

# US Patent & Trademark Office

## Patent Public Search | Text View

---

United States Patent	12391071
Kind Code	B2
Date of Patent	August 19, 2025
Inventor(s)	Jokinen; Mikko

---

### Tread block arrangement having a sipe

---

#### Abstract

A tread block arrangement is suitable for a tire or for a tread band for a tire. The tread block arrangement includes a tread block having a first sipe delimited by a first sipe wall, a second sipe wall and a bottom of the sipe. The first sipe wall and the second sipe wall are arranged parallel to each other and define a width of the sipe. At least the first sipe wall has an indentation to increase an empty volume of the sipe at the location of the indentation. The first sipe wall has an inclined section to form the indentation, wherein a distance between the first sipe wall and the second sipe wall increases towards the bottom of the sipe at the location of the inclined section. A tire has the tread block arrangement and a lamella plate for forming sipes of the tread block arrangement.

---

<b>Inventors:</b>	<b>Jokinen; Mikko (Tampere, FI)</b>
<b>Applicant:</b>	<b>Nokian Renkaat Oyj (Nokia, FI)</b>
<b>Family ID:</b>	<b>1000008766094</b>
<b>Assignee:</b>	<b>NOKIAN RENKAAT OYJ (Nokia, FI)</b>
<b>Appl. No.:</b>	<b>17/959981</b>
<b>Filed:</b>	<b>October 04, 2022</b>

#### Prior Publication Data

<b>Document Identifier</b>	<b>Publication Date</b>
US 20230131314 A1	Apr. 27, 2023

#### Foreign Application Priority Data

EP	21204231	Oct. 22, 2021
----	----------	---------------

---

#### Publication Classification

**Int. Cl.:** B60C11/03 (20060101); B60C11/11 (20060101); B60C11/12 (20060101)

**U.S. Cl.:**

**CPC** B60C11/0306 (20130101); B60C11/11 (20130101); B60C11/1204 (20130101);  
B60C11/1236 (20130101); B60C11/1263 (20130101); B60C2011/0339 (20130101);  
B60C2011/1254 (20130101)

## Field of Classification Search

**CPC:** B60C (11/1263); B60C (11/1281); B60C (11/1323); B60C (2011/1213); B60C  
(2011/1254); B60C (11/1204); B60C (11/1218)

---

## References Cited

### U.S. PATENT DOCUMENTS

Patent No.	Issued Date	Patentee Name	U.S. Cl.	CPC
7213625	12/2006	Martin et al.	N/A	N/A
9669663	12/2016	Berger et al.	N/A	N/A
2003/0029537	12/2002	Iwamura	152/209.18	B60C 11/12
2010/0218867	12/2009	Matsumoto	152/209.18	B60C 11/12
2012/0312438	12/2011	Shinzawa	152/209.8	B60C 11/0302
2015/0165828	12/2014	Kaji	152/209.18	B60C 11/11
2017/0120692	12/2016	Durand-Gasselin et al.	N/A	N/A
2019/0210410	12/2018	Tikka	N/A	B60C 11/0306
2021/0188012	12/2020	Rodriquez	N/A	B60C 11/1281

### FOREIGN PATENT DOCUMENTS

Patent No.	Application Date	Country	CPC
1090781	12/2000	EP	B60C 11/0306
3640058	12/2019	EP	N/A
3019096	12/2014	FR	N/A
2005104194	12/2004	JP	B60C 11/1218
2007126139	12/2006	JP	B60C 11/12
2002/060705	12/2001	WO	N/A
2013/007745	12/2012	WO	N/A
2018/083414	12/2017	WO	N/A

### OTHER PUBLICATIONS

JP 2007126139 Machine Translation (Year: 2007). cited by examiner

JP-2005104194-A Machine Translation (Year: 2005). cited by examiner

---

*Primary Examiner:* Smith; Katelyn W

*Assistant Examiner:* Boss; Wendy L

*Attorney, Agent or Firm:* Merchant & Gould P.C.

---

## Background/Summary

### CROSS-REFERENCE TO RELATED APPLICATIONS

(1) This application claims priority benefit of Serial No. 21204231.1, filed Oct. 22, 2021 in Europe, and which application is incorporated herein by reference. To the extent appropriate, a claim of priority is made to the above-disclosed application.

### TECHNICAL FIELD

(2) The present invention relates to a pneumatic tire (a.k.a. tyre) or a tread band having tread blocks, and being provided in the tread blocks with sipes, more particularly to an improved sipe structure or sipe arrangement of a tread block. The present invention also relates to lamella plates that are used in the manufacturing process of a pneumatic tire for making said sipe structure or sipe arrangement.

### BACKGROUND

(3) A tread of a known pneumatic tire is indicated in FIG. 1a. A pneumatic tire is known to include a tread which has circumferential and transversal grooves on its outer surface, said grooves defining a number of protruding parts, such as ribs and tread blocks. The tread is meant for a rolling contact against a ground surface, such as road. The grooves are meant for draining water and/or slush that is possibly located on the ground surface away from the tread, so that the contact between the tread and the ground surface is as good and consistent as possible. Certain types of tires such as winter tires are provided in the tread with a number of sipes at various angles with respect to a motion direction of the tire. The sipes not only serve a better tire-ground contact in rain, but also improve traction, braking and lateral stability on snow by trapping snow as well as providing more gripping edges. The sipes also make the rubber material to deform more easily, in effect making the tire appear softer. This also improves friction.

(4) The international patent application WO2013007745 discloses a tire, which includes a rolling surface having incisions that have a substantially transverse orientation, open onto the rolling surface, have a depth P, and form, on the rolling surface of the tire in the new condition, two edges defining at least one narrow portion of the incision having a mean width  $LE \leq 2 \text{ mm}$  and at least one wide portion of the incision having a mean width  $LL > 2 \text{ mm}$ , said wide and narrow portions being alternately arranged and extending over the entire depth P of the incision.

(5) The patent application EP3640058 discloses a sipe formed in a block of a pneumatic tire which includes a first inclined portion inclined against a tire radial direction, a second inclined portion formed at an outer side in the tire radial direction with respect to the first inclined portion and inclined in a direction opposite to the first inclined portion with respect to the tire radial direction, a bent portion communicated with the first inclined portion and the second inclined portion and bent to be protruded toward a direction in which a gap between the first inclined portion and the second inclined portion becomes narrow, and a widened portion formed at an inner side in the tire radial direction with respect to the first inclined portion and widened in a groove width more than the first inclined portion. The cross section of such sipe is a kind of a zig-zag pattern in the height direction. At the bottom of the zig-zag pattern is the widened portion.

(6) The patent application FR3019096 discloses a tread for a tire comprising at least two grooves of general circumferential orientation delimiting intermediate parts and edge parts, these orientation grooves generally circumferential being shaped to be present at least until the wear limit of the tread is reached, this tread comprising a tread surface. The tread comprises on its edge regions a plurality of cutouts for orientation generally transverse and of suitable depth to be present up to the wear limit of the tread, each cutout of general transverse orientation being formed of a first part opening onto the running surface and extended towards the inside of the strip by a hollow part forming a channel of average width greater than the average width of the groove.

(7) The international patent application WO02060705 relates to a tyre tread comprising a tread profile formed by numerous relief patterns defined by grooves which are oriented in the transversal and longitudinal directions of the tread. Each of said relief patterns comprises one contact face and lateral faces.

(8) The international patent application WO2018083414 discloses a tread for a pneumatic tire, comprising a long tread bar extending in a circumferential direction and comprising a contact surface that comes into contact with the ground, a first and a second side wall defining said contact surface, the long tread bar comprising a plurality of incisions which each have a first and a second end. The incisions (n, n+1) are successively arranged longitudinally on the contact surface in such a way that when an incision reaches its second end, another incision starts, at the same circumferential level on the long tread bar. Furthermore, from a certain depth in the tread, the incisions at least partially widen.

#### SUMMARY

(9) An object of the invention is to improve the properties of a pneumatic tire provided with lamellas and sipes in the tread block so that lamellas can work more efficiently in the sense of improved gripping and improved stability despite of wear of a surface of the tread band.

(10) Accordingly, a tread block arrangement is disclosed. The tread block arrangement is suitable for a tire or for a tread band for a tire. The tread block arrangement comprises tread blocks. A tread block limits a first sipe. The first sipe comprises deep parts separated by shallow parts. This has the effect that, because of the shallow parts, the first sipe does not significantly affect the stiffness of the tread block in which the first sipe is arranged. However, because of the deep parts, the first sipe may absorb some water of the surface, which improves the grip also near the first sipe. Moreover, to provide for sufficient stiffness, a depth of a deep part is at least three times a depth of a shallow part. Furthermore, because the first sipe preserves the stiffness of the tread block, it is possible to make a longer and/or a wider sipe, whereby the space for the water absorption may be increased. Each deep part is limited by two end walls, which are not parallel such that the deep part becomes longer when moving from bottom towards the tread. Thus, at least one of the end walls of the deep parts is inclined relative to a radial direction.

(11) According to a first aspect there is provided a tread block arrangement suitable for a tire or for a tread band for a tire, the tread block arrangement comprising: a tread block comprising at least a first sipe delimited by a first sipe wall, a second sipe wall and a bottom of the sipe, wherein the first sipe wall and the second sipe wall are arranged parallel to each other and define a width of the sipe, further wherein at least the first sipe wall has at least one indentation to increase an empty volume of the sipe at the location of the indentation, wherein the first sipe wall has an inclined section to form said at least one indentation, wherein a distance between the first sipe wall and the second sipe wall increases towards the bottom of the sipe at the location of the inclined section, and in the longitudinal direction of the inclined section the height of the inclination differs so that at one end of the inclined section the inclination starts at or near a top of the tread block and the inclination starts more and more deep in the sipe towards the other end of the inclined section.

(12) According to a second aspect there is provided a tire for a vehicle, the tire having a tread block arrangement comprising: a tread block comprising at least a first sipe delimited by a first sipe wall, a second sipe wall and a bottom of the sipe, wherein the first sipe wall and the second sipe wall are arranged parallel to each other and define a width of the sipe, further wherein at least the first sipe wall has at least one indentation to increase an empty volume of the sipe at the location of the indentation, wherein the first sipe wall has an inclined section to form said at least one indentation, wherein a distance between the first sipe wall and the second sipe wall increases towards the bottom of the sipe at the location of the inclined section, and in the longitudinal direction of the inclined section the height of the inclination differs so that at one end of the inclined section the inclination starts at or near a top of the tread block and the inclination starts more and more deep in the sipe towards the other end of the inclined section.

(13) According to a third aspect there is provided a lamella plate for forming a sipe to a tread block arrangement suitable for a tire or for a tread band for a tire, the lamella plate comprising: a first surface for forming a first wall of the sipe; a second surface opposite to the first surface for forming a second wall of the sipe; and a bottom edge for forming a bottom of the sipe, wherein the distance between the first surface and the second surface defines a thickness of the lamella plate and a width of the sipe, wherein the lamella plate further comprises one or more expanded sections for forming at least one inclined section at least to the first wall of the sipe, wherein the thickness of the lamella plate increases towards the bottom edge of the lamella plate at the location of the one or more expanded sections, and the expanded section has a first side and a hypotenuse forming an angle for forming the inclined section so that in the longitudinal direction of the inclined section the height of the inclination differs so that at one end of the inclined section the inclination starts at or near a top of the tread block and the inclination starts more and more deep in the sipe towards the other end of the inclined section.

(14) The dependent claims disclose preferable embodiments. The description explains these embodiments and discloses further embodiments.

---

## Description

### BRIEF DESCRIPTION OF THE DRAWINGS

- (1) FIG. 1*a* shows a pneumatic tire having a tread block arrangement forming the tread of the tire, the tread block arrangement limiting a groove pattern,
- (2) FIG. 1*b* shows applying a tread band onto a preform of a tire,
- (3) FIG. 1*c* shows half of a cross-section of a tire,
- (4) FIG. 2*a* shows, as a top view, a part of a tread block arrangement having sipes,
- (5) FIG. 2*b* shows, as a simplified top view, an example of a tread block having primary sipes and secondary sipes,
- (6) FIGS. 2*c*, 2*d* and 2*e* show examples of cross sections of different kinds of primary sipes having indentations,
- (7) FIG. 3*a* shows as a perspective view an example of a lamella plate for forming the primary sipes, in accordance with an embodiment of the invention,
- (8) FIG. 3*b* shows as a top view an example of a primary sipe formed by the lamella plate of FIG. 3*a*, in accordance with an embodiment of the invention,
- (9) FIG. 4*a* shows, as a top view, a part of another tread block arrangement having sipes,
- (10) FIG. 4*b* shows, as a top view, a part of the tread band of a new tire comprising the primary sipes of FIG. 3*b*, and
- (11) FIG. 4*c* shows, as a top view, the part of the tread band of a worn tire of FIG. 4*b*.

### DETAILED DESCRIPTION

- (12) In this description at least the following terms are used:
- (13) A sipe refers to a narrow groove provided in a tread block of a tire.
- (14) A lamella plate refers to a plate that is usable for forming a sipe in a moulding process. Thus, when a lamella plate is embedded to uncured rubber, and removed therefrom after curing the rubber, the shape of the sipe formed by the lamella plate is geometrically congruent with the lamella plate.
- (15) A lamella refers to a part of rubber arranged in between two sipes.
- (16) As is well known, a tire comprises a tread. The tread is formed of multiple tread blocks, including a first tread block and a second tread block. Each tread block may comprise a number of sipes, such as a primary sipe and a secondary sipe. Thus e.g. a first tread block may limit a primary first sipe and a secondary first sipe. Moreover, a (primary, secondary, etc.) sipe is arranged between two walls, the walls being comprised by the (first, second, etc.) tread block. These side walls are

called as first and second walls. When they concern e.g. a primary sipe, they are called a first primary wall and a second primary wall. Similar notation and/or numbering is also used for some other parts of the tire.

(17) In the following, the primary sipe, the secondary sipe, etc. as well as the first sipe, the second sipe etc. are generally called as the sipe or the primary sipe/secondary sipe, unless otherwise indicated, because the general principles of at least some embodiments are applicable to different sipes irrespective of where in the tire they are located. However, a tire may also have sipes which do not correspond with the structure of the sipes of embodiments of the invention. Such sipes are also called as secondary sipes in this specification.

(18) FIG. 1a shows a pneumatic tire **100** having a tread block arrangement **200** forming a tread **170** of the tire **100**. The tread **170** of the tire **100** (or a tread band **150**) refers to the part that makes contact with a base **900** such as a ground surface (e.g. a road or the ground) when in use. The tread **170** is meant for a rolling contact against the base **900**. The tread **170** is the outermost surface of the tread block arrangement **200**. The tread block arrangement comprises tread blocks **210**, i.e. blocks, as will be detailed below.

(19) The circumferential direction of the tire **100** is indicated by the arrow R in FIG. 1a and with the arrow SC in FIG. 1b. The axial and radial directions of the tire **100** are indicated by the AX and SR, respectively. The tread block arrangement **200** can be formed onto the tire **100** e.g. in a moulding process. As an alternative to moulding, the tread **170** of a tire can be made by applying a tread band **150** onto a preform **110** of a tire to form the tire **100** with the tread **170**. Referring to FIG. 1b, the tread band **150** may be a band extending in a longitudinal direction SL. Herein the longitudinal direction SL is perpendicular to a transversal direction ST and perpendicular to the thickness T of the tread band **150**. Moreover, the band **150** is applied such that the transversal direction ST of the band is applied parallel to the axial direction AX of the tire (see FIG. 1c).

Within the tire **100**, the longitudinal direction SL (See FIG. 1b) of the tread block arrangement is parallel to the circumferential direction SC of the tire **100**; and curves along the circumferential direction SC when the tread block arrangement **200** is on a tire. Moreover, the longitudinal direction of the tread block arrangement, i.e. the circumferential direction SC, is perpendicular to a transversal direction AX and perpendicular to the thickness T (see FIGS. 1b and 1c) of the tread block arrangement **200**. The thickness T is, on a tire, substantially parallel to the radial direction SR. The tread **170** of the tread band **150** faces outwards, and forms the tread **170** of the tire **100**. In this way, the tread band **150** also comprises a tread block arrangement **200** forming the tread **170**.

(20) FIG. 1c shows a half of a cross section of the pneumatic tire **100**. The tread **170** includes a primary boundary B1 and a secondary boundary B2 of the tread block arrangement **200**, and the tread **170** is located in between these boundaries. The transversal direction ST is parallel to the axial direction AX. The radial direction SR is substantially parallel to a normal of the tread **170**, and parallel to the thickness T of the tread block arrangement **200** (or the tread band **150**, if applicable). The circumferential direction SC is perpendicular to the plane of FIG. 1c (see also FIGS. 1a and 1b).

(21) The longitudinal direction of the tread block arrangement **200** is parallel to the longitudinal direction SL of the tread band **150** or parallel to the circumferential direction SC of the pneumatic tire **100**; depending on whether the arrangement **200** is a part of the tread band **150** or the pneumatic tire **100**. The longitudinal direction (SL, SC) may refer to either of the longitudinal directions in this disclosure unless indicated otherwise. The transversal direction (ST, AX) of the tread block arrangement **200** is parallel to the transversal direction ST of the tread band **150** or parallel to the axial direction AX of the pneumatic tire **100**, depending on whether the arrangement **200** is part of the tread band **150** or the pneumatic tire **100**. The thickness of the tread block arrangement **200** is parallel to the radial direction SR of the pneumatic tire **100** or the thickness of the tread band **150**.

(22) FIG. 2a shows a part of a tread block arrangement **200** of a pneumatic tire **100** in more detail.

The tread block arrangement **200** comprises tread blocks **210**, **220**, **230**, **240**. In this description, a block refers to a tread block. Referring to FIG. **2a**, a tread block arrangement **200** may comprise shoulder blocks **220**, **240**, middle blocks **210** and intermediate blocks **230**. In this description, a block refers to a part of the tread block arrangement **200** that is separated from other blocks of the tread block arrangement **200** by a portion of a groove. In this way, a block protrudes in the radial direction SR from a bottom of the grooves. A groove has a depth and a width. The depth of a groove may be at least 6 mm, such as at least 8 mm, such as from 6 mm to 50 mm. The width of a groove may be more than 3 mm, such as more than 4 mm. The width of the groove refers to a dimension that is perpendicular to the depth and a length of the groove, wherein the length of the groove is greater than the width of the groove, and the depth is parallel to a thickness T of the tread. A width of a groove may be e.g. at most 100 mm, such as at most 20 mm. In particular, a tread block arrangement comprises primary shoulder blocks **220** defining a primary boundary B1 of the tread block arrangement **200** (See. FIG. **2a**).

(23) The dimensions of the grooves mentioned above refer to a new tire which has not been in use, but at least the depth of the grooves decreases when the tire is in use.

(24) As indicated in FIGS. **2a** and **2b**, a tread block **210**, **220**, **230** limits a plurality of primary sipes **420**. The primary sipe **420** extends in a longitudinal direction LS of the primary sipe **420** a longer distance than in a direction of width or depth of the primary sipe **420**. The longitudinal direction LS of the primary sipe **420** is indicated in FIG. **2b**. If a cross-section of the primary sipe **420** has a shape of a zig-zag in the longitudinal direction, as it may have, the longitudinal direction LS follows the shape of the sipe **420**, as shown in FIG. **2b**. However, an average longitudinal direction LSa can be defined to extend in between the two ends of the primary sipe **420**. As an alternative, the primary sipe **420** may have a straight shape or a curved shape instead of a zig-zag.

(25) As indicated in FIGS. **2a** and **2b**, the average longitudinal direction LSa of the sipe may be transversal or substantially transversal with respect to the longitudinal direction SL of the tread band **150**. For example, the average longitudinal direction LSa of the primary sipe **420** may form an angle of at most 80 degrees with a transversal direction ST, AX of the tread block arrangement **200**.

(26) It should be noted that FIG. **2a** shows only some tread blocks having sipes but in practical implementations one or more sipes are formed to a majority of the tread blocks **210**, **220**, **230** or even to each tread block **210**, **220**, **230** of the tire **100**.

(27) In an embodiment, the tread block arrangement **200** comprises a primary part **202** and a secondary part **204**. The primary part **202** refers to that part of tread block arrangement **200** that is left in between the longitudinal central line CL and the primary boundary B1. The secondary part **204** refers to that part of tread block arrangement **200** that is left in between the longitudinal central line CL and the secondary boundary B2.

(28) FIG. **2b** shows one tread block **210**, **220**, **230** as a top view, according to an example of the invention. The tread block **210**, **220**, **230** comprises three primary sipes **420**, but it is possible that a tread block **210**, **220**, **230** can have only one or two primary sipes or more than three primary sipes **420**. It may also be possible that some tread blocks are without any sipes **420** or have only secondary sipes **430**.

(29) The primary sipes **420** of the tread block **210**, **220**, **230** of FIG. **2b** extend from one edge **211** of the tread block to the other edge **212** of the tread block **210**, **220**, **230**. In other words, one end **421** of the primary sipe **420** coincides one edge **211** of the tread block and another end **422** coincides the other edge **212** of the tread block, preferably in the longitudinal direction of the tread block. However, the primary sipes **420** may also be formed so that they are totally within the tread block and do not continue to either edge of the tread block, or that only one end of the primary sipe continues to an edge **211**, **212** of the tread block **210**. In that case, water and slush removal efficiency of the primary sipes may not be so high than when at least one end of the primary sipes stretches to an edge of the tread block, as is illustrated in FIG. **2b**.

(30) In FIG. 2b the primary sipes **420** have flat sections **423** and inclined sections **424**. The inclined sections **424** form at least one indentation **428** to the primary sipe **420**, wherein a distance between the first sipe wall **425** and the second sipe wall **426** (FIG. 2c) increases towards the bottom **427** of the sipe at the location of the inclined section **424**, but the width of the primary sipe **420** at both ends **421**, **422** in a longitudinal direction of the sipe is without the indentations. The indentations are not normally visible when the tread band is looked at the top but may become partly or totally visible when the tire wears. FIGS. 4b and 4c illustrate this showing a part of the tread band of a new tire (FIG. 4b) and a corresponding part of a worn tire (FIG. 4c).

(31) The cross sections of a tread block of the examples shown in FIGS. 2c, 2d and 2e are illustrative only and they are not drawn in scale and they are not showing possible details behind the cross section. FIG. 2c depicts an example where the inclined section **424** does not start immediately at the top of the surface of the tread block **210** but at a distance b from the surface of the tread block **210**. Hence, the width w of the sipe may first be substantially constant and starts to increase at the location where the inclined section **424** starts. FIG. 2d depicts an example where the inclined section **424** starts immediately at the top of the surface of the tread block **210**. FIG. 2e depicts an example where the wall **426** of the inclined section **424** is slightly curved in the vertical direction and possibly also in the horizontal direction wherein the surface of the wall **426** of the inclined section **424** is at least partly convex. The indentation increases an empty volume V of the sipe **420** at the location of the indentation.

(32) In accordance with some examples of the invention the indentation of the inclined section **424** can also be formed in such a way that in the longitudinal direction of the inclined section **424** the height of the inclination differs e.g. so that at one end of the inclined section **424** the inclination starts at or near the top of the tread block (i.e. the distance b is 0 or almost zero) and when proceeding towards the other end of the inclined section **424** the inclination starts more and more deep in the sipe (i.e. the distance b increases being the same or almost the same than the depth d of the sipe). This kind of sipe is illustrated in FIG. 3b and a lamella plate **490** for forming such a sipe is illustrated in FIG. 3a. As can be seen from FIG. 3a the indentation forms a kind of a sail.

(33) It should be noted that the depth d of the sipe need not be constant but may vary in the longitudinal direction of the sipe. Respectively, the height h of the lamella plate **490** may vary in the longitudinal direction. For example the example of the lamella plate **490** in FIG. 3a shows two locations **497** in which the bottom edge of the lamella plate **490** (i.e. the lower edge in the figure) is narrower (the height h is smaller) than at other parts of the lamella plate **490**. This has the consequence that the bottom of the sipe is lower at the corresponding locations. This may improve the stiffness of the lamellas between two adjacent sipes.

(34) As an example, the depth of the lower (shallow) parts of the primary sipe (and the narrower parts **497** of the lamella plate **490**) is from 0.1 mm to 2 mm, preferably from 0.15 mm to 1.0 mm, more preferably from 0.2 mm to 0.5 mm. The depth is preferably as small as practically possible, keeping in mind that a corresponding flat part of the lamella plate **490** requires some strength to join the tall parts. As an example, the depth of the shallow parts may be 0.3 mm, when the lamella plate **490** is made from steel. In an embodiment, the depth of both of the deep parts are from 5 mm to 15 mm, preferably from 6 mm to 8 mm. Typically the deep parts are somewhat shallower than the grooves. This also improves the stiffness of the tread blocks, while maintaining the water drainage properties of the grooves. As an example the depths of both of the deep parts are at most 90% of a depth of a groove of the tire. A depth of the grooves may be e.g. from 6 mm to 50 mm, such as from 6 mm to 15 mm, such as from 7 mm to 10 mm.

(35) When considering the shoulder blocks **220** i.e. those blocks at the edges of the tire **100**, one edge of the tread block may end to a groove and the opposite end of the tread block may end to the edge of the tire. On the other hand, when considering the middle blocks **210** and intermediate blocks **230**, i.e. those blocks between the shoulder blocks in the axial direction AX of the tire **100**, both edges of the tread block **210**, **230** may end to a groove in the tread.



(36) Such a primary sipe **420** has the effect that, because of the shallow part (or shallow parts), the primary sipe **420** does not significantly affect the stiffness of the tread block, in which the primary sipe **420** is arranged. The stiffness is not significantly affected, since the shallow part or shallow parts bind the neighbouring lamellas **430a**, **430b** together, whereby the stiffness remains intact. The term “lamella” refers to the rubber material in between two neighbouring sipes or in between a sipe and a groove. A lamella **430** is typically relatively thin, e.g. from 1 mm to 7 mm, the thickness referring to the distance in between the sipes (or the sipe and groove) defining the lamella.

Advantageously the lamella is from 3 to 7 mm, preferably from 4 to 6 mm thick. The aforementioned neighbouring lamellas **430a**, **430b** are the two lamellas, in between which the primary sipe **420** (and only the primary sipe **420**) is left. FIG. **2b** shows an example of the first lamella **430a** and the second lamella **430b**. Hence, a wall of the first lamella **430a** forms the first sipe wall **425** and a wall of the second lamella **430b** opposite to the wall of the first lamella **430a** forms the second sipe wall **426**, wherein a distance between the first lamella **430a** and the second lamella **430b** defines the width of the first sipe **420**, and a height of the first lamella **430a** and the second lamella **430b** define a height of the first sipe **420**.

(37) The primary sipes **420** can be manufactured, for example, by using the above mentioned lamella plate **490**, an example of which is depicted in FIG. **3a**. In practice, a plurality of such lamella plates **490** shall be used in manufacturing of a tire **100**, but it is sufficient to describe the process using one lamella plate **490** as an example. The lamella plate **490** is inserted into the tire **100** or tread band **150** during vulcanization of the polymer material, e.g. rubber, of the tread **170**. After vulcanization, the lamella plate **490** may be removed from the tire **100** or the tread band **150**. Referring to FIG. **3a**, the lamella plate **490** comprises flat sections **491** and expanded sections **492**. When the primary sipe **420** is formed, the expanded sections **492** of the lamella plate **490** form the inclined sections **424**.

(38) In the following, some details of the lamella plate **490** of FIG. **3a** and the corresponding primary sipe **420** will be described in more detail.

(39) In this example the lamella plate **490** forms a kind of a zig-zag pattern in the longitudinal direction. In the following, some terms regarding the zig-zag pattern are described. The zig-zag pattern has longer parts **493** (wider sections) and shorter parts **494** (narrower sections) at an angle with respect to each other. According to an example the angle is about 90°-120° but can be different from that. The locations where one longer part **493** and one shorter part **494** are joined, can be called as a corner **495** or a turning point or a knee or a deflection point. Different corners **495** may have different angles. In the example of FIG. **3a** three of the longer parts **493** form three flat sections **491** and two of the longer parts form the expanded sections **492** so that every other longer part **493** has the expanded section **492**. The expanded sections have been formed so that there is an insert or add-on part **496** attached with the longer part **493**.

(40) The lamella plate **490** has a first surface **490a** for forming the first wall **424** of the sipe **420** and a second surface **490b** (not visible on FIG. **3a**) opposite to the first surface **490a** for forming the second wall **426** of the sipe **420** and a bottom edge **490c** for forming the bottom of the sipe. The distance between the first surface **425** and the second surface **426** of the sipe **420** defines a thickness of the lamella plate **490** and a width  $w$  of the sipe **420**.

(41) In accordance with an embodiment of the lamella plate **490**, a top of the expanded section **492** is below a top edge **490d** opposite to the bottom edge **490c** of the lamella plate **490**, a bottom of the expanded section **492** is at a bottom edge **490c** of the lamella plate **490**, and a thickness of the lamella plate **490** is constant at the top edge **490d**.

(42) Alternatively, the lamella plate **490** may be formed by a moulding process using a mould, wherein the mould has formed so that it follows the desired form of the lamella plate **490** as a mirrored image. In other words, the form of the mould could be similar to the form of the primary sipe. Another alternative is to use a punching process in which an appropriately designed tool (a punch) of a punch press is forced through a sheet of an appropriate material such as metal, wherein

the tool forces a piece of the sheet to the desired form and separates the lamella plate from the sheet.

(43) In the example of FIG. 3a the add-on parts **496** are kind of triangles having two sides and a hypotenuse. A first side of the triangle (a.k.a. the base of the triangle) substantially corresponds the length of the respective longer part **493** and a second side of the triangle (a.k.a. the height of the triangle) substantially corresponds the height  $h$  of the respective longer part **493**. In the example of FIG. 3a a first add-on **492a** has the length  $l_1$  and height  $h_1$  and a second add-on **492b** has the length  $l_2$  and height  $h_2$ . The first side and the hypotenuse form an angle  $\alpha_1$  in the first add-on **492a** and  $\alpha_2$  in the second add-on **492b** as is indicated in FIG. 3a.

(44) It should be noted that the length of the add-on **492** (the length of the extended section) need not correspond with the length  $l$  of the longer part **493** of the lamella plate **490**, but can also be shorter. Respectively, the height of the add-on **492** (the width of the extended section) need not correspond with the height  $h$  of the longer part **493** of the lamella plate **490**, but can also be lower.

(45) In accordance with an example, the first angle  $\alpha_1$  may be about  $39^\circ$  and the second angle  $\alpha_2$  may be about  $35^\circ$ . If the height of the first add-on **492a** changes  $\pm 1.0$  mm and the length changes  $\pm 1.5$  mm, the first angle  $\alpha_1$  may vary between  $30^\circ$  and  $47^\circ$ . If the height of the second add-on **492a** changes  $\pm 1.0$  mm and the length changes  $\pm 1.5$  mm, the second angle  $\alpha_2$  may vary between  $26^\circ$  and  $45^\circ$ . It should be noted that these figures are just example of how changes in the height and/or length may affect to the angles  $\alpha_1$  and  $\alpha_2$ .

(46) If the tire **100** will also have secondary sipes which do not have the inclined sections they can be formed in the same way by utilizing a lamella plate designed for that purpose (not shown).

(47) As an alternative for using the lamella plates **490** in the manufacturing of the sipes to a tire **100**, a moulding process may be utilized. In that case a mould having a mirror image of the intended form of the tire **100** (including the grooves and sipes) is formed.

(48) The sipe **420** made by the lamella plate **490** has the same form as the lamella plate **490** but as a mirrored image. Hence, if the inclined sections of the primary sipe should be convex, the expanded sections of the lamella plate are respectively concave,

(49) The primary sipes **420** are transversal sipes. A transversal sipe **420** extends in an average longitudinal direction LSa that forms an angle of at most 80 degrees with the transversal direction ST, AX of the tread block arrangement **200**. What has been said above about the longitudinal direction LS and the average longitudinal direction LSa of the primary sipe **420** applies to also to directions of other sipes, mutatis mutandis.

(50) In an embodiment, at least half of the primary shoulder blocks **220** are provided with primary sipes **420** as discussed above for one of the primary shoulder blocks **220**. Thus, in an embodiment, at least half of the primary shoulder blocks **220** are provided with a primary sipe **420**.

(51) In an embodiment, all the primary shoulder blocks **220** are provided with primary sipes **420** as discussed above for one or more of the primary shoulder blocks **220**. Thus, in an embodiment, all the primary shoulder blocks **220** are provided with a primary sipe **420**.

(52) FIG. 4a shows another example of a part of a tread block arrangement **200** of a tire **100**. In this example the tread block arrangement **200** comprises shoulder blocks **220**, middle blocks **210** and intermediate blocks **230**.

(53) Referring to FIG. 2a, a tread **170** typically comprises also secondary shoulder blocks **240** defining a secondary boundary B2 such that a central line CL is left in between the primary boundary B1 and the secondary boundary B2. FIG. 2a shows the primary shoulder blocks **220** and the secondary shoulder blocks **240** in addition to the primary boundary B1 and the secondary boundary B2, and the central line CL. In addition the curved line CP denotes a central part of the tread **170** irrespective of its details. The central part CP comprises blocks.

(54) In an embodiment, at least half of the secondary shoulder blocks **240** are provided with primary sipes **420**, and at least the secondary sipes **420b** for one of the secondary shoulder blocks **240**. In an embodiment, all the secondary shoulder blocks **240** are provided with primary sipes **420**,

at least the secondary sipes **420b** for one or more of the secondary shoulder blocks **240**.

(55) As indicated above, each block **210**, **220** of the tread block arrangement **200** is separated from another block **210**, **220** of the tread block arrangement **200** by a portion of a groove pattern **310**.

(56) In accordance with an embodiment of the invention a top of the inclined section **424** is below a top of the sipe **420** and a bottom of the inclined section is at the bottom **427** of the sipe.

(57) In accordance with an embodiment of the invention the distance between the first sipe wall **425** and the second sipe wall **425** is constant at the top of the sipe **420** in a longitudinal direction LS of the sipe **420**.

(58) In accordance with an embodiment of the invention the first sipe wall **425** has a plurality of inclined sections **424** to form a plurality of indentations **428**.

(59) In accordance with an embodiment of the invention both the first sipe wall **425** and the second sipe wall **426** have one or more inclined sections **424**.

(60) In accordance with an embodiment of the invention the tread block arrangement **200** comprises at least a first lamella **430a** and a second lamella **430b**, wherein a wall of the first lamella **430a** forms the first sipe wall **425** and a wall of the second lamella **430b** opposite to the wall of the first lamella **430a** forms the second sipe wall **426**. A distance between the first lamella **430a** and the second lamella **430b** defines the width  $w$  of the first sipe **420**, and a height of the first lamella **430a** and the second lamella **430b** define a height  $h$  of the first sipe **420**.

(61) In accordance with an embodiment of the invention the top of the sipe forms a zig-zag pattern and the bottom **427** of the sipe forms a series of triangles.

(62) In accordance with an embodiment of the invention the inclined section **424** starts from a predetermined distance greater than zero from the top of the sipe **420**.

(63) In accordance with an embodiment of the invention a surface of the inclined section **424** is flat or convex.

(64) In accordance with an embodiment of the invention the first sipe wall **425** and the second sipe wall **426** have a plurality of indentations **424** so that indentations of the first sipe wall **425** and indentations of the second sipe wall **426** are located in an alternating manner in a longitudinal direction LS of the sipe **420**.

(65) In accordance with an embodiment of the invention a width  $w$  of the sipe **420** at both ends in a longitudinal direction LS of the sipe **420** is without the indentations, wherein a width  $w$  of the sipe at both ends is constant.

(66) In accordance with an embodiment of the invention a width  $w$  of the sipe **420** at the location of the indentations **424**, which are visible from the top of the sipe **420**, are indicative of weariness of the tread block arrangement **200**.

(67) In accordance with an embodiment of the invention the tire **100** comprises a plurality of tread blocks **210**, **220**, **230**, **240** around a circumference of the tire **100**.

(68) In accordance with an embodiment of the invention only a part of the plurality of tread blocks **210**, **220**, **230**, **240** of the tire **100** comprises sipes **420** having inclined sections **424**.

(69) In accordance with an embodiment of the invention the tire **100** comprises shoulder tread blocks **210**, **240** at both edges of the tread block arrangement **200**, and middle tread blocks **210** between the shoulder tread blocks in a transversal direction of the tread block **200** arrangement with respect to the circumferential direction SC of the tire **100**, wherein only the shoulder tread blocks **210**, **240** comprise sipes **420** having inclined sections **424**.

(70) In accordance with an embodiment of the invention a top of the expanded section **492** of the lamella plate **490** is below a top edge **490d** opposite to the bottom edge **490c** of the lamella plate **490**, a bottom of the expanded section **492** is at a bottom edge **490c** of the lamella plate **490**, and a thickness of the lamella plate **490** is constant at the top edge **490d**.

(71) In accordance with an embodiment of the invention the distance between the first sipe wall **425** and the second sipe wall **426** is constant at the top of the sipe **420**.

(72) In accordance with an embodiment of the invention the lamella plate **490** comprises a plurality

of deflection points **495** so that the deflection points **495** form a zig-zag pattern having narrower sections **494** and wider sections **493**, wherein the expanded sections **492** are located in one or more of the wider sections **493**.

(73) In accordance with an embodiment of the invention the expanded sections **492** of the lamella plate **490** are located in every other of the wider sections **493**, wherein there is one wider section **493** without the expanded section **492** between each two wider section **493** having the expanded section **492**. An example of this is illustrated in FIG. **3a** in which the lamella plate **490** has the first add-on **492a** in the second wider section **493** (from the left in the arrangement of FIG. **3a**), the next (third) wider section **493** in the longitudinal direction being without the add-on, and the next (fourth) wider section **493** having the second add-on **492b**.

(74) In accordance with an embodiment of the invention the lamella plate **490** comprises wider sections **493** at both ends of the lamella plate, wherein the wider sections **493** at both ends of the lamella plate **490** are without the expanded sections **492**.

(75) In accordance with an embodiment of the invention a surface of the expanded section **492** of the lamella plate **490** is flat or concave.

## Claims

1. A tread block arrangement for a tire or for a tread band for a tire, the tread block arrangement comprising: a tread block comprising a sipe delimited by a first sipe wall, a second sipe wall and a bottom of the sipe, wherein the first sipe wall and the second sipe wall are arranged parallel to each other and define a width of the sipe, wherein at least the first sipe wall has at least one indentation to increase an empty volume of the sipe at a location of the indentation, wherein the first sipe wall has an inclined section to form said at least one indentation, wherein a distance between the first sipe wall and the second sipe wall increases towards the bottom of the sipe at a location of the inclined section, and wherein in a longitudinal direction of the inclined section a height of inclination differs so that the inclination starts deeper in the sipe from one end towards an other end of the inclined section; wherein a top of the sipe forms a zig-zag pattern and the bottom of the sipe forms a series of triangles; wherein the sipe comprises a first part having a first depth, and a second part having a second depth less than the first depth, wherein portions of the first part are separated by the second part so that a depth of the sipes varies in a longitudinal direction of the sipe; wherein a top of the inclined section is below a top of the sipe, and a bottom of the inclined section is at the bottom of the sipe; and wherein the distance between the first sipe wall and the second sipe wall is constant at the top of the sipe in the longitudinal direction of the sipe throughout an entire length of the sipe.

2. The tread block arrangement according to claim 1, wherein the first sipe wall has a plurality of inclined sections to form a plurality of indentations.

3. The tread block arrangement according to claim 1, wherein both the first sipe wall and the second sipe wall have one or more inclined sections.

4. The tread block arrangement according to claim 1, further comprising: a first lamella, and a second lamella, wherein a wall of the first lamella forms the first sipe wall and a wall of the second lamella opposite to the wall of the first lamella forms the second sipe wall, wherein a distance between the first lamella and the second lamella defines the width of the first sipe, and a height of the first lamella and the second lamella define a height of the first sipe.

5. The tread block arrangement according to claim 1, wherein the inclined section starts from a predetermined distance greater than zero from the top of the sipe.

6. The tread block arrangement according to claim 1, wherein a surface of the inclined section is flat or convex.

7. The tread block arrangement according to claim 1, wherein the first sipe wall and the second sipe wall have a plurality of indentations so that indentations of the first sipe wall and indentations of

the second sipe wall are located in an alternating manner in a longitudinal direction of the sipe.

8. The tread block arrangement according to claim 1, wherein a width of the sipe at both ends in a longitudinal direction of the sipe is without the indentations, wherein a width of the sipe at both ends is constant.

9. A tire for a vehicle comprising the tread block arrangement according to claim 1.

10. The tire according to claim 9, wherein only a part of a plurality of tread blocks comprises sipes having inclined sections.

11. The tire according to claim 9, comprising shoulder tread blocks at both edges of the tread block arrangement, and middle tread blocks between the shoulder tread blocks in a transversal direction of the tread block arrangement with respect to a circumferential direction of the tire, wherein only the shoulder tread blocks comprise sipes having inclined sections.

12. The tread block arrangement according to claim 1, wherein the width of the sipe varies in a longitudinal direction of the sipe.

13. The tread block arrangement according to claim 1, wherein a depth of the second part of the sipe is from 0.1 mm to 2 mm and a depth a first part of the sipe is from 5 mm to 15 mm.

14. The tread block arrangement according to claim 1, wherein the depth the first part of the sipe is at most 90% of a depth of a groove of the tread block arrangement.

15. The tread block arrangement according to claim 1, wherein the first depth is less than a depth of a groove of the tread block arrangement.

16. The tread block arrangement of claim 1, wherein the sipe is totally within the tread block and does not continue to an edge of the tread block.

17. A tread block arrangement for a tire or for a tread band for a tire, the tread block arrangement comprising: a tread block comprising a sipe delimited by a first sipe wall, a second sipe wall and a bottom of the sipe, wherein the first sipe wall and the second sipe wall are arranged parallel to each other and define a width of the sipe, wherein at least the first sipe wall has at least one indentation to increase an empty volume of the sipe at a location of the indentation, wherein the first sipe wall has an inclined section to form said at least one indentation, wherein a distance between the first sipe wall and the second sipe wall increases towards the bottom of the sipe at a location of the inclined section, and wherein in a longitudinal direction of the inclined section a height of inclination differs so that the inclination starts deeper in the sipe from one end towards an other end of the inclined section; wherein a top of the sipe forms a zig-zag pattern and the bottom of the sipe forms a series of triangles; wherein the sipe comprises a first part having a first depth, and a second part having a second depth less than the first depth, wherein portions of the first part are separated by the second part so that a depth of the sipes varies in a longitudinal direction of the sipe; wherein the first sipe wall has a plurality of inclined sections to form a plurality of indentations; and wherein the sipe comprises a flat section arranged between two indentations of said plurality of indentations.

18. The tread block arrangement according to claim 17, wherein the second part of the sipe is provided in the flat section of the sipe.

---