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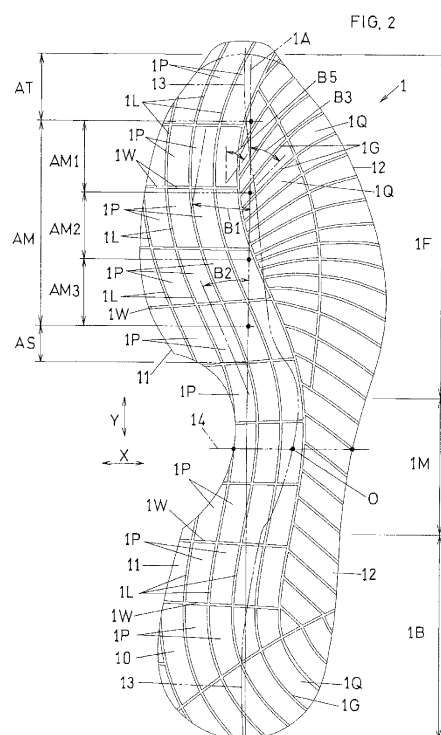
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(54) **SHOE OUTSOLE**

(57) An outsole of a shoe includes: a plurality of ridges having a tread surface to be in contact with a road surface; and at least one longitudinal groove defined between the plurality of ridges. At least in a partial area of each of a forefoot portion and a rear foot portion on a medial side of a foot, the plurality of ridges and the longitudinal groove extend in a longitudinal direction or a diagonal longitudinal direction and are set so that an angle of the ridges and that of the longitudinal groove with respect to a long axis of the outsole are in a range of 0° to 35°. A ratio of a length of the tread surface of the ridges with respect to a width of the tread surface is set to be 1.8 to 200. The width of the tread surface of the ridges is set to be greater than a width of the longitudinal groove by a factor of 2 to 100.



Description

Technical Field

[0001] The present invention relates to a technique relating to an outsole capable of contributing to improvement of frictional force produced between an outsole of a shoe and a road surface or a floor surface.

Background Art

[0002] A surface of an outsole is generally designed in consideration of an antislip function on a road surface or a floor surface wet with water or oil. Specifically, many protrusions or ridges are formed at the surface of the outsole.

Citation List

Patent Literature

[0003]

First patent document: JP 08-280406A (front page)
 Second patent document: JP 2001-17203A (front page)
 Third patent document: WO 07/043651A (front page)
 Fourth patent document: JP 10-510744W (front page)
 Fifth patent document: JP 2011-255030A (front page)
 Sixth patent document: JP 49-76822Y (front page)

Disclosure of Invention

[0004] Each of the aforementioned patent documents describes little about antislip performance on a dry (dried off) road surface or floor surface.

[0005] JP 08-280406A discloses antislip action on a floor surface wet with sweat during wearing of a shoe mainly in indoor space for playing of volleyball, for example. This prior-art technique discloses preferable dimensions for the depth of a groove and the width of a ridge.

[0006] This prior-art technique discloses an outsole in FIGS. 2 and 3 having a cross section where the depth of a groove is greater than the width of a ridge. This prior-art technique recites in paragraph 0014 that "FIG. 3 shows a state where blocks partitioned by recessed grooves fall in response to instantaneous shearing force generated during landing on the ground to make edge portions of the blocks stand up with respect to a floor surface, thereby cutting a water film to make antislip action act on a floor surface." Specifically, according to the disclosure of this prior-art technique, "experimental result shows that, with the width or the depth of a recessed groove not falling within a range represented by predetermined numerical values, a ridge cannot incline suc-

cessfully to make it difficult for antislip force to act on an edge itself."

[0007] However, the aforementioned prior-art technique does not disclose anything about an instance where the width of a ridge is greater than the depth of a groove.

[0008] JP 2001-17203A relates to a shoe for indoor exercise, particularly for exercise in water. This document recites in paragraph 0012 that, if a waveform groove has a wavelength approximate to that of a long straight line, excellent antislip properties are achieved in a bending direction. However, excellent antislip properties cannot be achieved in a direction parallel to a bending line.

[0009] WO 07/043651A discloses a shoe achieving high antislip performance on a floor surface wet with water or oil. This document discloses a tread block formed of a long ridge provided at an edge side on a medial side of a foot. However, this document does not disclose antislip performance on a dry road surface, etc.

[0010] The invention disclosed in JP 10-510744W is intended to enhance a shock absorbing function by largely deforming an element triangular in cross section in the vicinity of a basic osculating orbit and obtaining uniform contact pressure on an entire surface. However, the element triangular in cross section will degrade antislip performance on a road surface, etc.

[0011] JP 2011-255030A discloses an outsole where a ratio of a tread area with respect to a sole area at a heel portion or a toe portion is 0.35 to 0.65. This outsole may achieve excellent antislip effect during walking on a snowy road or an icy road surface. However, this document does not describe about antislip performance on a dry road surface.

[0012] In the invention of JP 49-76822Y, a longitudinally-long ridge is arranged on a lateral side of a foot, not on a medial side of the foot.

[0013] As understood from the description given above, each of the aforementioned documents is not intended to improve frictional force on the assumption that a shoe is used on a dry road surface. However, there is some type of a shoe such as a shoe for marathon to be used mainly on a dry road surface in many cases. Increasing frictional force produced in a direction of running between an outsole and a road surface, etc. will facilitate the running of a runner. Further, performance may be improved during a play.

[0014] Thus, it is an object of the present invention to provide an outsole of a shoe capable of contributing to increase in frictional force on a dry road surface or floor surface, for example.

Principle of Invention

[0015] A principle of the present invention will be described before description of a structure according to the present invention.

[0016] The present inventors examined an instance where an elongated ridge of an outsole treads on the

ground and made the following hypothesis. If force F is applied to a dry surface Sf of FIG. 6A in the lengthwise direction of a left ridge 1P, a substantial contact surface Cs (represented with dots) between the ridge 1P and the surface Sf will have a large area while the ridge 1P is not deformed seriously. By contrast, if the force F is applied in the width direction of a right ridge 1P, the ridge 1P is subjected to bending deformation to be deformed largely. Hence, the substantial contact surface Cs between the ridge 1P and the surface Sf will have a small area.

[0017] Next, based on the aforementioned hypothesis, the present inventors formed test pieces (first group) having rectangular parallelepiped shapes (cuboid) of different length-to-width ratios PI/Pw . Then, the present inventors applied the force F to each test piece and measured a friction coefficient (coefficient of friction) Fc with the surface Sf. The graph of FIG. 6B shows result of the measurement.

[0018] The test result of FIG. 6B shows that with the ratio PI/Pw being 1.8 or more, the friction coefficient Fc of a large value can be obtained.

[0019] Next, the present inventors prepared a different test piece (second group) Tex. shown in FIGS. 7A and 7B and measured the friction coefficient Fc. The graphs of FIGS. 7C, 7D, 8A, and 8B show results of the measurement. The height of the ridges 1P (tread height) of the test piece Tex. in the second group was set at four values shown in each of these graphs. The test piece Tex. was formed by stacking a midsole member 210 and an outsole member 110 stacked on a hard plate not shown in the drawings, and forming a plurality of ridges 1P and a plurality of grooves 1L in the outsole member 110.

[0020] FIGS. 7C and 7D show measurement result about a change rate of a friction coefficient and measurement result about a dynamic friction coefficient (coefficient of dynamic friction) respectively obtained with the surface Sf wet with water. FIGS. 8A and 8B show measurement result about a static friction coefficient (coefficient of static friction) and measurement result about a dynamic friction coefficient respectively obtained with the surface Sf in a dry condition. In these drawings, white circles show values obtained if the force F acts in a lengthwise direction Y of the ridges 1P as shown in FIG. 7A. Further, black circles show values obtained if the force F acts in the width direction of the ridges 1P as shown in FIG. 7B.

[0021] The results of FIGS. 8A and 8B show that, if the ridges 1P are arranged in such a manner as to apply force in the lengthwise direction Y (white circles), the friction coefficient Fc of a large value and large frictional force will be obtained. Referring to FIG. 7D, with the height of the ridges 1P being about 2.0 mm or more, a dynamic friction coefficient is found to be higher even on a wet surface if the force F is applied in the lengthwise direction Y of the ridges 1P.

[0022] The present inventors further conducted experiment using a different test piece (third group) to examine a relationship of the thickness of a midsole and the thick-

ness of an outsole with the friction coefficient Fc and a substantial area of the contact surface Cs. The graphs of FIGS. 9A and 9B show results of the experiment. As understood from comparison between these two graphs, the friction coefficient Fc and the substantial contact surface Cs are strongly correlated to each other. Specifically, making the outsole thinner relative to the midsole is generally found to increase the area of the contact surface Cs as shown in FIG. 9B. As a result, the friction coefficient Fc will be increased as shown in FIG. 9A.

[0023] A feature of the present invention common among independent claims is an outsole of a shoe, particularly an outsole made of a material containing soft elastomer as a principal component or a base. The outsole includes: a plurality of ridges (elongated protrusions, convexes, or treads) each having a tread surface (a contact surface) to be in contact with a road surface; and at least one longitudinal groove defined between the plurality of ridges, wherein:

at least in a partial area of each of a forefoot portion or a rear foot portion on a medial side of a foot, the plurality of ridges and the longitudinal groove extend in a longitudinal direction or in a diagonal longitudinal direction and are set so that an angle of the ridges with respect to a long axis of the outsole is in a range of 0° to 35° , and an angle of the groove with respect to the long axis is in a range of 0° to 35°

a ratio of a length of the tread surface of each of the ridges with respect to a width of the tread surface (a length ratio PI/Pw) is set to be 1.8 to 200; and the width of the tread surface of each of the ridges is set to be greater than a width of the longitudinal groove by a factor of 2 to 100 (i.e., the width of the tread surface is 2 to 100 times the width of the longitudinal groove).

[0024] Note that, in consideration of an area in a kicking phase, the at least partial area may be considered to be 16 square cm or more.

[0025] If the plurality of ridges and the longitudinal groove extending long in the longitudinal direction or in the diagonal longitudinal direction are provided in the partial area on the medial side of a foot, bending deformation of each of the long ridges caused by wear during treading on the ground during running will be extremely small. Meanwhile, absorption or dissipation of energy accompanying shear deformation will be increased by frictional force.

[0026] Hence, the shape of the ridges is unlikely to be deformed during treading on a dry road surface or floor surface, so that a large contact area with the road surface will be maintained. Accordingly, this will increase frictional force on the medial side of the outsole with the dry road surface, etc.

[0027] The forefoot portion on the medial side is a significant portion for letting a movement locus taken by a center of gravity pass through during running or walking

and is a portion where large reactive force to be applied forward is required during toe off. In the case that the aforementioned partial area is provided at the forefoot portion on the medial side of a foot, running may be facilitated or thrust may be increased.

[0028] Meanwhile, if the aforementioned partial area is provided at the rear foot portion on the medial side of a foot, the rear foot portion on the medial side becomes a significant portion for letting the movement locus taken by a center of gravity pass through and becomes a portion to tread on the ground after a first strike as a largest impact is given. Hence, a slip is unlikely to occur between the outsole and a dry road surface, etc. Thus, running may be facilitated not only along a course without a gradient but also on a sloping road or a curve.

[0029] Moreover, the presence of the longitudinal groove may contribute to weight reduction of the outsole and allow shear deformation of the ridges in such a manner that the ridges bulge toward the longitudinal groove. This will contribute to improvement of the performance of the outsole as a cushion.

[0030] In particular, the longitudinal groove formed between the ridges will contribute to suppressing a slip of the outsole in a direction toward a medial side and a direction toward a lateral side of a foot in the presence of fine particles of soil or sand etc. or water on a road surface.

[0031] In the present invention, an angle of the ridges and that of the longitudinal groove with respect to the long axis of the outsole are set in a range of 0° to 35° . Specifically, the ridges and the longitudinal groove on the medial side of a foot may be arranged parallel to the long axis, may be arranged with an inclination such that the ridges and the longitudinal groove extend closer to the long axis as the ridges and the longitudinal groove extend toward an anterior direction, or may be arranged with an inclination such that the ridges and the longitudinal groove extend closer to the long axis as the ridges and the longitudinal groove extend toward a posterior direction.

[0032] In terms of a relationship with a movement locus taken by a center of gravity, if the aforementioned angle exceeds 35° , the function of the longitudinally-long ridges will be reduced during running or walking.

[0033] In the present invention, if the aforementioned length ratio Pl/Pw is less than 1.8, the tread surface of the ridges will be deformed by bending deformation. Hence, this will make it impossible for the longitudinally-long ridges to achieve their function sufficiently.

[0034] Meanwhile, if the aforementioned length ratio Pl/Pw exceeds 200, the width of the ridges will be reduced seriously in terms of a relationship with an entire length of the outsole. For example, if the length ratio Pl/Pw exceeds 200, the width of the ridges generally becomes less than about 1.5 mm. This makes it likely that the ridges will be deformed in various ways to cause reduction in substantial tread area during treading on the ground.

[0035] If a ratio of the width of the tread surface of the

ridges with respect to the width of the longitudinal groove (width ratio Pw/Lw) is less than 2, the area of the tread surface of the ridges will be reduced to further reduce a substantial tread area during treading on the ground.

[0036] Meanwhile, if the aforementioned width ratio Pw/Lw exceeds 100, the width of the longitudinal groove will be about less than 0.1 mm, for example. This will make it impossible to manufacture the outsole or cause serious manufacturability reduction during manufacture.

[0037] In the present invention, if the ridges and the longitudinal groove are provided particularly on the medial side of the forefoot portion, the ratio Pw/Lw of the width of the tread surface of the ridges with respect to the depth of the longitudinal groove is preferably set to be 2 to 20.

[0038] If the ratio Pw/Ld is less than 2, the longitudinal groove becomes too deep and the outsole may become too thick. Alternatively, the width of the tread surface of the ridges may become too small to make it likely that a substantial tread area will be reduced during the aforementioned treading on the ground.

[0039] On the other hand, if the ratio Pw/Ld is greater than 20, the longitudinal groove becomes too shallow and the longitudinal groove may disappear due to wear of the outsole. Alternatively, the width of the ridges may become too large. This will make it difficult to provide a sufficient number of longitudinal grooves.

Brief Description of Drawings

[0040]

FIG. 1 is a medial side view of a shoe including an outsole according to a first embodiment of the present invention.

FIG. 2 is a bottom view of the outsole.

FIGS. 3A, 3B, and 3C are an enlarged perspective view, a longitudinal sectional view, and a transverse sectional view respectively, showing a part of a sole schematically.

FIGS. 4A and 4B are bottom views showing movement loci taken by a center of gravity during walking and during running respectively, and FIG. 4C is a bottom view showing frictional force applied to an outsole indicated by vectors.

FIGS. 5A and 5B are a bottom view and an enlarged transverse sectional view respectively, showing an outsole according to a second embodiment.

FIG. 6A is a perspective view showing a deformation state of a ridge with respect to a surface for explaining a principle of the present invention, and FIG. 6B is a graph showing a relationship between a length ratio of the ridge and a friction coefficient.

FIGS. 7A and 7B are perspective views each showing the shape of a test piece and a moving direction of the test piece, and FIGS. 7C and 7D are graphs showing a value of a change rate of a friction coefficient and a value of a dynamic friction coefficient

respectively obtained on a wet surface (wet with water) by using the test piece.

FIGS. 8A and 8B are graphs showing a value of a static friction coefficient and a value of a dynamic friction coefficient respectively obtained on a dry (dried off) surface by using the test piece.

FIG. 9A is a graph showing a relationship between a ratio of the thickness of a midsole and a dynamic friction coefficient, and FIG. 9B is a graph showing a relationship between a ratio of the thickness of a midsole and a substantial contact area.

FIG. 10A is a graph showing a relationship between a load applied to a tread surface and a friction coefficient, and FIGS. 10B and 10C are side views schematically showing bending deformation and shear deformation of a ridge respectively.

FIGS. 11A and 11B are graphs showing a relationship between a parameter R and a contact area and a relationship between the parameter R and a friction coefficient respectively.

FIG. 12A is an enlarged perspective view showing a virtual sample used for calculation of a friction coefficient, and FIG. 12B is a table showing result of simulation conducted to calculate a friction coefficient with an electronic calculator by using the virtual sample.

FIG. 13 is a table showing result of different simulation.

FIG. 14 is a table showing result of different simulation.

FIG. 15 is a table showing result of different simulation.

FIG. 16 is a table showing result of different simulation.

FIG. 17 is a table showing result of different simulation.

FIG. 18 is a table showing result of different simulation.

FIGS. 19A and 19B are tables each showing result of simulation.

FIGS. 20A and 20B are tables each showing result of simulation.

FIG. 21 is a table showing result of different simulation.

FIG. 22 is a table showing result of different simulation.

FIG. 23 is a table showing result of different simulation.

FIG. 24 is a table showing result of different simulation.

FIG. 25 is a table showing result of different simulation.

FIGS. 26A to 26F are plan views each showing different arrangement of ridges and a different shape of the ridges.

Description of Embodiments

[0041] Preferably, the outsole includes a tip area defined to extend through the forefoot portion on the medial side over a length that is 10% of a length of the long axis in a posterior direction starting from a tip of the outsole, and a main area defined to extend through the forefoot portion on the medial side over a length that is 30% of the length of the long axis in the posterior direction starting from a back end of the tip area;

the tread surfaces of the ridges as a whole has an area (a total area, a collective area) that is greater than a half of an area of the main area; and

the plurality of ridges and the longitudinal groove are provided at least in an anterior end portion of the main area.

[0042] In this case, the plurality of ridges and the longitudinal groove are provided in the anterior end portion of the main area directly posterior to the tip area extending over a length that is 10% of the length of the long axis. Thus, large frictional force will be obtained easily in a phase of forward kicking.

[0043] Preferably, the outsole has the main area divided equally in the longitudinal direction into three areas, which are a first area on an anterior side, a second area adjacent to the first area, and a third area on a posterior side;

at least one ridge of the plurality of ridges has an inclination in the first area such that the at least one ridge comes closer (approaches, extends closer) to the long axis as the at least one ridge extends in (toward) an anterior direction; and

the at least one ridge, or at least one other ridge of the plurality of ridges, has an inclination in the third area such that the at least one ridge or the at least one other ridge extends away from the long axis as the one ridge or the one other ridge extends in (toward) the anterior direction.

[0044] In this case, the ridge having an inclination in the third area such that the ridge extends away from the long axis as the ridge extends in the anterior direction and the ridge having an inclination in the first area opposite the former inclination extend in a direction in which frictional force acts that is to change along a movement locus taken by a weight center. Thus, use of the ridges will facilitate increase in a friction coefficient.

[0045] Preferably, of an edge-side half and a central-side half of the main area divided (equally) into two parts, an area (a total area, a collective area) of the tread surfaces of the plurality of ridges in the central half is set to be greater than a half of an area of the central half.

[0046] The aforementioned movement of locus is likely to pass through a central half portion on the medial side of a foot. Thus, the ridge provided in this portion will easily fulfill a function to increase a friction coefficient.

[0047] Preferably, the outsole has a sub-area adjacent to the main area and defined to extend through the forefoot portion on the medial side over a length that is 5% of the length of the long axis in the posterior direction starting from a posterior end of the main area; and

in the sub-area, an area (a total area, a collective area) of the tread surfaces of the plurality of ridges is set to be greater than a half of an area of a half of the sub-area.

[0048] This will increase frictional force to act in a phase of transition to a foot flat of making the forefoot portion tread on the ground.

[0049] Preferably, the outsole further includes a plurality of other ridges having a tread surface to be in contact with the road surface, and at least one diagonal groove defined between the plurality of other ridges, wherein:

at least in a partial area of an anterior half portion of the forefoot portion on a lateral side of a foot, the plurality of other ridges and the diagonal groove extend in a diagonal longitudinal direction and extend closer to an outer edge of the outsole as the ridges and the groove extend toward an anterior direction, with an angle of the ridges and an angle of the groove with respect to the long axis of the outsole set in a range of 20° to 45°; and

an angle between the plurality of ridges on the medial side and the plurality of ridges on the lateral side is set in a range of 10° to 60°.

[0050] During toe off of making a foot rise from the ground, the aforementioned movement locus makes a sudden change from a medial side toward a lateral side. The ridges on the medial side and the ridges on the lateral side defining an angle set in the aforementioned range are arranged to follow this sudden change. This will increase frictional force to act during the aforementioned toe off.

[0051] Preferably, a ratio Pw/Ld of the width of the tread surface of the ridges with respect to a depth of the longitudinal groove is set to be 3 to 15; and the depth of the longitudinal groove is set to be 0.2 to 2.5 mm.

[0052] In this case, the ratio Pw/Ld becomes greater than 3. Thus, the longitudinal groove does not become too deep and the outsole does not become too thick. Alternatively, the width of the tread surface of the ridges does not become too small to facilitate increase in a substantial tread area during the aforementioned treading on the ground.

[0053] Meanwhile, the ratio Pw/Ld becomes smaller than 15. Thus, the longitudinal groove does not become too shallow and the longitudinal groove can remain easily even in the presence of slight wear of the outsole. Alternatively, the width of the ridges does not become too large and a sufficient number of longitudinal grooves can be provided easily.

[0054] If the depth of the longitudinal groove is too small, the longitudinal groove will disappear in the presence of slight wear of the outsole. On the other hand, the depth of the longitudinal groove being too large not only necessitates increase in the thickness of the outsole but also results in a high likelihood of bending deformation

of the ridges caused by application of force in a width direction on the ridges, for example.

[0055] For the reasons given above, the depth of the longitudinal groove is preferably set to be 0.2 to 2.5 mm, more preferably, 0.4 to 2.0 mm, most preferably, 0.5 to 1.5 mm.

Embodiments

[0056] The present invention will be understood more clearly from the following description of preferred embodiments taken in conjunction with the accompanying drawings. Note however that the embodiments and the drawings are merely illustrative and should not be taken to define the scope of the present invention. The scope of the present invention shall be defined only by the appended claims. In the accompanying drawings, like reference numerals denote like components throughout the plurality of figures.

[0057] A feature described and/or illustrated in relation to one embodiment or one calculation example can be employed in the same form or in a similar form in one or more other embodiments or calculation examples, and/or can be employed in combination with or as an alternative to a feature in other embodiments.

[0058] A first embodiment of the present invention will be described below by referring to the drawings.

[0059] As shown in FIG. 1, in this embodiment, a shoe includes an outsole 1, a midsole 2, and an upper 3 covering an upper surface of a foot. To achieve the effect of the present invention, the midsole preferably has low hardness and the outsole preferably has high hardness.

[0060] The outsole 1 is to contact a road surface, etc., and to reduce a slip between a shoe and the road surface, etc. The outsole 1 is made of a material having higher resistance to wear than the midsole 2. The material of the outsole 1 can be a non-foam or a foam containing a thermoplastic elastomer or a soft elastomer such as rubber as a principal component or a base.

[0061] Regarding the physical properties (mechanical properties) of the outsole 1, the outsole 1 is generally set to have a higher Young's modulus and higher hardness than those of the midsole 2. For example, Asker hardness H_a from about 55 to 75° is applicable to the outsole 1.

[0062] The midsole 2 is arranged on the outsole 1 and absorbs impact occurring during landing on the ground. A foam of a thermoplastic resin such as EVA is applicable as the midsole 2.

[0063] As shown in FIGS. 1 to 3C, the outsole 1 includes a plurality of ridges 1P having a tread surface 10 to be in contact with a road surface, and a plurality of longitudinal grooves 1L defined between the plurality of ridges 1P. Like in this embodiment, the outsole 1 may include a transverse groove 1W between the ridges 1P.

[0064] Note that, for the convenience of drawing creation, the ridges 1P are illustrated as having a rectangular parallelepiped shape in FIG. 3A.

[0065] Like in this embodiment, the plurality of ridges

1P and the longitudinal grooves 1L of FIG. 2 may be provided to extend over a substantially entire region of a forefoot portion 1F, that of a middle foot portion 1M, and that of a rear foot portion 1B on a medial side 11 of a foot. At least in a partial area of each of the forefoot portion 1F and the rear foot portion 1B, the plurality of ridges 1P and the longitudinal grooves 1L extend in a longitudinal direction Y or in a diagonal longitudinal direction and are set so that an angle B1 and an angle B2 of the plurality of ridges 1P and the longitudinal grooves 1L with respect to a long axis 1A of the outsole 1 are in a range of 0° to 35°.

[0066] The forefoot portion 1F, the middle foot portion 1M, and the rear foot portion 1B mean parts covering a forefoot section, a middle foot section, and a rear foot section of a foot respectively not shown in the drawings. The forefoot section includes five metatarsal bones and 14 phalanges, etc. The middle foot section includes a navicular bone, a cuboid bone, and three cuneiform bones, etc. The rear foot section includes a talus and a calcaneal bone, etc.

[0067] The long axis 1A of the outsole 1 means a virtual line passing through a tip and a back end of the outsole 1 or a shoe. The medial side 11 of a foot means an inside area from a virtual curve 13 defined by connecting midpoints O in the longitudinal direction Y, each being a midpoint between two points where a virtual transversal line 14 perpendicular to the long axis 1A crosses an inner edge and an outer edge of the outsole 1. The phrase "divided (equally) into two parts" in the recitation "the main area is divided into two parts, which are an edge-side half and a central half" means that "the inside area is divided into two by a virtual curve defined by connecting midpoints in the longitudinal direction Y, each being a midpoint between a point where the transversal line 14 crosses the inner edge of the outsole 1 and the midpoint O."

[0068] The outsole 1 of FIG. 2 includes a tip area AT defined to extend through the forefoot portion 1F on the medial side 11 over a length that is 10% of the length of the long axis 1A in a posterior direction starting from a tip of the outsole 1, and a main area AM defined to extend through the forefoot portion 1F on the medial side 11 over a length that is 30% of the length of the long axis 1A in the posterior direction starting from a back end of the tip area AT.

[0069] In the main area AM, a sum of the area of the tread surface 10 of the plurality of ridges 1P is greater than a half of the area of the main area AM. The plurality of ridges 1P and the plurality of longitudinal grooves 1L are provided in an anterior end portion of the main area AM.

[0070] The outsole 1 has the main area AM divided in the longitudinal direction Y into three equal parts, a first, anterior area AM1, a second area AM2 adjacent to the first area AM1, and a third, posterior area AM3.

[0071] The plurality of ridges 1P and the longitudinal grooves 1L have the inclination B1 in the first area AM1 such that the ridges 1P and the longitudinal grooves 1L

extend closer to the long axis 1A as the ridges 1P and the longitudinal grooves 1L extend toward an anterior direction. Meanwhile, the plurality of ridges 1P and the longitudinal grooves 1L have the inclination B2 in the third area AM3 such that the ridges 1P and the longitudinal grooves 1L extend closer to the long axis 1A as the ridges 1P and the longitudinal grooves 1L extend toward a posterior direction.

[0072] Advantage achieved by the aforementioned inclinations B1 and B2 will be described below.

[0073] FIGS. 4A and 4B show movement loci 101 taken by a load center (weight center) during walking and during running respectively disclosed by WO 2010/038266A1. A sign 100 shows a long and thick groove formed in the outsole 1. The groove 100 is set so as to make the movement loci 101 get closer to the long axis 1A (FIG. 2).

[0074] Meanwhile, FIG. 4C shows a distribution of frictional force F measured by the present inventors.

[0075] As understood from the distribution of the force F in FIG. 4C, in the third area AM3 of FIG. 2, the force F will act on the long axis 1A in a direction approximate to the inclination B2. On the other hand, the movement loci 101 of FIGS. 4A and 4B go toward a lateral side 12 of a foot immediately before a toe portion rises from the ground. Thus, the force F will act in a direction approximate to the inclination B1 in the first area AM1 of FIG. 2

[0076] In the outsole 1 of FIG. 2, the main area AM is divided into two equal parts, the edge-side half and the central half, and a sum of the area of the tread surface 10 of the plurality of ridges 1P in the central half is set to be greater than a half of the area of the central half.

[0077] Further, the outsole 1 has a sub-area AS adjacent to the main area AM and defined to extend through the forefoot portion 1F on the medial side 11 over a length that is 5% of the length of the long axis 1A starting from a back end of the main area AM. In the sub-area AS, the area of the tread surface 10 of the plurality of ridges 1P is set to be greater than a half of the area of a half of the sub-area AS.

[0078] Like in this embodiment, a plurality of other ridges 1Q extending long in a transverse direction or in a diagonal direction may be provided further on the lateral side 12 of the outsole 1. Meanwhile, like in a second embodiment shown in FIGS. 5A and 5B, a plurality of longitudinally-long ridges 1Q extending in a longitudinal direction or in a diagonal longitudinal direction may be provided on the lateral side 12.

[0079] The outsole 1 of FIG. 2 further includes a diagonal groove 1G defined between the plurality of other ridges 1Q having a tread surface 10 to be in contact with a road surface.

[0080] At least in a partial area of an anterior half portion of the forefoot portion 1F on the lateral side 12 of a foot, the plurality of other ridges 1Q and the diagonal groove 1G extend in a diagonal longitudinal direction and extend closer to an outer edge of the outsole 1 as the ridges 1Q and the groove 1G extend toward an anterior

direction. An angle B3 of the ridges 1Q and the diagonal groove 1G with respect to the long axis 1A of the outsole 1 may be set in a range of 20° to 45°. An angle B5 between the ridges 1P on the medial side and the ridges 1Q on the lateral side may be set in a range of 10° to 60°

[0081] The aforementioned structure of the anterior half portion of the forefoot portion 1F will increase frictional force produced between the outsole 1 and a road surface when a load moves along the loci 101 shown in FIGS. 4A and 4B to rise of a foot from the ground.

[0082] On the other hand, the plurality of other ridges 1Q and the diagonal groove 1G are provided at a back end portion on the lateral side 12 of the outsole 1 of FIG. 2. The ridges 1Q and the diagonal groove 1G at the back end portion on the lateral side 12 have an inclination such that the ridges 1Q and the diagonal groove 1G extend away from the long axis 1A as the ridges 1Q and the diagonal groove 1G extend toward a posterior direction. This structure of the back end portion will produce large frictional force on a dry road surface during a first strike.

[0083] To clearly show the effect of the present invention achieved in a kicking phase of a forefoot section, analysis and calculation of the friction coefficient F_c using an electronic calculator (simulation) conducted by the present inventors will be described next.

[0084] A hypothesis of the calculation will be described first.

[0085] As shown in the graph of FIG. 10A, as a result of experiment, an outsole member is found to provide a friction coefficient that can be subjected to power approximation to mean contact pressure. An area required during the kicking phase is about a range of 40 mm square. A vertical load to be applied during the kicking phase is around 800 N. Specifically, the vertical load is considered to be about 0.5 Mpa.

[0086] A fall of a ridge during a slipping phase results from mixture of a component of bending deformation of FIG. 10B and a component of shear deformation of FIG. 10C. A high friction coefficient is achieved effectively by reducing bending deformation of the ridge and urging shear deformation. Through use of the following formulas (3.0) to (3.2) using a dimensionless parameter R_s , a ratio between a shear deformation component and a bending deformation component observed in deformation of the ridge can be anticipated.

$$R_s = \delta_s / \delta_b \dots (3.0)$$

$$\delta_b = 3F_t \cdot H / I \cdot E_a \dots (3.1)$$

$$\delta_s = F_t \cdot H / G \cdot k \cdot A \dots (3.2),$$

where:

F_t is frictional force applied to a tread surface of the ridge;

I is a second moment of area determined in an x-axis direction at a cross section of x (lengthwise direction) by y (transverse direction) of a test piece;

E_a is an initial elasticity modulus of the outsole member; and

G is a shear elasticity modulus.

[0087] Note that, the outsole member is an isotropic member. Thus, the shear elasticity modulus G was calculated based on an elasticity modulus E of the outsole member and a Poisson's ratio of 0.46. Test pieces used in this experiment all have rectangular cross sections, so that a shear correction factor k was set at 2/3 based on the Timoshenko beam theory.

[0088] FIGS. 11A and 11B show examples of experimental result. A contact area ratio is a dimensionless parameter obtained by dividing an actual contact area by the area of a surface of the ridge. A contact area ratio being 1 means that the surface of the ridge entirely contacts a floor surface. As understood from these drawings, a relationship of the aforementioned parameter R_s with a contact area ratio and a friction coefficient can be expressed by log approximation. This shows that the parameter R_s is determined to be usable for anticipating a contact area about a ridge of a given shape.

[0089] The friction coefficient F_c was calculated through the following steps (1) to (5):

(1) calculate a total area of a planar surface of a ridge in an area of 40 mm x 40 mm;

(2) calculate the dimensionless parameter R_s based on the set dimension of the ridge;

(3) calculate a contact area assumed to be actually in contact with a floor surface based on a product of the total area of the planar surface and a value obtained by substituting the dimensionless parameter R_s into a log approximate expression given in FIG. 11A;

(4) calculate mean contact pressure by dividing a vertical load 800 N by the contact area calculated in the step (3); and

(5) calculate the friction coefficient F_c by substituting the mean contact pressure into a power approximate expression given in FIG. 10A.

[0090] Moreover, as understood from the foregoing formulas (3.0) to (3.2), during the course of obtaining the parameter R_s , the initial elasticity modulus (Young's modulus) E_a of the outsole member is divided by the shear elasticity modulus G to exert no effect on the calculation. Further, an initial elasticity modulus (Young's modulus) E_m of a midsole member is also omitted from the calculation formulas. Meanwhile, in consideration of actual deforming behavior of a sole, the initial elasticity modulus (Young's modulus) E_a of the outsole member is preferably set in a range of about 1 to about 5 Mpa and

the initial elasticity modulus (Young's modulus) E_m of the midsole member is preferably set in a range of about 0.5 to about 1.0 Mpa.

[0091] FIG. 12A shows the shape of a virtual sample used for calculation of the friction coefficient F_c . This sample shape is approximate to the shape of the ridge according to the first embodiment of FIG. 2 and that of the ridge according to the second embodiment of FIG. 5A. Thus, values of parameters including a width P_w and a length P_l of the tread surface 10 of the ridge 1P set below are also applicable to the first and second embodiments. Calculations described below were all conducted for calculating the friction coefficient F_c on a dry surface.

[0092] FIGS. 12B and 13 show the friction coefficient F_c calculated by changing a depth L_d of a longitudinal groove and the width P_w of a ridge while fixing the other parameters at the following values:

Mt: Thickness of midsole fixed at 14 (mm);
 Bt: Base thickness of outsole fixed at 2 (mm);
 Lw: Width of longitudinal groove fixed at 0.5 (mm);
 Pl: Length of ridge fixed at 19 (mm);
 Wd: Depth of transverse groove fixed at 1 (mm); and
 Ww: Width of transverse groove fixed at 1 (mm).

[0093] FIG. 12B shows a value of the friction coefficient F_c determined if thrust is applied in the lengthwise direction of the ridge 1P. FIG. 13 shows a value of the friction coefficient F_c determined if thrust is applied in the width direction of the ridge 1P.

[0094] As understood from the table of FIG. 12B, a value of the friction coefficient F_c increases with increase in the width P_w of the ridge, irrespective of the depth L_d of the longitudinal groove. This is explained by the fact that, as the width P_w of the ridge becomes larger, a contact area increases in this calculation.

[0095] However, as understood from the table of FIG. 13, if force is applied in the width direction of the ridge 1P, a ratio P_w/L_d of the width P_w of the tread surface of the ridge 1P with respect to the depth L_d of the longitudinal groove being less than 2 or 3 reduces a value of the friction coefficient F_c seriously, as indicated in a section partitioned with bold lines in the table. Thus, the ratio P_w/L_d is preferably 2 or more, more preferably, 3 or more.

[0096] Meanwhile, as understood from the table of FIG. 13, if force is applied in the width direction of the ridge 1P, the ratio P_w/L_d of the width P_w of the tread surface of the ridge 1P with respect to the depth L_d of the longitudinal groove (height of the ridge) being 2 to 20, preferably 3 to 20 provides a large value of the friction coefficient F_c , as indicated in a section partitioned with bold lines in the table.

[0097] The outsole 1 such as one shown in each of FIGS. 2 and 5A of an actual shoe will be examined next.

[0098] The outsole 1 has larger specific gravity than the midsole 2 (FIG. 1). Thus, in consideration of speed or efficiency during running or walking, the outsole 1 preferably has a small thickness. Meanwhile, in consideration

of durability of the outsole 1, the outsole 1 preferably has a large thickness. Thus, a preferable thickness of the outsole 1 to be used for a play or general running may be from about 1.0 to about 5.0 mm.

[0099] On the other hand, in consideration of wear of the outsole 1, the aforementioned thickness of the outsole 1, and prevention of sudden bending of the outsole 1, the depth L_d of the longitudinal groove is preferably 0.2 to 2.5 mm, more preferably, 0.4 to 2.0 mm, most preferably, 0.5 to 1.5 mm.

[0100] If the width P_w of the aforementioned ridge is too large, a side slip due to rolling contact may be caused easily in the presence of extremely small particles of soil or sand on a road surface. Hence, in terms of a relationship with the aforementioned most preferable range of the depth L_d of the longitudinal groove, the ratio P_w/L_d is more preferably 15 or less.

[0101] Regarding a relationship between the height L_d and the width P_w of the ridge, to prevent the occurrence of a buckling phenomenon, a slenderness ratio $E_a \cdot (P_w/L_d)^2$ derived from Euler's formula preferably has a value greater than 4/3.

[0102] A value of the width L_w of the longitudinal groove and a value of the length P_l of the ridge shown in FIG. 12A will be examined next. FIG. 14 shows a value of the friction coefficient F_c calculated by changing the width L_w of the longitudinal groove and the length P_l of the ridge while fixing the other parameters at the following values. Calculation examples of FIGS. 14 to 25 were given by applying thrust in the lengthwise direction of the ridge 1P

Mt: Thickness of midsole fixed at 14 (mm);
 Bt: Base thickness of outsole fixed at 2 (mm);
 Ld: Depth of longitudinal groove fixed at 1 (mm);
 Pw: Width of ridge fixed at 5 (mm);
 Wd: Depth of transverse groove fixed at 1 (mm); and
 Ww: Width of transverse groove fixed at 1 (mm).

[0103] As understood from the table of FIG. 14, increase in the width L_w of the longitudinal groove will reduce the friction coefficient F_c . Meanwhile, increase in the length P_l of the ridge will increase the friction coefficient F_c .

[0104] In consideration of manufacture of the actual outsole 1 in each of FIGS. 2 and 5 and the value of the friction coefficient F_c given in FIG. 14, the width L_w of the longitudinal groove is preferably 0.05 to 1.5 mm, most preferably, 0.1 to 1.0 mm. Further, if the length P_l of the ridge exceeds 15 mm, the friction coefficient F_c approximates to a value obtained if the length P_l has an infinite value. Thus, the length P_l of the ridge is preferably set at 15 mm or more and set not to exceed an entire length of a sole.

[0105] A relationship between the width P_w of the ridge and the length P_l of the ridge shown in FIG. 12A will be examined next. FIG. 15 shows a value of the friction coefficient F_c calculated by changing the width P_w of the ridge and the length P_l of the ridge while fixing the other parameters at the following values:

Mt: Thickness of midsole fixed at 14 (mm);
 Bt: Base thickness of outsole fixed at 2 (mm);
 Ld: Depth of longitudinal groove fixed at 1 (mm);
 Lw: Width of longitudinal groove fixed at 0.5 (mm);
 Wd: Depth of transverse groove fixed at 1 (mm); and
 Ww: Width of transverse groove fixed at 1 (mm).

[0106] As indicated by bold lines in the table of FIG. 15, a value of a ratio PI/Pw being 1.8 to 300 is found to achieve the friction coefficient F_c of a large value. Further, as the width Pw of the ridge becomes larger, a value of the friction coefficient F_c is increased. However, in consideration of the aforementioned side slip, the width Pw of the ridge will preferably be 3 to 15 mm, more preferably, 3.5 to 12 mm, most preferably, 4 to 10 mm.

[0107] A relationship between the width Pw of the ridge and the width Lw of the longitudinal groove shown in FIG. 12A will be examined next. FIG. 16 shows a value of the friction coefficient F_c calculated by changing the width Pw of the ridge and the width Lw of the longitudinal groove while fixing the other parameters at the following values:

Mt: Thickness of midsole fixed at 14 (mm);
 Bt: Base thickness of outsole fixed at 2 (mm);
 Ld: Depth of longitudinal groove fixed at 1 (mm);
 Pl: Length of ridge fixed at 27 (mm);
 Wd: Depth of transverse groove fixed at 1 (mm); and
 Ww: Width of transverse groove fixed at 1 (mm).

[0108] As indicated by bold lines in the table of FIG. 16, if a ratio Pw/Lw is less than 2, a value of the friction coefficient F_c is small. If the ratio Pw/Lw is 2 or more or 4 or more, a value of the friction coefficient F_c is large. Thus, the ratio Pw/Lw is set at 2 or more, preferably, 4 or more.

[0109] Furthermore, in consideration of a problem relating to manufacture or the aforementioned side slip, the ratio Pw/Lw is set at 100 or less.

[0110] A relationship between the length ratio PI/Pw of the length PI of the ridge with respect to the width Pw of the ridge shown in FIG. 12A and the width ratio Pw/Lw of the width Pw of the ridge with respect to the width Lw of the longitudinal groove shown in FIG. 12 will be examined next. FIG. 17 shows a value of the friction coefficient F_c calculated by changing a value of the length ratio PI/Pw and a value of the width ratio Pw/Lw while fixing the other parameters at the following values:

Mt: Thickness of midsole fixed at 14 (mm);
 Bt: Base thickness of outsole fixed at 2 (mm);
 Ld: Depth of longitudinal groove fixed at 1 (mm);
 Wd: Depth of transverse groove fixed at 1 (mm); and
 Ww: Width of transverse groove fixed at 1 (mm).

[0111] As indicated by bold lines in the table of FIG. 17, the length ratio PI/Pw being 1.8 to 200 and the width ratio Pw/Lw being 2 to 100 are found to achieve the friction coefficient F_c of a large value.

[0112] Moreover, calculation was conducted by approximating a tread area to 40 mm square. Thus, a value of the friction coefficient F_c obtained if PI/Pw is 1.5 agrees with a value obtained if PI/Pw is 1.8. However, a correct tread area is increased with increase in the length ratio PI/Pw , so that PI/Pw is set at 1.8 or more.

[0113] In addition, a value of the friction coefficient F_c obtained if the length ratio PI/Pw is 5 agrees with a value obtained if the length ratio PI/Pw is 200. Thus, the length ratio PI/Pw will preferably be 4 or more, more preferably, 5 or more.

[0114] Meanwhile, if a value of the width ratio Pw/Lw is 2 or more, a value of the friction coefficient F_c is increased. If a value of the width ratio Pw/Lw is 4 or more, a value of the friction coefficient F_c is increased considerably. Thus, the width ratio Pw/Lw is set at 2 or more, preferably, 4 to 100.

[0115] Next, as shown in the table of FIG. 18, the friction coefficient F_c was calculated by changing various parameters. As shown in a section surrounded by bold lines of FIG. 18, a value of the friction coefficient F_c is small in each of ex. 502, ex. 503, ex. 508, and ex. 509. A point in common about a parameter among these four examples is that the depth Wd of the transverse groove is greater than those in the other examples. Specifically, the depth Wd of the transverse groove will preferably be 0 to 1.5 mm, more preferably, 0 to 1.0 mm.

[0116] Next, effect of a sectional shape of the ridge 1P and that of the longitudinal groove 1L shown in each of FIGS. 19A and 19B on the friction coefficient F_c was examined. A sectional shape of the longitudinal groove 1L having been subjected to the examination includes a groove "having a substantially trapezoidal shape wider at a bottom than at an opening" (dovetail groove) shown in FIG. 19A, and a substantially V-shape groove shown in FIG. 19B.

[0117] FIGS. 19A and 19B each show a value of the friction coefficient F_c calculated by changing a value of the depth Ld of the longitudinal groove (= a tread surface side width $Lw1$ of the longitudinal groove) and a value of a non-tread surface side width $Lw2$ of the longitudinal groove while fixing the other parameters at the following values.

[0118] The width Pw of the ridge 1P was set at a basic value of 5.0 mm in FIG. 19A.

[0119]

Mt: Thickness of midsole fixed at 14 (mm);
 Bt: Base thickness of outsole fixed at 2 (mm);
 Pl: Length of ridge fixed at 20 (mm);
 Wd: Depth of transverse groove fixed at 1 (mm); and
 Ww: Width of transverse groove fixed at 1 (mm).

[0120] As understood from the aforementioned examples, the longitudinal groove 1L may have the dovetail groove shape of FIG. 19A. Meanwhile, employing the V sectional shape of FIG. 19B reduces a value of the friction coefficient F_c . Specifically, a value of the friction coefficient

cient F_c is small in a section surrounded by bold lines of FIG. 19B. A reason therefor is that, if the longitudinal groove 1L has a V sectional shape, the area of the tread surface 10 of the ridge 1P is reduced.

[0121] Next, effect of a longitudinal sectional shape of the ridge 1P shown in each of FIGS. 20A and 20B on the friction coefficient F_c was examined. A sectional shape of the longitudinal groove 1L having been subjected to the examination includes an inverted trapezoidal shape of FIG. 20A and a trapezoidal shape of FIG. 20B.

[0122] FIGS. 20A and 20B each show a value of the friction coefficient F_c calculated by changing a length PI_1 of a tread surface and a length PI_2 of a non-tread surface of the ridge 1P while fixing the other parameters at the following values:

Mt: Thickness of midsole fixed at 14 (mm);
 Bt: Base thickness of outsole fixed at 2 (mm);
 Ld: Depth of longitudinal groove fixed at 1 (mm);
 Lw: Width of longitudinal groove fixed at 0.5 (mm);
 Pw: Width of ridge fixed at 5 (mm);
 Wd: Depth of transverse groove fixed at 1 (mm); and
 Ww: Width of transverse groove fixed at 1 (mm).

[0123] As understood from values of the friction coefficient F_c given in these tables, no serious effect will be exerted on the friction coefficient F_c by the longitudinal sectional shape of the ridge 1P

[0124] Next, instances of FIGS. 21 to 23 were examined in the presence of thin and shallow grooves G_s in a surface of the ridge 1P. The shape and the dimension of each groove G_s are shown in a corresponding table. The grooves G_s shown in FIG. 21 extend in the lengthwise direction of the ridge 1P. The grooves G_s shown in FIG. 22 extend in the width direction of the ridge 1P. The grooves G_s shown in FIG. 23 extend in a direction diagonal to the ridge 1P.

[0125] The number of the grooves G_s of FIG. 21 was set at three. A pitch of the grooves G_s of each of FIGS. 22 and 23 was set at 5 mm.

[0126] Each of the other parameters was fixed at the following value:

Mt: Thickness of midsole fixed at 14 (mm);
 Bt: Base thickness of outsole fixed at 2 (mm);
 Ld: Depth of longitudinal groove fixed at 1 (mm);
 Lw: Width of longitudinal groove fixed at 0.5 (mm);
 Pw: Width of ridge fixed at 5 (mm);
 Pl: Length of ridge set at infinite value;
 Wd: Depth of transverse groove fixed at 1 (mm); and
 Ww: Width of transverse groove fixed at 1 (mm).

[0127] A value of the friction coefficient F_c given in FIG. 21 shows that, in the presence of the thin and longitudinal grooves G_s , if a width V_w of the thin grooves G_s is 0.4 mm, a value of the friction coefficient F_c is reduced slightly largely. Thus, the width of the longitudinally-long grooves G_s to be formed in a surface of the ridge 1P is

preferably set at 0.4 mm or less. In other words, a groove at least shallower than 0.3 mm can be considered to be beyond the coverage of the longitudinal groove 1L according to the present invention.

[0128] A value of the friction coefficient F_c given in FIG. 22 shows that, in the presence of the transversely-long thin and shallow grooves G_s , if a depth V_d of these grooves G_s is 0.4 mm, a value of the friction coefficient F_c is reduced largely. Thus, if the grooves G_s are to be formed in a surface of the ridge 1P to extend in a transverse direction, the depth of these grooves G_s is preferably set at 0.4 mm or less. In other words, a transverse groove at least shallower than 0.3 mm can be considered to be beyond the coverage of the transverse groove 1W according to the present invention and the presence of such a shallow transverse groove can be considered to be ignorable.

[0129] A value of the friction coefficient F_c given in FIG. 23 shows that the presence of the shallow grooves G_s extending in the diagonal direction can be considered to be comparable to the aforementioned presence of the shallow transverse grooves G_s of FIG. 22.

[0130] FIG. 24 shows result of calculation of a value of the friction coefficient F_c in the presence of a plurality of protrusions P_p in a surface of the ridge 1P.

[0131] The friction coefficient F_c was calculated by changing the height of the protrusions P_p and a ratio of a total area of the protrusions P_p with respect to the area of the ridge 1P while fixing each parameter at the following value:

Mt: Thickness of midsole fixed at 14 (mm);
 Bt: Base thickness of outsole fixed at 2 (mm);
 Ld: Depth of longitudinal groove fixed at 1 (mm);
 Lw: Width of longitudinal groove fixed at 0.5 (mm);
 Pw: Width of ridge fixed at 5 (mm);
 Pl: Length of ridge fixed at 20 (mm);
 Wd: Depth of transverse groove fixed at 1 (mm); and
 Ww: Width of transverse groove fixed at 1 (mm).

[0132] As shown in a section surrounded by bold lines of FIG. 24, if the ratio of the aforementioned total area is large and the height of the protrusions is small, the friction coefficient F_c will not be reduced seriously. In other words, if the surface of the ridge 1P is given a pattern with thin and shallow grooves, protrusions and recesses resulting from the pattern may be considered to be ignorable.

[0133] FIG. 25 shows a value of the friction coefficient F_c in the presence of dimples DP or small protrusions (D_p) like small rectangular parallelepipeds formed at a surface of the ridge 1P. In the case of the dimples, a value in a vertical column prepared for small protrusions is given as a negative value.

[0134] A value of the friction coefficient F_c was calculated by changing the height of the small protrusions or the depth of the dimples and a ratio of a tread area with respect to the area of the ridge 1P while fixing each pa-

parameter at the following value:

Mt: Thickness of midsole fixed at 14 (mm);
 Bt: Base thickness of outsole fixed at 2 (mm);
 Ld: Depth of longitudinal groove fixed at 1 (mm);
 Lw: Width of longitudinal groove fixed at 0.5 (mm);
 Pw: Width of ridge fixed at 5 (mm);
 Pl: Length of ridge fixed at 20 (mm);
 Wd: Depth of transverse groove fixed at 1 (mm); and
 Ww: Width of transverse groove fixed at 1 (mm).

[0135] A value of the friction coefficient F_c given in FIG. 25 shows that, as long as a tread area on the surface of the ridge 1P is ensured, the presence of small dimples at the surface of the ridge 1P is considered not to affect the friction coefficient F_c seriously. Meanwhile, the presence of the small protrusions reduces a value of the friction coefficient F_c seriously. The small protrusions will cause not only reduction in a tread area but also bending deformation. Thus, these protrusions are preferably omitted from the surface of the ridge 1P.

[0136] FIGS. 26A to 26F each show different arrangement of ridges 1P and a different shape of the ridges 1P.

[0137] As shown in FIG. 26A, the ridges 1P may be arranged in a staggered pattern. As shown in FIG. 26B, the ridges 1P may have different widths Pw or different lengths Pl.

[0138] As shown in FIG. 26C, a planar shape of the ridges 1P may be a trapezoid or a parallelogram. In the case of FIG. 26C, the width of the ridges 1P can be determined by obtaining an average of a width Pwf at an anterior end and a width Pwb at a back end.

[0139] As shown in FIG. 26D, the ridges 1P may have a barrel shape or conversely, a shape recessed (constricted) at a center.

[0140] As shown in FIG. 26E, the ridges 1P and the longitudinal grooves 1L may be formed into a waveform. In this case, if an amplitude V1 of the waveform is large or if a wavelength V2 of a wave is small, the longitudinal groove 1L will contain a component of a transverse groove. This will reduce the friction coefficient F_c .

[0141] FIG. 26F shows an instance where transverse grooves are formed by providing notches 1C, etc. in the ridges 1P. If the depth of the notches 1C exceeds 0.5 mm and the width of the notches 1C is 0.5 times the width Pw of the ridges 1P or more, the friction coefficient F_c will be reduced. Meanwhile, if the depth of the notches 1C is 0.5 mm or less and the width of the notches 1C is less than 0.5 times the width Pw of the ridges 1P, the friction coefficient F_c will not be reduced seriously. Thus, such a depth and such a width of the notches 1C can be considered to be in the coverage of the present invention.

[0142] The preferred embodiments have been described above by referring to the drawings. A person with ordinary skill in the art who has read this specification will easily think of various changes and modifications within an obvious range.

[0143] For example, a midsole may be omitted. The

outsole 1 is only required to be provided at least in a partial area of a forefoot portion and/or a partial area of a rear foot portion. Further, the outsole 1 may be cut partially at the forefoot portion and/or the rear foot portion.

Specifically, the midsole 2 may be exposed at a longitudinal groove or a transverse groove of the outsole 1. If the midsole 2 is exposed, a "depth of the longitudinal groove" may be calculated based on a "depth of a groove provided in the outsole 1," or a "depth of a groove penetrating the outsole 1 to reach as far as the midsole 2."

[0144] The ridge of the present invention may be provided at one of a forefoot portion and a rear foot portion on a medial side of a foot. Such a case can also be a subject of application of each of the aforementioned embodiments and each of the simulation examples.

[0145] Thus, such changes and modifications are deemed to fall within the scope of the present invention defined by the appended claims.

20 Industrial Applicability

[0146] The present invention is applicable to a sole of a shoe suitable for running and walking.

25 Reference Signs List

[0147]

1: Outsole 10: Tread surface (Contact surface) 11: Medial side
 12: Lateral side
 1A: Long axis 13: Virtual curve 14: Virtual transversal line
 1F: Forefoot portion 1M: Middle foot portion
 1B: Rear foot portion
 1P: Ridge 1Q: Other ridge
 1G: Diagonal groove 1L: Longitudinal groove
 1W: Transverse groove
 2: Midsole 3: Upper
 B1, B2: AngleX: Perpendicular direction
 Y: Longitudinal direction
 AT: Tip area ET: Tip EB: Posterior end (Back end)
 AM: Main area AM1: First area
 AM2: Second area AM3: Third area
 AS: Sub-area
 Cs: Contact surface F: Force
 Ea: Young's modulus of outsole
 Em: Young's modulus of midsole
 Mt: Thickness of midsole Bt: Base thickness of outsole
 Ld: Depth of longitudinal groove
 Lw: Width of longitudinal groove
 Pw: Width of ridge Pw/Lw: Width ratio
 Pl: Length of ridge Pl/Pw: Length ratio
 Wd: Depth of transverse groove
 Ww: Width of transverse groove

Claims

1. An outsole of a shoe, the outsole comprising: a plurality of ridges each having a tread surface to be in contact with a road surface; and at least one longitudinal groove defined between the plurality of ridges, wherein:
 - at least in a partial area of each of a forefoot portion and a rear foot portion on a medial side of a foot, the plurality of ridges and the longitudinal groove extend in a longitudinal direction or in a diagonal longitudinal direction and are set so that angles of the ridges and the groove with respect to a long axis of the outsole are in a range of 0° to 35°;
 - a ratio of a length of the tread surface of each of the ridges with respect to a width of the tread surface is set to be 1.8 to 200; and
 - the width of the tread surface of each of the ridges is set to be greater than a width of the longitudinal groove by a factor of 2 to 100.
2. An outsole of a shoe, the outsole comprising: a plurality of ridges each having a tread surface to be in contact with a road surface; and at least one longitudinal groove defined between the plurality of ridges, wherein:
 - at least in a partial area of a rear foot portion on a medial side of a foot, the plurality of ridges and the longitudinal groove extend in a longitudinal direction or in a diagonal longitudinal direction and are set so that angles of the ridges and the groove with respect to a long axis of the outsole are in a range of 0° to 35°;
 - a ratio of a length of the tread surface of each of the ridges with respect to a width of the tread surface is set to be 1.8 to 200; and
 - the width of the tread surface of each of the ridges is set to be greater than a width of the longitudinal groove by a factor of 2 to 100.
3. The outsole according to claim 1 or 2, wherein a ratio of the width of the tread surface of each of the ridges with respect to a depth of the longitudinal groove is set to be 2 to 20.
4. An outsole of a shoe, the outsole comprising: a plurality of ridges each having a tread surface to be in contact with a road surface; and at least one longitudinal groove defined between the plurality of ridges, wherein:
 - at least in a partial area of a forefoot portion on a medial side of a foot, the plurality of ridges and the longitudinal groove extend in a longitudinal direction or in a diagonal longitudinal direction
- and are set so that angles of the ridges and the groove with respect to a long axis of the outsole are in a range of 0° to 35°;
- a ratio of a length of the tread surface of each of the ridges with respect to a width of the tread surface is set to be 1.8 to 200;
- the width of the tread surface of each of the ridges is set to be greater than a width of the longitudinal groove by a factor of 2 to 100; and
- a ratio of the width of the tread surface of each of the ridges with respect to a depth of the longitudinal groove is set to be 2 to 20.
5. The outsole according to claim 1 or 4, wherein:
 - the outsole includes a tip area defined to extend through the forefoot portion on the medial side over a length that is 10% of a length of the long axis in a posterior direction starting from a tip of the outsole, and a main area defined to extend through the forefoot portion on the medial side over a length that is 30% of the length of the long axis in the posterior direction starting from a back end of the tip area;
 - an area of the tread surfaces of the ridges is greater than a half of an area of the main area; and
 - the plurality of ridges and the longitudinal groove are provided at least in an anterior end portion of the main area.
6. The outsole according to claim 5, wherein:
 - the outsole has the main area divided equally in the longitudinal direction into three areas, which are a first area on an anterior side, a second area adjacent to the first area, and a third area on a posterior side;
 - at least one ridge of the plurality of ridges has an inclination in the first area such that the at least one ridge comes closer to the long axis as the at least one ridge extends in an anterior direction; and
 - the at least one ridge, or at least one other ridge of the plurality of ridges, has an inclination in the third area such that the at least one ridge or the at least one other ridge extends away from the long axis as the one ridge or the one other ridge extends in the anterior direction.
7. The outsole according to claim 5, wherein the main area is divided into two parts, which are an edge-side half and a central half, and an area of the tread surfaces of the plurality of ridges in the central half is set to be greater than a half of an area of the central half.
8. The outsole according to claim 5, 6 or 7, wherein:

the outsole has a sub-area adjacent to the main area and defined to extend through the forefoot portion on the medial side over a length that is 5% of the length of the long axis in the posterior direction starting from a back end of the main area; and
 in the sub-area, an area of the tread surfaces of the plurality of ridges is set to be greater than a half of an area of a half of the sub-area.

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9. The outsole according to any one of claims 1 and 4 to 8, wherein:

the outsole further comprises a plurality of other ridges each having a tread surface to be in contact with the road surface, and at least one diagonal groove defined between the plurality of other ridges, wherein:

15

at least in a partial area of an anterior half portion of the forefoot portion on a lateral side of a foot, the plurality of other ridges and the diagonal groove extend in a diagonal longitudinal direction and come closer to an outer edge of the outsole as the ridges and the groove extend in an anterior direction, with angles of the ridges and the groove with respect to the long axis of the outsole set in a range of 20° to 45°; and
 an angle between the plurality of ridges on the medial side and the plurality of other ridges on the lateral side is set in a range of 10° to 60°.

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10. The outsole according to any one of claims 1 to 9, wherein:

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a ratio of the width of the tread surface of each of the ridges with respect to a depth of the longitudinal groove is set to be 3 to 15; and
 the depth of the longitudinal groove is set to be 0.2 to 2.5 mm.

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11. The outsole according to claim 10, wherein:

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the depth of the longitudinal groove is set to be 0.4 to 2.0 mm.

12. The outsole according to claim 10, wherein:

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the depth of the longitudinal groove is set to be 0.5 to 1.5 mm.

55

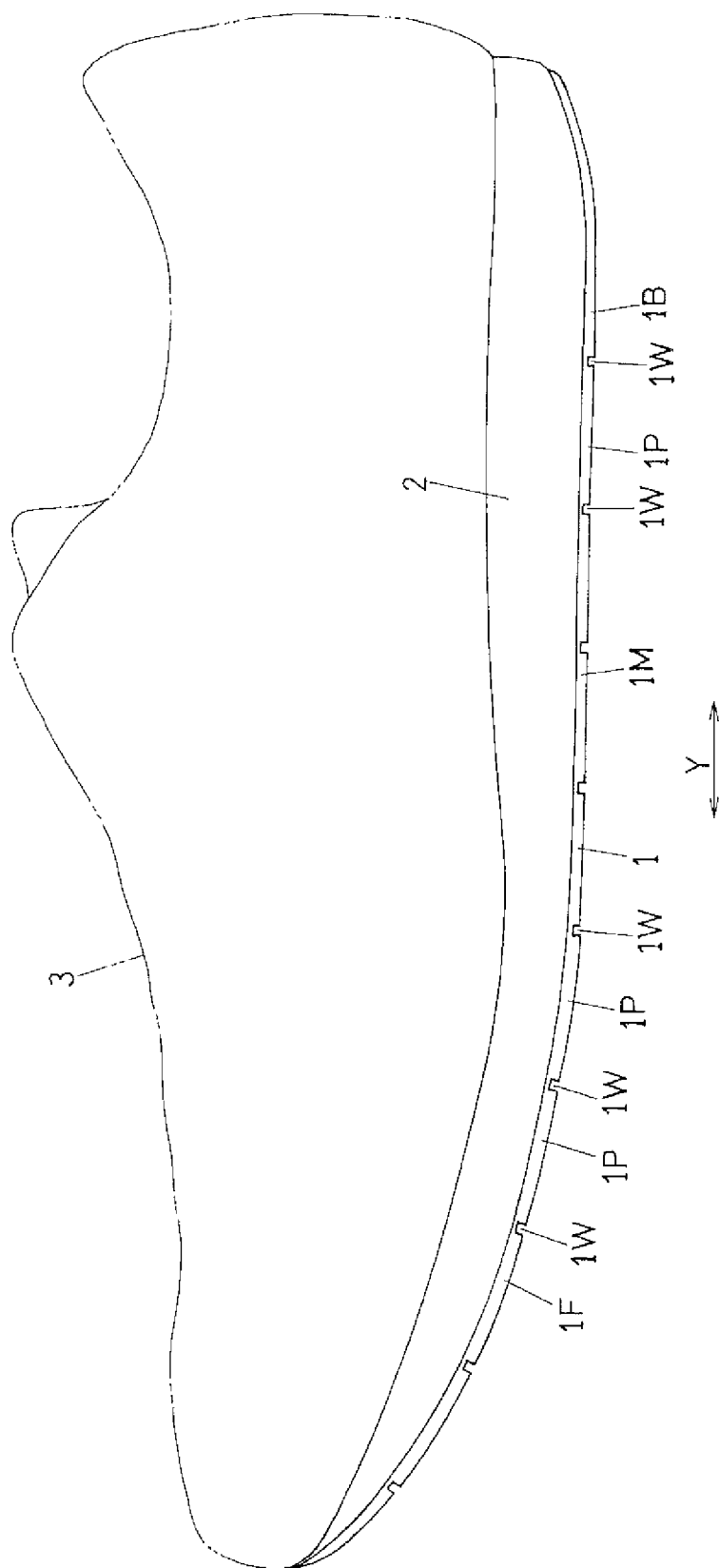
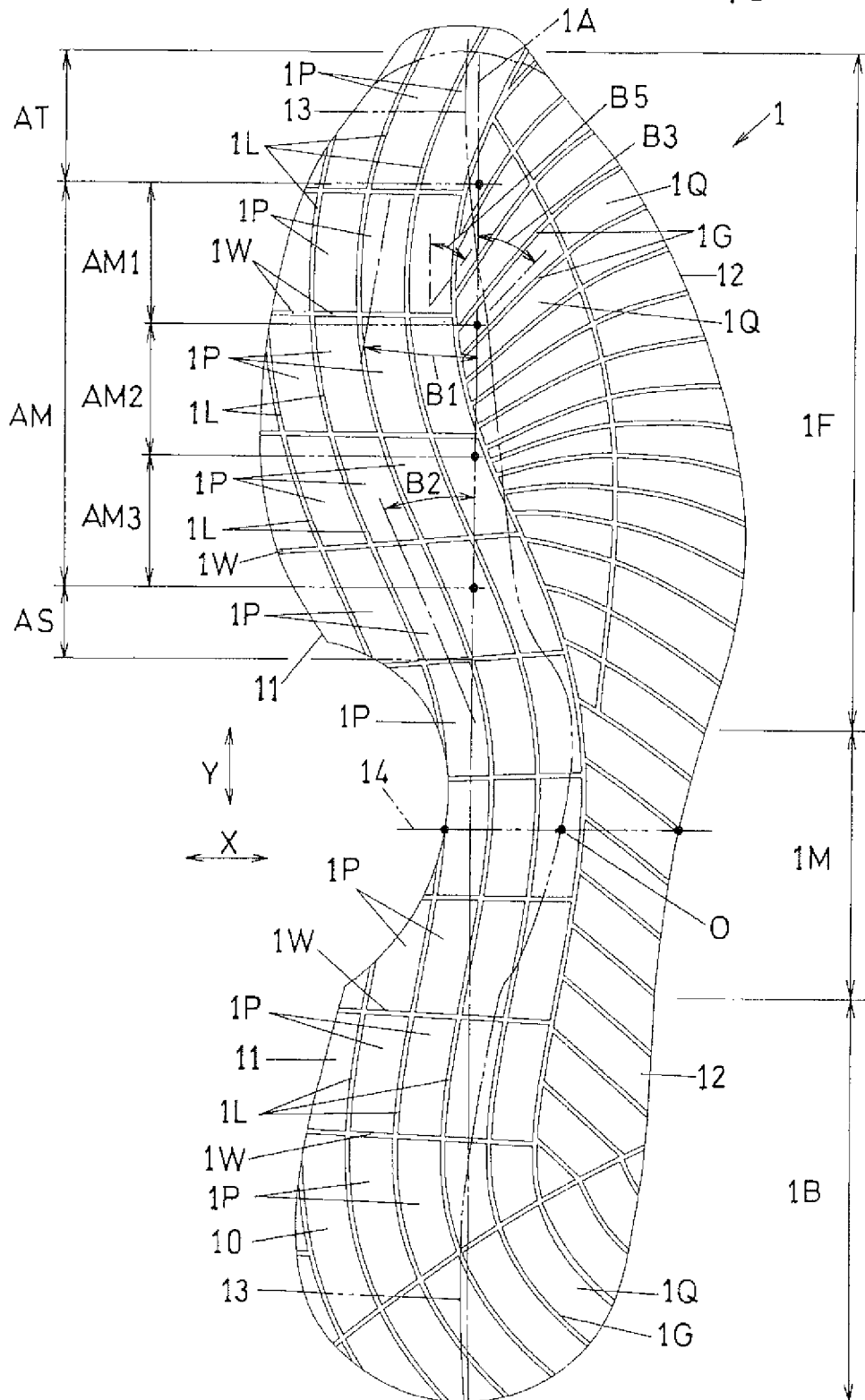
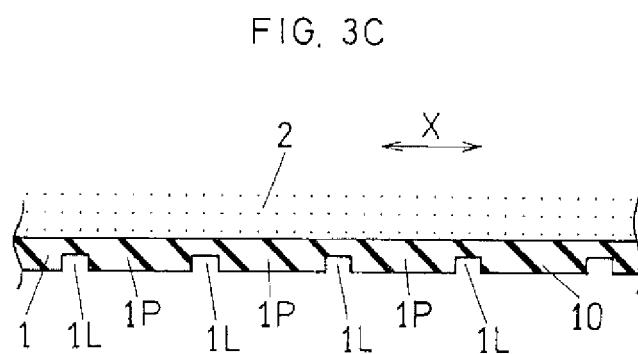
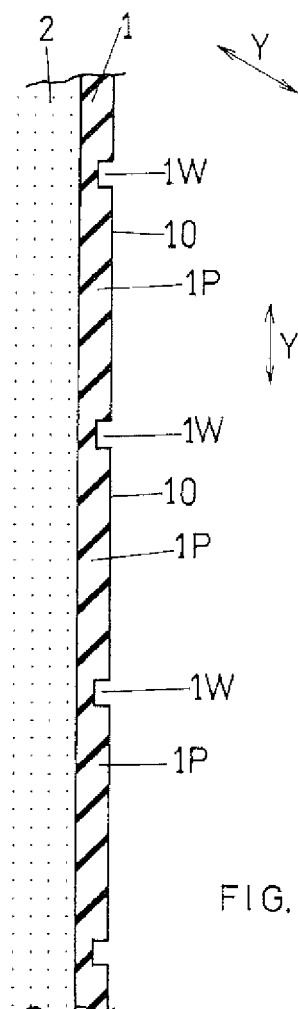
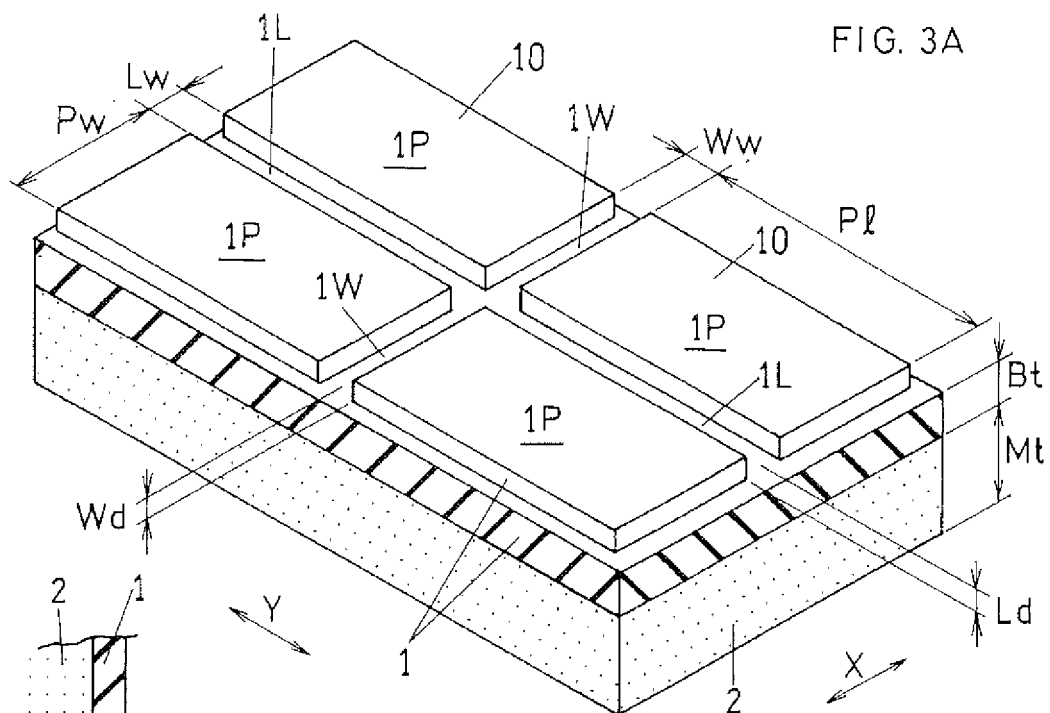


FIG. 1

FIG. 2





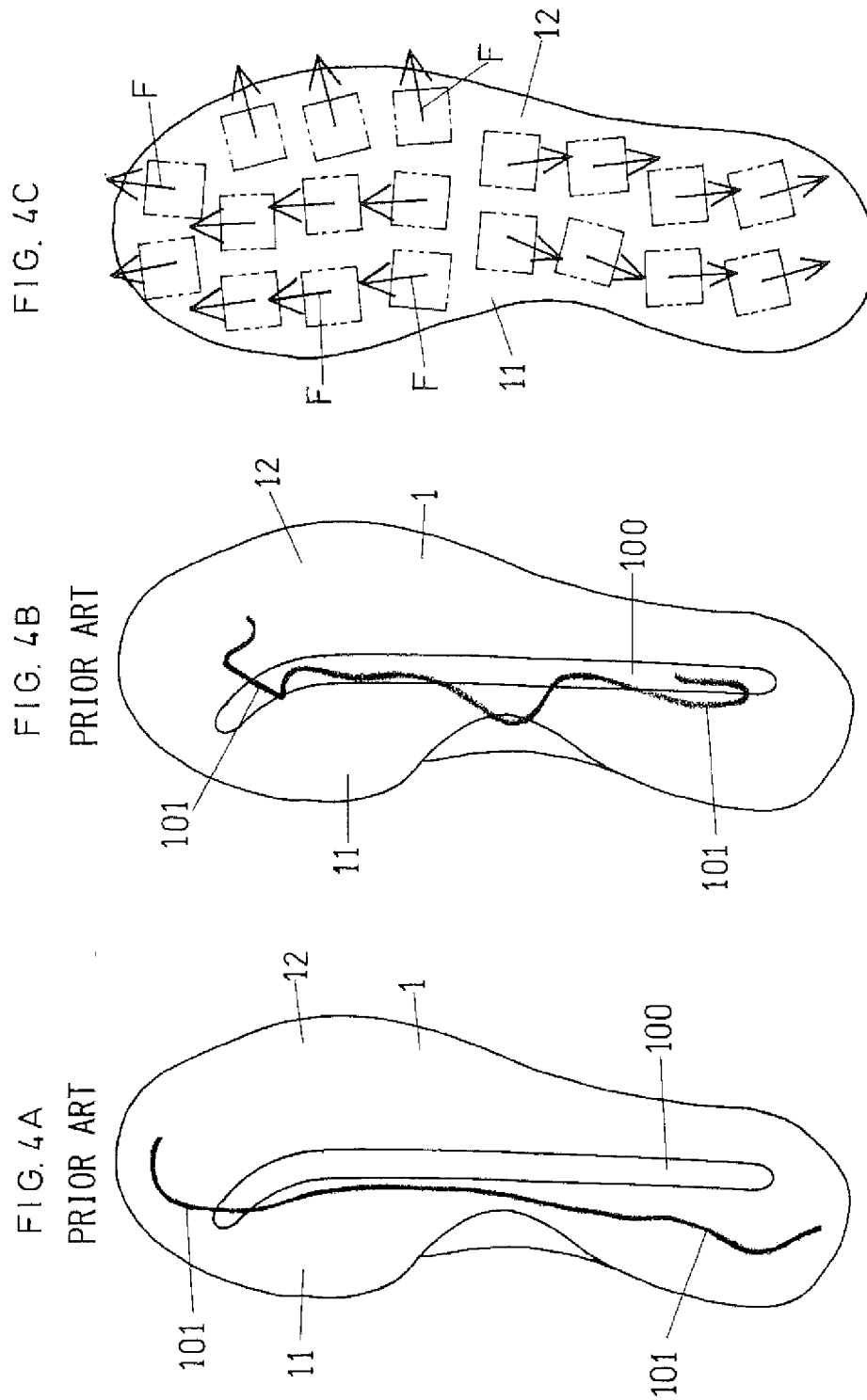


FIG. 5A

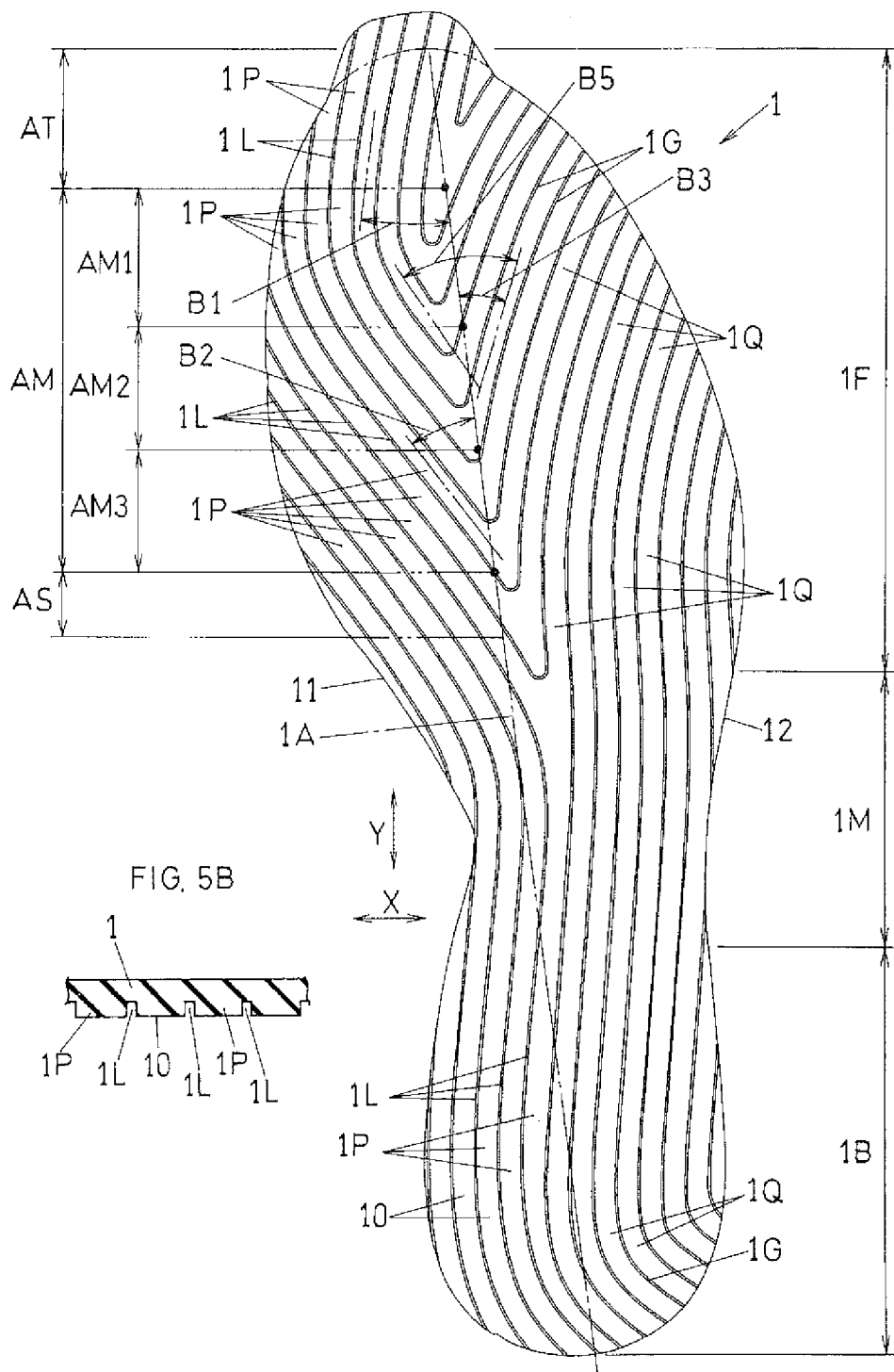
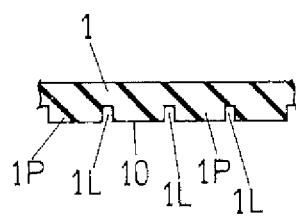


FIG. 5B



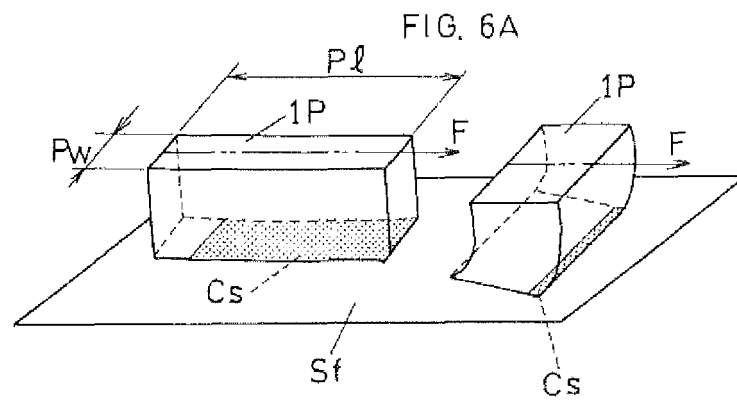
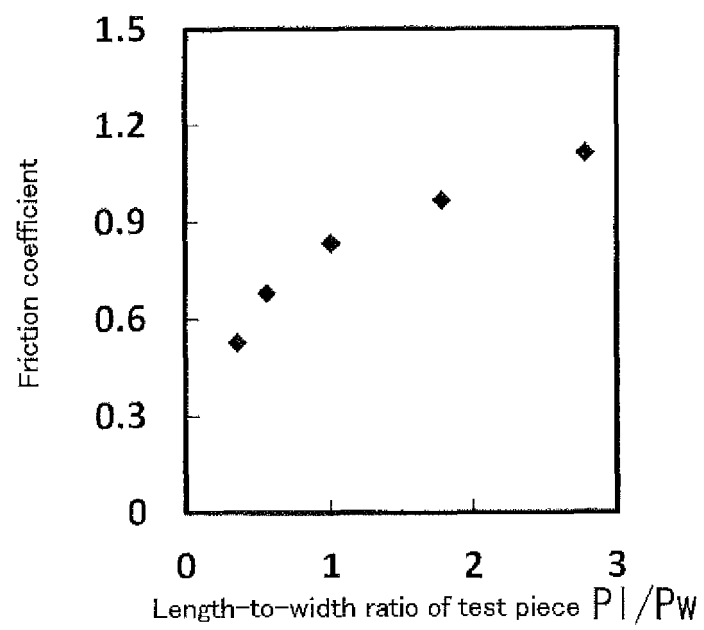


FIG. 6B



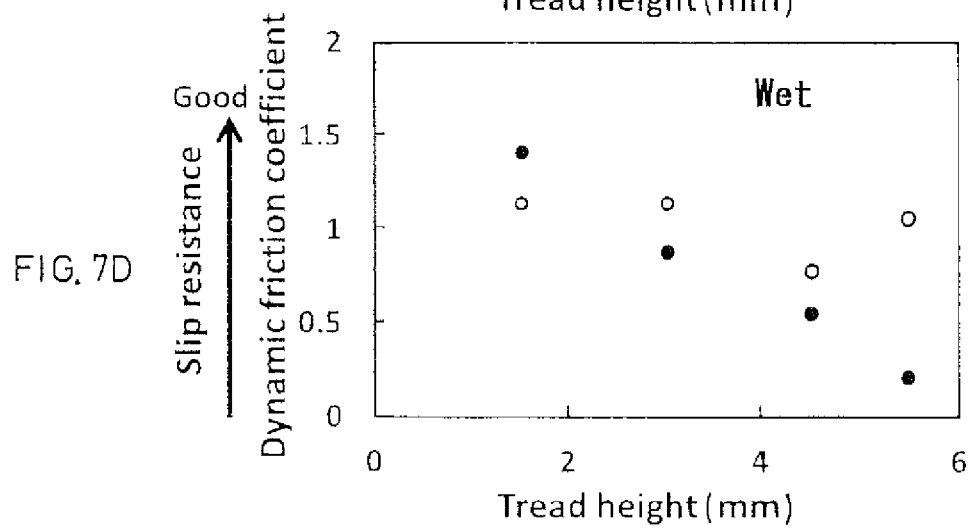
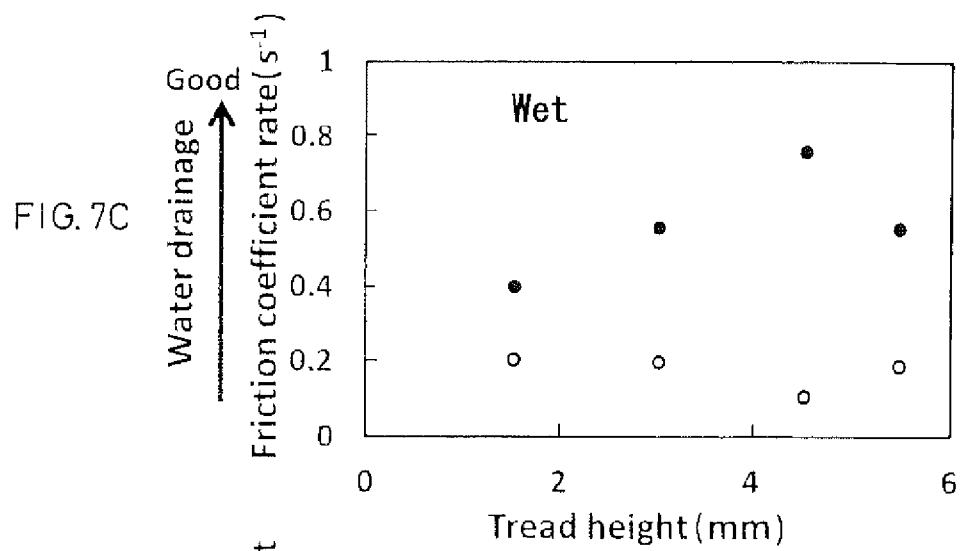
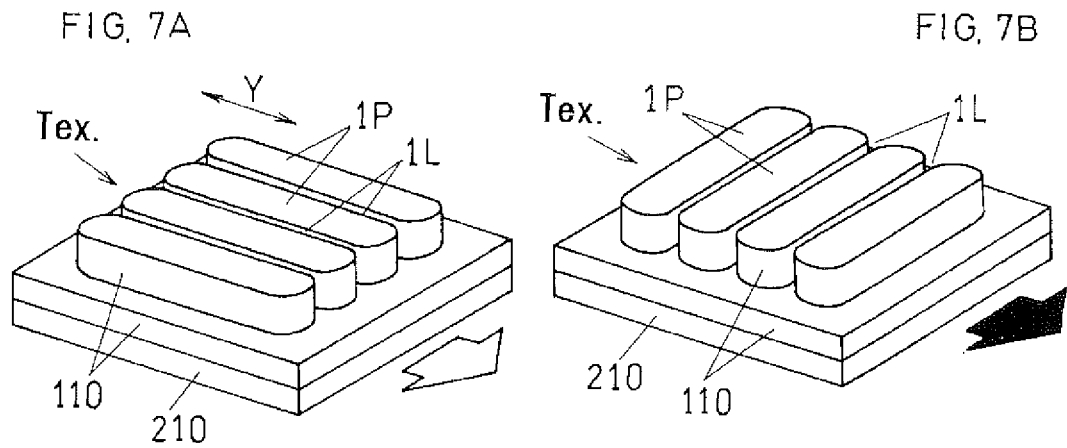


FIG. 8A

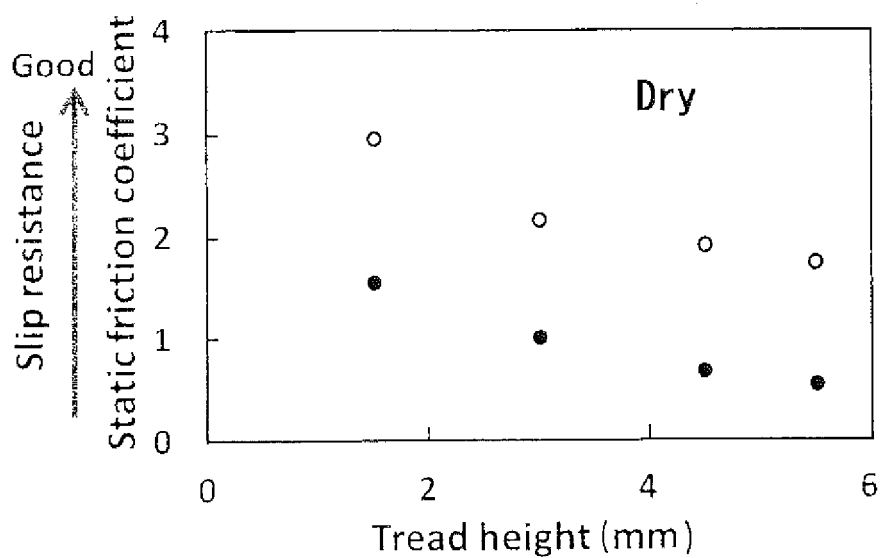


FIG. 8B

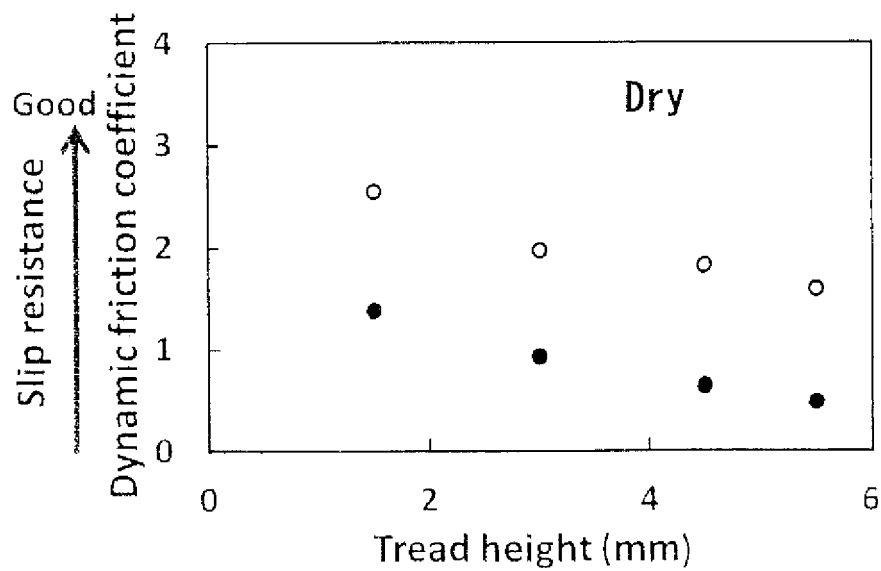


FIG. 9A

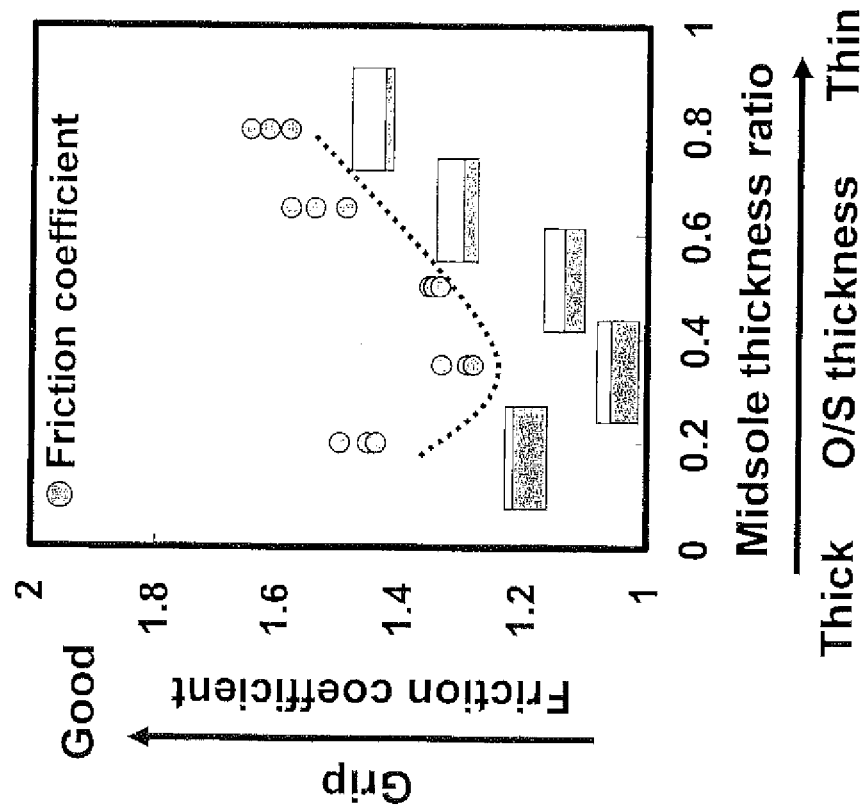


FIG. 9B

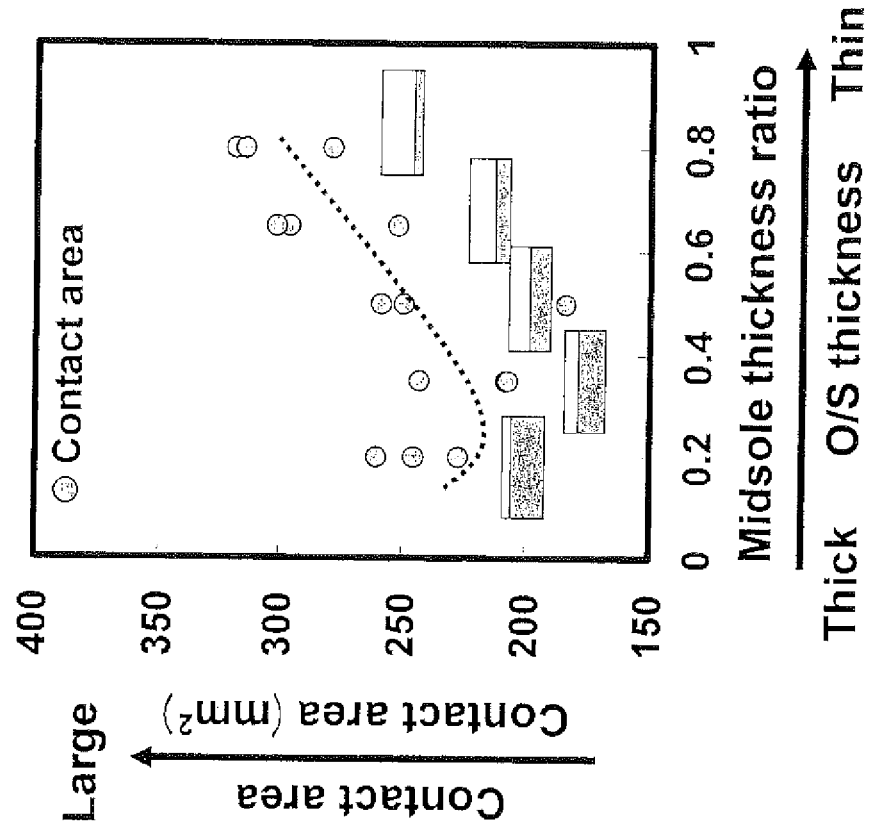


FIG. 10A

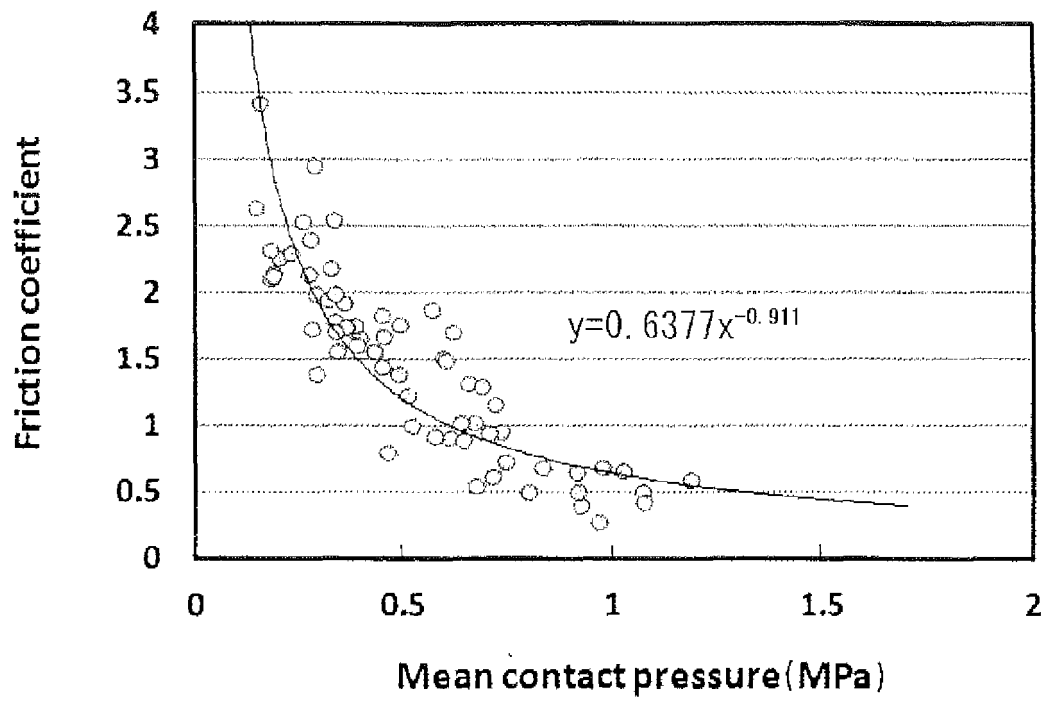


FIG. 10B

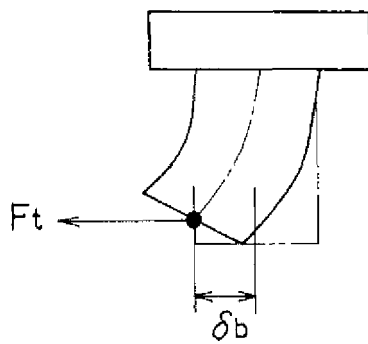


FIG. 10C

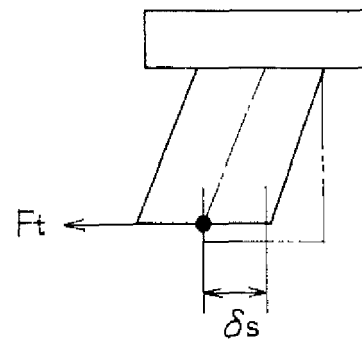


FIG. 11A

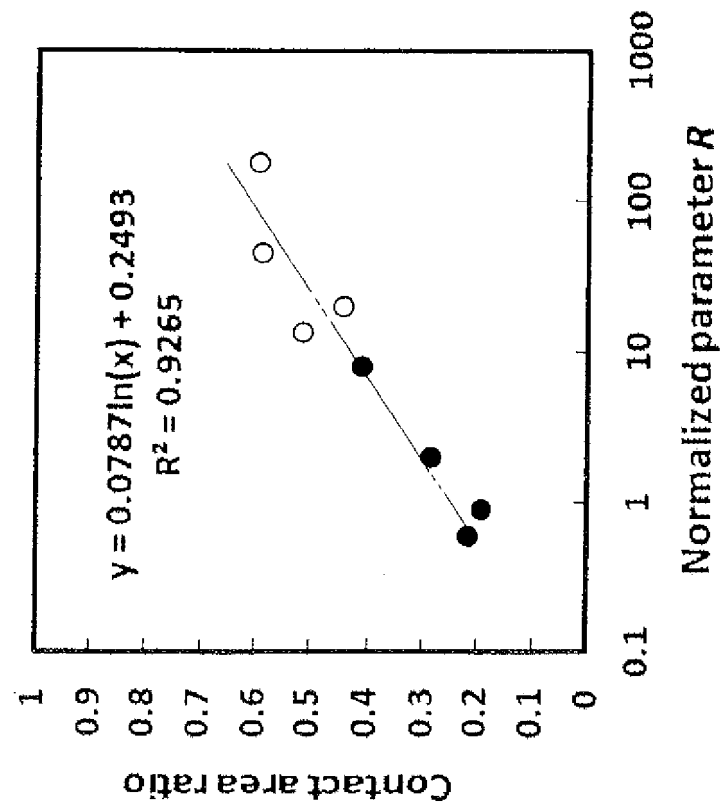


FIG. 11B

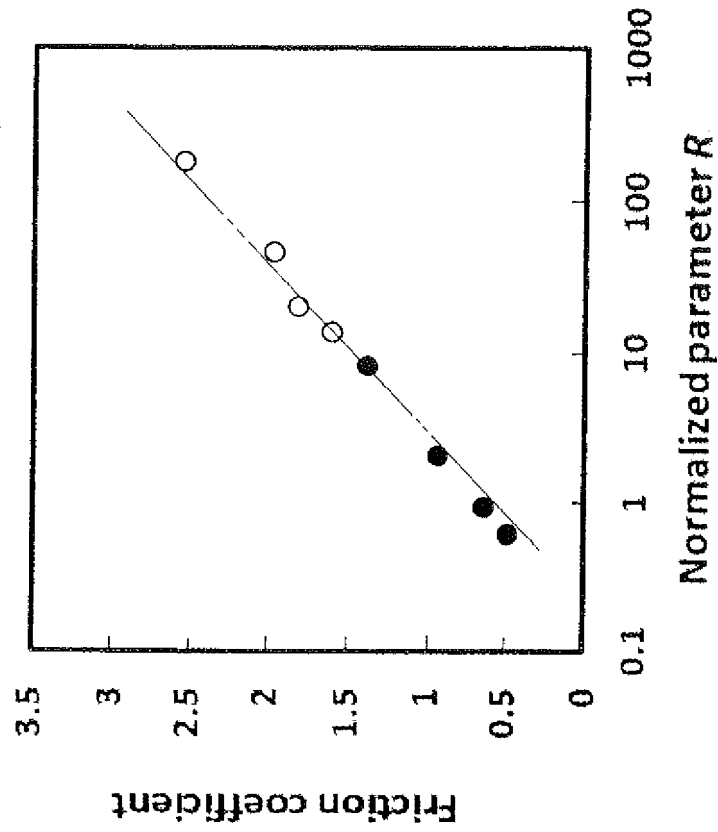


FIG. 12A

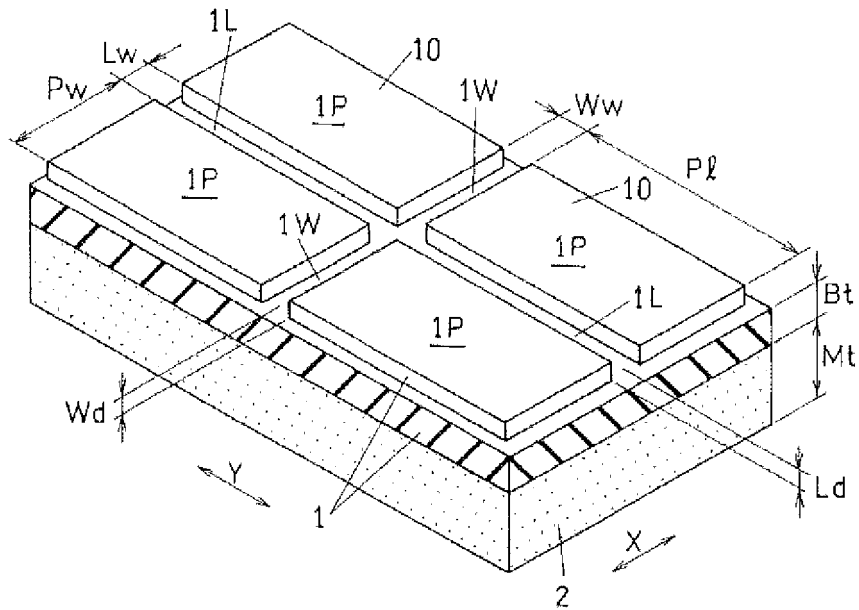


FIG. 12B

	Width of ridge						
	2	2.5	3	4	10	15	20
Depth of longitudinal 0.2~4(mm)	0.723	0.754	0.774	0.803	0.848	0.853	0.858

FIG.13

		Width of ridge mm							
		2	2.5	3	4	10	15	20	
Depth of longitudinal groove (mm)	0.2	0.647	0.698	0.735	0.799	1.000	1.079	1.139	
	0.3	0.586	0.636	0.672	0.735	0.933	1.012	1.071	
	0.4	0.542	0.591	0.627	0.689	0.885	0.964	1.023	
	0.5	0.508	0.556	0.592	0.654	0.848	0.926	0.985	
	1.000	0.400	0.447	0.482	0.541	0.732	0.809	0.868	
	1.5	0.336	0.381	0.416	0.475	0.663	0.740	0.798	
	2	0.290	0.334	0.369	0.427	0.613	0.691	0.748	
	2.5	0.253	0.298	0.332	0.389	0.574	0.652	0.710	
	3	0.223	0.267	0.301	0.358	0.543	0.620	0.678	
	4	0.175	0.218	0.252	0.309	0.492	0.570	0.627	

FIG. 14

	Length of ridge Pl (mm)						
	5.0	8.0	10.0	12.0	15.0	∞	
Width of longitudinal groove Lw (mm)	0.05	0.633	0.720	0.762	0.794	0.835	0.891
	0.1	0.628	0.714	0.755	0.787	0.829	0.884
	0.2	0.617	0.702	0.743	0.774	0.815	0.869
	0.5	0.586	0.667	0.706	0.736	0.774	0.826
	1.0	0.548	0.625	0.661	0.689	0.725	0.774
	1.5	0.503	0.574	0.607	0.633	0.666	0.712
	2.0	0.488	0.556	0.589	0.614	0.647	0.691
	2.5	0.450	0.513	0.544	0.567	0.597	0.638
	3.0	0.411	0.470	0.498	0.519	0.547	0.585

FIG.15

		Length of ridge Pl (mm)					
		5.0	8.0	10.0	12.0	15.0	300
Width of ridge Pw (mm)	3	0.560	0.637	0.673	0.701	0.737	0.785
	4	0.581	0.660	0.698	0.728	0.765	0.816
	5	0.586	0.667	0.706	0.736	0.774	0.826
	8	0.602	0.687	0.728	0.759	0.800	0.857
	9	0.599	0.686	0.727	0.758	0.800	0.857
	10	0.605	0.692	0.735	0.766	0.808	0.867
	12	0.600	0.689	0.732	0.763	0.806	0.867

FIG 18

		Width of ridge Pw(mm)							
		3	3.5	4	5	7	10	15	
	0.05	0.935	0.937	0.939	0.941	0.942	0.942	0.941	
	0.1	0.923	0.925	0.929	0.933	0.936	0.939	0.938	
	0.2	0.897	0.906	0.910	0.918	0.925	0.932	0.934	
	0.5	0.829	0.840	0.862	0.872	0.893	0.913	0.921	
	1.0	0.730	0.774	0.774	0.817	0.838	0.880	0.899	
	1.5	0.685	0.685	0.718	0.751	0.816	0.847	0.877	
	2.0	0.595	0.640	0.685	0.729	0.772	0.815	0.856	
	2.5	0.561	0.618	0.617	0.673	0.728	0.781	0.834	
	3.0	0.550	0.550	0.617	0.617	0.683	0.748	0.812	

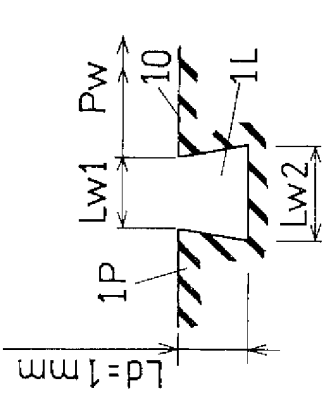
FIG.17

		Length ratio P_l/P_w							
		1	1.5	1.8	2	3	5	200	
	Width ratio P_w/L_w	1.5	0.640	0.646	0.646	0.652	0.652	0.657	0.657
		1.8	0.690	0.696	0.696	0.701	0.701	0.707	0.707
		2	0.715	0.721	0.721	0.726	0.726	0.732	0.732
		3	0.715	0.721	0.721	0.726	0.726	0.732	0.732
		4	0.770	0.776	0.776	0.781	0.781	0.787	0.787
		5	0.804	0.809	0.809	0.815	0.815	0.820	0.820
		8	0.853	0.858	0.858	0.864	0.864	0.869	0.869
		10	0.869	0.875	0.875	0.880	0.880	0.886	0.886
	100	0.928	0.934	0.934	0.939	0.939	0.944	0.944	

FIG. 18

	ex.501	ex.502	ex.503	ex.504	ex.505	ex.506	ex.507	ex.508	ex.509	ex.510
Ea(Mpa)	50	10	8	7	6	5	4	3	1.0	0.5
Em(Mpa)	5.0	5.0	3.0	2.0	-	2.0	2.0	1.0	0.5	-
Mt(mm)	20	18	16	16	0	14	10	8.0	5.0	0
Bt(mm)	0	0.5	1.0	1.5	2.0	2.0	2.0	3.0	5.0	10
Ld(mm)	3.0	2.5	2.0	1.5	1.0	0.5	1.0	2.0	3.0	5.0
Lw(mm)	1.0	1.5	2.0	0.1	0.2	0.1	0.4	2.0	2.0	3.0
Pw(mm)	4	6	4	3	5	2	8	4	8	12
Pw/Lw	4	4	2	30	25	20	20	2	4	4
Pl(mm)	∞	12	12	9	10	10	16	10	16	∞
Pl/Pw	∞	2	3	3	2	5	2	2.5	2	∞
Wd(mm)	0	2.0	2.5	1.0	1.0	1.0	1.0	2.5	3.0	0
Ww(mm)	0	1.0	1.0	0.5	0.5	1.0	4.0	2.0	2.0	0
Friction coefficient	0.792	0.558	0.459	0.732	0.746	0.738	0.796	0.431	0.527	0.837

FIG. 19A

			Lw1 (mm)				
			0.6	0.7	0.8	1	1.2
	Lw2 (mm)		0.797	0.797	0.797	-	-
	0.8		0.797	0.797	0.797	-	-
	1.2		0.747	0.747	0.747	0.747	0.747

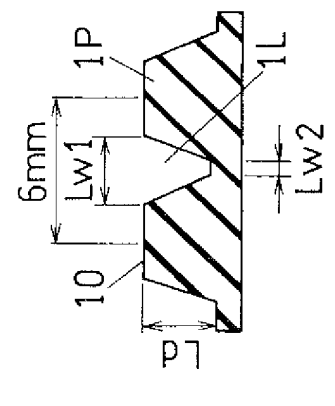
			Lw1 and Ld (mm)			
			1	1.5	2	4
	Lw2 (mm)		0.772	0.652	0.594	0.406
	0.5		0.772	0.652	0.594	0.406
	1.0		0.772	0.652	0.594	0.406

FIG. 19B

FIG.20A

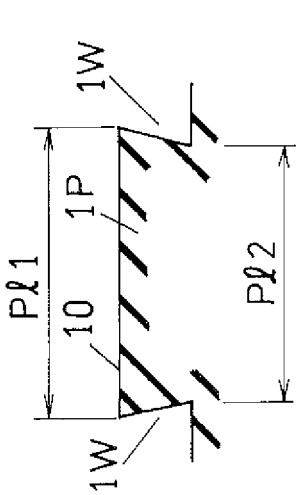
			Pℓ1 (mm)			
			10	12	15	20
	10		0.706	0.706	0.708	0.710
	15		-	-	0.774	0.777

FIG.20B

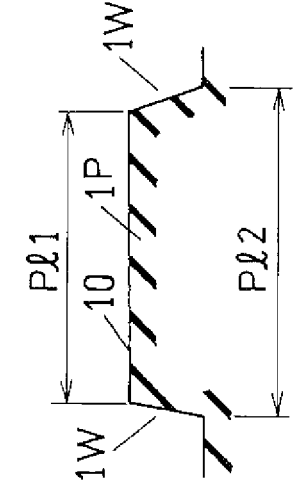
			Pℓ1 (mm)			
			10	12	14	16
	10		0.772	0.772	0.774	-
	15		0.818	0.818	0.821	0.821

FIG.21

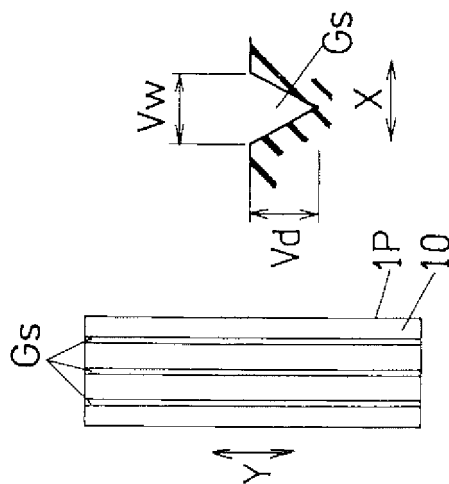
		Vw (mm)			
		0.1	0.2	0.3	0.4
	Vd (mm)	0.1	0.837	0.794	0.751
		0.2	0.837	0.794	0.751
		0.3	0.837	0.794	0.751
		0.4	0.823	0.781	0.738
					0.696

FIG.22

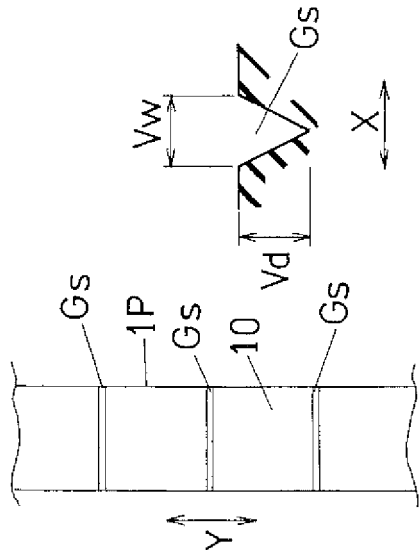
	Vd (mm)					Vw (mm)				
						0.828	0.1	0.2	0.3	0.4
						0.1	0.816	0.803	0.790	0.777
						0.2	0.722	0.711	0.700	0.688
						0.3	0.667	0.656	0.646	0.636
						0.4	0.627	0.618	0.608	0.598

FIG.24

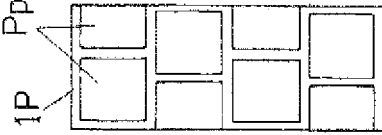
		Area of protrusion/area of ridge									
		40%	50%	60%	70%	80%	85%	90%	95%	100%	
	Height of protrusion	0	-	-	-	-	-	-	-	-	0.772
		0.05	0.290	0.362	0.434	0.506	0.577	0.613	0.649	0.684	-
		0.1	0.256	0.321	0.385	0.450	0.514	0.546	0.578	0.610	-
		0.3	0.202	0.254	0.306	0.359	0.412	0.438	0.465	0.491	-
		0.5	0.176	0.222	0.269	0.316	0.363	0.387	0.411	0.434	-

FIG. 23

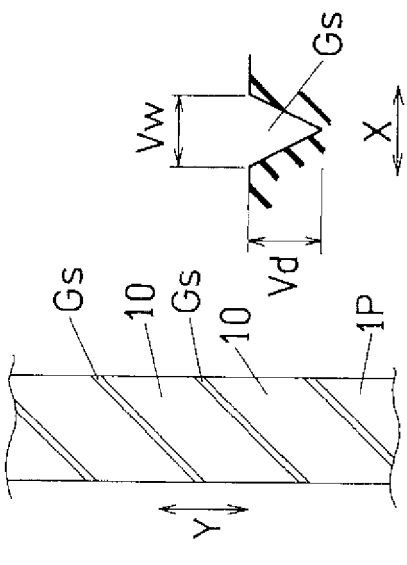
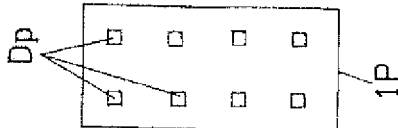
	Vd (mm)					Vw (mm)				
						0.828	0.1	0.2	0.3	0.4
						0.1	0.810	0.792	0.774	0.756
						0.2	0.717	0.702	0.686	0.670
						0.3	0.663	0.648	0.633	0.618
						0.4	0.623	0.610	0.596	0.582

FIG.25

		Tread area/area of ridge									
		40%	50%	60%	70%	80%	85%	90%	95%	100%	
		-0.1	0.335	0.410	0.485	0.558	0.630	0.666	0.701	0.737	-
	Height of small protrusion	-0.2	0.335	0.410	0.485	0.558	0.630	0.666	0.701	0.737	-
		-0.3	0.335	0.410	0.485	0.558	0.630	0.666	0.701	0.737	-
		0	-	-	-	-	-	-	-	-	0.772
		0.1	0.256	0.321	0.385	0.450	0.514	0.546	0.578	0.610	-
		0.2	0.222	0.279	0.336	0.393	0.450	0.478	0.507	0.535	-
		0.3	0.202	0.254	0.306	0.359	0.412	0.438	0.465	0.491	-

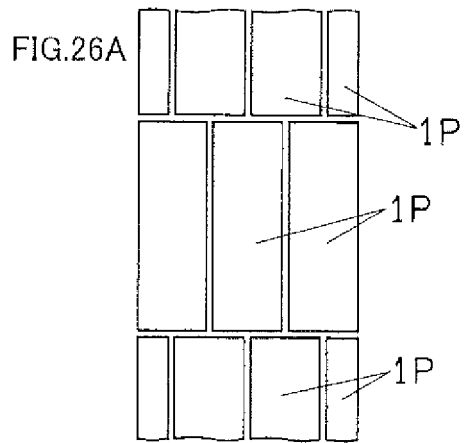


FIG.26D

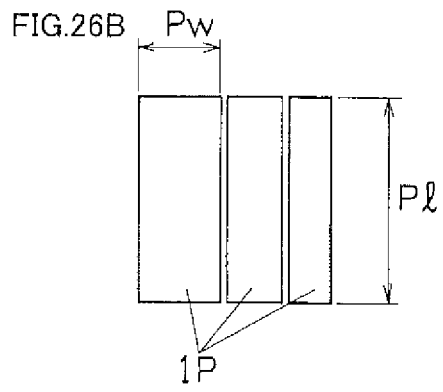
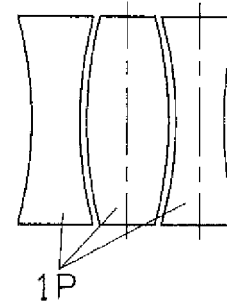


FIG.26E

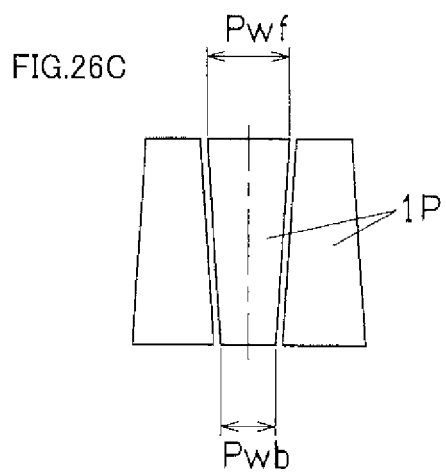
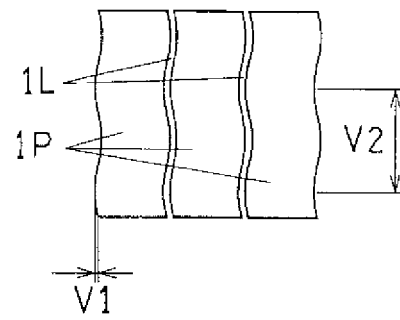
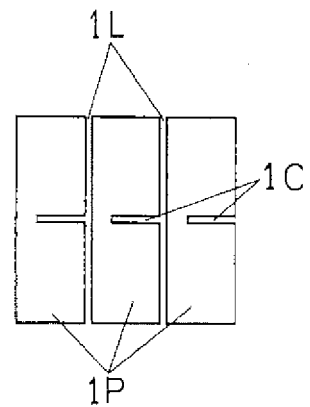


FIG.26F



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2014/062818

A. CLASSIFICATION OF SUBJECT MATTER

A43B13/14 (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)

A43B13/14

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

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2014
 Kokai Jitsuyo Shinan Koho 1971-2014 Toroku Jitsuyo Shinan Koho 1994-2014

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 A	JP 8-280406 A (Asics Corp.), 29 October 1996 (29.10.1996), paragraphs [0014], [0016], [0020]; fig. 1, 2, 5 (Family: none)	1-5, 10-12 6-9
A	JP 2012-135425 A (Bridgestone Sports Co., Ltd.), 19 July 2012 (19.07.2012), paragraphs [0017] to [0047]; fig. 1, 2 (Family: none)	1-12
A	JP 10-510744 A (Mircea Arcan), 20 October 1998 (20.10.1998), page 9, line 21 to page 10, line 9; fig. 2 & US 5509218 A & EP 798973 A & WO 1996/019128 A1 & IL 116447 A	1-12

☐ Further documents are listed in the continuation of Box C.☐ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search
24 July, 2014 (24.07.14)Date of mailing of the international search report
05 August, 2014 (05.08.14)Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.

REFERENCES CITED IN THE DESCRIPTION

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