



(51) International Patent Classification:  
**B29D 30/08** (2006.01)

(21) International Application Number:  
PCT/US2013/024171

(22) International Filing Date:  
31 January 2013 (31.01.2013)

(25) Filing Language: English

(26) Publication Language: English

(71) Applicants (for all designated States except US): **COMPAGNIE GENERALE DES ETABLISSEMENTS MICHELIN** [FR/FR]; 12 Cours Sablon, F-63000 Clermont-Ferrand (FR). **MICHELIN RECHERCHE ET TECHNIQUE S.A.** [CH/CH]; Route Louis Braille 10, CH-1763 Granges-Paccot (CH).

(72) Inventors; and

(71) Applicants (for US only): **COLBY, E. Bruce** [US/US]; c/o Michelin North America, Inc., Intellectual Property Department, 515 Michelin Road, Greenville, South Carolina 29605 (US). **IKONOMOV, Metodi L.** [US/US]; c/o Michelin North America, Inc., Intellectual Property Department, 515 Michelin Road, Greenville, South Carolina 29605 (US). **WIDMYER, Michael** [US/US]; c/o Michelin North America, Inc., Intellectual Property Department, 515 Michelin Road, Greenville, South Carolina 29605 (US).

**CHANDLER, Michael Collins** [US/US]; c/o Michelin North America, Inc., Intellectual Property Department, 515 Michelin Road, Greenville, South Carolina 29605 (US).

(74) Agents: **HRIVNAK, Bret A.** et al.; Hahn Loeser & Parks LLP, One GOJO Plaza Suite 300, Akron, Ohio 44311-1076 (US).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,

[Continued on next page]

(54) Title: METHODS FOR RETREADING TIRES USING COIL SPRINGS

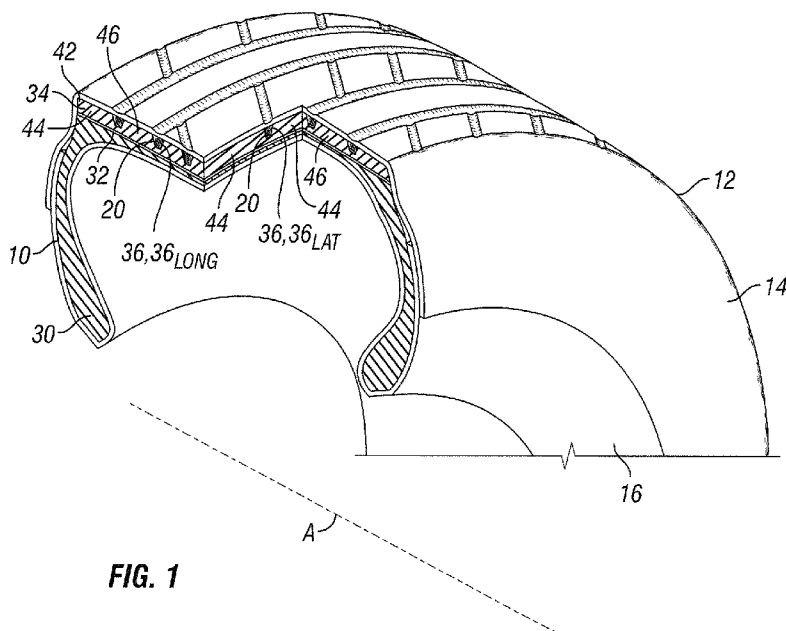


FIG. 1

(57) Abstract: The invention comprises a method of forming a retreaded tire. In particular embodiments, the method includes providing a tread having a top side configured to engage a ground surface during tire operation and a bottom side configured for attachment to an annular tire carcass, the tread including a void extending into a thickness of the tread from the top side of the tread. The method also includes arranging the tread around an outer circumference of the tire carcass in a desired position to form an assembled retreaded tire. Furthermore, the methods includes arranging a coil spring within the void of the tread. Subsequently, a curing membrane is placed around an outer circumference of the tread, an outer circumference of the circumferential band, and at least a portion of the tire carcass, and the assembled retreaded tire is cured with the coil spring arranged within the void.



TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, **Published:**  
ML, MR, NE, SN, TD, TG).

— *with international search report (Art. 21(3))*

**Declarations under Rule 4.17:**

— *of inventorship (Rule 4.17(iv))*

## METHODS FOR RETREADING TIRES USING COIL SPRINGS

### BACKGROUND OF THE INVENTION

#### Field of the Invention

[0001] This invention relates generally to methods for retreading tires, and more particularly, to methods for generally maintaining the dimensions or shape of voids in the tire tread during tire retreading operations.

#### Description of the Related Art

[0002] Retreaded tires are commonly manufactured by affixing a new tread atop an existing tire carcass, and securing the tread to the carcass by way of a curing process. In preparation for the curing process, a curing membrane or envelope is arranged about the tread to maintain the tread in a desired position atop the tire carcass and to create a seal between the retreaded tire assembly and the curing membrane. A bonding layer may be interposed between the tread and the tire carcass to promote bonding. Vacuum pressure is applied to the area between the curing membrane and the tread to substantially remove the air between the curing membrane and the tire assembly. The retread tire assembly with curing membrane is placed within a curing chamber, which often referred to as an autoclave, to bond the tread to the tire carcass, where the membrane-covered assembly is exposed to heat and pressure according to a desired curing process.

[0003] It is known for retread tire treads to include voids arranged along the outer, ground-engaging side of the tread, and extending into a thickness of the tread from the outer, ground-engaging side. For example, voids may comprise circumferential or lateral grooves arranged along the outer, ground-engaging side of the tread. In prior tire retreading processes, such voids can become misshapen or deformed due to curing forces caused by the vacuum pressure and/or curing pressure. That is, because the curing membrane is often not able to extend to the bottom of the groove, a vacuum-filled void can exist at the bottom of the groove, causing the groove bottom to “peak”, effectively reducing the depth of the void, which is referred to as the skid depth. Also, the curing pressure operating laterally against the tread shoulder can cause significant narrowing of the tread and narrowing of some or all of the circumferential grooves. This effect is very much accentuated when the tread thickness at below the groove, which is referred to as the undertread thickness, is less than 3 to 4 millimeters. These effects are compounded when bonding material becomes more malleable or fluid as the assembly is heated during the curing process.

## SUMMARY OF THE INVENTION

[0004] The present invention includes methods of forming a retreaded tire. In particular embodiments, such methods comprise providing a tread having a top side configured to engage a ground surface during tire operation and a bottom side configured for attachment to an annular tire carcass configured for receiving the tread, the tread including a void extending into a thickness of the tread from the top side of the tread. The tread is arranged around an outer circumference of the tire carcass in a desired position to form an assembled retreaded tire. Furthermore, a coil spring is arranged within the void of the tread. Such methods further include placing a curing membrane around an outer circumference of the tread, an outer circumference of the circumferential band, and at least a portion of the tire carcass, and curing the assembled retreaded tire with the coil spring arranged within the void.

[0005] 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 drawings wherein like reference numbers represent like parts of the invention.

## DETAILED DESCRIPTION OF THE DRAWINGS

[0006] FIG. 1 is a partial perspective view of a retreaded tire assembly having a coil spring arranged in various longitudinal and lateral grooves comprising voids arranged along, and extending depthwise into a thickness of the tread from an outer, ground-engaging side of the tread, the longitudinal grooves having a length extending in a circumferential direction of the tire assembly and in a lengthwise direction of the tread, the lateral grooves extend across a width of the tread, the figure also showing a partial cut-away of a curing membrane positioned in an installed arrangement about the tire, where a pressurization compartment arranged between the curing membrane and the tread is placed under pressure during curing operations according to an exemplary embodiment of the invention.

[0007] FIG. 2 is a lateral cross-sectional view of the retreaded tire assembly of FIG. 1 showing a coil spring arranged within each of a plurality of voids comprising longitudinal grooves extending into a thickness of the tread from an outer, ground-engaging side of the tread before placing the pressurization compartment under pressure in accordance with an embodiment of the invention.

[0008] FIG. 3A is a lateral cross-sectional detail view of a retreaded tire assembly showing each of the coil springs arranged at the bottom of each void and along a bonding

layer, where the voids comprise longitudinal grooves extending fully through the tread thickness and where the curing membrane has deformed into each of the voids due to pressure forces arising during curing operations in accordance with another embodiment of the invention.

[0009] FIG. 3B is a lateral cross-sectional detail view of a retreaded tire assembly showing a coil spring arranged at the bottom of each of the longitudinal grooves arranged in the tread, each longitudinal groove is arranged overtop a longitudinal groove arranged in the tire carcass in accordance with another embodiment of the invention.

[0010] FIG. 4A is a side view of a coil spring for arrangement within a void shown in FIGS. 1-3, the coil spring having an unexpanded length in an unexpanded configuration in accordance with an embodiment of the invention.

[0011] FIG. 4B is a side view of the coil spring of FIG. 4A for arrangement within a void shown in FIGS. 1-3, the coil spring having an expanded length in an expanded configuration in accordance with an embodiment of the invention.

[0012] FIG. 5 is a cross-sectional side view of a coil spring having a sleeve arranged around an outer extend of the coil spring, the sleeve and coil spring being shown in an expanded configuration in accordance with an embodiment of the invention.

[0013] FIG. 6 is a top view of a portion of a tread, and more specifically, of the outer, ground-engaging side of the tread where voids comprising longitudinal grooves containing coil springs extend lengthwise along a non-linear, zig-zagging path in accordance with an embodiment of the invention.

#### DETAILED DESCRIPTION OF PARTICULAR EMBODIMENTS

[0014] Particular embodiments of the present invention provide methods and apparatus for maintaining shape and/or volume of a void arranged along the outer, ground-engaging side of the tread, and extending into a thickness of the tread from the outer, ground-engaging side when forming a retreaded tire. By employing such methods and apparatus, the shape, volume, and arrangement of such voids along the tread outer, ground-engaging side are better maintained. In particular embodiments, such methods and apparatus inhibit the deformation of the voids.

[0015] Such methods may comprise methods for retreading a tire carcass (*i.e.*, tire casing), which may comprise a variety of steps. In particular embodiments, such methods

include the step of providing an annular tire carcass configured for receiving a tread. During retreading operations, an existing tire is typically prepared by removing at least a portion of the preexisting tread from the tire through an abrading or buffing operation, although it is understood that the preexisting tread may not be removed at all. The remaining portion of the tire is generally referred to as the tire carcass. In particular embodiments, the tire carcass forms an annular article generally including a pair of opposing sidewalls each extending radially outward from a bead to a central portion extending laterally between the sidewalls. During the retreading process, a tread is arranged along an outer side of the central portion to form a retreaded tire. It is generally understood that the tire carcass is previously manufactured, that is, previously molded and cured (or, in other words, vulcanized). With regard to the preexisting tread, if the preexisting tread is not removed or along a portion of the preexisting tread is removed, one or more voids or grooves may remain in the preexisting tread. It is understood that any desired tread and tire carcass may be employed. An exemplary tire tread and tire carcass are discussed further below with reference to the figures. This process, however, may be applicable to forming new tires where both the tread and tire carcass are new.

**[0016]** Particular embodiments of such methods may include the step of providing a tread having a top side configured to engage a ground surface during tire operation and a bottom side configured for attachment to an annular tire carcass configured for receiving the tread, the tread including a void extending into a thickness of the tread from the top side of the tread. Tire treads are often formed to include a tread pattern along an outer, ground-engaging side or face of the tread for engagement with a ground surface during tire operation. This outer, ground-engaging side is also referred to as a top side of the tread. It is understood that the top side and an opposing bottom side (also referred to as an underside) define the thickness of the tread. In particular instances, the tread pattern includes one or more tread features each comprising voids arranged along the top side, which extend into the tread thickness from the top side. For example, tread features may comprise grooves or sipes extending into the tread thickness. Sipes generally form thin voids molded or cut into the tread. By further example, grooves may comprise longitudinal and/or lateral grooves. “Longitudinal grooves” generally extend lengthwise (longitudinally) along a length of the tread, while “lateral grooves” generally extend lengthwise (longitudinally) along a width of the tread. The length of the tread extends in a lengthwise direction of the tread, while the width of the tread extends in a widthwise direction of the tread. Longitudinal grooves may

extend continuously around the tire to form circumferential grooves when the tread is arranged on a tire. Lateral grooves may also extend continuously across the width of the tread. It is understood that any grooves may extend lengthwise along any linear or nonlinear path. Furthermore, it is understood that any groove may extend continuously or discontinuously along the full length or width of the tread. Tread features comprising voids arranged along the top side are referred to herein as outer or top voids or top side voids.

**[0017]** It is also understood that any top side void, such as a groove, has a depth extending into the tread thickness from the outer, ground-engaging side. The void depth may extend partially through a thickness of the tread, and therefore, terminate at a bottom or bottom end of the void arranged within a thickness of the tread. The thickness of the tread remaining between the void bottom and the bottom side of the tread is referred to as the undertread. In particular embodiments, the depth of the groove extends through the tread thickness and to the bottom side of the tread. In such instances, it can be said that the void is exposed to, or is in operable communication with, the bottom side of the tread.

**[0018]** The outer-ground engaging side and at least a portion of the tread thickness may be divided into a plurality of tread elements by one or more top side voids and any lateral side edge of the tread. Exemplarily tread elements include ribs and/or blocks. Ribs and blocks each have a width generally extending laterally a distance less than the full tread width and which are bounded laterally by a two or more top side voids or one or more top side voids and a lateral tread edge. However, a rib generally extends the full length of the tread, while blocks extend partially along a length of the tread, such that multiple blocks may be arranged in a lengthwise direction of the tread that may otherwise form a rib. It is understood that one or more top side voids may extend fully through the tread thickness to parse the tread into a plurality of members, sections, or portions,

**[0019]** Further steps of such methods may include the step of arranging the tread around an outer circumference of the tire carcass in a desired position to form an assembled retreaded tire. Tire retreading generally comprises placing a new tread on the tire carcass. The new tread may be molded, and at least a portion thereof fully or partially cured prior to its application upon a tire carcass. Prior to applying the tread to the tire carcass, old tread material may be fully or partially removed from the tire carcass as desired and a bonding material arranged between the new tread and the tire carcass to promote adhesion and bonding there between. The bonding material may comprise any known material suitable for its intended purpose of bonding the new tread to the tire carcass. For example, the joining

material may include an adhesive or material curable by way of vulcanization, such as natural or synthetic rubber or any other elastomeric and/or polymeric material, which is commonly referred to as liaison rubber or cushion gum. As described above, the tread may be provided as a single, unitary member or may be assembled from multiple sections comprising different portions of the tread. Because the tread may be formed of separate portions or members, which may be employed to form a full length of the tread and/or may be used to form different portions of the tread width, the step of arranging the tread may include arranging each of the separate tread portions of the tread along the tire carcass.

**[0020]** Particular embodiments of the present methods may include the step of arranging a coil spring within the void of the tread. A coil spring is also referred to as a helical spring. The coil spring comprises a spring wire wound helically in a longitudinal direction of the spring to form a length of the spring. A coil spring may extend lengthwise between a pair of opposing terminal ends. In other variations, the spring may be an annular ring, such as when the ends are joined or attached to form an annular spring, which may comprise a garter spring, for example.

**[0021]** The length of the coil spring is configured to expand and contract, whereby the distance between winds in the helical spring increase and decrease with expansion and contraction, respectively. In particular embodiments, the coil spring is a tension spring, which is designed to resist lengthwise expansion of the spring such that the spring desires to return to a shorter, unstretched length. This way, such as when the spring is an annular spring, where the length of the spring is configured to form a ring, the spring may be stretched around the outer circumference of the tire, and later, upon arrangement of the spring within a void, such as a circumferential longitudinal void, the spring length shortens as the spring contracts. It is understood that when a coil spring is arranged within any void, the spring may remain in an unstretched configuration or in an expanded configuration, such that the spring squeezes against the tread with a clamping force. In other variations, the coil spring may comprise a compression spring, a torsion spring, a volute spring, or any other spring capable of achieving the intended purpose described herein. Any such spring may have a constant or variable width, where the cross-section of the spring or its windings may comprise any shape. Furthermore, the spring wire may have any desired cross-sectional shape, such as circular or rectangular.

**[0022]** In addition to expanding and contracting lengthwise, the coil spring may remain laterally flexible to also bend in one or more lateral directions along the length of the spring,

whereby a length of the spring is bent. Any such lateral direction is arranged perpendicular to the lengthwise direction of the coil spring. This allows the coil spring to laterally deform and flex, and thereby, for example, extend lengthwise along a non-linear path when arranged within a groove having a non-linear length, that is, a length extending longitudinally along a non-linear path. The spring wire may comprise any cross-sectional shape, including, for example, an ellipse (such a circle or oval), a quadrilateral (such as a square or rectangle), or a triangle.

**[0023]** Generally, one or more coil springs are arranged within a top side void to resist the tendency of the top side void to deform under the forces and pressures applied during curing operations in the retreading process. In particular instances, the coil spring is arranged along a bottom of the top side void. In instances, where the void extends through the tread thickness, such as when no undertread exists between a bottom of the void and the bottom side of the tread, arranging the coil spring at a bottom or end of the void comprises arranging the coil spring atop the tire carcass or a bonding layer arranged atop the tire carcass. In arranging the spring atop the tire carcass, in particular embodiments, there may be remnants of the preexisting tire tread remaining on the tire carcass – such as when the entire tread has not been fully removed or buffed from the tire carcass prior to installation of the new tread. This may be desired, for example, when attempting to reduce waste and re-use portions of the preexisting tread. In such instances, the coil spring may be arranged along the preexisting tread of the tire carcass. Furthermore, it is understood that the preexisting tread may include one or more voids, such as grooves, that were originally formed in the preexisting tread when new or that have been formed into the preexisting tread for purposes of installing the new tread during the retreading operation. It is also possible that voids may be arranged within the tire carcass in a layer of material arranged below the preexisting tread, which may or may not have been fully removed. As a result, the void of the new tread may be aligned with the void in the tire carcass such that the new void is arranged overtop the preexisting void. In such instances, the coil spring may be arranged at any location along the void of the new tread, which includes arranging the coil spring at a bottom of the void in the new tread. In arranging the coil spring at the bottom of the void in the new tread, the coil spring may also be arranged partially within the void in the tire carcass, which may also be arranged in the preexisting tread if present.

**[0024]** Additionally, or separately, the coil spring is arranged within the top side void such that the coil spring has a width approximately equal to a width of the void. It is

understood that one or more coil springs may be arranged within a top side void. For example, two or more may be stacked in a depthwise direction of the top side void (that is, stacked along a depth of the void). Additionally, or alternatively, the two or more may be arranged end-to-end or spaced apart along a length of the top side void.

**[0025]** The coil spring maybe arranged within any void discussed herein, including any lateral and/or longitudinal groove. In particular embodiments, for example, the coil spring is arranged in a longitudinal groove in any manner contemplated herein, and may extend substantially the full length of the groove. Therefore, when the longitudinal groove is a circumferential groove, the coil spring extends substantially the full annular length of the groove. In doing so, the coil spring may form an annular coil spring having a continuous length with no end. Such an annular spring may be permanently or temporarily formed by temporarily or permanently shaping and securing one or multiple coil springs in a ring configuration. Alternatively, the coil spring may have a terminal length, where the coil spring has a first terminal end and a second terminal end defining the length of the spring. In such occasions, a first end of the coil spring may be removably attached to the second end of the spring or any other portion of the spring length to for a coil spring extending annularly along the length of the circumferential groove and therefore form annular spring. In still other variations, the coil spring having terminal ends may be otherwise secured into the circumferential groove to extend substantially along the full annular length of the circumferential groove. Likewise, a coil spring may be secured or simply placed without constraint into any void or groove positioned along the top side of the tread.

**[0026]** It is understood that the coil spring is removable and may be reused for the same purpose in subsequent retreading operations. This is achievable because the coil spring is not substantially cured or bonded to the tread during curing operations. In particular embodiments, the tread is a precured tread, which means that the tread is at least partially cured, and accordingly, may be fully cured. In embodiments where the tread at least partially cured, the coil spring is less apt to bond to, or become embedded within, the tread. However, where the tread is uncured or not sufficiently cured, or when the top side void is exposed along a bottom side of the tread, where the top side void is in communication with the bonding layer arranged between the tread and the tire carcass, the tread and bonding layer materials are more ductile and able to bond. Therefore, in such embodiments, it may be possible for the coil spring to bond with, or become embedded within, the tread or the bonding layer.

[0027] Therefore, in particular embodiments, a removable and reusable coil spring is provided by forming the coil spring, or any sleeve covering the coil spring, from a material that does not generally bond with the tread material or the bonding layer material. For example, the coil spring may be formed of a metal, including any grade of steel, alloyed steel, or nickel. In more particular embodiments, the steel may comprise spring steel, carbon steel, stainless steel, manganese steel, beryllium copper, inconel (a nickel-chrome alloy). Furthermore, due to the exposure of heat during retreading operations, in particular embodiments, the material from which the spring is formed may also be, or instead comprise a high temperature material that is generally resistant to particular elevated temperatures. This way, the coil spring better retains its properties and characteristics while being exposed to elevated temperatures during curing operations, and even after the spring has been exposed to numerous heat cycles as the spring is reused in multiple curing operations. While elevated temperatures may comprise any desired curing temperature, in particular embodiments, for example, curing temperatures may exceed 100 degrees Celsius and even rise to 130 to 140 degrees Celsius. Exemplary high temperature materials for forming the coil spring include high temperature steels, such as carbon steels and chrome molybdenum steel, as well as high temperature ceramics, plastics, and other polymeric materials. The coil may also be coated or clad with a low-friction or non-stick coating to resist substantial bonding between the coil spring and the tread. The low-friction or non-stick coating may also be a high temperature resistant coating that is capable of resisting the curing temperatures and therefore able to substantially maintain its properties and characteristics during curing operations. For example, such a coating may comprise a Teflon<sup>®</sup> coating or a coating sold by Korolon<sup>™</sup>, such as a polymer based coating with solid lubricants referred to as Korolon 700<sup>™</sup>, a tungsten disulfide based coating with solid lubricants referred to as Korolon 800<sup>™</sup>, or a nickel-chrome based coating with solid lubricants referred to as Korolon 1350<sup>™</sup>. Likewise, with regard to the sleeve, the sleeve may be formed of, or coated with, any low-friction or non-stick material, which may also be a high temperature resistant material. For example, the sleeve may be formed of a flexible or elastomeric material, which may be coated with any such coating, which allows the spring to expand and contract as desired. The sleeve may also be formed from a ductile metal, which may extend less than the full length of the coil spring to allow the spring to expand and contract beyond the ends of the sleeve and allow the spring to be able to be mounted and dismounted from a top side void of a tread. In this way, the sleeve may have a length less than the length of the top side void within which it is or will be situated.

**[0028]** In addition to preventing bonding, a removable coil spring is achieved when the coil spring does not substantially penetrate, and therefore is not substantially cured into, a thickness of the tread and/or of the bonding layer during curing operations. Otherwise, the coil spring may not be removed without damaging the tread and the retreaded tire. Accordingly, in this case only, the thickness of the spring wire may be increased and/or the expansion of the coil spring may be reduced or eliminated such that the spacing between helical windings of the spring wire are reduced in the expanded spring configuration. This may be desired when the tread is not cured and/or when the spring is arranged along the bonding layer when the void extends through the tread thickness and is exposed along the tread bottom side. When reducing the expansion of the spring, a longer relaxed or unstretched coil spring would be required if trying to arrange the less-expanded spring along (that is span) the same length of the void.

**[0029]** The step of arranging the circumferential band may include expanding the coil spring prior to arrangement around the retreaded tire and within the top side void. For example, when employing an annular coil spring, the unstretched length of the coil spring is smaller than the circumference of the assembled retreaded tire and the top side void formed into the tread top side. For example, the unstretched length of the coil spring may be between 2% and 15% smaller than the circumference of the assembled retreaded tire or of the void length. An exemplary coil spring is discussed below in conjunction with the figures filed herewith.

**[0030]** Further steps of the present method may include the step of placing a curing membrane around an outer circumference of the tread and at least a portion of the tire carcass. It is understood that any known curing membrane to one of ordinary skill in the art, and any obvious variation thereof, may be employed in performing this step. Curing membranes are also referred to as curing envelopes within the industry. Generally, a curing membrane includes an outer body, shell, or membrane having a tread portion extending annularly to circumscribe the tread. The body includes a thickness and extends widthwise in a lateral or axial direction. The outer body typically extends widthwise the full width of the tread, and may extend further. The body may comprise one or more sections to achieve its purpose of covering the outer tread surface and becoming sealed to create an interior pressurization compartment between the tread and the curing membrane, which is at least initially placed under vacuum pressure during retread curing operations to substantially remove the air between the curing membrane and the tire assembly. Exemplary membranes

may partially cover tire carcass, such as when the curing membrane extends down each sidewall to engage a wheel upon which the tire carcass is mounted and cured. An exemplary retread curing membrane fully encompassing the retreaded tire is discussed below in conjunction with the figures filed herewith.

**[0031]** Particular embodiments of the present methods may include the step of curing the retreaded tire with the coil spring arranged within the void and the curing membrane. To form the retreaded tire, the assembled retreaded tire having an uncured bonding layer must be cured to bond the new tread to the tire carcass. Any method known in the art using a curing membrane may be employed to cure the retreaded tire assembly to form a retreaded tire. For example, the assembled retreaded tire may be arranged within a curing chamber known as an autoclave, where the tire is at least partially surrounded by air or other fluids heated and pressurized according to desired curing formulas or laws. This may include applying pressurized and heated fluids about the tire, or at least about an outer side of the assembled retreaded tire. This may also include expanding a curing bladder, such as by filling the curing bladder with a heated, pressurized fluid, within a central cavity of the tire carcass. Accordingly, particular embodiments of methods for tire retreading further include the step of placing the assembled retreaded tire with the curing membrane arranged thereabout into a curing chamber. It is also noted that, as previously mentioned, in particular embodiments the retreaded tire, as well as the curing membrane and coil spring, are exposed to elevated temperatures during the curing process to facilitate bonding of the tread to the tire carcass. For example, in particular embodiments, curing temperatures may rise to 130-140 degrees Celsius.

**[0032]** Other variations may be employed based upon the curing system or method employed. In particular embodiments, for example, the uncured, assembled retreaded tire is placed at least partially within the curing membrane or envelope for at least curing operations within a curing chamber. The curing membrane generally engages the outer side or surface of the tire carcass and tread, to form a skin-like member thereon at least extending circumferentially about the tire and laterally between opposing sidewalls and about the tread of the assembled tire. Any known membrane known in the art may be used. For example, one such membrane extends around the entire tire – circumferentially and laterally. By further example, the tire may be mounted on a wheel while a membrane extends from sidewall to sidewall about the tread. Regardless of the membrane employed, a compartment is generally formed between the membrane and the tire (tread and/or tire carcass), which may

be pressurized as desired during curing operations. The coil springs, by residing in the void, allow the curing membrane to effectively press the coil spring against the bottom of the groove, if not already arranged along the bottom of the groove, which in effect may either maintain or, in some cases, increase the depth of the void. It follows that particular embodiments of the present methods further include the step of removing the curing membrane and the coil spring after the step of curing has been performed.

**[0033]** In testing particular embodiments of these retreading methods, uncoated steel coil springs arranged within top side voids comprising longitudinal grooves. In certain tests, the grooves extended depthwise to a groove bottom, while in other tests, the bottom of the groove was exposed to the bonding layer. In each instance, it was found that, with use of uncoated steel coil springs, deformation of the grooves was substantially avoided, narrowing of the tread with was substantially improved, and the coil springs were removed without bonding to, or becoming embedded within, the tread or bonding layer.

**[0034]** The methods discussed above will now be discussed below in association with exemplary embodiments of the present invention.

**[0035]** As discussed above, any coil spring as contemplated herein is arranged around the assembled retreaded tire and within the void arranged in a top side of a tire tread to resist the tendency of the top side void to deform under the forces and pressures applied during curing operations in the retreading process. With reference to FIGS. **1-3B**, a retread tire assembly is shown with a coil spring **20** arranged within various voids arranged along an outer, ground-engaging side of the tread, the voids extending into a thickness of the tread from the outer, ground-engaging side of the tread during retread tire curing operations. The assembly **10** includes a curing membrane **12** arranged about the outer surfaces of the tire assembly **10** and any coil springs **20**. Although any type of curing membrane may be employed, in the embodiment shown in FIGS. **1-3**, the curing membrane **12** comprises two sections comprising an outer sleeve **14** arranged around a central tire portion including the tread, and an inner sleeve **16** overlapping the outer sleeve and extending around the remaining portions of the retreaded tire assembly, each sleeve extending annularly to form a ring or compartment encircling the retreaded tire assembly.

**[0036]** Generally, with reference to FIGS. **1-3B**, the retreaded tire assembly includes a tire carcass **30**, a tread **34**, and a bonding layer **32** arranged between the tread and tire carcass. The tread **34**, comprising an elastomeric material such as natural and/or synthetic rubber, for

example, generally forms a ring and is assembled about an outer circumference of the tire carcass. The tread **34** or portions of the tread may be uncured, precured, or partially cured. A bonding layer **32** arranged between the tread **34** and tire carcass **30** facilitates attachment of the tread to the tire carcass. The bonding layer **32** may comprise any known material capable of attaching the tread to the tire carcass, such as an adhesive or a curable elastomer or polymer, which may comprise cushion gum, for example. It is understood that the bonding layer may have any desired thickness. For example, the bonding layer thickness may extend up to approximately 1 millimeter. In particular embodiments, the bonding layer may not be employed, such as when a portion of the tread is uncured or partially cured.

[0037] The tread **34** has an outer, ground-engaging side **34<sub>s,o</sub>**, also referred to as a top side, configured to engage a ground surface during tire operation. The tread **34** also has an inner, tire-bonding side **34<sub>s,i</sub>**, also referred to as a bottom side, configured to attach the tread to the tire carcass **30**. The bonding layer **32** is arranged between the bottom side **34<sub>s,i</sub>** of the tread **34** and the tire carcass **30**. To achieve a desired tire performance, the tread **34** includes one or more tread features comprising voids **36** extending into the depth or thickness of the tread from the top side **34<sub>s,o</sub>** of the tread. In the embodiments shown, voids **36** comprise grooves, but in other embodiments, may comprise sipes, which generally form narrow grooves. In particular, with reference to FIG. 1, grooves **36** may form longitudinal grooves **36<sub>LONG</sub>** or lateral grooves **36<sub>LAT</sub>**. The longitudinal grooves **36<sub>LONG</sub>** shown extend annularly about the tread to form circumferential grooves. Furthermore, the longitudinal grooves have a length extending in a lengthwise direction of the tread along a linear path. Still, in other variations, the longitudinal grooves may have a length extending along any desired non-linear path, as is well known in the art. For example, with reference to FIG. 6, a longitudinal groove **36<sub>LONG</sub>** is shown having a length **L<sub>36</sub>** extending along a non-linear path, which zig-zags back-and-forth across the width of the tread **34** while extending generally in a lengthwise direction of the tread. Accordingly, a length **L<sub>20</sub>** of the coil spring arranged in each non-linear groove **36** also extends longitudinally in a non-linear path as it navigates the non-linear groove.

[0038] It is understood that the outer, ground-engaging side as well as at least a portion of the tread thickness may be divided by an arrangement of voids and/or lateral tread edges into a plurality of sub-regions each arranged atop a tread element. The tread elements may comprise, for example, ribs or blocks of various shapes and sizes, where the tread elements are at least partially formed by using one or more voids and/or a lateral tread edge to define a

boundary of the ribs or blocks. Generally, ribs extend continuously around the tread circumference, while blocks extend partially around the tread circumference. With reference to FIG. 1, for example, the tread outer, ground-engaging side  $34_{s,o}$  is divided by top side voids 36 and lateral tread edges 42 into a plurality of tread blocks 44 and ribs 46. In other embodiments, such as where the tread blocks were not separated along a length of the tread by top side voids, such as lateral grooves as shown in FIG. 1, a rib would be provided.

[0039] It is understood that a coil spring may be arranged at any location within the depth of a void. For example, in the embodiment shown in FIG. 2, each coil spring 20 is arranged within the depth  $D_{36}$  of each void 36, and more specifically, along a bottom 38 of each void 36, which comprises a longitudinal groove  $36_{LONG}$ . The region of the tread thickness arranged below the void bottom 38 and the tread bottom side  $34_{s,o}$  is referred to as the undertread 40. The undertread may have any desired thickness, but may, in particular instances comprise a very thin undertread having a thickness equal to or less than 3 to 4 millimeters or equal to or less than 1 millimeter. In the embodiment of FIG. 3A, however, no undertread is arranged below each void 36, and therefore, each void is in communication with the tread bottom side and with the bonding layer 32. In such instances, arranging each spring 36 at a bottom of the void comprises arranging a coil spring along the bonding layer 32. In other embodiments, where one or more exposed voids remain in the tire carcass, such as within and along the preexisting tread, arranging each spring at a bottom of the void includes arranging the spring at least partially within an exposed void in the tire carcass. For example, with reference to FIG. 3B, a coil spring 20 is shown arranged partially within each exposed void 48 in a preexisting tread layer 31 within the tire carcass 30, where each such void comprises a longitudinal groove.

[0040] If the coil spring does not fill the full depth of the void, it is understood that one or more coil springs may be arranged or stacked at different depths within the void depth to more fully consume or fill the volume within the void and support different portions of the void. Furthermore, stacking two or more coil springs may provide additional support to the void during curing operations, and may reduce the distance the curing membrane must extend into the void to engage a coil spring, such as when desiring the curing membrane to push the spring into the void bottom, against the bonding layer, or into a void arranged in the tire carcass. It is, however, generally not necessary for the coil spring to completely fill the void, since the curing membrane may extend into the void from the top side of the tread when the curing membrane is placed under vacuum pressure and/or when pressure within the autoclave

is applied to the outside of the curing membrane. In doing so, the curing membrane presses against the top of the spring, which in turn causes the spring to secure the spring within the void and even press the spring against the bottom and/or the sides of the groove in particular embodiments, to thereby maintain the groove geometry during curing operations. In instances such as in FIG. 3B, where the top side void extends fully through the tread thickness, it is understood that the curing membrane 12 may deform and extend into the top side void 36 and force the coil spring 20 into the bonding layer 32. In turn, the coil spring 20 deforms the bonding layer 32 to form a depression 33 in the bonding layer during curing operations, which, in effect, forms a deeper final top side void 36 as the depth  $D_{36}$  of the void continues through the tread thickness and into the depression formed in the bonding layer.

[0041] It is understood that the coil spring may have any desired width, and any width in relation to a width of the void. For example, with further reference to FIGS. 2 through 3B, the width  $W_{20}$  of each coil spring 20 is approximately equal to a width  $W_{36}$  of an occupying void 36. The width of each top side void may be variable, such that the width of the void varies along the length and/or depth of each such void.

[0042] It is understood that the coil spring may be arranged within any void in a relaxed or unstretched arrangement or in a stretched or expanded arrangement. For example, with reference to FIGS. 4A and 4B, a coil spring 20 comprising a tension spring is shown in a relaxed or unstretched arrangement and a stretched or expanded arrangement, respectively. A tension spring is designed to resist lengthwise stretching or expansion of the coil spring. It is understood, however, that any coil spring may be employed. In the figures shown, it is noted that each coil spring includes a spring wire 22 helically wound to form multiple windings 24, where each winding comprises a 360 degree wound length of the wire. It is understood that the spacing between each winding will increase between relaxed and expanded arrangements of the spring; however, the spacing between each winding in the relaxed arrangement be a zero distance (whereby no spacing exists) or any distance greater than zero (whereby a spacing exists). For example, in the embodiment of FIG. 4A, each winding abuts each adjacent winding of the wire 22 such that no spacing exists between adjacent windings in a relaxed arrangement of the spring. By further example, with reference to FIG. 4B, in an expanded arrangement, a spacing  $S_{24}$  exists between adjacent windings. It is also noted in the figures that the width  $W_{20}$  of each coil spring 20 is shown to generally remain constant over the length  $L_{20}$  of the spring – that is, each winding 24 has the same general width. However,

it is understood that the spring width may vary along a length of the spring, from coil winding to winding. It is also noted that, in particular embodiments where the void extends through the tread thickness and to a bottom side of the tread such that the spring engages the bonding layer, such as is shown in FIG. 3A, for example, a closer spacing between windings may reduce, deter, and even substantially prevent the bonding layer from consuming (that is, penetrating) a portion of the coil spring by reducing, deterring, and even substantially preventing bonding layer material from entering the spacing between windings. Therefore, closer the winding spacing may be employed when the bonding layer material is more ductile or free-flowing, while wider winding spacings may be employed when the bonding layer material is less ductile or free-flowing.

[0043] As stated above, a coil spring may be coated with a low-friction composition, or a sleeve may be arranged around the spring and along a length of the spring, to promote removal of the coil spring from the tread at the conclusion of the retreading process. With reference to FIG. 5, for example, a sleeve 26 is shown arranged around a width  $W_{20}$  and lateral perimeter of the spring. The sleeve may be formed of any desired material, which may comprise any elastomeric, polymeric, or even metal material. Therefore, the sleeve may be rigid, flexible, or deformable. By further example, sleeve may be formed of a corrugated structure, such as corrugated tubing. The sleeve may be fixed to the coil spring or removably arranged along the coil spring for easy replacement should the sleeve become damaged or overused.

[0044] While this invention has been described with reference to particular embodiments thereof, it shall be understood that such description is by way of illustration and not by way of limitation. Accordingly, the scope and content of the invention are to be defined only by the terms of the appended claims.

### CLAIMS

What is claimed is:

1. A method of forming a retreaded tire comprising:
  - providing a tread having a top side configured to engage a ground surface during tire operation and a bottom side configured for attachment to an annular tire carcass configured for receiving the tread, the tread including a void extending into a thickness of the tread from the top side of the tread;
  - arranging the tread around an outer circumference of the tire carcass in a desired position to form an assembled retreaded tire;
  - arranging a coil spring within the void of the tread;
  - placing a curing membrane around an outer circumference of the tread, an outer circumference of the circumferential band, and at least a portion of the tire carcass; and,
  - curing the assembled retreaded tire with the coil spring arranged within the void.
2. The method according to claim 1 further comprising the step of:
  - removing the curing membrane and the coil spring after the step of curing has been performed.
3. The method according to claim 1, where the void has an annular length and the coil spring has an annular length such that the annular length of the coil spring is arranged along the annular length of the void.
4. The method according to claim 3, where the step of arranging a coil spring includes expanding the coil spring prior to arrangement around the tread.
5. The method according to claim 3, where the coil spring has an unstretched length shorter than the annular length of the void.
6. The method according to claim 3, where the coil spring is formed of a metal material.
7. The method according to claim 1, where the coil spring is arranged along a bottom of the void.

8. The method according to claim 3, where the coil spring is arranged along a bottom of the void.
9. The method according to claim 7, where the coil spring arranged within the void has a width approximately equal to a width of the void.
10. The method according to claim 3, where the coil spring is arranged along a bottom of the void.
11. The method according to claim 1, where the coil spring arranged within the void has a width approximately equal to a width of the void.
12. The method according to claim 1, where the void is a longitudinal groove extending lengthwise in a longitudinal direction of the tread.
13. The method according to claim 12, where the void is continuous around the circumference of the tread.
14. The method according to claim 12, where the longitudinal groove extends lengthwise in a non-linear path to form a non-linear length of the longitudinal groove.
15. The method according to claim 1, where the longitudinal groove extends lengthwise in a non-linear path to form a non-linear length of the longitudinal groove.
16. The method according to claim 1, where the coil spring includes a removable sleeve arranged around a cross-sectional extent of the coil spring and along a length of the coil spring.
17. The method according to claim 16, where the void has an annular length and the coil spring has an annular length such that the annular length of the coil spring is arranged along the annular length of the void, the sleeve extending substantially along the full annular length of the coil spring.

18. The method according to claim 17, where the void is a longitudinal groove extending lengthwise in a longitudinal direction of the tread.
19. The method according to claim 18, where the void is continuous around the circumference of the tread.
20. The method according to claim 18, where the longitudinal groove extends lengthwise in a non-linear path to form a non-linear length of the longitudinal groove.

1/3

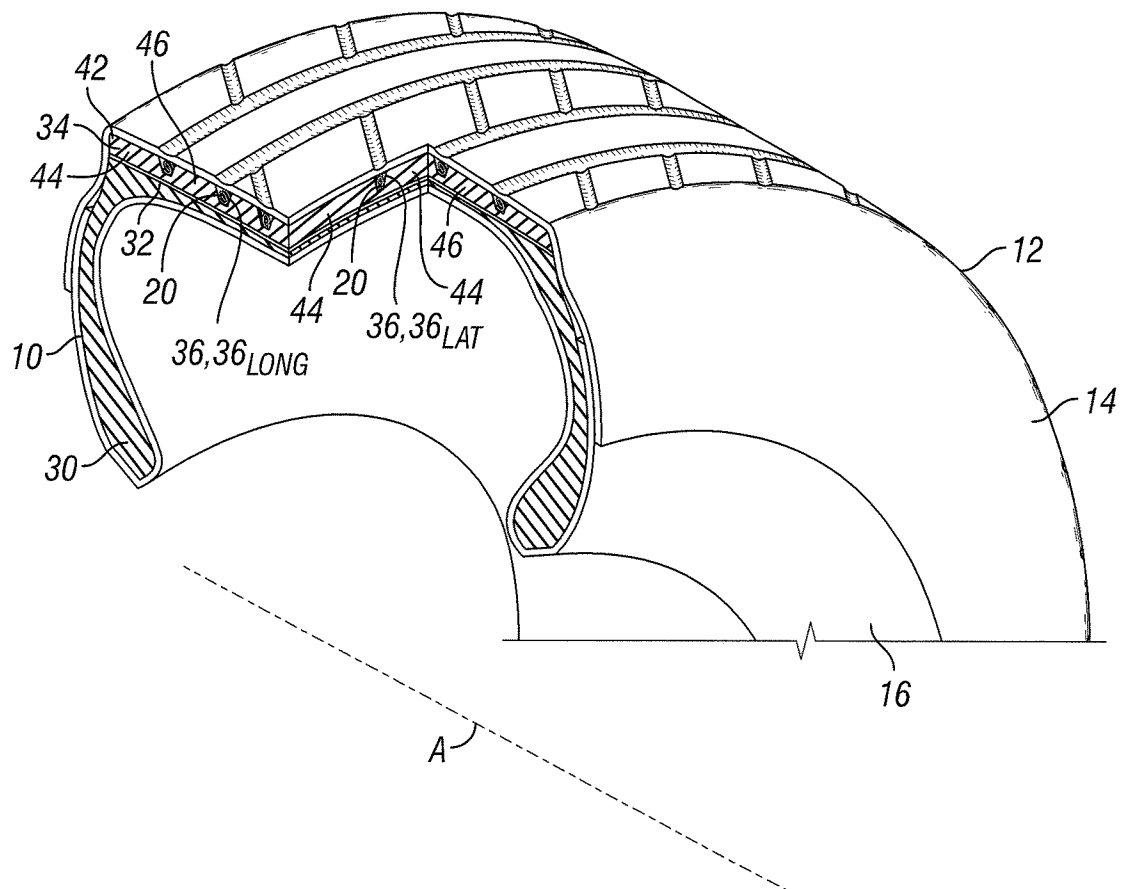


FIG. 1

2/3

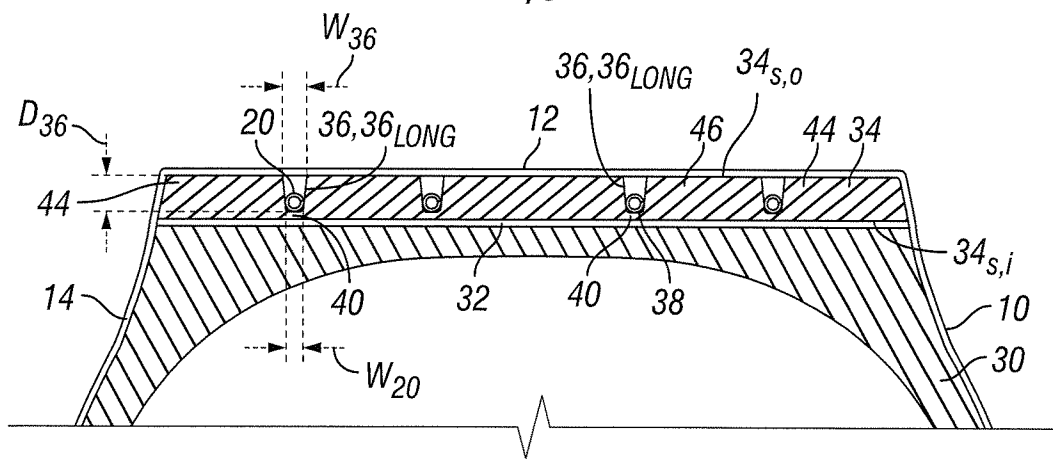


FIG. 2

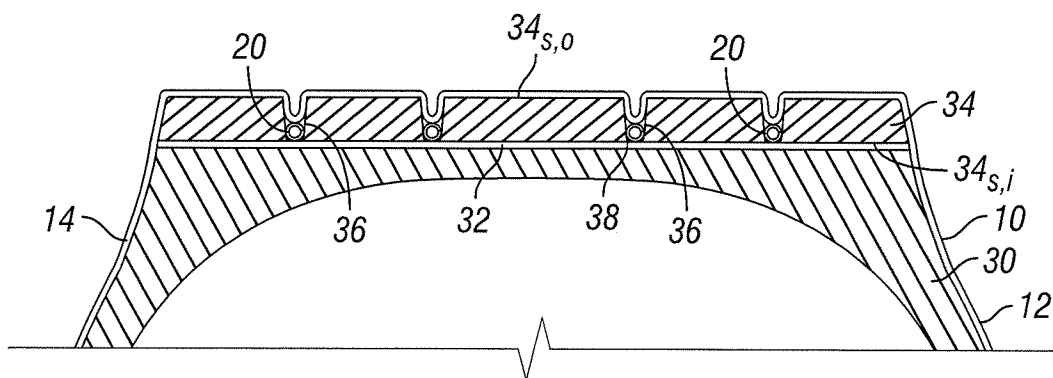


FIG. 3A

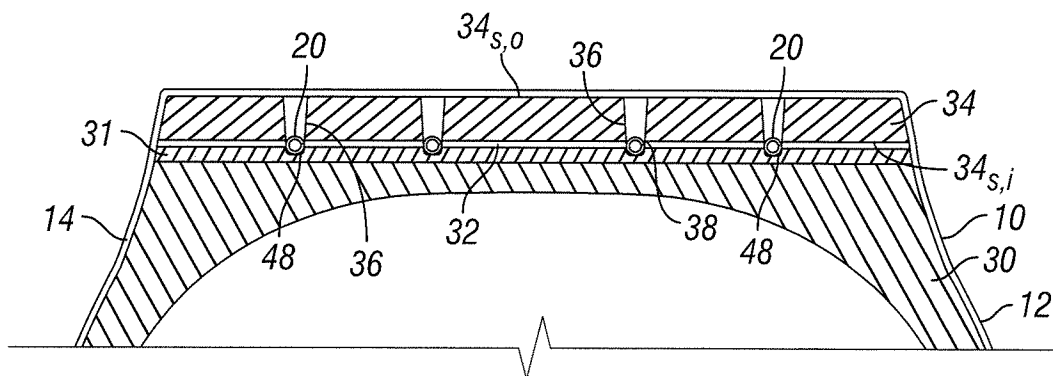


FIG. 3B

3/3

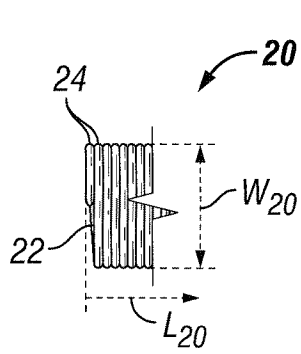


FIG. 4A

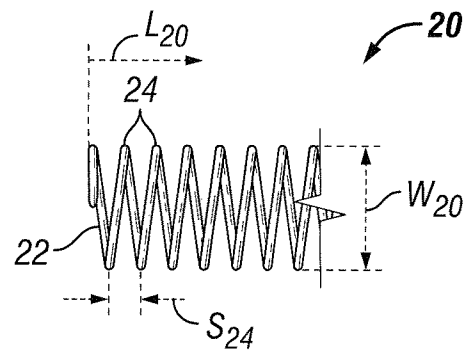


FIG. 4B

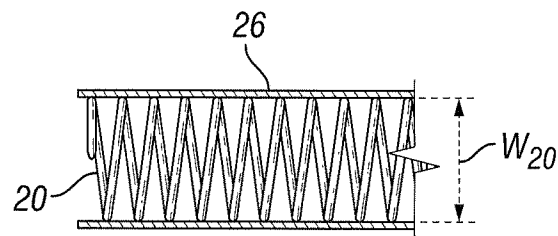


FIG. 5

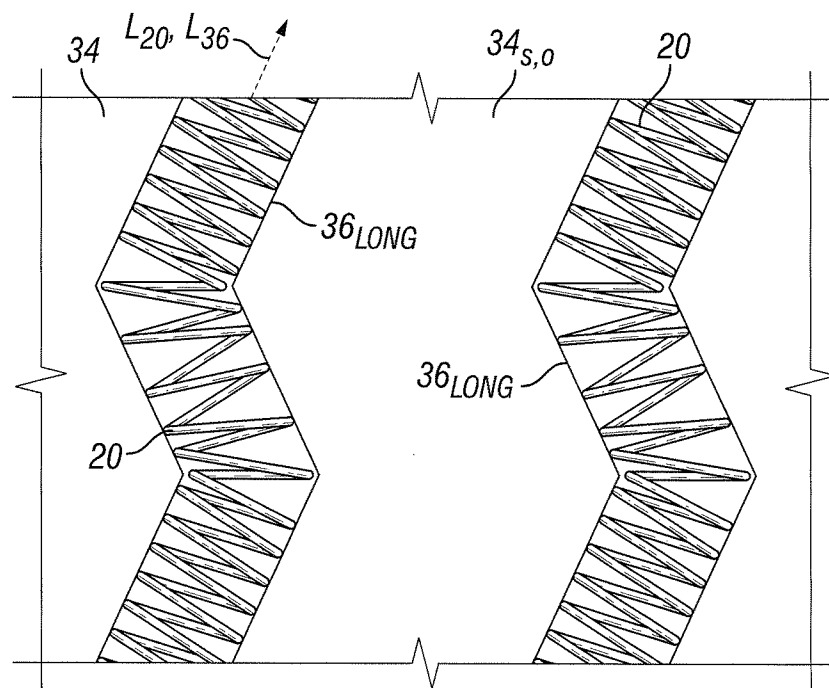


FIG. 6

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 13/24171

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - B29D 30/08 (2013.01)

USPC - 156/128.1

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)

IPC(8): B29D 30/08 (2013.01)

USPC: 156/128.1

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched  
additional USPC: 156/128.1, 128.6, 129, 130, 127, 117

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

PubWEST(PGPB,USPT,USOC,EPAB,JPAB); Google Patents, Google, PatBase

Search terms used: tire/tyre/tires, diameter, retread\$, tread\$, ground surface, tire carcass, void/opening/aperture/volume, circumference, coil spring, curing/cured/cures, stretched/unstretched length, width, longitudinal groove, membrane/film/sheet/envelope/cover

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category*       | Citation of document, with indication, where appropriate, of the relevant passages                    | Relevant to claim No.  |
|-----------------|-------------------------------------------------------------------------------------------------------|------------------------|
| Y<br>-----<br>A | US 2,479,474 A (CROCKER) 16 August 1949 (16.08.1949)<br>Figs 1, 4-5; col 1, ln 35-37; col 2, ln 20-67 | 1-15<br>-----<br>16-20 |
| Y               | US 4,850,834 A (HINSON et al.) 25 July 1989 (25.07.1989)<br>Fig 3; col 3 ln 10-36; col 5, ln 1-16     | 1-15                   |
| A               | JP 2002321659 A1 (YOSHIHARU et al.) 5 November 2002 (05.11.2002)<br>para [0007]; para [0013-0014]     | 16-17                  |
| A               | US 4,500,375 A (GOLDSTEIN) 19 February 1985 (19.02.1985)<br>Figs 1 and 4; col 5, ln 28-67             | 1-20                   |
| A               | US 4,011,125 A (PELLETIER) 8 March 1977 (08.03.1977)<br>Fig 6; col 4, ln 19-59                        | 1-20                   |

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

\* 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

"&amp;" document member of the same patent family

Date of the actual completion of the international search

18 March 2013 (18.03.2013)

Date of mailing of the international search report

08 APR 2013

Name and mailing address of the ISA/US

Mail Stop PCT, Attn: ISA/US, Commissioner for Patents  
P.O. Box 1450, Alexandria, Virginia 22313-1450

Facsimile No. 571-273-3201

Authorized officer:

Lee W. Young

PCT Helpdesk: 571-272-4300  
PCT OSP: 571-272-7774