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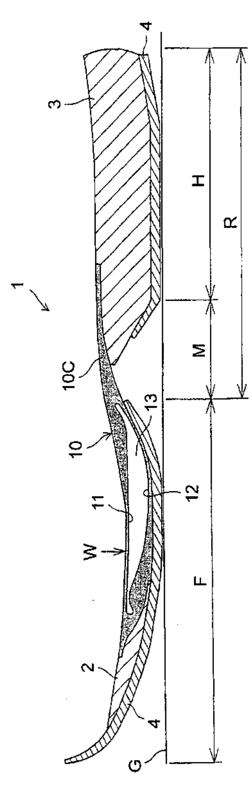
(54) **Sole structure for a shoe**

(57) A hard elastic body (10) having a longitudinally extending cavity (13) formed therein is provided mainly at a forefoot region (F) of a sole body. The cavity (13) is formed of a first curved surface (11) extending curvedly in a longitudinal direction and a second curved surface (12) disposed under the first curved surface (11) and extending curvedly in a longitudinal direction as well. A front and rear end of the second curved surface (12) is connected to a front and rear end of the first curved surface (11) respectively and an intermediate portion of the second curved surface (12) is spaced apart downwardly from an intermediate portion of the first curved surface (11). A path (PQ_1) between the front and rear end of the first curved surface (11) is substantially equal to a path (PQ_2) between the front and rear end of the second curved surface (12). When the first curved surface (11) is pressed downwardly, the sole body is deformed in such a way that a rear foot region (R) of the sole body is lifted upwardly.

FIG. 1



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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a sole structure for a shoe, and more particularly, to an improvement in bendability of a sole forefoot portion.

[0002] A sole of a shoe is typically formed of a soft elastic material to achieve cushioning properties and bendability or flexibility is also required at a sole forefoot portion to get a smooth 'ground-kicking' of the sole forefoot portion during running or walking. In a prior art shoe, bendability or flexibility of a sole forefoot portion is achieved by decreasing the thickness of the sole forefoot portion or forming a laterally extending bent groove at the sole forefoot portion.

[0003] However, in a conventional sole assembly, bending motion of a forefoot of a shoe wearer is transmitted to a sole forefoot portion of a shoe via an upper of the shoe at the time of bending of the forefoot portion of the shoe wearer. That is, a conventional sole assembly is not structured in such a way that bending motion of a forefoot of a shoe wearer does not directly bend the sole forefoot portion of a shoe.

[0004] The present invention has been made in view of these circumstances and its object is to provide a novel sole assembly for a shoe that is structured in such a way that bending motion of a forefoot of a shoe wearer directly bends the sole forefoot portion of a shoe. In other words, the current invention is directed to providing a sole assembly having an improved bendability.

SUMMARY OF THE INVENTION

[0005] The present invention is directed to a sole assembly for a shoe that has a sole body. The sole body has a flat-shaped cavity formed at a forefoot region thereof. The cavity is defined by a first and second curved surface that is formed of elastic material, connected to each other at a front and rear end and spaced apart at an intermediate portion. A path between the front end and the rear end of the first curved surface is substantially equal to a path between the front end and the rear end of the second curved surface. The sole body deforms in such a way that when the first curved surface is pressed downwardly a rear side region of the sole body is lifted upwardly.

[0006] According to the present invention, when the forefoot portion of the sole body is pressed downwardly prior to bending motion of the forefoot portion of a wearer's foot, the first curved surface deforms to come closer to the second curved surface and the sole body bends in such a way that rear side region of the cavity e.g. a rear foot region of the sole body is lifted upwardly.

[0007] In this case, since the sole body bends or buckles when it senses the bending motion of the forefoot portion of a wearer's foot, bending of the forefoot portion of the foot can be smoothly and directly transmitted to the sole body. In other words, loading of the weight of a shoe wearer causes bending of the sole body. Thereby, bendability of the sole body can be improved. Also, in this case, since the sole body bends with the cavity between the first and second curved surface contracted, wrinkles hardly occur on the top surface of the sole body at the time of bending of the sole body thereby preventing occurrence of blister or shoe sore of a foot and elongation of an outsole can be lessened at the time of bending of the sole body to prevent separation of the outsole.

[0008] The cavity formed by the first and second curved surface may be parallelogrammatical in shape.

[0009] The sole body may have an elastic body at the forefoot region, which has the cavity formed therein and is harder than the sole body.

[0010] The elastic body may have an upper area including the first curved surface and a lower area including the second curved surface. The bending rigidity of a front side portion of the upper area may be lower than that of a rear side portion of the upper area, and the bending rigidity of a rear side portion of the lower area is lower than that of a front side portion of the lower area.

[0011] In this case, when the compressive load is applied to the front side portion of lower rigidity of the first curved surface during bending motion of the forefoot portion of a foot, the front side portion of the first curved surface easily deforms downwardly to come closer to the second curved surface and the rear side portion of lower rigidity of the second curved surface easily deforms upwardly. Thereby, loading of the weight of a shoe wearer can be linked to bending motion of the sole body and thus, bendability of the sole body can be improved.

[0012] Also, in this case, since bending position of the sole body is located to the rear of the loading position of the compressive load from the forefoot portion of the foot, gripping area of the sole body relative to the ground can be enlarged, thereby enhancing the gripping power on leaving the ground.

[0013] A thickness of the front side portion of the upper area may be smaller than that of the rear side portion of the upper area, and a thickness of the rear side portion of the lower area may be smaller than that of the front side portion of the lower area. In this case, bending rigidity is modified by the variation of the thickness of the entire area.

[0014] A groove or through hole may be formed at a portion with a lower bending rigidity, or a rib may be formed at a portion with a higher bending rigidity. In this case, bending rigidity is modified by the variation of the thickness of the local area.

[0015] The rear side portion of the upper area and the front side portion of the lower area may have a FRP (or Fiber Reinforced Plastics) sheet interposed therein. FRP includes fibers such as carbon, glass, aramid fiber or the like.

[0016] The rear side portions of the upper area and the lower area of the elastic body may be united into a unit on the rear side of the first and second curved surface and may extend further rearward. A rearmost end of an extension of the unit may be disposed at a heel region of the sole body.

[0017] In this case, the extension of the elastic body facilitates upward movement of a rearfoot region of the sole body during bendingmotion of the forefoot portion of awearer' s foot. As a result, bending motion of the forefoot portion of the foot can be more smoothly transmitted to the sole body and bendability of the sole body can be further improved.

[0018] The cavity defined by the first and second curved surface may have a reinforced member to increase the rigidity of the sole body or the elastic body in a lateral direction. The reinforced member prevents the cavity from being collapsed easily.

[0019] The reinforcement member may be composed of laterally extending one or more ribs provided on the second curved surface. In the case of ribs provided along the bending lines of the forefoot portion of a foot, the forefoot portion of the sole body is easy to bend at a portion between the adjacent ribs, thereby displaying a 'navigating effect' relative to the foot during walking or running.

[0020] An elastic structure may be provided at the forefoot region of the sole body that is composed of a first plate having the first curved surface and a second plate having the second curved surface whose front and rear end is coupled to a front and rear end of the first plate respectively.

[0021] In another aspect of the present invention, bending rigidity of the forefoot region of the sole body may be adapted to change at two stages of a first bending rigidity to a second bending rigidity as the progress of bending during bending motion of the forefoot region of the sole body.

[0022] In this case, when the first curved surface deforms toward the second curved surface during bending motion of the forefoot portion of a wearer's foot, bending rigidity of the forefoot region of the sole body changes from the first bending rigidity to the second bending rigidity, thereby improving the bendability of the sole body.

[0023] Two-stage change of the bending rigidity of the sole body may be caused by substantially closing the cavity.

[0024] That is, in this case, the first bending rigidity is rigidity before the first curved surface contacts the second curved surface during bending motion of the sole body, and the second bending rigidity is rigidity when the first curved surface is in contact with the second curved surface with the cavity closed and both surfaces are integrated with each other. The second bending rigidity is far greater than the first bending rigidity with a cavity formed and it functions generally as a rigid body relative to the deformation of the sole body.

[0025] Therefore, when the first curved surface is in contact with the second curved surface, the sole body is hard to further deform and the sole body moves onto the motion of kicking the ground in the state of a rigid body, thereby improving ground-kicking motion of the sole body.

[0026] The cavity may be defined by a first curved surface formed of elastic material and including a downwardly convex curve and a second curved surface disposed under the first curved surface, formed of elastic material and including a downwardly convex curve. A front and rear end of the second curved surface is coupled to a front and rear end of the first curved surface respectively and an intermediate portion of the second curved surface is located downwardly away from an intermediate portion of the first curved surface. The sole body deforms in such a way that when the first curved surface is pressed downwardly a rear side region of the sole body is lifted upwardly.

[0027] In this case, when the first curved surface deforms to come closer to the second curved surface during bending motion of the forefoot portion of a wearer's foot, the sole body deforms in such a way that a rear foot region of the sole body is lifted upwardly. Thereby, bending of the forefoot portion of the foot can be smoothly and directly transmitted to the sole body, thus improving bendability of the sole body.

[0028] A soft elastic member (e.g. foamed material such as sponge) softer than the sole body may be inserted into at least a portion of the cavity.

[0029] In this case, suitable variation of position or expansion rate of the soft elastic member to be inserted into the cavity can modify the way of deformation of the first and second curved surface such as the amount of elastic deformation or restorative speed after elastic deformation of the first and second curved surface.

[0030] The elastic member may be composed of a plurality of members each extending substantially in a lateral direction.

[0031] A bottom surface of the sole body may constitute a sole ground contact surface. In this case, deformation of the bottom surface of the sole body becomes deformation of the ground contact surface, so that bending motion of the forefoot portion of a foot comes to bend the sole ground contact surface more directly.

[0032] The first and second curved surface may be adapted to cross a thenar eminence of a wearer's foot in a longitudinal direction.

[0033] In this case, when a load is applied from the thenar eminence of the foot to the sole assembly, a rear side portion of the sole forefoot portion is lifted upwardly. Thereby, a sole assembly can be achieved that is suitable for a running shoe in which repetitive loads act onto the thenar eminence of a foot.

[0034] The first and second curved surface is adapted to cross a first proximal phalanx of a wearer's foot in a lateral direction.

[0035] In this case, when a load is applied from the first toe to the sole assembly, the second surface deforms so as to promote the motion of the first toe toward the medial side. Thereby, load transfer toward a sole edge portion is conducted smoothly, and a sole assembly can be achieved that is suitable for a golf shoe in which the motion of the first toe of the foot toward the medial side is required at the time of impacting a golf ball.

[0036] The first and second curved surface is adapted to cross a fifth proximal phalanx of a wearer's foot in a lateral direction.

[0037] In this case, when a load is applied from the fifth toe to the sole assembly, the second curved surface deforms so as to restrain the motion of the fifth toe toward the lateral side. Thereby, a stop wall can be formed on the lateral side of the sole body that restrains downward deformation toward the lateral side relative to the sideways motion such as sidestepping. A sole assembly can thus be achieved that is suitable for a tennis shoe or basketball shoe.

[0038] The cavity may penetrate the sole body in a lateral direction so that bendability of the entire sole body in a lateral direction can be improved.

BRIEF DESCRIPTION OF THE DRAWINGS

[0039] For a more complete understanding of the invention, reference should be made to the embodiments illustrated in greater detail in the accompanying drawings and described below by way of examples of the invention. In the drawings, which are not to scale:

FIG. 1 is a side view of a sole assembly according to a first embodiment of the present invention;
FIG. 2 is an enlarged side view of a cavity of the sole assembly of FIG. 1;
FIG. 3 is an enlarged side view of an elastic body of the sole assembly of FIG. 1;
FIG. 4 is a side view illustrating a bent state of the sole assembly of FIG. 1;
FIG. 5 is a side view illustrating a further bent state of the sole assembly of FIG. 4;
FIG. 6 shows a side view of a sole assembly according to a second embodiment of the present invention;
FIG. 7 is a side view illustrating a bent state of the sole assembly of FIG. 6;
FIG. 8 is a side view of an elastic structure of a sole assembly according to a third embodiment of the present invention;
FIG. 9A is a partial side view of a sole assembly according to a fifth embodiment of the present invention;
FIG. 9B is a partial bottom view of the sole assembly of FIG. 9A;
FIG. 10A is a partial side view of a sole assembly according to a sixth embodiment of the present invention;
FIG. 10B is a partial bottom view of the sole assembly of FIG. 10A:
FIG. 10C shows a variant of the sole assembly of FIG. 10A;
FIG. 11A is a partial side view of a sole assembly according to a seventh embodiment of the present invention;
FIG. 11B is a partial bottom view of the sole assembly of FIG. 11A;
FIG. 12A is a partial side view of a sole assembly according to an eighth embodiment of the present invention;
FIG. 12B is a partial bottom view of the sole assembly of FIG. 12A;
FIG. 13 illustrates afoot pressure distribution diagram showing foot pressure during the period of striking onto the ground to leaving the ground in running along with a schematic view of an elastic body of FIG. 3 disposed in a longitudinal direction;
FIG. 14 a top plan view of a sole for a cleated shoe or a spiked shoe having studs at a sole forefoot portion along with a schematic view of an elastic body of FIG. 3 disposed in a longitudinal direction and with a bone structure of a foot;
FIG. 15 illustrates a foot pressure distribution diagram showing foot pressure at the time of impacting a golf ball along with a schematic view of an elastic body of FIG. 3 disposed in a lateral direction; and
FIG. 16 illustrates a foot pressure distribution diagram showing foot pressure during sidestepping in playing tennis or basketball along with a schematic view of an elastic body of FIG. 3 disposed in a lateral direction.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0040] FIGS. 1 to 5 show a sole assembly of a first embodiment of the present invention. As shown in FIG. 1, a sole assembly 1 in use for a shoe includes a sole body that is comprised of a sole body forefoot portion 2 disposed mainly at a forefoot region F of the sole assembly 1 and a sole body heel portion 3 disposed at a heel region H to a midfoot or plantar arch region M of the sole assembly 1. An outsole 4 that contacts the ground G is attached to the bottom surface of the sole body. A region including the heel region H and the midfoot region M of the sole assembly 1 is herein referred to as a 'rearfoot' region R.

[0041] The sole body may be formed of a soft elastic material. Specifically, thermoplastic synthetic resin foam such as ethylene-vinyl acetate copolymer (EVA) , thermosetting resin foam such as polyurethane (PU), or rubber material foam such as butadiene or chloroprene rubber is used.

[0042] Mainly at the forefoot region F of the sole assembly 1, there is provided an elastic body 10 having a flat shaped cavity or void 13 formed therein and extending in a longitudinal direction. The elastic body 10 is preferably formed of a hard elastic material having a greater modulus of elasticity than the sole body. The elastic body 10 may be formed of thermoplastic resin such as thermoplastic polyurethane (TPU), polyamide elastomer (PAE), ABS resin and the like. Alternatively, it may be formed of thermosetting resin such as epoxy resin, unsaturated polyester resin and the like.

[0043] The cavity 13 of the elasticbody 10 is preferably a through hole penetrating through the elastic body 10 in a lateral or shoe width direction. As shown in FIG. 2, the cavity 13 is formed of a first curved surface 11 extending curvedly in a longitudinal direction and a second curved surface 12 disposed under the first curved surface and extending curvedly in a longitudinal direction as well. The first and second curved surfaces 11, 12 are coupled to each other at points P and Q disposed at a front end and a rear end respectively. Intermediate portions of the first and second curved surfaces 11, 12 disposed between points P and Q are spaced apart from each other. A path between points P and Q of the first curved surface 11 i.e. a distance PQ_1 measured along the first curved surface 11 is substantially equal to a path between points P and Q of the second curved surface 12 i. e. a distance PQ_2 measured along the second curved surface 12.

[0044] Also, the first curved surface 11 includes a generally flat surface or slightly curved surface extending from a front end toward a rear end thereof and a downwardly convexly curved surface disposed at a rear end of the first curved surface 11. The second curved surface 12 includes an upwardly convexly curved surface disposed at a front end thereof and a downwardly convexly, slightly curved surface extending from a front end toward a rear end of the second curved surface 12.

[0045] As shown in FIG. 3, the elastic body 10 includes an upper area 10A having the first curved surface 11 and a lower area 10B having the second curved surface 12. The bending rigidity of a front side portion $10A_f$ of the upper area 10A is lower than that of a rear side portion $10A_r$ of the upper area 10A. The bending rigidity of a front side portion $10B_f$ of the lower area 10B is higher than that of a rear side portion $10B_r$ of the lower area 10B.

[0046] More specifically, as shown in FIG. 3, a thickness of the front side portion $10A_f$ of the upper area 10A is smaller than that of the rear side portion $10A_r$ of the upper area 10A. A thickness of the front side portion $10B_f$ of the lower area 10B is greater than that of the rear side portion $10B_r$ of the lower area 10B. That is, in this case, modification of the thickness of the entire area changes the bending rigidity of the elastic body 10.

[0047] In addition, a groove or through hole (not shown) may be formed at areas where a lower bending rigidity is required. Alternatively, ribs may be formed at areas where a higher bending rigidity is required. That is, in this case, modification of the thickness of the local area changes the bending rigidity of the elastic body 10.

[0048] The rear side portions $10A_r$, $10B_r$ of the upper and lower areas 10A, 10B of the elastic body 10 are united into a unit at the rear ends of the first and second curved surface 11, 12 and extend over the rear ends. A rear end of the extended portion 10C extends to the heel region H of the sole body (see FIG. 1).

[0049] Prior to bending motion of a forefoot portion of a shoe wearer, when the forefoot region F of the sole assembly 1 is pressed downwardly, a compressive load W (FIG. 1) deforms the first curved surface 11 to bend downwardly toward the second curved surface 12, as shown in FIG. 4. As a result, the sole assembly 1 buckles in such a way that the rearfoot region R of the sole assembly 1 is lifted upwardly (see FIG. 4) .

[0050] In this case, since the sole assembly senses bending motion of a forefoot portion of a wearer's foot to buckle, bending motion of the forefoot portion of the foot can be directly and smoothly transmitted to the sole assembly. In other words, bending or buckling of the sole assembly can be caused in conjunction with loading of shoe wearer's weight. Thereby, bendability of the sole assembly can be improved.

[0051] Moreover, since the front side portion $10A_f$ of the upper area 10A of the elastic body 10 has a lower bending rigidity than the rear side portion $10A_r$ of the upper area 10A and the rear side portion $10B_r$ of the lower area 10B has a lower bending rigidity than the front side portion $10B_f$ of the lower area 10B, when the compressive load W acts on the front side portion $10A_f$ or a lower rigid portion of the upper area 10A of the elastic body 10 during bending motion of a forefoot portion of a wearer's foot, the front side portion $10A_f$ easily bends downwardly, and a front side portion of the first curved surface 11 comes toward the second curved surface 12 and thus, the rear side portion $10B_r$, or a lower rigidportion of the lower area 10B easily buckles upwardly. As a result, bending motion of the forefoot portion of a wearer's foot can be more smoothly transmitted to the sole assembly, thereby enhancing bendability of the sole body.

[0052] Furthermore, in this case, since a bending or buckling position of the entire sole assembly is shifted rearward relative to an applied position of the compressive load W from the forefoot portion of a foot, a gripping area of the sole assembly relative to the ground surface G can be enlarged, thereby increasing gripping force at the time of kicking and leaving the ground.

[0053] Also, since the sole assembly 1 deforms as the cavity 13 encompassed by the first and second curved surface 11, 12 contracts, a wrinkle is hard to occur on the top surface of the sole body at the time of bending motion of the sole assembly thereby preventing occurrence of a blister or shoe sore on a shoe wearer's foot, and also, elongation of the outsole 4 is decreased at the time of bending motion of the sole assembly thereby preventing separation of the outsole 4 from the sole body.

[0054] Then, in the state shown in FIG. 4, the cavity 13 between the first and second curved surface 11, 12 is approximately closed. When the sole assembly 1 further bends from the state shown in FIG. 4, the upper area 10A and the lower area 10B of the elastic body 10 deform unitedly, as shown in a solid line of FIG. 5. A dotted line of FIG. 5 shows the state of FIG. 4.

[0055] Therefore, a first bending rigidity of the elastic body 10 in the state of FIGS. 1 to 4 differs from a second bending rigidity of the elastic body 10 in the state of FIGS. 4 to 5. That is, the bending rigidity of the elastic body 10 and thus the sole assemblyvaries from the first bending rigidity to the second bending rigidity at two stages as the progress of bending motion. Also, the second bending rigidity is far greater than the first bending rigidity in the case where a cavity 13 is formed. Therefore, when the bending rigidity shifts from the first rigidity to the second rigidity during bending deformation of the sole assembly, the elastic body 10 acts like a rigid body relative to deformation of the sole assembly, thereby improving hard elastic property at the time of kicking and leaving the ground.

[0056] In the first embodiment, as above-mentioned, an example has been described where a path between points P and Q of the first curved surface 11 or a distance PQ_1 measured along the first curved surface 11 is substantially equal to a path between points P and Q of the second curved surface 12 or a distance PQ_2 measured along the second curved surface 12 i. e. $PQ_1=PQ_2$. However, the present invention is not limited to such an example. The present invention can be applied to cases of $PQ_1 \neq PQ_2$ (i.e. $PQ_1<PQ_2$ and $PQ_1>PQ_2$)

[0057] In the case of $PQ_1<PQ_2$, due to an elastic elongation of a path between points P and Q of the first curved surface 11 at the time of deformation of the first curved surface 11, a path between points P and Q of the first curved surface 11 after elastic elongation may be substantially equal to a path between points P and Q of the second curved surface 12.

[0058] FIGS. 6 and 7 show a sole assembly of a second embodiment of the present invention. In these drawings, like reference numbers indicate identical or functionally similar elements.

[0059] As shown in FIG. 6, a soft elastic block 20 such as foamed material (e.g. sponge) softer than the sole body 2 is interposed at least at a portion of the cavity 13 of the elastic body 10.

[0060] In this embodiment, the way of deformation of the first and second curved surface 11, 12 such as the amount of elastic deformation or restorative speed after elastic deformation of the first and second curved surface 11, 12 can be adjusted by suitably changing expansion rate of the elastic block 10 inserted into the cavity 13 or the inserted position thereof. In addition, FIG. 7 illustrates the state in which the first and second curved surface 11, 12 is elastically deformed similarly to the state shown in FIG. 4.

[0061] FIGS. 8 shows an elastic structure constituting a sole assembly of a third embodiment of the present invention. In the drawing, like reference numbers indicate identical or functionally similar elements.

[0062] In the above-mentioned first and second embodiments, the elastic body 10 was shown that has a cavity 13 formed of the first and second curved surface 11, 12, whereas in this third embodiment, an elastic structure shown in FIG. 8 is used that comprises a band-shaped first and second plate 10A', 10B' whose opposite ends are coupled to each other. That is, in this case, a first curved surface 11 is formed of an inner surface of the first plate 10A' and a second curved surface 12 is formed of an inner surface of the second plate 10B'.

[0063] The elastic structure is preferably formed of a single loop member in which a first plate 10A' and a second plate 10B' are integrally formed with each other. This elastic structure is formed of a similar material to the elastic body 10 of the first and second embodiment. In this case as well, as with the first embodiment, modification of thickness or formation of grooves, through holes and ribs may be adopted in order to alter the rigidity of a front and rear side portion of the first and second plate 10A' , 10B' . Alternatively, the rigidity of a midsole into which the elastic structure is inserted may be locally altered.

[0064] In the first to third embodiments, the outsole 4 is provided on the bottom surface of the elastic body 10 or the second plate 10B' . At least a portion of the bottom surface of the elastic body 10 or the second plate 10B' may constitute a sole ground contact surface.

[0065] In this case, deformation of the second curved surface 12 becomes deformation of the ground contact surface, so that bending motion of the forefoot portion of a foot comes to bend the sole ground contact surface more directly.

[0066] FIGS. 9A and 9B show an elastic structure of a sole assembly of a fifth embodiment of the present invention. In the drawings, like reference numbers indicate identical or functionally similar elements.

[0067] Similar to the third embodiment, the elastic structure is formed of first and second plates 10A', 10B' that are coupled to each other at respective opposite ends. In this case, a connecting portion on the front side (or right side of FIG. 9A) of the first and second plate 10A', 10B' is integrated with each other. Each of the plates 10A' , 10B' extends rearward (or to the left of FIG. 9A) and a connecting element 5 that connects the first and second plates 10A', 10B' on their rear sides constitutes a rear-side connecting portion. Therefore, in this case, points P, Q on the first and second curved surface 11, 12 are disposed at positions shown in FIG. 9A.

[0068] Also, in the fifth embodiment, a cavity formed by the first curved surface 11 of the first plate 10A' and the second curved surface 12 of the second plate 10B' is generally parallelogrammatical shaped. Therefore, in this case, distances between points P, Q along the first and second curved surfaces 11, 12 are nearly equal to each other.

[0069] Moreover, hatched regions of the rear side portion of the first plate 10A' and the front side portion of the second plate 10B' are reinforced by FRP (i.e. Fiber Reinforced Plastic) sheets 14, 15 including carbon fibers, glass fibers, aramid fibers or the like. In forming a plate including such a FRP sheet, melted resin may be introduced into the molds with the FRP sheet inserted and held into the molds. The FRP sheet provided inside the elastic structure can enhance the rigidity of the desired portion of the elastic structure.

[0070] Furthermore, in the fifth embodiment, the rigidity of the midsole 2' can be made locally greater by increasing the thickness t_1 of the midsole 2' on the rear side of the first plate 10A' or increasing the thickness t_2 of the midsole 2' on the front side of the second plate 10B' .

[0071] FIGS. 10A and 10B show an elastic structure of a sole assembly of a sixth embodiment of the present invention. In the drawings, like reference numbers indicate identical or functionally similar elements. In FIG. 10B, there is also shown a portion of a foot-leaving curve, which indicates boundaries of ground contact regions of a plantar surface of a foot when the foot leaves the ground.

[0072] In the elastic structure, one or more ribs 16 are provided on the second curved surface 12 of the second plate 10B' . Each of the ribs 16 is formed of the similar-material (preferably a soft elastic material) to the second plate 10B' , extends substantially along a lateral direction or shoe width direction perpendicular to the page of FIG. 10A and are spaced apart in a longitudinal direction or left to right direction of FIG. 10A. Such ribs 16 can increase the rigidity of the elastic structure in a lateral direction, thereby restraining deformation of the cavity 13 to prevent collapse of the cavity 13.

[0073] In addition, ribs may be provided on the inner surface 11 of the first plate 10A', but the second plate 10B' on the lower surface side of the midsole 2' (or on the outsole side) is easier to deform than the first plate 10A' on the upper surface side of the midsole 2'. Therefore, as shown in FIG. 10A, in the case where ribs are provided on the second plate 10B'. the rigidity of the elastic structure is effectively improved.

[0074] Moreover, in this case, as shown in FIG. 10B, since each of the ribs 16 is disposed along the foot-leaving curve Lc of the forefoot portion of a foot, the forefoot portion is easy to bend at positions between the adjacent ribs 16. Thereby, weight transfer during walking or running is navigated or controlled by the ribs 16 and foot navigation effect can be achieved.

[0075] Additionally, each of the ribs 16 may extend linearly in a shoe width direction.

[0076] Also, as shown in FIG. 10C, a plurality of notches 16c may be formed on the bottom surface of the second plate 10B'. The notches 16c are located at positions corresponding to the positions of the ribs 16. In this case, a certain degree of rigidity is secured by the ribs 16 and bendability of the elastic structure can be improved by the notches 16c.

[0077] FIGS. 11A and 11B show an elastic structure of a sole assembly of a seventh embodiment of the present invention. In the drawings, like reference numbers indicate identical or functionally similar elements.

[0078] In the elastic structure, a plurality of protrusions 17 formed of soft elastic materials (e.g. foamed material such as sponge) are provided on the second curved surface 12 of the second plate 10B'. Each of the protrusions 17 extends substantially in a lateral direction and spaced apart in a longitudinal direction.

[0079] In this case, as compared with the second embodiment in which a single elastic block is provided, the way of elastic deformation of the first and second curved surface 11, 12 can be minutely adjusted.

[0080] FIGS. 12A and 12B show an elastic structure of a sole assembly of an eighth embodiment of the present invention. In the drawings, like reference numbers indicate identical or functionally similar elements.

[0081] In the elastic assembly, a protrusion 18 formed of soft elastic material is provided on the second curved surface 12 of the second plate 10B'. The protrusion 18 is formed with a plurality of grooves 18a that extend substantially in a lateral direction and that are spaced apart in a longitudinal direction.

[0082] In this case as well, as compared with the second embodiment in which a single elastic block is provided, the way of elastic deformation of the first and second curved surface 11, 12 can be minutely adjusted.

[0083] FIGS. 13 to 16 schematically illustrate examples where an upper area 10A and a lower area 10B constituting an elastic body 10 of the sole assembly of the present invention are applied to an actual shoe. Here, the elastic body 10 of the first embodiment is adopted in each shoe. In the drawings, like reference numbers indicate identical or functionally similar elements. Also, in the drawings, a segment DE indicates the position and direction of the elastic body 10 and a side view of the elastic body as viewed from the arrow direction relative to the segment DE is also shown.

[0084] FIG. 13 illustrates a running shoe in which the upper area 10A and the lower area 10B cross a thenar eminence of a wearer's foot in a longitudinal direction. In this case, when a load is applied from the thenar eminence of the foot to the sole assembly and the front side portion $10A_f$ of the upper area 10A deforms downwardly, the rear side portion $10B_r$ of the lower area 10B deforms upwardly and the rear side portion of the sole forefoot portion is lifted upwardly. Thereby, a sole assembly can be achieved that is suitable for a running shoe in which repetitive loads act onto the thenar eminence of a foot.

[0085] FIG. 14 illustrates a cleated shoe in which the upper area 10A and the lower area 10B cross a thenar eminence of a wearer's foot in a longitudinal direction and 4 pieces of cleats 25 are provided at a sole forefoot portion. In this case, since the rear side portion of the sole forefoot portion is lifted upwardly at the time of the load transfer, a smooth load transfer can be achieved between the longitudinally adjacent cleats.

[0086] FIG. 15 illustrates a golf shoe in which the upper area 10A and the lower area 10B cross a first proximal phalanx of a wearer's foot in a lateral direction. In this case, when a load is applied from the fifth toe to the sole assembly, the lower area 10B deforms so as to promote the motion of the first toe toward the medial side. Thereby, load transfer toward a sole edge portion is conducted smoothly, and a sole assembly can be achieved that is suitable for a golf shoe in which the motion of the first toe of the foot toward the medial side is required at the time of impacting a golf ball.

[0087] FIG. 16 illustrates a tennis shoe or basketball shoe in which the upper area 10A and the lower area 10B cross a fifth proximal phalanx of a wearer's foot in a lateral direction. In this case, when a load is applied from the fifth toe to the sole assembly, the lower area 10B deforms so as to restrain the motion of the fifth toe toward the lateral side. Thereby, a stop wall can be formed on the lateral side of the sole body that restrains downward deformation toward the lateral side relative to the sideways motion such as sidestepping. A sole assembly can thus be achieved that is suitable for a tennis shoe or basketball shoe.

[0088] A sole assembly for a shoe according to the invention comprises an elastic member extending from a rearfoot portion to a forefoot portion. The elastic member has a cavity therein defined between two longitudinally extending curved surfaces of the elastic member. The rigidity of the elastic member and/or the shape/reinforcement of the cavity are adapted so that the forefoot portion bends when downward pressure is applied thereto during activity. There may be two stages to the bending process, the second stage of which resists bending to a greater extent than the first stage.

[0089] Those skilled in the art to which the invention pertains may make modifications and other embodiments employing the principles of this invention without departing from its spirit or essential characteristics particularly upon considering the foregoing teachings. The described embodiments and examples are to be considered in all respects only as illustrative and not restrictive. The scope of the invention is, therefore, indicated by the appended claims rather than by the foregoing description. Consequently, while the invention has been described with reference to particular embodiments and examples, modifications of structure, sequence, materials and the like would be apparent to those skilled in the art, yet fall within the scope of the invention.

Claims

1. A sole assembly for a shoe having a sole body, wherein said sole body has a flat-shaped cavity formed at a forefoot region thereof, said cavity is defined by a first curved surface formed of elastic material and a second curved surface disposed under said first curved surface and formed of elastic material, a front and rear end of said second curved surface is coupled to a front and rear end of said first curved surface respectively, an intermediate portion of the second curved surface is located downwardly away from an intermediate portion of said first curved surface, a path between said front end and said rear end of said first curved surface is substantially equal to a path between said front end and said rear end of said second curved surface, and said sole body deforms in such a way that when said first curved surface is pressed downwardly a rear side region of said sole body is lifted upwardly.

2. A sole assembly of claim 1, wherein said cavity is parallelogrammatical in shape.

3. A sole assembly of claim 1, wherein said sole body has a hard elastic body at said forefoot region, said hard elastic body having said cavity formed therein and being harder than said sole body.

4. A sole assembly of claim 3 wherein said elastic body has an upper area including said first curved surface and a lower area including said second curved surface, the bending rigidity of a front side portion of said upper area is lower than that of a rear side portion of said upper area, and the bending rigidity of a rear side portion of said lower area is lower than that of a front side portion of said lower area.

5. A sole assembly of claim 4, wherein a thickness of said front side portion of said upper area is smaller than that of said rear side portion of said upper area, and a thickness of said rear side portion of said lower area is smaller than that of said front side portion of said lower area.

6. A sole assembly of claim 4, wherein a groove or through hole is formed at a portion with a lower bending rigidity, or a rib is formed at a portion with a higher bending rigidity.

7. A sole assembly of claim 4, wherein said rear side portion of said upper area and said front side portion of said lower area have a FRP sheet interposed therein.

8. A sole assembly of any one of claims 4 to 7, wherein said rear side portions of said upper area and said lower area of said elastic body are united into a unit on the rear side of said first and second curved surface and extends further rearward, and a rearmost end of an extension of said unit is disposed at a heel region of said sole body.

9. A sole assembly of claim 1, 2 or 3 , wherein said cavity defined by said first and second curved surface has a reinforced member to increase the rigidity of said sole body or said elastic body in a lateral direction.

10. A sole assembly of claim 9, wherein said reinforcement member is composed of one or more ribs provided on said second curved surface, said ribs extending substantially in a lateral direction.

11. A sole assembly of claim 1, wherein an elastic structure is provided at said forefoot region of said sole body, and said elastic structure is composed of a first plate including said first curved surface and a second plate including said second curved surface, a front and rear end of said second plate being coupled to a front and rear end of said first plate respectively.

12. A sole assembly for a shoe having a sole body, wherein said sole body has a flat-shaped cavity formed at a forefoot region thereof, said cavity is defined by a first curved surface formed of elastic material and a second curved surface disposed under said first curved surface and formed of elastic material, a front and rear end of said second curved surface is coupled to a front and rear end of said first curved surface, respectively, an intermediate portion of the second curved surface is located downwardly away from an intermediate portion of said first curved surface, and the bending rigidity of said forefoot region of said sole body changes at two stages of a first bending rigidity to a second bending rigidity as the progress of bending at the time of bending motion of said forefoot region of said sole body.

13. A sole assembly of claim 12, wherein said bending rigidity changes from said first bending rigidity to said second bending rigidity by substantially closing said cavity.

14. A sole assembly for a shoe having a sole body, wherein said sole body has a flat-shaped cavity formed at a forefoot region thereof, said cavity is defined by a first curved surface formed of elastic material and including a downwardly convex curve and a second curved surface disposed under said first curved surface, formed of elastic material and including a downwardly convex curve, a front and rear end of said second curved surface is coupled to a front and rear end of said first curved surface respectively, an intermediate portion of the second curved surface is located downwardly away from an intermediate portion of said first curved surface, and said sole body deforms in such a way that when said first curved surface is pressed downwardly a rear side region of said sole body is lifted upwardly.

15. A sole assembly of claim 1, 2, 3, 9, 12, 13 or 14, wherein a soft elastic member softer than said sole body is inserted into at least a portion of said cavity.

16. A sole assembly of claim 15, wherein said elastic member is composed of a plurality of members each extending substantially in a lateral direction.

17. A sole assembly of claim 1, 12 or 14, wherein a bottom surface of said sole body constitutes a sole ground contact surface.

18. A sole assembly of claim 1, 12 or 14, wherein said first and second curved surface crosses a thenar eminence of a wearer's foot in a longitudinal direction.

19. A sole assembly of claim 1, 12 or 14, wherein said first and second curved surface crosses a first proximal phalanx of a wearer's foot in a lateral direction.

20. A sole assembly of claim 1, 12 or 14, wherein said first and second curved surface crosses a fifth proximal phalanx of a wearer's foot in a lateral direction.

21. A sole assembly of claim 1, 2, 3, 9, 12 13 or 14, wherein said cavity penetrates said sole body in a lateral direction.

FIG. 1

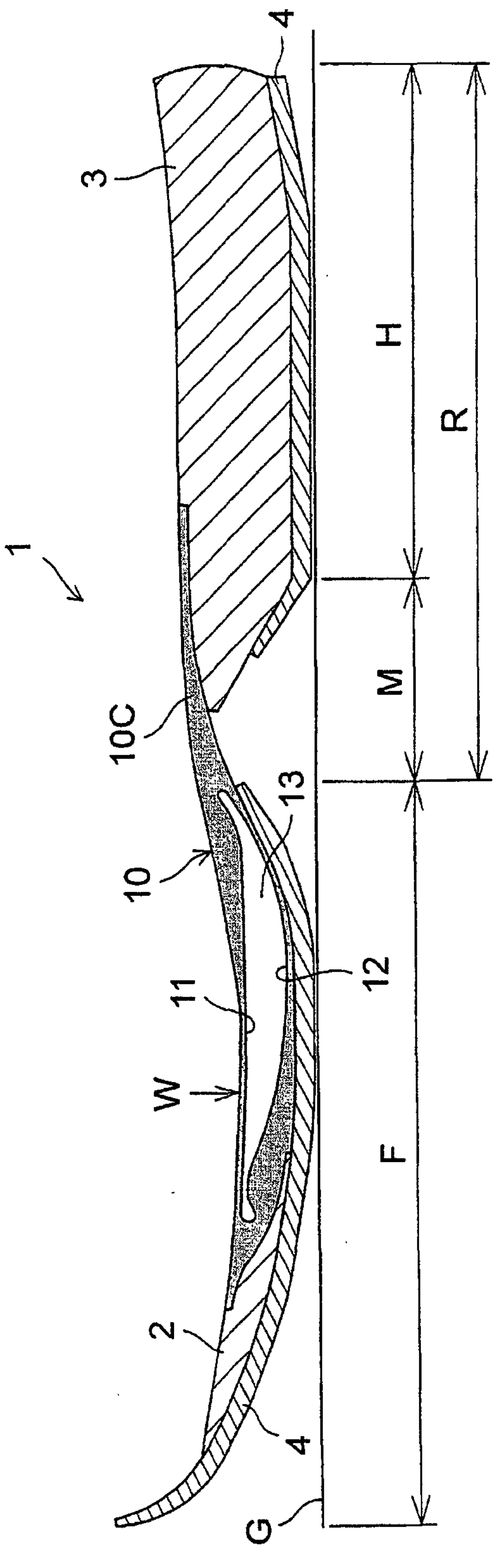


FIG. 2

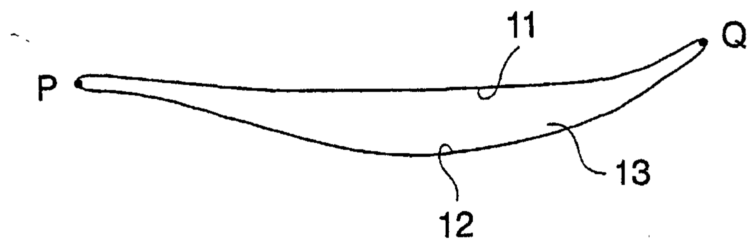


FIG. 3

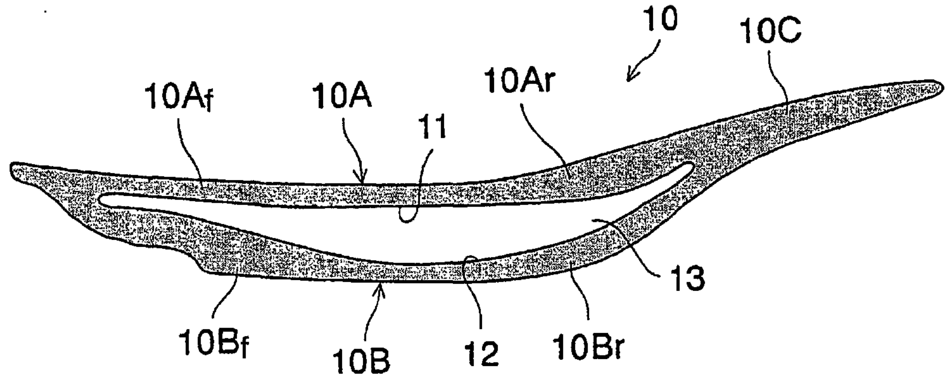


FIG. 4

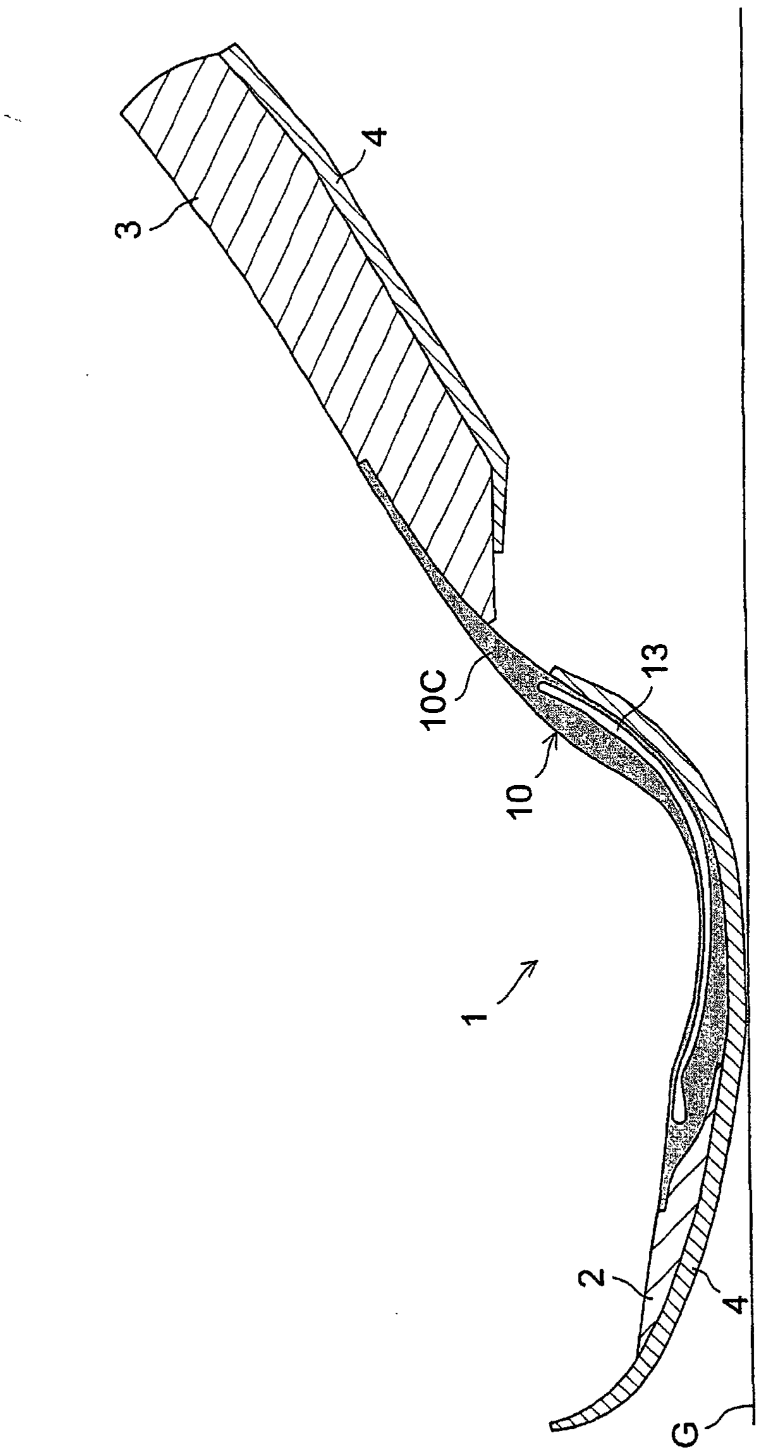


FIG. 5

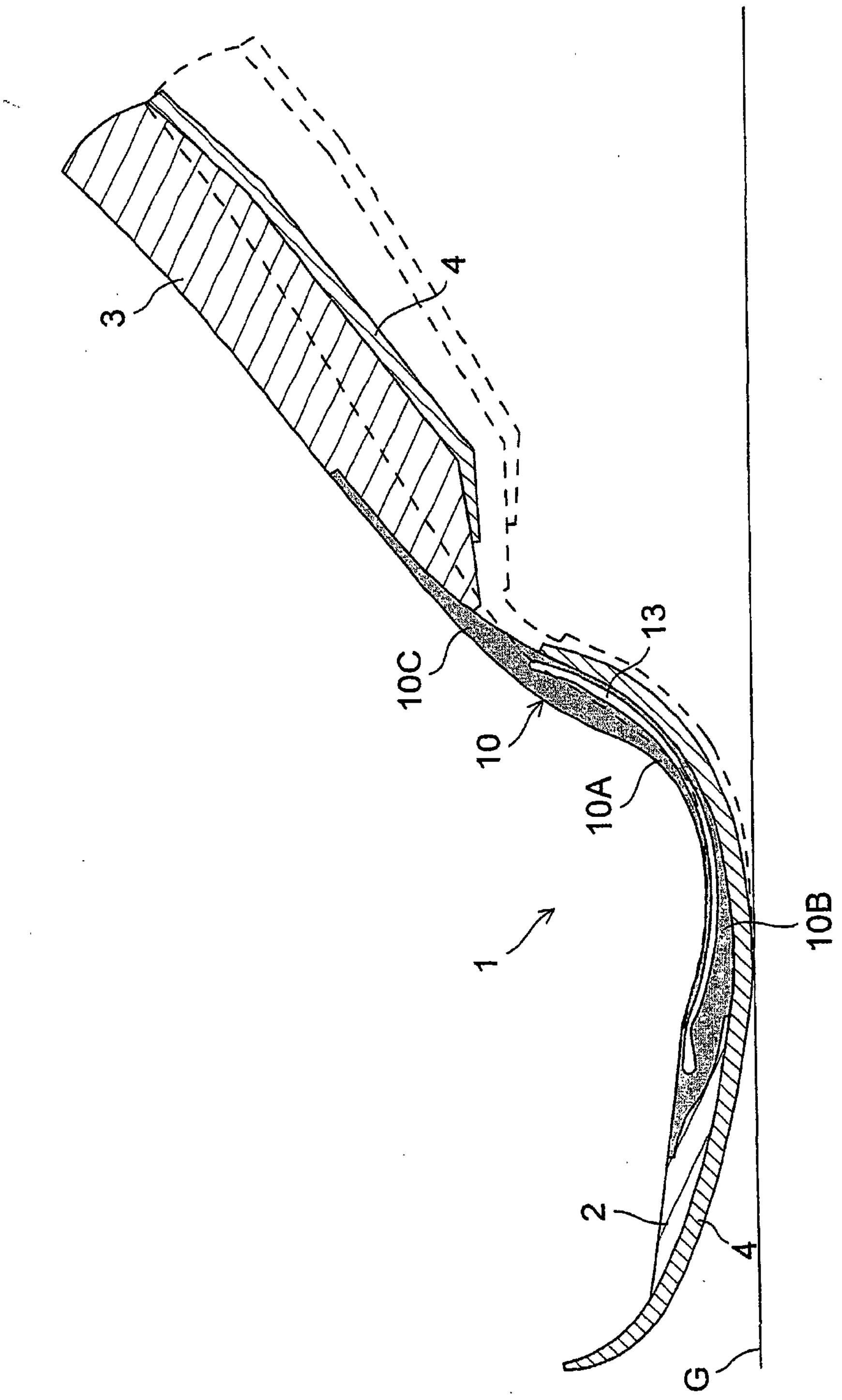


FIG. 6

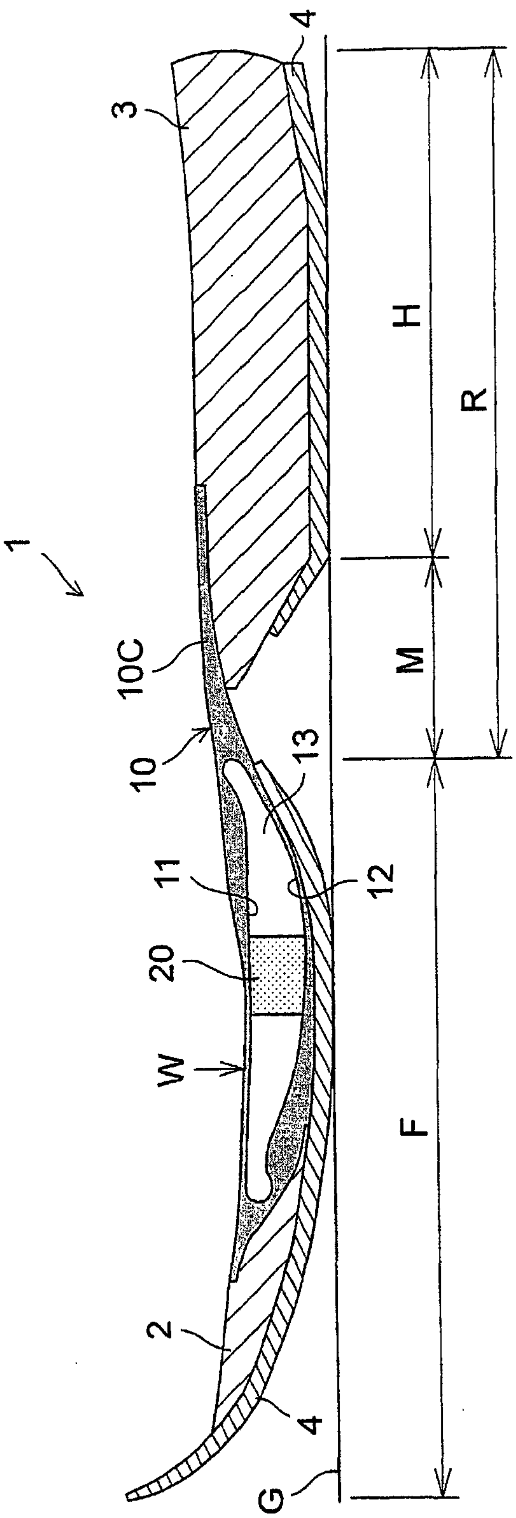


FIG. 7

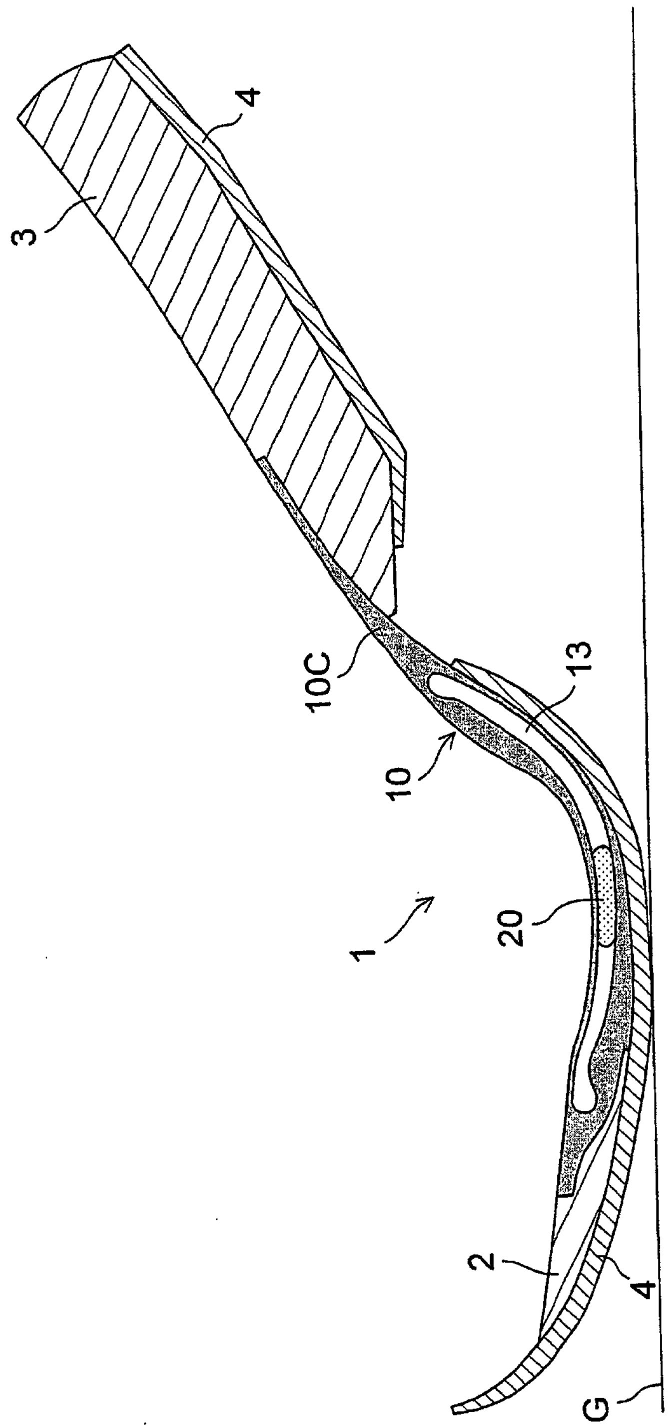


FIG. 8

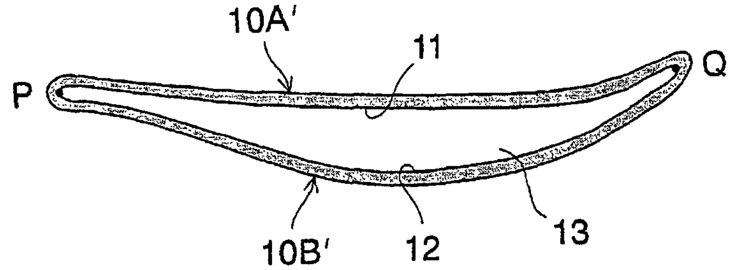


FIG. 9A

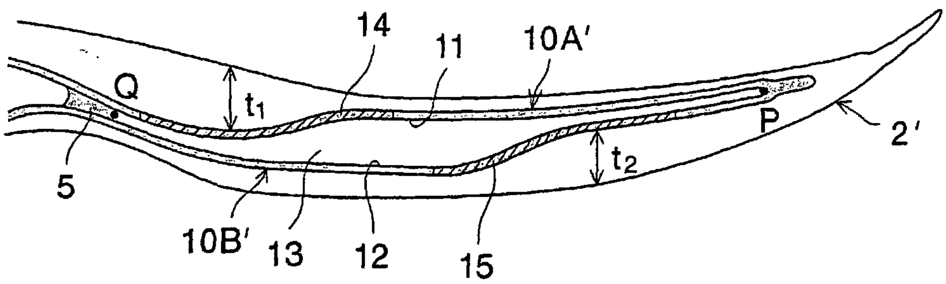


FIG. 9B

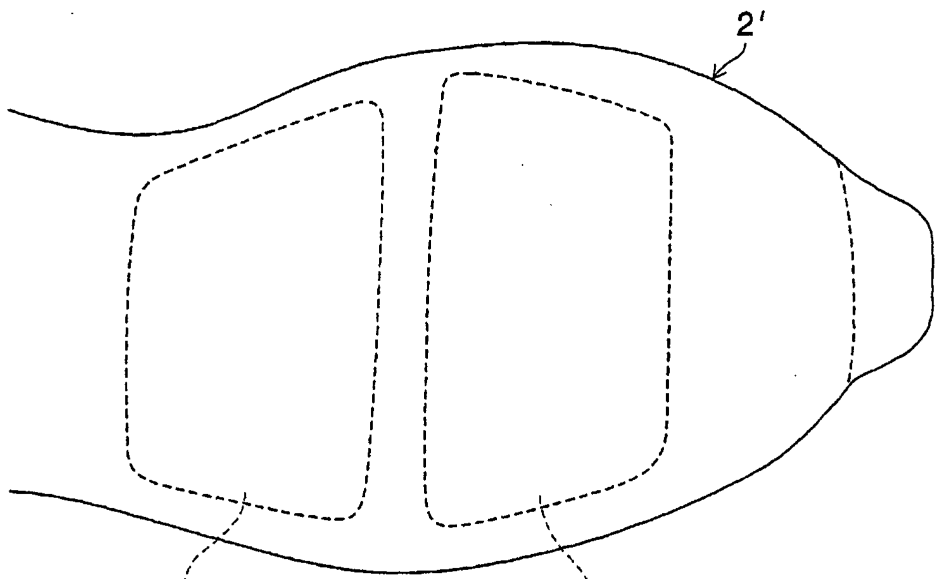


FIG. 10A

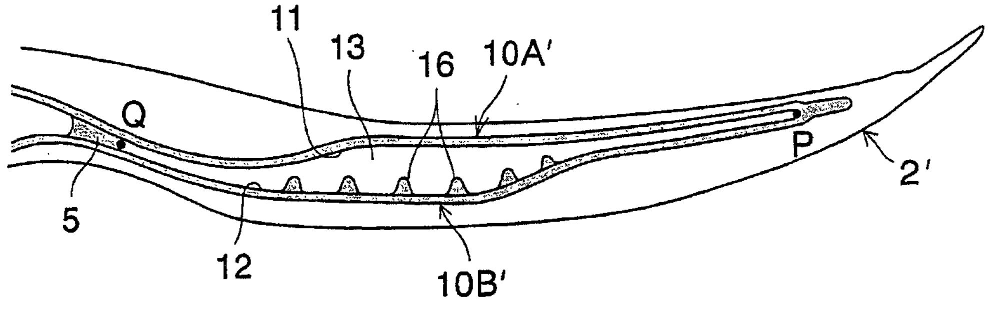


FIG. 10B

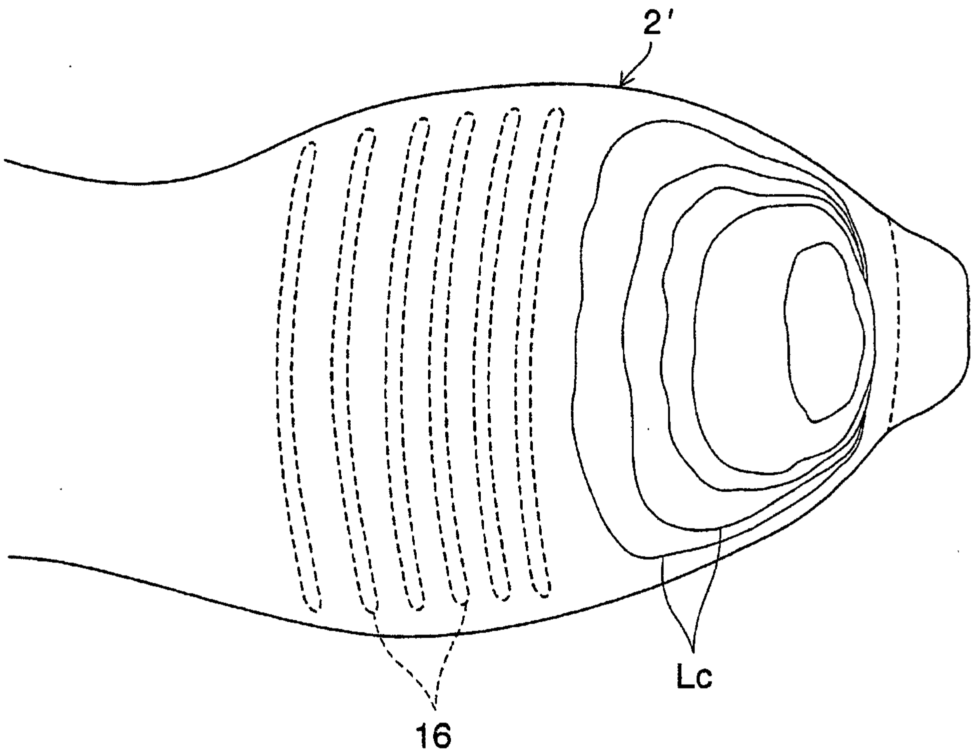


FIG. 10C

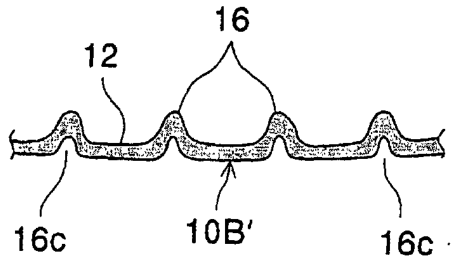


FIG. 11A

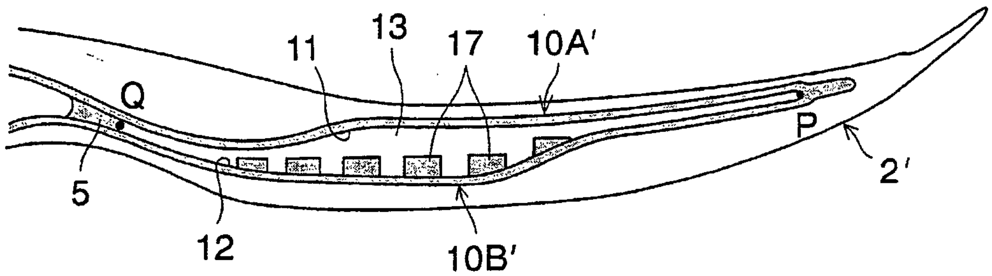


FIG. 11B

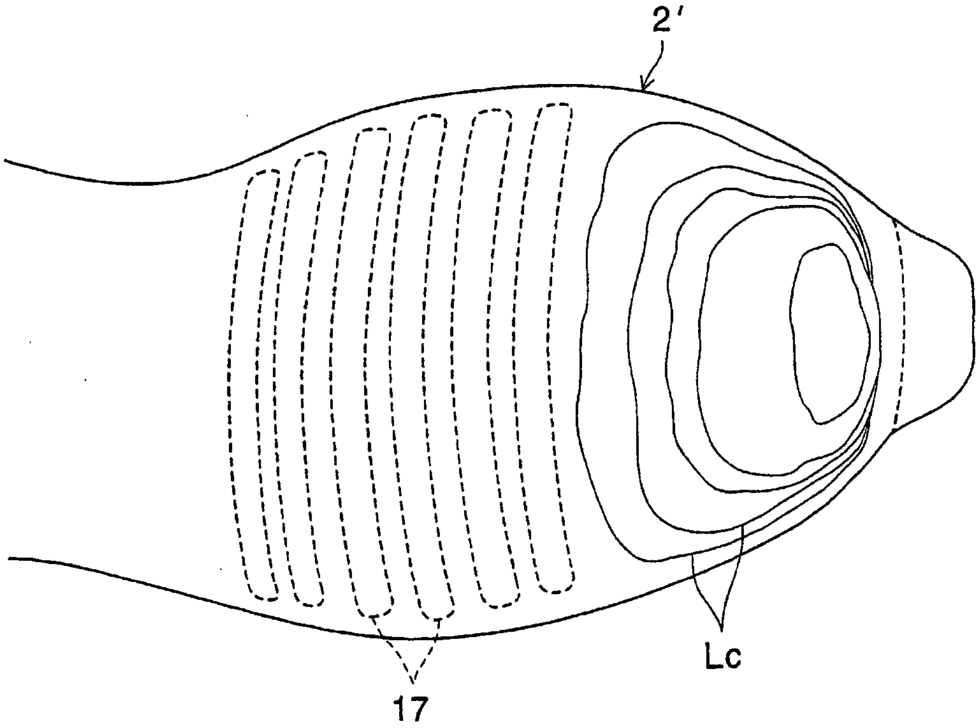


FIG. 12A

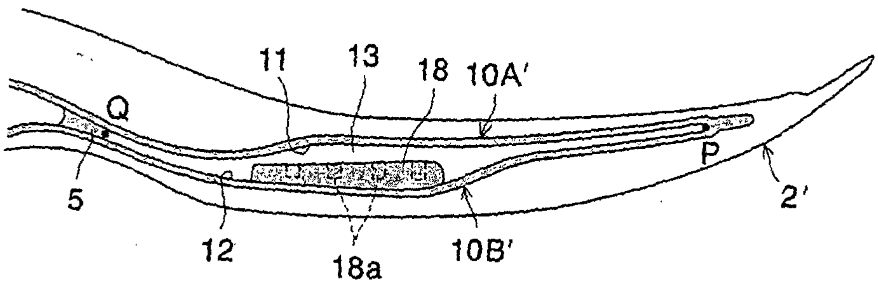


FIG. 12B

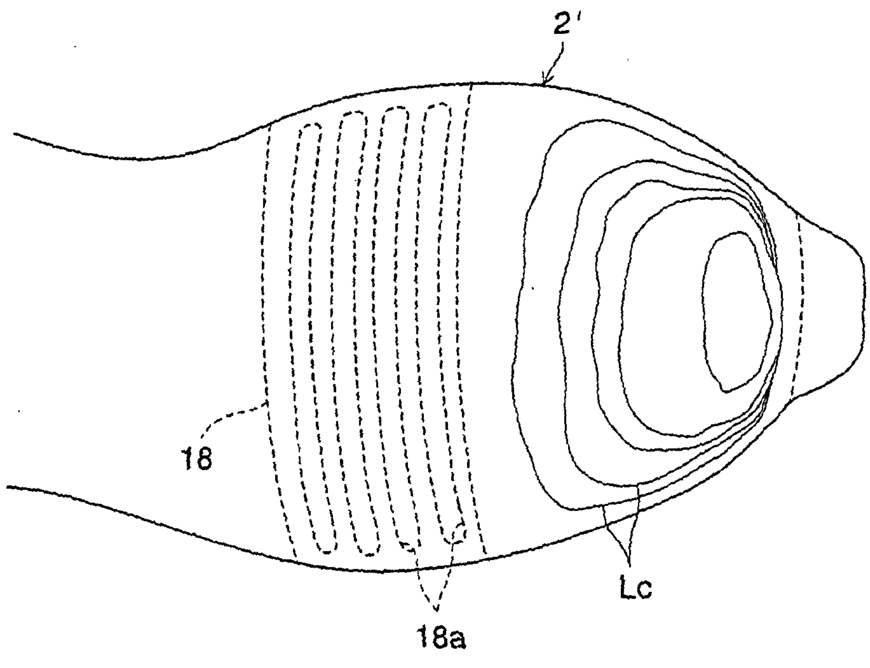


FIG. 13

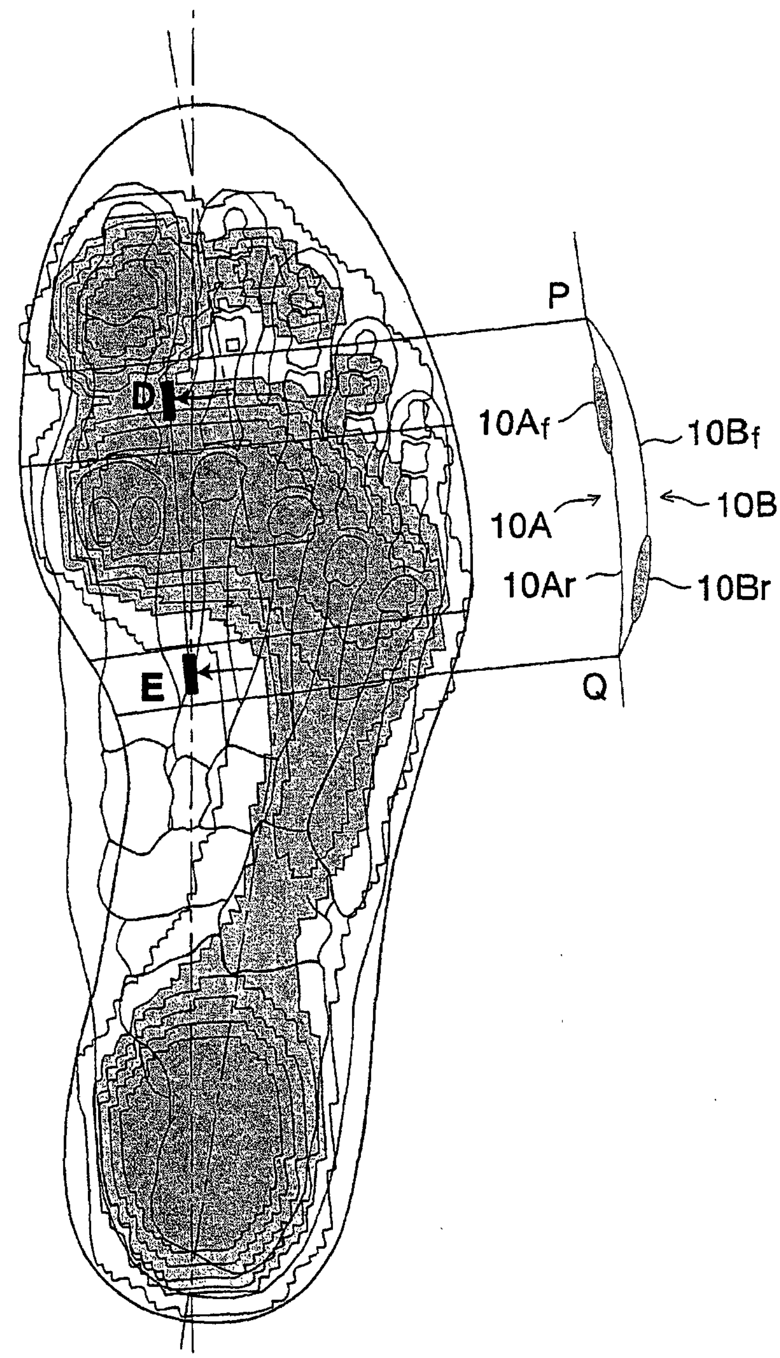


FIG. 14

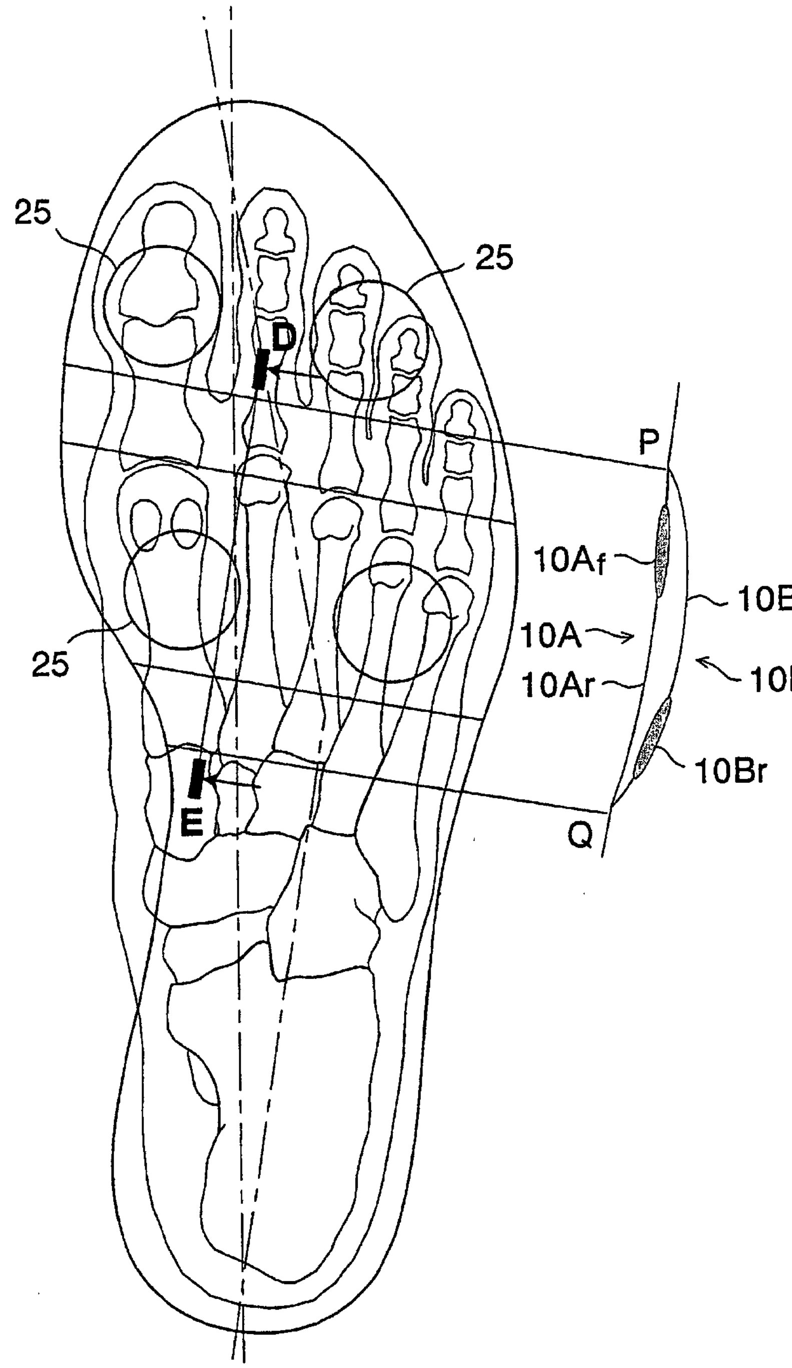


FIG. 15

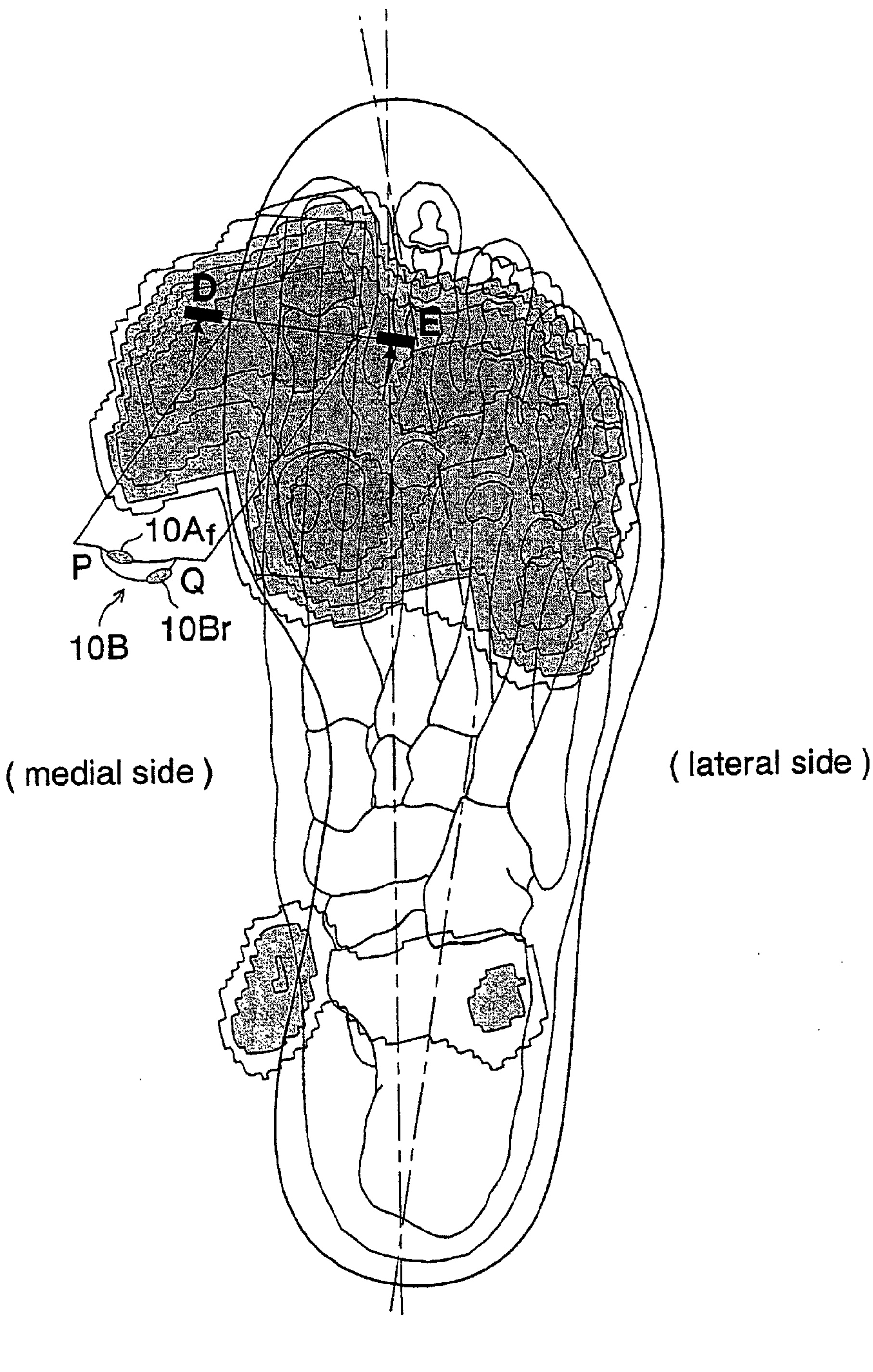
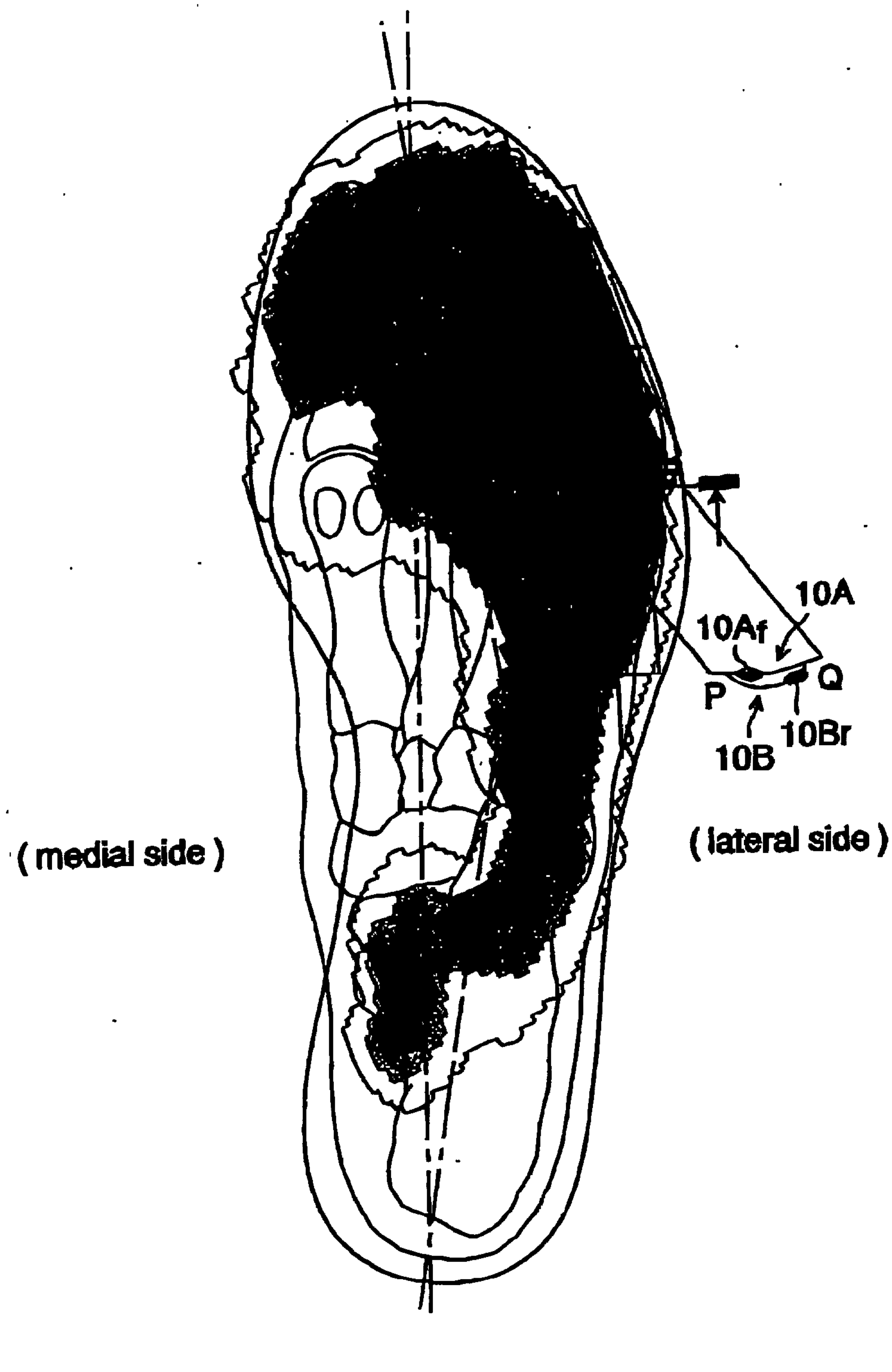


FIG. 16



European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 04 25 3346

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	US 4 910 884 A (SUTTON FRED A ET AL) 27 March 1990 (1990-03-27)	12	A43B13/14 A43B13/12 A43B13/16
A	* column 2, line 47 - line 63; figure 1 *	1,14	
A	EP 1 127 504 A (MIZUNO KK) 29 August 2001 (2001-08-29) * paragraph [0031]; figures 2-4 *	1,12,14	
A	US 4 237 625 A (COLE GEORGE S ET AL) 9 December 1980 (1980-12-09) * figures 1,5 *	1,12,14	

TECHNICAL FIELDS SEARCHED (Int.Cl.7)

A43B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	2 September 2004	Vesin, S

CATEGORY OF CITED DOCUMENTS

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 04 25 3346

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02-09-2004

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82