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- (81) **Designated States** (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.
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**Declarations under Rule 4.17:**

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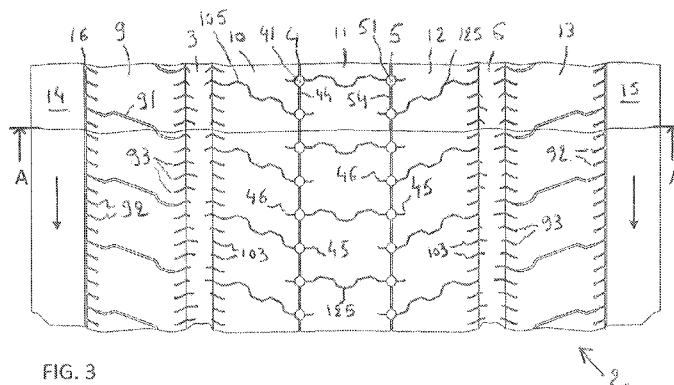
(54) **Title:** TRUCK TIRE TREAD AND TRUCK TIRE

FIG. 3

(57) **Abstract:** Heavy truck tire tread (1) having a longitudinal direction, a lateral direction and a thickness direction, said tread having a ground-engaging contact surface (CS) and comprising at least four main longitudinal grooves (3, 4, 5, 6) defining at least five main longitudinal ribs (9, 10, 11, 12, 13), the at least four main longitudinal grooves comprising at least one and not more than three open grooves (3, 6) and at least two partially hidden grooves (4, 5), each of said at least two partially hidden grooves comprising openings (41, 51) to the ground-engaging contact surface and an undersurface channel (42, 52) that is connected to the openings by ducts (43, 53) extending substantially in the thickness direction, longitudinal sipes (44, 54) extending substantially along the longitudinal direction connecting successive openings to the channel, said tread comprising at least two non-shoulder main ribs (10, 11, 12), said at least two non-shoulder main ribs comprising lateral sipes (105, 115, 125) extending in the lateral direction, the tread comprising at least 120 of said lateral sipes, wherein for each partially hidden groove: \* - a total surface area of all openings is less than 200 cm<sup>2</sup>; \* - an average height of said channel is greater than 5 mm; and \* - an average section area of said channel is greater than 15 mm<sup>2</sup>.



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## TRUCK TIRE TREAD AND TRUCK TIRE

### BACKGROUND OF THE INVENTION

#### Field of the Invention

[0001] This invention relates generally to a tire tread. More specifically, this invention relates to tire treads for heavy trucks, in particular tires for free-rolling wheels thereof (so called steer positions and trailer positions), especially tires for steer positions.

#### Description of the Related Art

[0002] Tire treads generally extend about the outer circumference of a tire to operate as the intermediary between the tire and a surface upon which it travels (the operating surface). Contact between the tire tread and the operating surface occurs along a footprint of the tire. Tire treads provide grip to resist tire slip that may result during tire acceleration, braking, and/or cornering. Tire treads may also include tread elements, such as ribs or lugs, and tread features, such as grooves and sipes, each of which may assist in providing target tire performance when a tire is operating under particular conditions. The tread pattern generally includes repetitions of identical sub-patterns, the length of such sub-pattern being referred to as the “pitch”. Each rib (seen in isolation) may have its own pitch and this pitch may be different from the pitch of the full tread including all tread elements and features.

[0003] One common problem faced by tire manufacturers is how to increase the wear resistance.

[0004] A solution is to increase the ratio of the tread surface being in contact with the operating surface. This ratio is known as the Contact Surface Ratio (CSR). Increasing the CSR is known to be beneficial for wear life. However, increasing the CSR is also known for harming the wet braking adherence performance of the tread. Wet braking adherence performance is a very important element that must not only be obtained with an unworn tread but also throughout the useful life of the tread as it progressively wears out.

[0005] Irregular wear is also a great concern as it can provoke vibrations becoming sensible by the driver in the steering wheel or produce a poor looking wear pattern, both of which leading to the tire being often removed from service at an early stage of its wear life.

[0006] Therefore, to further increase the wear performance of tires it may be desirous to propose a novel way to design a tire tread that would not result in compromising its wet braking performance or its resistance to irregular wear.

### SUMMARY OF THE INVENTION

[0007] The invention provides for a heavy truck tire tread having a longitudinal direction, a lateral direction and a thickness direction, said tread having a ground-engaging contact surface and comprising at least four main longitudinal grooves defining at least five main longitudinal ribs, the at least four main longitudinal grooves comprising at least one and not more than three open grooves and at least two partially hidden grooves, each of said at least two partially hidden grooves comprising openings to the ground-engaging contact surface and an undersurface channel that is connected to the openings by ducts extending substantially in the thickness direction, longitudinal sipes extending substantially along the longitudinal direction connecting successive openings to the channel, said tread comprising at least two non-shoulder main ribs, said at least two non-shoulder main ribs comprising lateral sipes extending in the lateral direction, the tread comprising at least 120 of said lateral sipes, wherein for each partially hidden groove:

- a total surface area of all openings is less than 200 cm<sup>2</sup>;
- an average height of said channel is greater than 5 mm; and
- an average section area of said channel is greater than 15 mm<sup>2</sup>.

[0008] Preferably, the total surface area of all openings is less than 100 cm<sup>2</sup>.

[0009] Preferably, the average section area of all ducts having a mean section area of at least 5 mm<sup>2</sup> is less than 100 mm<sup>2</sup>.

[0010] Preferably, the ratio between an average height of said lateral sipes and a tread depth is greater than 0.33.

[0011] Preferably, the ratio between the average height of said lateral sipes and the tread depth is greater than 0.5 and wherein the tread comprises at least 300 of said lateral sipes.

[0012] Preferably, the ratio between the average section area of all said ducts having a mean section area of at least 5 mm<sup>2</sup> and the average section area of the longitudinal channel is less than 1.

[0013] Preferably, each partially hidden groove comprises at least 100 openings to the ground-engaging contact surface (more preferably, at least 200).

[0014] Preferably, said lateral sipes are connected to the ducts.

[0015] Preferably, each of said ducts has at least one lateral edge sipes.

[0016] Preferably, said longitudinal sipes are undulated along the longitudinal direction of the tread.

[0017] Preferably, said lateral sipes are undulated along the lateral direction of the tread.

[0018] Preferably, said lateral and longitudinal sipes are undulated along the thickness direction of the tread.

[0019] Preferably, the tread pattern is directional.

[0020] Preferably, said lateral sipes are inclined relative to the lateral direction.

[0021] Preferably, said lateral sipes are inclined relative to the thickness direction.

[0022] The invention also provides for a heavy truck tire comprising such a tread.

[0023] The foregoing and other objects, features and advantages of the invention will be apparent from the following more detailed descriptions of a particular embodiment of the invention.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

[0024] FIG. 1 is a front view of a heavy truck tire comprising an embodiment of the disclosed tire tread.

[0025] FIG. 2 is a perspective view of the heavy truck tire of FIG. 1.

[0026] FIG. 3 is a front view of part of the tread of FIG. 1 and 2 showing details of its design at a much bigger scale.

[0027] FIG. 4 is a section view of the tread taken along curved line A-A on FIG. 3 showing other details of its design.

[0028] FIG. 5 is a magnified view of a detail D taken from FIG. 4.

### DETAILED DESCRIPTION OF A PARTICULAR EMBODIMENT

[0029] Reference will now be made in detail to an embodiment of the invention, example of which is illustrated in the drawings. This example is provided by way of explanation of the invention.

[0030] As shown in FIG. 1 and 2, a heavy truck tire 1 comprises a tread 2 according to an embodiment of the invention.

[0031] The tread 2 has a contact surface CS for engaging the operating surface on which the tire is rolling and the tire has sidewalls SW.

[0032] The tread has a longitudinal direction (also referred to as the circumferential direction), a lateral direction (also referred to as the axial or transverse direction) and a thickness direction (also referred to as the tread depth direction).

[0033] The tread has four main longitudinal grooves 3, 4, 5 and 6 going continuously around the circumference of the tire. Between tread shoulders 7 and 8, the four main longitudinal grooves define five main ribs 9, 10, 11, 12 and 13.

[0034] As better visible from the section view of FIG. 4, the tread may also include sacrificial ribs 14 and 15 defined respectively next to the shoulders 7 and 8 by sacrificial grooves 16 and 17. Compared to main ribs, sacrificial ribs are much thinner and their contact surface is offset to a lower radius. Sacrificial ribs have been used for years in heavy truck tires, especially for long haul steer axle application, to combat irregular wear; they are not providing a significant effect on the traction or braking performances of the tire.

[0035] The main grooves 3 and 6 closest to the tread shoulders will now be referred to as the “shoulder grooves”. The main grooves 4 and 5 located in the center of the tread will now be referred to as the “intermediate grooves”.

[0036] The main ribs 9 and 13 between shoulders and shoulder grooves will now be referred to as the “shoulder ribs”. The main ribs 10 and 12 between shoulder grooves and intermediate grooves will now be referred to as the “intermediate ribs”. The rib 11 between the two intermediate grooves 4 and 5 will now be referred to as the “center rib”. In a tread having six main ribs (and not five as in the described embodiment), there would be two center ribs, one on either side of a center groove.

[0037] As better visible on the combination of FIG. 3 and 4 which are showing a portion of the disclosed tread 2 at a much bigger scale, the main grooves 3, 4, 5 and 6 are either open grooves or partially hidden grooves. A partially hidden groove is a groove which is not fully visible because openings alternate with portions where only a narrow cut is connecting an undersurface channel to the contact surface of the tread. Narrow cuts in tread are referred to as “sipes”. Compared to an open groove, a partially hidden groove allows for a greater contact surface area but is still able to efficiently convey water out of the contact patch when the tire is rolling on a wet ground.

[0038] According to the invention, the tread has at least one and not more than three open grooves and at least two partially hidden grooves.

[0039] In an embodiment of the invention and as represented in the drawings, the two shoulder grooves 3 and 6 are open grooves and the two intermediate grooves 4 and 5 are partially hidden grooves.

[0040] In the partially hidden grooves 4 and 5, openings 41 and 51 in the contact surface CS connect respectively with undersurface channels 42 and 52 via ducts 43 extending in the thickness direction of the tread.

[0041] It is apparent especially from FIGS. 4 and 5, that at a point in the wear life of the tread, the tread will have worn to an extent that the channels emerge at the contact surface and provide additional open grooves.

[0042] In the embodiment of FIGS. 1 to 5, the ducts have a generally cylindrical shape. In this embodiment, the openings have a diameter of 4 mm (section area of 12.6 mm<sup>2</sup>) and there are 240 of them for each intermediate groove in this embodiment of the invention. The total surface area of the openings is therefore as low as 60.3 cm<sup>2</sup>.

[0043] The undersurface channels 42 and 52 are 5 mm wide and 7 mm high in average, their average section area being 31 mm<sup>2</sup>.

[0044] In this embodiment, the section area of the ducts is much smaller than the section area of the channels, the ratio between the section area of the ducts and the section area of the longitudinal channel is about 0.4. If the ducts have variable sections along their length and different sizes between, this ratio must be calculated using the average section area of those ducts having a mean section area of at least 5 mm<sup>2</sup>, excluding smaller ones from the

average. Similarly if the channel has a variable section area along its length, it has to be averaged over its full length.

[0045] The drawings showing only one embodiment with cylindrical ducts, it is understood that ducts may have a different size or shape (the openings being for instance substantially rectangular with the longer side in the longitudinal direction) and the ducts may be in a different number. For instance, another embodiment of the invention would have a lower number of ducts, the ducts having a greater section area.

[0046] Longitudinal sipes **44** and **54** connect their respective channel and ducts to the contact surface **CS** as best visible from FIG. **5**. Those sipes may be straight as shown by the section view or they may be undulated along the thickness direction of the tread in order for both sides of the sipe to interlock when the tread rubber is being compressed in the tire contact patch.

[0047] The intermediate ribs **10** and **12** have lateral sipes **105** and **125** extending across them. Those sipes may be more or less high but preferably (as shown in dotted lines on FIG. **4** and **5**) their height is comparable to the length of the ducts **43** on which they connect.

[0048] The ratio between the average height of said lateral sipes and the tread depth is about 0.65 in this embodiment. There are 120 lateral sipes for each intermediate rib in this embodiment.

[0049] As shown on FIG. **3**, seen from above the contact surface, the lateral sipes are inclined from the lateral direction. This inclination angle is between 10° and 40°, for instance 25° as shown here when considering where the lateral sipes intersect the edges of the intermediate ribs on the contact surface. In this embodiment, the lateral sipes undulate along their length.

[0050] The center rib **11** also has similar lateral sipes **115** and in the same number as in an intermediate rib. Those sipes are not inclined relative to the lateral direction in order for the tread to keep a substantially symmetric pattern. The full tread has therefore a total of 360 lateral sipes.

[0051] The shoulder ribs **9** and **13** may have engravings **91** and **13**. Those engravings are preferably very shallow to keep the shoulder ribs as solid as possible.

[0052] Narrow lateral edge sipes (so-called micro-sipes) **92**, **93**, **103** are molded along both edges of the shoulder ribs **9** and **13** and on the facing edges of the intermediate ribs **10** and **12**. Similar lateral edge sipes **45** and **46** are connected to the ducts **43**.

[0053] Starting from the contact surface **CS**, lateral sipes and micro-sipes may be inclined by a small angle from the tread thickness direction toward the entrance of the footprint (that is to say in the rotation direction of the tire, see arrows on the shoulders of the tread). This angle is between 5° and 25°, for instance 12°.

[0054] As visible on FIG. **4**, the bottom of the open grooves is protected by stone ejectors **35**. Stone ejectors may also be provided at the bottom of the channels in their open sections (where the ducts connect to the channel).

[0055] As visible on the drawings, the tread pattern is directional, meaning that the tire has to be mounted in a given direction to perform consistently. The preferred rolling direction is generally indicated by arrows molded on the shoulders of the tread.

[0056] It should be understood from the foregoing description that various modifications and changes may be made to the embodiments of the present invention without departing from its true spirit. The foregoing description is provided for the purpose of illustration only and should not be construed in a limiting sense. Only the language of the following claims should limit the scope of this invention.

## CLAIMS

What is claimed is:

1. A heavy truck tire tread (1) having a longitudinal direction, a lateral direction and a thickness direction, said tread having a ground-engaging contact surface (CS) and comprising at least four main longitudinal grooves (3, 4, 5, 6) defining at least five main longitudinal ribs (9, 10, 11, 12, 13), the at least four main longitudinal grooves comprising at least one and not more than three open grooves (3, 6) and at least two partially hidden grooves (4, 5), each of said at least two partially hidden grooves comprising openings (41, 51) to the ground-engaging contact surface and an undersurface channel (42, 52) that is connected to the openings by ducts (43, 53) extending substantially in the thickness direction, longitudinal sipes (44, 54) extending substantially along the longitudinal direction connecting successive openings to the channel, said tread comprising at least two non-shoulder main ribs (10, 11, 12), said at least two non-shoulder main ribs comprising lateral sipes (105, 115, 125) extending in the lateral direction, the tread comprising at least 120 of said lateral sipes, wherein for each partially hidden groove:
  - a total surface area of all openings is less than 200 cm<sup>2</sup>;
  - an average height of said channel is greater than 5 mm; and
  - an average section area of said channel is greater than 15 mm<sup>2</sup>.
2. A heavy truck tire tread according to claim 1 wherein the total surface area of all openings is less than 100 cm<sup>2</sup>.
3. A heavy truck tire tread according to any preceding claim wherein the average section area of all ducts having a mean section area of at least 5 mm<sup>2</sup> is less than 100 mm<sup>2</sup>.
4. A heavy truck tire tread according to any preceding claim wherein the ratio between an average height of said lateral sipes and a tread depth is greater than 0.33.
5. A heavy truck tire tread according to any preceding claim wherein the ratio between the average height of said lateral sipes and the tread depth is greater than 0.5 and wherein the tread comprises at least 300 of said lateral sipes.

6. A heavy truck tire tread according to any preceding claim wherein the ratio between the average section area of all said ducts having a mean section area of at least 5 mm<sup>2</sup> and the average section area of the longitudinal channel is less than 1.
7. A heavy truck tire tread according to any preceding claim wherein each partially hidden groove comprises at least 100 openings to the ground-engaging contact surface.
8. A heavy truck tire tread according to any preceding claim wherein said lateral sipes are connected to the ducts.
9. A heavy truck tire tread according to any preceding claim wherein each of said ducts has at least one lateral edge sipes (45).
10. A heavy truck tire tread according to any preceding claim wherein said longitudinal sipes are undulated along the longitudinal direction of the tread.
11. A heavy truck tire tread according to any preceding claim wherein said lateral sipes are undulated along the lateral direction of the tread.
12. A heavy truck tire tread according to any preceding claim wherein said lateral and longitudinal sipes are undulated along the thickness direction of the tread.
13. A heavy truck tire tread according to any preceding claim wherein the tread pattern is directional.
14. A heavy truck tire tread according to any preceding claim wherein said lateral sipes are inclined relative to the lateral direction.
15. A heavy truck tire tread according to any preceding claim wherein said lateral sipes are inclined relative to the thickness direction.
16. A heavy truck tire comprising a tread according to any preceding claim.

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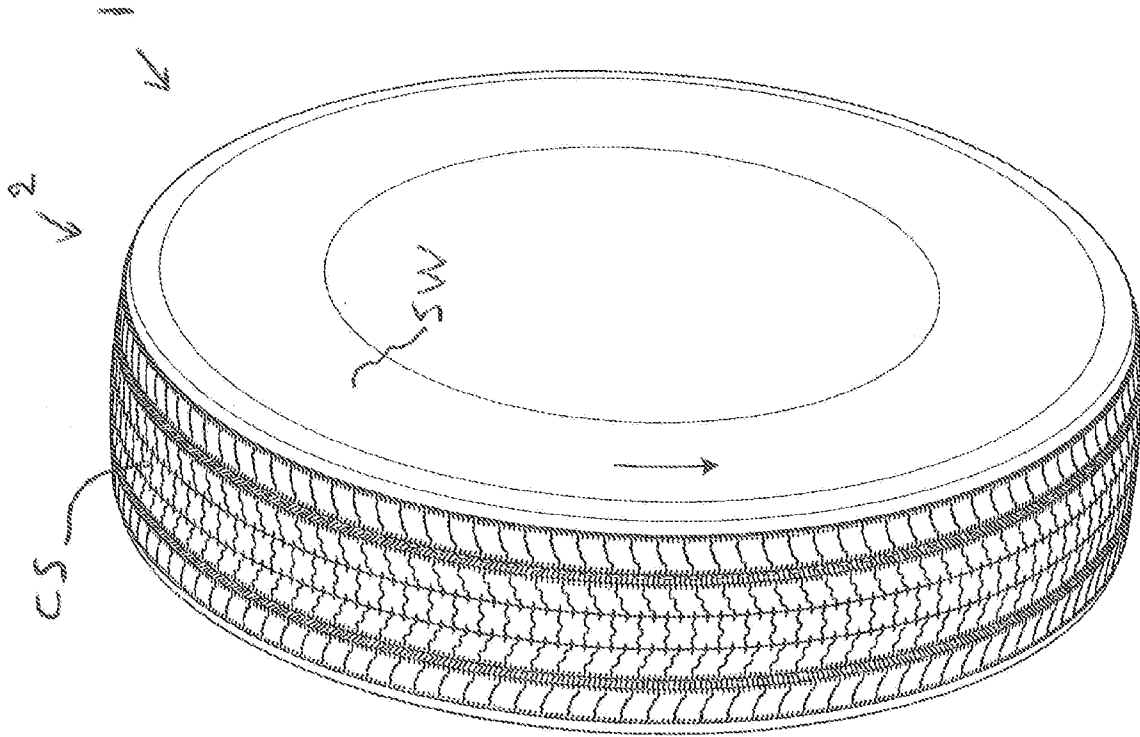


FIG. 2

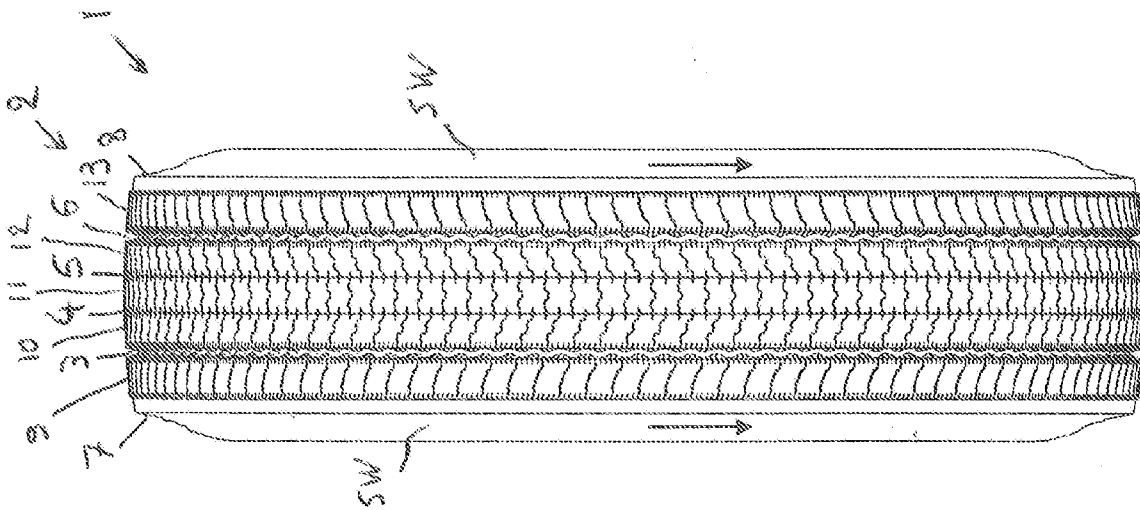


FIG. 1

2/2

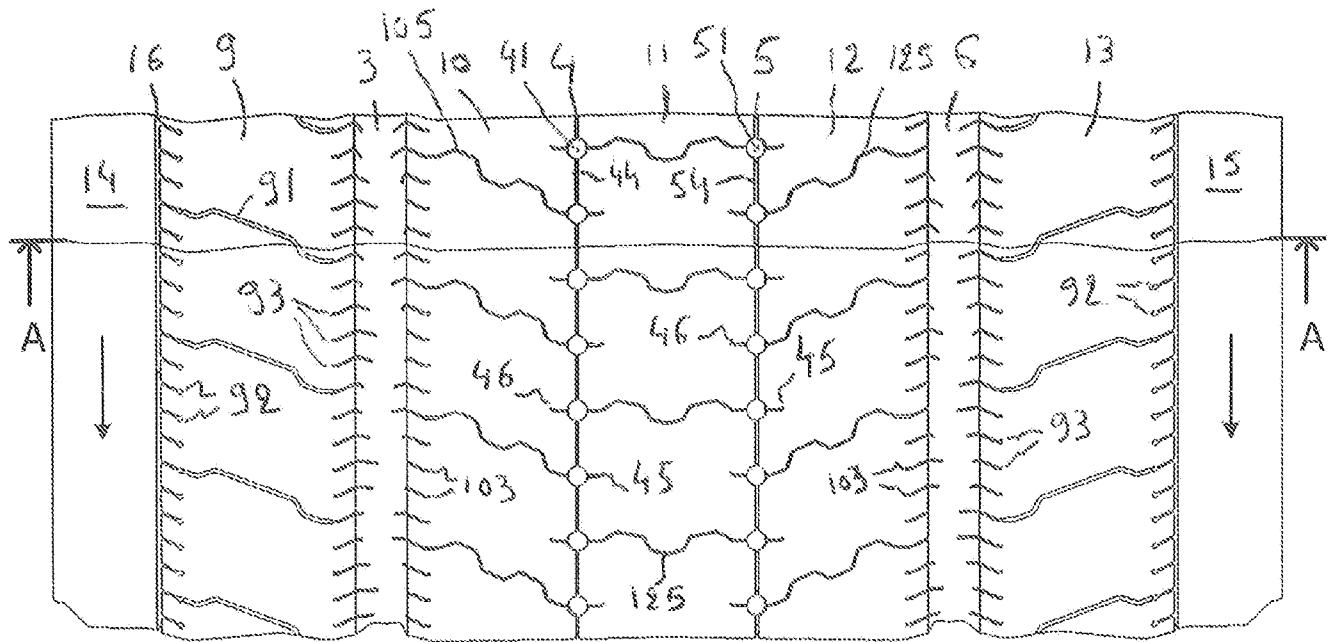
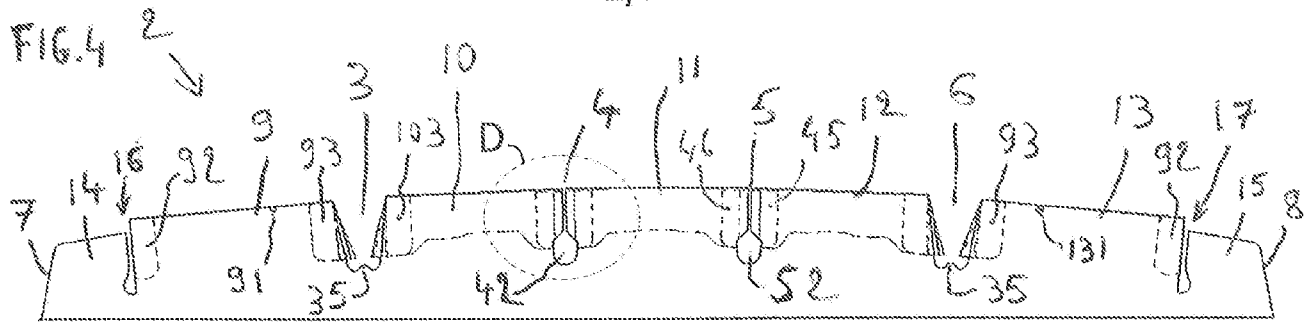
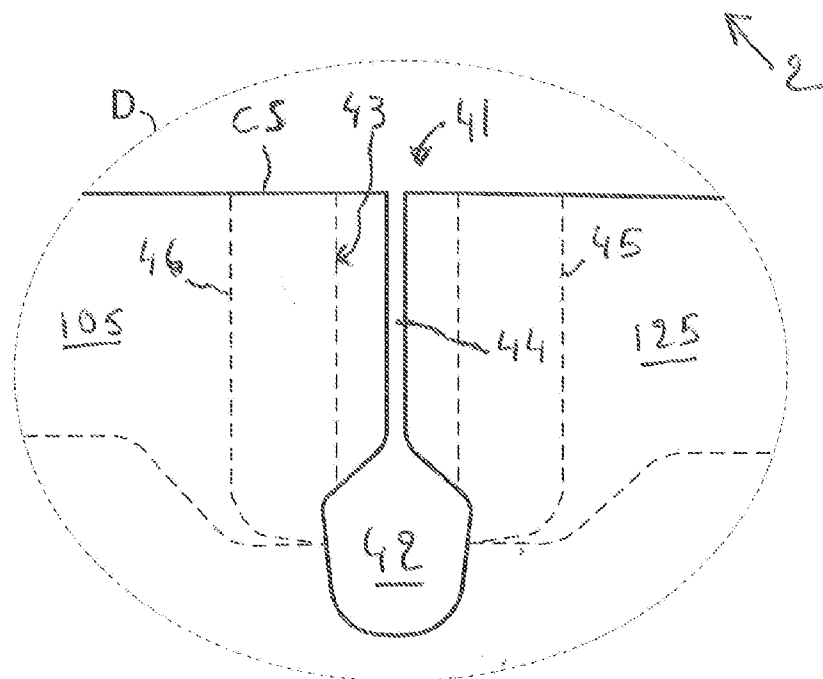


FIG. 3



## INTERNATIONAL SEARCH REPORT

International application No  
PCT/US2015/048468

A. CLASSIFICATION OF SUBJECT MATTER  
INV. B60C11/03 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)  
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<br>A    | FR 2 940 185 A1 (MICHELIN SOC TECH [FR]; MICHELIN RECH TECH [CH])<br>25 June 2010 (2010-06-25)<br>abstract; claims 1-3,5,8; figures 2,6,7<br>paragraphs [0043] - [0047], [0052]<br>-----<br>-/-                                            | 1,4,8,<br>10,14,16<br><br>2,7,12   |



Further documents are listed in the continuation of Box C.



See patent family annex.

\* Special categories of cited documents :

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"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

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Date of the actual completion of the international search

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23/05/2016

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## INTERNATIONAL SEARCH REPORT

International application No

PCT/US2015/048468

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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| A         | abstract; claims 1,2,8-10; figures 1,2<br>paragraphs [0028] - [0031], [0055] -<br>[0057], [0059], [0060]<br>----- | 4                             |
| X         | WO 2015/114128 A1 (MICHELIN & CIE [FR];<br>MICHELIN RECH TECH [CH])<br>6 August 2015 (2015-08-06)                 | 1,3,4,7,<br>8,11,13,<br>14,16 |
| A         | abstract; claims 1, 6; figures 1-4<br>paragraphs [0025], [0026], [0050] -<br>[0054]<br>-----                      | 2                             |

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2015/048468

| Patent document<br>cited in search report | Publication<br>date | Patent family<br>member(s)                                                                                                                      | Publication<br>date                                                                                          |
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