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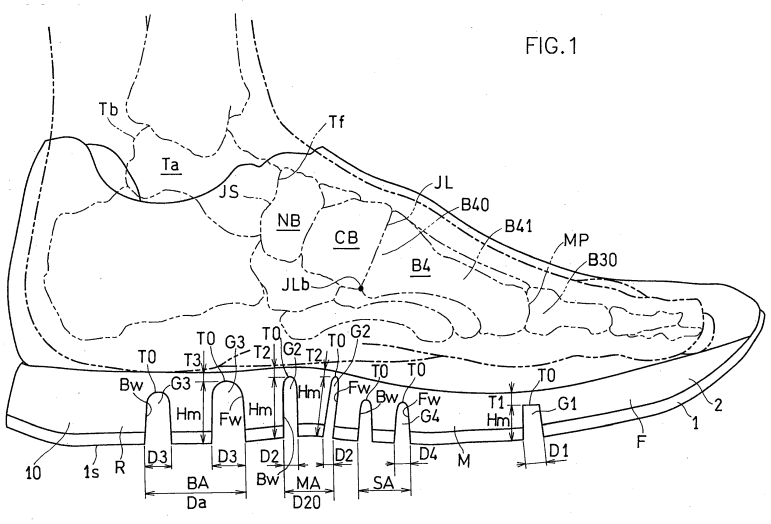
(54) SHOE SOLE DESIGNED FOR WINDLASS MECHANISM

(57) The second transverse groove, provided in an area between the Chopart's joint and the Lisfranc joint, including the navicular bone where the arch of the foot is highest, is deeper than the first transverse groove, and is equal to or deeper than the third transverse groove. Therefore, the rest of the midsole is thin and it becomes easier for the shoe sole to flex, thereby facilitating the upward displacement of the area where the arch is highest. Thus, it is possible to suppress the lowering of the arch even if an exercise is continued over a long time. On the other hand, a flexion area including at least one third transverse groove is provided directly below the talus, and has a larger width than other transverse grooves. This makes it easier for the rear foot portion directly below the talus to flex, thereby facilitating the upward displacement of the area of the arch.

FIG. 1



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Description

TECHNICAL FIELD

[0001] The present invention relates to a shoe sole focusing on the windlass mechanism.

BACKGROUND ART

[0002] Shoes with multiple or many transverse grooves extending in the transverse direction on the bottom surface of the shoe sole are well known in the art.

CITATION LIST

PATENT LITERATURE

[0003]

First Patent Document: US7,168,190 B1 (front page)
Second Patent Document: US2011-016746 A1 (front page)
Third Patent Document: US2011-232130 A1 (front page)
Fourth Patent Document: PCT/US2004/033111 (abstract)
Fifth Patent Document: JP07-289306 A (abstract)

SUMMARY OF INVENTION

[0004] However, these conventional techniques are probably not focusing on the windlass mechanism and using this mechanism.

[0005] Now, it is known that when the MP joint is hyperextended, the plantar aponeurosis is tensioned to thereby pull the calcaneal bone forward, thus increasing the arch height, and this series of actions is called the "windlass mechanism".

[0006] It is known that the arch being raised by the windlass mechanism enables an efficient transmission of the kick force when kicking off the ground while walking or running. On the other hand, lowering of the arch may lead to flatfoot and hallux valgus.

[0007] With recent shoes of which the middle foot portion is hardened with resin parts, the middle foot portion of the sole does not easily deform, and the foot movement is restricted. Thus, the deformation of the arch of the foot tends to be small. Therefore, even if the toe portion has an easy-to-flex structure, the arch portion of the sole does not flex so as to protrude upward.

[0008] On the other hand, shoes of which the sole easily deforms are also sold in recent years, but with these shoes, the arch portion of the sole is likely to drop, causing the arch of the foot to lower. Therefore, with these shoes, the arch is unlikely to rise. That is, no shoes have been developed, which likely take advantage of the windlass mechanism while running.

[0009] It is therefore an object of the present invention to provide a structure of a shoe sole with which it is possible to raise and maintain the arch height by utilizing the windlass mechanism.

[0010] A shoe sole of the present invention includes:

an outsole having a tread surface and placed at least in a fore foot portion and a rear foot portion; and
a midsole placed above the outsole and placed in the fore foot portion, a middle foot portion and the rear foot portion, wherein:

the outsole and/or the midsole define:

a first transverse groove continuously extending in a transverse direction from a medial edge so as to reach at least a longitudinal axis of a foot at a position of a metatarsal phalangeal joint and/or a base of a proximal phalanx of first to third toes;
at least one second transverse groove continuously extending in the transverse direction from the medial edge so as to reach at least the longitudinal axis, in an area between a Chopart's joint of the first toe to a posterior end of a Lisfranc joint; and
at least one third transverse groove continuously extending in the transverse direction from the medial edge so as to reach at least the longitudinal axis, in an area between an anterior end to a posterior end of a talus, wherein:

the second and third transverse grooves are provided so as to be depressed upwardly from a bottom surface of the shoe sole;
each of the grooves has a front wall surface and a rear wall surface opposing the front wall surface, which the front and rear wall surfaces define each of the grooves;
an average value of a width of a flexion area is larger than an average groove width of the first transverse groove and is larger than an average groove width of each of the at least one second transverse groove, wherein the flexion area is an area extending from a most anterior one of the front wall surfaces of the at least one third transverse groove to a most posterior one of the rear wall surfaces of the at least one third transverse groove; and
an average depth of the at least one second transverse groove is larger than an average depth of the first transverse groove and is equal to or larger than an average depth of each of the at least one third transverse groove.

[0011] According to the present invention, the presence of the second transverse groove and the third transverse groove allows for a portion of the shoe sole from

the middle foot portion to the rear foot portion to deform (flex) into an upwardly protruding shape. Therefore, when the toe is elevated facing upward and the MP joint is extended over the first transverse groove, the plantar muscles, including at least the plantar aponeurosis, are rolled up upward, thereby tensioning the plantar aponeurosis, which makes it easier for the arch of the foot to rise.

[0012] Particularly, the second transverse groove, provided in an area between the Chopart's joint and the Lisfranc joint, including the navicular bone where the arch of the foot is highest, is deeper than the first transverse groove, and is equal to or deeper than the third transverse groove. Therefore, the rest of the midsole is thin and it becomes easier for the shoe sole to flex, thereby facilitating the upward displacement of the area where the arch is highest.

[0013] That is, if no reinforcement device is provided in the middle foot portion, the midsole in the middle foot portion tends to be thick along the arch of the foot. Therefore, with the second transverse groove having a large depth, the shoe sole is easily flexed over the second transverse groove even if the midsole overall has a large average thickness.

[0014] Therefore, it is possible to suppress the lowering of the arch even if an exercise is continued over a long time.

[0015] On the other hand, a flexion area including at least one third transverse groove is provided directly below the talus, and has a larger width than other transverse grooves. This makes it easier for the rear foot portion directly below the talus to flex, thereby facilitating the upward displacement of the area of the arch.

[0016] Note that the groove width of the second transverse groove is smaller than the width of the flexion area, thereby making it possible to suppress the lowering of the arch. Moreover, the flexion area has a large width and thus easily undergoes compressive deformation, which makes it possible to absorb the impact on the heel.

[0017] The term "flexion area" as used in the present invention means that where there are a plurality of third transverse grooves, the groove ratio is 30% or more and less than 100%, wherein the groove ratio is the total value of the groove widths of the plurality of third transverse grooves with respect to the distance from the most anterior one of the front wall surfaces of the plurality of third transverse grooves, which are directly below the talus, to the most posterior one of the rear wall surfaces of the plurality of third transverse grooves. This is because a sufficient ease of flexing cannot be obtained if it is less than 30%. Note that for a similar reason, the groove ratio is preferably 40% or more, and most preferably 50% or more.

[0018] The "longitudinal axis of the foot" as used in the present invention is represented by a straight line that connects between the center of the heel and the midpoint between the center of the ball of the big toe and the center of ball of the little toe.

[0019] The term "to extend in the transverse direction" does not only mean to extend in the exact transverse direction that is perpendicular to the longitudinal axis, but also include a diagonally slant direction and a meandering shape.

[0020] The phrase "the first transverse groove extends in the transverse direction at the position of the MP joint (metatarsal phalangeal joint) or the base of the proximal phalanx of the first to third toes" means that at least a portion of the first transverse groove is provided so as to overlap with a portion of the MP joint or the base of the proximal phalanx of the first to third toes.

[0021] The term "groove width" as used in the present invention means the width of a groove at the lower end thereof where an opening is formed. Therefore, the average groove width means the average value of the width of the groove at the lower end thereof where an opening is formed. Note that the term "average groove width" means that the width of the first or second transverse groove may locally be larger than the width of the flexion area.

[0022] The groove width of each groove is preferably about 1 mm to 50 mm.

[0023] The reason for the groove width of each groove to be 1 mm or more is for allowing the shoe sole to flex into an upwardly protruding shape in the middle foot portion. Note that the groove width exceeding 50 mm will hinder the stability of the foot support.

[0024] Note that the term "average depth" means that the first or third transverse groove may locally be deeper than the second transverse groove. Where the groove has a V-letter shape or a U-letter shape, the average depth means the value obtained by averaging the largest depths along the cross section parallel to the longitudinal axis. That is, it means the average depth for the area where V-shaped or U-shaped depressions are connected together.

BRIEF DESCRIPTION OF DRAWINGS

[0025]

FIG. 1 is a schematic medial side view showing a shoe for the left foot according to Embodiment 1 of the present invention.

FIG. 2 is a schematic lateral side view showing a shoe for the right foot according to Embodiment 1 of the present invention.

FIG. 3 is a schematic bottom view showing the same.

FIG. 4 is a schematic medial side view showing the shoe with its shoe sole being flexed.

FIG. 5 is a schematic bottom view showing a shoe sole of Embodiment 2.

FIG. 6 is a schematic medial side view showing a shoe according to Embodiment 3 of the present invention.

FIG. 7 is a schematic medial side view showing a shoe according to Embodiment 4 of the present in-

vention.

FIG. 8 is a schematic medial side view showing a shoe according to Embodiment 5 of the present invention.

FIG. 9 is a schematic medial side view showing a shoe sole according to Embodiment 6 of the present invention.

FIG. 10 is a schematic bottom view showing a shoe sole of Embodiment 7.

FIG. 11 is a schematic cross-sectional view showing a shoe according to Embodiment 8 of the present invention.

FIG. 12 is a schematic cross-sectional view showing the shoe with its shoe sole being flexed.

FIG. 13 is a plan view showing the foot bone structure.

FIGS. 14A, 14B and 14C are graphs showing test results for Test Example 1, Test Example 2 and Reference Example, respectively.

DESCRIPTION OF EMBODIMENTS

[0026] Preferably, an average groove width of at least one of the third transverse groove is larger than the average groove width of the first transverse groove and is larger than the average groove width of each of the at least one second transverse groove.

[0027] In this case, the flexing capability of the rear foot portion will further improve.

[0028] More preferably, the shoe sole further includes an auxiliary transverse groove continuously extending in the transverse direction from the medial edge so as to reach at least the longitudinal axis at a position directly below a base or a shaft of a first metatarsal bone.

[0029] In this case, with the auxiliary transverse groove being placed slightly anterior to the deepest second transverse groove, the shoe sole will likely flex smoothly in conformity with the shape of the arch whose apex is at the navicular bone.

[0030] Note that the shaft refers to a portion between the base and the head, and the thickness thereof typically changes smoothly. The base refers to a portion of each bone that is close to the posterior (heel side) joint and that is slightly expanding to a greater thickness, and it is referred to also as the proximal head. On the other hand, the head refers to a portion of each bone that is close to the anterior (toe side) joint and that is slightly expanding to a greater thickness, and it is referred to also as the distal head.

[0031] More preferably, an average depth of the auxiliary transverse groove is smaller than the average depth of the second transverse groove, and an average groove width of the auxiliary transverse groove is smaller than the average groove width of at least one of the third transverse groove.

[0032] The auxiliary transverse groove having a small depth and a small width will further smoothen the flexion of the shoe sole in conformity with the shape of the arch whose apex is at the navicular bone, and will not assist in lowering the arch of the foot.

[0033] Preferably, the first transverse groove is depressed upwardly from the tread surface.

[0034] This makes it easier for the MP joint to be extended over the first transverse groove.

[0035] In this case, more preferably, each of the grooves is defined by the front wall surface, the rear wall surface and a ceiling above;

a thickness from an upper surface of the midsole to the ceiling of the first transverse groove is set to be 0.5 mm or more and 10 mm or less and less than 12 mm at a thinnest portion;

a thickness from the upper surface of the midsole to the ceiling of the second transverse groove is set to be 0.5 mm or more and 10 mm or less at a thinnest portion; and

a thickness from the upper surface of the midsole to the ceiling of the third transverse groove is set to be 0.5 mm or more and 10 mm or less at a thinnest portion.

[0036] In this case, the midsole flexes at the thinnest portion. Therefore, if the thickness of the first transverse groove to the ceiling is over 12 mm at the thinnest portion or if the thickness of the second and third transverse grooves to the ceiling is over 10 mm at the thinnest portion, the midsole will not easily flex.

[0037] If the thinnest portion is less than 0.5 mm, it will be difficult to manufacture the midsole.

[0038] Preferably, a maximum depth of the second and third transverse grooves is 5 mm or more and 40 mm or less;

the maximum depth of each of the at least one second transverse groove is larger than a thickness of a portion of the midsole that is directly above an area where the second transverse groove having that maximum depth is provided; and

the maximum depth of each of the at least one third transverse groove is larger than a thickness of a portion of the midsole that is directly above an area where the third transverse groove having that maximum depth is provided.

[0039] In this case, as the second and third transverse grooves are deep, a thin portion is formed in the middle foot portion of the midsole, thereby allowing for the shoe sole to flex in the middle foot portion.

[0040] Preferably, the average depths of the second and third transverse grooves are 5 mm or more and 40 mm or less;

the average depth of at least one, preferably two or more, of the second transverse groove is larger than an average thickness of a portion of the midsole that is directly above an area where the at least one second transverse groove is provided; and

the average depth of at least one of the third transverse groove is larger than an average thickness of a portion of the midsole that is directly above an area where the at least one third transverse groove is provided.

[0041] In this case, as the second and third transverse grooves are deep and the midsole is thin, it is even easier

for the shoe sole to flex in the middle foot portion.

[0042] Note that if the maximum depth or the average depth is less than 5 mm, the shoe sole will not easily flex. On the other hand, if these values are over 40 mm, the shoe sole will be too thick.

[0043] Preferably, the second transverse groove continuously extends across the shoe sole from the medial edge to a lateral edge of the foot; and
the second transverse groove has a larger average depth on a medial side of the foot than an average depth thereof on a lateral side of the foot.

[0044] The arch of the foot is higher on the medial side than on the lateral side. Therefore, as the average depth of the second transverse groove is larger on the medial side than on the lateral side, the shoe sole can easily flex following the rise of the arch of the foot.

[0045] Preferably, the third transverse groove continuously extends across the shoe sole from the medial edge to a lateral edge of the foot; and
the third transverse groove has a larger average depth on a medial side of the foot than an average depth thereof on a lateral side of the foot.

[0046] The arch of the foot is higher on the medial side than on the lateral side. Therefore, as the average depth of the third transverse groove is larger on the medial side than on the lateral side, the shoe sole can easily flex following the rise of the arch of the foot.

[0047] Preferably, there are a plurality of second transverse grooves, and the average depth of at least two second transverse grooves is larger than the average depth of the first transverse groove and is equal to or larger than the average depth of each of the at least one third transverse groove.

[0048] In this case, the middle foot portion can easily flex smoothly.

[0049] Preferably, there are a plurality of third transverse grooves, and an average groove width of at least two of the third transverse grooves is larger than the average groove width of the first transverse groove and is larger than the average groove width of each of the at least one second transverse groove.

[0050] In this case, the posterior end of the middle foot portion can easily flex smoothly in conformity with the posterior portion of the arch of the foot.

[0051] Preferably, the shoe sole is further provided with a longitudinal groove extending from the first transverse groove to the third transverse groove; and
the shoe sole further comprises a band portion placed in the longitudinal groove, the band portion extending from the fore foot portion, which is anterior to the first transverse groove, to the rear foot portion, which is posterior to the third transverse groove, the band portion being secured to the shoe sole in the fore foot portion and in the rear foot portion, and the band portion being formed by a material that is less stretchable than the midsole and the outsole.

[0052] In this case, when the toes are elevated, a similar load to that on the plantar aponeurosis is applied on the band portion, and then the shoe sole flexes because the band is less stretchable. Thus, the arch is likely to rise when the toes are elevated.

[0053] More preferably, an abrasion-resistant material, which is less susceptible to abrasion than the band portion, is attached to a lower surface of the band portion, and the band portion and the abrasion-resistant material together form the band.

[0054] In this case, the band can be placed close to the tread surface.

[0055] More preferably, a bottom surface of the band is placed above the tread surface.

[0056] Where there are projecting objects such as stones on the road surface, as the band lands on such a projecting object, a flexing force may inadvertently be applied to the shoe sole. As the bottom surface of the band is afloat, it is possible to suppress such an inadvertent flexion.

EMBODIMENTS

[0057] 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.

[0058] Embodiments of the present invention will now be described with reference to the drawings.

[0059] FIGS. 1 to 4 show Embodiment 1. Note that in order to facilitate the description of the invention, FIG. 1 shows the medial side of a shoe for the left foot whereas FIG. 2 shows a lateral side view of a shoe for the right foot.

[0060] As shown in FIGS. 1 and 2, a shoe sole includes an outsole **1,** and a midsole **2.** In various figures, minute grooves (so-called a design) formed on a tread surface **1S** of the outsole 1 are omitted.

[0061] In the present embodiment, the outsole **1** and the midsole **2** are placed across the fore foot portion **F,** the middle foot portion **M** and the rear foot portion **R.** The outsole **1** is formed by a foamed or non-foamed rubber, for example, and has the tread surface **1s** which has a higher abrasion resistance than the midsole **2** and which is to be in contact with the road surface.

[0062] The midsole **2** is formed by a foamed resin such as EVA, for example, and is placed on the outsole 1, as shown in FIG. 2, for reducing the impact of landing. Therefore, the midsole **2** is formed thicker than the outsole 1.

[0063] The hardness of the midsole **2** is preferably 45 to 75 degrees and more preferably 50 to 70 degrees in JIS C hardness, for example.

[0064] In the present embodiment, a first transverse groove **G1,** second transverse grooves **G2,** third trans-

verse grooves **G3,** and auxiliary transverse grooves **G4** are formed both in the outsole **1** and in the midsole **2.** As shown in FIG. 3, each of the transverse grooves **G1** to **G4** extends from a medial edge **10** to a lateral edge **11** in a direction perpendicular to the longitudinal axis **A1** or in a slant direction crossing the longitudinal axis **A1.**

[0065] Note that as is clearly shown in FIG. **13,** the longitudinal axis **A1** is placed along a straight line that connects between the midpoint **03** (between the ball **O1** of the big toe and the ball **05** of the little toe) and the center **04** of the heel.

[0066] In FIG. 1, the first transverse groove **G1** continuously extends in the transverse direction **X** from the medial edge **10** to the lateral edge 11 (FIG. 3) at the position of the metatarsal phalangeal joint **MP** and/or the base **B30** of the proximal phalanx **B3** of the first to third toes. The first transverse groove **G1** makes it easier for the metatarsal phalangeal joint **MP** to flex.

[0067] The second transverse grooves **G2** continuously extend in the transverse direction **X** from the medial edge **10** to the lateral edge 11 (FIG. 3), in an area between the Chopart's joint **JS** of the first toe and the posterior end **JLb** of the Lisfranc joint **JL.** In the present embodiment, there are two (a plurality of) second transverse grooves **G2,** and the two second transverse grooves **G2** work in cooperation with each other, thereby forming the middle foot flexion area **MA.**

[0068] Note that **NB** denotes the navicular bone, and **CB** denotes the medial cuneiform bone.

[0069] The third transverse grooves **G3** continuously extend in the transverse direction **X** from the medial edge **10** to the lateral edge 11 (FIG. 3), in an area between the anterior end **Tf** and the posterior end **Tb** of the talus **Ta.** In the present embodiment, there are two (a plurality of) third transverse grooves **G3,** and the two third transverse grooves **G3** work in cooperation with each other, thereby forming the rear foot flexion area **BA.**

[0070] The auxiliary transverse grooves **G4** continuously extend in the transverse direction **X** from the medial edge 10 to the lateral edge 11 (FIG. 3) at a position directly below the base **B40** or the shaft **B41** of the first metatarsal bone **B4.**

[0071] In the present embodiment, there are two (a plurality of) auxiliary transverse grooves **G4,** and the two auxiliary transverse grooves **G4** work in cooperation with each other, thereby forming an auxiliary flexion area **SA.**

[0072] The first to fourth transverse grooves **G1** to **G4** are provided so as to be depressed upwardly from the bottom surface of the shoe sole, i.e., the tread surface 1s in the present embodiment. Note that the first transverse groove **G1** may be formed so as to be depressed downwardly from the upper surface of the midsole **2.**

[0073] Each of the grooves **G1** to **G4** includes a front wall surface **Fw,** a rear wall surface **Bw** opposing the front wall surface **Fw,** and a ceiling **T0,** which define the groove **G1** to **G4.**

[0074] In the present embodiment, the middle foot flexion area **MA** is defined as an area extending from the most anterior one of the front wall surfaces **Fw** of the plurality of second transverse grooves **G2** to the most posterior one of the rear wall surfaces **Bw** of the plurality of second transverse grooves **G2.** The average value of the width **D20** of the middle foot flexion area **MA** is larger than the average groove width **D1** of the first transverse groove **G1.**

[0075] Note that the average value of the width **D20** of the middle foot flexion area **MA** may be less than or equal to the average distance from the anterior end **Tf** to the posterior end **Tb** of the talus **Ta.**

[0076] The rear foot flexion area **BA** is defined as an area extending from the most anterior one of the front wall surfaces **Fw** of the plurality of third transverse grooves **G3** to the most posterior one of the rear wall surfaces **Bw** of the plurality of third transverse grooves **G3.** The average value of the width **Da** of the rear foot flexion area **BA** is larger than the average groove width **D 1** of the first transverse groove **G1,** and is larger than the average groove width **D20** of the middle foot flexion area **MA.**

[0077] In the present embodiment, the average groove width **D3** of each of the third transverse grooves **G3** is larger than the average groove width **D1** of the first transverse groove **G1,** and is larger than the average groove width **D2** of each of the second transverse grooves **G2.**

[0078] In order to expect that windlass will raise the foot arch, the soles **1** and **2** need to flex and deform so as to protrude upward in the middle foot portion **M.** Then, the groove widths of the second to fourth transverse grooves **G2** to **G4** may possibly decrease. There are also manufacturing-related problems. Therefore, the average groove width of each of the first to fourth transverse grooves **G1** to

[0079] **G4** would need to be at least about 1 mm.

[0080] On the other hand, the maximum value of the average groove width of each of the first to fourth transverse grooves **G1** to **G4** would be 50 mm. If the value exceeds 50 mm, the sole itself, which supports the sole of the foot, drops down, thereby leading to lowering of the arch.

[0081] In view of the above, the range of the average groove width for each of the first to fourth transverse grooves **G1** to **G4** is preferably 2 mm to 40 mm and most preferably about 3 mm to 30 mm.

[0082] As can be seen from a comparison between FIG. 1 and FIG. 2, the second to fourth transverse grooves **G2** to **G4** become shallower from the medial edge 10 toward the lateral edge 11.

[0083] Therefore, the second transverse groove **G2** has a larger average depth on the medial side of the foot than that on the lateral side of the foot. Similarly, the third transverse groove **G3** has a larger average depth on the medial side of the foot than that on the lateral side of the foot. Similarly, the fourth transverse groove **G4** has a larger average depth on the medial side of the foot than that on the lateral side of the foot.

[0084] In FIG. 2, the average depth **H2** of each of the

second transverse grooves **G2** is larger than the average depth **H1** of the first transverse groove **G1,** and is equal to or larger than the average depth H3 of each of the third transverse grooves **G3.**

[0085] On the other hand, the average depth **H4** of the auxiliary transverse groove **G4** is smaller than the average depth **H2** of the second transverse groove **G2,** and the average groove width **D4** of the auxiliary transverse groove **G4** is smaller than the average groove width **D3** of the third transverse groove **G3.**

[0086] The average depths **H2** and **H3** of the second and third transverse grooves **G2** and **G3** are set to be about 5 mm to 40 mm. If the average depths **H2** and **H3** are smaller than 5 mm, the effect of this mechanism cannot be so expected, whereas if they are larger than 40 mm, the sole will be too thick. In view of this, the above value is preferably 7 mm to 35 mm, and most preferably 10 mm to 30 mm.

[0087] The average depth **H2** of at least one of the second transverse grooves **G2** is larger than the average thickness **T2a** of a portion of the midsole **2** that is directly above an area where the transverse groove is provided. On the other hand, the average depth **H3** of at least one of the third transverse grooves **G3** is larger than the average thickness **T3a** of a portion of the midsole **2** that is directly above an area where the transverse groove is provided.

[0088] For similar reasons to those for the average depth, the maximum depth **Hm** of the second and third transverse grooves **G2** and **G3** of FIG. 1 is preferably about 5 mm to 40 mm, more preferably about 7 mm to 35 mm, and most preferably about 10 mm to 30 mm.

[0089] The average depth **H2** of each of the two second transverse grooves **G2** is larger than the average depth **H1** of the first transverse groove **G1,** and is equal to or larger than the average depth H3 of each of the third transverse grooves **G3.**

[0090] In FIG. 1, the maximum depth **Hm** of each of the second transverse grooves **G2** is larger than the thickness of a portion of the midsole **2** that is directly above an area where the transverse groove having that maximum depth is provided. On the other hand, the maximum depth **Hm** of each of the third transverse grooves **G3** is larger than the thickness of a portion of the midsole **2** that is directly above an area where the transverse groove having that maximum depth is provided.

[0091] As shown in FIG. 1, the thickness **T1** from the upper surface of the midsole **2** to the ceiling **T0** of the first transverse groove **G1** is set to be 0.5 mm or more and less than 12 mm at the thinnest portion.

[0092] On the other hand, the thickness **T2** from the upper surface of the midsole **2** to the ceiling T0 of the second transverse groove **G2** is set to be 0.5 mm or more and 10 mm or less at the thinnest portion.

[0093] The thickness **T3** from the upper surface of the midsole 2 to the ceiling **T0** of the third transverse groove **G3** is set to be 0.5 mm or more and 10 mm or less at the thinnest portion.

[0094] The average groove width **D3** of each of the two third transverse grooves **G3** is larger than the average groove width **D1** of the first transverse groove **G1** and is larger than the average groove width **D2** of each of the second transverse grooves **G2.**

[0095] Next, the deformation of the shoe in the present embodiment will be described briefly.

[0096] When the fore foot portion **F** of FIG. 1 faces up as indicated by a solid line with respect to a virtual line of FIG. 4, and the MP joint **MP** is extended over the first transverse groove **G1,** the plantar aponeurosis is rolled up upward, thereby tensioning the plantar aponeurosis, which urges the arch of the foot to rise. During this movement, the lower portion of the sole shrinks in the longitudinal direction **Y** over the area of the second to fourth transverse grooves **G2** to **G4,** and the outsole **1** and the midsole **2** deform into an upwardly protruding shape. Thus, the arch of the foot is likely to be raised during this movement.

[0097] Next, other examples of the present invention will be described.

[0098] In other examples to be described below, like elements to those of Embodiment 1 will be denoted by like reference numerals, and only those structures that are different from Embodiment 1 will be described.

[0099] As shown in Embodiment 2 of FIG. 5, some or all of the second to fourth transverse grooves **G2** to **G4** may be set to a length such that they extend from the medial edge 10 toward the lateral edge 11 past the longitudinal axis A1 but do not reach the lateral edge 11. The arch of the foot is high on the medial side, and the effect of the windlass mechanism can be therefore expected as long as the medial side portion of the sole can flex sufficiently.

[0100] Preferably, the transverse grooves **G1** to **G4** can extend over about 2/3 the total width from the medial edge **10** to the lateral edge 11 in the area where the transverse grooves **G1** to **G4** are provided.

[0101] Note that as opposed to the example shown in FIG. 5, the second and third transverse grooves **G2** and **G3** may be provided across the total width, whereas the first and fourth transverse grooves **G1** and **G4** are provided so as to extend from the medial edge **10** past the longitudinal axis **A1** and into a part of the lateral side portion.

[0102] As with the first transverse groove **G1** shown in FIG. 5, the transverse grooves **G1** to **G4** do not need to be extending in a direction perpendicular to the longitudinal axis **A1,** but may be extending in a slant direction crossing the longitudinal axis **A1.**

[0103] In Embodiment 3 of FIG. 6, there may be a single, i.e., only one, second transverse groove **G2** that is deeper than the third transverse groove **G3.** In this example, the depth of a second transverse groove **G2** that is immediately anterior to the posterior second transverse groove **G2** is smaller than the depth of one of the third transverse grooves **G3.**

[0104] Where there is one second transverse groove

G2 that is deeper than the third transverse groove **G3,** as in this example, at least the ceiling **T0** of the second transverse groove **G2** is preferably placed directly below the navicular bone **NB.** This is because the navicular bone **NB** is located at the apex of the arch of the foot.

[0105] In Embodiment 4 of FIG. 7, there is only one each of the first transverse groove **G1,** the second transverse groove **G2** and the third transverse groove **G3.** In this case, the width **Da** of the third transverse groove **G3** is generally equal to the rear foot flexion area BA.

[0106] As shown in Embodiments 5 and 6 of FIGS. **8** and **9,** the width **D2** of the second transverse groove **G2** may be larger than the width **D3** of any of all the third transverse grooves **G3.** In the various examples, the cross-sectional shape of the transverse grooves **G1** to **G4** may be an inverted U-letter shape, an inverted V-letter shape, a trapezoidal shape, or the like.

[0107] FIGS. **10** to **12** show Embodiment 7.

[0108] In this example, the shoe sole is further provided with a longitudinal groove **GL** extending from the first transverse groove **G1** to the third transverse groove **G3** of FIG. 10. A part of a band 3 is accommodated and placed in the longitudinal groove **GL.**

[0109] The band 3 of FIG. 11 includes a band portion **30** and an abrasion-resistant material 31 layered together. The abrasion-resistant material 31 is formed by a rubber, for example, and is more resistant to abrasion than the band portion 30. On the other hand, the band portion 30 is formed by a non-stretchable tape material. Thus, the band 3 is a band-shaped member that does not substantially stretch even when pulled, but can flex and slack.

[0110] The band 3 extends from the fore foot portion **F,** which is anterior to the first transverse groove **G1,** to the rear foot portion **R,** which is posterior to the third transverse groove **G3,** and is secured to the shoe sole in the fore foot portion F and in the rear foot portion **R.**

[0111] As shown in FIG. 11, the bottom surface of the band 3 is placed above the tread surface 1s. In the fore foot portion F and the rear foot portion **R,** the band **3** is sandwiched between the outsole 1 and the midsole **2,** with the lower surface of the band 3 being afloat.

[0112] As shown in FIG. 12, the band 3 is tensioned when the toe is elevated or flexed, thereby facilitating the flexion of the middle foot portion **M** such as to raise the arch of the sole as indicated by the solid line.

[0113] Next, Text Examples (Sample 1 and Sample 2) and Reference Example (Ref.) will be illustrated in order to elucidate the effects of the present invention.

[0114] First, Sample 1 having a structure specified in FIGS. 1 to 4, and Sample 2 having a structure specified in FIGS. **10** to **12** were produced as samples. On the other hand, an ordinary school shoe with no deep transverse grooves was provided as a reference example.

[0115] Using one male as the subject, angles of deformation of the sole and the foot portion while running (3.5 min/km) were measured for a plurality of iterations, and the average values were calculated.

[0116] The angle θ along the vertical axis of FIG. **14A** represents the angle of elevation of the first toe. The angle **As** along the vertical axis of **FIG. 14B** represents the angle of flexion of the sole about the middle foot portion. The angle **Af** along the vertical axis of FIG. **14C** represents the angle of flexion of the vertical arch of the foot.

[0117] Note that the horizontal axis in FIGS. **14A** to **14C** represents the percentage of the length of time from landing until kick-off.

[0118] As can be seen from FIG. **14A,** the angle θ, i.e., the angle of elevation of the first toe, over the period of heel contact, heel rise and toe off is larger for Sample 1 and Sample 2 than for Reference Example.

[0119] As can be seen from FIG. **14B,** the angle As, i.e., the angle of flexion of the sole about middle foot portion, over the period of heel contact, heel rise and toe off is larger for Sample 1 and Sample 2 than for Reference Example. Particularly, it can be seen that Sample 2, which is provided with the band, has an even larger value of the angle As than Sample 1.

[0120] As can be seen from FIG. **14C,** the angle **Af,** i.e., the angle of flexion of the vertical arch of the foot, at heel contact is smaller for Sample 1 and Sample 2 than for Reference Example. However, the angle **Af** is larger for Sample 1 and Sample 2 than for Reference Example over the period of heel rise and toe off. Particularly, it can be seen that Sample 2, which is provided with the band 3, has an even larger value of the angle **Af** than Sample 1.

[0121] Thus, it can be expected that shoes of Samples 1 and 2 will realize the effect of the windlass mechanism, and wearing shoes of Samples 1 and 2 will increase or maintain the arch height of the foot.

[0122] While preferred embodiments have been described above with reference to the drawings, various obvious changes and modifications will readily occur to those skilled in the art upon reading the present specification.

[0123] For example, the first transverse groove may be provided only in one of the outsole and the midsole.

[0124] The band itself may be formed by an abrasion-resistant material such as an aramid fiber. Where the band is provided, the second transverse groove G2 and the third transverse groove G3 may be of the same depth or width.

[0125] Thus, such changes and modifications are deemed to fall within the scope of the present invention, which is defined by the appended claims.

INDUSTRIAL APPLICABILITY

[0126] The present invention is applicable to a shoe sole of a shoe for walking, running, training, etc.

REFERENCE SIGNS LIST

[0127]

1: Outsole, 1s: Tread surface
2: Midsole

3: Band, 30: Band portion, 31: Abrasion-resistant material
10: Medial edge, 11: Lateral edge
A1: Longitudinal axis
B3: Proximal phalanx, B30: Base
B4: First metatarsal bone, B40: Base, B41: Shaft
BA: Rear foot flexion area, MA: Middle foot flexion area, SA: Auxiliary flexion area
D1, D2, D3, D4: Average groove width, Da, D20: Width
Bw: Rear wall surface, Fw: Front wall surface, T0: Ceiling
F: Fore foot portion, M: Middle foot portion, R: Rear foot portion
G1: First transverse groove, G2: Second transverse groove, G3: Third transverse groove, G4: Auxiliary transverse groove, GL: Longitudinal groove
H1, H2, H3, H4: Average depth, Hm: Maximum depth
JS: The Chopart's joint, JL: LISFRANC joint, JLb: Posterior end
NB: Navicular bone, CB: Medial cuneiform bone
MP: Metatarsal phalangeal joint
Ta: Talus, Tb: Posterior end, Tf Anterior end
T1, T2, T3: Thickness
T2a, T3a: Average thickness
X: Transverse direction, Y: Longitudinal direction

Claims

1. A shoe sole comprising:

an outsole 1 having a tread surface 1s and placed at least in a fore foot portion F and a rear foot portion R; and
a midsole 2 placed above the outsole 1 and placed in the fore foot portion F, a middle foot portion M and the rear foot portion R, wherein:

the outsole 1 and/or the midsole 2 define:

a first transverse groove G1 continuously extending in a transverse direction X from a medial edge 10 so as to reach at least a longitudinal axis A1 of a foot at a position of a metatarsal phalangeal joint MP and/or a base B30 of a proximal phalanx B3 of first to third toes;
at least one second transverse groove G2 continuously extending in the transverse direction X from the medial edge 10 so as to reach at least the longitudinal axis A1, in an area between a Chopart's joint JS of the first toe to a posterior end Sb of a Lisfranc joint JL; and
at least one third transverse groove G3 continuously extending in the transverse direction X from the medial edge 10 so as to reach at least the longitudinal axis A1, in an area between an anterior end Tf to a posterior end Tb of a talus Ta, wherein:

the second and third transverse grooves G3 are provided so as to be depressed upwardly from a bottom surface 1s, 2s of the shoe sole;
each of the grooves G1 to G3 has a front wall surface Fw and a rear wall surface Bw opposing the front wall surface Fw, the front and rear wall surfaces defining each of the grooves;
an average value of a width Da of a flexion area BA is larger than an average groove width D1 of the first transverse groove G1 and is larger than an average groove width D2 of each of the at least one second transverse groove G2, wherein the flexion area BA is an area extending from a most anterior one of the front wall surfaces Fw of the at least one third transverse groove G3 to a most posterior one of the rear wall surfaces Bw of the at least one third transverse groove **G3;** and
an average depth **H2** of the at least one second transverse groove **G2** is larger than an average depth **H1** of the first transverse groove **G1** and is equal to or larger than an average depth **H3** of each of the at least one third transverse groove **G3.**

2. The shoe sole according to claim 1, wherein an average groove width **D3** of at least one of the third transverse groove **G3** is larger than the average groove width **D1** of the first transverse groove **G1** and is larger than the average groove width **D2** of each of the at least one second transverse groove **G2.**

3. The shoe sole according to claim 2, further comprising an auxiliary transverse groove **G4** continuously extending in the transverse direction **X** from the medial edge **10** so as to reach at least the longitudinal axis **A1** at a position directly below a base **B40** or a shaft **B41** of a first metatarsal bone **B4.**

4. The shoe sole according to claim 3, wherein an average depth **H4** of the auxiliary transverse groove **G4** is smaller than the average depth **H2** of the second transverse groove **G2,** and an average groove

width of the auxiliary transverse groove **G4** is smaller than the average groove width **D3** of at least one of the third transverse groove **G3.**

5. The shoe sole according to claim 1, wherein the first transverse groove **G1** is depressed upwardly from the tread surface 1s.

6. The shoe sole according to claim 5, wherein:

each of the grooves **G1** to **G3** is defined by a front wall surface **Fw,** a rear wall surface **Bw** and a ceiling **T0** above;
a thickness **T1** from an upper surface of the midsole **2** to the ceiling **T0** of the first transverse groove **G1** is set to be 0.5 mm or more and less than 12 mm at a thinnest portion;
a thickness **T2** from the upper surface of the midsole **2** to the ceiling **T0** of the second transverse groove **G2** is set to be 0.5 mm or more and 10 mm or less at a thinnest portion; and
a thickness **T3** from the upper surface of the midsole **2** to the ceiling **T0** of the third transverse groove **G3** is set to be 0.5 mm or more and 10 mm or less at a thinnest portion.

7. The shoe sole according to claim 1, wherein:

a maximum depth **Hm** of the second and third transverse grooves **G2** and **G3** is 5 mm or more and 40 mm or less;
the maximum depth **Hm** of each of the at least one second transverse groove **G2** is larger than a thickness of a portion of the midsole **2** that is directly above an area where the second transverse groove having that maximum depth is provided; and
the maximum depth **Hm** of each of the at least one third transverse groove **G3** is larger than a thickness of a portion of the midsole 2 that is directly above an area where the third transverse groove having that maximum depth is provided.

8. The shoe sole according to claim 1, wherein:

the average depths **H2** and **H3** of the second and third transverse grooves **G2** and **G3** are 5 mm or more and 40 mm or less;
the average depth **H2** of at least one of the second transverse groove **G2** is larger than an average thickness **T2a** of a portion of the midsole **2** that is directly above an area where the at least one second transverse groove is provided; and
the average depth **H3** of at least one of the third transverse groove **G3** is larger than an average thickness **T3a** of a portion of the midsole **2** that is directly above an area where the at least one third transverse groove is provided.

9. The shoe sole according to claim 1, wherein:

the second transverse groove **G2** continuously extends across the shoe sole from the medial edge **10** to a lateral edge 11 of the foot; and
the second transverse groove **G2** has a larger average depth on a medial side of the foot than an average depth of the second transverse groove on a lateral side of the foot.

10. The shoe sole according to claim 1, wherein:

the third transverse groove **G3** continuously extends across the shoe sole from the medial edge **10** to a lateral edge 11 of the foot; and
the third transverse groove **G3** has a larger average depth on a medial side of the foot than an average depth of the third transverse groove on a lateral side of the foot.

11. The shoe sole according to claim 1, wherein the at least one second groove **G2** comprises a plurality of second transverse grooves **G2,** and the average depth **H2** of at least two second transverse grooves **G2** is larger than the average depth **H1** of the first transverse groove **G1** and is equal to or larger than the average depth **H3** of each of the at least one third transverse groove **G3.**

12. The shoe sole according to claim 2, wherein the at least one third transverse groove **G3** comprises a plurality of third transverse grooves **G3,** and an average groove width of at least two of the third transverse grooves **G3** is larger than the average groove width **D1** of the first transverse groove **G1** and is larger than the average groove width **D2** of each of the at least one second transverse groove **G2.**

13. The shoe sole according to claim 1, wherein:

the shoe sole is further provided with a longitudinal groove **GL** extending from the first transverse groove **G1** to the third transverse groove **G3;** and
the shoe sole further comprises a band portion **30** placed in the longitudinal groove **GL,** the band portion **30** extending from the fore foot portion **F,** which is anterior to the first transverse groove **G1,** to the rear foot portion **R,** which is posterior to the third transverse groove **G3,** the band portion **30** being secured to the shoe sole in the fore foot portion **F** and in the rear foot portion **R,** and the band portion **30** being formed by a material that is less stretchable than the midsole **2** and the outsole **1.**

14. The shoe sole according to claim 13, wherein an abrasion-resistant material 31, which is less susceptible to abrasion than the band portion **30,** is attached to a lower surface of the band portion 30, and the band portion **30** and the abrasion-resistant material 31 together form a band **3.**

15. The shoe sole according to claim 14, wherein a bottom surface of the band **3** is placed above the tread surface **1s.**

FIG. 1

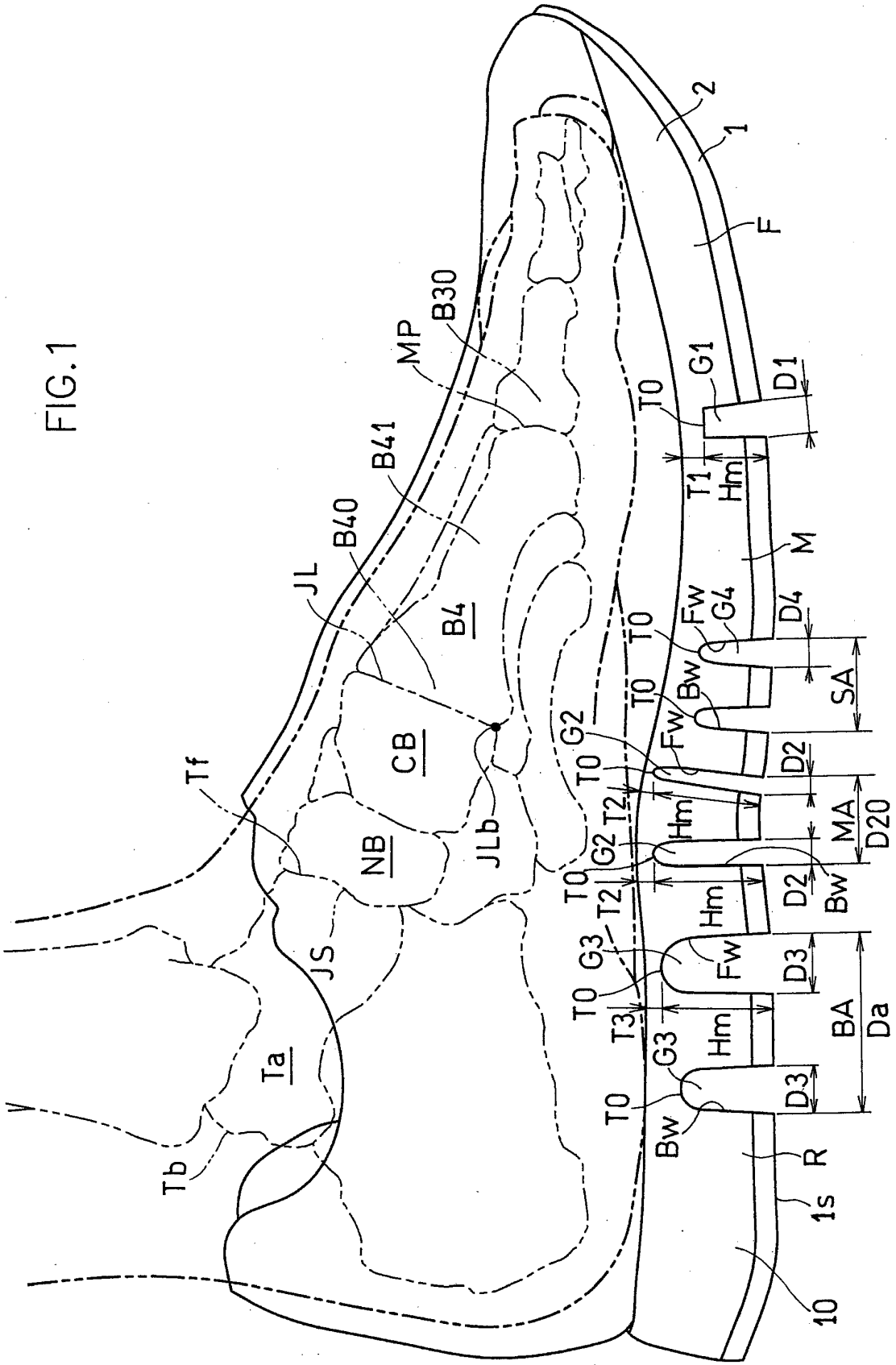

Tf
Tb
Ta
JS
NB
CB
JLb
JL
B40
B41
B4
MP
B30
F
2
1
G1
D1
T0
T1
Hm
M
Fw
G4
D4
Bw
SA
G2
D2
T2
MA
D20
G3
T3
D3
BA
Da
R
1s
10

FIG.2

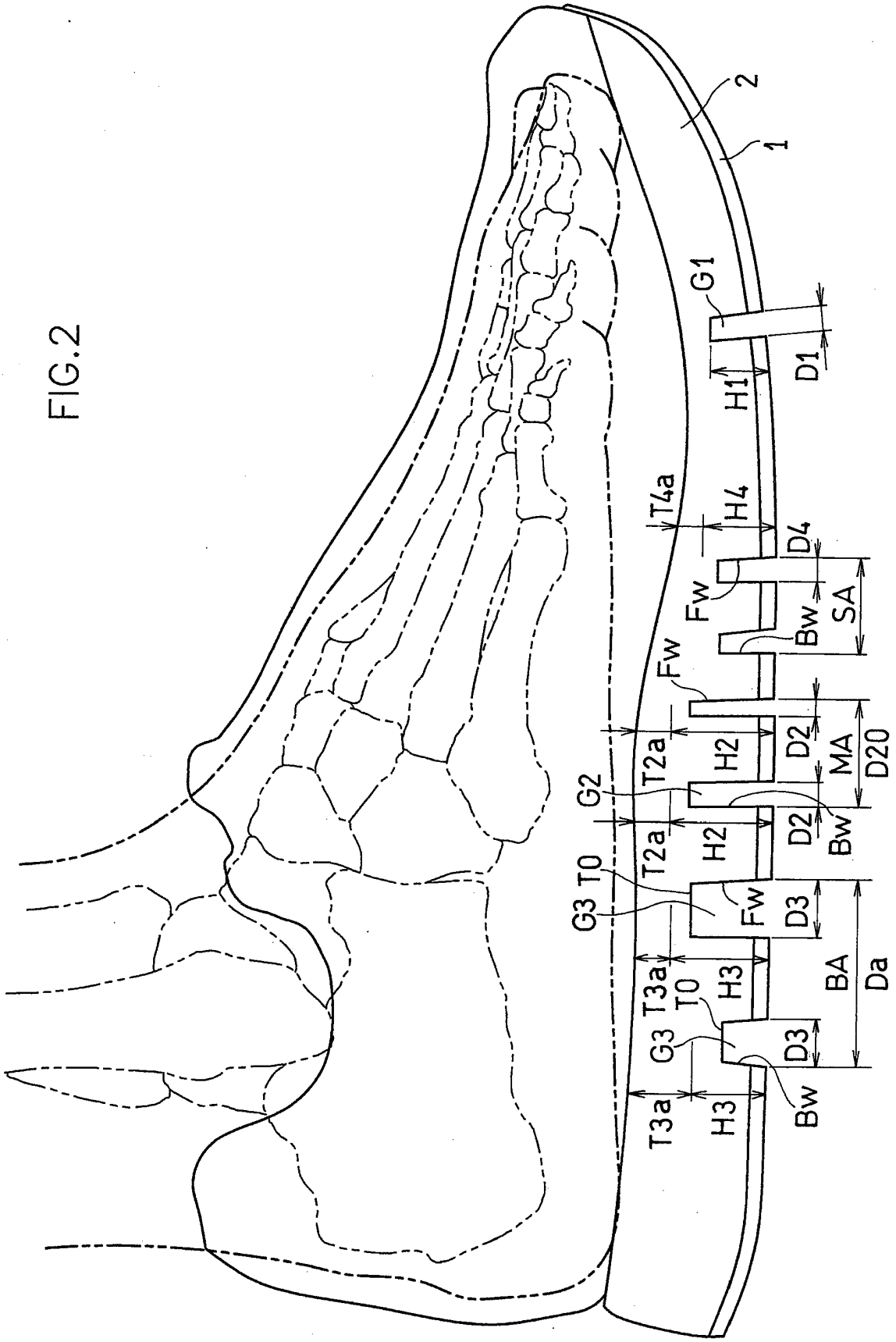

2
1
G1
D1
H1
T4a
H4
D4
Fw
Bw
SA
Fw
T2a
H2
D2
MA
D20
G2
T2a
H2
D2
Bw
G3 T0
Fw
D3
T3a
T0
H3
BA
Da
G3
D3
T3a
H3
Bw

FIG.3

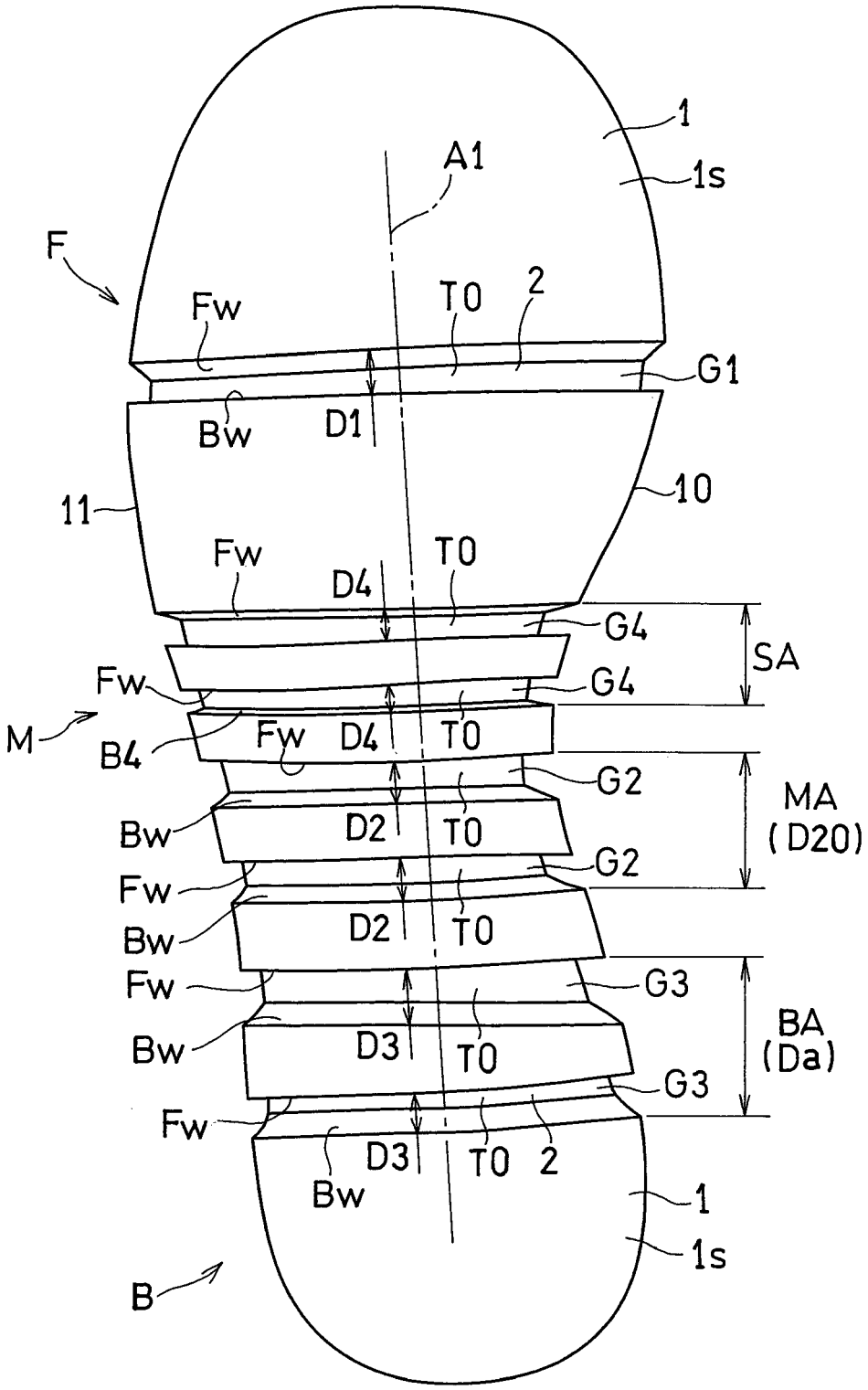

1
A1
1s
F
Fw
T0
2
G1
Bw
D1
11
10
Fw
T0
D4
G4
SA
Fw
G4
M
B4
Fw
D4
T0
G2
MA
(D20)
Bw
D2
T0
Fw
G2
Bw
D2
T0
Fw
G3
Bw
D3
T0
BA
(Da)
G3
Fw
D3
T0
2
Bw
1
1s
B

FIG.4

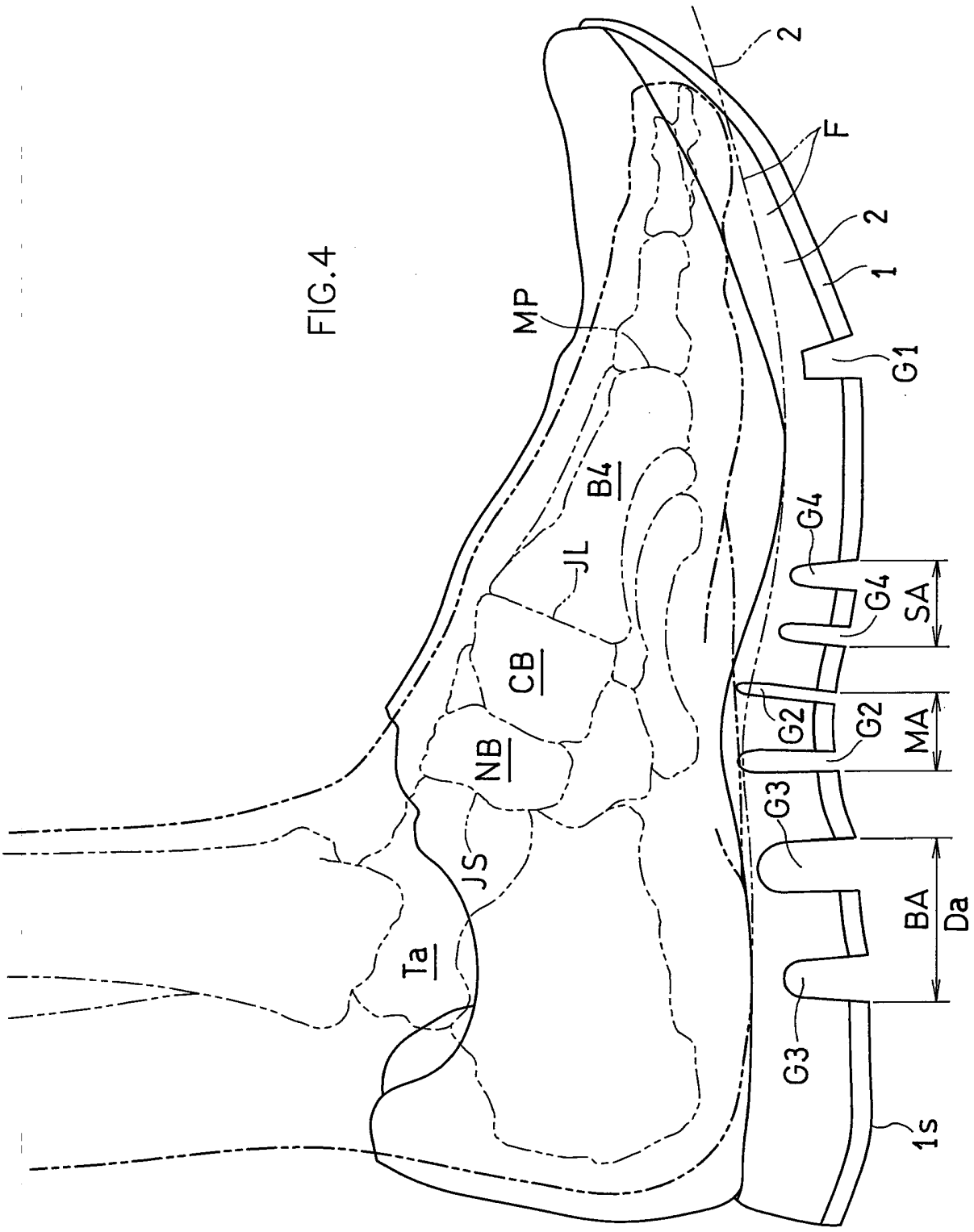


FIG.5

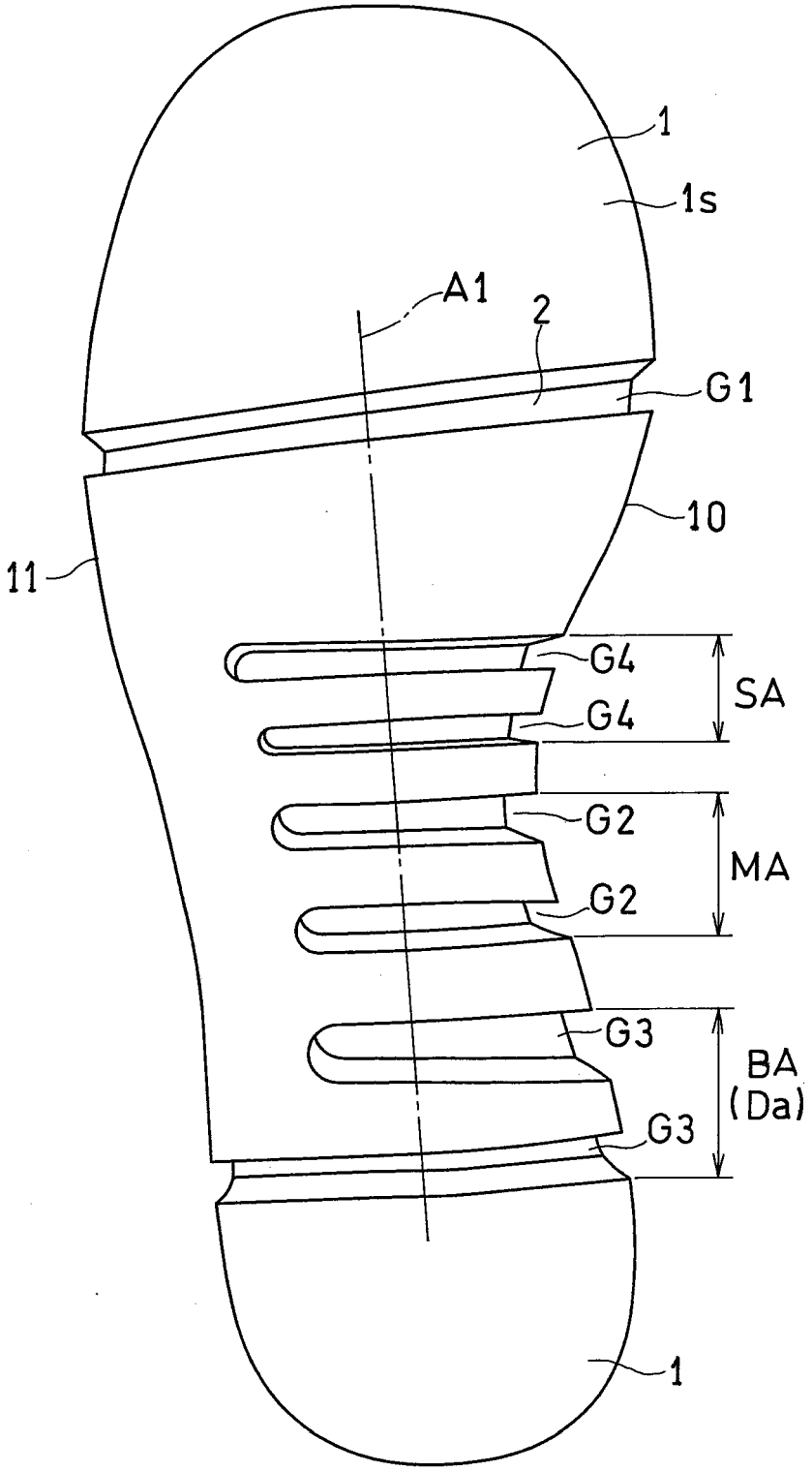


FIG. 6

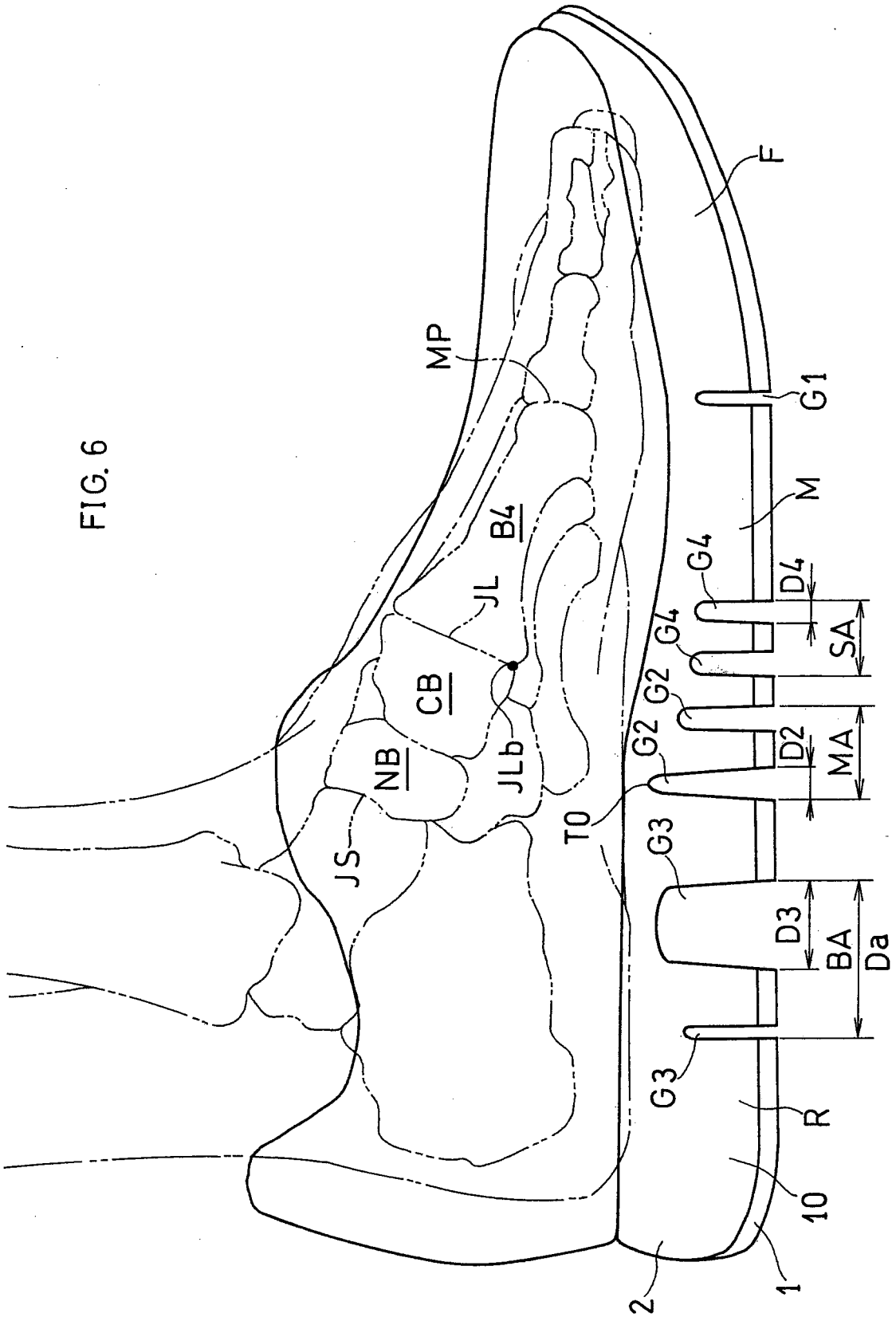

MP
F
G1
M
B4
JL
G4
D4
SA
CB
G4
G2
G2
D2
MA
NB
JLb
G2
T0
G3
JS
D3
BA
Da
G3
R
10
2
1

FIG. 7

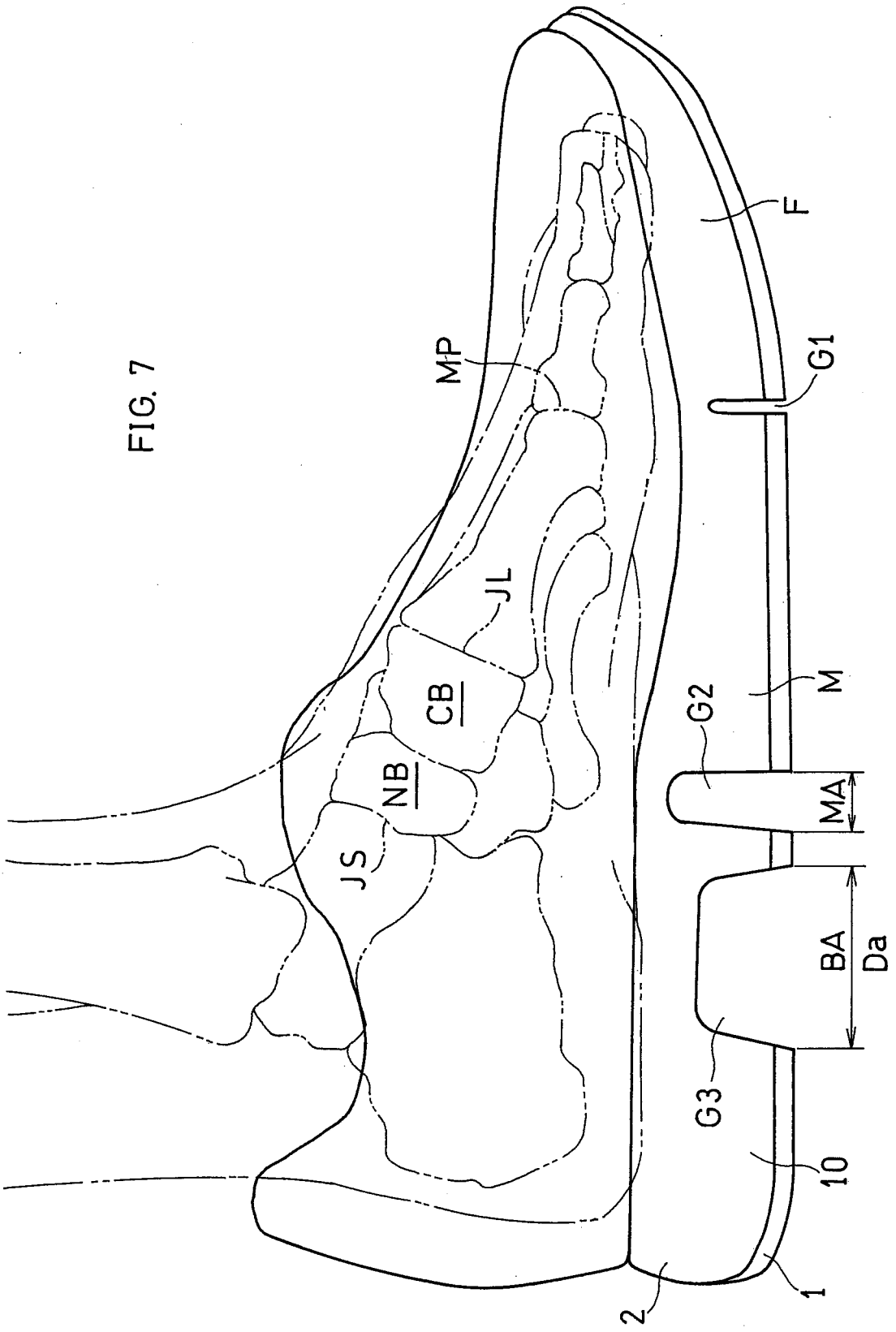


FIG. 8

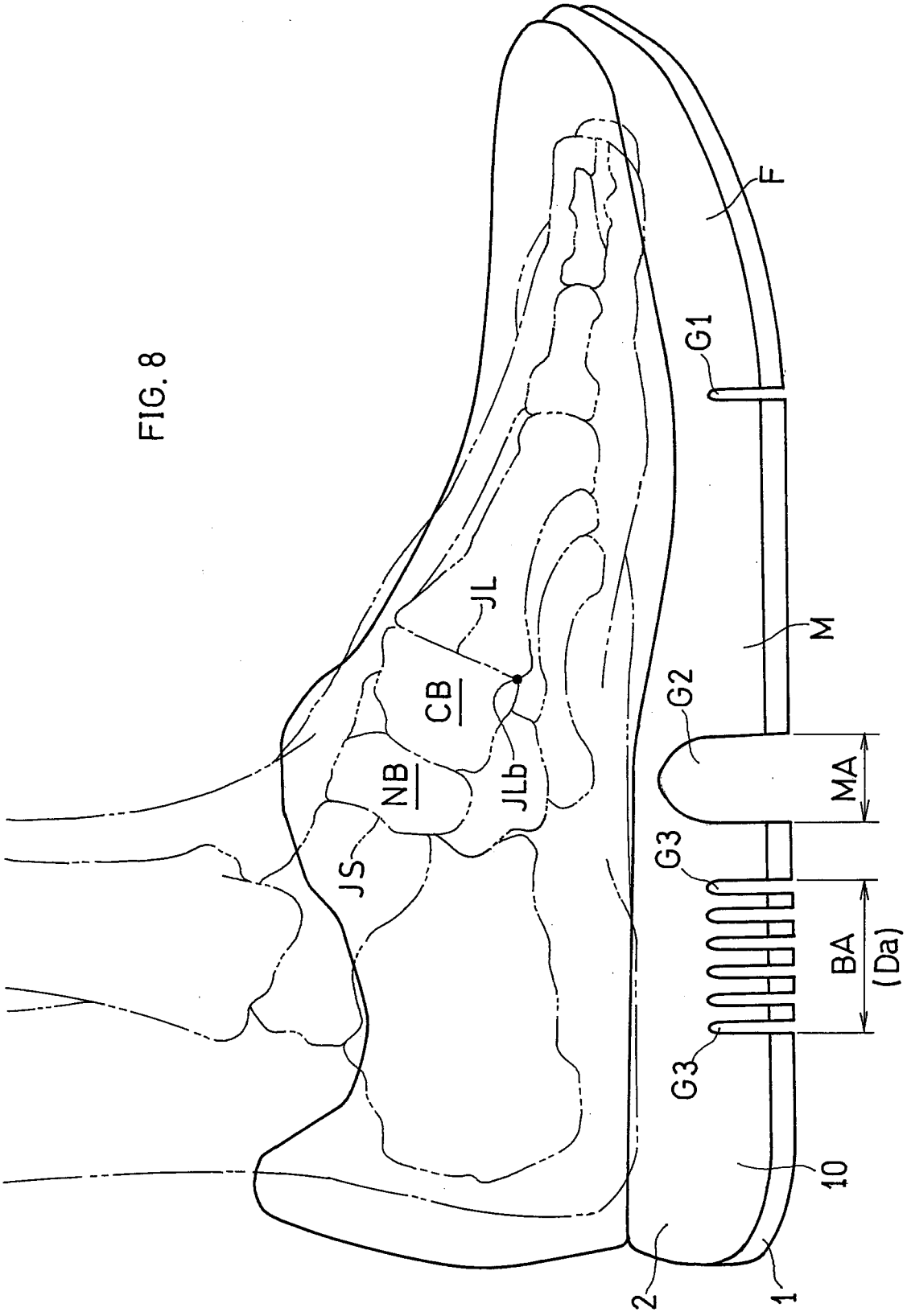


FIG. 9

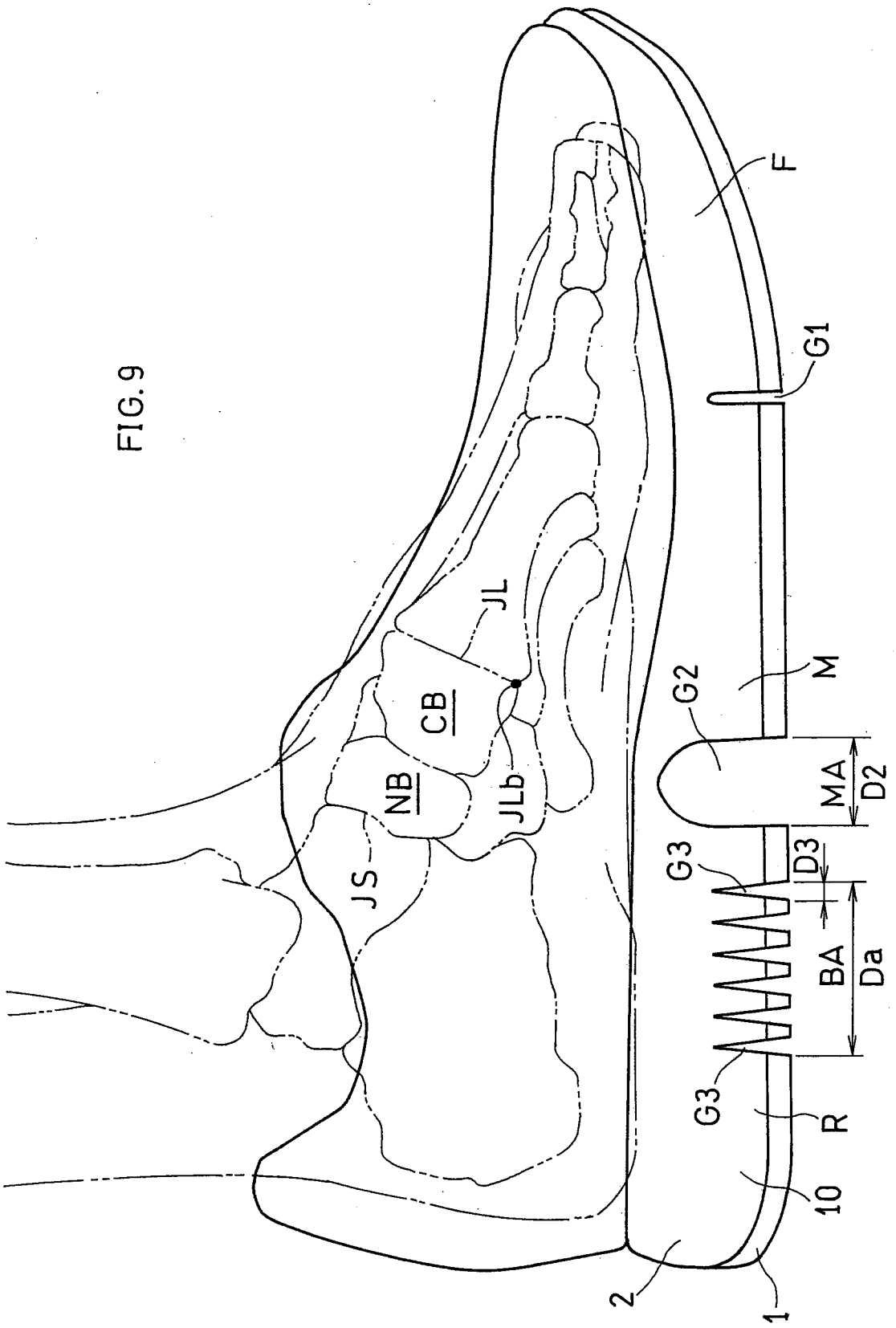


FIG.10

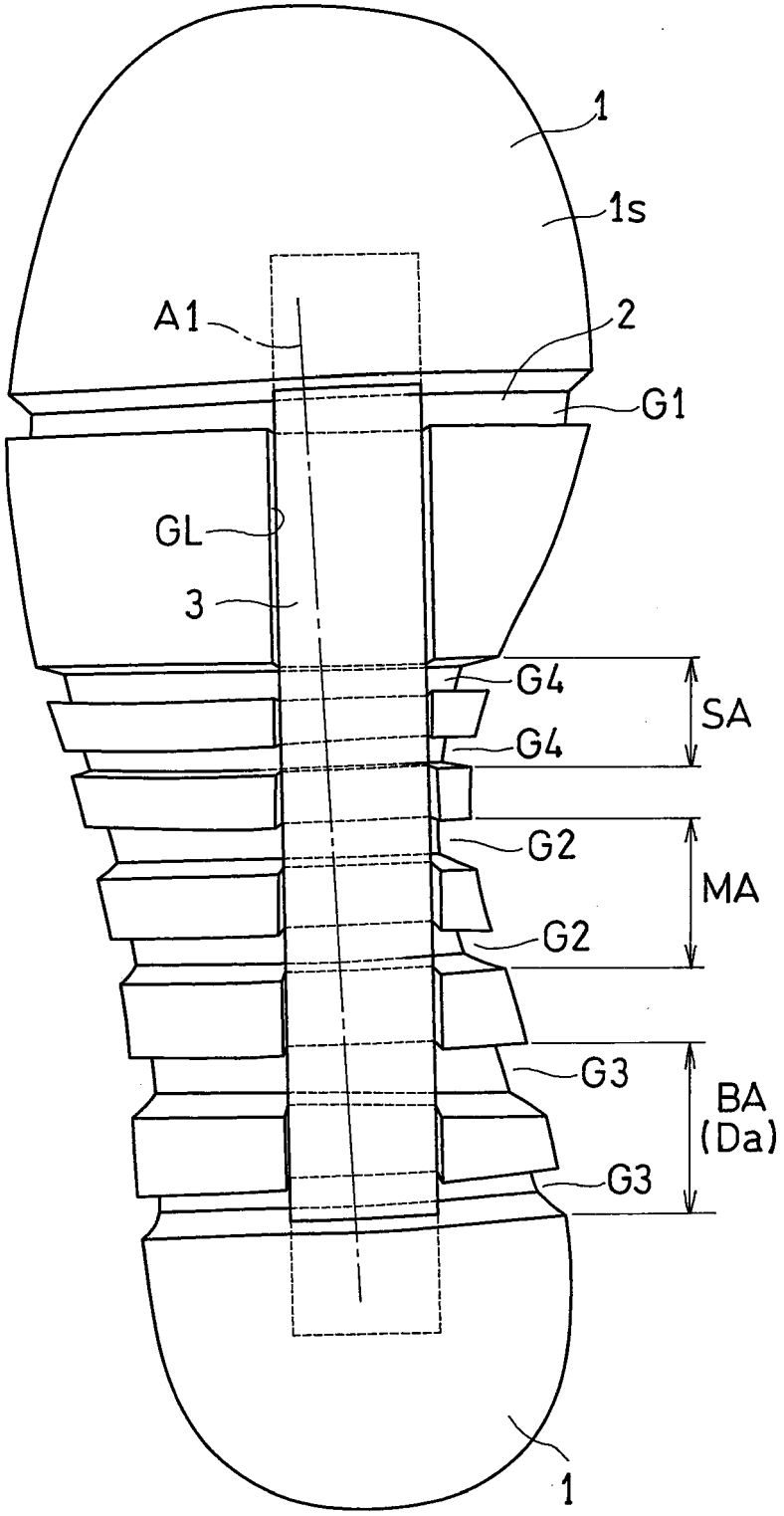


FIG. 11

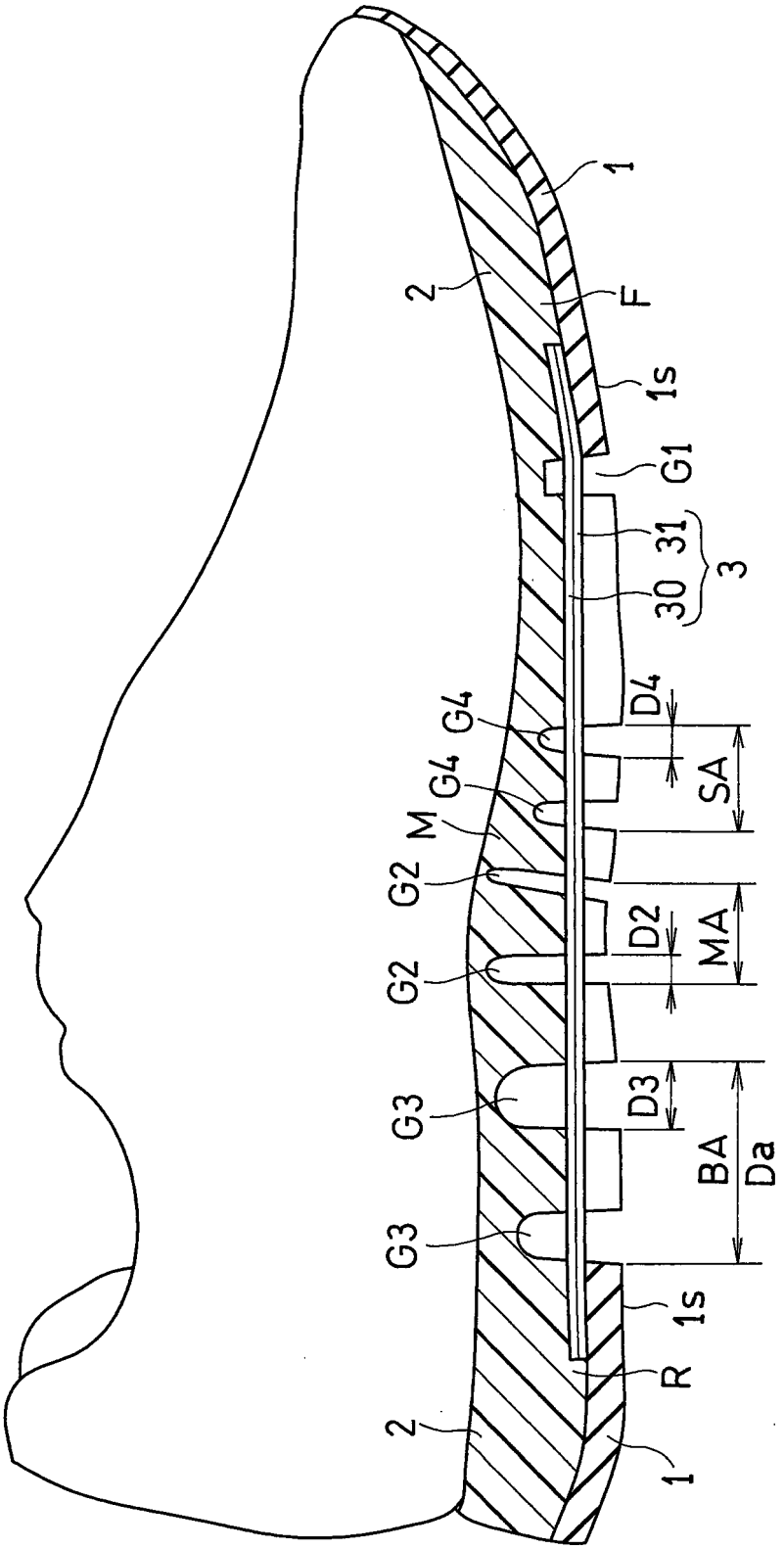


FIG.12

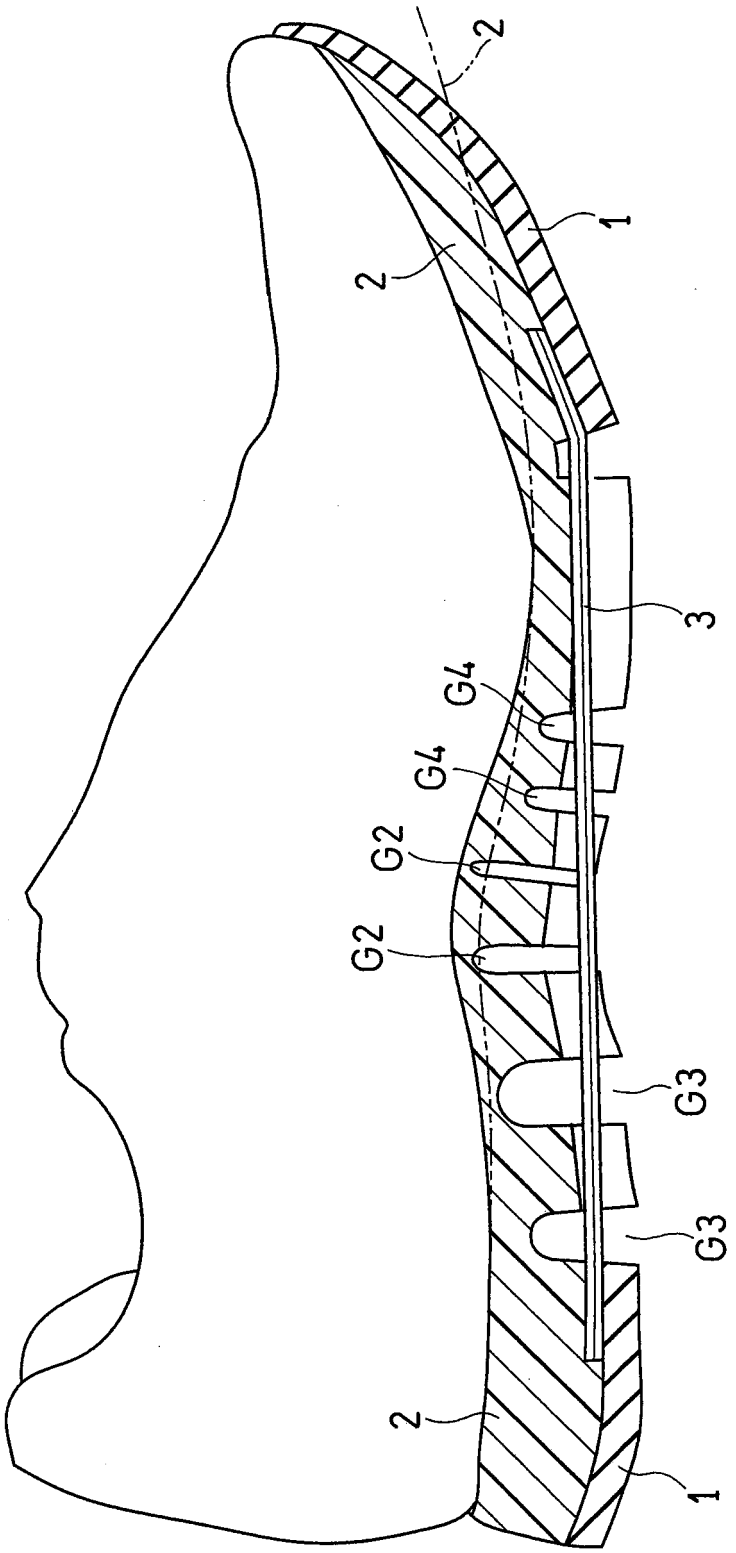


FIG. 13

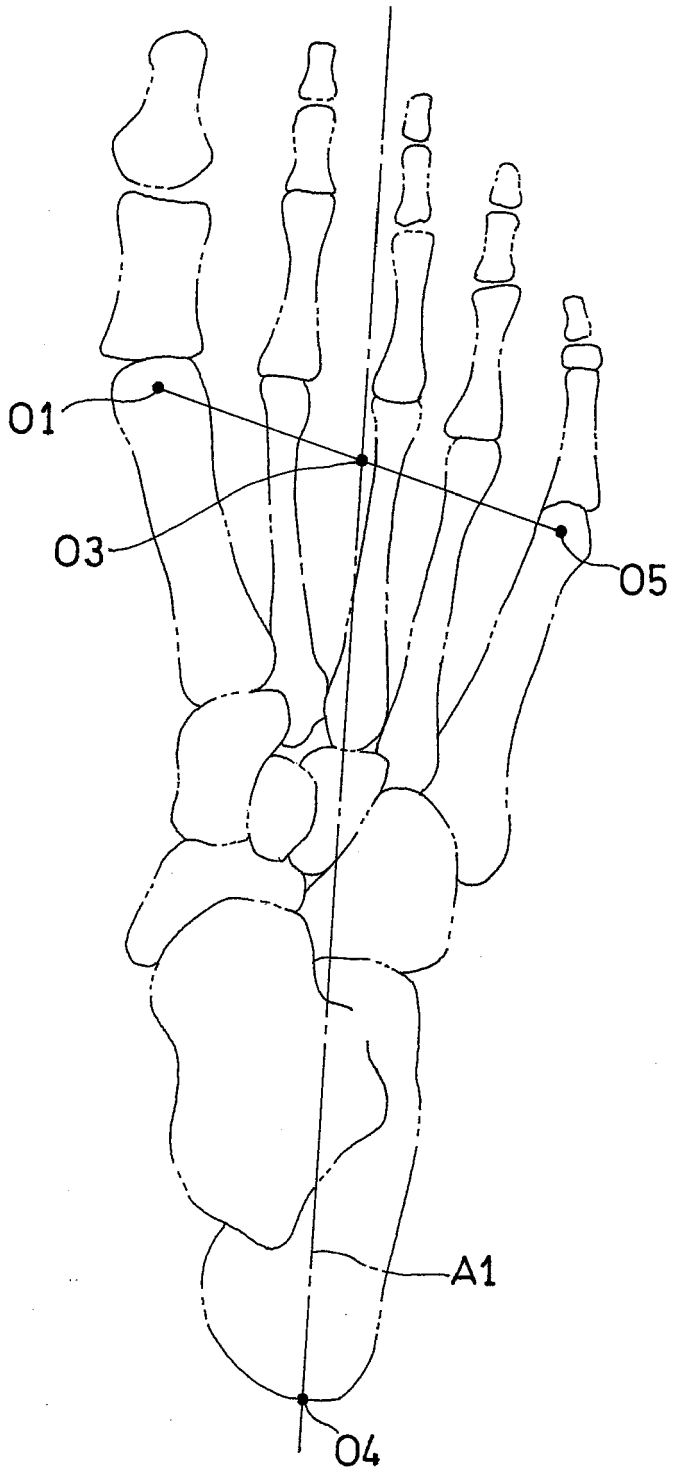


FIG. 14A

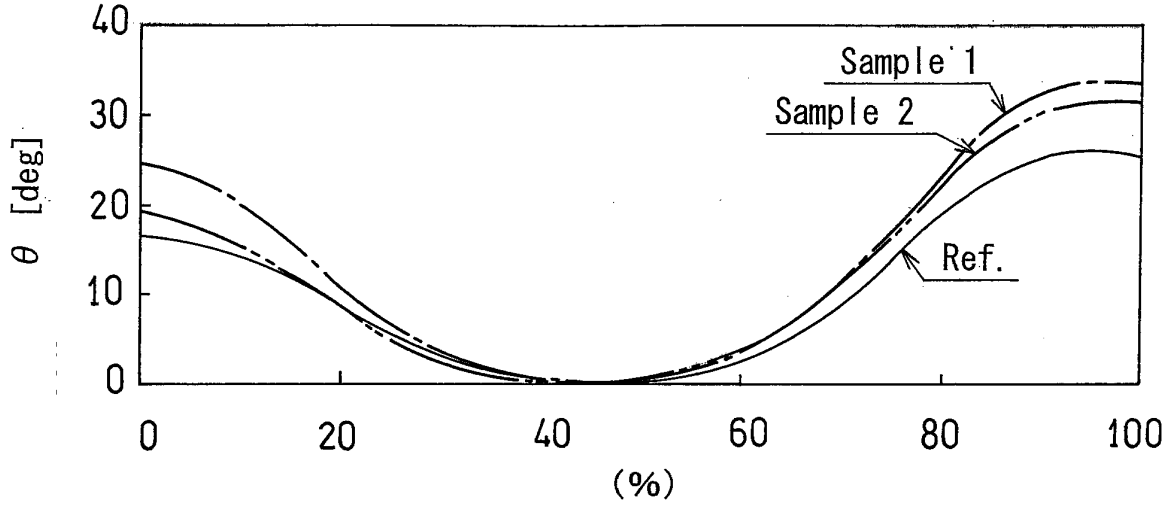


FIG. 14B

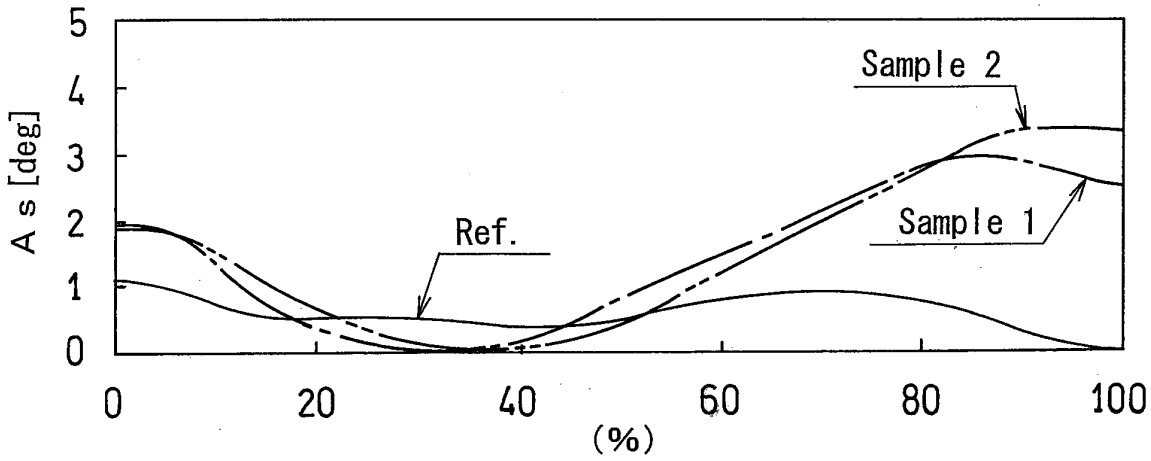
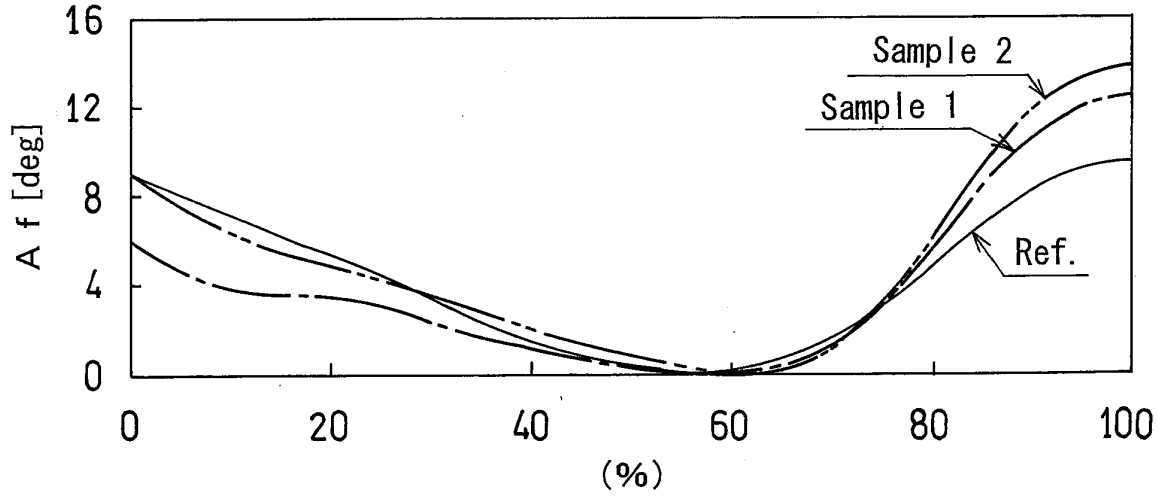


FIG. 14C



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/077867

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)
A43B1/00-23/30

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 1996-2012
Kokai Jitsuyo Shinan Koho 1971-2012 Toroku Jitsuyo Shinan Koho 1994-2012

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.
A	WO 2010/038266 A1 (Asics Corp.), 08 April 2010 (08.04.2010), entire text; all drawings & US 2011/185590 A1 & EP 2332432 A1	1-15
A	JP 11-123101 A (Asics Corp.), 11 May 1999 (11.05.1999), entire text; all drawings (Family: none)	1-15

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
03 December, 2012 (03.12.12)	11 December, 2012 (11.12.12)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/077867

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CD-ROM of the specification and drawings annexed to the request of Japanese Utility Model Application No. 37916/1992(Laid-open No. 75204/1994) (Malcolm, G. Blissett), 25 October 1994 (25.10.1994), entire text; all drawings & EP 0260777 A2	1-15
A	JP 2008-29717 A (Pigeon Corp.), 14 February 2008 (14.02.2008), entire text; all drawings (Family: none)	1-15
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