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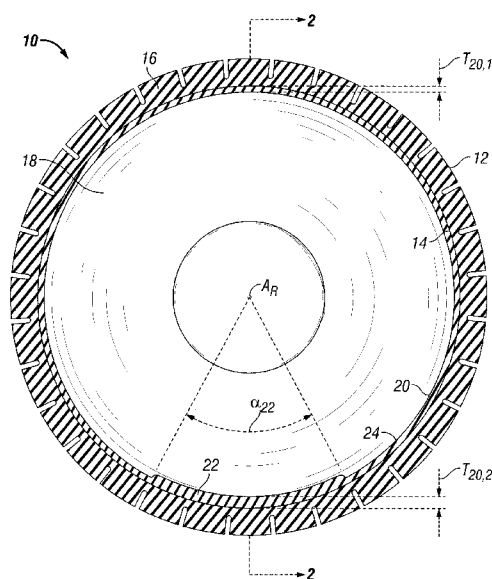


FIG. 1

(57) Abstract: Embodiments of the invention include a method for balancing a pneumatic tire including the following steps: determining that a tire is imbalanced, the tire having an interior side including an undertread region spaced apart by a thickness of the tire from a tread of the tire; identifying a balancing weight amount for application to the interior side of the tire at a balancing location; applying a sealant coating annularly around the tire along the undertread region, the coating formed of a sealant material having a thickness that is variable in an annular direction of the tire, the variation in thickness providing a balancing mass arranged at a balancing location to substantially reduce the imbalance, the balancing mass substantially comprising the balancing weight amount. Embodiments also include a tire having a coating formed by the method and an apparatus for performing the method.

CORRECTING TIRE IMBALANCE USING VARIABLE THICKNESS
SEALING COATING

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] This invention relates generally to tires, and more specifically to the correction of tire imbalances in pneumatic tires using a variable thickness sealing coating, such as a puncture sealing coating.

Description of the Related Art

[0002] Pneumatic tires are known to be susceptible to damage during normal tire operation, which may result in punctures, lacerations, or other abrasions, for example. To facilitate temporary use of a damaged tire the tire can be repaired or replaced, a sealing coating, such as a puncture sealant, is used to temporarily fill punctures and small lacerations to maintain pressurization or inflation of the tire.

[0003] It is also known for tires to have mass imbalances around the tire, such that as the tire rotates the mass imbalance causes an imbalance in rotational forces, which can result in tire hopping, vibration, and/or uneven wear, for example. When electing to apply a sealing coating to the interior of a tire, tire balancing is achieved by using a balancing method separate from the sealing coating, such as arranging one or more balance weights at a balancing location located on a wheel upon which the tire is mounted or applying a liquid solution containing solids to the interior surface of the tire at a balancing location with a brush or the like spanning a distance of 70 to 100 degrees around the tire.

[0004] To improve efficiencies and limit the need for multiple processes to both apply a sealing coating and to balance a tire, there is a need to utilize the sealing coating to achieve a balanced tire.

SUMMARY OF THE INVENTION

[0005] Embodiments of the invention include a method for balancing a pneumatic tire comprising the steps of: determining that a tire is imbalanced, the tire being a pneumatic tire forming a toroid having an exterior side and an interior side, the interior side having an undertread region spaced apart by a thickness of the tire from a tread arranged along the exterior side of the tire; identifying a balancing weight amount for application to the interior

side of the tire at a balancing location; applying a sealant coating annularly around the tire along the undertread region, the coating formed of a sealant material having a thickness that is variable in an annular direction of the tire, the variation in thickness providing a balancing mass arranged at a balancing location to substantially reduce the imbalance, the balancing mass substantially comprising the balancing weight amount.

[0006] Additional embodiments of the invention include a tire having a variable thickness sealant coating formed by the method recited in any method described herein, the tire being substantially balanced.

[0007] Further embodiments of the invention include an apparatus configured to form a variable thickness sealing coating per any method recited herein, the apparatus having a programmable logic controller and a memory storage device containing stored instructions executable by the controller, the stored instructions comprising instructions for performing each step of any method recited herein, the instructions including: determining instructions for determining that a tire is imbalanced, the tire being a pneumatic tire forming a toroid having an exterior side and an interior side, the interior side having an undertread region spaced apart by a thickness of the tire from a tread arranged along the exterior side of the tire; identifying instructions for identifying a balancing weight amount for application to the interior side of the tire at a balancing location; applying instructions for applying a sealant coating annularly around the tire along the undertread region, the coating formed of a sealant material having a thickness that is variable in an annular direction of the tire, the variation in thickness providing a balancing mass arranged at a balancing location to substantially reduce the imbalance, the balancing mass substantially comprising the balancing weight amount.

[0008] The foregoing and other embodiments, 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

[0009] FIG. 1 is a side sectional view of a tire having a sealing coating arranged along an interior side of the tire, in accordance with an exemplary embodiment of the invention.

[0010] FIG. 2 is front sectional view of the tire tread shown in FIG. 1 taken along line 2-2.

[0011] FIG. 3 is front sectional view of a method for applying a sealing coating to an interior of a tire, in accordance with an exemplary embodiment of the invention.

[0012] FIG. 4 is partial side sectional view of a method for applying a sealing coating to an interior of a tire, in accordance with an exemplary embodiment of the invention.

[0013] FIG. 5 is a perspective view of a controller for use with the strip extruder of FIGS. 3 and 4.

DETAILED DESCRIPTION OF PARTICULAR EMBODIMENTS

[0014] Embodiments of the invention comprise methods of balancing a pneumatic tire, and pneumatic tires formed by such methods, as well as pneumatic tires having a variable thickness sealing coating arranged along an interior side of the tire, in a region under the tread.

[0015] A pneumatic tire generally forms a toroid having an exterior side and an interior side, the interior side having a central undertread region extending annularly around the tire and opposite a tread region extending annularly along the exterior side of the tire. A pneumatic tire also includes a pair of sidewalls each extending radially inward from one of opposing tread side edges defining a width of the tread. Each sidewall extends radially inward to a bead area for mounting the tire on a wheel and defining an annular opening to the interior side of the tire. The rotational axis of the tire extends through the center of each central opening. A pneumatic tire may be of a tubeless or non-tubeless variety.

[0016] Particular embodiments of such methods of balancing include a step of determining that a tire is imbalanced. It is appreciated that the step of determining that a tire is imbalanced may comprise any known manner using any known apparatus for determining tire imbalance. For example, static or dynamic methods of determining tire imbalance may be used to perform the step of determining using any known static or dynamic balancing machine, each of which determine whether a tire is statically or dynamically balanced/imbalanced, respectively. In particular instances, the step of determining includes identifying an imbalance weight amount and imbalance location for a tire. By doing so, the imbalance weight amount and the imbalance location may be employed to accomplish a step of identifying a balancing weight amount for application to the interior side of the tire at a balancing location, which is further discussed below. It is appreciated that the imbalance amount may identify a location of increased weight or reduction in weight (that is, a location

of high or low mass, respectively) around the tire. This increase or reduction in weight is the imbalance weight amount. The imbalance weight amount at the imbalance location creates a mass imbalance around the tire, which results in a rotational force imbalance statically or dynamically during tire rotation.

[0017] Particular embodiments of such methods of balancing a pneumatic tire include a step of identifying a balancing weight amount for application to the interior side of the tire at a balancing location. A balancing weight amount is also referred to as an imbalance-correcting weight amount. This step of identifying may be achieved by any known manner using any known apparatus. In particular embodiments, the step of identifying is performed in cooperation with, or as part of, the step of determining that a tire is imbalanced. For example, various balancing machines are employed to not only determine whether a tire is statically and/or dynamically balanced or imbalanced, such machines can also determine a balancing weight amount to apply at a balancing location along the tire to counteract the imbalance, and thereby reduce or correct the imbalance to achieve a substantially balanced tire. The balancing location is located along an interior side of the tire and is often identified as being located in an annular direction by a particular angle from a reference location of the tire. In certain embodiments, this reference location is an imbalance location of the tire, or any other known location. Commonly, but not necessarily, the balancing mass is arranged substantially opposite the imbalance location, that is, at a location substantially 180 degrees around the tire from the imbalance location. This does not mean that the balancing mass does not extend further in either or both annular directions from the 180 degree location. For example, the balancing mass may extend for a particular distance in an annular direction, which can be defined by a particular angle, whether or not the balancing location is arranged opposite the imbalance location. In particular embodiments, the balancing mass extends along the tread underside region of the interior side in an annular direction substantially up to a 30 degree angle (as measured from the rotational axis of the tire) or up to a 90 degree angle. In other embodiments, the sealing coating extends annularly up to 70 degrees or substantially up to 70 to 100 degrees.

[0018] Particular embodiments of such methods include a step of applying a sealant coating annularly around the tire along the undertread region. The coating is formed of a sealant material, which in its applied form comprises any solid yet ductile sealant material known to one of ordinary skill configured to seal punctures and/or small cuts or abrasions yet

able to generally remain in its applied shape during tire operation so to maintain a tire balanced or near balanced condition at least until the tire wears or other conditions change to alter tire balance. While the material may remain sufficiently ductile to flow when a puncture or small laceration penetrates the tire thickness, the material is not sufficiently ductile to allow the sealant material to flow and pool at the bottom of a tire when the tire is at rest. Any such material is also referred to as a ductile solid sealant material, and may comprise an elastomer or elastomeric composition or a polymer or polymeric composition, for example.

[0019] The step of applying provides a sealant coating having a thickness, the thickness being variable in an annular direction of the tire. By doing so, the variation in thickness provides a balancing mass arranged at the balancing location to reduce the imbalance. Such imbalance may even be substantially reduced or corrected. To do so, the balancing mass substantially comprises the balancing weight amount. In particular embodiments, the balancing mass is an increase in mass along the sealing coating configured to balance or offset an imbalance generated by an imbalance mass comprising an increase in mass at the imbalance location of the tire. In other embodiments, the balancing mass is a reduction in mass along the sealing coating configured to balance or offset an imbalance mass comprising a reduction in mass at the imbalance location of the tire.

[0020] The balancing mass is arranged at the balancing location. The balancing mass is formed by creating a reduction or increase in the thickness of the sealing coating at the balancing location. As noted above, the balancing mass may extend any desired length or distance in an annular direction along the undertread region of the interior tire side. For example, in particular embodiments, the sealing coating extends up to substantially 30 degrees in the annular direction as measured from the rotational axis of the tire. In other embodiments, the sealing coating extends annularly up to 70 degrees or substantially up to 70 to 100 degrees. It is also appreciated that the balancing mass at the balancing location may extend partially or fully across the width of the sealing coating and/or of the tread underside region.

[0021] It is appreciated that the step of applying may be performed in accordance with any known manner using any known apparatus for forming a strip of sealing material, except that any such manner and apparatus is modified to form a variable thickness sealing coating that provides a balancing mass arranged at a balancing location along the interior side

of a tire to reduce a tire imbalance. For example, in particular embodiments, a strip extruder extrudes a strip of balancing material that is applied and wound along the interior tire side in the undertread region. An exemplary strip extruder is described in U.S. Pat. No. 4,398,583. The strip generated by the strip extruder may be applied to the tire as it is being extruded directly or after navigating a path from the extruder to the tire, such that the strip is being applied while remaining connected to the extruder. In other variations, a strip is formed and later applied after the strip has been formed and separated from the extruder, such as by a cutting operation, for example. It is appreciated that a strip can be formed by another manner, such as when cutting strips from a sheet, and later applying one or more of such strips to the interior side of the tire.

[0022] In applying a sealing coating, in particular embodiments, a single continuous strip is wound multiple revolutions in an annular direction around the interior side of the tire in the form of a spiral. In other embodiments, multiple strips are wrapped one or more revolutions in an annular direction around the interior side of the tire. In any such embodiment, the single strip of each of the multiple strips has a length extending generally in an annular direction of the tire. Additionally, in any such embodiment, multiple strips or multiple windings of a single strip are arranged side-by-side in a direction of the tire width. The direction of the tire width is also referred to as the axial direction of the tire, and is synonymous with the widthwise direction of the tread or undertread region of the interior tire side. It is appreciated that when applying any strip in an annular direction of the tire, in particular embodiments, the tire rotates to facilitate annular application of the strip through one or more windings. Yet other variations include arranging a plurality of strips having a length extending in a direction of the tire width such that multiple strips are arranged side-by-side in an annular direction of the tire. It is appreciated that in any side-by-side arrangement, adjacent strips or windings of a single strip may overlap at least slightly to ensure complete coverage along the undertread region of the interior tire side.

[0023] As noted above, the step of applying provides a sealant coating having a variable thickness, the thickness being variable in an annular direction of the tire, where the variation in thickness provides a balancing mass arranged at a balancing location to reduce the imbalance. As also noted above, the balancing mass may comprise an increase in mass or a reduction in mass at a balancing location of the tire. When employing a strip extruder, in particular embodiments this increase or reduction in mass is achieved by altering the

application speed of the strip to the tire. By reducing the application speed, the local thickness of the strip being applied increases. By increasing the application speed, the local thickness of the strip being applied decreases. This alteration in the application speed may be achieved by either altering the extrusion speed (extrusion rate) of the extruder or altering the rotation speed of the tire upon which the strip is being applied.

[0024] In other variations, when the strip is being pre-formed prior to application along a tire, the extrusion speed may be altered or the structure upon which the strip is being formed may move at a rate to achieve the desired strip thickness. Such a structure may comprise a spool, for example. It is also appreciated that when forming the sealing coating from multiple strips, constant thickness strips may be employed to generate the variable thickness sealing coating. For example, it is appreciated that the terminal ends of each strip may overlap at a balancing location to form a desired balancing mass. By further example, the variable thickness sealing coating may be formed of multiple layers of strip, such as where a first layer of constant thickness is applied and a limited second layer is applied to form the variation in thickness and, as a result, the balancing mass.

[0025] With regard to the completed sealing coating, the coating is substantially continuous in the annular and a widthwise directions of the coating, where “substantially” accounts for any manufacturing variances or tolerances that may provide small gaps or spacings between strips or windings of strips in a side-by-side arrangement, at the beginning and/or end of a strip or joints between strips. While the sealing coating may be selectively applied to cover any percentage of the undertread region of the interior side, in particular embodiments, the sealing coating substantially covers the undertread region.

[0026] It is appreciated that one or more of the steps in any embodiment of the methods for arranging sealant material along an interior side of a pneumatic tire to reduce a tire imbalance may be performed manually or may be automated. In particular embodiments, the step of applying is performed using one or more controllers to monitor and alter the speed and thickness of the strip being applied to achieve the variable thickness sealing coating. In further embodiments, each step of determining an imbalance, identifying a balancing mass and balancing location, and applying a sealing coating to the interior side of the tire are performed using one or more controllers, where instructions for performing each step stored

on a computer readable memory device and executable by the one or more controllers automatically or at the command of a user.

[0027] In an exemplary embodiment, a tire is rotated at a constant speed relative to a strip of sealing material being applied and a strip extruder is forming a strip of sealing material at a constant rate, which is concurrently being applied along the undertread region of the interior tire side in an annular direction of the tire to generate a portion of the sealing coating having a predetermined thickness. When approaching the balancing location, where a change in sealing coating thickness is desired to create the balancing mass, the application speed of the strip to the tire for a desired duration is altered to obtain a desired increase or reduction in strip thickness to form the requisite balancing mass at the balancing location. Knowing that certain application speeds generate certain strip thicknesses, formation of the sealing coating may be controlled manually.

[0028] When utilizing one or more controllers, a controller coupled with an encoder or similar device identifies and tracks the rotational movement of the balancing location of the tire as previously identified in the step of identifying. When approaching the balancing location, where a change in sealing coating thickness is desired to create the balancing mass, a controller alters the application speed of the strip to the tire for a desired duration.

[0029] In particular embodiments, the step of applying includes monitoring the local thickness of the applied strip, which facilitates adjustment of strip thickness as needed to form a desired balancing mass. While this may be performed manually, formation of strip thickness can be measured using one or more sensors. In exemplary embodiments, a first sensor is arranged to measure a distance to the undertread region of the interior tire side from a reference location while a second sensor measures the distance to the strip from the reference location, the difference in the two measurements equaling the local thickness of the strip as applied to the tire. These measurements may be taken on opposing sides of the strip applicator, or in other locations around the strip applicator. If the strip thickness does not substantially equal the desired thickness, the application speed of the strip may be further altered to achieve the desired strip thickness. Accordingly, in particular embodiments, the step of applying includes adjusting the application speed based upon the measured strip thickness to achieve an altered strip thickness.

[0030] Additional embodiments of the invention comprise a tire having a variable thickness tire sealant coating formed in accordance with any embodiment of the methods discussed above or otherwise herein, such that the tire is substantially balanced, whether statically balanced or dynamically balanced.

[0031] Further embodiments of the invention include an apparatus for performing at least the step of applying a coating sealant in accordance with any embodiment of such step, where in additional embodiments, any such apparatus is configured to perform at least one or both steps determining and identifying as discussed above in accordance with any embodiment thereof. For any such embodiment of the apparatus, one or more controllers are included in operable communication with a memory storage having stored thereon instructions for performing any step of the methods discussed herein, the instructions being executable by the one or more controllers to perform any corresponding step. In particular embodiments, the apparatus is, or includes, a strip extruder.

[0032] Particular embodiments of the methods discussed above will now be described in further detail below in association with the figures filed herewith and exemplary apparatus for performing particular embodiments of the methods.

[0033] With reference to an exemplary embodiment in FIGS. 1 and 2, a tire **10** is shown having a sealing coating **20** applied to an interior side **14** of the tire. In particular, tire **10** includes an annular tread **16** in part defining an exterior side **12** of the tire. A pair of sidewalls **18** extend radially inward toward a rotational axis A_R of the tire from opposing sides of the tread defining a width W_{16} of the tread **16**. While the sealing coating **20** is applied to an interior side of the tire, more specifically, the coating is applied to an undertread region of the interior side **14**, the undertread region being offset by a thickness of the tire from a portion of the exterior side **12** associated with tread **16**. In particular, FIG. 2 shows the undertread region to have a width W_{14u} , which is substantially equal to the width W_{16} of the tread **16**. The sealing coating **20** is shown to have a width at least substantially equal to the undertread region width W_{14u} or the tread width W_{16} . It is appreciated that the width of the sealing coating may extend along the transition connecting the tread/undertread region with an associated sidewall **18**.

[0034] In the embodiment shown in FIGS. 1-2, the sealing coating **20** includes a balancing mass **22** characterized as having a balancing weight amount. Balancing mass **22** is

shown to have a thickness $T_{20,2}$ that is greater than a remaining thickness $T_{20,1}$ associated with the remainder of the sealing coating. While the remainder of the sealing coating is shown to be of a substantially constant thickness, it is appreciated that the remainder thickness may vary or include surface texture without detracting from the benefits and purpose of the balancing mass **22**. With particular reference to FIG. **1**, it is also noted that the balancing mass **22** extends around the interior side **14** by a particular angle α_{22} , which is less than 180 degrees. It is contemplated that in other embodiments, angle α_{22} is substantially equal to 180 or less, substantially equal to 70 to 100 degrees, or up to 30 degrees.

[0035] In the embodiment shown in FIGS. **1-2**, the sealing coating **20** comprises a single, continuous strip **24** extending a single revolution in an annular direction around the interior side **14** of tire **10**. In the embodiment shown in FIG. **3**, the sealing coating **20** comprises a single, continuous strip **24** wound multiple revolutions in an annular direction around the interior side **14** of tire **10** to form a spiral. Stated differently, the strip extends in an annular direction along a spiral path.

[0036] With reference to exemplary embodiments shown in FIGS. **3-4**, a strip extruder **30** is shown extruding and applying a strip **24** of sealing material to form sealing coating **20**. The coating is shown to comprise a single layer. A tire support **40** is shown to support the tire during coating application. In the exemplary embodiment shown, tire support **40** includes a tire driving member **42** comprising a roller driven by any desired power source for the purpose of rotating the tire during application of the strip **24** and coating **20**. It is contemplated that roller may be fixed or freely rotatable and not driven by a power source, and instead may be manually operated.

[0037] With continued reference to the exemplary embodiments in FIGS. **3-4**, extruder **30** includes an extension **32** protruding into the tire **10** and configured to extrude and apply the strip **24** directly to the interior tire side **14**, as opposed to forming the strip independently and later applying the strip by separate action. As noted previously, the thickness of the strip is controlled by varying the rate of extrusion or by varying the rotational speed of the tire. In one exemplary manner for controlling the thickness of coating **20** and the corresponding strip **24**, a first sensor **34** measures a distance d_T to a strip **24** extruded from extruder **30** to determine the applied thickness of the strip. If the sensor is arranged a known distance d_i from the interior surface, then the strip thickness is equal to the known distance d_i .

minus the distance d_T to the strip from the sensor. Other known manners of determining the strip thickness may be employed in other variations. For example, with reference to FIG. 4, in lieu of knowing the distance d_i based upon a known position of the first sensor **34** relative the tire, a second sensor **36** may be employed to determine the distance d_r from the second sensor an to the undertread region of the interior tire side local to or adjacent to the extruder. By knowing the distance Δ_{34} , Δ_{36} between each of the first and second sensor, respectively, and a reference location, such as the rotational axis A_R in the exemplary embodiment, the thickness of the strip can be determined. In the embodiment shown, an effective radius r_{EFF} is determined to extend from the rotational axis A_R and to the undertread region of the interior tread side by adding distances d_r and Δ_{36} while an effective radius r_T is determined to extend from the rotational axis A_R and to the extruded tread strip **24** of the interior tread side by adding distances d_r and Δ_{34} . Accordingly, the strip thickness is obtained by subtracting distance r_T from distance r_{EFF} . Accuracy is improved if any one or more sensors are located in close relation to the output end of the extruder, from which the strip is extruded. In the example shown in FIG. 4, the first and second sensors **34**, **36** are arranged in close relation and on opposing sides of the extruder in an annular direction of the tire.

[0038] With reference to FIG. 3, an encoder **38** is shown to identify the balancing location and any imbalance location identified by the methods discussed herein and to maintain such identification during rotation of the tire. It is contemplated that any other known manner and apparatus for identifying and maintain such identification of the balancing location and any imbalance location during tire rotation may be employed. By maintaining such identification during tire rotation, the extruder is able to alter its extrusion speed or the device driving tire rotation of the tire is able to alter the tire rotation speed as the balancing location approaches to control the thickness of any strip along the balancing location to achieve a desired balancing mass.

[0039] To better control the performance of such methods and cooperation between the various sensors and encoders, a controller is shown in FIG. 5.

[0040] It is appreciated that any sensor (such as sensors **34**, **36** in FIGS. 3-4) generates a signal response as a function of the distance between the sensor and an extruded strip or interior tire side. The signal response may be represented by a value, which may represent current, voltage, resistance, or any other characteristic of the signal response.

Ultimately, the signal is sent to the programmable logic controller **50**, such by way of input/output (I/O) cable **56**, for evaluation and processing. Without limitation, the signal may instead be sent by wireless communication to controller **50**, such as without limitation by infrared signal or radio frequency, by one or more cables, including without limitation fiber optics, or any other method or means known to those having ordinary skill in the art. The same can be said for any encoder (such as encoder **38** in FIG. **3**) as to measuring a circumference of the tire and maintaining the position of a balancing location and any imbalance location. The controller **50** interprets the received signal as the intended measurement, which is stored in a memory storage device for processing.

[0041] In particular embodiments, the controller **50** may utilize signal-measurement functions or tables to convert a signal response into a corresponding measurement. Controller **50** includes a logic processor **51**, which may be a microprocessor, a memory storage device **52**, such as RAM (random access memory), ROM (read-only memory), PROM (programmable read-only memory) and at least one input/output (I/O) cable **56** for communicating with the extruder **30**. Further, the controller **50** may include an I/O slot **53** for housing an I/O card having I/O cable connector **57**. An operator may utilize a user-interface **58** to monitor the sensor measurements and to program, or otherwise control or instruct, the operation of controller **50** and the extruder **30**, which includes performing each step and method as discussed herein. The user-interface **58** and the controller **50** may communicate by way of I/O cable **56**. It is also contemplated that wireless communications may exist between the controller **50**, the user-interface **58**, and the extruder **30**. Communication between any balancing machine may also be provided to provide balancing mass and balancing location information for further processing and performance of the methods discussed herein.

[0042] Generally, the controller **50** may be programmed by any known graphical or text language. Programmed instructions, data, input, and output may be stored in a memory storage device **52**, which is accessible to the processor **51**. Particularly, programmed instructions related to the methods disclosed herein may be stored in the memory storage device and executed by the processor **51**. The memory storage device **52** may comprise any commercially known storage device, such as hard disk drives, optical storage devices, flash memory, and the like. The processor **51** executes programmed instructions and may perform the calculations and measurements described herein, and execute the instructions pertaining to the methods disclosed herein as well as other operations discussed herein. The memory

storage device **52** also stores inputs, outputs, and other information, such as, for example, functions and tables for use by processor **51** in performing its operations. In addition to performing distance conversions and measurements, the controller **50** may also be programmed to generate signal-measurement functions or tables based upon received input.

[0043] 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.

[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 only and should not be construed as limiting the scope of the claimed invention. Accordingly, the scope and content of the invention are to be defined only by the terms of the following claims. Furthermore, it is understood that the features of any specific embodiment discussed herein may be combined with one or more features of any one or more embodiments otherwise discussed or contemplated herein unless otherwise stated.

CLAIMS

What is claimed is:

1. A method for balancing a pneumatic tire, the method comprising:

determining that a tire is imbalanced, the tire being a pneumatic tire forming a toroid having an exterior side and an interior side, the interior side having an undertread region spaced apart by a thickness of the tire from a tread arranged along the exterior side of the tire;

identifying a balancing weight amount for application to the interior side of the tire at a balancing location;

applying a sealant coating annularly around the tire along the undertread region, the coating formed of a sealant material having a thickness that is variable in an annular direction of the tire, the variation in thickness providing a balancing mass arranged at a balancing location to substantially reduce the imbalance, the balancing mass substantially comprising the balancing weight amount.
2. The method of claim 1, where the step of determining that a tire is imbalanced includes identifying an imbalance weight amount and imbalance location for a tire, where in the step of applying, the balancing location is arranged substantially opposite the imbalance location.
3. The method of any one of claims 1 to 2, where the sealing coating is substantially continuous in the annular and a widthwise directions of the coating.
4. The method of any one of claims 1 to 3, where the sealing coating substantially covers the undertread portion.
5. The method of any one of claims 1 to 4, where the sealing coating is formed by applying a plurality of strips, the strips being arranged side-by-side to form the coating.
6. The method of claim 5, where the plurality of strips each have a length arranged to extend in an annular direction of the tire.
7. The method of any one of claims 1 to 4, where the sealing coating is formed by applying a single continuous strip wound one or more revolutions in an annular direction around the tire in a spiral configuration.

8. The method of claim 7, where the single continuous strip is wound multiple revolutions around the tire.
9. The method of any one of claims 1 to 8, where the balancing mass comprises an increase in weight.
10. The method of any one of claims 1 to 8, where the balancing mass comprises a reduction in weight.
11. The method of any one of claims 5 to 8, where the strip is extruded, and where the balancing mass is formed by varying an application rate of the strip to the tire, the application rate being that rate by which the strip is applied in the step of applying.
12. The method of claim 9, where the application rate is varied by altering a rate by which the tire is rotated during the step of applying.
13. The method of any one of claims 9 and 10, where the application rate is varied by altering a rate by which the strip is extruded.
14. The method of any one of claims 1 to 13, where the sealant coating comprises a single layer of sealant material.
15. The method of any one of claims 1 to 14, the coating having a width extending substantially across a width of the undertread region, where the coating thickness is also variable in a direction of the coating width.
16. The method of any one of claims 1 to 15, where the imbalance amount identifies a location of high or low mass around the tire, the imbalance location generally creating a mass imbalance around the tire, which results in a rotational force imbalance during tire rotation.
17. The method of any one of claims 1-16, where the step of determining that a tire is imbalanced is accomplished using a static balancing method.
18. The method of any one of claims 1 to 17, where the method includes a step of monitoring the thickness of the applied strip.
19. A tire having a variable thickness sealant coating formed by the method recited in any one of claims 1 to 18, the tire being substantially balanced.

20. An apparatus configured to form a variable thickness sealing coating as recited in any one of claims 1 to 18, the apparatus having a programmable logic controller and a memory storage device containing stored instructions executable by the controller, the stored instructions comprising instructions for performing each step of any method recited in any one of claims 1 to 18, the instructions including:

determining instructions for determining that a tire is imbalanced, the tire being a pneumatic tire forming a toroid having an exterior side and an interior side, the interior side having an undertread region spaced apart by a thickness of the tire from a tread arranged along the exterior side of the tire;

identifying instructions for identifying a balancing weight amount for application to the interior side of the tire at a balancing location;

applying instructions for applying a sealant coating annularly around the tire along the undertread region, the coating formed of a sealant material having a thickness that is variable in an annular direction of the tire, the variation in thickness providing a balancing mass arranged at a balancing location to substantially reduce the imbalance, the balancing mass substantially comprising the balancing weight amount.

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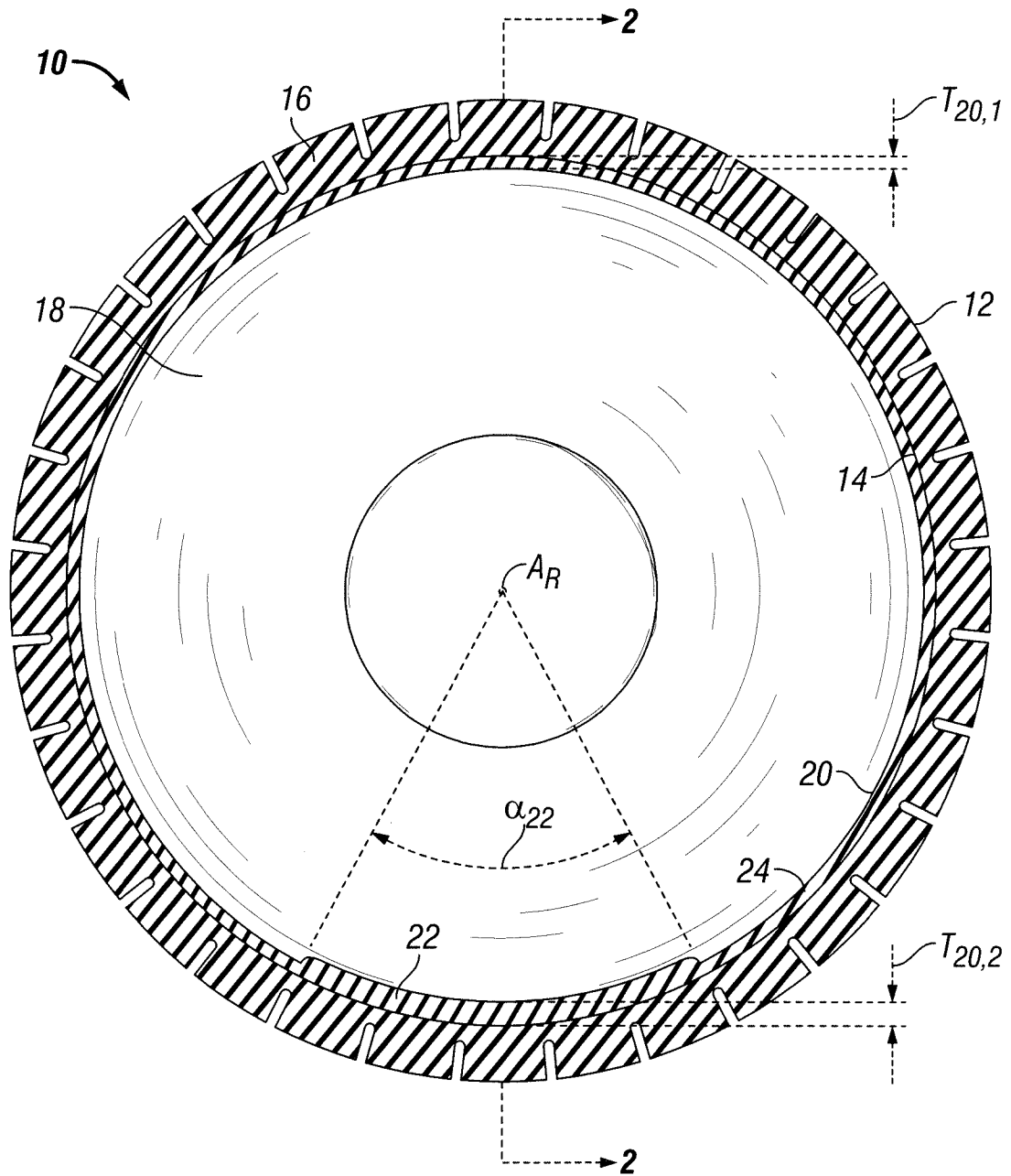


FIG. 1

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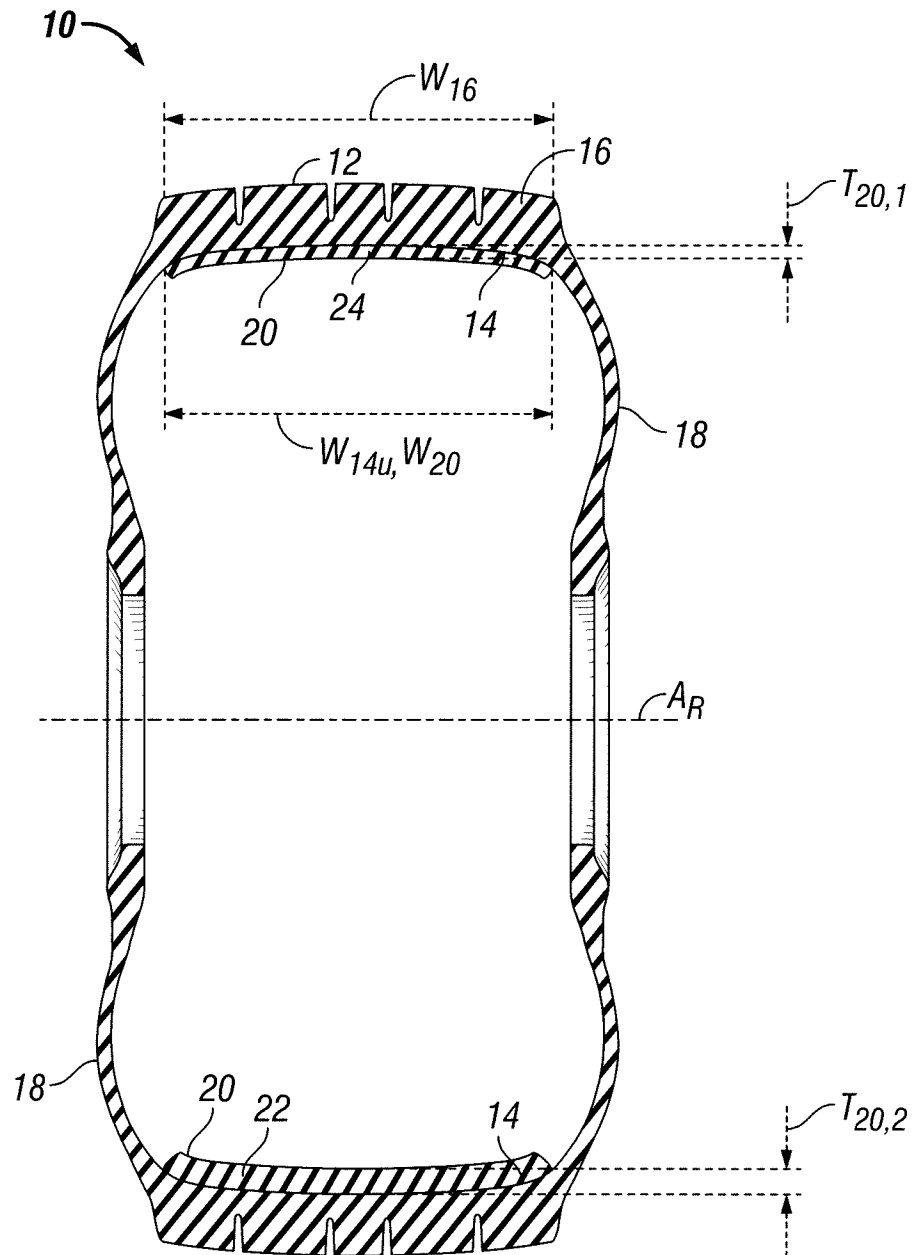
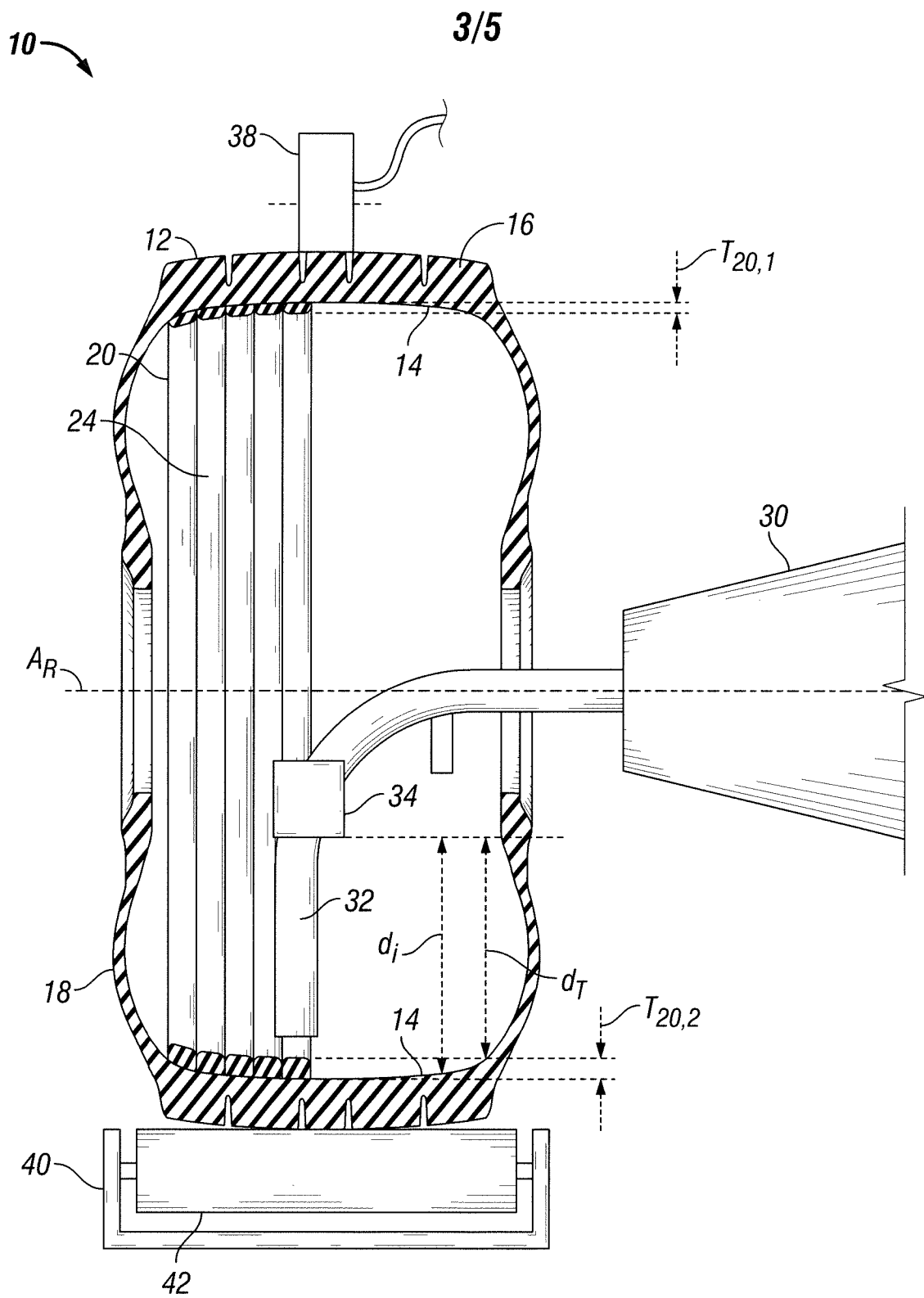


FIG. 2

**FIG. 3**

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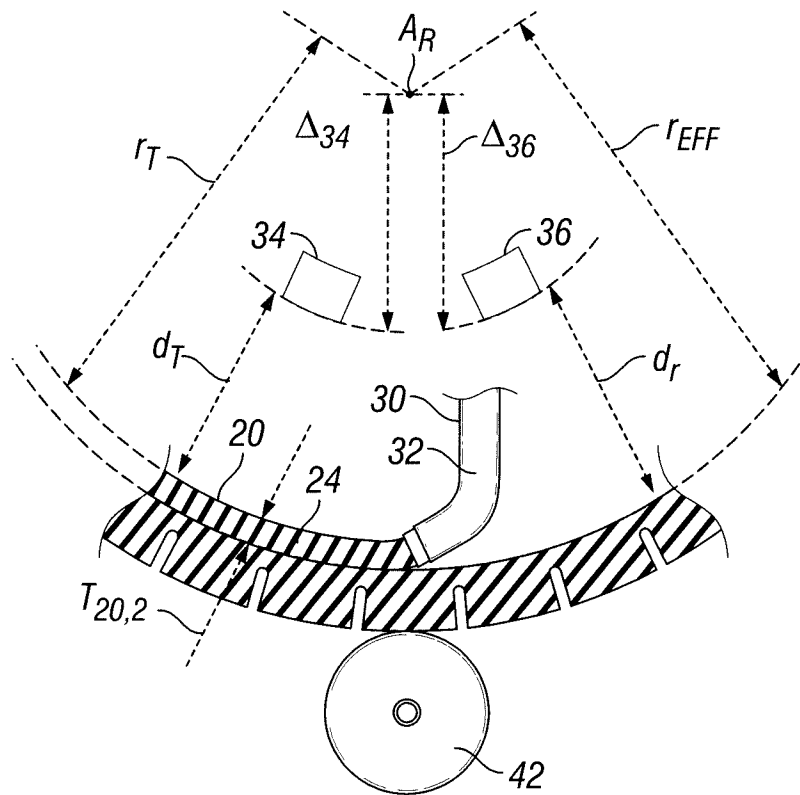


FIG. 4

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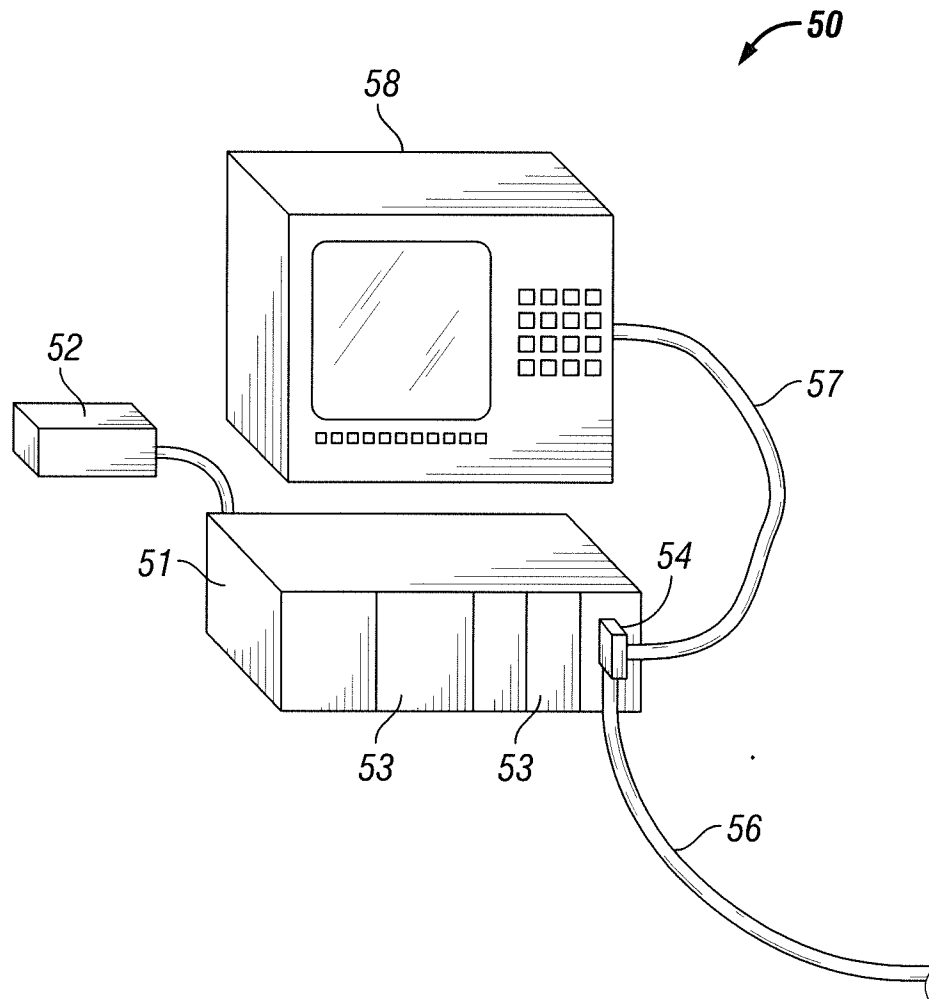


FIG. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2014/072344

A. CLASSIFICATION OF SUBJECT MATTER

INV. B60C19/12 B60C19/00 B29C73/16 B29D30/06
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B60C B29C B29D

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	US 2003/150544 A1 (NAITO MITSURU [JP] ET AL) 14 August 2003 (2003-08-14) paragraphs [0034], [0035], [0054]; claims 1-14 -----	1-20
X	JP 2001 018609 A (YOKOHAMA RUBBER CO LTD) 23 January 2001 (2001-01-23) paragraphs [0014], [0017] - [0019]; figures 1-3 -----	1-20



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search

7 July 2015

Date of mailing of the international search report

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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