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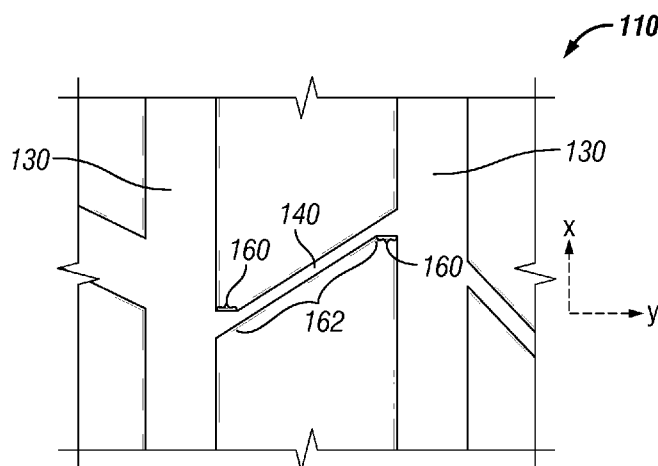


FIG. 3

(57) Abstract: The present invention includes tire treads (110, 210, 310) and methods for forming the same. In particular embodiments, the tread includes one or more sipes (140, 240, 340) each having a length extending from an elongate void. The sipes each include a first portion of the sipe length extending from the elongate void at a junction, where the first portion extends along a path oriented at an angle of 75 to 105 degrees relative to a side of the elongate void at the junction or to a longitudinal direction of the tread. The sipes also include a second portion of the sipe length extending from the first portion along a path oriented at an angle of less than 75 degrees or more than 105 degrees relative to the side of the elongate void at junction or to the longitudinal direction of the tread. The first portion of the sipe length is equal to or less than 10% of the sipe length.



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TIRE TREADS WITH IMPROVED SIPES AND METHODS OF FORMING THE SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to, and the benefit of, International Application No. PCT/US2016/035120 filed on May 31, 2016 with the U.S. Patent Office (as the US Receiving Office), which is hereby incorporated by reference.

BACKGROUND OF THE INVENTIONField of the Invention

[0002] This invention relates generally to tire treads having sipes, and methods for forming the same.

Description of the Related Art

[0003] Sipes are very narrow or thin voids arranged in a tire tread such that, during tire operation, opposing sides of the sipe contact one another from time to time. Sipes may also be referred to as “lamelles”. Sipes are commonly formed using molding elements, which are referred to herein as “sipe-molding members,” which comprise relatively thin members arranged within a mold cavity to form a sipe during molding operations. Sipes generally have a void width of 2 mm to 1.5 mm or less.

[0004] When sipes are arranged to engage or intersect a groove such that the sipe is arranged at an angle sufficiently less than 90 degrees, a tread element having a relatively sharp corner is formed at the junction of sipe and groove. It has been ascertained that sipe-molding members can experience unintentional deformation and damage during molding operations, such as when demolding the molded article from the mold. In particular, during demolding operations, stresses are concentrated at the base of a the sipe, such that tearing can occur at the base of the sipe when demolding the tread from the mold, and more specifically the sipe-molding member from the tire tread.

[0005] Accordingly, there is a need to provide a manner for reducing tearing of sipes in a molded tread during demolding.

SUMMARY OF THE INVENTION

[0006] The present invention comprises tire treads, which may exist independently or form a component of a tire, and methods of forming the tire treads, and apparatus for performing the same. In particular embodiments, the invention comprises a method including placing a volume of polymeric material within a mold, the mold having a molding cavity configured to at least mold a tire tread, where the molding cavity includes one or more sipe-molding members each extending outwardly from a base of the molding cavity and into the molding cavity to a free edge of the corresponding sipe-molding member, each sipe-molding member having a length extending between opposing side edges of the sipe-molding member, the length extending transverse to the base, the base configured to form an outer, ground-engaging side of the tire tread, the outer, ground-engaging side of the tire tread being configured to engage a tire operating surface during tire operation. Each of the one or more sipe-molding members arranged adjacent to an elongate void-forming member at a junction, the elongate void-forming member is configured to form an elongate void of the tire tread, where for each of the one or more sipe-molding members, a first portion of the sipe-molding member length extending from one of the opposing side edges at the junction extends along a path oriented relative to a side of the elongate void-forming member at the junction or relative to a longitudinal direction of the elongate void-forming member or tread within a range of 75 to 105 degrees. Each of the one or more sipe-molding members includes a second portion of the sipe-molding member length extending from the first portion along a path where at least a portion of the path is oriented relative to a side of the elongate void-forming member at the junction or relative to the longitudinal direction of the elongate void-forming member or tread within a range of less than 75 degrees or greater than 105 degrees, where the first portion length is equal to or less than 10% of the sipe-forming element length. The first portion may be configured to form a chamfer, fillet, or reverse fillet at the junction for eliminating a sharp corner at the junction. The method further includes curing the volume of polymeric material within the mold cavity to form a molded tire tread, and demolding the molded tire tread from the molding cavity after the step of curing, wherein the tread includes a sipe corresponding to each of the sipe-molding members, where the tread formed adjacent the junction is unharmed during the step of demolding and, in particular, unharmed at the chamfer, fillet, or reverse fillet.

[0007] Further embodiments of the invention comprise the mold described in the prior paragraph.

[0008] Yet further embodiments of the invention comprise a tire tread, the tread including one or more sipes each extending into a thickness of the tire tread from an outer, ground-engaging side of the tread and from an elongate void of the tire tread. Each of the one or more sipes have a first portion of the sipe length extending from the elongate void at a junction, where the first portion extends along a path oriented relative to a side of the elongate void at the junction or relative to a longitudinal direction of the elongate void or tread within a range of 75 to 105 degrees. Each of the one or more sipes has a second portion of the sipe length extending from the first portion along a path where at least a portion of the path is oriented relative to the side of the elongate void at the junction or relative to the longitudinal direction of the elongate void or tread within a range of less than 75 degrees or more than 105 degrees. The first portion is equal to or less than 10% of the sipe length. The first portion may include a recess extending a partial height of the sipe, where the recess is arranged at the bottom of the sipe.

[0009] 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

[0010] FIG. 1 is a partial top view of a tread design taken from the outer, ground-engaging side of the tread.

[0011] FIG. 2 is a cross-section of the tread design of FIG. 1 taken at line 2-2 at the intersection of a sipe and a longitudinal groove.

[0012] FIG. 3 is a top view of a sipe-molding member positioned within a mold, in accordance with an embodiment of the invention.

[0013] FIG. 4A is a perspective view of a sipe-molding member, in accordance with an embodiment of the invention.

[0014] FIG. 4B is a perspective view of the sipe-molding member first portion, in accordance

with an embodiment of the invention

[0015] FIG. 5 is a top view of a sipe-molding member positioned within a mold, in accordance with an embodiment of the invention.

[0016] FIG. 6A is a perspective view of a sipe-molding member, in accordance with an embodiment of the invention.

[0017] FIG. 6B is a cross-section of the sipe-molding member of FIG. 6A taken at line 6B-6B, in accordance with an embodiment of the invention.

[0018] FIG. 7 is a top view of a sipe-molding member positioned within a mold, in accordance with an embodiment of the invention.

[0019] FIG. 8 is a perspective view of the sipe-molding member, in accordance with an embodiment of the invention.

DETAILED DESCRIPTION OF PARTICULAR EMBODIMENTS

[0020] Embodiments of the invention comprise tire treads, which may or may not be attached to a tire, and methods and apparatus for molding a tire tread, with or without a tire, and demolding the same without notably damaging the tire tread – at least at a junction between a particular sipe and groove. The present invention is configured to preserve and maintain the structural integrity of a tire tread at the junction of a sipe and an elongate void, such as a groove or another sipe, where at a least a portion of the sipe extends along a path extending at an angle much less than 90 degrees relative to the groove or to a path along which the elongate void extends at the junction of the sipe and elongate void. In certain instances, the path along which the elongate extends is a longitudinal centerline of the elongate void, the longitudinal centerline extending in the direction of the elongate void length at the middle of the elongate void width. By preserving and maintaining the structural integrity of the tire tread at this junction, significant stresses otherwise concentrated at the base of sipe are reduced. This includes reducing or eliminating any sharp corners at the point where each sipe engages, abuts, or intersects the elongate void.

[0021] In certain embodiments, the invention comprises a tire tread having one or more sipes each having a length, a depth, and the thickness, each extending in a direction perpendicular to one another, the depth extending from within a thickness of the tread and to a top, outer side of

the tire tread, the outer side being configured for engaging a tire operating surface during tire operation. The sipe length extends from an elongate void at an junction between the sipe and the elongate void. In particular embodiments, the elongate void is a groove or another sipe, each of which may be a longitudinal or lateral groove or sipe. A longitudinal groove or sipe extends primarily in the longitudinal direction of the tread, while a lateral groove or sipe extends primarily in the lateral direction of the tread. The longitudinal direction is the direction used to define the length of the tread. The lateral direction is the direction used to define the width of the tread, and which is perpendicular to the longitudinal direction. The sipe extending from the elongate void can be described as having a first portion extending from the elongate void at the junction, the first portion having a length forming a portion of the sipe length and extending along a path oriented relative to a side of the elongate void at the junction or relative to a longitudinal direction of the elongate void or of the tread within a range of 75 to 105 degrees. The sipe includes a second portion having a length also forming a portion of the sipe length, the second portion extending from the first portion along a path where at least a portion of the path is oriented relative to the side of the elongate void at the junction or relative to the longitudinal direction of the elongate void or of the tread within a range of less than 75 degrees or greater than 105 degrees, or, in other words, within a range of greater than 15 degrees or less than -15 degrees relative to a lateral direction of the elongate void or of the tread. In other variations, the path along with the second portion extends is oriented relative to the side of the elongate void at the junction or relative to the longitudinal direction of the elongate void or of the tread within a range of less than 75 degrees or greater than 105 degrees, meaning the whole portion, and not at least a portion, of the path along second portion extends is within the stated range or within other ranges contemplated herein. It is appreciated that the path along which each of the first and second portions may be linear or non-linear, non-linear being any curvilinear path or path formed by two or more line segments, or any combination thereof. In measuring the angle of the path for each of the first and second portion, actual angles may be measured along the path, or a line best fitting the non-linear path over the length of any such first and second portion may be measured, where the best fitting line may be obtained using any known method, such as linear regression or linear least squares fitting, for example. In particular embodiments, the first portion is equal to or less than 10% or 3% of the sipe length. It is appreciated that other variations may exist and be employed, singularly or in any combination unless any such

combination is not possible. For example, in one variation, the angles by which the first portion extends ranges from 80 to 100 degrees, in lieu of 75 to 105 degrees. Also, the second portion may extend to any other portion of the sipe length. For example, in certain variations, the second portion extends to a second first portion arranged at the other end of the sipe length where the sipe engages (abuts or intersects) a second elongate void at a second junction, where the second first portion has a length forming a portion of the sipe length and extending along a path oriented relative to a side of the second elongate void at the junction or relative to the longitudinal direction of the tread within a range of 75 and 105 degrees, or in accordance with any other variation of any first portion described herein. It is also appreciated that any first portion may extend a partial height of the sipe, or a full height of the sipe. Any first portion may also form or include a protrusion or a recess, either of which may form extend a partial or full height of the sipe. Further, any first portion may form a chamfer, fillet, or reverse fillet. Other variations are discussed herein, such as those described in association with the figures below or those resulting from the methods of forming described below.

[0022] In particular embodiments, the invention comprises a method for molding a tread includes placing a volume of polymeric material within a mold, the mold having a molding cavity configured to at least mold a tire tread. The volume of uncured polymeric material may comprise any desired uncured polymeric material, including any desired tire tread material, such as any natural or synthetic rubber. The volume of polymeric material is placed into the mold cavity. In being configured to at least mold a tire tread, it is appreciated that the molding cavity may be configured to form a tire tread alone or the tire tread in combination with one or more other molded objects or products, such as a tire. Accordingly, the mold may be a tire tread mold, which may be generally flat or planar, or annular. The mold may also be a tire mold where the tread is molded with the tire. In any event, the mold cavity is defined by a length, a width, and a depth. The mold cavity length extends in a direction of the tread length, and therefore each of which may extend in a linear, non-linear, or circumferential (annular) direction. The depth of the mold cavity forms a thickness of the tread. Heat is applied to the mold to allow the polymeric material to adapt to the shape of the mold cavity, and ultimately to cure the polymeric material in its molded form. It is appreciated the tread mold and all components may be formed of any desired material or materials, such as aluminum, steel or ceramic.

[0023] The molding cavity includes one or more sipe-molding members each extending outwardly from a base of the molding cavity and into the molding cavity to a free edge of the corresponding sipe-molding member. Each sipe-molding member has a height extending outwardly from the base of the molding cavity to the free edge of the sipe-molding member to define an elevational height or depth of a molded sipe. This height may not be the full height of the sipe-forming member, as this height captures the height of the sipe-forming portion of the sipe-molding member. It is appreciated that the sipe-molding member may also include an attachment portion extending from the sipe-forming portion that is configured to extend into the mold to facilitate attachment thereto. Each sipe-molding member also has a length extending between opposing side edges of the sipe-molding member, the length extending transverse to the base. The base is configured to form an outer, ground-engaging side of the tire tread, the outer, ground-engaging side of the tire tread being configured to engage a tire operating surface during tire operation (that is, the radially outer side of the tire tread). The base of the mold cavity defines one extent of the mold cavity thickness or depth. Each of the height, length, and thickness extend generally in directions perpendicular to each other. It is appreciated that the sipe-molding members may be configured to mold a sipe of any design. For example, the sipe-molding member, and a corresponding molded sipe, may be of any shape and may have a thickness that constant or variable. Further, the sipe-molding member, in any embodiment described previously, the thickness may be generally planar (where the thickness extends along a linear path) or extend in varying directions in a direction of the height or length, such as when the thickness extends along a non-linear path in any of the height and/or length. A “non-linear” path as referenced herein may be a curvilinear path or an undulating path. “Undulating” as used herein connotes that the path alternatives between multiple changes in direction resulting in a plurality of peaks and valleys, for example. In other words, an undulating path zig zags back and forth multiple instances to provide two or more peaks or valleys (that is, two or more apexes or troughs). As noted previously, the non-linear path may be curvilinear, but may also comprise a plurality of linear segments, or any combination thereof, to form an effective non-linear path. It is appreciated that the sipe-molding members and the groove-molding elements may be constructed from any known material, such as steel, aluminum, or ceramic. Still further, each sipe-molding member may be arranged within the mold in accordance with any desired manner, such being removably affixed within the mold or being fixed within the mold.

[0024] In particular embodiments, each of the one or more sipe-molding members is arranged adjacent to an elongate void-forming member at a junction, the elongate void-forming member being configured to form an elongate void within the tire tread. The elongate void-forming member may form any elongate void, such as a sipe or groove, for example. As described in association with the tread above, sipe or groove may form a lateral or longitudinal sipe or groove. A longitudinal groove or sipe extends primarily in a longitudinal direction of the tire tread or a circumferential direction of a tire, or of the cavity forming the same. In arranging the sipe-molding member adjacent to an elongate void-forming member, at the junction, the sipe-molding member may engage, abut, extend from, or intersect the elongate void-forming member. It is also appreciated that the sipe-molding member may extend the full or partial height of the elongate void-molding member.

[0025] For each of the one or more sipe-molding members, a first portion of the sipe-molding member length extending from one of the opposing side edges at the junction extends along a path oriented relative to a side of the elongate void-forming member at the junction or relative to a longitudinal direction of the elongate void-forming member or of the tread within a range of 75 to 105 degrees. In other embodiments, the angle is substantially 90 degrees, or 75 to 90 degrees, 80 to 100 degrees, or 90 degrees to 105 degrees, and forms a like path along the first portion of a tire tread. The sipe-molding member also includes a second portion of the sipe-molding member length extending from the first portion along a path where at least a portion of the path, or the entire path, is oriented relative to a side of the elongate void-forming member at the junction or relative to the longitudinal direction of the elongate void-forming member or of the tread within a range of less than 75 degrees or greater than 105 degrees. This second portion is arranged more centrally relative to, or interior of, the first portion, and is opposite the one of the opposing side edges from which the first portion extends (meaning, the first portion is arranged between the second portion and the one of the opposing side edges from which the first portion extends). In certain instances, this second portion continues to the other of the opposing side edges defining the length of the sipe-molding member, or extends partially toward the other of the opposing side edges. In exemplary embodiments, the second portion extends a length that is equal to or greater than 50% of the sipe-molding member length, while in other exemplary embodiments, the second portion extends a length that is equal to or greater than 80% of the

sipe-molding member length. In any such embodiment, or in any other embodiment, the first portion is equal to or less than 10% or 3% of the sipe-molding member length. It is appreciated that each of the first and second portion lengths may extend linearly or non-linearly, and may be defined by the stated ranges as described above in association with the tread, where the angles may be measured at any location along the length of the path or, when the path is non-linear at any location along the path or along a line that best fits the non-linear path according to linear regression or other known methods.

[0026] In particular embodiments, each of the one or more sipe-molding members extends from and between a pair of elongate void-molding elements. It is appreciated that the pair of elongate void-molding elements may be configured to mold a pair of elongate voids, such as forming any combination of one or more sipes and grooves, each of which may be longitudinal or lateral. Longitudinal and lateral sipes and grooves may each extend along any linear or non-linear path, but it's the overall direction of the lengthwise extension of each that defines whether the groove is a longitudinal or lateral groove. In such instances, a first portion extends inwardly along the sipe-molding member length from each of the opposing side edges. In any such embodiment having a pair of first portions arranged at opposing side edges, the second portion may extend from and between the opposing first portions, or may extend along any portion of the sipe-molding member length between the opposing first portions. In these embodiments, the extent of each first portion of the pair of first portions may be of any length, such as being equal to or less than 10% or 3% of the sipe-molding member length, for example. It is appreciated that each of the pair of first portions may be of the same or different length and of the same or different design, and any combination thereof.

[0027] It is appreciated that the first portion be arranged in any manner relative to the second portion. For example, in certain embodiments, for each of the one or more sipe-molding members, the first and second portions are each associated with different surfaces of the sipe-forming element. In other words, a surface forming the second portion is not shared with, or separate from, the first portion. In other variations, or each of the one or more sipe-molding members, the first and second portions are associated with different portions of a continuous contoured surface of the sipe-molding member. In other words, a surface forming the second portion is shared with the first portion. In either embodiment, in certain variations, for each of

the one or more sipe-molding members, the first portion extends a partial height of the sipe-molding member between the base and the free edge. In extending a partial height, in certain variations, to relieve stress concentrations at the base of the sipes, for each of the one or more sipe-molding members, the first portion is arranged in close proximity to, or even adjacent to, the base of the molding cavity.

[0028] It is appreciated that in any embodiment discussed herein and in any arrangement discussed herein, the first portion may form a projection extending from a thickness of the sipe-molding member, the projection configured to mold a recess in a tread, the recess forming a location of increased thickness along the length of a molded sipe in the first portion. Based upon the previously discussed arrangements between first and second portions, the projection may extend a partial for full height of the sipe-molding member or of the sipe-forming portion of said member. Further, this projection may form any shape. For example, in certain instances, for each of the one or more sipe-molding members, the projection is configured to form a chamfer or fillet. In other variations, the projection is configured to form a reverse fillet.

[0029] In some embodiments, a sharp corner may be eliminated by providing a bend in the length of the sipe-molding member, which may at least in part be formed by a fillet. In various embodiments, the bend modifies the path of the sipe-molding member allowing the sipe-molding member to terminate into a groove-molding member at generally 90 degrees, or simply by increasing the angle of intersection at the sharp corner. The bend may further allow a sipe-molding member to maintain a constant thickness the entire length of the sipe-molding member.

[0030] However, in other embodiments, a sipe-molding member may have a variable thickness. A variable thickness may be provided in combination with any embodiment described herein. A variable thickness sipe-molding member includes a sipe-molding member with a profile for forming a sipe with a variable thickness. The variable thickness may be an intermediate thickness and/or a variation of the thickness of the free edge and/or base. The variable thickness may extend the entire length of the sipe-molding member or only a portion of the sipe-molding member. In one particular embodiment, a sipe-molding member includes an intermediate section for forming the variable thickness. The intermediate section may be arranged between the opposing terminal ends of the sipe-molding member. Further the variable thickness may be arranged between the free end and the base of the sipe-molding member. Thereby, the

intermediate section comprises a thick portion extending about the perimeter of the intermediate section. In contrast, the intermediate section may be the thick portion with a thin portion extending about the perimeter of the intermediate section, or a combination of these embodiments. Yet, in other embodiments, the variable thickness may extend from an intermediate section to a terminal end, free end, and/or base. Further, a variable thickness sipe and/or sipe-molding member may include multiple intermediate sections. To this end, a variable thickness sipe-molding member may include alternating thin and thick portions extending the length and/or the elevational height of the sipe-molding member. Variable thickness sipes are used to improve tread performance characteristics. Although the variable thickness sipe-molding member is discussed in combination with the bend, it is further contemplated a variable thickness sipe-molding member may be used in combination with any of the other embodiments or features discussed herein.

[0031] In particular embodiments, the volume of polymeric material is cured within the mold cavity to form a molded tire tread according to any desired method of curing using any desired apparatus. Subsequently, the molded tire tread is demolded from the molding cavity after the step of curing, wherein the tread includes a sipe corresponding to each of the sipe-molding members, where the tread formed adjacent the junction is unharmed during the step of demolding. It is appreciated that the cured tread may be demolded manually or automatically in accordance with any desired method and the use of any desired apparatus. The cured tread formed by the tread mold includes one or more sipes formed by and shaped as the sipe-molding members and one or more elongate voids in accordance with any embodiment or variation contemplated herein.

[0032] Particular embodiments of the tire tread and the mold described above configured to prevent mold damage at the junction will now be described in further detail below in association with the figures filed herewith providing exemplary embodiments of the tire treads and molds.

[0033] With reference to FIGS. 1-2, a prior art tire tread **10** is illustrated. In FIG. 1 the tire tread **10** is illustrated from the ground-engaging side **20** of the tread, comprising a plurality of tread elements **22**. The tire tread **10** includes elongate voids forming grooves **30** and sipes **40** that together form the plurality of tread elements **22**. Grooves **30** extend in a longitudinal direction **X** of the tire tread. This longitudinal direction **X** is a circumferential direction when the tread is

affixed to a tire. In this embodiment, sipes **40** extend between and from the longitudinal grooves **30**. The sipes **40** extend primarily in a lateral direction **Y** of the tread **10** and at an oblique angle to the grooves **30** – such that opposing corners of tread elements **22** located opposing sides of a sipe **40** at the junction of the sipe and groove **30** are formed at obtuse and acute angles. Specifically, a sharp corner **50** having an acute angle is formed where the sipe **40** intersects the groove **30**. FIG. 2 is a cross-section of the tire tread taken at line 2-2 of FIG. 1. This cross-section illustrates sharp corners **50** at a junction between sipe **40** and groove **30**, which extend the depthwise direction **Z** of the sipe **40**. Stresses concentrate at the bottom of the sharp corners at the junction causing damage of the sipes during demolding operations.

[0034] Turning to FIG. 3, an embodiment of the present invention illustrates a tire tread **110** that includes particular improvements. In this embodiment, a first portion **160** of the sipe is formed at each lateral end of a sipe **140**. The sharp corner between the sipe and the groove are eliminated by the sipe first portion **160** having an angle between 75 and 105 degrees at a junction where sipe **140** extends from groove **130**. More specifically, the sipe **140** may form a substantially 90 degree angle at the junction between the sipe **140** and the groove **130**. In FIG. 3, the sipe first portions **160** are illustrated as chamfers. Extending between an opposing pair of the sipe first portions **160** and arranged centrally on the sipe **140** is the sipe second portion **162**.

[0035] FIGS. 4A-4B illustrate a sipe-molding member **180** for forming the sipe in FIG. 3 wherein the sipe-molding member extends outwardly from a base **174** of a mold cavity **172** within a mold **170**. The sipe-molding member includes a sipe-forming portion **182** and an optional mold-attachment portion **184**. The mold-attachment portion is optional, as there are many known ways of attaching the mold element to the mold, any of which may be used with the sipe-forming portion of the sipe-molding member shown. The sipe-molding member has a length **L** defined by opposing side edges **186** and a height **H** terminating at a free end **188**. A thickness **T** of the sipe-molding member is perpendicular to both the length **L** and height **H**. At one of the side edges **186**, the sipe-molding member is shown engaging a groove-forming member **190**. Corresponding to the sipe first portion **160**, as illustrated in FIG. 3, is the member first portion **192** of the sipe-forming portion **182** for forming a sipe. Extending between an opposing pair of member first portions **192** and arranged centrally on the sipe-forming portion **182** is the member second portion **194**. In FIG. 4A, the member first portions **192** and member

second portion **194** extend along a linear path the length **L** of the sipe-forming portion **182**. The member second portion **194** extends this linear path at an angle less than 75 degrees, or greater than 105 degrees, relative the groove-forming member **190**. The member first portions **192** form projections extending the full height of the sipe-forming portion **182**. In FIG. **4A**, the projections are configured to form a chamfer. In this particular embodiment and as illustrated by FIG. **4B**, the length of the first portion **L₁** is 10% or less of the length **L** of the sipe-forming portion. Further illustrated by figure **4B** is the sipe-molding member thickness **T** and the projection thickness **T_P**. In various embodiments, the projection thickness **T_P** may be 0.75 mm to 3 mm having a chamfer angle α of 80 to 110 degrees. Thereby, the length of the member first portion **L₁** is a function of the projection thickness **T_P** and the chamfer angle α .

[0036] FIG. **5** illustrates a tire tread **210** having a sipe **240** comprising sipe first portions **260** and a sipe second portion **262** arranged centrally there between. The sipe first portions **260** comprise a bend **220**. In this particular embodiment, the bend **220** eliminate the sharp corner at a junction between the sipe **240** and a groove **230**. Specifically, the bend **220** transitions a sipe, extending primarily in a lateral direction **Y** of the tread **210** and at an oblique angle to the grooves **230**, to intersect the grooves **230** at approximately 90 degrees. This bend can be described as being formed by one side of the sipe comprising a fillet. It is also shown that the first portion has a constant thickness, although in other variations, the thickness may be variable.

[0037] FIGS. **6A** and **6B** illustrate the sipe-molding member **280** for forming the sipe in FIG. **5**. The sipe-molding member **280** includes a sipe-forming portion **282** and an optional mold-attachment portion **284**. The mold-attachment portion is optional, as there are many known ways of attaching the mold element to the mold, any of which may be used with the sipe-forming portion of the sipe-molding member shown. The sipe-molding member **280** has a length **L** defined by opposing side edges **286** and a height **H** terminating at a free end **288**. A thickness **T** of the sipe-molding member **280** is perpendicular to both the length **L** and height **H**. The sipe-molding member **280** is configured to engage a groove-forming member at the side edges **286**. The sipe-molding member **280** comprises bends **296** for returning the sipe-molding member into the groove-molding member wherein the sipe-molding member and the groove-molding member are generally perpendicular to one another. As describe in relation to the sipe **240** of FIG. **5**, the sipe-molding member **280** also includes a pair of member first portions **292** with a member

second portion **294** there between. The length L_1 of each member first portion **292** is 10% or less than the length L of the sipe-forming portion **282**. By example, L_1 may be 2.2 mm to 3 mm from the adjacent groove molding element or the side edge of the sipe-molding member.

[0038] FIGS. **6A-6B** further illustrate a sipe-molding member having a variable thickness. The variable thickness may be an intermediate thickness or a variation in the thickness of the ends, edges and/or base of the sipe-forming portion **282**. The example of a variable thickness, as illustrated by FIGS. **6A-6B**, includes a sipe-molding member **280** where the thickness of the sipe-molding member includes an intermediate section **298** having an intermediate thickness T_{INT} arranged between the opposing side edges **286** having a sipe thickness t . In this particular embodiment, a thick portion having the sipe thickness t extends at least partially around the intermediate thickness T_{INT} . The thick portion is illustrated at the free end **288**, each terminal end **286** and at the base **274**, corresponding to the thickness t of the sipe-molding member **280**. It is appreciated that the variable thickness features may be combined with any other embodiments contemplated or shown in any figure of this application.

[0039] In the embodiments shown in FIGS. **7-8**, a tire tread **310** having a sipe **340** and a sipe-molding member **380** for molding the sipe **340** is illustrated, respectively. The sipe **340** of FIG. **7** is illustrated having a first portion **360** that forms or includes a recess **362** extending a partial height of the sipe **340**. The partial height recess is arranged at the bottom of the sipe **340**, opposite the outer, ground-engaging side. It is appreciated, however, that the partial height recess may be arranged at any location or at multiple locations along the height of the sipe. It is also appreciated that the partial height projection may be used in combination with any of the embodiments described herein. This recess is described further below with regard to a sipe-molding member shown in FIG. **8**, as the sipe-molding member in FIG. **8** represents the positive of the sipe depicted in FIG. **7**. Therefore, the projection described in association with the sipe-molding member also describes the void formed thereby, or, more specifically, the recess of the sipe molded into the tire tread of FIG. **7**.

[0040] FIG. **8** illustrates a sipe-molding member **380** for forming the sipe in FIG. **7** wherein the sipe-molding member extends outwardly from a base **374** of a mold cavity **372** within a mold **370**. The sipe-molding member includes a sipe-forming portion **382**. The sipe-molding member has a length L defined by opposing side edges **386** and height H terminating at a free end **388**. A

thickness **T** of the sipe-molding member is perpendicular to both the length **L** and the height **H**. At one of the side edges, the sipe-molding member is configured to engage a groove-forming member. Corresponding to the sipe first portion **360**, as illustrated in FIG. 7, is the member first portion **392** of the sipe-forming portion **382** for forming a sipe. Extending between an opposing pair of member first portions **392** is the member second portion **394**. In FIG. 8, the length **L** of the sipe-forming portion **382** extends a non-linear path. At least a portion of the sipe-forming The non-linear path extends a lateral direction along an average general path having an angle of 75 to 105 degrees relative to a longitudinal groove-forming member.

[0041] A partial height projection **383** extends from the sipe-molding member **380** at the base **374** of the mold cavity **372**. The partial height projection **383** has a projection height **H_P**, a projection thickness **T_P**, and a projection length **L_P** which forms a triangular pyramid. It is, however, appreciated the partial height projection may comprise other geometric shapes such as prisms comprising multiple sides. Likewise, the partial height projection may further comprise the characteristics previously described, including a chamfer, a fillet, a reverse fillet, and a bend. In particular embodiments of the embodiment illustrated by FIG. 7, the partial height projection **383** may comprise a projection height **H_P** ranging from 1.5 mm to 3 mm, a projection thickness **T_P** ranging from sipe-molding member thickness **T** + 0.75mm to sipe-molding member thickness **T** + 3 mm, a projection length **L_P** ranging from 0.75 mm to 3 mm.

[0042] 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.

[0043] While this invention has been described with reference to particular embodiments

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

CLAIMS

What is claimed is:

1. A method of molding a tire tread, the method comprising:

placing a volume of polymeric material within a mold, the mold having a molding cavity configured to at least mold a tire tread, where:

the molding cavity includes one or more sipe-molding members each extending outwardly from a base of the molding cavity and into the molding cavity to a free edge of the corresponding sipe-molding member, each sipe-molding member having a length extending between opposing side edges of the sipe-molding member, the length extending transverse to the base, the base configured to form an outer, ground-engaging side of the tire tread, the outer, ground-engaging side of the tire tread being configured to engage a tire operating surface during tire operation,

each of the one or more sipe-molding members arranged adjacent to an elongate void-forming member at a junction, the elongate void-forming member is configured to form an elongate void of the tire tread, where for each of the one or more sipe-molding members, a first portion of the sipe-molding member length extending from one of the opposing side edges at the junction extends along a path oriented relative to a side of the elongate void-forming member at the junction or relative to a longitudinal direction of the elongate void-forming member or tread within a range of 75 to 105 degrees,

where each of the one or more sipe-molding members includes a second portion of the sipe-molding member length extending from the first portion along a path where at least a portion of the path is oriented relative to a side of the elongate void-forming member at the junction or relative to the longitudinal direction of the elongate void-forming member or tread within a range of less than 75 degrees or greater than 105 degrees, where the first portion length is equal to or less than 10% of the sipe-forming element length and is configured to form a chamfer, fillet, or reverse fillet at the junction for eliminating a sharp corner at the junction;

curing the volume of polymeric material within the mold cavity to form a molded tire tread; and

demolding the molded tire tread from the molding cavity after the step of curing, wherein the tread includes a sipe corresponding to each of the sipe-molding members, where the tread formed adjacent the junction is unharmed at the chamfer, fillet, or reverse fillet during the step of demolding.

2. The method of claim 1, where for each of the one or more sipe-molding members, the first and second portions are each associated with different surfaces of the sipe-forming element.
3. The method of claim 1, where for each of the one or more sipe-molding members, the first and second portions are associated with different portions of a continuous contoured surface of the sipe-molding member.
4. The method of any one of claims 2 and 3, where for each of the one or more sipe-molding members, the first portion extends a partial height of the sipe-molding member between the base and the free edge.
5. The method of claim 4, where for each of the one or more sipe-molding members, the first portion is arranged adjacent to the base of the molding cavity.
6. The method of any one of claims 1 to 5, wherein the first portion engages the elongate void-forming member at an angle of substantially 90 degrees relative to the elongate groove-forming member.
7. The method of any one of claims 1 to 6, where for each of the one or more sipe-molding members, the first portion forms a projection extending from a thickness of the sipe-molding member.
8. The method of any one of claims 1 to 7, where for each of the one or more sipe-molding members, the first portion is a portion of increased thickness of the sipe-molding member.
9. The method of any one of claims 1 to 8, where for each of the one or more sipe-molding members, the first portion has a length of 2.2 mm to 3 mm.

10. The method of any one of claims 1 to 9, where for each of the sipe-forming elements, the portion of the sipe-molding member extending from the base to the free end has a substantially constant thickness.
11. The method of any one of claims 7 to 10, where the projection extending from a thickness of the sipe-molding member is a partial height projection arranged at the free edge of the sipe-molding member.
12. A tire tread comprising:
 - one or more sipes each extending into a thickness of the tire tread from an outer, ground-engaging side of the tread and from an elongate void of the tire tread;
 - each of the one or more sipes having a first portion of the sipe length extending from the elongate void at a junction, where the first portion extends along a path oriented relative to a side of the elongate void at the junction or relative to a longitudinal direction of the elongate void or tread within a range of 75 to 105 degrees,
 - each of the one or more sipes having a second portion of the sipe length extending from the first portion along a path where at least a portion of the path is oriented relative to the side of the elongate void at the junction or relative to the longitudinal direction of the elongate void or tread within a range of less than 75 degrees or more than 105 degrees,
 - where the first portion is equal to or less than 10% of the sipe length and includes a recess extending a partial height of the sipe, where the recess is arranged at the bottom of the sipe.
13. The tire tread of claim 12, where for each of the one or more sipes, the first and second portions are each associated with different surfaces of the sipe.
14. The tire tread of any one of claims 12 and 13, where for each of the one or more sipes, the first and second portions are associated with different portions of a continuous contoured surface of the sipe.
15. The tire tread of any one of claims 12 to 14, where for each of the one or more sipes, the first portion extends a partial height of the sipe.

16. The tire tread of any one of claims 12 to 15, where for each of the one or more sipes, the first portion includes a second recess forming a location of increased thickness along the sipe length.
17. The tire tread of any one of claims 12 to 16, where for each of the one or more sipes, the first portion is arranged adjacent to the bottom of the sipe.
18. The tire tread of any one of claims 12 to 17, where for each of the one or more sipes, the first portion includes a chamfer, fillet, or reverse fillet.
19. The tire tread of any one of claims 12 to 18, where for each of the one or more sipes, the first portion has a length of 2.2 mm to 3 mm.
20. The tire tread of any one of claims 12 to 19, where for each of the one or more sipes, the elongate void is a groove.

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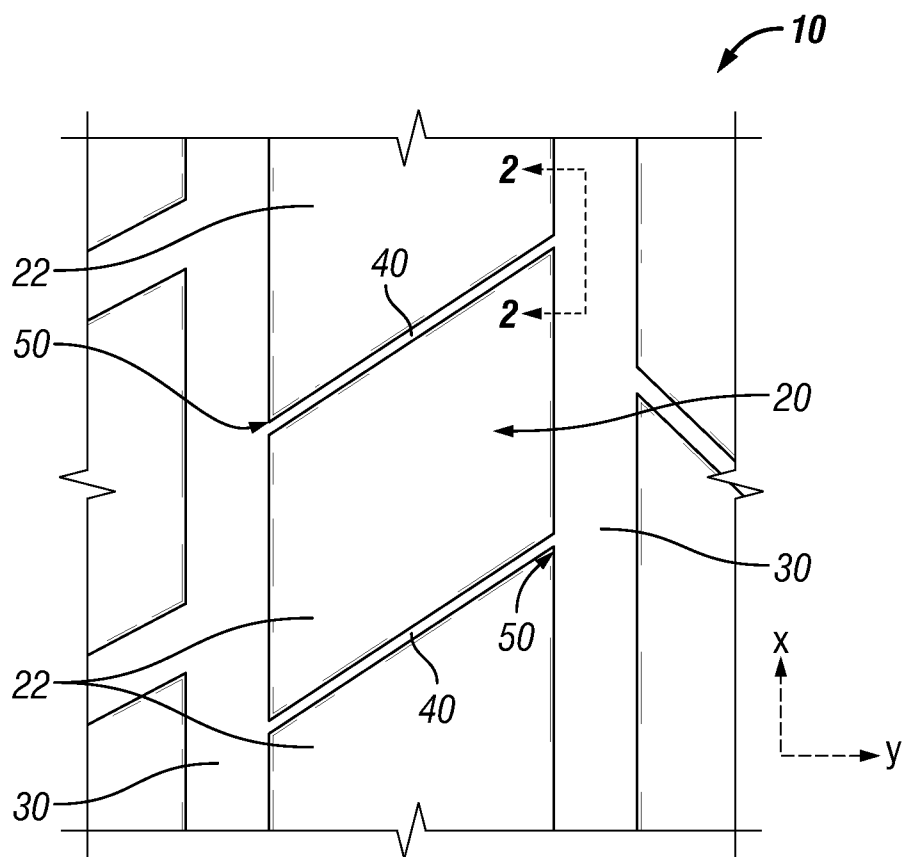


FIG. 1

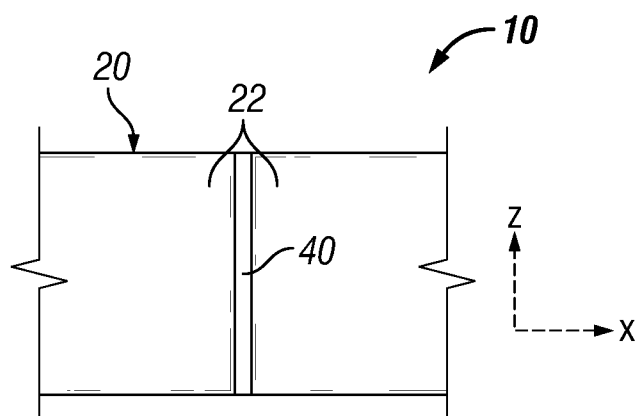


FIG. 2

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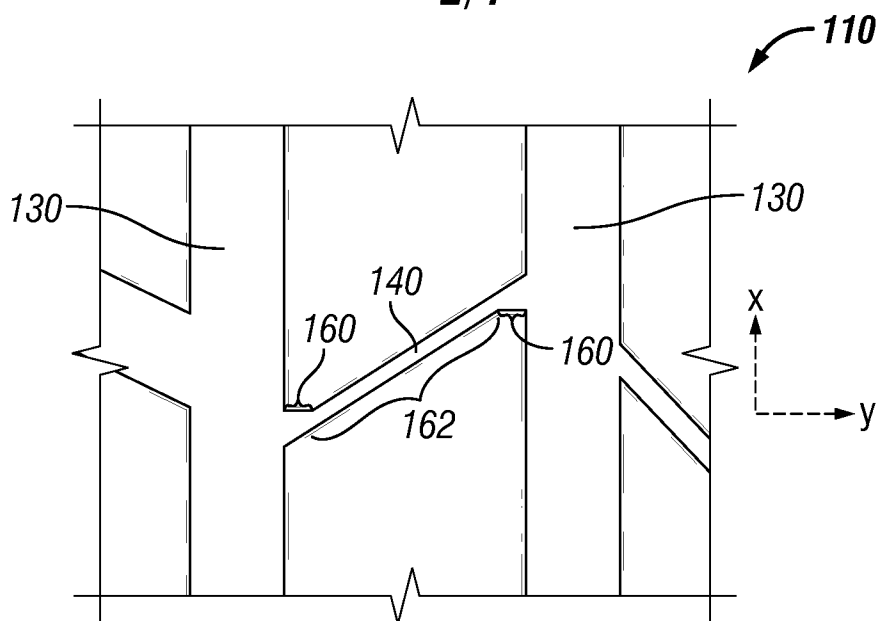


FIG. 3

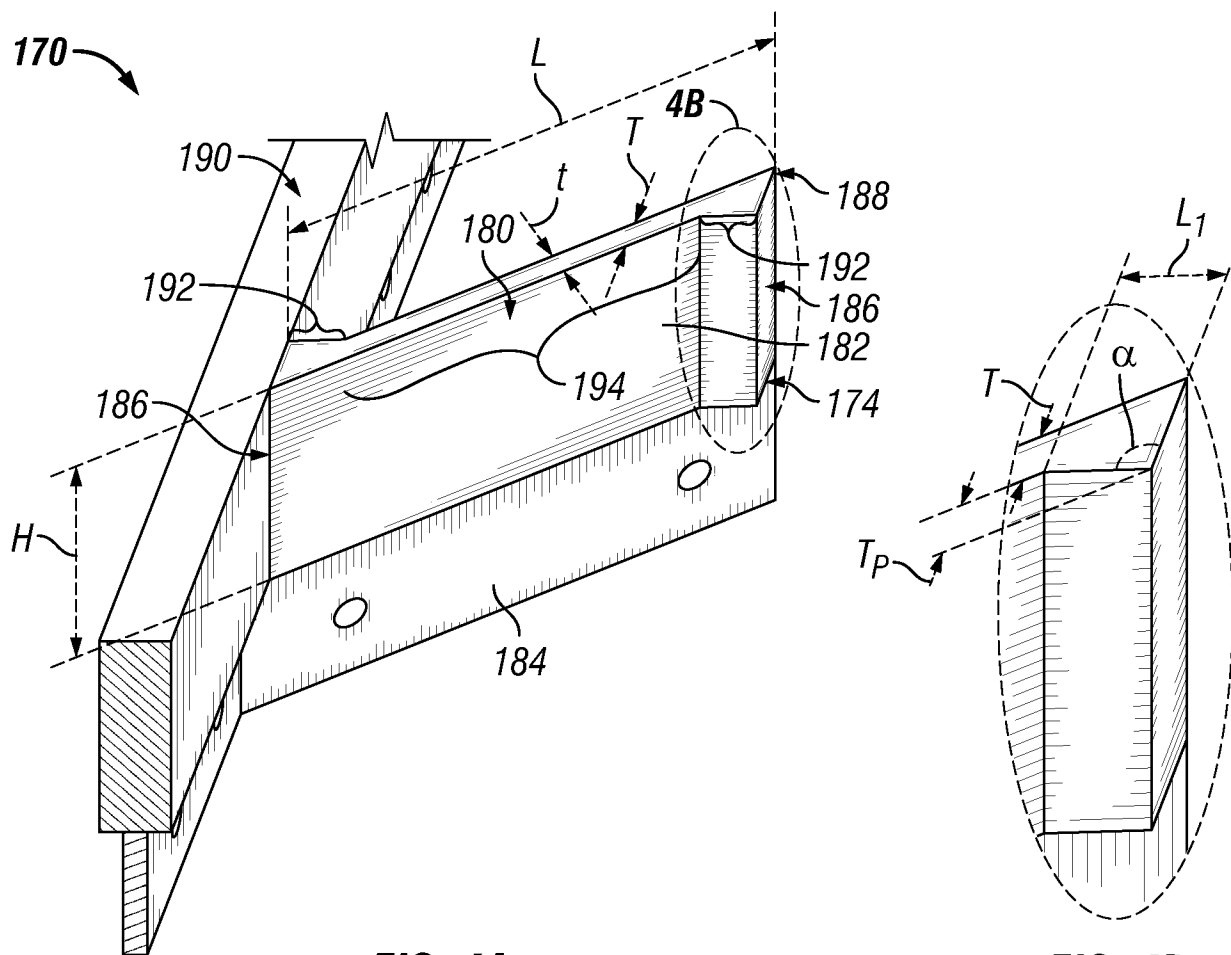


FIG. 4A

FIG. 4B

FIG. 5

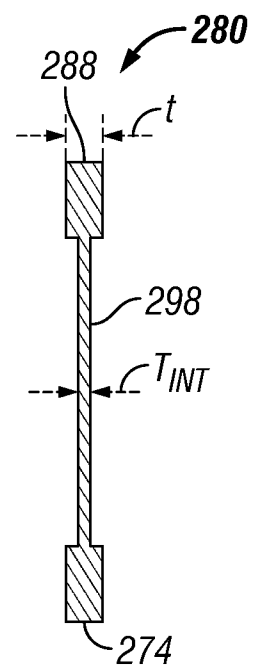


FIG. 6B

FIG. 6A

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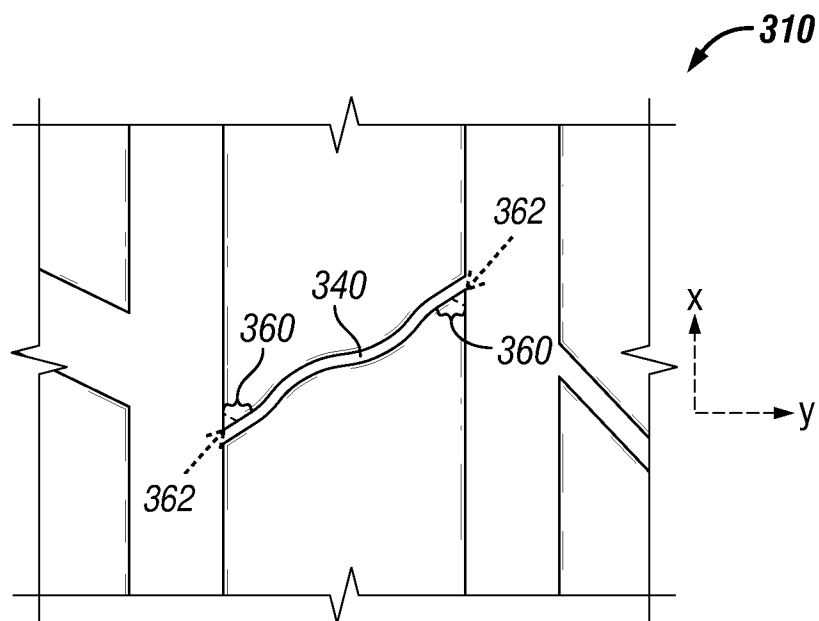


FIG. 7

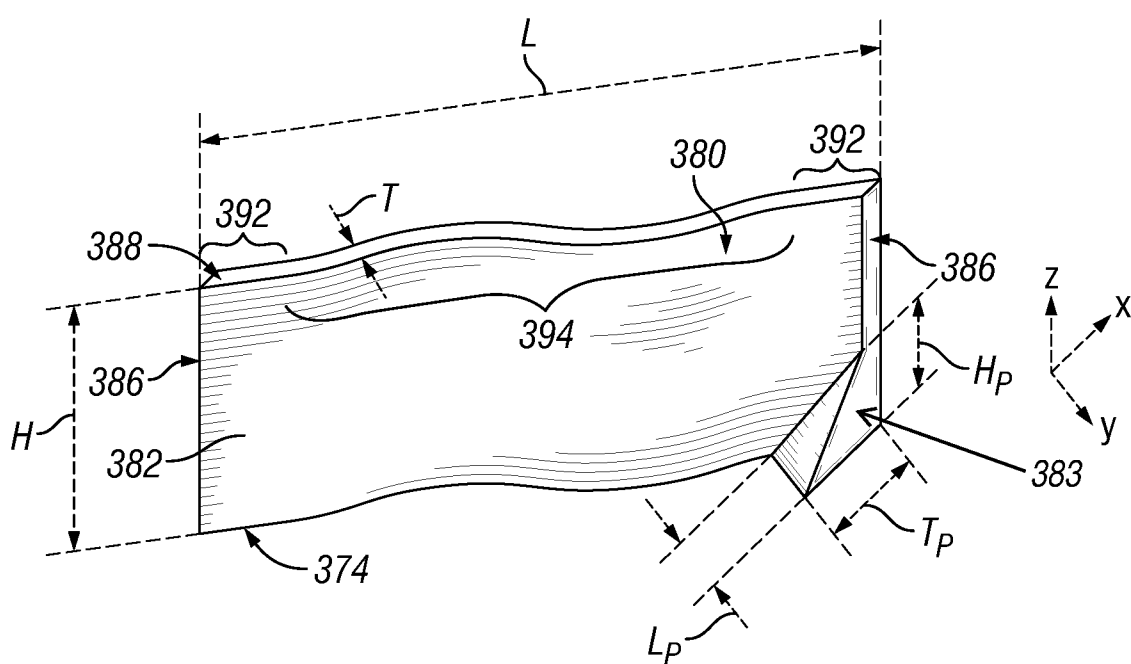


FIG. 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2017/034990

A. CLASSIFICATION OF SUBJECT MATTER
INV. B29D30/06 B60C11/13 B60C11/12
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)
B29D B60C

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

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

EPO-Internal

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	EP 3 015 286 A1 (SUMITOMO RUBBER IND [JP]) 4 May 2016 (2016-05-04)	1,12
A	paragraph [0070] - paragraph [0076] paragraph [0084] - paragraph [0087] figures 1,2,7	2-11, 13-20

X	US 6 332 485 B1 (MATSUMOTO HIROYUKI [JP]) 25 December 2001 (2001-12-25)	1,12
A	column 4, line 48 - column 5, line 10; figures 1,2a-2d column 6, line 16 - line 21	2-11, 13-20



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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

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"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

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Date of mailing of the international search report

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2017/034990

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