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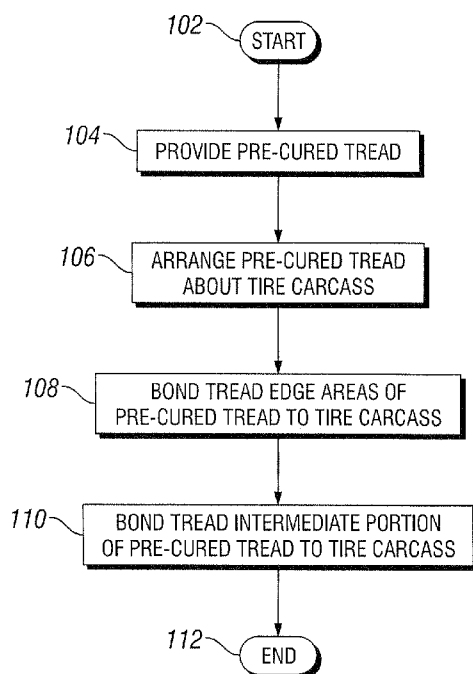
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- (54) **Title:** METHOD FOR IMPROVED BONDING OF TREAD EDGES FOR TIRE RETREADING OPERATIONS

**FIG. 1**

- (57) **Abstract:** Particular embodiments of the invention concerns methods of forming a retreaded tire with improved tread edge area bonding, and re-treaded tires formed thereby. One embodiment of such methods includes forming an unbonded retreaded tire by arranging a pre-cured tread annularly around an annular tire carcass with a bonding layer arranged there between. The pre-cured tread includes a pair of opposing tread edges laterally-spaced to define a width of the pre-cured tread. The method also includes bonding the tread of the unbonded tire to the tire carcass to form a bonded retreaded tire by sufficiently pressurizing and heating the curing chamber to cure the bonding layer of the unbonded tire, which includes at least partially bonding a pair of laterally-spaced tread edge areas of the pre-cured tread to the tire carcass prior to an intermediate portion of the pre-cured tread located between the pair of laterally-spaced tread edge areas.



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METHOD FOR IMPROVED BONDING OF TREAD EDGES
FOR TIRE RETREADING OPERATIONS

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] This invention relates generally to methods and apparatuses for manufacturing retreaded tires, and treads for retreading tires. More specifically, this invention relates to methods and apparatuses for curing a retreaded tire without a curing membrane.

Description of the Related Art

[0002] A retreaded tire consists of a new pre-cured tread attached to a pre-existing tire carcass. The tire carcass is prepared to receive the new pre-cured tread by removing the prior tread, such as through buffing or abrading operations. The new pre-cured tread is then applied to the tire carcass with a bonding layer comprising bonding material to secure the new tread to the carcass. Subsequently, a flexible curing membrane (or envelope) is arranged at least partially around the tire to create a sealed fluid chamber between the curing membrane and the tire. The combination of a retreaded tire with an installed curing membrane is referred to herein as a tire-membrane assembly.

[0003] In operation, multiple tire-membrane assemblies are placed within a tire curing chamber, such as an autoclave. Each tire-membrane assembly is then placed in fluid communication with a vacuum source. The vacuum source substantially removes gas between the tire and the curing membrane. Subsequently, while the tire-membrane assembly is under vacuum pressure, the curing chamber is also heated and positively pressurized, such that a pressure force is applied to the flexible curing membrane. Accordingly, the flexible curing membrane is forced into grooves and other sufficiently sized voids arranged along the top side (*i.e.*, outer or exposed side) of the tread during curing operations.

[0004] Because these flexible curing membranes are used to separately cure numerous retreaded tires, the membranes undergo numerous flexing cycles due to the repeated penetration of grooves and sufficiently sized voids arranged along the top side of the tread, which can notably reduce the useful life of the flexible curing membrane. Additionally, the membranes frequently wear out from normal use, due at least in part to repeated motion, exposure to changing or elevated temperature, and pressure changes. Thus, it is desirable to develop more efficient curing processes that do not require consumable curing membranes.

[0005] Furthermore, the curing membrane may tend to compress the tread, which may alter the cured dimensions of the tread. Therefore, there is also a need to improve the retreading process by reducing any instabilities or deforming forces acting on or impacting the tread.

SUMMARY OF THE INVENTION

[0006] Particular embodiments of the invention concerns methods of forming a retreaded tire with improved tread edge area bonding, and retreaded tires formed thereby. One embodiment of such methods includes forming an unbonded retreaded tire by arranging a pre-cured tread annularly around an annular tire carcass with a bonding layer arranged there between. The pre-cured tread includes a pair of opposing tread edges laterally-spaced to define a width of the pre-cured tread. The method also includes bonding the tread of the unbonded tire to the tire carcass to form a bonded retreaded tire by sufficiently pressurizing and heating the curing chamber to cure the bonding layer of the unbonded tire, which includes at least partially bonding a pair of laterally-spaced tread edge areas of the pre-cured tread to the tire carcass prior to an intermediate portion of the pre-cured tread located between the pair of laterally-spaced tread edge areas.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. 1 is a flow chart describing a method of forming a retreaded tire including various steps in accordance with an embodiment invention.

[0008] FIG. 2 is sectional view of an unbonded retreaded tire including edge-bonding material in accordance with an embodiment of the invention.

[0009] FIG. 3 is a partial sectional view of an unbonded retreaded tire in accordance with a second embodiment of the invention.

[0010] FIG. 4 is a plan view of an unbonded retreaded tire being cured in a curing chamber in cooperation with a second heat source in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION OF PARTICULAR EMBODIMENTS

[0011] Particular embodiments of the invention include methods of forming a retreaded tire and a retreaded tire formed by methods described herein.

[0012] Particular embodiments of such methods include forming an unbonded retreaded tire, which includes arranging a pre-cured tread annularly around an outer circumference of

an annular tire carcass with a bonding layer comprising uncured bonding material arranged between the pre-cured tread and the annular tire carcass. The tread includes a pair of opposing tread edges laterally-spaced to define a width of the pre-cured tread. The unbonded retreaded tire has a thickness extending between inner and outer sides of the unbonded retreaded tire. The annular tire carcass comprises a pair of sidewalls spaced apart in an axial direction of the tire, each of the pair of sidewalls extending radially inward from an undertread portion to a bead portion. The outer side of the unbonded retreaded tire may also be described as having a first lateral portion and a second lateral portion, which are spaced apart and arranged on opposing axial sides of the tire. Accordingly, the first lateral portion includes a first sidewall and associated bead portion and the second lateral portion includes a second sidewall and associated bead portion. The pair of opposing tread edges form terminal edges of the tread, to thereby define the width of the tread. The width or widthwise direction of the tread extends perpendicular to a length of the tread, which ultimately extends around the outer circumference of the tire in an installed arrangement, where the lengthwise and widthwise directions both extend perpendicular to each other and to a thickness of the tread, which extends in a radial direction of the tire in the installed arrangement. It is appreciated that the unbonded retreaded tire may be assembled by any method known to one of ordinary skill in the art.

[0013] Still further embodiments of such methods include bonding the tread of the unbonded retreaded tire to the tire carcass in a curing chamber to form a bonded retreaded tire by pressurizing the curing chamber and sufficiently heating the curing chamber using a chamber heat source to cure the bonding layer of the unbonded retreaded tire. In such instances, the step of curing is performed without use of any flexible curing membrane arranged fully or partially along the unbonded retreaded tire. As such, the tire is arranged within a curing chamber and substantially exposed to pressurized and heated gas(es) contained within a curing chamber. In the curing chamber, heat is generated by a chamber heating source, external to the unbonded retreaded tire. The heating source may comprise any known or useful heat source suitable for its purpose of heating the curing chamber. In particular instances of such embodiments, the pressure to which the curing chamber is pressurized is a sufficiently high pressure, such as at least 6 bar, for example. Other elevated pressures may be employed when curing different tires. It is contemplated that the curing operations can occur while the tire is mounted on a wheel or any other desired mounting structure. Generally, the curing chamber provides a controlled environment where a tire is bonded in

accordance with a recipe or formula identifying any combination of one or more pressures and temperatures for certain durations. It is appreciated that bonding operations can be performed within one or more curing chambers. It is also appreciated that the same or different chambers can be used for performing other operations. Embodiments of such techniques are a departure from earlier curing methods that require use of a curing membrane to remain arranged around or engaged with the unbonded retreaded tire during curing operations.

[0014] In particular embodiments, the unbonded retreaded tire is cured (that is, the tread is bonded to the tire carcass) without use of a flexible curing membrane subsequent to assembling the unbonded retreaded tire. When doing so, the tread edges may lift and separate from the tire carcass. To resolve these issues, the methods discussed below may be used to facilitate improved bonding of each tread edge and the portion of the tread adjoining each tread edge (referred to collectively as the “tread edge area”) to the tire carcass.

[0015] For example, in particular embodiments where the curing chamber is generally heated by a chamber heating source, the step of bonding further includes at least partially bonding a pair of laterally-spaced tread edge areas of the pre-cured tread to the tire carcass prior to an intermediate portion of the pre-cured tread located between the tread edge areas of the tread. Stated another way, the step of bonding further includes at least partially curing bonding material arranged between the tread and the tire carcass at, or adjacent to, each of the tread edge areas prior to at least partially curing bonding material arranged at an intermediate portion of the tread located between the pair of tread edge areas (also referred to as an intermediate portion of the bonding layer). By doing so, tread edge areas associated with each of a pair of opposing edges of the tread are generally bonded to the tire carcass prior to bonding an intermediate portion of the tread between the pair of opposing tread edges, which substantially reduced or eliminates the lifting of the tread edges as the intermediate portion of the bonding layer cures and bonds an intermediate portion of the tread to the tire carcass. It is appreciated at least partially bonded or cured contemplates partial or full bonding or curing. Moreover, it is appreciated that a tread edge area as used herein includes the areas of the tire tread and other areas of the tire, such as areas of the bonding layer and of the tire carcass, arranged in close proximity to a corresponding tread edge of the pre-cured tread. Accordingly, a tread edge area includes the tread edge. In particular embodiments, the tread edge area may extend inward from a tread edge in a lateral or axial direction toward a centerline of the tire tread by a distance up to substantially 0.5 inches (12.7 millimeters) or up

to substantially 1 or 2 inches (25.4 or 50.8 mm), for example. (For exemplary reference, see tread edge areas **227** extending a distance from the each tread edge to the dashed lines in FIGS. 2 and 3). Described differently, the tread edge area may extend inward from a tread edge in a lateral or axial direction toward a centerline of the tread comprise a distance up to substantially 5%, 10%, 20%, or 25% of the tread width, for example. In any event, the distance is less than 50% the tread width. In bonding a tread edge area, it is appreciated that bonding may not be completely achieved, but rather substantially complete to account for imperfections in bonding the tire tread and the tread edge to the tire carcass, where the imperfections may occur at the tread edge or within the tire inward the tread edge.

[0016] In particular embodiments of the methods, the prioritized curing of the tread edges, in the step of bonding, is accomplished by heating more quickly or rapidly portions of the bonding layer arranged adjacent to (that is, associated with) each of the pair of laterally-spaced tread edge areas of the tread to a curing temperature relative to an intermediate portions of the bonding layer (or of the tread) arranged between the pair of laterally-spaced tread edge areas. In particular embodiments, this prioritized curing is accomplished by exposing portions of the bonding layer arranged adjacent to each of the pair of laterally-spaced tread edge areas to heat prior to exposing the intermediate portion of the tread or bonding layer to heat in the retreaded tire. In other embodiments, prioritized heating is accomplished by increasing the transfer of heat to portions of the bonding layer associated with the pair of laterally-spaced tread edge areas at any time during the heating process. In any event, any such embodiment may be accomplished by heating portions of the bonding layer associated with each the pair of laterally-spaced tread edge areas by use of a secondary heat source, the secondary heat source directing focused heat local to the bonding layer associated with at least one of the pair of laterally-spaced tread edge areas of the tread. It is appreciated that the secondary heat source may extend fully around a circumference of the tire at a radius corresponding to the edge of the bonding layer. In other variations, where the secondary heat source extends partially around a circumference of the tire: (1) additional secondary heat sources may be employed to, in combination, sufficiently heat the tread edge substantially around the tire; or (2) the tire may be configured to rotate to thereby apply sufficient heat around the tire. Rotation of the tire may also be practiced even when the secondary heat source extends substantially around the tire to overcome any effects of gravity when curing the tire in a static arrangement.

[0017] It is appreciated that the secondary heat source may comprise any heat source

capable of directing heat locally at a tread edge area by conduction, convention, or radiation. For example, in exemplary embodiments, the secondary heat source is an electric heater (that is, an electric resistance or resistive heater), where electrical energy is converted to heat when a source of electricity supplies an electric current to an electrically resistive material comprising a resistor or conductor. It is appreciated that any known electric heater of any form may be employed. For example, an electric heater may comprise flexible silicone rubber, wire, film, or tape. By further example, an electric heater may comprise a coating, where the electrically resistive material may be applied in any known manner. For example, the material may be sprayed or printed onto the tread, the bonding layer, and/or the tire carcass. Accordingly, in particular embodiments, the coating may comprise a preformed layer of material, a sprayed coating, or a printed coating of conductive ink or any other conductive material. It is appreciated that the arrangement of electrically resistive material along any tread edge area extends between a pair of ends to form a break, such that a current may be generated between a pair of electrodes arranged on each side of the break (that is, at each of the pair of ends) to supply the necessary electrical current to heat the electrically resistive material, and thereby the edges of the bonding layer. It is also appreciated that the electric heater may be arranged external or internal to the tire, and more specifically to the tread and to the bonding layer. In other exemplary embodiments, the secondary heat source is a radiant heater, a forced-air heater, a jet heater, a microwave source, an infra red source, an ultrasound source, or an induction heater, each of which may be arranged external to the tire in contacting or spaced apart arrangements. In particular variations, the external heater may form a ring, whereby a pair of ring heaters are provided, where each of the pair of ring heaters are arranged adjacent to (that is, in close relation or in contact with) one of the pair of tread edge areas of the bonding layer or of the tire tread.

[0018] In one of the exemplary embodiments where the secondary heat source comprises an electrical heater, in the step of bonding, prioritized curing of the tread edges is accomplished by arranging an electrically resistive material along each of the pair of tread edge areas, where current is passed through the electrically resistive material to heat the bonding layer associated with each of the pair of tread edges relative to the intermediate portion of the bonding layer and/or tread in the step of bonding from a current source. It is appreciated that in arranging the electrically resistive material along each of the pair of tread edge areas, the electrically resistive material may be arranged along any surface of the tread or bonding layer, or within a thickness of the tread or bonding layer. It is also appreciated

that the electrically resistive material may form a portion of the bonding layer. While any material may be employed suitable to provide heat to the tread edge area, in particular embodiments, when the electrically resistive material is an electrically resistive coating, the coating is a conductive ink formed of a carbon-based material.

[0019] In other embodiments, to improve bonding of the tread edge areas, the step of forming includes arranging an edge-bonding material between the pre-cured tread and the tire carcass at each of a pair of opposing tread edge areas, the edge-bonding material being configured to bond each of the pair of tread edge areas to the tire carcass before bonding an intermediate portion of the tread to the tire carcass. By arranging the edge-bonding material at target locations, improved bonding of the tread to the tire carcass is achieved, whereby the tread edges are sufficiently bonded to the tire carcass prior to bonding the intermediate portion of the tire tread. It is appreciated that the edge-bonding material may form a portion of the bonding layer or may be provided in addition to the bonding layer along each of the pair of tread edge areas in any continuous or discontinuous arrangement.

[0020] In particular embodiments, the edge-bonding material is a high viscosity material characterized as having sufficient tack and viscosity to facilitate immobilization of the tread during the curing process, where in the step of bonding, the high viscosity material cures to at least partially bond the tread to the tire carcass, maintaining its viscosity, tack, and shape in the process. In such embodiments, the viscosity of the high viscosity bonding material is selected to sufficiently immobilize the tread during curing operations, which facilitates proper bonding of the tread to the tire carcass and prevents the lifting of the edges of the tread. For example, in particular embodiments, the high viscosity bonding material has a viscosity of at least 30 Mooney units. In specific embodiments, the viscosity level can be in excess of 60 Mooney units. In particular embodiments, the high viscosity bonding material is polymeric, such that in the step of bonding, the high viscosity material cures to at least partially bond tread to the tire carcass. It is appreciated that in particular embodiments, the high viscosity bonding material forms the bonding layer or a portion of the bonding layer, such as each of the tread edge areas, for example. It is also appreciated that the high viscosity bonding layer may be arranged between the tread and the tire carcass in addition to the bonding layer, where the high viscosity bonding layer is arranged between the bonding layer and either the pre-cured tread or the tire carcass in each of the pair of opposing tread edge areas.

[0021] It is appreciated that the viscosity of the high viscosity bonding material may be greater or less than 30 Mooney units based upon the desired bonded shape of the tread in the

circumferential and /or lateral directions and/or based upon the materials from which the tread and the tire carcass are formed. For example, the greater the curvature along which the tread bends circumferentially and/or laterally, it may be more beneficial to further increase the viscosity of the high viscosity bonding material, and vice versa. It is also appreciated that the bonding layer may be formed of different bonding layer materials, where certain portions of the bonding layer in the lateral direction (*i.e.*, in an axial or widthwise direction) are formed of bonding material having different viscosity, where at least certain portions of the bonding layer are formed of the high viscosity bonding material, which has a higher viscosity than other portions of the bonding layer, whether such other portions are formed of bonding material of normal or higher viscosity. For example, the tread edge areas of the bonding layer may be formed of high viscosity bonding material that is of higher viscosity of than bonding material arranged along an intermediate portion of the bonding layer between the pair of opposing tread edge areas.

[0022] While electrically resistive material is considered a second heat source, it can also be considered an edge-bonding material. Accordingly, in particular embodiments, the edge-bonding material is an electrically resistive material, where such material and its use is also described above and elsewhere herein in additional detail. In accordance therewith, in an exemplary embodiment, the edges of the bonding layer are painted with an electrically resistive ink (or coating) that acts as a heater when electrical current flows through it. In a particular method, the ink (or coating) is subjected to an electrical current at the early stage of the curing cycle. The ink heats up and heats the edge of the bonding layer, bringing it to curing temperature quicker than the intermediate portion of the bonding layer. In such a case, a closed loop control system is used to regulate the temperature of the electrically resistive material (or any other secondary heater discussed herein) to the cure temperature. With experimentation, it is also possible to forego the control system and instead heat the edges for a predetermined time based on the type and dimension of the tire and bonding layer material.

[0023] In particular embodiments, the edge-bonding material is a material that cures at a more rapid rate than the bonding material arranged along an intermediate portion of the bonding layer arranged between the edge-bonding material. By doing so, the tread edge areas are bonded prior to the intermediate portion, which thereby reduces the possibility of the tread edge areas from separating from the tire carcass, which could deter sufficient bonding between the tread and the tire carcass.

[0024] It is appreciated that any of the improvements to the methods to improve bonding

of each tread edge area (which includes each tread edge) during the curing process may be combined and practiced in any combination. Moreover, it is appreciated that any edge-bonding material may be a local substitute for the bonding layer in each of the pair of opposing tread edge areas, may comprise the entire bonding layer, where practicable, or may be arranged between the bonding layer and either the pre-cured tread or the tire carcass in each of the pair of opposing tread edge areas.

[0025] Embodiments of the invention disclosed herein further include bonded retreaded tires produced using the method described above.

[0026] Particular embodiments of the methods (and associated systems) discussed above will now be described in further detail below in association with the figures filed herewith exemplifying the performance of the methods in association with particular embodiments of the tread.

[0027] Turning now to FIG. 1, a flow chart of a method **100** for forming a retreaded tire. Method **100** begins at **102** and proceeds to **104** where a step of providing a pre-cured tread is performed and to **106** for arranging the pre-cured tread about a tire carcass – to form an unbonded retreaded tire as more fully discussed above. After the unbonded retreaded tire is formed, method **100** continues to **108** where a step of bonding the tread edge areas of the tread to the tire carcass is performed as more fully discussed above. Thereafter, at **110** the intermediate portion of the tread is bonded to the tire carcass. By doing so, the tread edge areas are bonded to the tire carcass prior to the intermediate portion of the tire tread so to prevent the tread edge areas from lifting during the bonding step. Subsequent to completing step **110**, method **100** terminates at **112** in the embodiment shown. It is appreciated that different or additional steps, or variations of these steps, may be employed in other embodiments.

[0028] Variations of such methods are further discussed above in accordance with different embodiments.

[0029] With reference to FIG. 2, various components of an assembled unbonded retreaded tire **200** is shown in accordance with an exemplary embodiment. In particular, unbonded retreaded tire **200** includes at least tire carcass **221**, bonding layer **222**, and tread **223**. Bonding layer **222** includes one or more uncured bonding materials disposed between tire carcass **221** and tread **223**. Tread **223** is a pre-cured tread arranged annularly around an outer circumference of an annular tire carcass. The tread further includes a pair of opposing tread

edges **223_{TE}** laterally-spaced relative to centerline **CL** to define a width **W** of the tread. The width or widthwise direction of the tread is shown to extend perpendicular to a length of the tread, which ultimately extends around the outer circumference of the tire in an installed arrangement, and perpendicular to a thickness of the tread, which extends in a radial direction of the tire in the installed arrangement.

[0030] In the embodiment of FIG. 2, the unbonded retreaded tire includes an edge-bonding material **224** arranged between the pre-cured tread and the tire carcass approximately or substantially within each of a pair of opposing tread edge areas **227** each generally located adjacent one of the pair of tread edges **223_{TE}** between the tread and the tire carcass to improve bonding of the tread to the tire carcass, as more fully discussed above. Each tread edge area **227** extends from one of the tread edges **223_{TE}** inward (that is, in a direction of the tread width) toward the tread centerline **CL**, such as to the imaginary dashed lines shown, for example. The area arranged between the pair of opposing tread edge areas **227** is referred to as an intermediate portion or area **228**. It is appreciated that tread edge areas **227** and intermediate portion or area **228** refer to tread edge areas and intermediate portions/areas of the tread or more generally of the tire and its components. As discussed above, in particular embodiments, the edge-bonding material **224** is one or more of: a fast curing bonding material, a high viscosity material, an electrically resistive material, or any other material suitable for facilitating bonding of the tread edge area prior to bonding of the intermediate portion of the tread to the tire carcass.

[0031] In the embodiment of FIG. 2, the edge-bonding material **224** operates as a substitute for the bonding layer material at each of the tread edge areas in the bonding layer **222**, such that the edge-bonding material forms a portion of the bonding layer **222**. It is appreciated that the portion of the bonding layer **222** arranged between edge-bonding material portions **224** is referred to as an intermediate portion **225** of the bonding layer. As discussed above, in other variations, the edge-bonding material **224** may instead be arranged between the bonding layer **222** and the tread **223** and/or the tire carcass **221**. For example, with reference to FIG. 3, which shows an additional element **226** arranged between the tire tread **223** and the tire carcass **221**, and more specifically between bonding layer **222** and the tread **223**. It is appreciated that element **226** may represent either an edge-bonding material or a secondary heat source (discussed further below) arranged internal to the tire along each of the pair of laterally-spaced tread edge areas. It is also appreciated that additional segments of the edge-

bonding material may be arranged across the tread width or atop or below the edge-bonding material shown to form layers of edge-bonding material.

[0032] As discussed above, with reference now to FIG. 4, where an unbonded retreaded tire is arranged within a curing chamber 300 during curing or bonding operations, the curing chamber is generally heated by a chamber heating source 320. However, in particular embodiments, where a pair of laterally-spaced tread edge areas of the tread are at least partially bonded to the tire carcass prior to an intermediate portion of the tread located between the tread edge areas, a secondary heat source 340 is arranged adjacent to or in close proximity to each tread edge area to facilitate this prioritized bonding whereby each of the pair of laterally-spaced tread edge areas of the tread or bonding layer are heated to a curing temperature quicker than the intermediate portion of the tread or bonding layer. In accordance with an exemplary embodiment shown in FIG. 4, each the pair of laterally-spaced tread edge areas are heated by the secondary heat source 340 (in addition to chamber heating source 320), the secondary heat source directing focused heat local to at least one of the pair of laterally space-apart tread edge areas of the tread or of the bonding layer. It is understood that in particular embodiments, the secondary heat source extends substantially around a circumference of the tire, while in other embodiments, a plurality of secondary heat sources may be employed to, in combination, sufficiently heat the tread edge substantially around the tire or the tire may be configured to rotate to thereby apply sufficient heat around the tire. It is appreciated that the secondary heat source may comprise any heat source capable of directing heat locally at a tread edge area. For example, in exemplary embodiments, the secondary heat source is a radiant heater, resistive contact heater, electrically resistive ink heater, electrically resistive coating heater, a forced-air heater, a jet heater, a microwave source, a infra red source, a ultrasound source, an induction heater, or other source discussed above or source that is suitable for its intended purpose. It is noted that the heat source is shown to be arranged external to the tire in FIG. 4. In other embodiments, it is contemplated that the secondary heat source is arranged internal to the tire. For example, element 226 in FIG. 3 represents a secondary heat source arranged internal to the tire 220. While an internal secondary heat source 226 may comprise any desired heat source suitable for its intended purpose or a source, in particular embodiments, as more fully discussed above, an internal secondary heat source comprises an electric heater.

[0033] The present invention may be utilized in association with retreaded tires, which may be utilized on particular types of vehicles or in specific applications. Nevertheless, the present invention may be utilized in association with any type of tire to form new or retreaded tire and as such, any type of tire may provide an embodiment of the present invention. Exemplary tire types for use with the subject invention further include light truck tires, heavy truck tires, off the road tires, bus tires, aircraft tires, bicycle tires, motorcycle tires, and passenger vehicle tires.

[0034] 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.

[0035] 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. As used herein, the term process or method refers to one or more steps that may be performed in any order without departing from the scope of the invention. Also, some steps may be optional and may be omitted.

CLAIMS

What is claimed is:

1. A method of forming a retreaded tire comprising:

forming an unbonded retreaded tire, which includes arranging a pre-cured tread annularly around an outer circumference of an annular tire carcass with a bonding layer comprising uncured bonding material arranged between the pre-cured tread and the annular tire carcass, the pre-cured tread including a pair of opposing tread edges laterally-spaced to define a width of the pre-cured tread;

and

bonding the tread of the unbonded tire to the tire carcass in a curing chamber to form a bonded retreaded tire by pressurizing the curing chamber and sufficiently heating the curing chamber using a chamber heating source to cure the bonding layer of the unbonded retreaded tire, which includes at least partially bonding a pair of laterally-spaced tread edge areas of the pre-cured tread to the tire carcass prior to an intermediate portion of the pre-cured tread located between the pair of laterally-spaced tread edge areas of the pre-cured tread.

2. The method of claim 1, where in the step of bonding each of the pair of laterally-spaced tread edge areas of the bonding layer are heated to a curing temperature quicker than the intermediate portion of the bonding layer.

3. The method of claim 1, where each the pair of laterally-spaced tread edge areas are heated by a secondary heat source, the secondary heat source directing focused heat local to at least one of the pair of laterally space-apart tread edge areas.

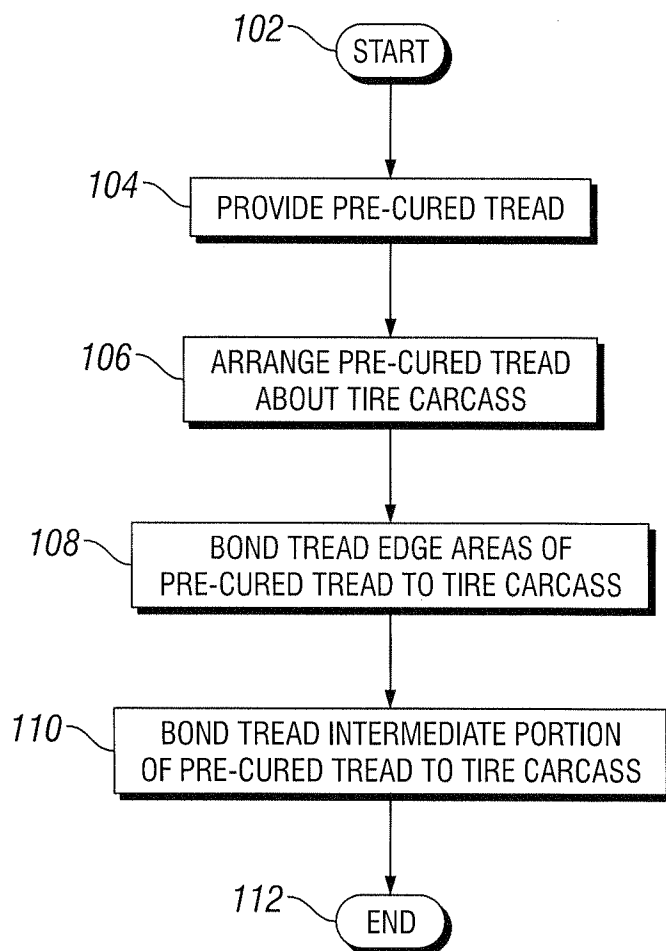
4. The method of claim 3, where the secondary heat source is arranged external to the unbonded retreaded tire.

5. The method of claim 4, where the secondary heat source is at least one of a radiant heater, an electrically resistive heater, a forced-air heater, a microwave source, an infra red source, an ultrasound source, and an induction heater.

6. The method of claim 3, where the secondary heat source is arranged internal to the unbonded retreaded tire.

7. The method of claim 1, where an electrically resistive material is locally arranged at each of the pair of tread edge areas and supplied with electric current to locally heat each of the pair of tread edges relative to the transfer of heat to the intermediate portion.
8. The method of claim 7, where the electrically resistive material is a coating.
8. The method of claim 7, where the electrically resistive material is a conductive ink.
9. The method of claim 7, where the electrically resistive material is a carbon-based material.
10. The method of claim 7, where the electrically resistive material is arranged internal to the unbonded retreaded tire.
11. The method of claim 1, where an edge-bonding material is arranged between the pre-cured tread and the tire carcass at each of a pair of opposing tread edge areas, the edge-bonding material being configured to bond each of the pair of tread edge areas to the tire carcass before bonding an intermediate portion of the tread to the tire carcass.
12. The method of claim 11, where the edge-bonding material is a high viscosity material with sufficient tack and viscosity to facilitate immobilization of the pre-cured tread during the curing process, where in the step of bonding, the high viscosity material cures to at least partially bond tread to the tire carcass, maintaining its viscosity, tack, and shape in the process.
13. The method of claim 12, where the high-viscosity uncured bonding material has a viscosity of at least 30 Mooney units.
14. The method of claim 11, where the edge-bonding material forms a portion of the bonding layer.

15. The method of claim 11, where the edge-bonding material is arranged between the bonding layer and either the pre-cured tread or the tire carcass in each of the pair of opposing tread edge areas.
16. The method of claim 10, where the edge-bonding material is an electrically resistive material such that in the step of bonding, an electrical current is supplied to locally heat each of the pair of tread edge areas relative to the intermediate portion.
17. The method of claim 15, where the electrically resistive material is a coating or a conductive ink.
18. The method of claim 1, where the unbonded retreaded tire is arranged in fluid communication with pressurized and heated gas contained within the curing chamber.
19. The method of claim 10, where the edge-bonding material is a material that cures at a more rapid rate than the bonding material arranged along an intermediate portion of the bonding layer arranged between the edge-bonding material.
20. The method of claim 10, where the edge-bonding material is a local substitute for the bonding layer in each of the pair of opposing tread edge areas.

1/4**FIG. 1**

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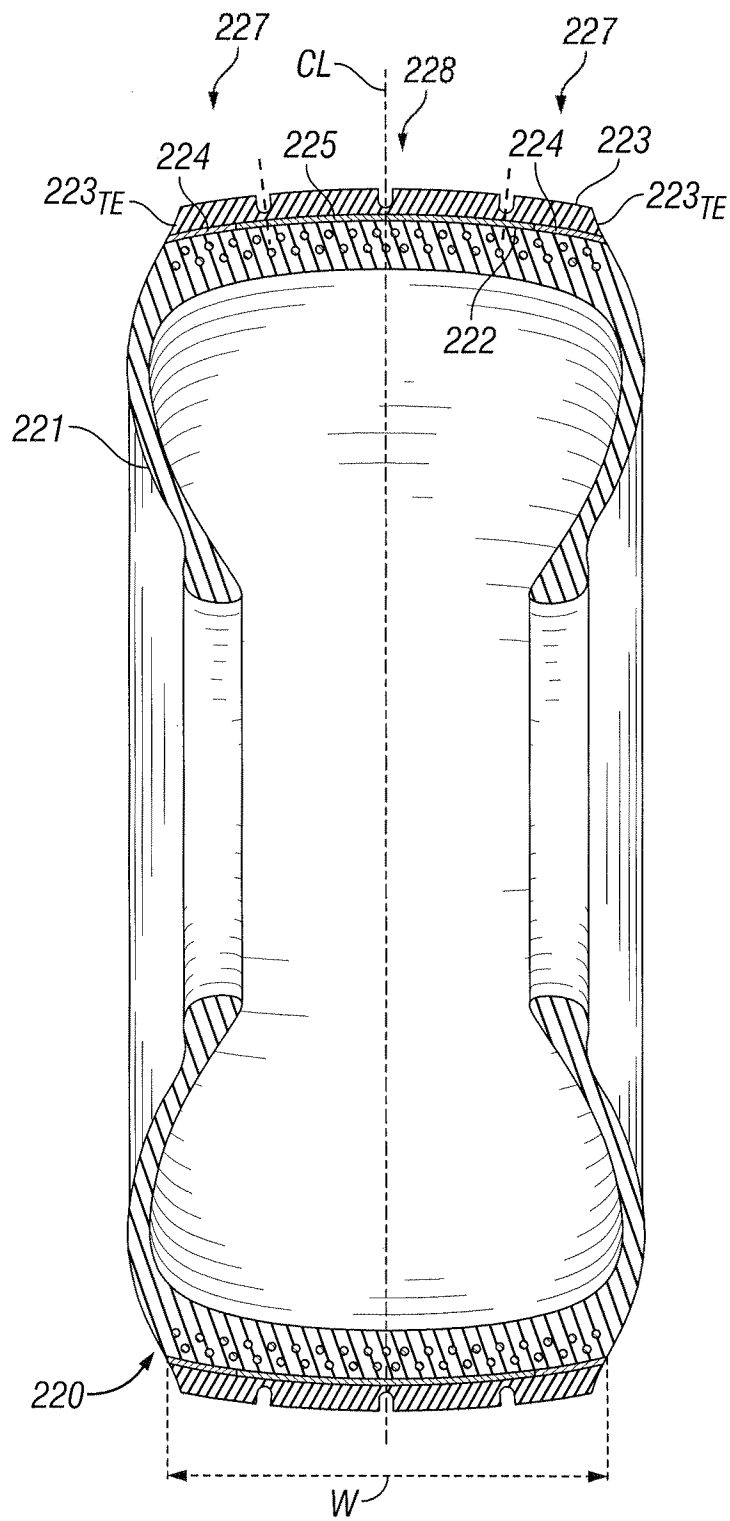


FIG. 2

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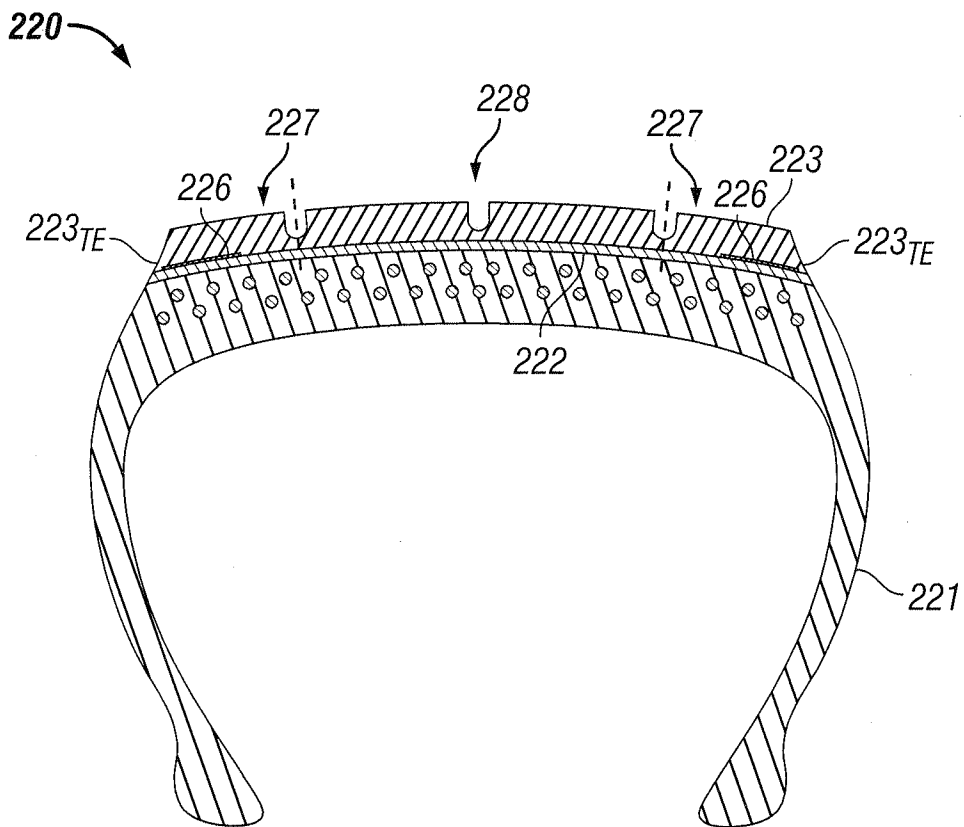


FIG. 3

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300 

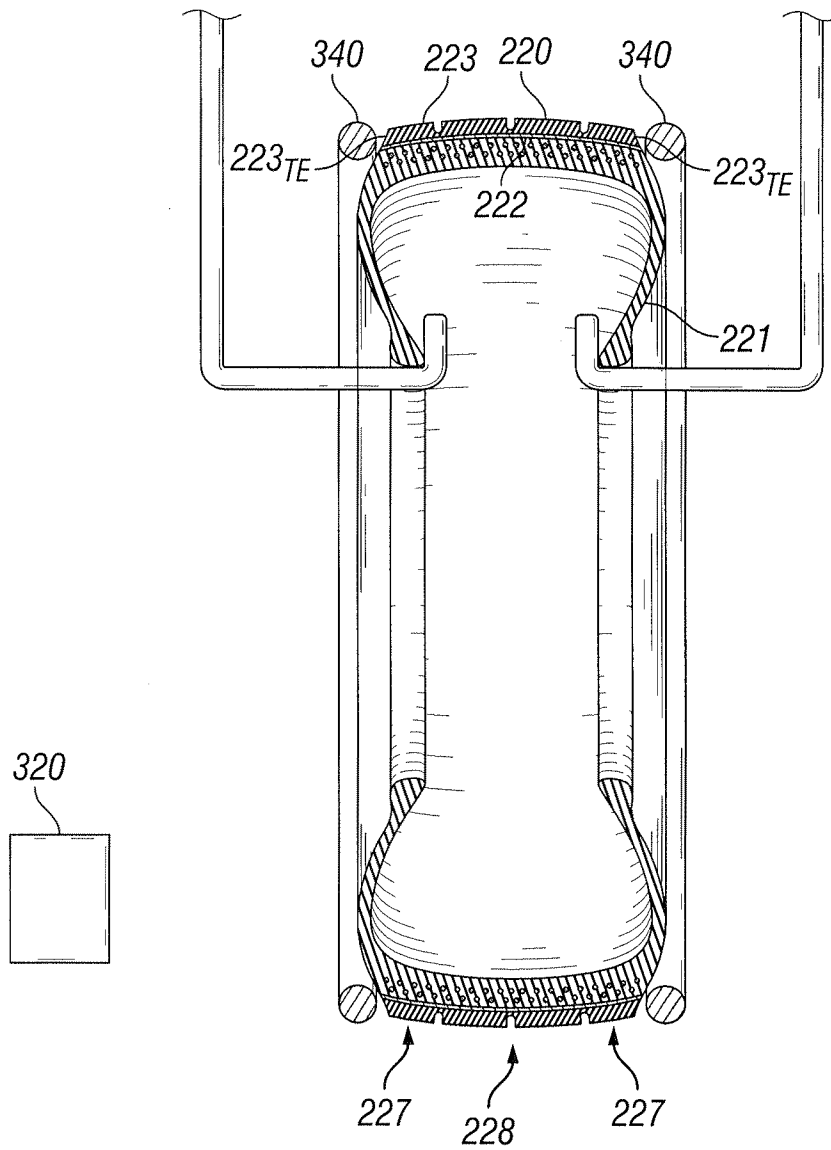


FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 14/14178

A. CLASSIFICATION OF SUBJECT MATTER IPC(8) - B60C 1/00; B60C 11/00 (2014.01) USPC - 152/209.6, 209.18, 188; 264/36.14 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) USPC (152/209.6; 152/209.18; 152/188; 152/537; 152/526; 156/96; 156/110.1; 156/130.5; 156/275.5; 156/359; 156/394.1; 156/909; 219/635; 264/36.14; 264/326; 264/327; 264/552; 249/78; 425/19; 425/40; 425/41; 425/50) Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched USPC (152/209.6; 152/209.18; 152/188; 152/537; 152/526; 156/96; 156/110.1; 156/130.5; 156/275.5; 156/359; 156/394.1; 156/909; 219/635; 264/36.14; 264/326; 264/327; 264/552; 249/78; 425/19; 425/40; 425/41; 425/50) -- keyword delimited Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) PatBase, Google Patents/Scholar - Terms: tire tyre localized sectional regional heat vulcanization cure carcass casing tread retread bind bond connect adhere electric bonding-agent adhesive cushion gum edge corner side pre-cured uncured electrically-resistive coat ink tack internal adhesive material element binding resin periphery outer end raw		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2011/0056627 A1 (ARGENZIA et al.) 10 March 2011 (10.03.2011) para [0002], [0019]-[0022], [0026]; figure 1	1 and 2
Y		3-6 and 18
A		7, 8a, 8b, 9-17 and 19-20
Y	US 2012/0111464 A1 (KIMIYA et al.) 10 May 2012 (10.05.2012) para[0015], [0016], [0057], [0090], [0122]; figures 10 and 11	3-5
A		7, 8a, 8b, 9-17 and 19-20
Y	US 6,350,402 B1 (KOBAYASHI) 26 Feb 2002 (26.02.2002) col 2 ln 13-15; col 3, ln 57-62; col 4, ln 33-40 and 46-52; col 5, ln 8-10; figure 2; abstract	6 and 18
A	US 4,093,481 A (SCHELMANN) 6 June 1978 (06.06.1978) -- the entire patent	7, 8a, 8b, 9-17 and 19-20
A	US 4,536,242 A (GRIPENHOLT et al.) 20 Aug 1985 (20.08.1985) -- the entire patent	7, 8a, 8b, 9-17 and 19-20
A	WO 2013/002823 A1 (PAN et al.) 3 Jan 2013 (03.01.2013) -- the entire patent	7, 8a, 8b, 9-17 and 19-20
A	US 2013/0206311 A1 (FUDEMOTO et al.) 15 Aug 2013 (15.08.2103) -- the entire patent	7, 8a, 8b, 9-17 and 19-20
A	US 6,818,872 B2 (MITAMURA et al.) 16 Nov 2004 (16.11.2004)	7, 8a, 8b, 9-17 and 19-20
☐ 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 "&" document member of the same patent family		
Date of the actual completion of the international search 21 April 2014 (21.04.2014)		Date of mailing of the international search report 12 MAY 2014
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