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(54) **WINTER TYRE**

WINTERREIFEN

PNEU D'HIVER

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(56) References cited:

EP-A1- 1 623 818

EP-A2- 0 952 011

WO-A1-2013/174737

JP-A- 2000 006 618

EP 2 961 620 B1

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Description

[0001] The present invention relates to a winter tyre.

[0002] Such a tyre is preferably intended to be mounted on wheels of high power and speed vehicles, like for example SUVs or particularly heavy sports cars.

[0003] A winter tyre typically comprises a tread band on which a plurality of circumferential and transversal grooves are formed. Such grooves delimit a corresponding plurality of blocks. Each of such blocks generally has a plurality of sipes. Each sipe defines in the respective block two adjacent block portions separated by the sipe.

[0004] The function of the sipes is essentially to offer further gripping edges on the snow-covered ground and to hold a certain amount of snow inside them, so as to offer a friction with the snow on the road surface greater than that offered by the tread band itself. Moreover, thanks also to the greater softness of the mixture typically used in winter tyres with respect to that typically used in summer tyres, and to the mobility of the two block portions defined by each sipe, the sipes allow the winter tyre to adapt better to the snow-covered road surface. Overall, thanks to the sipes it is possible to achieve an improvement in the performance of the tyre during acceleration, braking, cornering and as far as the lateral grip on a snow-covered road surface is concerned.

[0005] The provision of the sipes does, however, reduce the performance of the tyre on a snow-free road surface, be it dry or wet.

[0006] This reduction in performance is considered to be due to the fact that the different portions of the block separated by the sipes, being able to move with respect to one another, are not capable of offering sufficient resistance to tangential (or "shear") stresses applied to the block during acceleration, cornering or braking on a snow-free road surface, with consequent deformation of the block and reduction of its contact surface with the road surface itself.

[0007] The expression "circumferential" or "circumferentially" is used referring to a direction substantially parallel to the rolling direction of the tyre, i.e. a direction substantially parallel to the axial middle plane of the tyre.

[0008] The expression "axial" or "axially" is used referring to a direction substantially parallel to the rotation axis of the tyre, i.e. a direction substantially perpendicular to the axial middle plane of the tyre.

[0009] The expression "radial" or "radially" is used referring to a direction substantially perpendicular to the rotation axis of the tyre and belonging to a plane containing such a rotation axis.

[0010] The expression "longitudinal" or "longitudinally" is used referring to a main direction of extension of the sipe.

[0011] The expression "lateral stress", with reference to the tyre, or to the blocks, or to the sipes, is used to indicate a stress acting, on a plane tangent to the tyre, along a direction that is tilted with respect to the longitudinal direction.

[0012] The expression "profile which is substantially rectilinear" is used, referring to any surface portion of the sipe or of the blocks, to indicate that such a surface portion lies substantially on a plane or is shifted from such a plane by a negligible distance with respect to the longitudinal and radial dimensions of the same surface portion. Such a distance is considered negligible when it is not greater than one twentieth of the overall longitudinal extension of the surface portion.

[0013] The expression "profile which is substantially undulating" is used, with reference to any surface portion, to indicate the line defined, on an incident plane parallel both to the longitudinal direction of the sipe and to a plane tangent to the aforementioned surface portion, by a sequence of curvilinear or rectilinear lengths, which, going from a line defined by the intersection of the aforementioned incident plane with a reference plane different from said incident plane, progressively move apart from such a line until a first maximum shift point is reached, to then progressively move towards the aforementioned line until a null shift point is reached, such a sequence of lengths then proceeding with the same profile on the opposite side with respect to the aforementioned line and so on.

[0014] The "profile which is substantially undulating" can thus be defined by an alternating sequence of lengths that, in the aforementioned incident plane, create a line comprising an alternating sequence of portions with opposite concavity, wherein each of such portions can be defined both by a curved line and by a zigzag broken line.

[0015] As a particular case of a surface having a "profile which is substantially undulating" a surface comprising an alternating sequence of concave and convex portions is herein referred to.

[0016] Each concave and convex portion has, in the aforementioned incident plane, a maximum shift point from the aforementioned reference plane. The plurality of maximum shift points defined in each concave and convex portion when sectioning such a concave and convex portion with a plurality of incident planes that are parallel to one another defines a crest of the respective concave or convex portion.

[0017] The expression "transversal section" is used to refer to a section defined by any plane inclined by any angle with respect to the longitudinal direction of the sipe.

[0018] Preferably, such an inclined plane is perpendicular to the longitudinal direction of the sipe.

[0019] EP 0952011 discloses a pneumatic tire comprising a tread which comprises block-shaped land portions and a plurality of specific sipes formed on the block-shaped land portions. At least in one portion in the direction of the depth of the sipe, the sipe has an amplitude in the direction of the width of the sipe and extends in the transverse direction of the tire, and at least one portion of each sipe in the direction of the depth of the sipe is disposed at an offset position relative to an other portion of the sipe in a circumferential direction of the tire.

[0020] EP 1623818, corresponding with the preamble of claim 1, discloses a mold blade for forming sipes and

the sipe so formed in a tire tread element to have three-dimensional portions. In the formed sipe (20), the three-dimensional portion creates a constant interlocking of the opposing sipe faces. The blade and the sipe have two radially adjacent rows of projections, wherein the projections are separated by a planar section, the planar section having a defined length and width.

[0021] WO 2013/174737 discloses a tread profile for a vehicle tyre with profile positives such as profile blocks or tread belts, which have fine sipes. The width of a fine sipe is limited by two fine sipe walls which are arranged parallel with one another and which enclose an empty volume between them, and wherein the fine sipe walls have bulges which increase the empty volume of the fine sipe at the location of the bulge and which are arranged distributed in an axial direction and in a radial direction on the fine sipe wall. JP 2003-118322 describes a winter tyre comprising a tread band in which at least one sipe comprises a corrugated or zigzag portion extending along a direction and a flat portion at the opposite sides of the corrugated portion along said direction. In an alternative embodiment, the flat portion is arranged under the corrugated portion.

[0022] WO 2012/164449 describes a winter tyre comprising a tread band on which a plurality of grooves is provided, at least one block delimited by the plurality of grooves, at least one sipe formed on the block and extending between a top and a bottom of the sipe and shaped so as to define, on each block portion separated by the sipe, a first surface facing the other block portion and extending from the top to an intermediate depth of the sipe, which has an undulating profile, and a second surface facing the other block portion, radiused to the first surface and extending from the intermediate depth up to the bottom, which has a rectilinear profile.

[0023] WO 2012/164450 describes a winter tyre provided with sipes shaped so as to define, on each block portion separated by a sipe, a first surface facing the other block portion and extending from the top to an intermediate depth of the sipe and a second surface facing the other block portion, radiused to the first surface and extending from the intermediate depth up to the bottom, in which the first surface has a profile which is rectilinear and the second surface has a profile which is undulating.

[0024] Hereafter reference will be made without distinction to the sipes or to one (or both) of the surfaces of the block portions separated by each sipe and facing the sipe itself. Indeed, the profile of the aforementioned surfaces matches the profile of the sipe.

[0025] The Applicant has realised that, in order to obtain optimal performance of the tyre during acceleration, braking or cornering on a snow-covered road surface, it is advantageous to provide the tyre with sipes whose radially outer portion has a profile which is substantially undulating. The Applicant has indeed observed that the profile which is substantially undulating has a greater linear extension, under the same longitudinal extension, with respect to a profile which is substantially rectilinear

and, therefore, offers a greater gripping edge on the snow-covered road surface and greater ability to hold snow.

[0026] The Applicant has also noted that the provision in the sipes of a profile which is substantially undulating, ensuring a mutual interconnection between the two block portions separated by each sipe, determines a high rigidity of the blocks with respect to lateral stresses and, consequently, excellent behaviour of the tyre as far as the lateral stability on a snow-covered road surface is concerned.

[0027] The Applicant has, however, noted that the provision in the tyre of sipes having a profile which is substantially undulating involves a degradation in the performance of the tyre as far as the lateral stability on a snow-free road surface is concerned when such a tyre is subjected to lateral stresses of a certain degree. The Applicant has attributed such a degradation to the excessive abrasion occurring on the two block portions separated by each sipe due to the mutual sliding of such block portions when they are subjected to the aforementioned lateral stresses.

[0028] The Applicant has noted that, in order to improve the aforementioned performance on a snow-free road surface, without penalizing the aforementioned performance on a snow-covered road surface, it is advantageous to use sipes having a substantially rectilinear profile arranged in a radially inner position with respect to a substantially undulating profile. The Applicant has indeed observed that the provision of a substantially rectilinear profile makes it possible to minimise the above-discussed sliding, thus reducing the negative effects produced thereby.

[0029] However, the Applicant has verified that, particularly in extreme lateral stress conditions on a snow-free road surface, like for example in the case of rapid and sudden turning with particularly powerful and heavy vehicles, problems of lateral stability remain in those tyres provided with sipes of the type described for example in WO 2012/164449.

[0030] The Applicant attributes the cause of such problems to an excessive yielding and mobility of the blocks at the respective radially inner portions thereof.

[0031] The Applicant has realised that in order to greatly improve the performance of the tyre as far as the lateral stability on a snow-free road surface is concerned it is necessary to have a good interconnection between the radially inner portions of the two block portions separated by each sipe.

[0032] The Applicant has perceived that it is possible to obtain such interconnection by providing, in the radially inner portions of the blocks, a profile which is substantially undulating.

[0033] The Applicant has, however, verified that it is appropriate to keep in a first radially outer portion of the sipe a profile which is substantially undulating and in a second more radially inner portion with respect to the aforementioned first portion a profile which is substan-

tially rectilinear. This is in order to achieve all of the positive effects (described above) produced by such profiles on a snow-covered road surface and on a snow-free road.

[0034] The Applicant has finally found that it is possible to greatly improve the performance of the tyre as far as the lateral stability on a snow-free road surface is concerned and under extreme stress conditions, at the same time ensuring optimal behaviour on a snow-covered road surface during acceleration, braking or cornering and regarding the lateral grip, providing the tyre with sipes having both at a radially outer portion thereof and at a radially inner portion thereof a profile which is substantially undulating, such sipes also having at a radially intermediate portion thereof arranged between said radially outer portion and said radially inner portion a profile which is substantially rectilinear.

[0035] The present invention therefore relates to, in an aspect thereof, a winter tyre according to claim 1.

[0036] The Applicant believes that the provision of a profile which is substantially undulating both at the radially outer portion and at the radially inner portion of the sipes ensures high interconnection between the block portions separated by the sipes, with consequent high rigidity of the block and, therefore, better response of the tyre to all stresses, even extreme ones, which the tyre is subjected to when used both on a snow-covered road surface and on a snow-free road surface. At the same time, the interposition of a substantially rectilinear profile between the aforementioned substantially undulating profiles ensures adequate control of mutual sliding of the block portions separated by each sipe when the block is subjected to extreme lateral stresses, nullifying the negative effects produced by such sliding.

[0037] The present invention, in the aforementioned aspect, can have at least one of the preferred characteristics indicated hereafter, both individually and in combination.

[0038] According to the invention, said first profile and second profile are defined by a plurality of concave and convex portions arranged in an alternating sequence along a direction parallel to a longitudinal direction of said at least one sipe. In this way the desired interconnection between the block portions separated by the sipes is ensured along the entire longitudinal extension of each sipe.

[0039] Preferably, said longitudinal direction is parallel to a plane which is tangent to a radially outer surface of said tread band at said two block portions facing said sipe. The radial extension of each sipe is therefore constant in the entire tread band, thus guaranteeing homogeneous behaviour of the tyre on a snow-covered road surface.

[0040] More preferably, said longitudinal direction is tilted with respect to both an axial direction and a circumferential direction of the tyre. In this way, the rigidity given to the blocks by the interconnection of the two block portions defined by each sipe produces its advantageous effects both in response to axial stresses, like for example in the case of a sudden turn, and in response to circum-

ferential stresses, like for example in the case of sudden acceleration or braking.

[0041] In preferred embodiments of the present invention, said concave and convex portions extend on opposite sides with respect to said reference plane.

[0042] Preferably, said concave and convex portions extend symmetrically on opposite sides with respect to said reference plane.

[0043] Preferably, each of the concave and convex portions of the first profile has a respective first crest whose distance from said reference plane progressively increases moving away in a radial direction from said intermediate portion to said top portion.

[0044] Preferably, each of the concave and convex portions of the second profile has a respective second crest whose distance from said reference plane progressively increases moving away in a radial direction from said intermediate portion towards said bottom portion.

[0045] Preferably, the distance of said first crest from said reference plane is substantially null at said intermediate portion.

[0046] Preferably, the distance of said second crest from said reference plane is substantially null at said intermediate portion.

[0047] In a preferred embodiment of the present invention, said surface has, in a transversal section taken at each concave portion of the first profile, a respective convex portion of the second profile and, in a transversal section taken at each convex portion of the first profile, a respective concave portion of the second profile.

[0048] In this case, the overall profile of the sipe is such that, in each transversal section of the sipe, the first profile and the second profile are arranged on opposite sides with respect to the aforementioned reference plane.

[0049] Preferably, said tread band comprises a central annular portion astride of an axial middle plane and two annular shoulder portions arranged on axially opposite sides with respect to the central annular portion, the central annular portion being separated from each annular shoulder portion by a respective circumferential groove.

[0050] Preferably, the sipe described above is provided on the blocks of said central annular portion and of only one of said annular shoulder portions.

[0051] More preferably, when the tyre is mounted on a rim forming a wheel of a motor vehicle, said annular shoulder portion is axially more external than the central annular portion with respect to said motor vehicle.

[0052] The Applicant has in fact verified that the sipe described above with reference to the first preferred embodiment of the present invention, produces its advantageous effects when provided in the portions of the tyre identified above. The blocks of the other annular shoulder portion of the tyre can in this case be provided with sipes of a different type, for example of a type similar to the sipes described in WO 2012/164450.

[0053] In further embodiments of the present invention, said surface has, in a transversal section taken at each concave portion of the first profile, a respective concave

portion of the second profile and, in a transversal section taken at each convex portion of the first profile, a respective convex portion of the second profile.

[0054] In this case, the overall profile of the sipe is such that, in each transversal section of the sipe, the first profile and the second profile are arranged on the same side with respect to the aforementioned reference plane.

[0055] The Applicant has verified that the sipe described above with reference to the further preferred embodiments of the present invention produces its advantageous effects when provided on one of the annular shoulder portions of tyres of the "directional-type", i.e. in tyres that, in use, are stressed mainly at one of the two annular shoulder portions.

[0056] According to the invention, each of the concave and convex portions of the second profile comprises a radially outer surface portion, a radially inner surface portion and an intermediate surface portion arranged between said radially outer surface portion and said radially inner surface portion, wherein said intermediate surface portion is substantially parallel to said reference plane.

[0057] The Applicant has verified that providing such a profile at the radially inner portion of the sipe ensures a greater interconnection effect between the adjacent block portions, with consequent further stiffening of the blocks.

[0058] Preferably, each of the concave and convex portions of the second profile has a respective third crest whose distance from said reference plane progressively increases moving away in a radial direction from the aforementioned intermediate portion to said intermediate surface portion.

[0059] More preferably, the distance of said third crest from said reference plane progressively decreases moving away in a radial direction from said intermediate surface portion towards said bottom portion.

[0060] Preferably, the distance of said third crest from said reference plane is substantially null at said intermediate portion.

[0061] In a further preferred embodiment of the present invention, said surface has, in a transversal section taken at each concave portion of the first profile, a respective concave portion of the second profile and, in a transversal section taken at each convex portion of the first profile, a respective convex portion of the second profile.

[0062] The Applicant has verified that such a sipe carries out its advantageous effects when foreseen in the blocks of the annular shoulder portions of the tyre. The blocks of the central annular portion of the tyre can in this case be provided with sipes of a different type, for example of a type similar to the sipes described in WO 2012/164449.

[0063] In another preferred embodiment of the present invention, said surface has, in a transversal section taken at each concave portion of the first profile, a respective convex portion of the second profile and, in a transversal section taken at each convex portion of the first profile, a respective concave portion of the second profile.

[0064] Preferably, said tread band comprises a central annular portion astride of an axial middle plane and two annular shoulder portions arranged on axially opposite sides with respect to the central annular portion, the central annular portion being separated from each annular shoulder portion by a respective circumferential groove, wherein said at least one sipe is provided only on the blocks of said annular shoulder portions.

[0065] The Applicant has verified that such a sipe particularly produces its advantageous effects when provided in the blocks of the annular shoulder portions of the tyre. The blocks of the central annular portion of the tyre can in this case be provided with sipes of a different type, for example of the type similar to the sipes described in WO 2012/16449 and/or WO 2012/16450.

[0066] In a different embodiment, said tread band comprises a central annular portion astride of an axial middle plane and two annular shoulder portions arranged on axially opposite sides with respect to the central annular portion, the central annular portion being separated from each annular shoulder portion by a respective circumferential groove, wherein said at least one sipe is provided only on the blocks of said central annular portion.

[0067] Preferably, when said surface is sectioned with an incident plane, said first profile and second profile define respective lines which are substantially sinusoidal.

[0068] In further preferred embodiments of the present invention, when said surface is sectioned with an incident plane, said first profile and second profile define respective zigzag broken lines.

[0069] Preferably, said zigzag broken lines comprise an alternating sequence of a first rectilinear length and a second rectilinear length.

[0070] Further characteristics and advantages of the present invention will become clearer from the following detailed description of its preferred embodiments, made with reference to the attached drawings. In such drawings:

- figure 1 is a schematic perspective view of a significant portion of a tyre in accordance with an exemplifying embodiment of the present invention;
- figure 2 is a schematic perspective view, in an enlarged scale, of a part of a block of the tyre of figure 1;
- figures 3a, 3b and 3c are schematic views, respectively from above (figure 3a), in a transversal section taken along the reference plane A1-A1 of figure 3a (figure 3b) and in perspective (figure 3c), of a sipe not forming part of the present invention used in the tyre of figure 1;
- figures 4a, 4b and 4c are schematic views, respectively from above (figure 4a), in a transversal section taken along the reference plane A1-A1 of figure 4a (figure 4b) and in perspective (figure 4c), of a sipe not forming part of the present invention used in the tyre of figure 1;
- figures 5a, 5b and 5c are schematic views, respectively from above (figure 5a), in a transversal section

taken along the reference plane A1-A1 of figure 5a (figure 5b) and in perspective (figure 5c), of an embodiment of a sipe according to the present invention used in the tyre of figure 1;

- figures 6a, 6b and 6c are schematic views, respectively from above (figure 6a), in a transversal section taken along the reference plane A1-A1 of figure 6a (figure 6b) and in perspective (figure 6c), another embodiment of a sipe according to the present invention used in the tyre of figure 1.

[0071] With reference to figure 1, reference numeral 1 wholly indicates an exemplifying embodiment of a tyre in accordance with the present invention.

[0072] The tyre 1 comprises a carcass structure (not visible) arranged toroidally around an axis Z (substantially coinciding with the rotation axis of the tyre), a belt structure (not visible) arranged in a radially outer position with respect to the carcass structure and a tread band 2 arranged in a radially outer position with respect to the belt structure and having a radially outer surface 3 configured to come into contact with a road surface on which the tyre 1 is intended to roll.

[0073] On the tread band 2 a central annular portion C astride of an axial middle plane (not shown) and two annular shoulder portions S1, S2 arranged on axially opposite sides with respect to the central annular portion C can be identified. The central annular portion C is separated from each annular shoulder portion S1, S2 by a respective circumferential groove 4. The portion S1 is the one that, when the tyre 1 is mounted on a wheel of a motor vehicle, is located in an axially outer position with respect to the central annular portion C from the vehicle.

[0074] Further grooves, also generically indicated with 4, extending along circumferential and transversal directions are also provided on the tread band 2. All of the grooves 4 delimit a plurality of blocks 5 which are arranged in sequence preferably along a circumferential direction Y.

[0075] On each block 5 one or more sipes 6 are provided, the sipes extending along a longitudinal direction X that, like in the embodiment herein described and illustrated, can be tilted with respect both to the axial direction Z and to the circumferential direction Y.

[0076] For example, the longitudinal direction X can be tilted with respect to the axial direction Z by an angle α that is preferably greater than about 2°, more preferably greater than about 5° (figures 3a, 4a, 5a and 6a). The angle α is preferably lower than about 45°, more preferably lower than about 40°. Even more preferably, the angle α is comprised between about 2° and about 45°, more preferably between about 5° and about 40°, for example equal to about 35°.

[0077] The aforementioned longitudinal direction X is preferably parallel to a plane which is tangent to the radially outer surface 3 of the tread band 2 at two block portions 9, 10, facing said sipe 6.

[0078] For the sake of simplicity of illustration, refer-

ence numerals 4, 5 and 6 are associated with just some of the grooves, blocks and sipes, respectively.

[0079] Alternative embodiments of the tyre 1 in which the blocks 5 have different configuration and orientation from those illustrated herein and in which the sipes 6 have different longitudinal extension and orientation from those illustrated herein are provided.

[0080] Preferably, each sipe 6 is open, at the opposite longitudinal ends 6a, 6b, on a pair of grooves 4 that delimit the block 5 itself, so that the sipe 6 crosses through the block 5 from one side to the other.

[0081] As shown in figure 2, each sipe 6 extends between a top portion 7 of the block 5, open on the radially outer surface 3 of the tread band 2, and a bottom portion 8 of the block 5, defined in a radially inner position of the tread band 2.

[0082] Each sipe 6 defines, in the block 5, said two block portions, which are respectively indicated with 9 and 10. Such a block portions are adjacent to one another, separated by the sipe 6 and spaced apart by an amount m that is kept substantially constant along the longitudinal direction X of the sipe 6 (figures 3a, 4a, 5a and 6a).

[0083] Such a measurement m is for example greater than about 0.1 mm, more preferably greater than about 0.2 mm. The measurement m is preferably lower than about 0.8 mm, more preferably lower than about 0.6 mm. Even more preferably, the measurement m is comprised between about 0.1 mm and about 0.8 mm, more preferably between about 0.2 mm and about 0.6 mm, for example equal to about 0.4 mm.

[0084] Each block portion 9, 10 comprises a respective surface facing the sipe 6. Such a surface is configured identically to the sipe 6, so that what is said herein below with reference to the sipe 6 applies in an absolutely identical manner to each of the aforementioned surfaces and vice-versa.

[0085] At least some of the sipes 6 of the tyre 1 are shaped as described below.

[0086] Figures 3a, 3b and 3c show a sipe 6 not forming part of the present invention. Such a sipe 6 comprises a radially outer portion 61, a radially inner portion 62 and an intermediate portion 63 arranged between the radially outer portion 61 and the radially inner portion 62.

[0087] The radially outer portion 61 and the radially inner portion 62 both have a profile which is substantially undulating, whereas the intermediate portion 63 has a profile which is substantially rectilinear.

[0088] Hereafter, the profile of the radially outer portion 61 is indicated as "first profile" and the profile of the radially inner portion 62 is indicated as "second profile".

[0089] The intermediate portion 63 is substantially flat. It defines in the block 5 a reference plane, indicated in figure 3a and 3b with P. Such a reference plane P is parallel to the longitudinal direction X of the sipe 6 and preferably coincides with a radial plane of the tyre 1.

[0090] The radial extension h3 of the intermediate portion 63 is equal to a fraction of the overall radial extension

H of the sipe 6. Preferably, the overall radial extension H is greater than 4 times the radial extension h3 of the intermediate portion 63. Preferably the overall radial extension H is greater than 5 times the radial extension h3 of the intermediate portion 63. For example, H can be equal to about 7 mm and h3 can be equal to about 1 mm.

[0091] Preferably, the intermediate portion 63 is arranged at a distance h1 from the top portion 7 of the block 5 comprised between about 1 mm and about 4 mm and at a distance h2 from the bottom portion 8 of the block 5 comprised between about 1 mm and about 10 mm, more preferably between about 2 mm and about 6 mm. For example, h1 and h2 can be equal to about 3 mm.

[0092] The first profile is suitably radiused to the intermediate portion 63 and is defined by a plurality of concave 61a and convex 61b portions arranged in alternating sequence along a direction parallel to the longitudinal direction X of the sipe 6. Preferably, the concave 61a and convex 61b portions extend symmetrically on opposite sides with respect to the reference plane P.

[0093] Similarly, the second profile is suitably radiused to the intermediate portion 63 and is defined by a plurality of concave 62a and convex 62b portions arranged in alternating sequence along the aforementioned direction parallel to the longitudinal direction X of the sipe 6, such concave 62a and convex 62b portions preferably extending symmetrically on opposite sides with respect to the reference plane P.

[0094] For the sake of simplicity of illustration, reference numerals 61a, 61b are associated with just some of the aforementioned concave portions and reference numerals 62a, 62b are associated with just some of the aforementioned convex portions.

[0095] The sipe 6 shown in figure 3a, 3b and 3c is shaped so that, in any transversal section of the sipe 6 (like for example the transversal section from which figure 3b originates) the first profile and the second profile are arranged on opposite sides with respect to the reference plane P. With specific reference to figure 3b, the shape of the sipe 6 is thus such that, on the section plane, at each concave portion 61a of the first profile there is a respective convex portion 62b of the second profile and at each convex portion 61b of the first profile there is a respective concave portion 62a of the second profile.

[0096] Moving along the longitudinal direction X of the sipe 6, at a central portion of each of the concave 61a and convex 61b portions of the first profile there is a respective crest 610a, 610b whose distance from the reference plane P progressively increases (preferably linearly) moving away from the intermediate portion 63 in the radial direction until the top portion 7 of the block 5 is reached. Similarly, at a central portion of each of the concave 62a and convex 62b portions of the second profile there is a respective crest 620a, 620b whose distance from the reference plane P progressively increases (preferably linearly) moving away from the intermediate portion 63 in the radial direction towards the bottom portion 8 of the block 5.

[0097] The crests 610a and 610b thus consist, in each of the concave 61a, 62a and convex 61b, 62b portions of the first profile and of the second profile, respectively, of plurality of points belonging to incident planes that are parallel to one another (each point belonging to one of said planes, so that the aforementioned points are aligned) having the maximum distance from the reference plane P with respect to the distance from the aforementioned reference plane of any other point of the respective concave 61a, 62a and convex 61b, 62b portion belonging to the same incident plane.

[0098] Preferably, at the intermediate portion 63 the distance A of the crests 610a, 610b, 620a, 620b from the reference plane P is substantially null, whereas at the top 7 and bottom 8 portions of the block 5 the distance A of the crests 610a, 610b, 620a, 620b from the reference plane P is comprised between about 0.5 mm and about 2 mm, preferably between about 1 mm and about 1.5 mm, for example equal to about 1.25 mm.

[0099] The first profile and the second profile extend along the longitudinal direction X of the sipe 6 for a length comprised between 50% and 100 % of the entire longitudinal extension of the sipe 6. In the case in which there are areas of the sipe 6 not having the aforementioned profiles, such areas are coplanar to the intermediate portion 63 and are preferably provided both upstream and downstream of the aforementioned profiles along the longitudinal direction X (i.e. at the opposite longitudinal ends 6a, 6b of the sipe 6). In this case, preferably, the areas upstream and downstream have identical longitudinal and radial extensions.

[0100] In the embodiments herein illustrated, the first profile is configured so that, when sectioned with any incident plane, a zigzag broken line is obtained, which is clearly shown in figure 3a.

[0101] Preferably, the zigzag broken line comprises an alternating sequence of first and second rectilinear lengths, respectively indicated with 101 and 102, radiused together so that the broken line has, at the crests 610a, 610b, 620a, 620b, rounded vertices.

[0102] Preferably, the first and second rectilinear lengths 101, 102 extend substantially parallel to the axial direction Z and to the circumferential direction Y, respectively. In particular, there is a maximum shifting from the axial direction Z of about 2° and a maximum shifting from the circumferential direction Y of about 5°.

[0103] Moreover, all of the first rectilinear lengths 101 preferably have a substantially constant extension D, for example comprised between about 1.5 mm and about 10 mm, preferably between about 2 mm and about 6 mm, for example equal to about 4 mm, whereas the second rectilinear lengths 102 preferably have an extension d shorter than that of the first rectilinear lengths, for example comprised between 1.5 mm and about 10 mm, preferably between about 2 mm and about 5 mm, for example equal to about 3.5 mm.

[0104] The sipe 6 of figures 3a, 3b and 3c has a preferred use in the blocks 5 of the central annular portion

C and of the annular shoulder portion S1, in an axially outer position with respect to the vehicle on which the wheel comprising the tyre 1 is mounted. The blocks 5 of the annular shoulder portion S2 can in this case be provided with sipes of a different type, for example of the type similar to the sipes described in WO 2012/164450.

[0105] Figures 4a, 4b and 4c schematically show another sipe 6 not forming part of the present invention used in the tyre 1.

[0106] In such a figure, structural and functional elements that are identical to those described above with reference to figures 3a, 3b and 3c are marked with the same reference numeral and are not described any further.

[0107] The sipe 6 of figures 4a, 4b and 4c differs from that of figure 3a, 3b and 3c only in that, in any transversal section of the sipe 6 (like for example the transversal section from which figure 4b originates) the first profile and the second profile are arranged on the same side with respect to the reference plane P. With particular reference to figure 4b, the shape of the sipe 6 is thus such that, on the section plane, at each concave portion 61a of the first profile there is a respective concave portion 62b of the second profile and at each convex portion 61b of the first profile there is a respective convex portion 62a of the second profile.

[0108] The sipe 6 of figures 4a, 4b and 4c has a preferred use in the blocks 5 of one of the shoulder portions S1, S2 of a tyre 1 of the "directional-type".

[0109] Figures 5a, 5b and 5c and figures 6a, 6b, 6c schematically show two embodiments of the sipe 6 used in the tyre 1 of the present invention.

[0110] In such figures, structural and functional elements that are identical to those described above with reference to figures 3a, 3b and 3c are marked with the same reference numeral and are not described any further.

[0111] The sipe 6 of figures 5a, 5b and 5c and of figures 6a, 6b, 6c differs from that of figures 3a, 3b and 3c only for the different shape of the second profile and for the different radial dimensions of the radially outer portion 61, of the radially inner portion 62 and of the intermediate portion 63.

[0112] In particular, each of the concave portions 62a of the second profile comprises a radially outer surface portion 72a, a radially inner surface portion 73a and an intermediate surface portion 74a. Similarly, each of the convex portions 62b of the second profile comprises a radially outer surface portion 72b, a radially inner surface portion 73b and an intermediate surface portion 74b arranged between the radially outer surface portion 72b and the radially inner surface portion 73b.

[0113] In any transversal section of the sipe 6, the intermediate surface portions 74a, 74b are substantially rectilinear and are apart from the reference plane P by the distance A discussed above.

[0114] The radially outer surface portions 72a, 72b and the radially inner surface portions 73a, 73b are properly

radiused to the intermediate surface portions 74a, 74b.

[0115] The crest 610a, 610b of each of the concave 62a and convex 62b portions of the second profile has a distance from the reference plane P that progressively increases (preferably linearly) moving away in the radial direction from the intermediate portion 63 up to the intermediate surface portion 74a, 74b, to then proceed parallel to the reference plane P at the intermediate surface portion 74a, 74b and finally progressively decrease (preferably linearly) moving away from the intermediate surface portion 74a, 74b in the radial direction towards the bottom portion 8 of the block 5. Preferably, such a distance is substantially null at the intermediate portion 63 and at the bottom portion 8.

[0116] The radial extension h3 of the intermediate portion 63 is preferably lower than (for example half) the radial extension h3 of the sipe 6 shown in figures 3a, 3b, 3c, the radial extension H being equal. For example, in the embodiments shown in figures 5a, 5b, 5c and 6a, 6b, 6c h3 it can be equal to about 0.5 mm.

[0117] Preferably, the intermediate portion 63 is arranged at a distance h1 from the top portion 7 of the block 5 that is lower than the distance h1 of the sipe 6 shown in figures 3a, 3b, 3c, the overall radial extension H being equal. Consequently, the intermediate portion 63 is arranged at a distance h3 from the bottom portion 8 of the block 5 that is greater than the distance h2 of the sipe 6 shown in figures 3a, 3b, 3c, the overall radial extension H being equal. For example, in the embodiments shown in figures 5a, 5b, 5c and 6a, 6b, 6c h1 can be equal to about 2 mm and h2 can be equal to about 4.5 mm.

[0118] Preferably, the intermediate surface portion 74a, 74b has a radial extension h2''' which is equal to the radial extension h3 of the intermediate portion 63. For example, h2''' can be equal to about 0.5 mm.

[0119] Preferably, the intermediate surface portion 74a, 74b is arranged at a distance h2' from the intermediate portion 63 that is equal to the distance h2" from the bottom portion 8. For example h2' and h2" can be equal to about 2 mm.

[0120] With particular reference to figures 5a, 5b, 5c, the sipe 6 shown in such figures has a configuration such that, like in figures 4a, 4b and 4c, in any transversal section of the sipe 6 (like for example the transversal section from which figure 5b originates) the first profile and the second profile are arranged on the same side with respect to the reference plane P. On the section plane, therefore, at each concave portion 61a of the first profile there is a respective concave portion 62b of the second profile and at each convex portion 61b of the first profile there is a respective convex portion 62a of the second profile.

[0121] The sipe 6 of figures 5a, 5b and 5c has a preferred use in the blocks 5 of the annular shoulder portions S1, S2 of the tyre 1. The blocks of the central annular portion C can in this case be provided with sipes of a different type, for example of the type similar to the sipes described in WO 2012/164449.

[0122] On the other hand, with particular reference to figures 6a, 6b, 6c, the sipe 6 shown in such figures has a configuration such that, like in figures 3a, 3b and 3c, in any transversal section of the sipe 6 (like for example the transversal section from which figure 6b originates) the first profile and the second profile are arranged on opposite sides with respect to the reference plane P. On the section plane, therefore, at each concave portion 61a of the first profile there is a respective convex portion 62b of the second profile and at each convex portion 61b of the first profile there is a respective concave portion 62a of the second profile.

[0123] The sipe 6 of figures 6a, 6b and 6c has a preferred use in the blocks 5 of the annular shoulder portions S1 and S2 of the tyre 1. The blocks of the central annular portion C can in this case be provided with sipes of a different type, for example of a type similar to the sipes described in WO 2012/16449 and/or WO 2012/16450.

[0124] The sipe 6 of figures 6a, 6b and 6c can also have an use in the blocks 5 of the central annular portion C of the tyre 1. The blocks of the annular shoulder portions S1 and S2 can in this case be provided with sipes of a different type, for example of a type similar to the sipes described in WO 2012/16449 and/or WO 2012/16450.

[0125] Of course, a man skilled in the art can make further modifications and variants to the invention described above in order to satisfy specific and contingent use requirements, said variants and modifications in any case being within the scope of protection as defined by the following claims.

Claims

1. A winter tyre (1), comprising a tread band (2) wherein a plurality of blocks (5) is defined, at least some of said blocks (5) comprising at least one sipe (6) extending from a top portion (7) of the block (5) towards a bottom portion (8) of the block (5), wherein said at least one sipe (6) defines two adjacent block portions (9, 10) in the block (5), each of said two block portions (9, 10) comprising a surface facing said at least one sipe (6), said surface comprising:

- a radially outer portion (61) having a first profile which is undulating;
- a radially inner portion (62) having a second profile which is undulating;
- an intermediate portion (63) arranged between said radially outer portion (61) and said radially inner portion (62) and having a third profile which is rectilinear; wherein said intermediate portion (63) defines a reference plane (P) coinciding with a radial plane of the tyre (1),

characterised in that

- said first profile and second profile are defined by a plurality of concave (61a, 62a) and convex (61b, 62b) portions arranged in an alternating sequence with respect to said reference plane (P) along a direction parallel to a longitudinal direction (X) of said at least one sipe (6); and **in that**

- each of the concave (62a) and convex (62b) portions of the second profile comprises a radially outer surface portion (72a, 72b), a radially inner surface portion (73a, 73b) and an intermediate surface portion (74a, 74b) arranged between said radially outer surface portion (72a, 72b) and said radially inner surface portion (73a, 73b), wherein said intermediate surface portion (74a, 74b) is parallel to said reference plane (P).

2. A tyre (1) according to claim 1, wherein said longitudinal direction (X) is parallel to a plane which is tangent to a radially outer surface (3) of said tread band (2) at said two block portions (9, 10) facing said sipe (6).
3. A tyre (1) according to claim 1 or 2, wherein said longitudinal direction (X) is tilted with respect to both an axial direction (Z) and a circumferential direction (Y) of the tyre (1).
4. A tyre (1) according to claim 1, wherein said concave (61a, 62a) and convex (61b, 62b) portions extend symmetrically on opposite sides with respect to said reference plane (P).
5. A tyre (1) according to claim 1 or according to claim 4, wherein each of the concave (61a) and convex (61b) portions of the first profile has a respective first crest (610a, 610b) whose distance from said reference plane (P) progressively increases moving away in a radial direction from said intermediate portion (63) to said top portion (7).
6. A tyre (1) according to claim 1 or according to any one of claims 4 to 5, wherein each of the concave (62a) and convex (62b) portions of the second profile has a respective second crest (620a, 620b) whose distance from said reference plane (P) progressively increases moving away in a radial direction from said intermediate portion (63) towards said bottom portion (8).
7. A tyre (1) according to any one of the previous claims, wherein said surface has, in a transversal section taken at each concave portion (61a) of the first profile, a respective convex portion (62b) of the second profile and, in a transversal section taken at each convex portion (61b) of the first profile, a respective concave portion (62a) of the second profile.

8. A tyre (1) according to anyone of the previous claims, wherein said tread band (2) comprises a central annular portion (C) astride of an axial middle plane and two annular shoulder portions (S1, S2) arranged on axially opposite sides with respect to the central annular portion (C), the central annular portion (C) being separated from each annular shoulder portion (S1, S2) by a respective circumferential groove (4), wherein said at least one sipe (6) is provided on the blocks (5) of said central annular portion (C) and of only one of said annular shoulder portions (S1, S2).
9. A tyre (1) according to claim 8, wherein when the tyre (1) is mounted on a rim forming a wheel of a motor vehicle, said annular shoulder portion (S1, S2) is axially more external than the central annular portion (C) with respect to said motor vehicle.
10. A tyre (1) according to any one of claims 1 to 6, wherein said surface has, in a transversal section taken at each concave portion (61a) of the first profile, a respective concave portion (62a) of the second profile and, in a transversal section taken at each convex portion (61b) of the first profile, a respective convex portion (62b) of the second profile.
11. A tyre (1) according to claim 10, wherein said tread band (2) comprises a central annular portion (C) astride of an axial middle plane and two annular shoulder portions (S1, S2) arranged on axially opposite sides with respect to the central annular portion (C), the central annular portion (C) being separated from each annular shoulder portion (S1, S2) by a respective circumferential groove (4), wherein said at least one sipe (6) is provided only on the blocks (5) of said annular shoulder portions (S1, S2).
12. A tyre (1) according to claim 10, wherein said tread band (2) comprises a central annular portion (C) astride of an axial middle plane and two annular shoulder portions (S1, S2) arranged on axially opposite sides with respect to the central annular portion (C), the central annular portion (C) being separated from each annular shoulder portion (S1, S2) by a respective circumferential groove (4), wherein said at least one sipe (6) is provided only on the blocks (5) of said central annular portion (C).
13. A tyre (1) according to any one of the previous claims, wherein when said surface is sectioned with an incident plane, said first profile and second profile define respective lines which are sinusoidal.
14. A tyre (1) according to any one of the previous claims, wherein when said surface is sectioned with an incident plane, said first profile and second profile define respective zigzag broken lines; said zigzag broken lines comprising an alternating sequence of a

first rectilinear length (101) and a second rectilinear length (102).

5 Patentansprüche

1. Winterreifen (1), umfassend einen Laufflächenring (2), in dem eine Vielzahl von Blöcken (5) definiert ist, wobei zumindest einige der Blöcke (5) zumindest eine Lamelle (6) umfassen, die sich von einem oberen Abschnitt (7) des Blocks (5) zu einem unteren Abschnitt (8) des Blocks (5) erstreckt, wobei die zumindest eine Lamelle (6) zwei benachbarte Blockabschnitte (9, 10) in dem Block (5) definiert, wobei jeder der zwei Blockabschnitte (9, 10) eine Oberfläche umfasst, die zu der zumindest einen Lamelle (6) weist, wobei die Oberfläche umfasst:

- einen radial äußeren Abschnitt (61) mit einem ersten Profil, das wellenförmig ist;
- einen radial inneren Abschnitt (62) mit einem zweiten Profil, das wellenförmig ist;
- einen mittleren Abschnitt (63), der zwischen dem radial äußeren Abschnitt (61) und dem radial inneren Abschnitt (62) angeordnet ist und ein drittes Profil aufweist, das geradlinig ist;

wobei der mittlere Abschnitt (63) eine Referenzebene (P) definiert, die mit einer radialen Ebene des Reifens (1) zusammenfällt,

dadurch gekennzeichnet, dass

- das erste Profil und das zweite Profil durch eine Vielzahl von konkaven (61a, 62a) und konvexen (61b, 62b) Abschnitten definiert werden, die in einer alternierenden Abfolge in Bezug auf die Referenzebene (P) entlang einer Richtung parallel zu einer Längsrichtung (X) der zumindest einen Lamelle (6) angeordnet sind; und dass
- jeder der konkaven (62a) und konvexen (62b) Abschnitte des zweiten Profils einen radial äußeren Oberflächenabschnitt (72a, 72b), einen radial inneren Oberflächenabschnitt (73a, 73b) und einen mittleren Oberflächenabschnitt (74a, 74b), der zwischen dem radial äußeren Oberflächenabschnitt (72a, 72b) und dem radial inneren Oberflächenabschnitt (73a, 73b) angeordnet ist, umfasst, wobei der mittlere Oberflächenabschnitt (74a, 74b) parallel zu der Referenzebene (P) ist.

2. Reifen (1) nach Anspruch 1, wobei die Längsrichtung (X) parallel zu einer Ebene ist, die tangential zu einer radial äußeren Oberfläche (3) des Laufflächenrings (2) an den zwei Blockabschnitten (9, 10), die zu der Lamelle (6) weisen, verläuft.
3. Reifen (1) nach Anspruch 1 oder 2, wobei die Längs-

richtung (X) schräg in Bezug sowohl auf eine axiale Richtung (Z) als auch eine Umfangsrichtung (Y) des Reifens (1) verläuft.

4. Reifen (1) nach Anspruch 1, wobei die konkaven (61a, 62a) und konvexen (61b, 62b) Abschnitte sich symmetrisch auf gegenüberliegenden Seiten in Bezug auf die Referenzebene (P) erstrecken.
5. Reifen (1) nach Anspruch 1 oder nach Anspruch 4, wobei jeder der konkaven (61a) und konvexen (61b) Abschnitte des ersten Profils einen jeweiligen ersten Scheitel (610a, 610b) aufweist, dessen Abstand von der Referenzebene (P) progressiv im Verlauf in einer radialen Richtung von dem mittleren Abschnitt (63) weg zu dem oberen Abschnitt (7) hin zunimmt.
6. Reifen (1) nach Anspruch 1 oder nach einem der Ansprüche 4 und 5, wobei jeder der konkaven (62a) und konvexen (62b) Abschnitte des zweiten Profils einen jeweiligen zweiten Scheitel (620a, 620b) aufweist, dessen Abstand von der Referenzebene (P) progressiv im Verlauf in einer radialen Richtung von dem mittleren Abschnitt (63) weg zu dem unteren Abschnitt (8) hin zunimmt.
7. Reifen (1) nach einem der vorhergehenden Ansprüche, wobei die Oberfläche in einem Querschnitt an jedem konkaven Abschnitt (61a) des ersten Profils einen jeweiligen konvexen Abschnitt (62b) des zweiten Profils aufweist, und in einem Querschnitt an jedem konvexen Abschnitt (61b) des ersten Profils einen jeweiligen konkaven Abschnitt (62a) des zweiten Profils aufweist.
8. Reifen (1) nach einem der vorhergehenden Ansprüche, wobei der Laufflächenring (2) einen zentralen ringförmigen Abschnitt (C) zu beiden Seiten einer axialen Mittelebene sowie zwei ringförmige Schulterabschnitte (S1, S2) aufweist, die auf axial entgegengesetzten Seiten in Bezug auf den zentralen ringförmigen Abschnitt (C) angeordnet sind, wobei der zentrale ringförmige Abschnitt (C) von jedem ringförmigen Schulterabschnitt (S1, S2) durch eine jeweilige umlaufende Nut (4) getrennt ist, wobei die zumindest eine Lamelle (6) an den Blöcken (5) des zentralen ringförmigen Abschnitts (C) und nur eines der ringförmigen Schulterabschnitte (S1, S2) vorgesehen ist.
9. Reifen (1) nach Anspruch 8, wobei, wenn der Reifen (1) an einer Felge zur Bildung eines Rads eines Motorfahrzeugs montiert ist, der ringförmige Schulterabschnitt (S1, S2) in Bezug auf das Motorfahrzeug axial weiter außen liegt als der zentrale ringförmige Abschnitt (C).
10. Reifen (1) nach einem der Ansprüche 1 bis 6, wobei

die Oberfläche in einem Querschnitt an jedem konkaven Abschnitt (61a) des ersten Profils einen jeweiligen konvexen Abschnitt (62b) des zweiten Profils aufweist, und in einem Querschnitt an jedem konvexen Abschnitt (61b) des ersten Profils einen jeweiligen konkaven Abschnitt (62a) des zweiten Profils aufweist.

11. Reifen (1) nach Anspruch 10, wobei der Laufflächenring (2) einen zentralen ringförmigen Abschnitt (C) zu beiden Seiten einer axialen Mittelebene und zwei ringförmige Schulterabschnitte (S1, S2) umfasst, die auf axial entgegengesetzten Seiten in Bezug auf den zentralen ringförmigen Abschnitt (C) angeordnet sind, wobei der zentrale ringförmige Abschnitt (C) von jedem ringförmigen Schulterabschnitt (S1, S2) durch eine jeweilige umlaufende Nut (4) getrennt ist, wobei die zumindest eine Lamelle (6) nur an den Blöcken (5) der ringförmigen Schulterabschnitte (S1, S2) vorgesehen ist.
12. Reifen (1) nach Anspruch 10, wobei der Laufflächenring (2) einen zentralen ringförmigen Abschnitt (C) zu beiden Seiten einer axialen Mittelebene und zwei ringförmige Schulterabschnitte (S1, S2) umfasst, die auf axial entgegengesetzten Seiten in Bezug auf den zentralen ringförmigen Abschnitt (C) angeordnet sind, wobei der zentrale ringförmige Abschnitt (C) von jedem ringförmigen Schulterabschnitt (S1, S2) durch eine jeweilige umlaufende Nut (4) getrennt ist, wobei die zumindest eine Lamelle (6) nur an den Blöcken (5) des zentralen ringförmigen Abschnitts (C) vorgesehen ist.
13. Reifen (1) nach einem der vorhergehenden Ansprüche, wobei, wenn die Oberfläche eine auftreffende Ebene schneidet, das erste Profil und das zweite Profil jeweilige Linien definieren, die sinusförmig sind.
14. Reifen (1) nach einem der vorhergehenden Ansprüche, wobei, wenn die Oberfläche eine auftreffende Ebene schneidet, das erste Profil und das zweite Profil jeweilige zickzackförmige unterbrochene Linien definieren; wobei die zickzackförmigen unterbrochenen Linien eine alternierende Abfolge einer ersten geradlinigen Länge (101) und einer zweiten geradlinigen Länge (102) umfassen.

Revendications

1. Pneu d'hiver (1) comprenant une bande de roulement (2) dans laquelle est définie une pluralité de pavés (5), au moins certains desdits pavés (5) comprenant au moins une lamelle (6) s'étendant depuis une partie supérieure (7) du pavé (5) vers une partie inférieure (8) du pavé (5), où ladite au moins une

lamelle (6) définit deux parties de pavé adjacentes (9, 10) dans le pavé (5), chacune desdites deux parties de pavé (9, 10) comprenant une surface faisant face à ladite au moins une lamelle (6), ladite surface comprenant :

- une partie radialement externe (61) ayant un premier profil qui est ondulé ;
- une partie radialement interne (62) ayant un deuxième profil qui est ondulé ;
- une partie intermédiaire (63) agencée entre ladite partie radialement externe (61) et ladite partie radialement interne (62) et ayant un troisième profil qui est rectiligne ; où ladite partie intermédiaire (63) définit un plan de référence (P) coïncidant avec un plan radial du pneu (1),

caractérisé en ce que

- ledit premier profil et ledit deuxième profil sont définis par une pluralité de parties concaves (61a, 62a) et convexes (61b, 62b) agencées en une séquence alternée par rapport audit plan de référence (P) suivant une direction parallèle à une direction longitudinale (X) de ladite au moins une lamelle (6) ; et **en ce que**
 - chacune des parties concave (62a) et convexe (62b) du deuxième profil comprend une partie de surface radialement externe (72a, 72b), une partie de surface radialement interne (73a, 73b) et une partie de surface intermédiaire (74a, 74b) agencée entre ladite partie de surface radialement externe (72a, 72b) et ladite partie de surface radialement interne (73a, 73b), où ladite partie de surface intermédiaire (74a, 74b) est parallèle audit plan de référence (P).
2. Pneu (1) selon la revendication 1, dans lequel ladite direction longitudinale (X) est parallèle à un plan qui est tangent à une surface radialement externe (3) de ladite bande de roulement (2) au niveau desdites deux parties de pavé (9, 10) faisant face à ladite lamelle (6).
 3. Pneu (1) selon la revendication 1 ou 2, dans lequel ladite direction longitudinale (X) est inclinée à la fois par rapport à une direction axiale (Z) et à une direction circonférentielle (Y) du pneu (1).
 4. Pneu (1) selon la revendication 1, dans lequel lesdites parties concaves (61a, 62a) et convexes (61b, 62b) s'étendent symétriquement sur des côtés opposés par rapport audit plan de référence (P).
 5. Pneu (1) selon la revendication 1 ou 4, dans lequel chacune des parties concave (61a) et convexe (61b) du premier profil présente une première crête respective (610a, 610b) dont la distance par rapport audit plan de référence (P) augmente progressivement en s'éloignant dans une direction radiale de ladite partie intermédiaire (63) vers ladite partie supérieure (7).
 6. Pneu (1) selon la revendication 1 ou l'une quelconque des revendications 4 et 5, dans lequel chacune des parties concave (62a) et convexe (62b) du deuxième profil présente une deuxième crête respective (620a, 620b) dont la distance par rapport audit plan de référence (P) augmente progressivement en s'éloignant dans une direction radiale de ladite partie intermédiaire (63) vers ladite partie inférieure (8).
 7. Pneu (1) selon l'une quelconque des revendications précédentes, dans lequel ladite surface présente, dans une section transversale prise au niveau de chaque partie concave (61a) du premier profil, une partie convexe respective (62b) du deuxième profil et, dans une section transversale prise au niveau de chaque partie convexe (61b) du premier profil, une partie concave respective (62a) du deuxième profil.
 8. Pneu (1) selon l'une quelconque des revendications précédentes, dans lequel ladite bande de roulement (2) comprend une partie annulaire centrale (C) à cheval sur un plan médian axial et deux parties d'épaulement annulaires (S1, S2) agencées sur des côtés axialement opposés par rapport à la partie annulaire centrale (C), la partie annulaire centrale (C) étant séparée de chaque partie d'épaulement annulaire (S1, S2) par une rainure circonférentielle respective (4), où ladite au moins une lamelle (6) est prévue sur les pavés (5) de ladite partie annulaire centrale (C) et d'une seule partie desdites parties d'épaulement annulaires (S1, S2).
 9. Pneu (1) selon la revendication 8, dans lequel, lorsque le pneu (1) est monté sur une jante formant une roue d'un véhicule automobile, ladite partie d'épaulement annulaire (S1, S2) est axialement plus externe que la partie annulaire centrale (C) par rapport audit véhicule automobile.
 10. Pneu (1) selon l'une quelconque des revendications 1 à 6, dans lequel ladite surface présente, dans une section transversale prise au niveau de chaque partie concave (61a) du premier profil, une partie concave respective (62a) du deuxième profil et, dans une section transversale prise au niveau de chaque partie convexe (61b) du premier profil, une partie convexe respective (62b) du deuxième profil.
 11. Pneu (1) selon la revendication 10, dans lequel ladite bande de roulement (2) comprend une partie annulaire centrale (C) à cheval sur un plan médian axial et deux parties d'épaulement annulaires (S1, S2)

agencées sur des côtés axialement opposés par rapport à la partie annulaire centrale (C), la partie annulaire centrale (C) étant séparée de chaque partie d'épaulement annulaire (S1, S2) par une rainure circconférentielle respective (4), où ladite au moins une lamelle (6) n'est prévue que sur les pavés (5) desdites parties d'épaulement annulaires (S1, S2). 5

12. Pneu (1) selon la revendication 10, dans lequel ladite bande de roulement (2) comprend une partie annulaire centrale (C) à cheval sur un plan médian axial et deux parties d'épaulement annulaires (S1, S2) agencées sur des côtés axialement opposés par rapport à la partie annulaire centrale (C), la partie annulaire centrale (C) étant séparée de chaque partie d'épaulement annulaire (S1, S2) par une rainure circconférentielle respective (4), où ladite au moins une lamelle (6) n'est prévue que sur les pavés (5) de ladite partie annulaire centrale (C). 10
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13. Pneu (1) selon l'une quelconque des revendications précédentes, dans lequel, lorsque ladite surface est divisée par un plan incident, ledit premier profil et ledit deuxième profil définissent des lignes respectives qui sont sinusoïdales. 25

14. Pneu (1) selon l'une quelconque des revendications précédentes, dans lequel, lorsque ladite surface est divisée par un plan incident, ledit premier profil et ledit deuxième profil définissent des lignes discontinues en zigzag respectives ; lesdites lignes discontinues en zigzag comprenant une séquence alternée d'une première longueur rectiligne (101) et d'une deuxième longueur rectiligne (102) . 30
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FIG.1

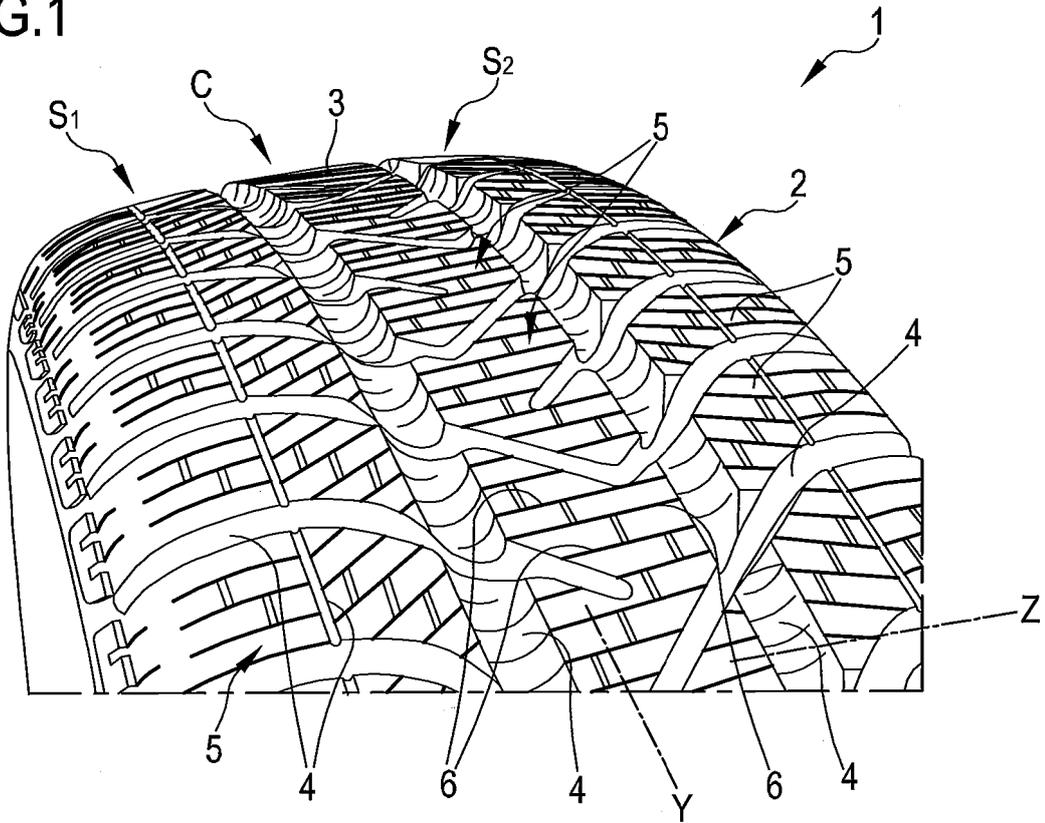


FIG.2

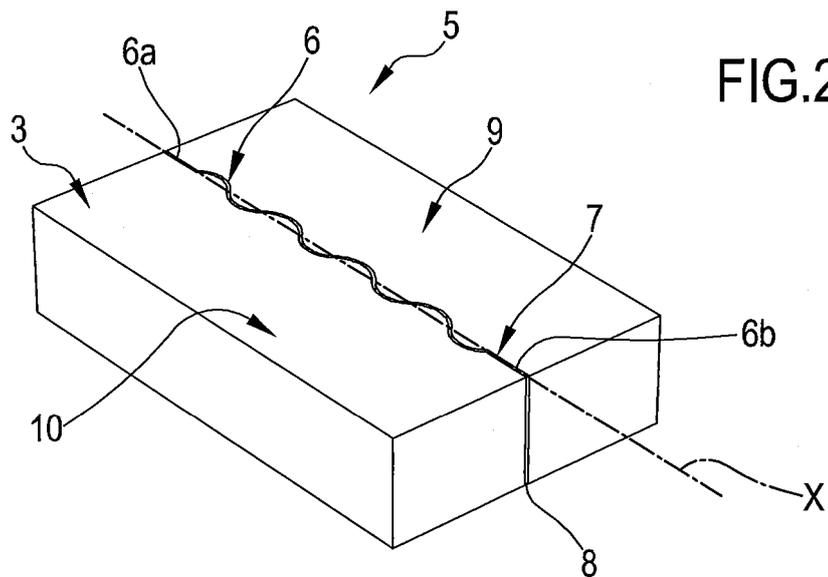


FIG.3b

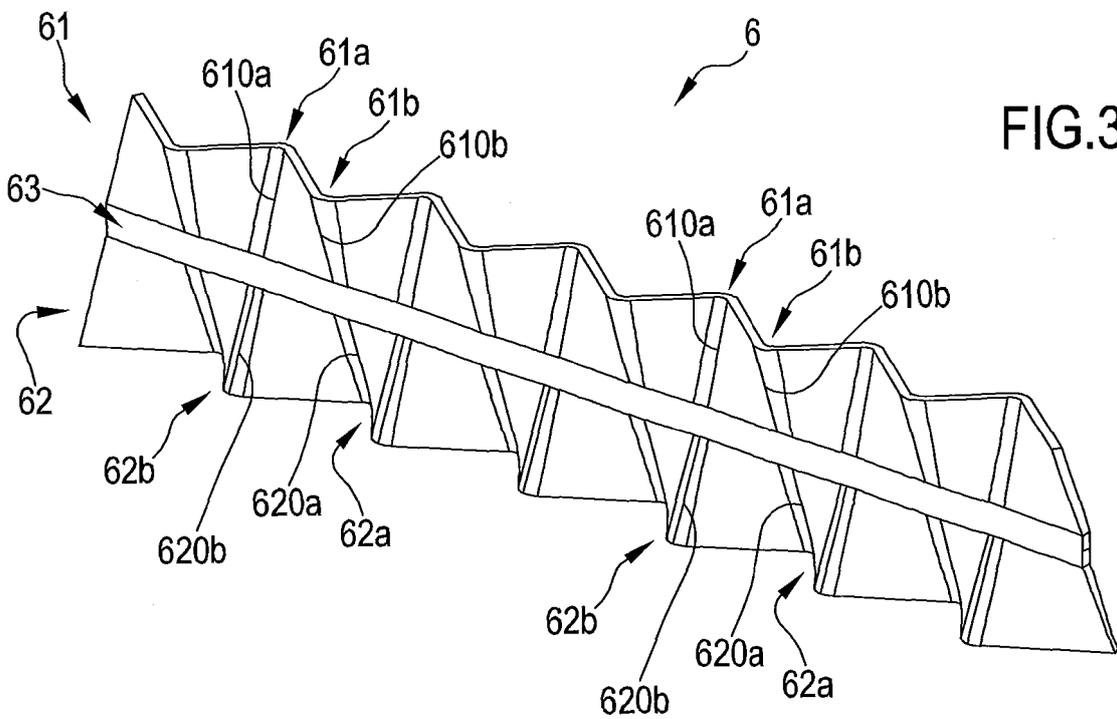
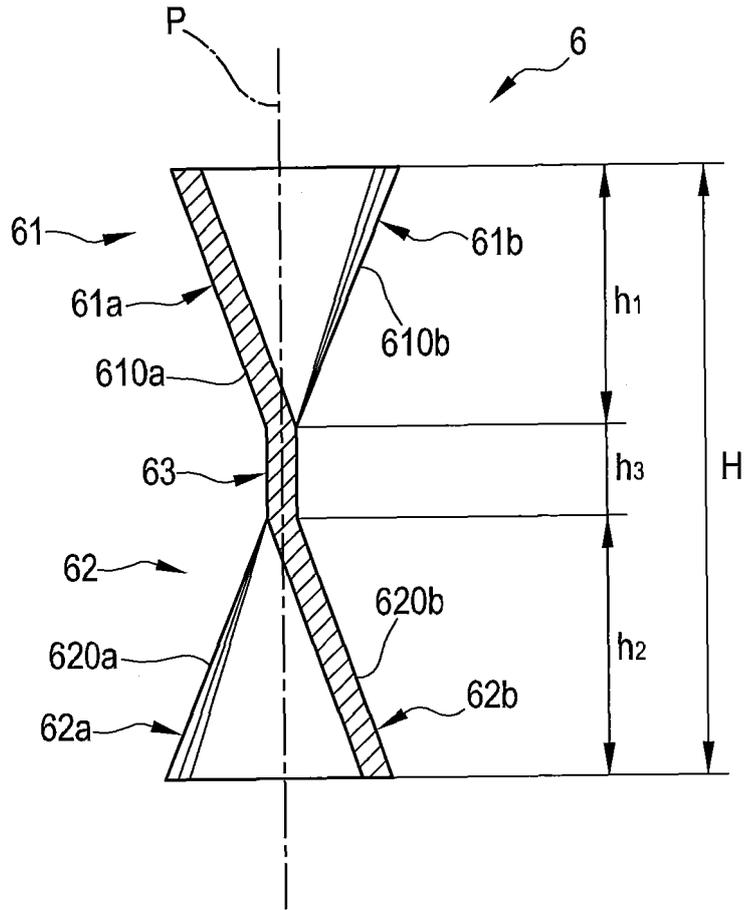


FIG.3c

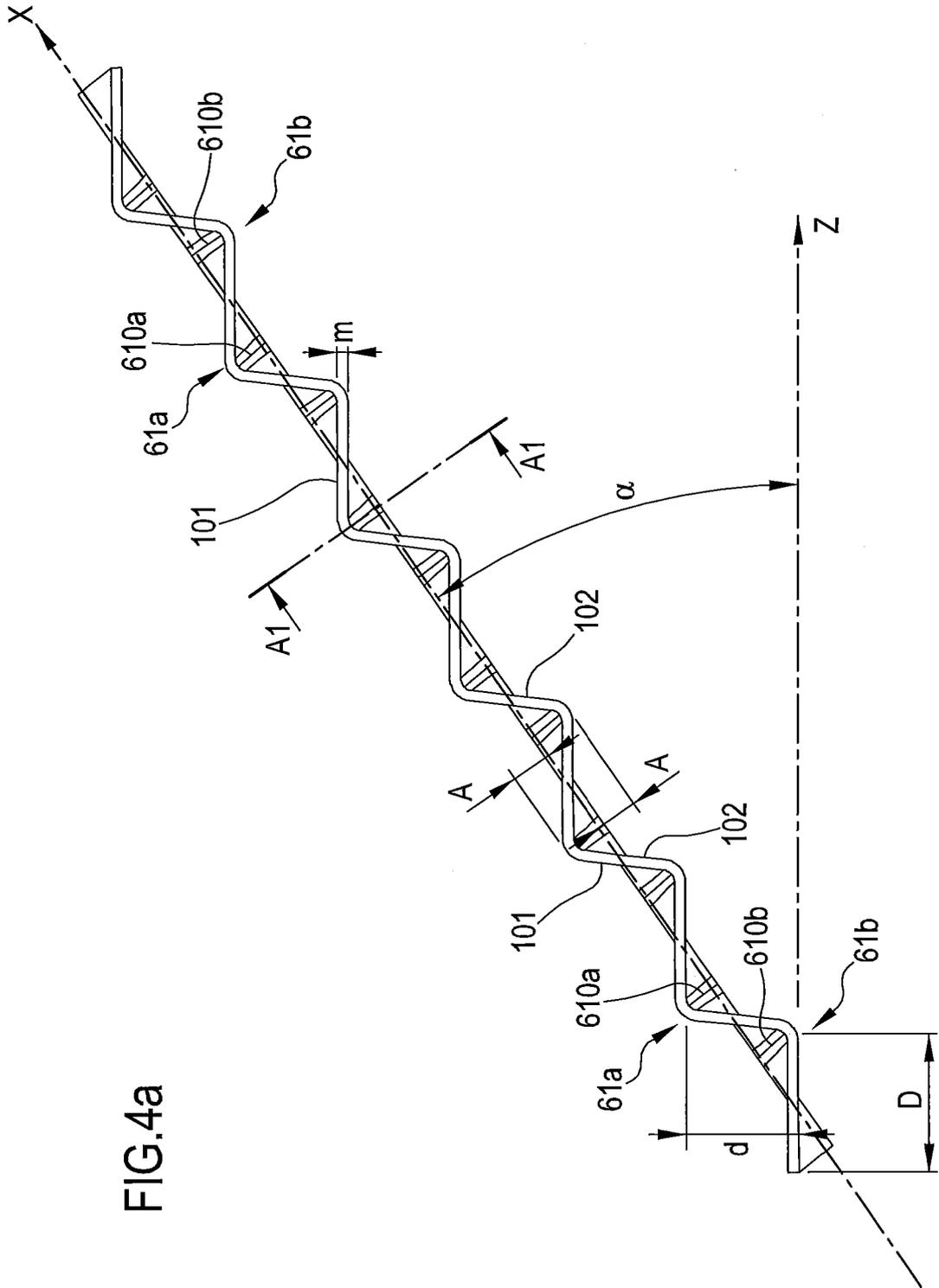


FIG. 4a

FIG.4b

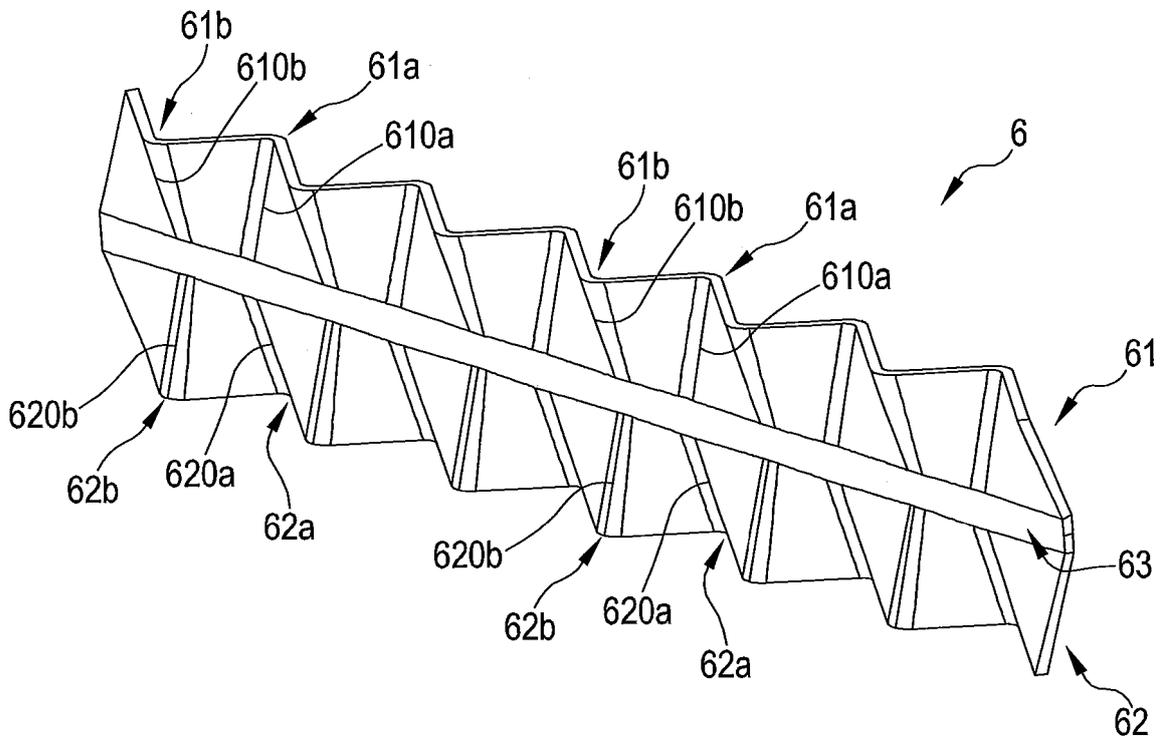
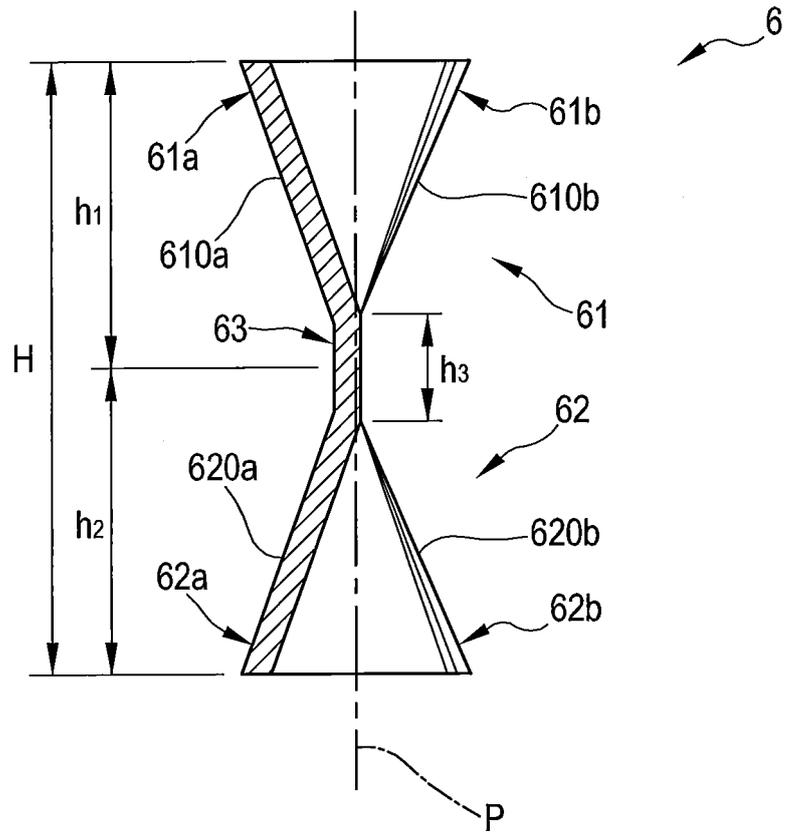


FIG.4c

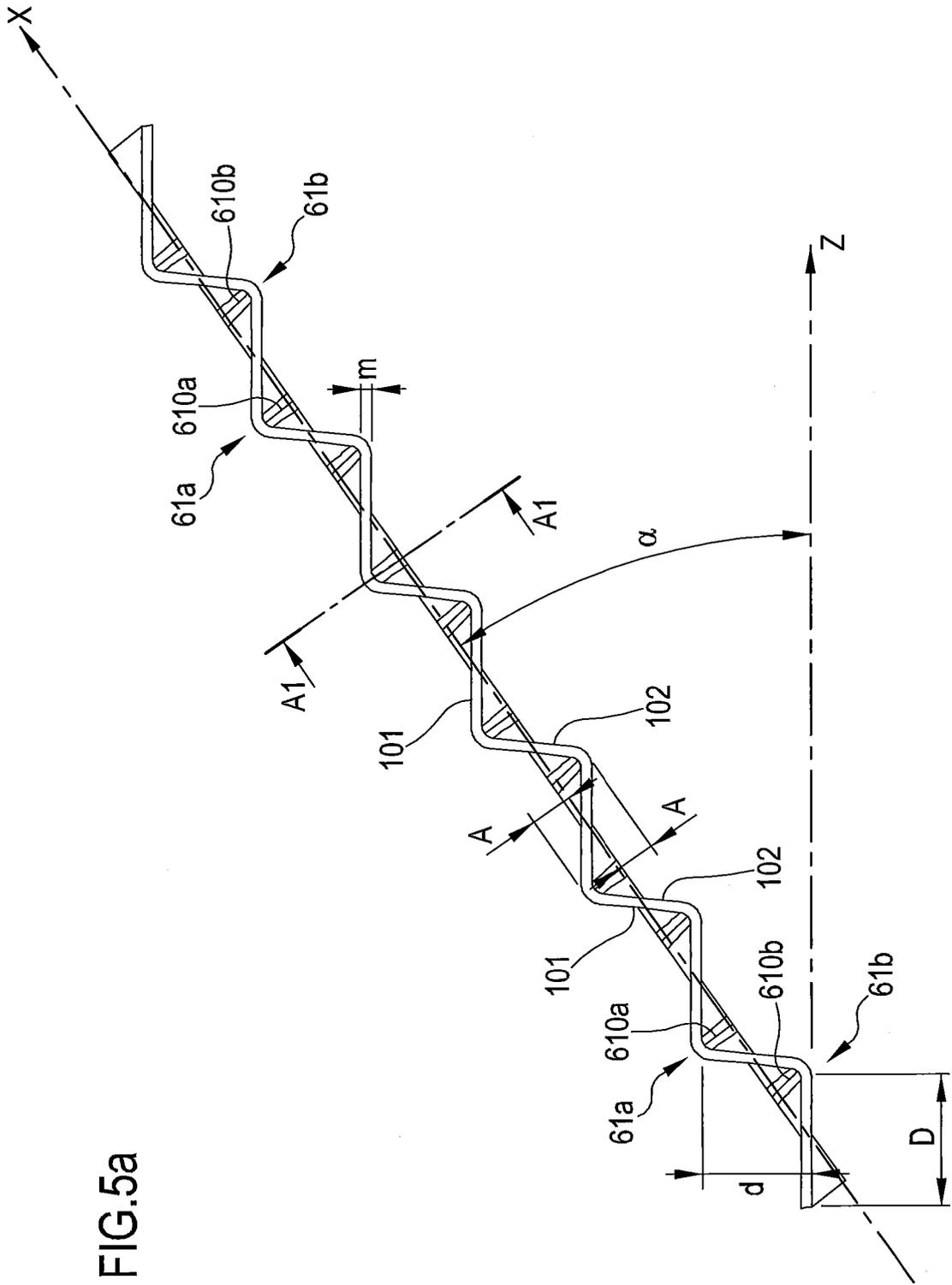


FIG. 5a

FIG.5b

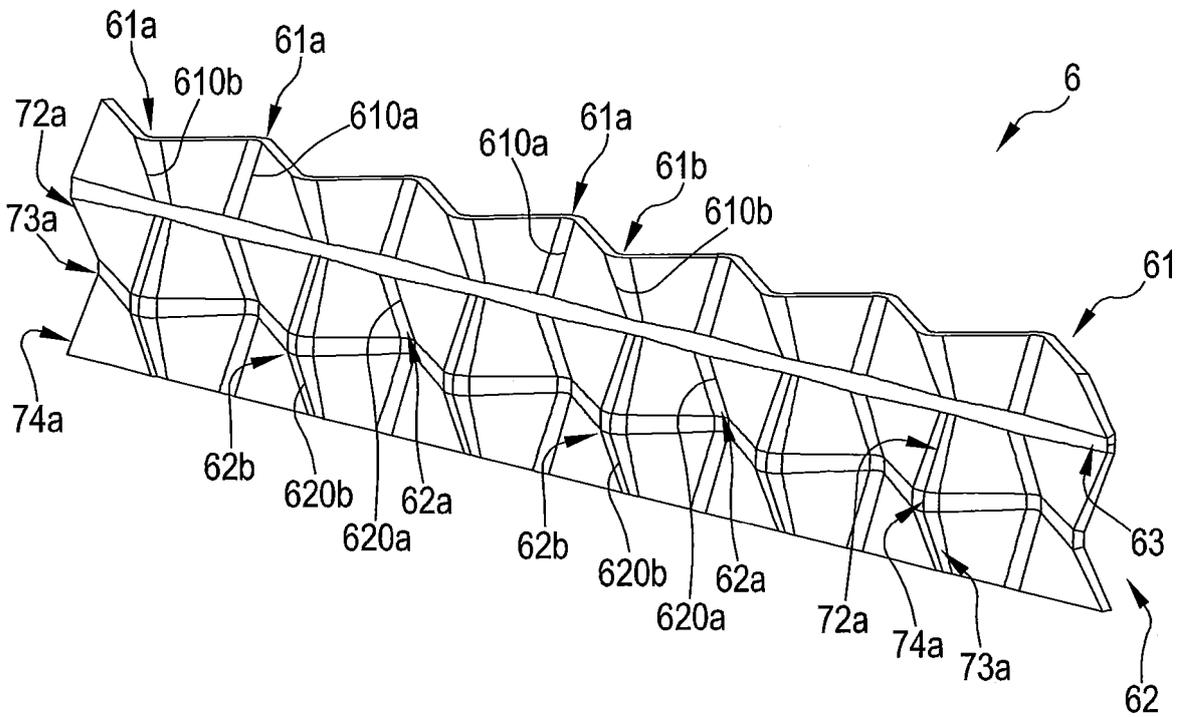
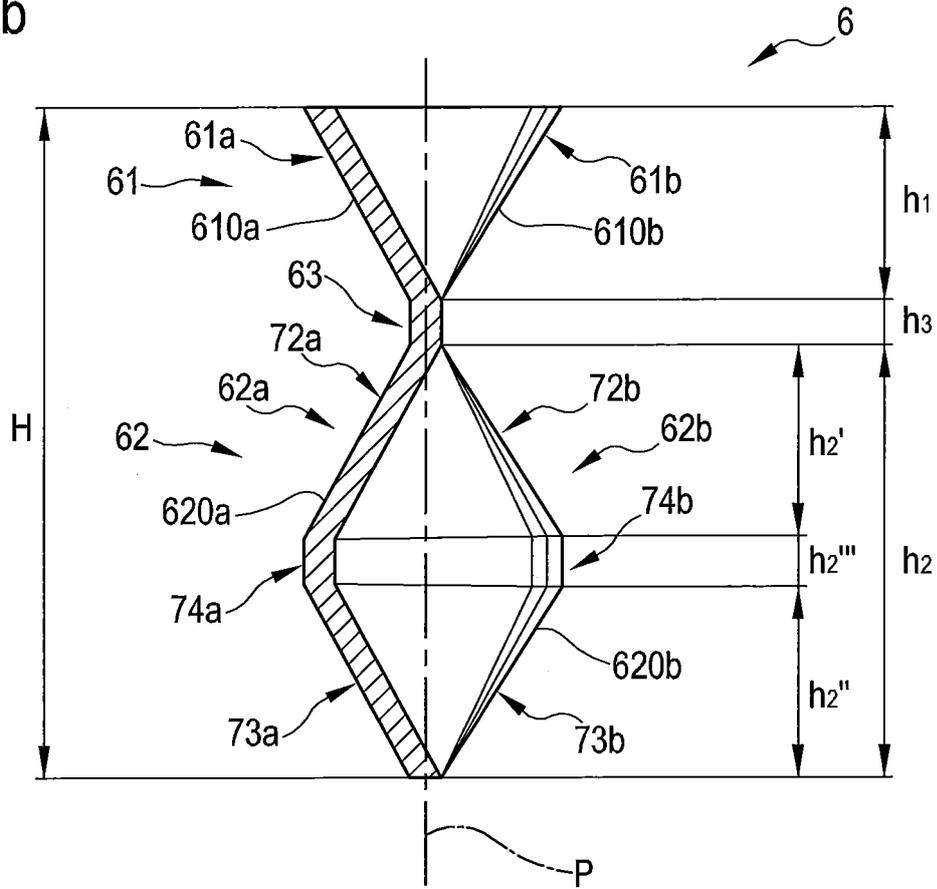


FIG.5c

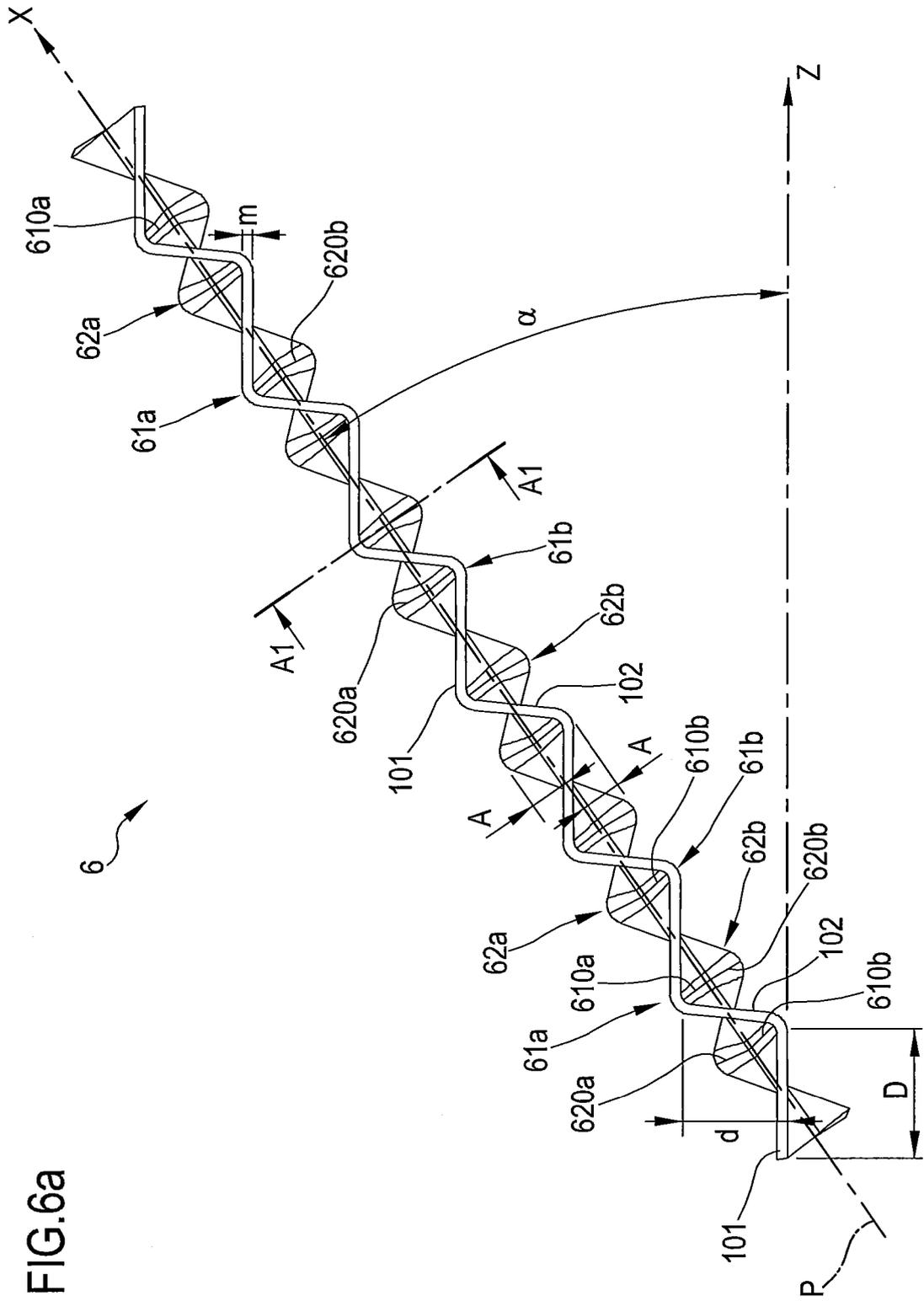


FIG.6b

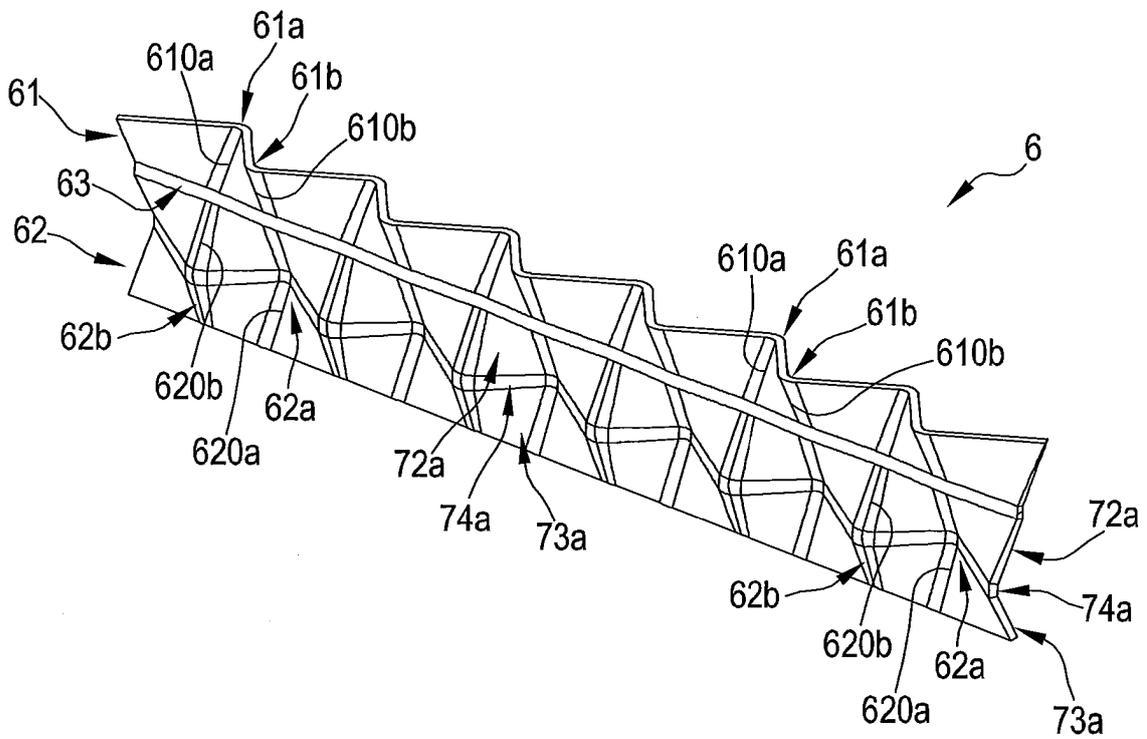
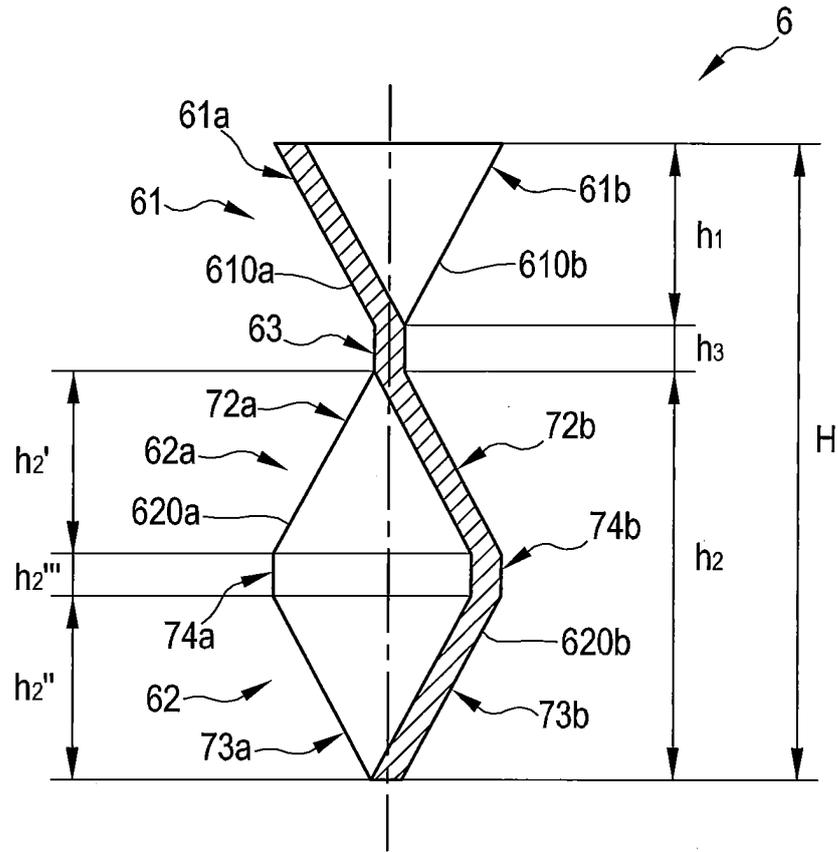


FIG.6c

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- EP 0952011 A [0019]
- EP 1623818 A [0020]
- WO 2013174737 A [0021]
- JP 2003118322 A [0021]
- WO 2012164449 A [0022] [0029] [0062] [0121]
- WO 2012164450 A [0023] [0052] [0104]
- WO 201216449 A [0065] [0123] [0124]
- WO 201216450 A [0065] [0123] [0124]