric, while the sidewall stiffening ply includes metallic reinforcements biased relative to the radial direction of the tire. This invention focuses on segmenting the body ply to deter the migration of oxygen to the tire summit.

[0003] It has been found that tire endurance can be affected by the migration of oxygen through the tire carcass, where the oxygen reacts with the rubber to increase the cross-link density of the rubber. By doing so, the elastic modulus of the rubber increases while the rubber peel strength and elongation-to-break properties decrease. Additionally, the reinforcements within the body ply, which can be cords or cables, can act as a conduit for oxygen to the summit of a tire, where the summit is the central portion of the tire arranged

between the sidewalls of the tire and which contains the tire tread. While an inner liner may reduce this migration of oxygen, oxygen may still migrate to the body ply reinforcements and ultimately to the tire summit.

[0004] Therefore, there is a need to further impede the migration of oxygen, and more generally air or gases, to the summit of a tire.

SUMMARY OF THE INVENTION

[0005] Embodiments of the present invention include a pneumatic tire and a method for forming a pneumatic tire. In particular embodiments, a pneumatic tire includes a pair of annular beads spaced apart in an axial direction of the tire, the pair of annular beads comprising a first annular bead and a second annular bead. The pneumatic tire also includes a central portion including a tire tread and extending annularly around the tire and between a first sidewall and a second sidewall, the first sidewall extending radially outward from the first bead and to the central annular portion, the second sidewall extending radially outward from the second bead and to the central annular portion. Said tire further includes a first side body ply and optionally a second side body ply arranged within a thickness of the tire, each of the first and second side body plies comprising a sheet of elastomeric material reinforced with elongate reinforcements. The first side body ply extends from an outer terminal end of the first side body ply radially inward along an axially-outer side portion of the first sidewall to an axially-outer side of the first bead, and around a radially-inner side of the first bead to an axially-inner side of the first bead, and radially outward along an axially-inner side portion of the first sidewall to an inner terminal end of the first side body ply. When present, the second side body ply extends from an outer terminal end of the second side body ply radially inward along an axially-outer side portion of the second sidewall to an axially-outer side of the second bead, and around a radially-inner side of the second bead to an axially-inner side of the second bead, and radially outward along an axially-inner side portion of the second sidewall to an inner terminal end of the second side body ply.

[0006] Further embodiments of the invention form a method of forming a pneumatic tire. Particular embodiments of the method include: (1) arranging a pair of annular beads spaced apart in an axial direction of an uncured tire assembly, the pair of annular beads comprising a first annular bead and a second annular bead; (2) arranging a first side body ply and a second side body ply within the uncured tire assembly, each of the first and second side body plies comprising a sheet of elastomeric material reinforced with

elongate reinforcements; and, (3) curing the uncured tire assembly to form a pneumatic tire according to any embodiment contemplated above or otherwise described herein.

[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 widthwise sectional view of a tire having a side body ply and a central body ply, according to an embodiment of the invention.

[0009] FIG. **2** is a partial widthwise sectional view of a tire having a side body ply and a central body ply, in accordance with another embodiment of the invention.

[0010] FIG. **3** is a partial widthwise sectional view of a tire having a side body ply and a central body ply, in accordance with yet another embodiment of the invention.

[0011] FIG. **4** is a partial widthwise sectional view of a tire having a side body ply and a central body ply, in accordance with still another embodiment of the invention.

[0012] FIG. **5** is a sectioned top view of the side and central body plies of FIG. **1**, taken below a tread and belt of the tire.

[0013] FIG. **6** is a sectioned top view of the side and central body plies taken below a tread and belt of the tire, in accordance with another embodiment of the invention.

[0014] FIG. **7** is a partial widthwise sectional view of a tire having a segmented body ply, in accordance with another embodiment of the invention.

[0015] FIG. **8** is a partial widthwise sectional view of a tire having a segmented body ply, in accordance with yet another embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0016] Embodiments of the present invention comprise pneumatic tires and methods for forming any such inventive pneumatic tire, where any such pneumatic tire is characterized as having a body ply formed of multiple sections or segments, in lieu of having a single body ply extending from bead to bead and radially outward at each turn-up relative each bead. One benefit of the inventive tire construction contemplated herein is to reduce the migration of oxygen or other gases from the bead or sidewall areas to the tire summit. Other benefits may also be realized by this tire construction.

[0017] It is appreciated that for any known pneumatic tire construction, that is, the assembly of components forming the pneumatic tire, for any body ply formed of a single sheet of reinforced material, the segmented body ply discussed herein is substituted therefor to form the inventive pneumatic tire. More particular embodiments of the invention will now be described more fully.

[0018] Generally, the pneumatic tire includes a pair of annular beads 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. The pair of annular beads can be said to comprise a first annular bead and a second annular bead. 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.

[0019] A pneumatic tire also generally includes a central annular portion. The central annular portion forms the portion of the tire arranged between a pair of tire sidewalls, which includes the tire tread. Specifically, the central portion extends annularly around the tire and between a first sidewall and a second sidewall of the tire, the first sidewall extending radially outward from the first bead and to the central annular portion, the second sidewall extending radially outward from the second bead and to the central annular portion. The "summit" of the tire refers generally to the central annular portion, and more specifically refers to the region of the central annular portion surrounding the widthwise centerline of the central portion (which is commonly also the widthwise centerline of the tire).

[0020] It is appreciated that, in certain embodiments, the central portion (and a thickness thereof) includes a belt comprising one or more belt plies, the belt extending annularly around the tire. As with any body ply, the belt plies each comprise a sheet of elastomeric material reinforced with elongate reinforcements, such as cord or cable. The belt is arranged below the tire tread. Commonly, the belt is arranged between the tire tread and any body ply extending within the central portion, but any known or desired variation may be employed.

[0021] With reference to FIGS. **1-4**, exemplary embodiments of a pneumatic tire **10** is shown. In each embodiment, the tire **10** includes a pair of sidewalls **12**, each of which include a bead **18**. A bead filler **19** is shown arranged atop each bead **18**. The sidewalls **12** extend radially outward to a central portion **14**. The central portion includes a tread **16** and a belt **30** comprising belt plies $\mathbf{30_1}$, $\mathbf{30_2}$. The belt is shown to extend in a lateral direction of the tire (also referred to as an axial direction or widthwise direction of the tire) between belt side edges **32** to define a width of the belt. It is noted that the widthwise or lateral centerline of the tire is represented by the broken line identified as **CL** in the figures.

[0022] As noted previously, in lieu of a continuous body ply extending between the pair of beads, a segmented body ply is provided. It follows that, in particular embodiments, the inventive tire includes a first side body ply and a second side body ply arranged within a thickness of the tire. It can be said that the first side body ply and the second side body ply together form a segmented body ply.

[0023] The first side body ply has an outer terminal end and an inner terminal end. In the pneumatic tire, the first side body ply extends from its outer terminal end radially inward toward the rotational axis of the tire and to an axially-outer side of the first bead. The axially-outer side is the side of the first bead facing the axially-outer side of the first sidewall and facing away from the second bead or the widthwise centerline of the tire. The first side body ply continues its extension from the axially-outer side of the bead, and along the radially-inner or bottom side of the bead to the axially-inner side of the bead. The axially-inner side is the side of the first bead facing the axially inner side of the first sidewall and facing the second bead or the widthwise centerline of the tire. From the axially-inner side of the bead, the first side body ply extends radially outward to its inner terminal end. In summary, the first side body ply wraps partially around the first bead as the first side body ply extends from an outer side of the first sidewall and to an inner side of the first sidewall.

[0024] With reference again to FIGS. **1-4**, **7**, and **8**, various exemplary embodiments of a pneumatic tire **10** are shown and include a first side body ply $\mathbf{20_1}$ and a second body ply $\mathbf{20_2}$ (shown in FIG. **1** only). Each first side body ply $\mathbf{20_1}$ has an outer terminal end **22** and an inner terminal end **24**. Each first side body ply $\mathbf{20_1}$ is shown to extend from its outer terminal end **22** radially inward toward the rotational axis of the tire and to an axially-outer side $\mathbf{OS_{18}}$ of the first bead $\mathbf{18_1}$. This portion of the first side body ply $\mathbf{20_1}$ is referred to as an outer portion (or axially-outer portion) or turn-up $\mathbf{20_o}$ of the first side body ply, the outer terminal end **22** forming a turn-up ending along the turn-up. The axially-outer

side $\mathbf{OS_{12}}$ is the side of the first bead $\mathbf{18_1}$ facing the axially-outer side $\mathbf{OS_{12}}$ of the first sidewall $\mathbf{12_1}$ and facing away from the second bead $\mathbf{18_2}$ or the widthwise centerline **CL** of the tire. The first side body ply $\mathbf{20_1}$ continues its extension from the axially-outer side $\mathbf{OS_{18}}$ of the first bead $\mathbf{18_1}$, and along the radially-inner or bottom side $\mathbf{BS_{18}}$ of the bead to the axially-inner side $\mathbf{IS_{18}}$ of the bead. The axially-inner side $\mathbf{IS_{18}}$ is the side of the first bead $\mathbf{18_1}$ facing the axially inner side $\mathbf{IS_{12}}$ of the first sidewall $\mathbf{12_1}$ and facing the second bead or the widthwise centerline **CL** of the tire. From the axially-inner side $\mathbf{IS_{18}}$ of the bead, the first side body ply $\mathbf{20_1}$ extends radially outward to its inner terminal end **24**. This inner extension of the first side body ply $\mathbf{20_1}$ from the bead $\mathbf{18_1}$ is referred to as an inner portion (or axially-inner portion) and is identified as $\mathbf{20_I}$ in the figure. The same is true for the second side body ply $\mathbf{20_2}$, shown in association with a second sidewall $\mathbf{12_2}$ and a second bead $\mathbf{18_2}$ of the pair of beads.

[0025] In similar fashion to the first side body ply, the second side body ply has an outer terminal end and an inner terminal end. In the pneumatic tire, the second side body ply extends from its outer terminal end radially inward toward the rotational axis of the tire and to an axially-outer side of the second bead. The axially-outer side is the side of the second bead facing the axially outer side of the second sidewall and facing away from the first bead or the widthwise centerline of the tire. The second side body ply continues its extension from the axially-outer side of the bead, and along the radially-inner or bottom side of the bead to the axially-inner side of the bead. The axially-inner side is the side of the second bead facing the axially inner side of the second sidewall and facing the first bead or the widthwise centerline of the tire. From the axially-inner side of the bead, the second side body ply extends radially outward to its inner terminal end. In summary, the second side body ply wraps partially around the second bead as the second side body ply extends from an outer side of the second sidewall and to an inner side of the second sidewall.

[0026] In certain embodiments, the inner terminal end of the first side body ply extends further and into the central portion of the tire. When extending into the central portion, to improve securement of the inner terminal end of the first side body ply in certain instances, the inner terminal end of the first side body ply is arranged underneath or below (radially inward) a belt or at least one belt ply, such that the tire belt overlaps the first side body ply or, in other words, where the belt is partially arranged overtop (radially outward) the inner terminal end of the first side body ply, such that the belt is arranged between the tread and the first side body ply. Additionally, or in the alternative, the inner terminal end of the

second side body ply extends further and into the central portion of the tire. When extending into the central portion, to improve securement of the inner terminal end of the second side body ply in certain instances, the inner terminal end of the second side body ply is arranged underneath or below (radially inward) a belt comprising one or more belt plies, such that the tire belt overlaps the second side body ply or, in other words, where the belt is partially arranged overtop (radially outward) the inner terminal end of the second side body ply, such that the belt is arranged between the tread and the second side body ply. In certain embodiments, each inner terminal end of the first and second side body plies is arranged a distance of at least 25 millimeters (mm) from one of a pair of side edges of the belt or belt ply, the pair of side edges defining a width of the belt or belt ply. Stated differently, the first and second side body plies each overlap the belt by at least 25 mm. In other variations, each inner terminal end of the first and second side body plies is arranged 25 to 40 mm from one of a pair of side edges of the belt or belt ply.

[0027] With reference to FIG. **1** and the exemplary tire **10** shown, an inner terminal end **24** of the first side body ply $\mathbf{20_1}$ extends from an axially inner portion of the first sidewall $\mathbf{12_1}$ and into the central portion **14** of the tire. The inner terminal end **24** of the first side body ply $\mathbf{20_1}$ is arranged underneath or below the tire belt **30**, such that the tire belt overlaps the first side body ply or, in other words, where the belt is partially arranged overtop (radially outward) the inner terminal end of the first side body ply, such that the belt is arranged between the tread and the first side body ply. The inner terminal end **24** of the first side body ply $\mathbf{20_1}$ is spaced apart by a distance $\Delta_{24/32}$ of at least 25 millimeters (mm) from a corresponding or adjacent side edge **32** of the belt **30** arranged closest to the inner terminal end, on the same corresponding side of the tire centerline **CL**. In other variations, distance $\Delta_{24/32}$ is 25 to 40 mm.

[0028] It is appreciated that in certain instances, the outer terminal end of any first or second side body ply is arranged within the central portion, in addition to or separate from the inner terminal end of the corresponding side body ply. By way of example, with reference to an exemplary embodiment shown in FIG. **2** , an outer terminal end **22** of first side body ply $\mathbf{20_1}$ is arranged within the central portion **14** of the tire. As with the inner terminal end of any first or second side body ply, the outer terminal end may be arranged below the belt to improve securement thereof. Also, in an effort to stagger the locations of ply endings, when desired, the second terminal end is spaced apart from the inner terminal

end of the corresponding first or second side body ply within the central portion. As can be seen in FIG. **2**, the outer terminal end **22** of the first side body ply $\mathbf{20_1}$ in the exemplary tire **10** is arranged below the belt **30** and spaced apart laterally from the inner terminal end **24** of the first side body ply. Specifically, the outer terminal end **22** of the first side body ply $\mathbf{20_1}$ is located underneath belt **30** by a distance $\Delta_{22/32}$ from the corresponding belt edge **32** (that is, from the closest belt edge arranged along the same side of the tire centerline **CL**). While distance $\Delta_{22/32}$ may comprise any desired distance, in particular embodiments, distance $\Delta_{22/32}$ is at least 15 mm and in other instances, 15 to 25 mm. In any such embodiment, the distance $\Delta_{24/32}$ between inner terminal end **24** of the first side body ply and the corresponding belt edge **32** may form any desired distance, including any distance noted previously or elsewhere herein.

[0029] It is appreciated that the first and second side body plies may exist without any additional body ply extending there between, such that the first and second side body plies, and each of their inner and outer terminal ends, are spaced apart. In other variations, a central body ply is arranged within a thickness of the tire to extend from the first side body ply and to the second side body ply, such that the segmented body ply comprises the first and second side body plies and the central body ply. In doing so, the central body ply overlaps with at least one or both the first and second side body plies along the inner terminal ends thereof. In other words, a first side edge of the central body ply overlaps with the first side body ply and/or a second side edge of the central body ply overlaps with the second side body ply, where the first and second side edges of the central body ply define a lateral width of the central body ply. It is appreciated that in certain instances, the central body ply overlaps one or both of the first and second side body plies, where the central body ply is arranged on top of, that is, radially outward of, the overlapped portion of the respective first or second side body ply. In other instances, one or both of the first and second side body plies overlap the central body ply, where the central body ply is arranged below, that is, radially inward of, the overlapped portion of the respective first or second side body ply. It is appreciated that this overlap distance may comprise any desired distance, although in certain embodiments, the overlap is at least 10 mm. When the central body ply overlaps one or both of the first and second side body plies, in certain variations, the central body ply is arranged between the inner and outer terminal ends of each of the first and second side body plies. In doing so, an outer portion of the first or second side body ply including the outer terminal end

thereof extends along the outer side of the corresponding first or second sidewall and into the central portion such that the outer terminal end is positioned within the central portion of the tire.

[0030] With reference to the exemplary embodiment shown in FIG. **1**, a central body ply **26** is shown extending across a width of the central portion **14** of the tire, and from the first side body ply $\mathbf{20_1}$. The central body ply **26** is arranged below the tire tread **16** and belt **30**. Additionally, the central body ply **26** is shown to overlap with the first side body ply $\mathbf{20_1}$ along the inner terminal end **24** thereof. Stated differently, a first side edge **28** of the central body ply **26** overlaps with the first side body ply $\mathbf{20_1}$. Of specific note, the central body ply **26** is specifically shown arranged on top of, that is, radially outward of, the overlapped portion of the respective first side body ply $\mathbf{20_1}$. It is noted that opposing, spaced apart side edges **28** of the central body ply define a lateral width $\mathbf{W_{26}}$ of the central body ply, as best shown in FIGS. **5** and **6**, by example. The overlap between the central body ply and the first side body ply is represented in FIG. **1** as distance $\Delta_{24/28}$, which, as stated above, is at least 10 mm in certain embodiments. It is also appreciated that each side edge **28** of the central body ply **26** is arranged under the belt or along a sidewall of the tire. In the embodiment shown, a side edge **28** of the central body ply **26** is arranged under the belt **30** by a distance $\Delta_{28/32}$ (forming the distance between side edge **28** and belt edge **32**), which is at least 5 mm or 5 to 10 mm in certain embodiments. Of course, other desired distances may be employed.

[0031] With reference now to the exemplary embodiment shown in FIG. **2**, a tire **10** is shown to include a central body ply **26** that is arranged between the outer and inner terminal ends **22**, **24** of the first side body ply $\mathbf{20_1}$. In doing so, an outer portion of the first or second side body ply $\mathbf{20_1}$ including the outer terminal end **22** thereof extends along the axially-outer side $\mathbf{OS_{12}}$ of the first sidewall **12** and into the central portion **14** such that the outer terminal end **22** is positioned within the central portion of the tire such that the outer terminal end is spaced apart from the corresponding or adjacent belt edge **32** by a distance $\Delta_{22/32}$, which may comprise any distance noted herein. Additionally, the outer and inner terminal ends **22**, **24** are shown spaced apart by a distance $\Delta_{22/24}$, which may comprise any distance although in certain embodiments distance $\Delta_{22/24}$ is at least 10 mm.

[0032] In particular instances where the outer terminal end of any first or second side body ply is positioned along a corresponding sidewall of the tire, meaning, the outer

terminal end is not arranged along the center portion of the tire, a secondary outer side body ply is arranged to overlap a corresponding first or second side body ply at the outer terminal end thereof and extend therefrom to a location within the central portion of the tire. This may be done in lieu of extending the outer portion of any first or second side body ply into the central portion of the tire. The secondary outer side body ply is considered a second outer side body ply, considering the outer turn-up of the corresponding first or second side body ply (also referred to as the outer portion of the corresponding first or second body ply) as a first outer side body ply. The outer ply has a length extending annularly around the tire and a width defined by (and extending to and from) a first terminal edge and a second terminal edge. Further to the arrangement of the secondary outer side ply within the pneumatic tire, the first terminal edge of the secondary outer side body ply overlaps with the corresponding first or second side body ply while the second terminal edge of the secondary outer side ply is arranged within the central portion of the tire. In certain embodiments, when overlapping with the corresponding first or second side body ply, the secondary outer side ply is arranged between the corresponding side body ply and the corresponding first or second bead or vice versa in other embodiments. Additionally, when the second terminal edge is arranged within central portion of the tire, it is appreciated that the second terminal edge may be arranged under the tire belt and/or may overlap with the central body ply when present. Lastly, in certain instances, the second terminal edge is spaced apart from the inner terminal end of the corresponding first or second side body ply.

[0033] With reference to the exemplary embodiments of FIGS. **3** and **4**, the outer terminal end **22** of first side body ply $\mathbf{20_1}$ is positioned along a first sidewall $\mathbf{12_1}$ of the exemplary tire **10**. In this embodiment, a secondary outer side body ply **40** is arranged to overlap the first side body ply $\mathbf{20_1}$ at the outer terminal end **22** thereof and extend therefrom to a location within the central portion **14** of the tire. The outer ply has a width defined by (and extending to and from) a first terminal edge **42** and a second terminal edge **44**. In each embodiment, the first terminal edge **42** of the secondary outer side body ply **40** is shown to overlap with the corresponding first side body ply $\mathbf{20_1}$ while the second terminal edge **44** of the secondary outer side ply is arranged within the central portion **14** of the tire. With specific reference to FIG. **3**, in overlapping with the first side body ply $\mathbf{20_1}$, the first side body ply $\mathbf{20_1}$ is arranged between the secondary outer side body ply **40** and the first bead **18**. With specific reference to FIG. **4**, in overlapping with the first side body ply **20**, the secondary outer side ply **40** is arranged between the first side body ply $\mathbf{20_1}$ and the first bead **18**.

Additionally, in each embodiment shown, the second terminal edge **44** is arranged within central portion **14** of the tire, such that the second terminal edge is arranged under the tire belt **30** and overtop central body ply **26** such that the central body ply is arranged between the secondary outer side body ply and the first side body ply $\mathbf{20_1}$. It is finally noted that in each such embodiment, the second terminal edge **44** is spaced apart from the belt edge **32** by a distance $\Delta_{32/44}$, which may comprise any distance contemplated for distance $\Delta_{22/32}$ herein Likewise, in the embodiment shown in FIG. **3**, the distance $\Delta_{24/44}$ between second terminal edge **44** and the inner terminal end **24** of the first side body ply $\mathbf{20_1}$ may comprise any distance contemplated for distance $\Delta_{22/32}$ herein.

[0034] It is appreciated that each of the first and second side body plies, as well as the central body ply, secondary outer body ply, and intermediate body ply (discussed further below), when present, comprise a sheet of elastomeric material reinforced with elongate reinforcements. It is appreciated that any known or desired sheet of reinforced elastomeric material may be employed. Elastomeric material includes natural or synthetic rubber or a blend thereof, while the elongate reinforcements include any desired cord or cable. Cord is commonly formed of one or more textiles, such as aramid, nylon, and polyester, for example, in the form of one or more strands woven, wound, and/or twisted into a desired cord configuration. It is appreciated that any known cord may be employed. Cable is commonly formed of one or more metals, such as steel, for example, in the form of one or more wires woven, wound, and/or twisted into a desired cord configuration. It is appreciated that any known cable may be employed.

[0035] As to the arrangement of the elongate reinforcements within the pneumatic tire, any arrangement may be employed. For example, in certain instances, the first and second side body plies extend generally in a radial direction of the pneumatic tire (referred to as a "radial extension"), as commonly employed in radial tires. As is known, this radial extension describes the elongate reinforcements of the first and second side body plies when extending within the first and second sidewalls, respectively, but if and when these first and second side body plies extend into the central portion of the tire and into the vicinity of the tire tread and belt, this radial extension transitions into an extension in the lateral direction of the tire. The lateral direction can also be described as extending in the direction of the tire width or in an axial direction of the tire (a direction forming or parallel with the rotational

axis of the tire). Of course, in other variations, the elongate reinforcements in the first and second side body plies may extend in any other direction biased to the radial direction.

[0036] As to the arrangement of the elongate reinforcements of the central body ply, when present in the pneumatic tire, in certain embodiments, the elongate reinforcements of the central body ply extends in the same direction of the elongate reinforcements of first and second side body plies. In certain instances, this same direction is the lateral direction of the tire, as described above. In other variations, the elongate reinforcements in the central body ply are arranged in the tire to extend in a direction different from the direction along which the elongate reinforcements extend in the first and second side body plies. For example, in certain instances, the elongate reinforcements of the central body ply extend in a direction biased relative to the lateral direction of the tire.

[0037] With reference to the exemplary embodiment shown in FIG. **5**, an exemplary tire **10** is shown in a top, radially outer view with the tread and belt removed to show the central body ply **26** with elongate reinforcements **26R** and first and second side body plies $\mathbf{20_1}$, $\mathbf{20_2}$ with elongate reinforcements **20R**. In this embodiment, the elongate reinforcements **26R** of the central body ply **26** are shown to extend in the same direction of the elongate reinforcements **20R** of first and second side body plies $\mathbf{20_1}$, $\mathbf{20_2}$, where each of the reinforcements **20R**, **26R** extend in a lateral direction of the tire in the central portion of the tire. The same reinforcements **20R**, in the embodiment shown, extend in a radial direction of the tire when extending into each sidewall from the central portion. With reference now to the exemplary embodiment shown in FIG. **6**, the elongate reinforcements **26R** in the central body ply are shown to extend in a direction different from the direction along which the elongate reinforcements **20R** extend in the first and second side body plies $\mathbf{20_1}$, $\mathbf{20_2}$. It is also noted that the elongate reinforcements **26R** of the central body ply **26** extend in a direction biased to the lateral direction of the tire **10**.

[0038] In certain instances, a portion of the segmented body ply terminates at or near the bead before otherwise wrapping around the bead to form a turning-up along an axially-outer side of the tire. In such instances, a portion of the segmented body ply extends radially inward or downward from the central portion of the tire and terminates at a location at or along the bead, or near the corresponding bead at a location radially outward from the bead without wrapping around the bottom of the bead and then radially upward to form a turn-up along an axially-outer side of the bead. In certain embodiments, the terminal end of said portion of the body ply terminates radially outward from a radial centerline of the

corresponding bead by a distance of at least 5 mm, and in other embodiments by 5 to 10 mm, although other distances may be employed. In doing so, it is appreciated that the terminal end of the portion of the body ply is arranged radially outward from, at, or along the bead filler. In other variations, the terminal end of the portion of the body ply is arranged at or below the bead. The terminal end may even wrap to a location below the bead or along an outer side of the bead without forming a turn-up extending radially outward from or above the bead. Because this portion of the body ply (a bead-terminating portion) does not form a turn-up, a first side body ply and a second side body ply are each included, where each are arranged such that each forms a turn-up along each corresponding bead and such that the corresponding terminal end of the bead-terminating portion is arranged between inner and outer portions of the corresponding first and second side body ply. While the outer and inner terminal ends of the first and second body ply may be positioned as desired, in certain embodiments the outer and inner terminal ends are offset by a distance, which may be any distance, although in certain embodiments, said distance is at least 10 mm. In such instances, the outer terminal end for each of the first and second side body plies may be arranged a greater or closer distance from the associated bead than the inner terminal end of the corresponding first or second side body ply. It is appreciated that the outer and inner terminal end of the first and second body plies may be arranged any distance from the bead, where at least the inner terminal end is positioned along the respective sidewall (that is, it does not extend into the central portion of the tire) even though the outer terminal end either is positioned along the corresponding sidewall or extends into the central portion of the tire as otherwise contemplated herein. In certain instances, the outer terminal end is arranged 35 to 60 mm from the radial centerline of a corresponding bead. It is also appreciated that the bead-terminating portion of the segmented body ply may form a portion of a central body ply or any other ply arranged within the segmented body ply. For example, in lieu of forming a portion of a central body ply, on each side of the tire, the bead-terminating portion forms an intermediate body ply extending from the central portion of the tire. In doing so, the intermediate body ply may or may not extend from underneath the belt. Also, the intermediate body ply may be employed with or without a central body ply.

[0039] By way of example, with reference to FIGS. **7** and **8**, a portion of the segmented body ply terminates near a first bead $\mathbf{18}_1$ without partially wrapping around the bead to form a turn-up along the axially-outer side $\mathbf{OS}_{12}$ of the sidewall $\mathbf{12}_1$. Specifically, with regard to the embodiment of FIG. **7**, the portion of the segmented body ply terminating

near the first bead $\mathbf{18_1}$ is a side edge **28** of central body ply **26**, while a first side body ply $\mathbf{20_1}$ wraps around the first bead to form a turn-up such that the central body ply is arranged between outer and inner portions $\mathbf{20_o}$, $\mathbf{20_i}$ of the first side body ply. Side edge **28** of the central body ply **26** is arranged a distance $\Delta_{18/28}$ radially outward from the radial centerline $\mathbf{CL_{18}}$ of the first bead. In other embodiments, with reference to FIG. **8**, the portion of the segmented body ply terminating near the first bead $\mathbf{18_1}$ is a lower terminal edge **52** of a first intermediate body ply $\mathbf{50_1}$, the first intermediate body ply extending from an upper terminal edge **54** arranged underneath the belt **30** in the central portion **14** of the tire to the lower terminal edge **52** along the first sidewall $\mathbf{12_1}$. A second intermediate ply may be arranged along the second sidewall (not shown) in similar fashion. In this embodiment, a first side body ply $\mathbf{20_1}$ wraps around the first bead $\mathbf{18_1}$ to form a turn-up such that the lower terminal edge **52** of the intermediate body ply $\mathbf{50_1}$ is arranged between outer and inner portions $\mathbf{20_o}$, $\mathbf{20_i}$ of the first side body ply. Lower terminal edge **52** of the intermediate body ply $\mathbf{50_1}$ is arranged a distance $\Delta_{18/52}$ radially outward from the radial centerline $\mathbf{CL_{18}}$ of the first bead. It is appreciated that the upper terminal edge **54** of first intermediate body ply $\mathbf{50_1}$ may be arranged in any fashion contemplated herein when an inner terminal end of any first body ply extends into the central portion of the tire. In the embodiment shown, the upper terminal edge **54** is arranged below the belt **30** in the central portion **14** of the tire and by a distance $\Delta_{32/54}$ from the corresponding belt edge **32**. Distance $\Delta_{32/54}$ may be any distance contemplated herein for distance $\Delta_{24/32}$, which pertains to the distance between an associated belt edge and inner terminal end of a first body ply. It is also noted that the overlap of central body ply **26** and intermediate body ply **50** is represented by distance $\Delta_{28/54}$, which may comprise any distance $\Delta_{24/28}$ as contemplated herein for the overlap between the central body ply and a first side body ply. The segmented body ply in each embodiment shown may or may not be similarly configured along the second sidewall/second half of a tire in other embodiments.

[0040] It is appreciated that a segmented body ply may include any combination of the embodiments discussed herein, such as where only one of a first and second side body ply is employed, where any intermediate and secondary side body ply are employed together along the same sidewall, and where any intermediate and secondary side body ply are arranged within one of the two sidewalls in any pneumatic tire. It is also appreciated that a tire may include a segmented body ply alone or together with any one or more conventional body plies or one or more additional segmented body ply. In instances where a plurality of

segmented body plies are included in a single tire, the plurality may comprise the same or different segmented body ply designs.

[0041] It is also 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). Generally, in particular embodiments, any such pneumatic tire is formed by:

- arranging a pair of annular beads spaced apart in an axial direction of an uncured tire assembly, the pair of annular beads comprising a first annular bead and a second annular bead;
- arranging a first side body ply and a second side body ply within the uncured tire assembly, each of the first and second side body plies comprising a sheet of elastomeric material reinforced with elongate reinforcements,
- curing the uncured tire assembly to form a pneumatic tire, the pneumatic tire having a central portion including a tire tread and extending annularly around the tire and between a first sidewall and a second sidewall, the first sidewall extending radially outward from the first bead and to the central annular portion, the second sidewall extending radially outward from the second bead and to the central annular portion;
- the first side body ply extending from an outer terminal end of the first side body ply radially inward along an axially-outer side portion of the first sidewall to an axially-outer side of the first bead, and around a radially-inner side of the first bead to an axially-inner side of the first bead, and radially outward along an axially-inner side portion of the first sidewall to an inner terminal end of the first side body ply;
- the second side body ply extending from an outer terminal end of the second side body ply radially inward along an axially-outer side portion of the second sidewall to an axially-outer side of the second bead, and around a radially-inner side of the second bead to an axially-inner side of the second bead, and radially outward along an axially-inner side portion of the second sidewall to an inner terminal end of the second side body ply.

[0042] In certain instances, the inner terminal end of each of the first and second side body ply is arranged in the uncured tire assembly such that in the pneumatic tire, the inner terminal end of each of the first and second side body ply is positioned below a belt

extending annularly below the tire tread within a thickness of the central annular portion of the tire. Additionally, or separately, in certain variations, each inner terminal end of each of the first and second side body ply is arranged in the uncured tire assembly such that in the pneumatic tire, each inner terminal end of each of the first and second side body ply is located 10 to 40 millimeters from one of a pair of side edges of the belt, the pair of side edges defining a width of the belt. As discussed previously in association with the pneumatic tire, other dimensions may be employed.

[0043] In particular variations, where a central body ply is arranged within the uncured tire assembly such that in the pneumatic tire, the central body ply extends within a thickness of the tire from the first side body ply and to the second side body ply, the central body ply being bonded to each of the first side body ply and the second side body ply and comprising a sheet of elastomeric material reinforced with elongate reinforcements.'

[0044] 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.

[0045] 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 pneumatic tire comprising:

a pair of annular beads spaced apart in an axial direction of the tire, the pair of annular beads comprising a first annular bead and a second annular bead;

a central portion including a tire tread and extending annularly around the tire and between a first sidewall and a second sidewall, the first sidewall extending radially outward from the first bead and to the central portion, the second sidewall extending radially outward from the second bead and to the central portion; and,

a first side body ply and a second side body ply arranged within a thickness of the tire, each of the first and second side body plies comprising a sheet of elastomeric material reinforced with elongate reinforcements,

the first side body ply extending from an outer terminal end of the first side body ply radially inward along an axially-outer side portion of the first sidewall to an axially-outer side of the first bead, and around a radially-inner side of the first bead to an axially-inner side of the first bead, and radially outward along an axially-inner side portion of the first sidewall to an inner terminal end of the first side body ply,

the second side body ply extending from an outer terminal end of the second side body ply radially inward along an axially-outer side portion of the second sidewall to an axially-outer side of the second bead, and around a radially-inner side of the second bead to an axially-inner side of the second bead, and radially outward along an axially-inner side portion of the second sidewall to an inner terminal end of the second side body ply.

2. The pneumatic tire of claim 1, where the inner terminal end of each of the first and second side body ply is arranged below a belt extending annularly below the tire tread within a thickness of the central annular portion of the tire.
3. The pneumatic tire of claim 2, where each inner terminal end of each of the first and second side body ply is arranged 10 to 40 millimeters from one of a pair of side edges of the belt, the pair of side edges defining a width of the belt.
4. The pneumatic tire of any one of claims 1 to 3, where a central body ply extends within a thickness of the tire from the first side body ply and to the second side body ply, the central body ply being bonded to each of the first side body ply and the

second side body ply and comprising a sheet of elastomeric material reinforced with elongate reinforcements.

5. The pneumatic tire of claim 4, where the central body ply overlaps both the first and second side body plies.
6. The pneumatic tire of claim 5, where the central body ply is arranged between the inner and outer terminal ends of each of the first and second side body plies.
7. The pneumatic tire of any one of claims 4 to 6, where the central body ply is formed of the same material forming each of the first and second side body plies.
8. The pneumatic tire of any one of claims 4 to 7, where the elongate reinforcements of the central body ply extend in the same direction as the elongate reinforcements of the first and second side body plies.
9. The pneumatic tire of any one of claims 4 to 8, where the elongate reinforcements of the central body ply extend in a direction biased relative to a lateral direction of the tire.
10. The pneumatic tire of any one of claims 4 to 9, where the elongate reinforcements of the central body ply extend in a different direction relative to the elongate reinforcements of the first and second side body plies.
11. The pneumatic tire of any one of claims 1 to 10, where a first intermediate body ply is arranged to extend from the central portion of the tire and to a terminal location along the first sidewall at or radially outward the first annular bead, the first intermediate body ply being arranged between inner and outer portions of the first side body ply.
12. The pneumatic tire of claim 11, where a second intermediate body ply is arranged to extend from the central portion of the tire and to a terminal location along a second sidewall at or radially outward the second annular bead, the second intermediate body ply being arranged between inner and outer portions of the second side body ply.
13. The pneumatic tire of any one of claims 4 to 10, where the central body ply is arranged to extend from the central portion of the tire and to a terminal location along a first sidewall at or radially outward the first annular bead, the central body ply being arranged between inner and outer portions of the first side body ply.
14. The pneumatic tire of claim 13, where the central body ply is arranged to extend from the central portion of the tire and to a terminal location along a second sidewall at or radially outward the second annular bead, the central body ply being arranged between inner and outer portions of the second side body ply.

15. A method of forming a pneumatic tire, the method comprising:

arranging a pair of annular beads spaced apart in an axial direction of an uncured tire assembly, the pair of annular beads comprising a first annular bead and a second annular bead;

arranging a first side body ply and a second side body ply within the uncured tire assembly, each of the first and second side body plies comprising a sheet of elastomeric material reinforced with elongate reinforcements; and,

curing the uncured tire assembly to form a pneumatic tire according to any one of claims 1 to 14.

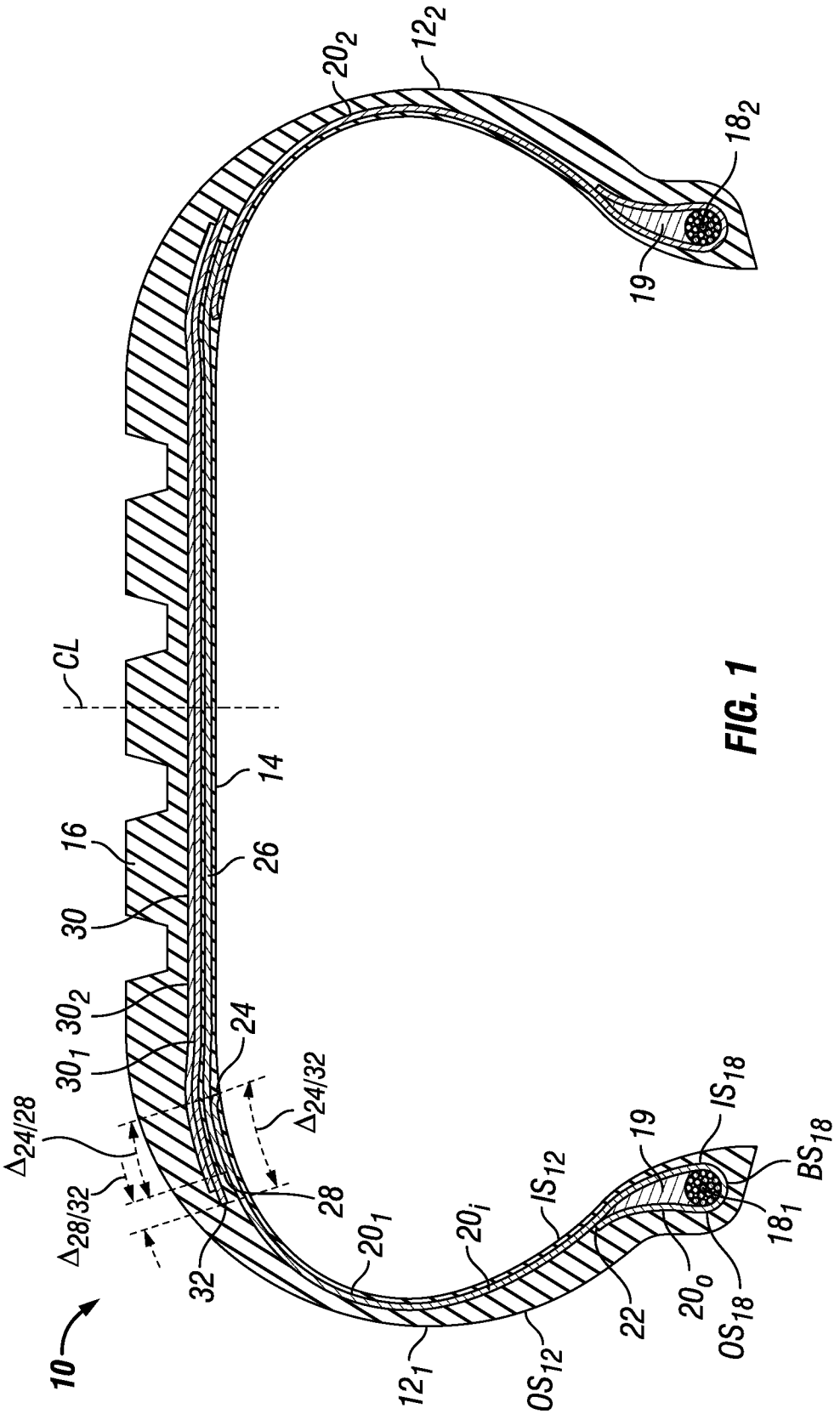

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18_2
19
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30_1
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32
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20_i
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OS_{18}
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OS_{12}
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FIG. 1

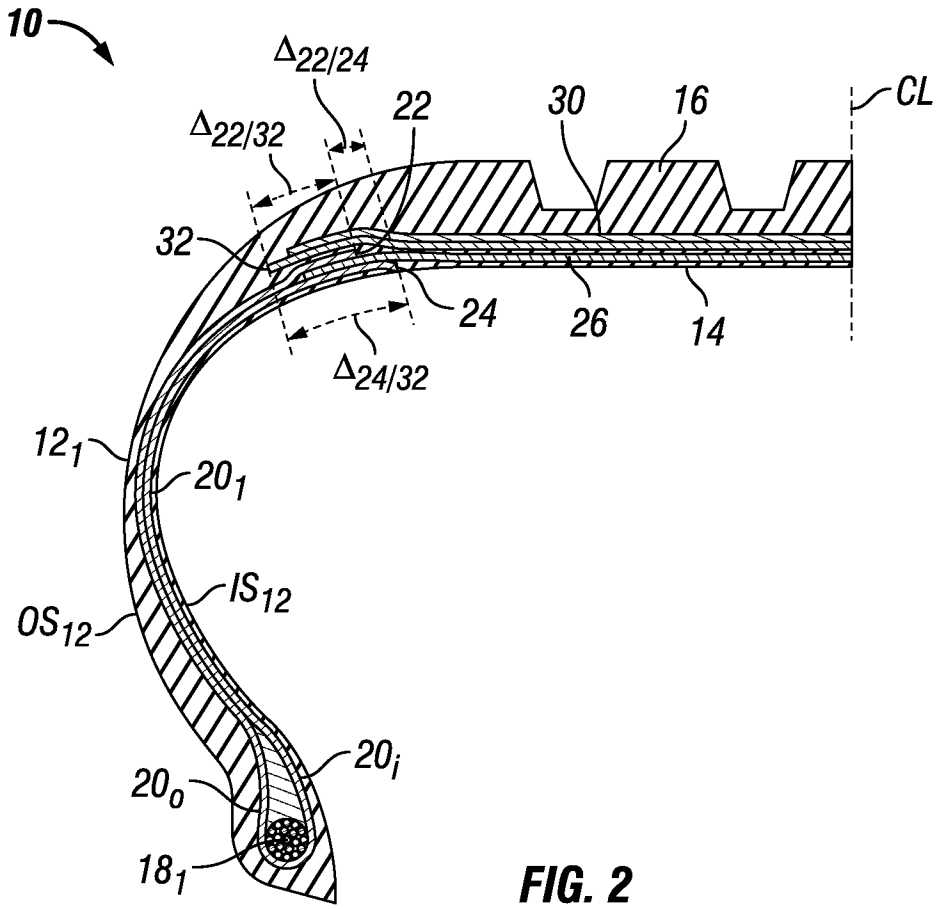

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OS_{12}
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20_o
18_1

FIG. 2

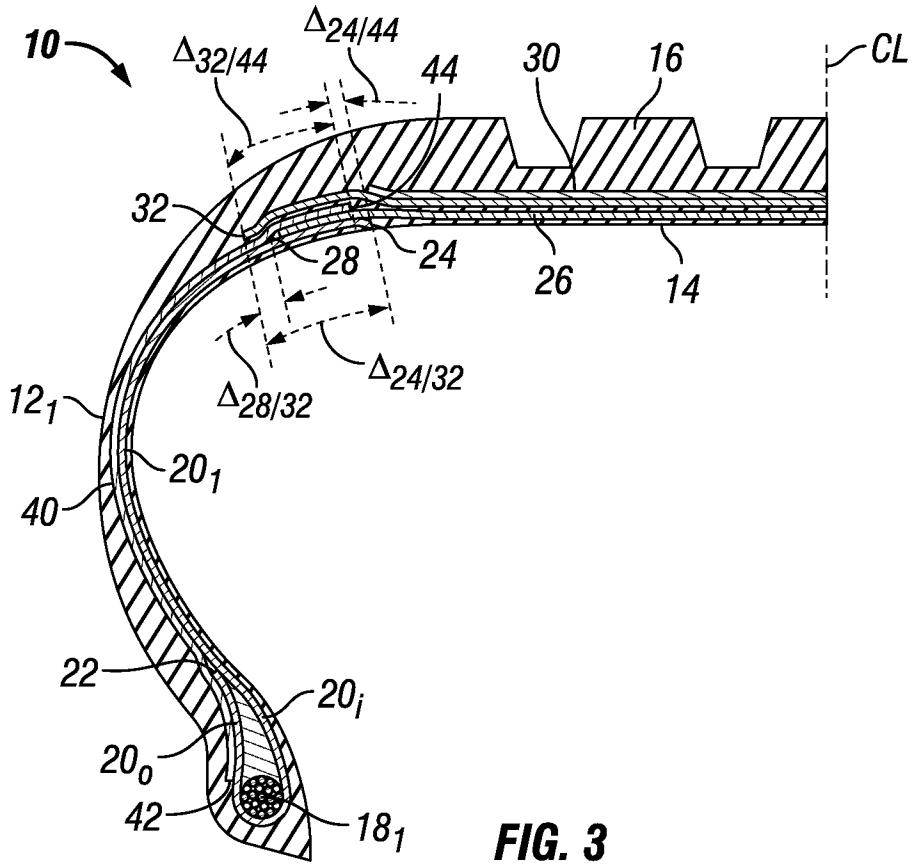

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FIG. 3

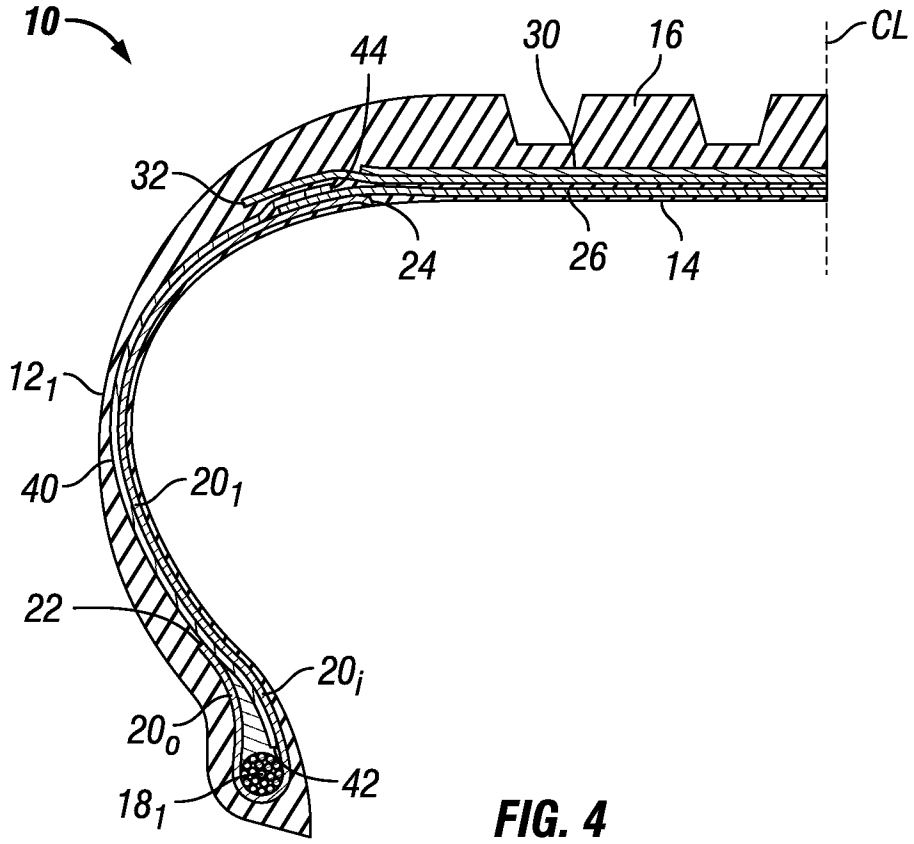

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FIG. 4

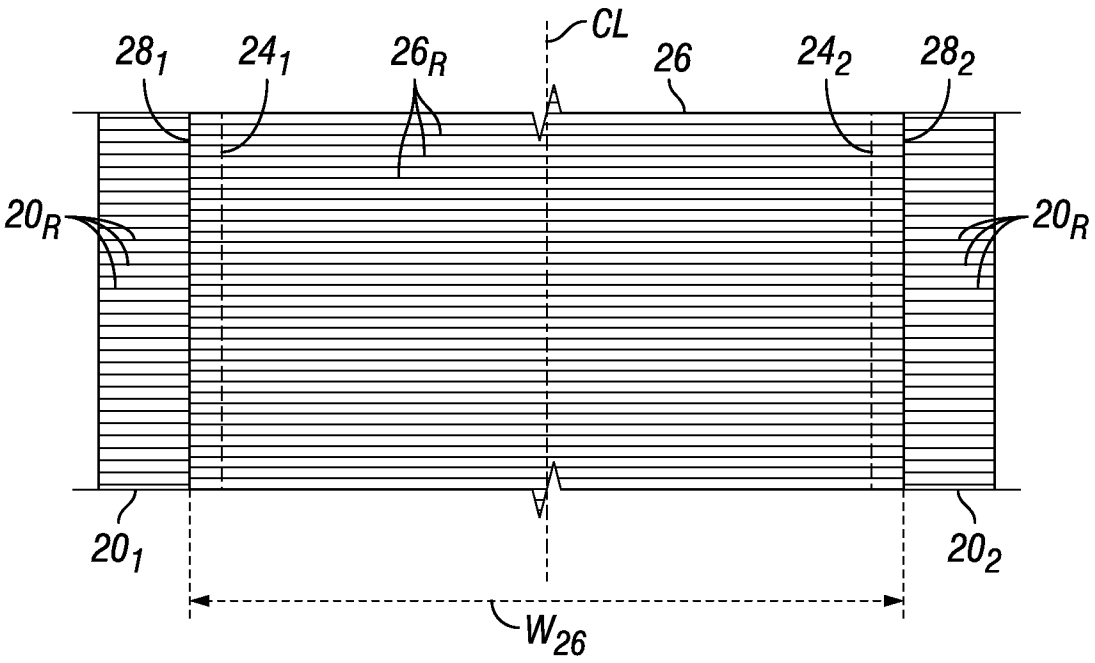

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20_2
W_{26}

FIG. 5

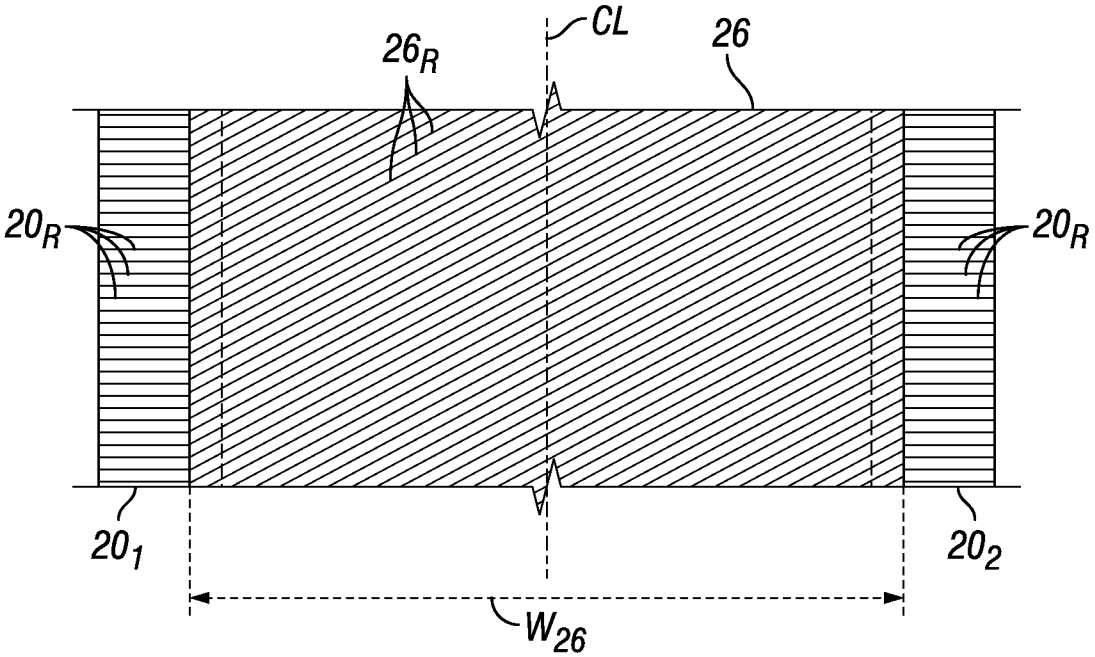

CL
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20_R
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W_{26}

FIG. 6

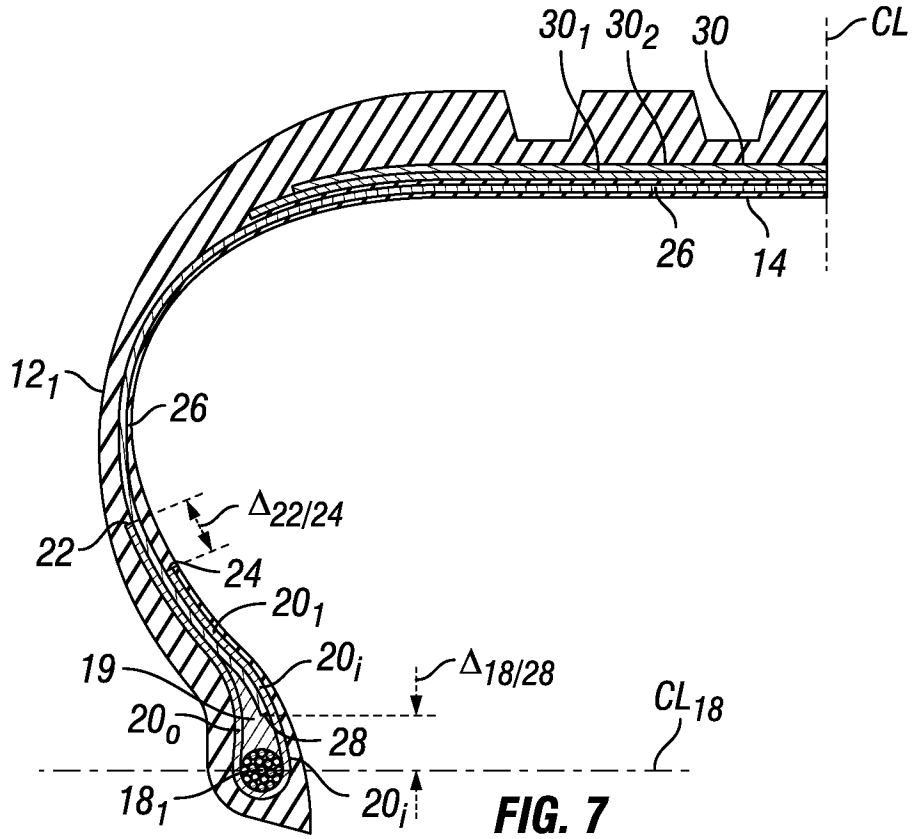

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FIG. 7

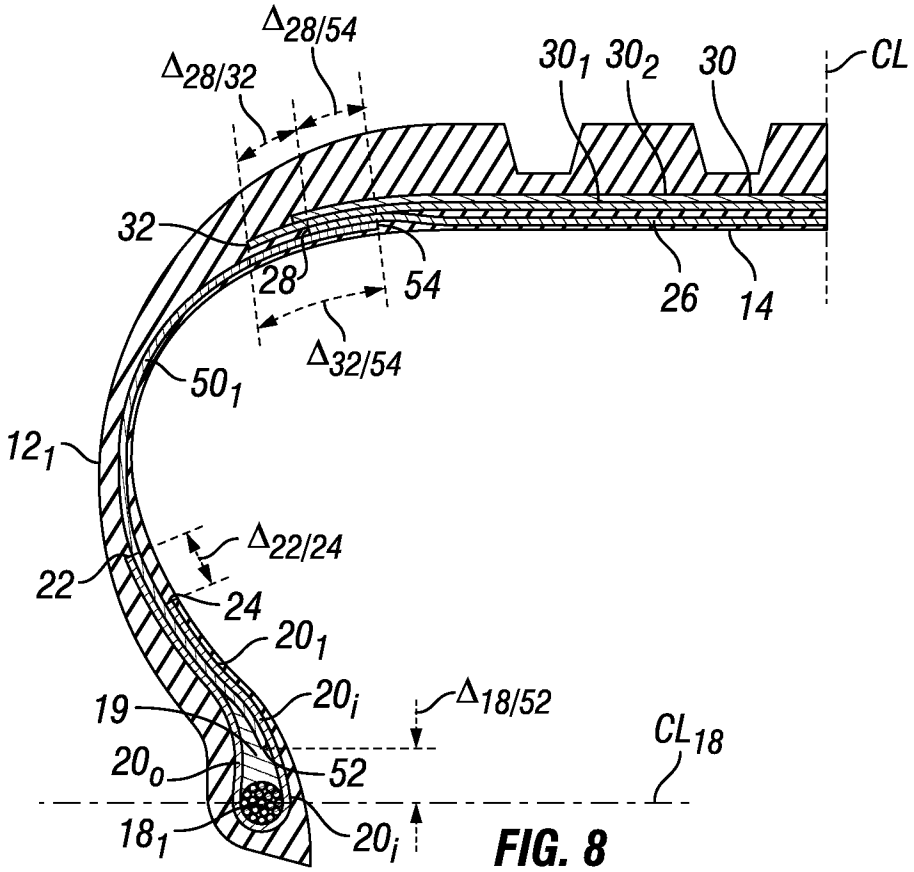

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FIG. 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2015/061414

A. CLASSIFICATION OF SUBJECT MATTER
INV. B60C9/02
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

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

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X	US 2010/108229 A1 (HATA HIROSHI [JP]) 6 May 2010 (2010-05-06) paragraphs [0021] - [0031]; figure 1	1-3
X	US 2014/261949 A1 (MARELLA ANTHONY R [US] ET AL) 18 September 2014 (2014-09-18) paragraphs [0013] - [0024]; figure 1	1-3

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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"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
27 July 2016	08/08/2016

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	Buergo, Javier

1

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2015/061414

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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1

Form PCT/ISA/210 (continuation of second sheet) (April 2005)

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Information on patent family members

International application No
PCT/US2015/061414

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