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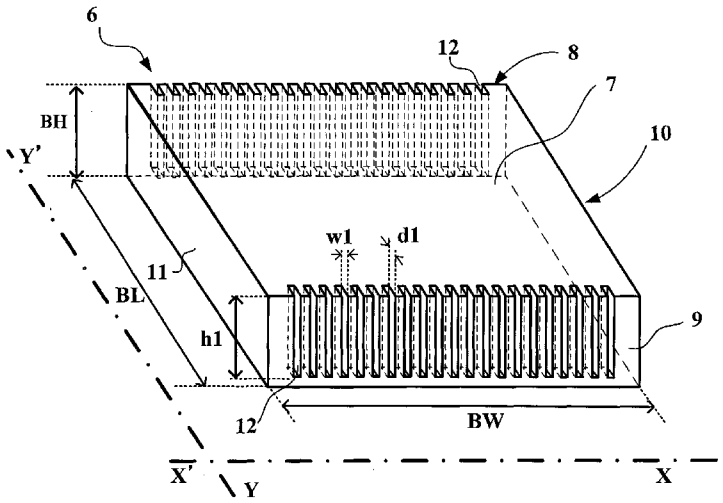
(54) **Title**: A TIRE COMPRISING A TREAD

FIG.3



(57) **Abstract**: A tire (1) having improved grip on melting ice is provided, wherein each of blocks (6) of a tread (2) of the tire (1) comprises a plurality of incisions (12) circumferentially extending to form openings to one of sub grooves (5) of at both of frontal faces (8, 9) of the tire (1), each of the openings has an opening width (w1), a ratio of the sum of the opening widths (w1) of the incisions (12) on each of the frontal faces (8, 9) to a block width (BW) is between 10% and 60%, the incisions (12) have a depth (d1) circumferentially extending, and a height (h1) radially extending, a ratio of the depth (d1) to a block length (BL) is between 0 and 30%, a ratio of the height (h1) to a block height (BH) is more than 50%.

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DESCRIPTION

Title of Invention

A TIRE COMPRISING A TREAD

1. FIELD OF THE INVENTION

[0001] This invention relates to tires having treads suitable for "winter tires" (also known as studless tires) without being provided with studs capable of rolling over ground surfaces covered with ice or black ice.

[0002] It relates more particularly to treads for winter tires specifically suited to rolling under "melting ice" conditions under a temperature range of typically between -5°C and 0° C.

2. BACKGROUND

[0003] The problem in general: Within such a range, the pressure of the tires during the passage of a vehicle brings about surface melting of the ice, which is covered with a thin layer of water harmful to the grip of these tires.

[0004] In order to improve the grip on the melting ice, tire manufacturers have provided different solutions related to the tires having the treads provided with incisions (grooves and/or sipe), which can absorb and/or store the harmful water (JP2014-144777, WO2010/084848).

[0005] There is a constant objective of tire manufacturers to moreover improve the grip on ice, especially under melting ice.

[0006] The specific problem solved by the present invention: Now, on continuing their researches, the applicants have discovered as a new solution a tire having a novel and specific tread, which can efficiently absorb and store the harmful water during the rolling of the tire so that it is made possible to achieve the above objective, that is to say to improve the grip on melting ice without such as the above attachments.

3. SUMMARY OF THE INVENTION

[0007] As a tire has a geometry of revolution about an axis of rotation, the geometry of the tire is generally described in a meridian plane containing the axis of rotation of the tire, and the following definitions of directions of the tire are understood in the present application:

- A radial direction is a direction perpendicular to the axis of rotation of the tire;
- An axial direction is a direction parallel to the axis of rotation of the tire;
- A circumferential direction is a direction perpendicular to the meridian plane.

[0008] A plane being perpendicular to the axis of rotation of the tire and passing through the middle of a tread surface of the tire is referred to as an equatorial plane of the tire.

[0009] In what follows, expressions "radially", "axially" and "circumferentially" respectively mean "in the radial direction", "in the axial direction" and "in the circumferential direction". Expressions "radially on the inside (radially inner or radially internal), or respectively radially on the outside (radially outer or radially external)" mean "closer or, respectively, further away, from the axis of rotation of the tire, in the radial direction, than". Expressions "axially on the inside (axially inner or axially interior) or respectively axially on the outside (axially outer or axially exterior)" mean "closer or, respectively further away, from the equatorial plane, in the axial direction, than". Respective dimensions of a given element in the radial, axial and circumferential directions will also be denoted "radial thickness or height", "axial width" and "circumferential length" of this element. Expression "laterally" mean "in the circumferential or axial direction".

[0010] Moreover, any interval of values denoted by the expression "between a and b" represents the range of values of greater than "a" and of less than "b" (ie the

limits a and b excluded) Whereas any interval of values denoted by the expression "from a to b" means the range of values going from "a" to "b" (i.e. including the strict limits a and b).

[0011] The abbreviation "phr" signifies parts by weight per hundred parts of elastomer or rubber (of the total of the elastomers if several elastomers are present).

[0012] In the present description, unless expressly indicated otherwise, each Tg (glass transition temperature) is measured in a known way by DSC (Differential Scanning Calorimetry) according to Standard ASTM D3418 (1999).

[0013] Thus, as a first object (and a first aspect) of the invention is [1] a tire (1) which has a tread (2) having a contact surface (3) intended to come into contact with ground during rolling, the tread (2) comprising one or more of main grooves (4) circumferentially extending, a plurality of sub grooves (5) axially extending, and a plurality of blocks (6) delimited by the main grooves (4) and the sub grooves (5), the blocks (6) respectively having a top face (7) forming the contact surface (3) of the tread (2), two frontal faces (8, 9) axially extending and respectively facing to one of the sub grooves (5), and two lateral faces (10, 11) circumferentially extending and respectively facing to one of the main grooves (4), the blocks (6) also having a block width (BW), a block length (BL) and a block height (BH), the blocks (6) respectively provided with a plurality of incisions, the tire, being characterized in that the incisions include a plurality of incisions (12) circumferentially extending to form openings to one of the sub grooves (5) at both of the frontal faces (8, 9), each of the openings has an opening width (w1), a ratio of the sum of the opening widths (w1) of the incisions (12) on each of the frontal faces (8, 9) to the block width (BW) is between 10% and 60% (preferably, between 15% and 50%, more preferably, between 20% and 40%, still more preferably,

between 30% and 40%), the incisions (12) have a depth (d1) circumferentially extending, and a height (h1) radially extending, a ratio of the depth (d1) to the block length (BL) is between 0 and 30% (preferably, between 1% and 20%, more preferably, between 2% and 10%, still more preferably, between 3% and 5%), a ratio of the height (h1) to the block height (BH) is more than 50% (preferably, more than 70% and up to 100%, more preferably, more than 90% and up to 100%, still more preferably, equal to 100%).

[0014] When the blocks (6) of the tread (2) starts or end to contact with ground during rolling of the tire (1), that is, when the pressure is concentrated on one of sides forming the top face (7) and the frontal faces (8, 9), the incisions (12), which are one side open incisions, are capable of absorbing the harmful water by capillarity of the incisions (12), and which makes it possible to more effectively improve the grip on the melting ice, especially for acceleration and/or braking on straightly traveling.

[0015] Below the indicated minimum ratios relative to width (w1), depth (d1) and height (h1) of the incisions (12), there is a risk to that the effect produced by the incisions will fade, whereas above the recommended maximum ratios relative to width (w1) and depth (d1) of the incisions (12), there is a risk to decrease rigidity of each of the blocks in the axial direction or the circumferential direction, which may affect stability performance of the tire.

[0016] [2] As an aspect of the invention is the tire (1) according to [1], wherein the incisions include one or more of additional incisions (13) axially extending to form openings to the main grooves (4) at both of the lateral faces (10, 11), wherein each of the openings has an opening width (w2), and wherein the additional incisions (13) have a depth (d2) axially extending, and a height (h2) radially extending.

[0017] Preferably, a ratio of the height (h2) to the block height (BH) is more than 50% (more preferably, more than 70% and up to 100%, still more preferably, more than 90% and up to 100%, particularly, equal to 100%).

[0018] The additional incisions (13), which are both side open incisions, may reinforce improvement of the grip on the melting ice.

[0019] [3] As an aspect of the invention is the tire (1) according to [2], wherein the incisions include a plurality of the incisions (14) circumferentially extending to form openings to one of the additional incisions (13) at one of wall faces of the additional incisions (12), and wherein each of the openings has an opening width (w3), and wherein the incisions (14) has a depth (d3) axially extending, and a height (h3) radially extending.

[0020] Preferably, a ratio of the sum of the opening widths (w3) of the incisions (14) extending to be open to one of wall faces of the additional incision(s) (13) to the depth (d3) of the additional incisions (13) is between 10% and 60%, more preferably, between 15% and 50%, still more preferably, between 20% and 40%, notably, between 30 and 40%. Particularly, a ratio of the depth (d3) of the incisions (14) to the block length (BL) is between 0 and 30%, more particularly, between 1% and 20%, still more particularly, between 2% and 10%, notably, between 3% and 5%. Advantageously a ratio of the height (h3) of the incisions (14) to the height (h2) of the additional incision(s) (13) is more than 50%, more advantageously, more than 70% and up to 100%, still more advantageously, more than 90% and up to 100%, notably, equal to 100%.

[0021] The incisions (14), which are one side incisions, make it possible to more effectively improve the grip on the melting ice, especially for acceleration and/or braking on straightly traveling.

[0022] Below the indicated minimum ratios relative to width (w3), depth (d3) and height (h3) of the incisions (14), there is a risk to that the effect produced by

the incisions will fade, whereas above the recommended maximum ratios to width (w3), depth and (d3) of the incisions (14), there is a risk to decrease rigidity of each of the blocks in the axial direction, which may affect stability performance of the tire.

[0023] [4] As an aspect of the invention is the tire (1) according to [3], wherein the incisions include a plurality of the incisions (15) at one or both, preferably both, of the lateral faces (10, 11), the incisions (15) axially extending to form openings at one of the lateral faces (10,11), and wherein each of the openings has an opening width (w4), and wherein the incisions (15) has a depth (d4) axially extending, and a height (h4) radially extending.

[0024] Preferably, a ratio of the sum of the opening widths (w4) of the incisions (15) axially extending to be open at one of the lateral faces (10, 11) to the block length (BL) is between 10% and 60%, preferably, between 15% and 50%, more preferably, between 20 and 40%. Particularly, a ratio of the depth (d4) of the incisions (15) to the block width (BW) is between 0 and 30%, more particularly, between 1% and 20%, still more particularly, between 2% and 10%, notably, between 3% and 5%. Advantageously a ratio of the height (h4) of the incisions (15) to the block height (BH) is more than 50%, more advantageously, more than 70% and up to 100%, still more advantageously, more than 90% and up to 100%, notably, equal to 100%.

[0025] The additional incisions (15), which are one side open incisions, may further reinforce improvement of the grip on the melting ice, especially when turning.

[0026] Below the indicated minimum ratio, there is a risk to that the effect produced by the incisions will fade, whereas above the recommended maximum ratio, there is a risk to decrease rigidity of each of the blocks in the circumferential direction, which affect dry grip performance of the tire.

[0027] [5] As an aspect of the invention is the tire (1) according to any one of [1] to [4], wherein the opening width (w1, w2, w3, w4) of the incisions (12, 13, 14,

15) is between 0.1 and 3.0 mm, preferably, between 0.2 and 2.5 mm, more preferably, between 0.3 and 2.0 mm, more preferably, from 0.4 to 1.5 mm.

[0028] Below the indicated minimum or maximum ratio, there is a risk to that the effect produced by the incisions will fade due to decrease of volume or capillarity of the incisions.

[0029] [6] As an aspect of the invention is the tire (1) according to any one of [1] to [5], wherein a water contact angle on the wall face of each of the incisions (12, 13, 14, 15) is lower than that on the top face (7) by more than 30° (preferably, more than 60°, more preferably, equal to or more than 90°).

[0030] [7] As an aspect of the invention is the tire (1) according to [6], wherein the water contact angle on the wall face of each of the incisions (12, 13, 14, 15) is lower than 80° (more particularly, by less than 50°, still more particularly, by equal to or less than 20°).

[0031] The wall face of each of the incisions (12, 13, 14, 15) may more effectively help the incisions to absorb and store the harmful water during the rolling of the tire.

[0032] Preferably, the bottom of each of the incisions (12, 13, 14, 15) exhibits equivalent contact angle to that on the wall face of each of the incisions (12, 13, 14, 15).

[0033] The water contact angle can be measured at about 25°C based on JIS R3257: 1999 (sessile drop method and vertical plate method).

[0034] The wall face of each of the incisions (12, 13, 14, 15) exhibits lower contact angle than that on the top face (7), which may be obtained by virtue of suitable treatment methods, for example using a plasma treatment such as DC plasma treatment or RF plasma treatment.

[0035] Gas used during the plasma treatment is a mixed gas containing nitrogen and oxygen, preferably about 80% of nitrogen and about 20% of oxygen, more

preferably normal atmospheric air (78% of nitrogen, 21% of oxygen and 1% of trace gases).

[0036] Preferably, the operational pressure used during the plasma treatment is from 1.0 to 0.1 Pa, and the treatment time is from 10 to 900 seconds, more preferably, from 90 to 900 seconds.

[0037] The lower contact angle on the wall face of each of the incisions (12, 13, 14, 15) than that on the top face (7) may be also obtained by covering the wall face (of each of the incisions (12, 13, 14, 15) with a hydrophilic material).

[0038] [8] As an aspect of the invention is the tire (1) according to [6] or [7], wherein a product of each of the opening widths (w1, w2, w3, w4) and the water contact angle on the wall face of each of the incisions (12, 13, 14, 15) is between 3 and 30 mm·° (mm·degree), preferably between 5 and 20 mm·°.

[0039] Below the indicated minimum or maximum, there is a risk to that the effect produced by the incisions will fade due to the relation between the opening width and the water contact angle on the wall face.

[0040] [9] As an aspect of the invention is the tire (1) according to any one of [1] or [8], wherein the tread (2) comprises a rubber composition that comprises at least a diene elastomer, reinforcing filler and a vulcanization system.

[0041] The diene elastomer is generally understood to mean an elastomer resulting at least in part (i.e. a homopolymer or a copolymer) from diene monomers (monomers bearing two carbon-carbon double bonds which may or may not be conjugated).

[0042] The diene elastomer is preferably selected from the group consisting of natural rubber, synthetic polyisoprenes, polybutadienes, butadiene copolymers, isoprene copolymers and the mixtures thereof. Such copolymers are more preferably selected from the group consisting of butadiene/styrene copolymers (SBRs), isoprene/butadiene copolymers (BIRs), isoprene/styrene

copolymers (SIRs), isoprene/butadiene/styrene copolymers (SBIRs) and mixtures thereof.

[0043] The rubber composition may contain a single diene elastomer or a mixture of several diene elastomers, it being possible for the diene elastomer(s) to be used in combination with any type of synthetic elastomer other than a diene elastomer, or even with polymers other than elastomers, for example thermoplastic polymers.

[0044] The reinforcing filler is preferably selected from the group consisting of carbon black, inorganic filler and the mixture thereof.

[0045] All carbon blacks, especially blacks of the HAF, ISAF or SAF type, conventionally used in tires are suitable as carbon blacks. As non-limiting examples of such blacks, mention may be made of the N115, N134, N234, N330, N339, N347 and N375 blacks.

[0046] Such inorganic filler comprises silica, especially highly dispersible silicas, for example the Ultrasil 7000 and Ultrasil 7005 silicas from Evonik, the Zeosil 1165 MP, 1135 MP and 1115 MP silicas from Rhodia, the Hi-Sil EZ150G silica from PPG, the Zeopol 8715, 8745 and 8755 silicas from Huber.

[0047] As other examples of inorganic filler that can be used in the rubber composition, mention will also be made of mineral fillers of the aluminous type, in particular alumina (Al_2O_3), or aluminium (oxide) hydroxides, or else reinforcing titanium oxides, for example described in WO 99/28376 (US 6 610 261) and WO 00/73372 (US 6 747 087).

[0048] A person skilled in the art will understand that, as filler equivalent to the reinforcing inorganic filler described in the present section, a reinforcing filler of another nature, in particular organic nature, could be used, provided that this reinforcing filler is covered with an inorganic layer, such as silica, or else comprises functional sites, in particular hydroxyl sites, at its surface that

require the use of a coupling agent in order to form the bond between the filler and the elastomer.

[0049] The vulcanization system is preferably based either on sulphur or on sulphur donors and/or on peroxide and/or on bismaleimides, vulcanization accelerators, vulcanization activators and optionally vulcanization retarders.

[0050] The rubber composition may also comprise all or some of the standard additives customarily used in the elastomer compositions intended for the manufacture of tires, such as for example plasticizer system selected from the group consisting of liquid plasticizer, hydrocarbon resin and the mixture thereof, pigments, protective agents, such as antiozone waxes, chemical antiozonants, antioxidants, antifatigue agents, reinforcing resins, methylene acceptors (for example phenolic novolac resin) or methylene donors (for example HMT or H3M).

[0051] [10] As an aspect of the invention is the tire (1) according to [9], wherein the rubber composition comprises less than 10 phr of the protective agent, preferably, less than 5 phr, more preferably, less than 3 phr.

[0052] Each of the above aspects including each of the preferred range(s) and/or matter(s) may be applied to any one of the other aspects or the embodiments of the invention.

4. BRIEF DESCRIPTION OF THE DRAWINGS

[0053] Other characteristics and advantages of the invention arise from the description made hereafter in reference to the annexed drawings which show, as nonrestrictive examples, of the embodiments of the object of the invention.

[0054] In these drawings:

FIG. 1 shows a schematic view of a tire cross sectional view according to the present invention;

[0055] FIG. 2 shows a plan view of a tread according to the present invention;

[0056] FIG. 3 shows a schematic view of a block of a first embodiment;

[0057] FIG. 4 shows a plan view of a block of the first embodiment;

[0058] FIG. 5 shows a schematic view of a block of a second embodiment;

[0059] FIG. 6 shows a plan view of a block of the second embodiment;

[0060] FIG. 7 shows a plan view of a block of a third embodiment;

[0061] FIG. 8 shows a plan view of a block of a fourth embodiment;

[0062] FIG. 9 shows a schematic view of a block of a reference;

[0063] FIG. 10 shows a plan view of a block of the reference.

5. DETAILED DESCRIPTION OF THE INVENTION

[0064] The appended FIG. 1 schematically (in particular not to a specific scale) represents, in radial cross section, a tire (1) according to the present invention.

[0065] The tires of the invention are particularly intended to be equipped to passenger motor vehicles, including 4×4 (four-wheel drive) vehicles and SUV (Sport Utility Vehicles) vehicles, and also industrial vehicles in particular chosen from vans and heavy duty vehicles (i.e., bus or heavy road transport vehicles (lorries, tractors, trailers)).

[0066] In the FIG. 1, the tire (1) has a tread (2) having a contact surface (3) intended to come into contact with ground during rolling, the tread (2) comprising main grooves (4) circumferentially extending.

[0067] The FIG. 2 illustrates the tread (2) which comprises the main grooves (4) circumferentially (in the circumferential direction (Y-Y')) extending, sub grooves (5) axially (in the axial direction (X-X')) extending, and a plurality of blocks (6) delimited by the circumferential main grooves (4) and the sub grooves (5).

[0068] The FIGs. 3 to 10 illustrate the block (6) which has a top face (7) forming the contact surface of the tread, two frontal faces (8, 9) axially extending and respectively facing to one of the sub grooves, and two lateral faces (10, 11) circumferentially extending and respectively facing to one of the main grooves, the block (6) provided with a plurality of incisions (12, 13, 14, 15).

[0069] In the FIGs. 3, 5 and 9, the block has a block length extending in circumferential direction (BL: 25.4 mm), a block width extending in axial direction (BW: 23.8 mm) and a block height extending in radial direction (BH: 9.0 mm).

[0070] In the FIGs. 3 and 4, the block (6) is provided with forty two incisions (12) at both of the frontal faces (8, 9), that is, twenty one incisions (12) at each of frontal faces (8, 9), the incisions (12) circumferentially extending to be open to one of the sub grooves, that is, the incisions (12) being one side open incisions, wherein the opening width (w1) is 0.4 mm, and wherein a ratio of the sum of the opening widths of the incisions (12) on each of the lateral faces (8, 9) to the block width (BW) is about 35%. The incisions (12) have a depth (d1: 0.8 mm) exhibiting in the circumferential direction, and a height (h1: 9.0 mm) extending in the radial direction, a ratio of the depth (d1) to the block length (BL) is about 3.3%, and a ratio of the height (h1) to the block height (BH) is 100%.

[0071] In the FIGs. 5 and 6, comparing with the embodiment shown in the FIGs. 3 and 4, the block (6) is additionally provided with two incisions (13) which axially extend to be open to the main grooves at both of the lateral faces (10, 11), that is, the additional incisions (13) are both side open incisions, wherein the opening width (w2) of the additional incisions (13) is 1.0 mm, and wherein the additional incisions (13) have a depth (d2: 23.8 mm) extending in the axle direction, and a height (h2: 9.0 mm) extending in the radial direction.

[0072] In the FIG. 7, comparing with the embodiment shown in the FIGs. 5 and 6, the block (6) is additionally provided with forty two incisions (14), which are one side open incisions, circumferentially extending to be open to each of the other incisions (13) axially extending to open at both of the lateral faces (10, 11), wherein total number of the incisions (14) is 82, wherein the opening

width (w3) of the additional incisions (14) is 0.4 mm, and wherein the incisions (14) have a depth (d3: 0.4 mm) extending in the circumferential direction. The incisions (14) have also a height (h3: 9.0 mm) in the radial direction, though the h3 is not shown in FIG. 7.

[0073] The FIG. 8 illustrates that, comparing with the embodiment shown in the Fig.7, the block (6) is additionally provided with thirty incisions (15) at both of the lateral faces (10, 11), that is, fifty incisions (15) at each of the lateral faces (10, 11), the incisions (15) axially extending to be open at one of the lateral face (10, 11), that is, the incisions (15) being one side open incisions, wherein the opening width of the additional incisions (15) is 0.4 mm, and wherein the incisions (15) have a depth (d4: 0.4 mm) extending in the axial direction. The incisions (15) have also a height (h4: 9.0 mm) in the radial direction, though the h4 is not shown in FIG. 8.

[0074] In the FIGs. 9 and 10, the block (6) is provided with two incisions (13) axially extending to be open at both of the lateral faces (10, 11), that is, the both sides of the incisions (13) being both side open incisions to the main grooves, wherein the opening width (w2) is 1.0 mm, and wherein the incisions (13) have a depth (d2: 23.8 mm) extending in the axial direction, and a height (h2: 9.0 mm) in the radial direction.

[0075] The invention is further illustrated by the following non-limiting examples.

6. EXAMPLES OF THE IMPLEMENTATION OF THE INVENTION

6-1. Preparation of the rubber compositions and of the treads

[0076] In these tests, three block samples (identified as B-1 (a reference), B-2 and B-3 (examples according to the present invention)) comprising a rubber composition based on a diene elastomer (SBR/BR) are compared, and a formulation of the rubber composition (content of the various products in phr) is given in Table 1.

[0077]

Table 1

	Rubber composition
SBR (1)	60
BR (2)	40
Carbon black (3)	100
Non aromatic oil (4)	30
Hydrocarbon resin (5)	40
ZnO	1.5
Stearic acid	0.2
Sulphur	1.4
Accelerator (6)	1.6

(1) SBR: SBR (Sn star-branched) with 27% of styrene units and 24% of1,2-units of the butadiene part bearing a silanol function at the end of the elastomer chain (Tg = -48°C);
(2) BR with 0.3% of 1,2 vinyl; 2.7% of trans; 97% of cis-1,4 (Tg = -105°C);
(3) ASTM grade N234 (Cabot)
(4) Oleic sunflower oil ("Agripure 80" from Cargiil, Weight percent oleic acid: 100%);
(5) Hydrocarbon resin C5/C9 type ("Escorez ECR-373" from Exxon);
(6) N-dicyclohexyl-2-benzothiazolesulphenamide ("Santocure CBS" from Flexsys).

[0078] The diene elastomer(s), the reinforcing filler and the various other ingredients, with the exception of the vulcanization system, were successively introduced into an internal mixer having an initial vessel temperature of approximately 60°C; the mixer was thus approximately 70% full (% by volume). Thermomechanical working (non-productive phase) was then carried out in one stage, which lasted in total approximately 3 to 4 minutes, until a maximum "dropping" temperature of 165°C was reached. The mixture thus obtained was recovered and cooled and then sulphur and an accelerator of sulphenamide type were incorporated into an external mixer (homofinisher)

at 30°C, everything being mixed (productive phase) for an appropriate time (for example between 5 and 12 min).

[0079] The composition thus obtained was subsequently calendered, either in the form of sheets (for example, thickness: 2 to 3 mm) or of fine sheets of rubber, for the measurement of their physical or mechanical properties, or in the form of profiled elements which could be used directly, after cutting and/or assembling to the desired dimensions, for example as tire semi-finished products, in particular as tire treads.

[0080] Each of the three block samples has a block design having a plurality of incisions as shown in Table 2.

[0081]

Table 2

	Reference	Example	
	B1	B2	B3
Figure	Fig.10	Fig.4	Fig.4
Width of both sides open incision [w2] (mm)	1.0	1.0	1.0
Width of one side open incision [w1,w3, w4] (mm)	-	0.4	0.4

[0082] Subsequently, after cuing, a plasma treatment was performed on the wall faces and also the radially bottoms of the incisions in the example (B-3) according to the present invention with a DC plasma method, for 90 seconds using normal atmospheric air as a processing gas. During the plasma treatment, the top faces in each of the examples were covered with a carbon tape as a masking material. The DC power used to generate plasma was 9 W and the operational pressure was about 0.1 MPa.

6-2. Test results

[0083] Water contact angles on the top faces and the wall faces of the incisions of the three block samples are expressed in Table 3. Unit of the result is degree.

The water contact angle was measured at about 25°C based on JIS R3257: 1999 (sessile drop method).

[0084]

Table 3

	Reference		Examples			
	B1		B2		B3	
Face	Top face	Wall face of the incisions	Top face	Wall face of the incisions	Top face	Wall face of the incisions
Contact angle (°) (7)	110	110	110	110	110	15

(7) Measured at about 25 °C based on JIS R3257: 1999.

[0085] Friction coefficients on ice for the three block samples are given in Table 4, a value greater than that of the reference (B-1), arbitrarily set at 100, indicating an improved result, i.e. an aptitude for a shorter braking distance. The principle is based on a block sample that slides at a given speed (for example equal to 5 km/h) over an ice track (temperature of the ice set at -2° C) with an imposed load (for example equal to 3 kg/cm2). The forces generated in the direction of travel (Fx) of the pad and perpendicular to the travel (Fz) are measured; the ratio Fx/Fz determines the friction coefficient of the test specimen on ice. The principle of this test is well known to person skilled in the art (see for example Patent Applications EP 1 052 270, EP 1 505 112 and WO 2010/009850). That makes it possible to evaluate, under representative conditions, the grip on melting ice that would be obtained during a running test on a vehicle equipped with tires whose tread consists of the same rubber compositions.

[0086]

Table 4

	Reference	Examples	
	B1	B2	B3
Melting ice grip index (8)	100	130	145

(8) Friction test on icy road (at -2 °C).

[0087] The results from Table 4 demonstrate that the examples (B-2 and B-3) provided with the specific incisions circumferentially extending have surely improved friction coefficient on ice rather than the reference.

CLAIMS

1. A tire (1) which has a tread (2) having a contact surface (3) intended to come into contact with ground during rolling, the tread (2) comprising one or more of main grooves (4) circumferentially extending, a plurality of sub grooves (5) axially extending, and a plurality of blocks (6) delimited by the main grooves (4) and the sub grooves (5);

the blocks (6) respectively having a top face (7) forming the contact surface (3) of the tread (2), two frontal faces (8, 9) axially extending and respectively facing to one of the sub grooves (5), and two lateral faces (10, 11) circumferentially extending and respectively facing to one of the main grooves (4), the blocks (6) also having a block width (BW), a block length (BL) and a block height (BH), the blocks (6) respectively provided with a plurality of incisions, the tire, being characterized in that:

- the incisions include a plurality of incisions (12) circumferentially extending to form openings to one of the sub grooves (5) at both of the frontal faces (8, 9);

- each of the openings has an opening width (w1);

- a ratio of the sum of the opening widths (w1) of the incisions (12) on each of the frontal faces (8, 9) to the block width (BW) is between 10% and 60%;

- the incisions (12) have a depth (d1) circumferentially extending, and a height (h1) radially extending;

- a ratio of the depth (d1) to the block length (BL) is between 0 and 30%;

- a ratio of the height (h1) to the block height (BH) is more than 50%.

2. The tire (1) according to Claim 1, wherein the incisions include one or more of additional incisions (13) axially extending to form openings to the main grooves (4) at both of the lateral faces (10, 11), wherein each of the openings has an opening width (w2), and wherein the additional incisions (13) have a depth (d2) axially extending, and a height (h2) radially extending.

3. The tire (1) according to Claim 2, wherein the incisions include a plurality of the incisions (14) circumferentially extending to form openings to one of the additional incisions (13) at one of wall faces of the additional incisions (12), and wherein each of the openings has an opening width (w3), and wherein the incisions (14) has a depth (d3) axially extending, and a height (h3) radially extending.

4. The tire (1) according to Claim 3, wherein the incisions include a plurality of the incisions (15) at one or both of the lateral faces (10, 11), the incisions (15) axially extending to form openings at one of the lateral faces (10, 11), and wherein each of the openings has an opening width (w4), and wherein the incisions (15) has a depth (d4) axially extending, and a height (h4) radially extending.

5. The tire (1) according to any one of Claims 1 to 4, wherein the opening width (w1, w2, w3, w4) of the incisions (12, 13, 14, 15) is between 0.1 and 3.0 mm.

6. The tire (1) according to any one of Claims 1 to 5, wherein a water contact angle on the wall face of each of the incisions (12, 13, 14, 15) is lower than that on the top face (7) by more than 30°.

7. The tire (1) according to Claim 6, wherein the water contact angle on the wall face of each of the incisions (12, 13, 14, 15) is lower than 80°.

8. The tire (1) according to Claim 6 or Claim 7, wherein a product of each of the opening widths (w1, w2, w3, w4) and the water contact angle on the wall face of each of the incisions (12, 13, 14, 15) is between 3 and 30 mm·°.

9. The tire (1) according to any one of Claims 1 to 8, wherein the tread (2) comprises a rubber composition that comprises at least a diene elastomer, reinforcing filler and a vulcanization system.

10. The tire (1) according to Claim 9, wherein the rubber composition that comprises less than 10 phr of protective agent.

FIG.1

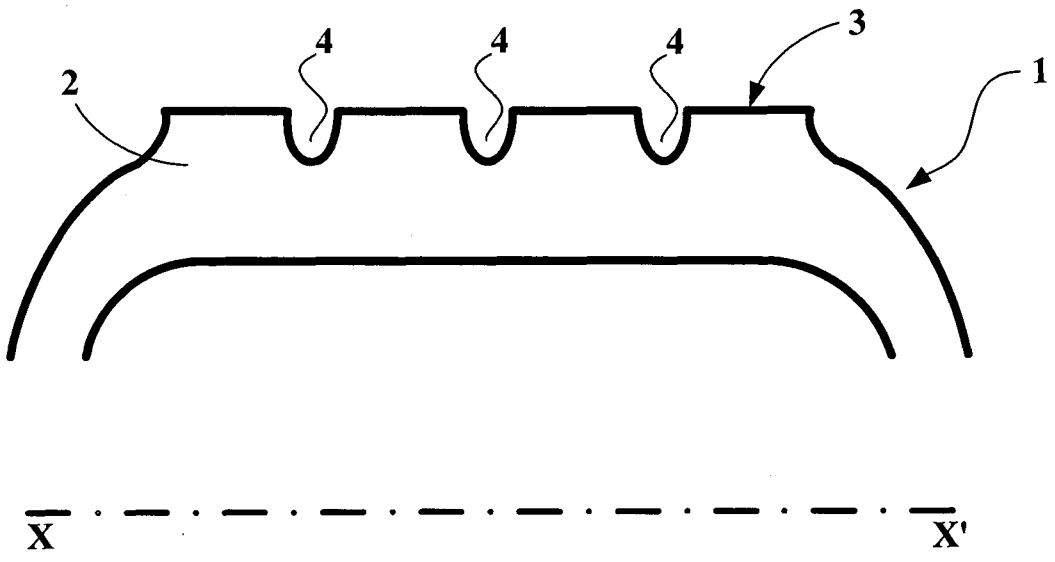


FIG.2

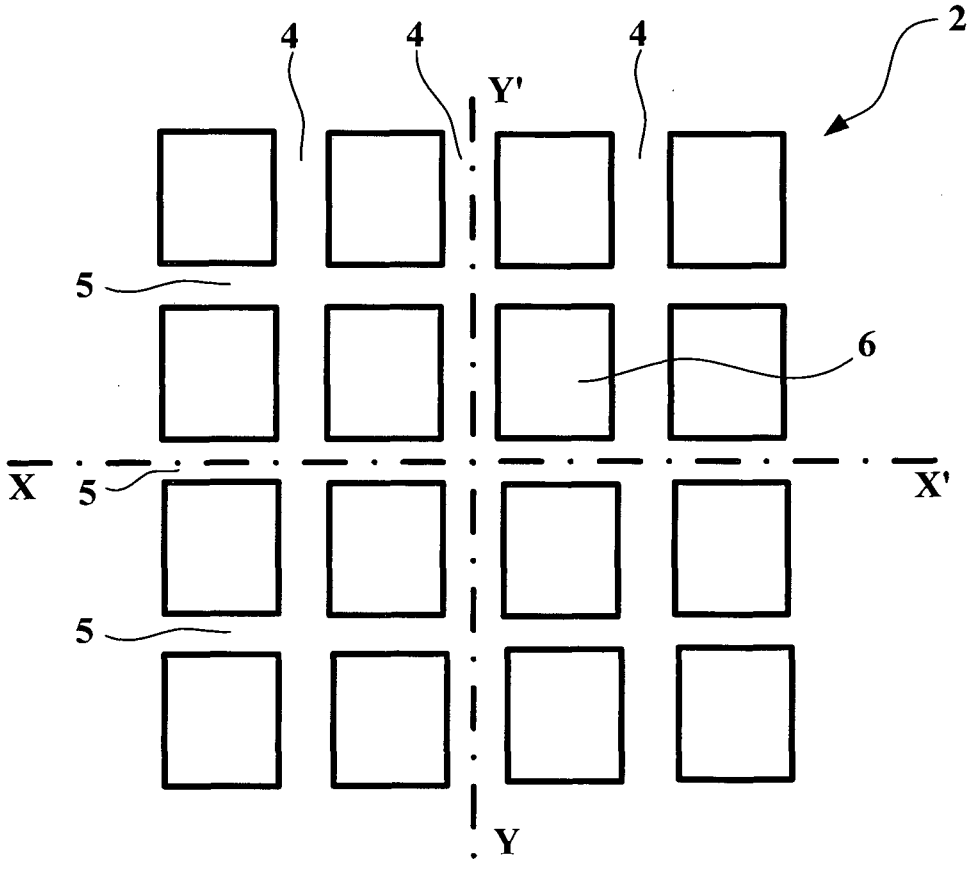


FIG.3

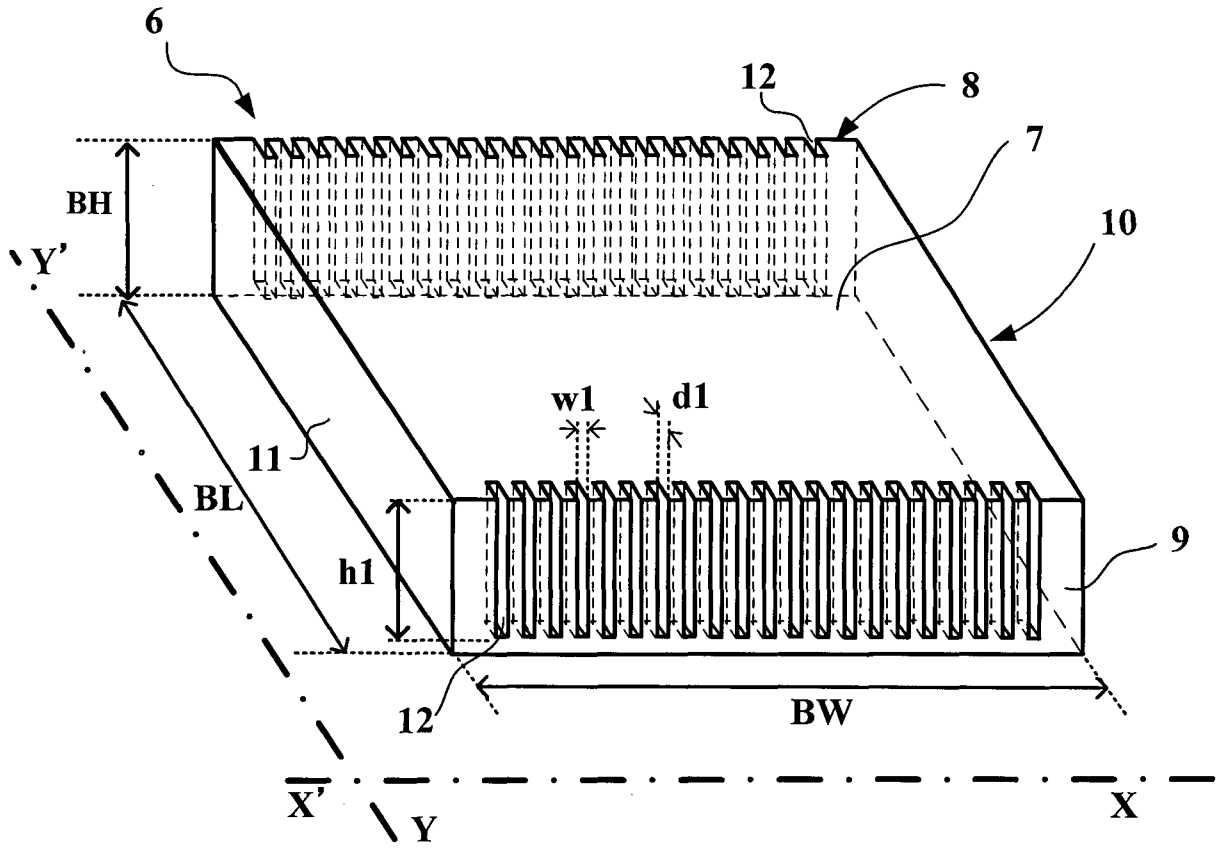


FIG.4

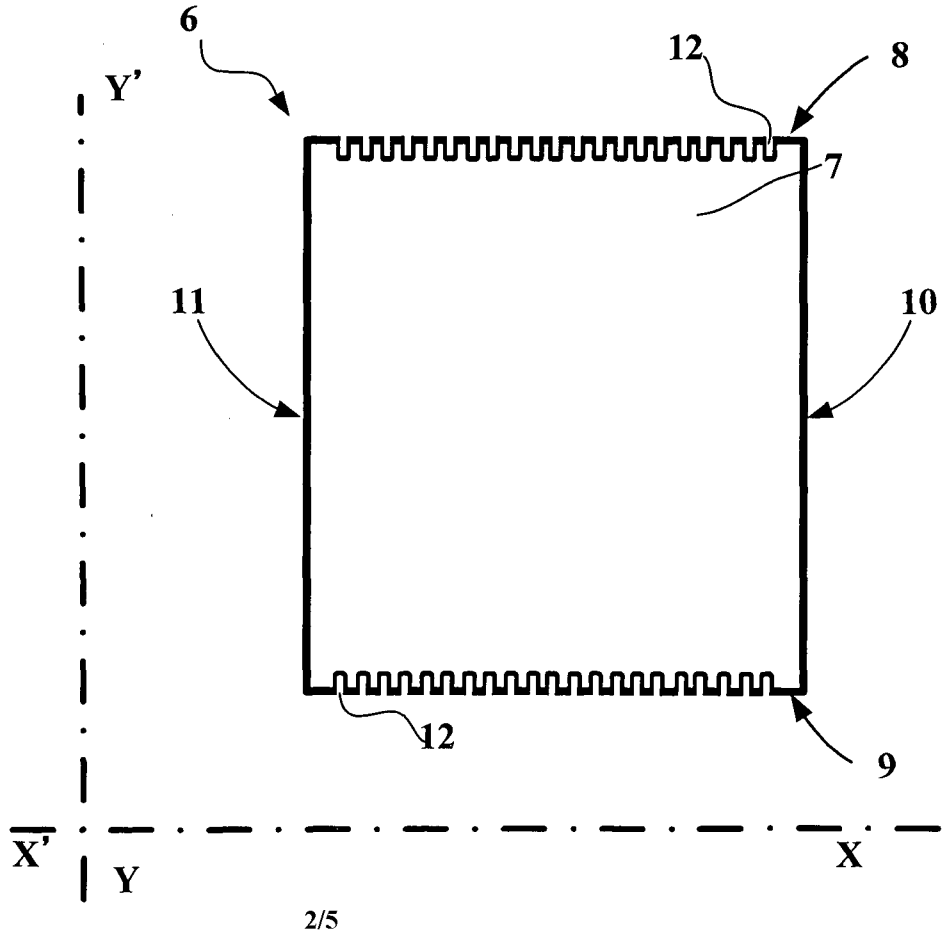


FIG.5

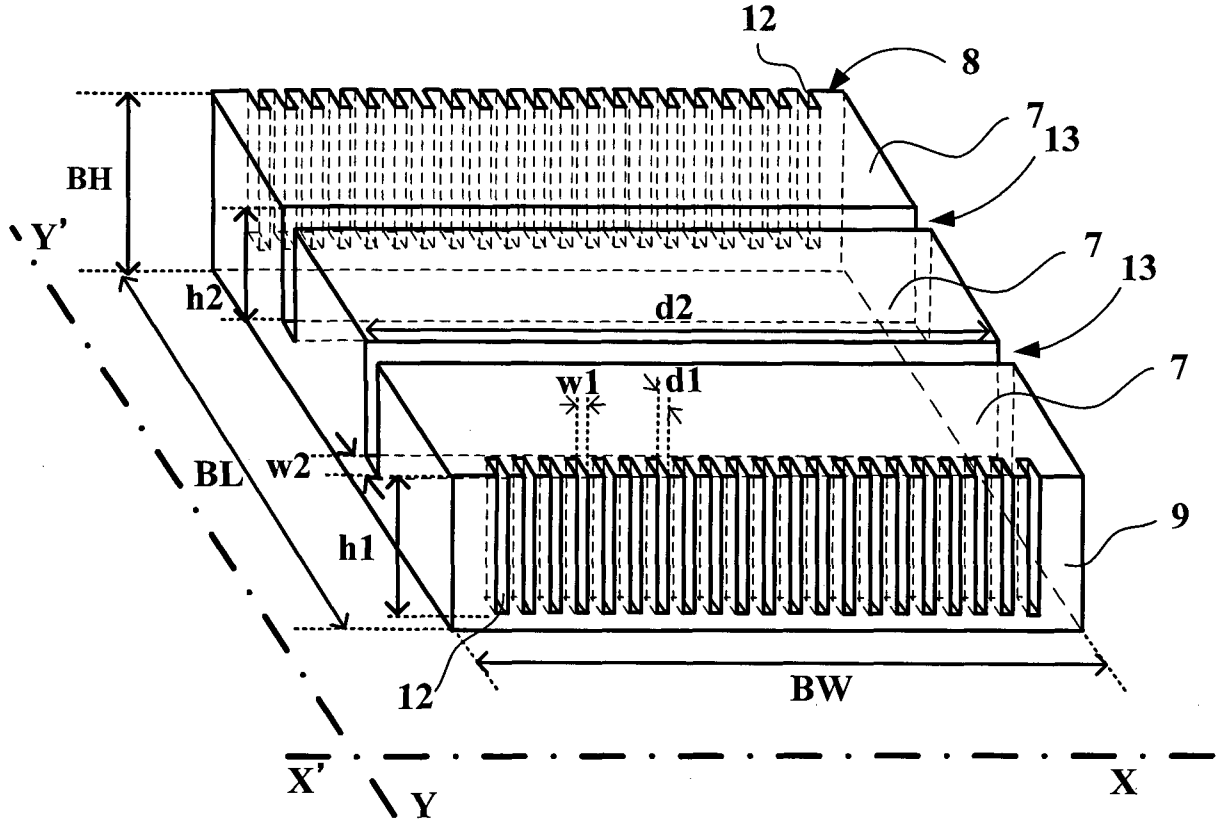

12
8
7
13
7
13
7
9
BH
Y'
h2
d2
w1
d1
BL
w2
h1
12
BW
X'
Y
X

FIG.6

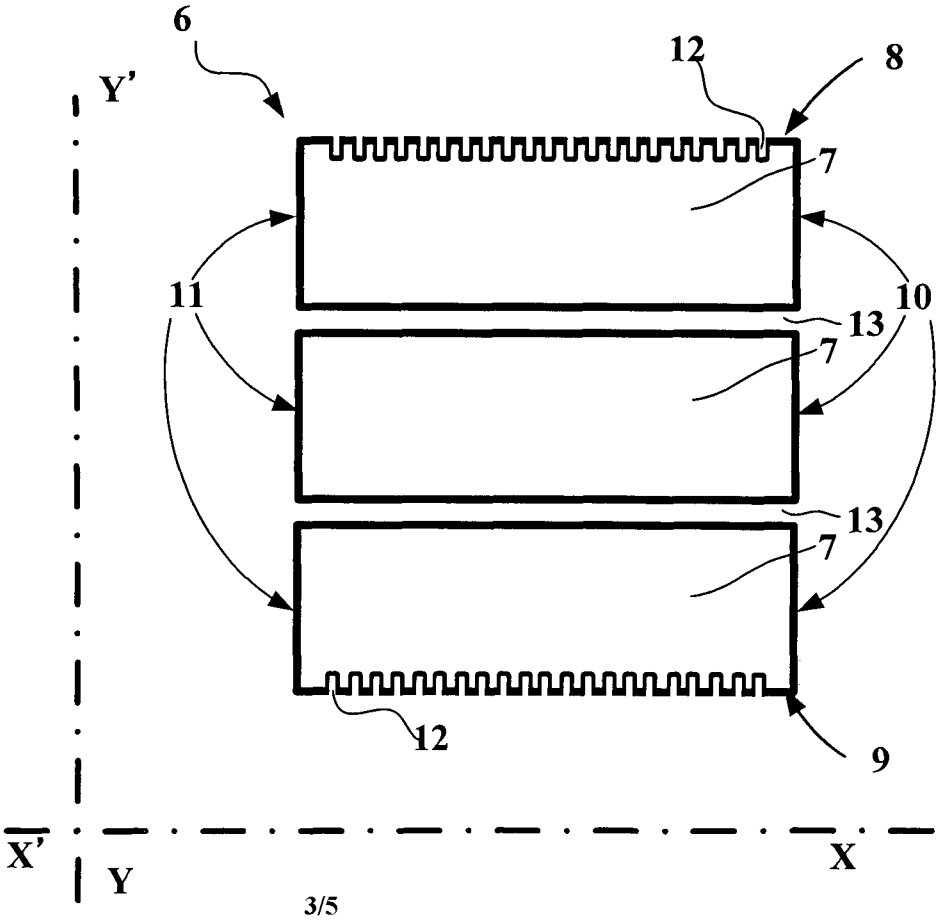

6
12
8
Y'
7
11
10
13
7
13
7
12
9
X'
Y
X

FIG.7

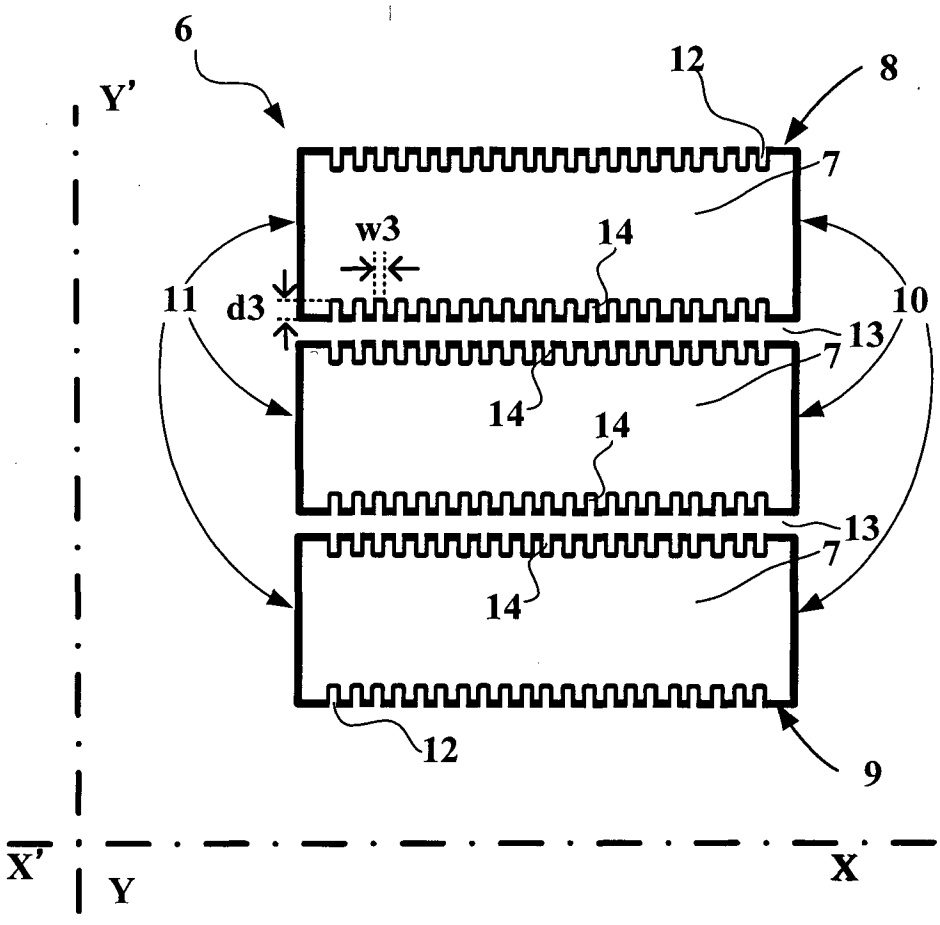

6
12
8
Y'
7
w3
14
11
d3
10
13
7
14
14
13
7
14
12
9
X'
Y
X

FIG.8

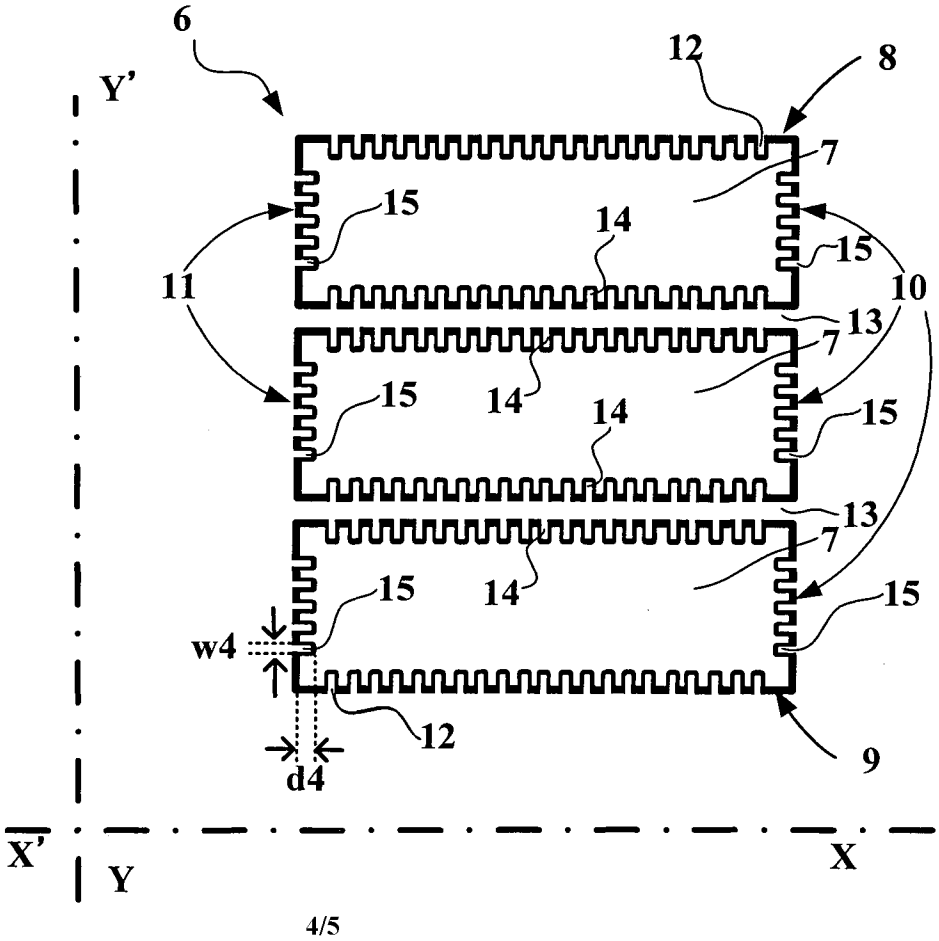

6
12
8
Y'
7
15
14
15
11
10
13
7
15
14
14
15
13
7
15
14
15
w4
12
9
d4
X'
Y
X

FIG.9

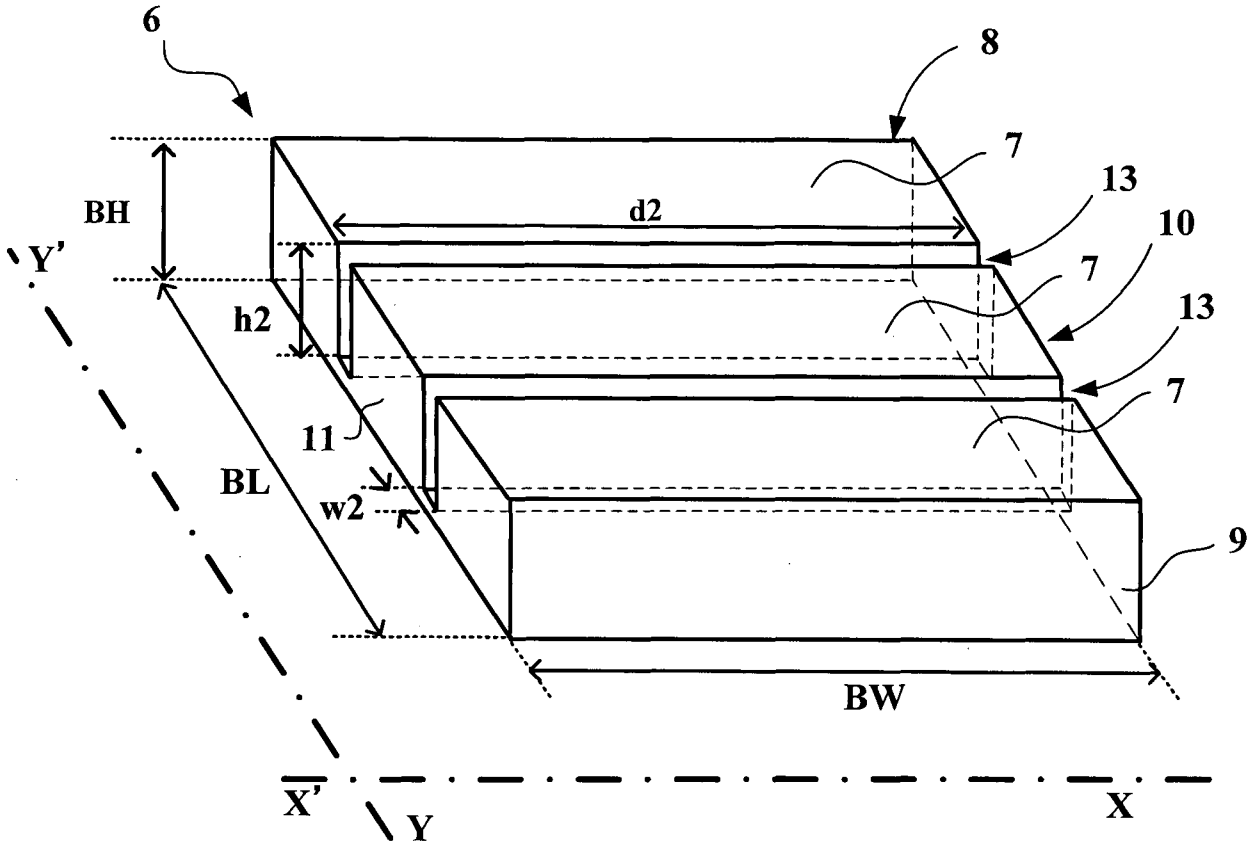
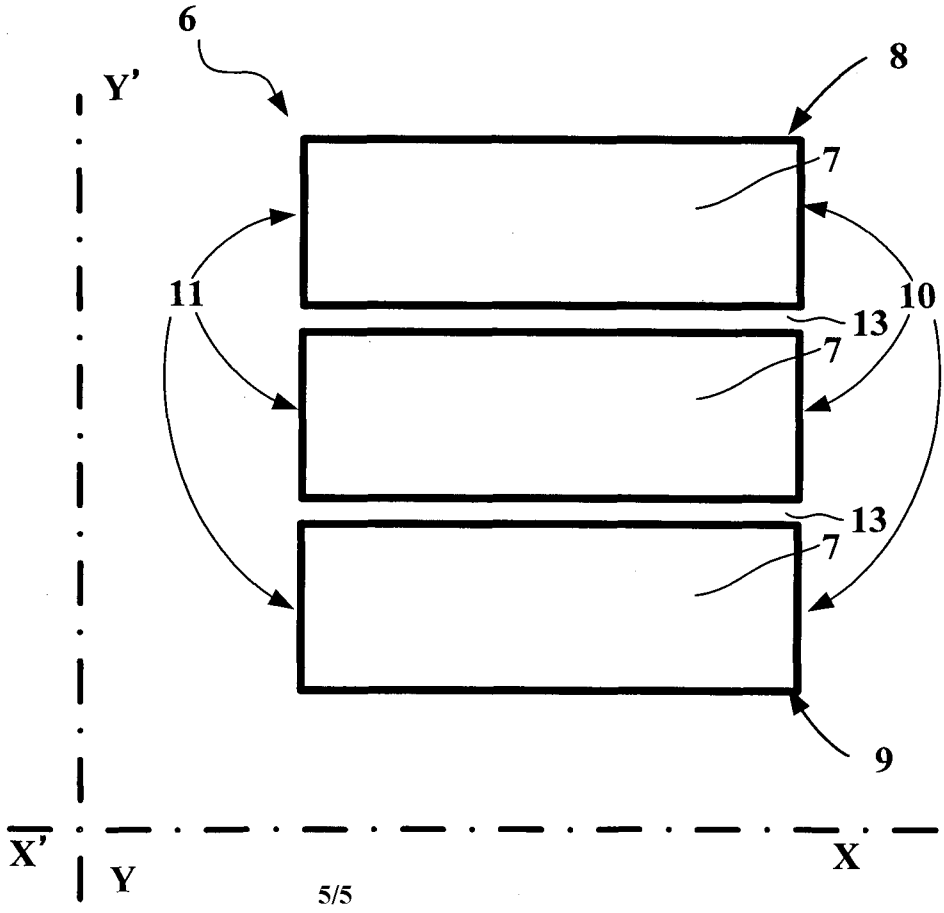


FIG.10



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2015/086149

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. B60C11/12(2006.01)i, B60C11/03(2006.01)i

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)

Int.Cl. B60C11/12, B60C11/03

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

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2016
Registered utility model specifications of Japan 1996-2016
Published registered utility model applications of Japan 1994-2016

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 2006-321342 A (BRIDGESTONE CORP.)2006.11.30, paragraphs [0023],[0026]-[0027],[0037]-[0038],Figs. 1-4 (Family: none)	1-3, 5 4, 6-10
Y	JP 2009-78654 A (BRIDGESTONE CORP.) 2009.04.16, paragraph [0030], Fig. 4 (Family: none)	4, 6-10
A	JP 7-101210 A (BRIDGESTONE CORP.) 1995.04.18, paragraphs [0011]-[0012],[0019],[0021],Figs. 1-2, Figs. 11-12 (Family: none)	1-10

☐ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
01.03.2016	15.03.2016

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