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(54) **SHOE WITH NATURALLY CONTOURED SOLE**

SCHUH MIT NATÜRLICH PROFILIERTER SOHLE

CHAUSSURE A SEMELLE PROFILEE NATURELLEMENT

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EP 0 424 471 B1

Description

Background of the Invention

This invention relates to a shoe, such as a street shoe, athletic shoe, and especially a running shoe, with a contoured sole. More particularly, this invention relates to a novel contoured sole design for a shoe which improves the inherent stability and efficient motion of the load bearing shod foot in extreme lateral motion. Still more particularly, this invention relates to a shoe wherein the shoe sole has a side portion or portions that conform to the natural shape of the foot, particularly the sides. Finally, this invention relates to a shoe sole with sole portions and contoured side portions that have a constant thickness, when measured in frontal plane cross sections, permitting the foot to react naturally with the ground as it would if the foot were bare, while continuing to protect and cushion the foot.

By way of introduction, barefoot populations universally have a very low incidence of running "overuse" injuries, despite very high activity levels. In contrast, such injuries are very common in shoe shod populations, even for activity levels well below "overuse". Thus, it is a continuing problem with a shod population to reduce or eliminate such injuries and to improve the cushioning and protection for the foot. It is primarily to an understanding of the reasons for such problems and to proposing a novel solution according to the invention to which this improved shoe is directed.

A wide variety of designs are available for running shoes which are intended to provide stability, but which lead to a constraint in the natural efficient motion of the foot and ankle. However, such designs which can accommodate free, flexible motion in contrast create a lack of control or stability. A popular existing shoe design incorporates an inverted, outwardly-flared shoe sole wherein the ground engaging surface is wider than the heel engaging portion. However, such shoes are unstable in extreme situations because the shoe sole, when inverted or on edge, immediately becomes supported only by the sharp bottom sole edge where the entire weight of the body, multiplied by a factor of approximately three at running peak, is concentrated. Since an unnatural lever arm and force moment are created under such conditions, the foot and ankle are destabilized and, in the extreme, beyond a certain point of rotation about the pivot point of the shoe sole edge, forcibly cause ankle strain. In contrast, the unshod foot is always in stable equilibrium without a comparable lever arm or force moment and, at its maximum range of inversion motion, about 20°, the base of support on the barefoot heel actually broadens substantially as the calcaneal tuberosity contacts the ground. This is in contrast to the conventionally available shoe sole bottom which maintains a sharp, unstable edge.

Existing running shoes interfere with natural foot and ankle biomechanics, disrupting natural stability and efficient natural motion. They do so by altering the natu-

ral position of the foot relative to the ground, during the load-bearing phase of running or walking. The foot in its natural, bare state is in direct contact with the ground, so its relative distance from the ground is obviously constant at zero. Even when the foot tilts naturally from side to side, either moderately when running or extremely when stumbling or tripping, the distance always remains constant at zero.

In contrast, existing shoes maintain a constant distance from the ground - the thickness of the shoe sole - only when they are perfectly flat on the ground. As soon as the shoe is tilted, the distance between foot and ground begins to change unnaturally, as the shoe sole pivots around the outside corner edge. With conventional athletic shoes, the distance most typically increases at first due to the flared sides and then decreases; many street shoes with relatively wide heel width follow that pattern, though some with narrower heels only decrease. All existing shoes continue to decrease the distance all the way down to zero, by tilting through 90 degrees, resulting in ankle sprains and breaks.

A corrected shoe sole design, however, avoids such unnatural interference by neutrally maintaining a constant distance between foot and ground, even when the shoe is tilted sideways, as if in effect the shoe sole were not there except to cushion and protect. Unlike existing shoes, the corrected shoe would move with the foot's natural sideways pronation and supination motion on the ground. To the problem of using a shoe sole to maintain a naturally constant distance during that sideways motion, there are two possible geometric solutions, depending upon whether just the lower horizontal plane of the shoe sole surface varies to achieve natural contour or both upper and lower surface planes vary.

In the two plane solution, the naturally contoured design, which is the subject of this application and will be described in Figures 1-28, both upper and lower surfaces or planes of the shoe sole vary to conform to the natural contour of the human foot. The two plane solution is the most fundamental concept and naturally most effective. It is the only pure geometric solution to the mathematical problem of maintaining constant distance between foot and ground, and the most optimal, in the same sense that round is only shape for a wheel and perfectly round is most optimal. On the other hand, it is the least similar to existing designs of the two possible solutions and requires computer aided design and injection molding manufacturing techniques.

CA-A-1 176 458 shows footwear with an outsole, particularly constructed for anti-skid characteristics on an ice surface, with a contoured side portion that does not maintain the same thickness as the underneath sole portion, when measured in frontal plane cross sections.

It is thus an overall objective of this invention to provide a novel shoe design which approximates the barefoot. It has been discovered, by investigating the most extreme range of ankle motion to near the point of ankle sprain, that the abnormal motion of an inversion ankle

sprain, which is a tilting to the outside or an outward rotation of the foot, is accurately simulated while stationary. With this observation, it can be seen that the extreme range stability of the conventionally shod foot is distinctly inferior to the barefoot and that the shoe itself creates a gross instability which would otherwise not exist.

Even more important, a normal barefoot running motion, which approximately includes a 7° inversion and a 7° eversion motion, does not occur with shod feet, where a 30° inversion and eversion is common. Such a normal barefoot motion is geometrically unattainable because the average running shoe heel is approximately 60% larger than the width of the human heel. As a result, the shoe heel and the human heel cannot pivot together in a natural manner; rather, the human heel has to pivot within the shoe but is resisted from doing so by the shoe heel counter, motion control devices, and the lacing and binding of the shoe upper, as well as various types of anatomical supports interior to the shoe.

Thus, it is an overall objective to provide an improved shoe design which is not based on the inherent contradiction present in current shoe designs which make the goals of stability and efficient natural motion incompatible and even mutually exclusive. It is another overall object of the invention to provide a new contour design which simulates the natural barefoot motion in running and thus avoids the inherent contradictions in current designs.

It is another objective of this invention to provide a running shoe which overcomes the problem of the prior art.

It is another objective of this invention to provide a shoe wherein the outer extent of the flat portion of the sole of the shoe includes all of the support structures of the foot but which extends no further than the outer edge of the flat portion of the foot sole so that the horizontal plane outline of the top of the flat portion of the shoe sole coincides as nearly as possible with the load-bearing portion of the foot sole.

It is another objective of the invention to provide a shoe having a sole which includes a side contoured like the natural form of the side or edge of the human foot and conforming to it.

It is another objective of this invention to provide a novel shoe structure in which the contoured sole includes a shoe sole thickness that is precisely constant in the side portions and contoured side portions, when measured in frontal plane cross sections, and therefore biomechanically neutral, even if the shoe sole is tilted to either side, or forward or backward.

It is another objective of this invention to provide a shoe having a sole fully contoured like and conforming to the natural form of the non-load-bearing human foot and deforming under load by flattening just as the foot does.

It is still another objective of this invention to provide a new stable shoe design wherein the heel lift or wedge increases in the sagittal plane the thickness of the shoe

sole or toe taper decrease therewith so that the sides of the shoe sole which naturally conform to the sides of the foot also increase or decrease by exactly the same amount, so that the thickness of the shoe sole in a frontal planar cross section is always constant.

It is another objective of this invention to provide a shoe having a shoe having a naturally contoured design as described wherein the sides of the shoe are abbreviated to essential structural support and propulsion elements to provide flexibility and in which the density of the shoe sole may be increased to compensate for increased loading.

It is another objective of this invention to provide a shoe sole design which includes a plurality of freely articulating essential structural support elements in the sole of the shoe which are consistent with the sole of the foot and are free to move independently of each other to follow the motion of the freely articulating bone structures of the foot.

It is still another object of this invention to provide a shoe of the type described wherein the material of the sole is removed except beneath essential structural support elements of the foot.

It is another object of this invention to provide a shoe of the type described with treads having an outer or a base surface which follows the theoretically ideal stability plane.

It is yet another overall object of this invention to provide a shoe construction having a design defined by the natural shape of an unloaded foot and which deforms upon loading to approximate at least the theoretically ideal stability plane.

It is still another object of this invention to provide a shoe construction wherein a plot of the range of inversion and eversion motion defines a curve with substantially no vertical component variation over a range of at least 40 degrees.

It is still another object of this invention to provide a shoe having a sole edge surface which terminates in a laterally extending portion made from a flexible material and structured to terminate upon loading in a position which approximates or is in parallel with the theoretically ideal stability plane.

It is yet another object of this invention to provide a shoe with a plurality of frontal plane slits located at predetermined locations in said shoe sole.

It is still another objective of this invention to provide a correct method of measuring the thickness of shoe sole contours.

It is another objective of the invention to provide a shoe having a sole which includes a rounded sole edge contoured like the natural form of the side or edge of the human foot but in a geometrically precise manner so that the shoe sole thickness is precisely constant, even if the shoe sole is tilted to either side, or forward or backward.

It is still another object of this invention to provide a shoe sole of the type described wherein the bottom or outer sole of the shoe includes most or all of the special

contours of the new design, while other portions of the shoe such as the midsole and heel lift are produced conventionally.

It is still another object of this invention to provide a shoe of the type described which further includes enhancements which are included in the structure which defines the theoretically ideal stability plane.

It is still another object of this invention to provide a shoe of the type described wherein the enhancements which are included in the structure which defines the theoretically ideal stability plane are applied to the dual-plane embodiments of the invention as here described.

These and other objectives of the invention are achieved by claim 1 and will become apparent from a detailed description of the invention which follows taken in conjunction with the accompanying drawings. Preferred embodiments are subjects of the dependent claims.

Brief Description of the Drawings

In the drawings:

Fig. 1 is a perspective view of a typical running shoe known to the prior art to which the invention is applicable;

Fig. 2 shows, in Figs. 2A and 2B, the obstructed natural motion of the shoe heel in frontal planar cross section rotating inwardly or outwardly with the shoe sole having a flared bottom in a conventional prior art design such as in Fig. 1; and in Figs. 2C and 2D, the efficient motion of a narrow rectangular shoe sole design;

Fig. 3 is a frontal plane cross section showing a shoe sole of uniform thickness that conforms to the natural shape of the human foot, the novel shoe design according to the invention;

Fig. 4 shows, in Figs. 4A-4D, a load-bearing flat component of a shoe sole and naturally contoured stability side component, as well as a preferred horizontal periphery of the flat load-bearing portion of the shoe sole when using the sole of the invention;

Fig. 5 is diagrammatic sketch in Figs. 5A and 5B, showing the novel contoured side sole design according to the invention with variable heel lift;

Fig. 6 is a side view of the novel stable contoured shoe according to the invention showing the contoured side design;

Fig. 7D is a top view of the shoe sole shown in Fig. 6, wherein Fig. 7A is a cross-sectional view of the forefoot portion taken along lines 7A of Figs. 6 or 7;

Fig. 7B is a view taken along lines 7B of Figs. 6 and 7; and Fig. 7C is a cross-sectional view taken along the heel along lines 7C in Figs. 6 and 7;

Fig. 8 is a drawn comparison between a conventional flared sole shoe of the prior art and the contoured shoe sole design according to the invention;

Fig. 9 shows, in Figs. 9A-9C, the extremely stable conditions for the novel shoe sole according to the

invention in its neutral and extreme situations;

Fig. 10 is a side cross-sectional view of the naturally contoured sole side showing in Fig. 10A how the sole maintains a constant distance from the ground during rotation of the shoe edge; and showing in Fig. 10B how a conventional shoe sole side cannot maintain a constant distance from the ground.

Fig. 11 shows, in Figs. 11A-11E, a plurality of side sagittal plane cross-sectional views showing examples of conventional sole thickness variations to which the invention can be applied;

Fig. 12 shows, in Figs. 12A-12D, frontal plane cross-sectional views of the shoe sole according to the invention showing a theoretically ideal stability plane and truncations of the sole side contour to reduce shoe bulk;

Fig. 13 shows, in Figs. 13A-13C, the contoured sole design according to the invention when applied to various tread and cleat patterns;

Fig. 14 illustrates, in a rear view, an application of the sole according to the invention to a shoe to provide an aesthetically pleasing and functionally effective design;

Fig. 15 shows a fully contoured shoe sole design that follows the natural contour of the bottom of the foot as well as the sides.

Fig. 16 is a diagrammatic frontal plane cross-sectional view of static forces acting on the ankle joint and its position relative to the shoe sole according to the invention during normal and extreme inversion and eversion motion.

Fig. 17 is a diagrammatic frontal plane view of a plurality of moment curves of the center of gravity for various degrees of inversion for the shoe sole according to the invention, and contrasted to the motions shown in Fig. 2;

Fig. 18 shows, in Figs. 18A and 18B, a rear diagrammatic view of a human heel, as relating to a conventional shoe sole (Fig. 18A) and to the sole of the invention (Fig. 18B);

Fig. 19 shows the naturally contoured sides design extended to the other natural contours underneath the load-bearing foot such as the main longitudinal arch;

Fig. 20 illustrates the fully contoured shoe sole design extended to the bottom of the entire non-loadbearing foot;

Fig. 21 shows the fully contoured shoe sole design abbreviated along the sides to only essential structural support and propulsion elements;

Fig. 22 illustrates the application of the invention to provide a street shoe with a correctly contoured sole according to the invention and side edges perpendicular to the ground, as is typical of a street shoe;

Fig. 23 shows a method of establishing the theoretically ideal stability plane using a perpendicular to a tangent method;

Fig. 24 shows a circle radius method of establishing the theoretically ideal stability plane.

Fig. 25 illustrates an alternate embodiment of the invention wherein the sole structure deforms in use to follow a theoretically ideal stability plane according to the invention during deformation;

Fig. 26 shows an embodiment wherein the contour of the sole according to the invention is approximated by a plurality of line segments;

Fig. 27 illustrates an embodiment wherein the stability sides are determined geometrically as a section of a ring; and

Fig. 28 shows a shoe sole design that allows for unobstructed natural eversion/inversion motion by providing torsional flexibility in the instep area of the shoe sole.

Fig. 29 shows several embodiments wherein the bottom sole includes most or all of the special contours of the new designs and retains a flat upper surface.

Fig. 30 shows, in Figs. 30A - 30C, an enhancement applied to the naturally contoured sides embodiment of the invention.

Detailed Description of the Preferred Embodiment

A perspective view of an athletic shoe, such as a typical running shoe, according to the prior art, is shown in Fig. 1 wherein a running shoe 20 includes an upper portion 21 and a sole 22. Typically, such a sole includes a truncated outwardly flared construction of the type best seen in Fig. 2 wherein the lower portion 22a of the sole heel is significantly wider than the upper portion 22b where the sole 22 joins the upper 21. A number of alternative sole designs are known to the art, including the design shown in U.S. Patent No. 4,449,306 to Cavanagh wherein an outer portion of the sole of the running shoe includes a rounded portion having a radius of curvature of about 20mm. The rounded portion lies along approximately the rear-half of the length of the outer side of the midsole and heel edge areas wherein the remaining border area is provided with a conventional flaring with the exception of a transition zone. The U.S. Patent to Misevich, No. 4,557,059 also shows an athletic shoe having a contoured sole bottom in the region of the first foot strike, in a shoe which otherwise uses an inverted flared sole.

In such prior art designs, and especially in athletic and in running shoes, the typical design attempts to achieve stability by flaring the heel as shown in Figs. 2A and 2B to a width of, for example, 3 to 3-1/2 inches on the bottom outer sole 22a of the average male shoe size (10D). On the other hand, the width of the corresponding human heel foot print, housed in the upper 21, is only about 2.25 in. for the average foot. Therefore, a mismatch occurs in that the heel is locked by the design into a firm shoe heel counter which supports the human heel by holding it tightly and which may also be reinforced by motion control devices to stabilize the heel.

Thus, for natural motion as is shown in Figs. 2A and 2B, the human heel would normally move in a normal range of motion of approximately 15°, but as shown in Figs. 2A and 2B the human heel cannot pivot except within the shoe and is resisted by the shoe. Thus, Fig. 2A illustrates the impossibility of pivoting about the center edge of the human heel as would be conventional for barefoot support about a point 23 defined by a line 23a perpendicular to the heel and intersecting the bottom edge of upper 21 at a point 24. The lever arm force moment of the flared sole is at a maximum at 0° and only slightly less at a normal 7° inversion or eversion and thus strongly resists such a natural motion as is illustrated in Figs. 2A and 2B. In Fig. 2A, the outer edge of the heel must compress to accommodate such motion. Fig. 2B illustrates that normal natural motion of the shoe is inefficient in that the center of gravity of the shoe, and the shod foot, is forced upwardly, as discussed later in connection with Fig. 17.

A narrow rectangular shoe sole design of heel width approximating human heel width is also known and is shown in Figs. 2C and 2D. It appears to be more efficient than the conventional flared sole shown in Figs. 2A and 2B. Since the shoe sole width is the same as human sole width, the shoe can pivot naturally with the normal 7° inversion/eversion motion of the running barefoot. In such a design, the lever arm length and the vertical motion of the center of gravity are approximately half that of the flared sole at a normal 7° inversion/eversion running motion. However, the narrow, human heel width rectangular shoe design is extremely unstable and therefore prone to ankle sprain, so that it has not been well received. Thus, neither of these wide or narrow designs is satisfactory.

Fig. 3 shows in a frontal plane cross section at the heel (center of ankle joint) the general concept of the applicant's design: a shoe sole 28 that conforms to the natural shape of the human foot 27 and that has a constant thickness (s) in frontal plane cross sections. The surface 29 of the bottom and sides of the foot 27 should correspond exactly to the upper surface 30 of the shoe sole 28. The shoe sole thickness as measured in frontal plane cross sections is defined as the shortest distance (s) between any point on the upper surface 30 of the shoe sole 28 and the lower surface 31 by definition, the surfaces 30 and 31 are consequently parallel (Figs. 23 and 24 will discuss measurement methods more fully). In effect, the applicant's general concept is a shoe sole 28 that wraps around and conforms to the natural contours of the foot 27 as if the shoe sole 28 were made of a theoretical single flat sheet of shoe sole material of uniform thickness, wrapped around the foot with no distortion or deformation of that sheet as it is bent to the foot's contours. To overcome real world deformation problems associated with such bending or wrapping around contours, actual construction of the shoe sole contours of uniform thickness will preferably involve the use of multiple sheet lamination or injection molding techniques.

Figs. 4A, 4B, and 4C illustrate in frontal plane cross section a significant element of the applicant's shoe design in its use of naturally contoured stabilizing sides 28a at the outer edge 28b of a shoe sole 28 illustrated generally at the reference numeral 28. It is thus a main feature of the applicant's invention to eliminate the unnatural sharp bottom edge, especially of flared shoes, in favor of a naturally contoured shoe sole outside 31 as shown in Fig. 3. The side or inner edge 30a of the shoe sole stability side 28a is contoured like the natural form on the side or edge of the human foot, as is the outside or outer edge 31a of the shoe sole stability side 28a to follow a theoretically ideal stability plane. According to the invention, the thickness (s) of the shoe sole 28 is maintained exactly constant, even if the shoe sole is tilted to either side, or forward or backward. Thus, the naturally contoured stabilizing sides 28a, according to the applicant's invention, are defined as the same as the thickness 33 of the shoe sole 28 so that, in cross section, the shoe sole comprises a stable shoe sole 28 having at its outer edge naturally contoured stabilizing sides 28a with a surface or outer edge 31a representing a portion of a theoretically ideal stability plane and described by naturally contoured sides equal to the thickness (s) of the sole 28. The top of the shoe sole 30b coincides with the shoe wearer's load-bearing footprint, since in the case shown the shape of the foot is assumed to be load-bearing and therefore flat along the bottom. A top edge 32 of the naturally contoured stability side 28a can be located at any point along the contoured side 29 of the foot, while the inner edge 33 of the naturally contoured side 28a coincides with the perpendicular sides 34 of the load-bearing portions 28b of the shoe sole 28. In practice, the shoe sole 28 is preferably integrally formed from the portions 28b and 28a. Thus, the theoretically ideal stability plane includes the contours 31a merging into the lower surface 31b of the sole 28.

Preferably, the peripheral extent 36 of the load-bearing portion of the sole 28b of the shoe includes all of the support structures of the foot but extends no further than the outer edge of the foot sole 37 as defined by a load-bearing footprint, as shown in Fig. 4D, which is a top view of the upper shoe sole surface 30b. Fig. 4D thus illustrates a foot outline at numeral 37 and a recommended sole outline 36 relative thereto. Thus, a horizontal plane outline of the top of the load-bearing portion of the shoe sole, therefore exclusive of contoured stability sides, should, preferably, coincide as nearly as practicable with the load-bearing portion of the foot sole with which it comes into contact. Such a horizontal outline, as best seen in Figs. 4D and 7D, should remain uniform throughout the entire thickness of the shoe sole eliminating negative or positive sole flare so that the sides are exactly perpendicular to the horizontal plane as shown in Fig. 4B. Preferably, the density of the shoe sole material is uniform.

Another significant feature of the applicant's invention is illustrated diagrammatically in Fig. 5. Preferably,

as the heel lift or wedge 38 of thickness (s1) increases the total thickness (s + s1) of the combined mid-sole and outsole 39 of thickness (s) in an aft direction of the shoe, the naturally contoured sides 28a increase in thickness exactly the same amount according to the principles discussed in connection with Fig. 4. Thus, according to the applicant's design, the thickness of the inner edge 33 of the naturally contoured side is always equal to the constant thickness (s) of the load-bearing shoe sole 28b in the frontal cross-sectional plane.

As shown in Fig. 5B, for a shoe that follows a more conventional horizontal plane outline, the sole can be improved significantly according to the applicant's invention by the addition of a naturally contoured side 28a which correspondingly varies with the thickness of the shoe sole and changes in the frontal plane according to the shoe heel lift 38. Thus, as illustrated in Fig. 5B, the thickness of the naturally contoured side 28a in the heel section is equal to the thickness (s + s1) of the shoe sole 28 which is thicker than the shoe sole 39 thickness (s) shown in Fig. 5A by an amount equivalent to the heel lift 38 thickness (s1). In the generalized case, the thickness (s) of the shoe contoured side portion is thus always equal to the thickness (s) at the forefoot of the shoe sole portion.

Fig. 6 illustrates a side cross-sectional view of a shoe to which the invention has been applied and is also shown in a top plane view in Fig. 7. Thus, Figs. 7A, 7B and 7C represent frontal plane cross-sections taken along the forefoot, at the base of the fifth metatarsal, and at the heel, thus illustrating that the shoe sole thickness is constant at each frontal plane cross-section, even though that thickness varies from front to back, due to the heel lift 38 as shown in Fig. 6, and that the thickness of the naturally contoured sides is equal to the shoe sole thickness in each Fig. 7A-7C cross section. Moreover, in Fig. 7D, a horizontal plane overview of the left foot, it can be seen that the contour of the sole follows the preferred principle in matching, as nearly as practical, the load-bearing sole print shown in Fig. 4D.

Fig. 8 thus contrasts in frontal plane cross section the conventional flared sole 22 shown in phantom outline and illustrated in Fig. 2 with the contoured shoe sole 28 according to the invention as shown in Figs. 3-7.

Fig. 9 is suitable for analyzing the shoe sole design according to the applicant's invention by contrasting the neutral situation shown in Fig. 9A with the extreme tilting situations shown in Figs. 9B and 9C. Unlike the sharp sole edge of a conventional shoe as shown in Fig. 2, the effect of the applicant's invention having a naturally contoured side 28a is totally neutral allowing the shod foot to react naturally with the ground 43, in either an inversion or eversion mode. This occurs in part because of the unvarying thickness along the shoe sole edge which keeps the foot sole equidistant from the ground in a preferred case. Moreover, because the shape of the outer surface 31a of the shoe contoured side 28a is exactly like that of the edge of the foot, the shoe is enabled to react naturally with the ground in a manner as closely as

possible simulating the foot. Thus, in the neutral position shown in Fig. 9, any point 40 on the top surface 30b of the shoe sole 30 closest to ground lies at a distance (s) from the ground surface 43. That distance (s) remains constant even for extreme situations as seen in Figs. 9B and 9C.

A main point of the applicant's invention, as is illustrated in Figs. 9B and 9C, is that the design shown is stable in an in extremis situation. The theoretically ideal plane of stability is where the stability plane is defined as sole thickness which is constant under all load-bearing points of the foot sole for any amount from 0° to 90° rotation of the sole to either side or front and back. In other words, as shown in Fig. 9, if the shoe is tilted from 0° to 90° to either side or from 0° to 90° forward or backward representing a 0° to 90° foot dorsiflexion or 0° to 90° plantarflexion, the foot will remain stable because the sole thickness (s) between the foot and the ground always remain constant because of the exactly contoured sides. By remaining a constant distance from the ground, the stable shoe allows the foot to react to the ground as if the foot were bare while allowing the foot to be protected and cushioned by the shoe. In its preferred embodiment, the new naturally contoured sides will effectively position and hold the foot onto the load-bearing foot print section of the shoe sole, reducing or eliminating the need for heel counters and other relatively rigid motion control devices.

Fig. 10A illustrates how the inner edge 30a of the naturally contoured sole side 28a is maintained at a constant distance (s) from the ground through various degrees of rotation of the edge 31a of the shoe sole such as is shown in Fig. 9. Figure 10B shows how a conventional shoe sole pivots around its lower edge 42, which is its center of rotation, instead of around the upper edge 40, which, as a result, is not maintained at constant distance (s) from the ground, as with the invention, but is lowered to .7(s) at 45° rotation and to zero at 90° rotation.

Fig. 11 shows typical conventional sagittal plane shoe sole thickness variations, such as heel lifts or wedges 38, or toe taper 38a, or full sole taper 38b, in Figs. 11A-11E and how the naturally contoured sides 28a equal and therefore vary with those varying thicknesses as discussed in connection with Fig. 5.

Fig. 12 illustrates an embodiment of the invention which utilizes varying portions of the theoretically ideal stability plane 51 in the naturally contoured sides 28a in order to reduce the weight and bulk of the sole, while accepting a sacrifice in some stability of the shoe. Thus, Fig. 12A illustrates the preferred embodiment as described above in connection with Fig. 5 wherein the outer edge 31a of the naturally contoured sides 28a follows a theoretically ideal stability plane 51. As in Figs. 3 and 4, the contoured surfaces 31a, and the lower surface 31b of the sole 28 lie along the theoretically ideal stability plane 51. The theoretically ideal stability plane 51 is defined as the plane of the surface of the bottom or lower surface 31b of the shoe sole, wherein the shoe

sole 28 conforms to the natural shape of the wearer's foot sole particularly the sides, and has a constant thickness in frontal plane cross sections. As shown in Fig. 12B, an engineering trade-off results in an abbreviation within the theoretically ideal stability plane 51 by forming a naturally contoured side surface 53a approximating the natural contour of the foot (or more geometrically regular, which is less preferred) at an angle relative to the upper plane of the shoe sole 28 so that only a smaller portion of the contoured side 28a defined by the constant thickness lying along the contoured surface 31a is coplanar with the theoretically ideal stability plane 51. Figs. 12C and 12D show similar embodiments wherein each engineering trade-off shown results in progressively smaller portions of contoured side 28a, which lies along the theoretically ideal stability plane 51. The portion of the contoured surface 31a merges into the upper side surface 53a of the naturally contoured side.

The embodiment of Fig. 12 may be desirable for portions of the shoe sole which are less frequently used so that the additional part of the side is used less frequently. For example, a shoe may typically roll out laterally, in an inversion mode, to about 20° on the order of 100 times for each single time it rolls out to 40°. For a basketball shoe, shown in Fig. 12B, the extra stability is needed. Yet, the added shoe weight to cover that infrequently experienced range of motion is about equivalent to covering the frequently encountered range. Since, in a racing shoe this weight might not be desirable, an engineering trade-off of the type shown in Fig. 12D is possible. A typical running/jogging shoe is shown in Fig. 12C. The range of possible variations is limitless, but includes at least the maximum of 90° in inversion or eversion, as shown here in Fig. 12A and at least 120°, as shown previously in Fig. 3.

Fig. 13 shows the theoretically ideal stability plane 51 in defining embodiments of the shoe sole having differing tread or cleat patterns. Thus, Fig. 13 illustrates that the invention is applicable to shoe soles having conventional bottom treads. Accordingly, Fig. 13A is similar to Fig. 12B further including a tread portion 60, while Fig. 13B is also similar to Fig. 12B wherein the sole includes a cleated portion 61. The surface 63 to which the cleat bases are affixed should preferably be on the same plane and parallel the theoretically ideal stability plane 51, since in soft ground that surface rather than the cleats become load-bearing. The embodiment in Fig. 13C is similar to Fig. 12C showing still an alternative tread construction 62. In each case, the load-bearing outer surface of the tread or cleat pattern 60-62 lies along the theoretically ideal stability plane 51.

Fig. 14 shows, in a rear cross sectional view, the application of the invention to a shoe to produce an aesthetically pleasing and functionally effective design. Thus, a practical design of a shoe incorporating the invention is feasible, even when applied to shoes incorporating heel lifts 38 and a combined midsole and out-

ersole 39. Thus, use of a sole surface and sole outer contour which track the theoretically ideal stability plane does not detract from the commercial appeal of shoes incorporating the invention.

Fig. 15 shows a fully contoured shoe sole design that follows the natural contour of all of the foot, the bottom as well as the sides. The fully contoured shoe sole assumes that the resulting slightly rounded bottom when unloaded will deform under load and flatten just as the human foot bottom is slightly rounded unloaded but flattens under load; therefore, shoe sole material must be of such Composition as to allow the natural deformation following that of the foot. The design applies particularly to the heel, but to the rest of the shoe sole as well. By providing the closest match to the natural shape of the foot, the fully contoured design allows the foot to function as naturally as possible. Under load, Fig. 15 would deform by flattening to look essentially like Fig. 14. Seen in this light, the naturally contoured side design in Fig. 14 is a more conventional, conservative design that is a special case of the more general fully contoured design in Fig. 15, which is the closest to the natural form of the foot, but the least conventional. The amount of deformation flattening used in the Fig. 14 design, which obviously varies under different loads, is not an essential element of the applicant's invention.

Figs. 14 and 15 both show in frontal plane cross section the essential concept underlying this invention, the theoretically ideal stability plane, which is also theoretically ideal for efficient natural motion of all kinds, including running, jogging or walking. Fig. 15 shows the most general case of the invention, the fully contoured design, which conforms to the natural shape of the unloaded foot. For any given individual, the theoretically ideal stability plane 51 is determined, first, by the desired shoe sole thickness (s) in a frontal plane cross section, and, second, by the natural shape of the individual's foot surface 29, to which the theoretically ideal stability plane 51 is by definition parallel.

For the special case shown in Fig. 14, the theoretically ideal stability plane for any particular individual (or size average of individuals) is determined, first, by the given frontal plane cross section shoe sole thickness (s); second, by the natural shape of the individual's foot; and, third, by the frontal plane cross section width of the individual's load-bearing footprint 30b, which is defined as the upper surface of the shoe sole that is in physical contact with and supports the human foot sole, as shown in Fig. 4.

The theoretically ideal stability plane for the special case is composed conceptually of two parts. Shown in Figs. 14 and 4 the first part is a line segment 31b of equal length and parallel to 30b at a constant distance (s) equal to shoe sole thickness. This corresponds to a conventional shoe sole directly underneath the human foot, and also corresponds to the shoe sole portion 28b under flattened portion of the bottom of the load-bearing foot sole. The second part is the naturally contoured

stability side outer edge 31a located at each side of the first part, line segment 31b. Each point on the contoured side outer edge 31a is located at a distance which is exactly shoe sole thickness (s) from the closest point on the contoured side inner edge 30a, consequently, the inner and outer contoured edges 31A and 30A are by definition parallel.

In summary, the theoretically ideal stability plane is the essence of this invention because it is used to determine a geometrically precise bottom contour of the shoe sole based on a top contour that conforms to the contour of the foot. This invention specifically claims the exactly determined geometric relationship just described. It can be stated unequivocally that any shoe sole contour, even of similar contour, that exceeds the theoretically ideal stability plane will restrict natural foot motion, while any less than that plane will degrade natural stability, in direct proportion to the amount of the deviation.

Fig. 16 illustrates in a curve 70 the range of side to side inversion/eversion motion of the ankle center of gravity 71 from the shoe according to the invention shown in frontal plane cross section at the ankle. Thus, in a static case where the center of gravity 71 lies at approximately the mid-point of the sole, and assuming that the shoe inverts or everts from 0° to 20° to 40°, as shown in progressions 16A, 16B and 16C, the locus of points of motion for the center of gravity thus defines the curve 70 wherein the center of gravity 71 maintains a steady level motion with no vertical component through 40° of inversion or eversion. For the embodiment shown, the shoe sole stability equilibrium point is at 28° (at point 74) and in no case is there a pivoting edge to define a rotation point as in the case of Fig. 2. The inherently superior side to side stability of the design provides pronation control (or eversion), as well as lateral (or inversion) control. In marked contrast to conventional shoe sole designs, the applicant's shoe design creates virtually no abnormal torque to resist natural inversion/eversion motion or to destabilize the ankle joint.

Fig. 17 thus compares the range of motion of the center of gravity for the invention, as shown in curve 70, in comparison to curve 80 for the conventional wide heel flare and a curve 82 for a narrow rectangle the width of a human heel. Since the shoe stability limit is 28° in the inverted mode, the shoe sole is stable at the 20° approximate barefoot inversion limit. That factor, and the broad base of support rather than the sharp bottom edge of the prior art, make the contour design stable even in the most extreme case as shown in Figs. 16A-16C and permit the inherent stability of the barefoot to dominate without interference, unlike existing designs, by providing constant, unvarying shoe sole thickness in frontal plane cross sections. The stability superiority of the contour side design is thus clear when observing how much flatter its center of gravity curve 70 is than in existing popular wide flare design 80. The curve demonstrates that the contour side design has significantly

more efficient natural 7° inversion/eversion motion than the narrow rectangle design the width of a human heel, and very much more efficient than the conventional wide flare design; at the same time, the contour side design is more stable *in extremis* than either conventional design because of the absence of destabilizing torque.

Fig. 18A illustrates, in a pictorial fashion, a comparison of a cross section at the ankle joint of a conventional shoe with a cross section of a shoe according to the invention when engaging a heel. As seen in Fig. 18A, when the heel of the foot 27 of the wearer engages an upper surface of the shoe sole 22, the shape of the foot heel and the shoe sole is such that the conventional shoe sole 22 conforms to the contour of the ground 43 and not to the contour of the sides of the foot 27. As a result, the conventional shoe sole 22 cannot follow the natural 7° inversion/eversion motion of the foot, and that normal motion is resisted by the shoe upper 21, especially when strongly reinforced by firm heel counters and motion control devices. This interference with natural motion represents the fundamental misconception of the currently available designs. That misconception on which existing shoe designs are based is that, while shoe uppers are considered as a part of the foot and conform to the shape of the foot, the shoe sole is functionally conceived of as a part of the ground and is therefore shaped flat like the ground, rather than contoured like the foot.

In contrast, the new design, as illustrated in Fig. 18B, illustrates a correct conception of the shoe sole 28 as a part of the foot and an extension of the foot, with shoe sole sides contoured exactly like those of the foot, and with the frontal plane thickness of the shoe sole between the foot and the ground always the same and therefore completely neutral to the natural motion of the foot. With the correct basic conception, as described in connection with this invention, the shoe can move naturally with the foot, instead of restraining it, so both natural stability and natural efficient motion coexist in the same shoe, with no inherent contradiction in design goals.

Thus, the contoured shoe design of the invention brings together in one shoe design the cushioning and protection typical of modern shoes, with the freedom from injury and functional efficiency, meaning speed, and/or endurance, typical of barefoot stability and natural freedom of motion. Significant speed and endurance improvements are anticipated, based on both improved efficiency and on the ability of a user to train harder without injury.

These figures also illustrate that the shoe heel cannot pivot plus or minus 7 degrees with the prior art shoe of Fig. 18A. In contrast, the shoe heel in the embodiment of Fig. 18B pivots with the natural motion of the foot heel.

Figs. 19A-D illustrate, in frontal plane cross sections, the naturally contoured sides design extended to the other natural contours underneath the load-bearing

foot, such as the main longitudinal arch, the metatarsal (or forefoot) arch, and the ridge between the heads of the metatarsals (forefoot) and the heads of the distal phalanges (toes). As shown, the shoe sole thickness remains constant as the contour of the shoe sole follows that of the sides and bottom of the load-bearing foot. Fig. 19E shows a sagittal plane cross section of the shoe sole conforming to the contour of the bottom of the load-bearing foot, with thickness varying according to the heel lift 38. Fig. 19F shows a horizontal plane top view of the left foot that shows the areas 85 of the shoe sole that correspond to the flattened portions of the foot sole that are in contact with the ground when load-bearing. Contour lines 86 and 87 show approximately the relative height of the shoe sole contours above the flattened load-bearing areas 85 but within roughly the peripheral extent 35 of the upper surface of sole 30 shown in Fig. 4. A horizontal plane bottom view (not shown) of Fig. 19F would be the exact reciprocal or converse of Fig. 19F (i.e. peaks and valleys contours would be exactly reversed).

Figs. 20A-D show, in frontal plane cross sections, the fully contoured shoe sole design extended to the bottom of the entire non-load-bearing foot. Fig. 20E shows a sagittal plane cross section. The shoe sole contours underneath the foot are the same as Figs. 19A-E except that there are no flattened areas corresponding to the flattened areas of the load-bearing foot. The exclusively rounded contours of the shoe sole follow those of the unloaded foot. A heel lift 38, the same as that of Fig. 19, is incorporated in this embodiment, but is not shown in Fig. 20.

Fig. 21 shows the horizontal plane top view of the left foot corresponding to the fully contoured design described in Figs. 20A-E, but abbreviated along the sides to only essential structural support and propulsion elements. Shoe sole material density can be increased in the unabbreviated essential elements to compensate for increased pressure loading there. The essential structural support elements are the base and lateral tuberosity of the calcaneus 95, the heads of the metatarsals 96, and the base of the fifth metatarsal 97. They must be supported both underneath and to the outside for stability. The essential propulsion element is the head of first distal phalange 98. The medial (inside) and lateral (outside) sides supporting the base of the calcaneus are shown in Fig. 21 oriented roughly along either side of the horizontal plane subtalar ankle joint axis, but can be located also more conventionally along the longitudinal axis of the shoe sole. Fig. 21 shows that the naturally contoured stability sides need not be used except in the identified essential areas. Weight savings and flexibility improvements can be made by omitting the non-essential stability sides. Contour lines 86 through 89 show approximately the relative height of the shoe sole contours within roughly the peripheral extent 35 of the undeformed upper surface of shoe sole 30 shown in Fig. 4. A horizontal plane bottom view (not shown) of Fig. 21 would be the exact reciprocal or con-

verse of Fig. 21 (i.e. peaks and valleys contours would be exactly reversed).

Fig. 22A shows a development of street shoes with naturally contoured sole sides incorporating the features of the invention. Fig. 22A develops a theoretically ideal stability plane 51, as described above, for such a street shoe, wherein the thickness of the naturally contoured sides equals the shoe sole thickness. The resulting street shoe with a correctly contoured sole is thus shown in frontal plane heel cross section in Fig. 22A, with side edges perpendicular to the ground, as is typical. Fig. 22B shows a similar street shoe with a fully contoured design, including the bottom of the sole. Accordingly, the invention can be applied to an unconventional heel lift shoe, like a simple wedge, or to the most conventional design of a typical walking shoe with its heel separated from the forefoot by a hollow under the instep. The invention can be applied just at the shoe heel or to the entire shoe sole. With the invention, as so applied, the stability and natural motion of any existing shoe design, except high heels or spike heels, can be significantly improved by the naturally contoured shoe sole design.

Fig. 23 shows a method of measuring shoe sole thickness to be used to construct the theoretically ideal stability plane of the naturally contoured side design. The constant shoe sole thickness of this design is measured at any point on the contoured sides along a line that, first, is perpendicular to a line tangent to that point on the surface of the naturally contoured side of the foot sole and, second, that passes through the same foot sole surface point.

Fig. 24 illustrates another approach to constructing the theoretically ideal stability plane, and one that is easier to use, the circle radius method. By that method, the pivot point (circle center) of a compass is placed at the beginning of the foot sole's natural side contour (frontal plane cross section) and roughly a 90° arc (or much less, if estimated accurately) of a circle of radius equal to (s) or shoe sole thickness is drawn describing the area farthest away from the foot sole contour. That process is repeated all along the foot sole's natural side contour at very small intervals (the smaller, the more accurate). When all the circle sections are drawn, the outer edge farthest from the foot sole contour (again, frontal plane cross section) is established at a distance of "s" and that outer edge coincides with the theoretically ideal stability plane. Both this method and that described in Fig. 23 would be used for both manual and CAD/CAM design applications.

The shoe sole according to the invention can be made by approximating the contours, as indicated in Figs. 25A, 25B, and 26. Fig. 25A shows a frontal plane cross section of a design wherein the sole material in areas 107 is so relatively soft that it deforms easily to the contour of shoe sole 28 of the proposed invention. In the proposed approximation as seen in Fig. 25B, the heel cross section includes a sole upper surface 101 and a bottom sole edge surface 102 following when

deformed an inset theoretically ideal stability plane 51. The sole edge surface 102 terminates in a laterally extending portion 103 joined to the heel of the sole 28. The laterally-extending portion 103 is made from a flexible material and structured to cause its lower surface 102 to terminate during deformation to parallel the inset theoretically ideal stability plane 51. Sole material in specific areas 107 is extremely soft to allow sufficient deformation. Thus, in a dynamic case, the outer edge contour assumes approximately the theoretically ideal stability shape described above as a result of the deformation of the portion 103. The top surface 101 similarly deforms to approximately parallel the natural contour of the foot as described by lines 30a and 30b shown in Fig. 4.

It is presently contemplated that the controlled or programmed deformation can be provided by either of two techniques. In one, the shoe sole sides, at especially the midsole, can be cut in a tapered fashion or grooved so that the bottom sole bends inwardly under pressure to the correct contour. The second uses an easily deformable material 107 in a tapered manner on the sides to deform under pressure to the correct contour. While such techniques produce stability and natural motion results which are a significant improvement over conventional designs, they are inherently inferior to contours produced by simple geometric shaping. First, the actual deformation must be produced by pressure which is unnatural and does not occur with a bare foot and second, only approximations are possible by deformation, even with sophisticated design and manufacturing techniques, given an individual's particular running gait or body weight. Thus, the deformation process is limited to a minor effort to correct the contours from surfaces approximating the ideal curve in the first instance.

The theoretically ideal stability plane can also be approximated by a plurality of line segments 110, such as tangents, chords, or other lines, as shown in Fig. 26. Both the upper surface of the shoe sole 28, which coincides with the side 30a of the foot 27, and the bottom surface 31a of the naturally contoured side can be approximated. While a single flat plane 110 approximation may correct many of the biomechanical problems occurring with existing designs, because it can provide a gross approximation of the both natural contour of the foot and the theoretically ideal stability plane 51, the single plane approximation is presently not preferred, since it is the least optimal. By increasing the number of flat planar surfaces formed, the curve more closely approximates the ideal exact design contours, as previously described. Single and double plane approximations are shown as line segments in the cross section illustrated in Fig. 26.

Fig. 27 shows a frontal plane cross section of an alternate embodiment for the invention showing stability sides component 28a that are determined in a mathematically precise manner to conform approximately to the sides of the foot. (The center or load-bearing shoe sole portion 28b would be as described in Fig. 4.) The

side portions 28a would be a quadrant of a circle of radius $(r + r^1)$, where distance (r) must equal sole thickness (s) ; consequently the sub-quadrant of radius (r^1) is removed from quadrant $(r + r^1)$. In geometric terms, the component side 28a is thus a quarter or other section of a ring. The center of rotation 115 of the quadrants is selected to achieve a sole upper side surface 30a that closely approximates the natural contour of the side of the human foot.

Fig. 27 provides a direct bridge to another invention by the applicant, a shoe sole design with quadrant stability sides.

Fig. 28 shows a shoe sole design that allows for unobstructed natural inversion/eversion motion of the calcaneus by providing maximum shoe sole flexibility particularly between the base of the calcaneus 125 (heel) and the metatarsal heads 126 (forefoot) along an axis 120. An unnatural torsion occurs about that axis if flexibility is insufficient so that a conventional shoe sole interferes with the inversion/eversion motion by restraining it. The object of the design is to allow the relatively more mobile (in eversion and inversion) calcaneus to articulate freely and independently from the relatively more fixed forefoot, instead of the fixed or fused structure or lack of stable structure between the two in conventional designs. In a sense, freely articulating joints are created in the shoe sole that parallel those of the foot. The design is to remove nearly all of the shoe sole material between the heel and the forefoot, except under one of the previously described essential structural support elements, the base of the fifth metatarsal 97. An optional support for the main longitudinal arch 121 may also be retained for runners with substantial foot pronation, although would not be necessary for many runners. The forefoot can be subdivided (not shown) into its component essential structural support and propulsion elements, the individual heads of the metatarsal and the heads of the distal phalanges, so that each major articulating joint set of the foot is paralleled by a freely articulating shoe sole support propulsion element, an anthropomorphic design; various aggregations of the subdivisions are also possible. An added benefit of the design is to provide better flexibility along axis 122 for the forefoot during the toe-off propulsive phase of the running stride, even in the absence of any other embodiments of the applicant's invention; that is, the benefit exists for conventional shoe sole designs.

Fig. 28A shows in sagittal plane cross section a specific design maximizing flexibility, with large non-essential sections removed for flexibility and connected by only a top layer (horizontal plane) of non-stretching fabric 123 like Dacron polyester or Kevlar. Fig. 28B shows another specific design with a thin top sole layer 124 instead of fabric and a different structure for the flexibility sections: a design variation that provides greater structural support, but less flexibility, though still much more than conventional designs. Not shown is a simple, minimalist approach, which is comprised of single frontal plane slits in the shoe sole material (all layers

or part): the first midway between the base of the calcaneus and the base of the fifth metatarsal, and the second midway between that base and the metatarsal heads. Fig. 28C shows a bottom view (horizontal plane) of the inversion/eversion flexibility design.

Fig. 29 shows a non-optimal but interim or low cost approach to shoe sole construction, whereby the midsole and heel lift 127 are produced conventionally, or nearly so (at least leaving the midsole bottom surface flat, though the sides can be contoured), while the bottom or outer sole 128 includes most or all of the special contours of the new design. Not only would that completely or mostly limit the special contours to the bottom sole, which would be molded specially, it would also ease assembly, since two flat surfaces of the bottom of the midsole and the top of the bottom sole could be mated together with less difficulty than two contoured surfaces, as would be the case otherwise. The advantage of this approach is seen in the naturally contoured design example illustrated in Fig. 29, which shows some contours on the relatively softer midsole sides, which are subject to less wear but benefit from greater traction for stability and ease of deformation, while the relatively harder contoured bottom sole provides good wear for the load-bearing areas.

Fig. 29B shows in bottom view the outline of a bottom sole 128 made from flat material which can be conformed topologically to a contoured midsole of either the one or two plane designs by limiting the side areas to be mated to the essential support areas discussed in Fig. 21; by that method, the contoured midsole and flat bottom sole surfaces can be made to join satisfactorily by coinciding closely, which would be topologically impossible if all of the side areas were retained on the bottom sole.

Figs. 30A-30C, frontal plane cross sections, show an enhancement to the previously described embodiments of the shoe sole naturally contoured side invention. As stated earlier, one major purpose of that design is to allow the shoe sole to pivot easily from side to side with the foot 90, thereby following the foot's natural inversion and eversion motion; in conventional designs shown in Fig. 39a, such foot motion is forced to occur within the shoe upper 21, which resists the motion. The enhancement is to position exactly and stabilize the foot, especially the heel, relative to the preferred embodiment of the shoe sole; doing so facilitates the shoe sole's responsiveness in following the foot's natural motion. As shown in Fig. 30B and 30C, naturally contoured inner stability sides 131 hold the pivoting edge 31 of the load-bearing foot sole in the correct position for direct contact with the flat upper surface of the conventional shoe sole 22, so that the shoe sole thickness (s) is maintained at a constant thickness (s) in the naturally contoured sides 28a when the shoe is everted or inverted, following the theoretically ideal stability plane 51.

The form of the enhancement is inner shoe sole stability sides 131 that follow the natural contour of the

sides 91 of the heel of the foot 27, thereby cupping the heel of the foot. The inner stability sides 131 can be located directly on the top surface of the shoe sole and heel contour, or directly under the shoe insole (or integral to it), or somewhere in between. The inner stability sides are similar in structure to heel cups integrated in insoles currently in common use, but differ because of its material density, which can be relatively firm like the typical mid-sole, not soft like the insole. The difference is that because of their higher relative density, preferably like that of the uppermost midsole, the inner stability sides function as part of the shoe sole, which provides structural support to the foot, not just gentle cushioning and abrasion protection of a shoe insole. In the broadest sense, though, insoles should be considered structurally and functionally as part of the shoe sole, as should any shoe material between foot and ground, like the bottom of the shoe upper in a slip-lasted shoe or the board in a board-lasted shoe.

The inner stability side enhancement is particularly useful in Converting existing conventional shoe sole design embodiments, as constructed within prior art, to an effective embodiment of the side stability quadrant 26 invention. This feature is important in constructing prototypes and initial production of the invention, as well as an ongoing method of low cost production, since such production would be very close to existing art.

The inner stability sides enhancement is most essential in cupping the sides and back of the heel of the foot and therefore is essential on the upper edge of the heel 27 of the shoe sole 28, but may also be extended around all or any portion of the remaining shoe sole upper edge. The size of the inner stability sides should, however, taper down in proportion to any reduction in shoe sole thickness in the sagittal plane.

The inner shoe sole stability sides 131 enhancement positions and stabilizes the foot relative to the shoe sole, and maintains the constant shoe sole thickness (s) of the naturally contoured sides 28a design, as shown in Figs. 30B and 30C; Fig. 30A shows a conventional design. The inner shoe sole stability sides 131 conform to the natural contour of the foot sides 29, which determine the theoretically ideal stability plane 51 for the shoe sole thickness (s). In essence, the approach provides a low cost or interim method of adapting existing conventional "flat sheet" shoe manufacturing to the naturally contoured design described in previous figures.

Thus, it will clearly be understood by those skilled in the art that the foregoing description has been made in terms of the preferred embodiment and various changes and modifications may be made without departing from the scope of the present invention which is to be defined by the appended claims.

Claims

1. A shoe sole (28) for a shoe (20) or other footwear, such as a street or athletic shoe, comprising:

an upper surface (30, 30a, 30b) that conforms substantially to the natural shape of at least a part of a sole (29) of a wearer's foot (27), said shape including at least a part of the load-bearing portion of at least a curved side of the foot sole (29); and

a lower, ground-contacting surface (31); and at least a sole portion (28b) including said upper surface (30b) and at least one naturally contoured side portion (28a) merging with said sole portion (28b) and with said upper surface (30a) conforming substantially to the shape of the corresponding side of the sole (29) of said foot (27);

wherein said shoe sole (28) has a variable thickness (S) when measured in about sagittal plane cross sections;

characterized in that

said sole portion (28b) and said contoured side portion (28a) have a substantially uniform thickness (S) when measured in about frontal plane cross sections;

said shoe sole thickness (S) is defined as about the shortest distance between any point on about said upper, foot-contacting surface (30) and the closest point on about said lower, ground-contacting surface (31), when measured in about frontal plane cross sections; and in that

said substantially uniform thickness (S) is different when measured in at least two separate frontal plane cross sections wherein the shoe sole (28) has at least one said contoured side portion (28a) with substantially uniform thickness (S) of at least 20 degrees, so that there are at least two different thicknesses (S) of said at least one contoured side portion (28a), when measured in said two separate about frontal plane cross sections.

2. The shoe sole (28) as set forth in claims 1, wherein said shoe sole thickness (S) is greater in a heel area (125) than that in a forefoot area (126).
3. The shoe sole (28) as set forth in claims 1 or 2, wherein said shoe sole (28) is made of non-rigid material with sufficient flexibility to substantially allow said wearer's foot sole (29) to flatten naturally under a body weight load in the same manner as when said foot sole (29) is load-bearing directly on the ground (43);

therefore, when under said body weight load, the flexibility of said foot sole (29) allows the load-bearing surface (30) of said shoe sole (28), and the load-bearing surface of said foot sole (29) in contact with it, to substantially parallel the surface of said ground (43), when measured in frontal plane cross sections;

and the flexibility of said shoe sole (28) also allows said upper surface (30) of shoe sole (28), including at least said contoured side portion (30a) to substantially conform continually to the changing shape of a wearer's foot sole (29) even when said foot sole flattens in a natural manner under said body weight load.

4. The shoe sole (28) as set forth in claims 1-3, wherein said contoured side portion (28a) of at least 20 degrees merges with at least a sole portion (28b) substantially proximate to the heads of the metatarsals (96) of the wearer's foot.

5. The shoe sole (28) as set forth in claims 1-4, wherein said contoured side portion (28a) of at least 20 degrees merges with at least a sole portion (28b) substantially proximate to a base of the fifth metatarsal (97) of the wearer's foot.

6. The shoe sole (28) as set forth in claims 1-5, wherein said contoured side portion (28a) of at least 20 degrees merges with at least a sole portion (28b) substantially proximate to a lateral tuberosity of the calcaneus (95) of said wearer's foot (27).

7. The shoe sole (28) as set forth in claims 1-6, wherein said contoured side portion (28a) of at least 20 degrees merges with at least a medial sole portion (28b) substantially proximate to a base of the calcaneus (95) of said wearer's foot (27).

8. The shoe sole (28) as set forth in claims 1-7, wherein said contoured side portion (28a) of at least 20 degrees merges with at least a sole portion (28b) substantially proximate to the heads of the metatarsals (96) of said wearer's foot (27).

9. The shoe sole (28) as set forth in claims 1-8, wherein said contoured side portion (28a) of at least 20 degrees merges with at least a sole portion (28b) substantially proximate to the head of the first distal phalanx (98) of said wearer's foot (27).

10. The shoe sole (28) as set forth in claims 1-9, wherein at least a substantial part of said at least one sole portion (28b) is merged with said at least one contoured side portion (28a).

11. The shoe sole (28) as set forth in claims 1-10, wherein at least two contoured side portions (28a), including one portion substantially proximate to the head of the first metatarsal (96) and one portion substantially proximate to the first distal phalanx (98), are separated by an area directly between them with no said contoured side portion (28a).

12. The shoe sole (28) as set forth in claims 1-11, wherein at least two said contoured side portions

(28a) are separated by an area directly between them having a sole portion (28b) that is merged with a contoured side that has a thickness which is less than the thickness of said sole portion (28b);

said contoured side portion (28a) and said sole portion (28b) thicknesses being measured in frontal plane cross sections.

13. The shoe sole (28) as set forth in claims 1-12, wherein at least a part of the upper surface (30b) of said at least one sole portion (28b) conforms substantially to the natural contours of said sole (29) of said load-bearing foot (27) of said wearer.

14. The shoe sole (28) as set forth in claims 1-13, wherein at least a part of said upper surface (30b) of said at least one sole portion (28b) conforms substantially to the natural contour of the bottom of said sole (29) of said wearer's foot (27) when not under a load.

15. The shoe sole (28) as set forth in claims 1-14, wherein, at least in the calcaneal area (95), at least a part of said upper surface (30b) of said at least one sole portion (28b) conforms substantially to the natural contour of the bottom of the sole (29) of said wearer's foot (27) when not under a load.

16. The shoe sole (28) as set forth in claims 1-15, wherein at least a part of said upper surface (30b) of said at least one sole portion (28b) is substantially flat.

17. The shoe sole (28) as set forth in claims 1-16, wherein said contoured side portions (28a) are sufficient to maintain lateral stability of said wearer's foot (27) throughout its full range of sideways pronation and supination motion in a manner substantially equivalent to that of said wearer's foot (27) when bare on said ground (43);

that firm lateral stability can be demonstrated by a simple relative comparison test made by said wearer, who can simulate a common inversion ankle sprain while standing in a stationary position;

first, said wearer's unshod foot (27) is tilted out laterally in inversion to the extreme 20 degree limit of the range of motion of a subtalar ankle joint of said wearer's foot to demonstrate firm lateral stability;

second, the same inversion motion is repeated by said wearer shod with the shoe sole (28) with contoured side portions (28a) with substantially uniform thickness (s) to demonstrate the substantially equivalent firm lateral stability; and third, in contrast, the same inversion motion is repeated again, very carefully, by said

wearer shod with any conventional shoe sole (22) to expose its gross lack of lateral stability.

18. The shoe sole (28) as set forth in claims 1-17, wherein the density of said at least one contoured side portion (28a) is greater than the density of the material used in said sole portion (28b), in order to compensate for increased pressure loading during inversion and eversion motion of said foot.
19. The shoe sole (28) as set forth in claims 1-18, wherein at least said contoured side portion (28a) of at least 30 degrees merges with a heel portion (125) of said sole portion (28b);

and said substantially uniform thickness (S) of said shoe sole (28) in said heel area (125) with contoured side portion (28a) of at least 30 degrees, as measured in a frontal plane cross section, is different from said substantially uniform thickness (S) of said shoe sole in said forefoot area (126) which extends through said at least one contoured side portion (28a) of at least 30 degrees, also as measured in about frontal plane cross sections.

20. The shoe sole (28) as set forth in claims 1-19, wherein said substantially uniform thickness (S) of said shoe sole (28) extends through at least a contoured side portion (28a) providing direct structural support between said sole (29) of said foot (27) and said ground (43) through a sideways tilt of at least 45 degrees;

said uniform thickness (S) of said shoe sole (28) is different in at least two separate frontal plane cross sections wherein said shoe sole (28) has a contoured side portion (28a) of at least 45 degrees, so that there are at least two different thicknesses (S) of said contoured side portions (28a), when measured in about frontal plane cross sections; the thickness (S) of said at least one contoured side portion (28a) is measured with at least one frontal plane cross section taken proximate to a heads of the wearer's metatarsals (96) and the thickness (S) of another said contoured side portion (28a) is measured in at least one other about frontal plane cross section taken proximate to a base of the wearer's fifth metatarsal (97).

21. The shoe sole (28) as set forth in claims 1-20, wherein said substantially uniform thickness (S) of said forefoot (126) of the shoe sole (28) is different in at least two separate frontal plane cross sections wherein said shoe sole (28) has at least one contoured side portion (28a) with a substantially uniform thickness extending through a sideways tilt of

at least 45 degrees, so that there are at least two different thicknesses (S) of said contoured side portions (28a) in said shoe sole forefoot area (126), when measured in about frontal plane cross sections.

22. The shoe sole (28) as set forth in claims 1-21, wherein the shoe sole has said substantially uniform thickness (S), when measured in about frontal plane cross sections, in all parts of said shoe sole (28) providing direct structural support between said wearer's load-bearing sole (29) of said foot (27) and said ground (43);

the direct load-bearing portion of said shoe sole (28) includes both any portion of said at least one sole portion (28b) and any portion of said at least one contoured side portion (28a) which become directly load-bearing when said shoe sole (28) on said ground (43) is tilted sideways, away from an upright position; said substantially uniform thickness of the shoe sole (28) extends through at least one said contoured side portion (28a) providing direct structural support between said sole (29) of said foot (27) and said ground (43) through a sideways tilt of at least 20 degrees;

whereby, as measured in about frontal plane cross sections, said substantially uniform thickness (S) of said shoe sole (28), especially including said contoured side portion (28a), maintains a lateral stability of said foot (27) on said shoe sole (28) like that when said foot (27) is bare on said ground (43), especially during sideways pronation and supination motion occurring when said shoe sole (28) is in contact with said ground (43).

23. The shoe sole (28) as set forth in claims 1-22, wherein said substantially uniform thickness (S) of said shoe sole (28), as measured in about frontal plane cross sections, extends through at least part of said at least one contoured side portion (28a) of at least 30 degrees.

24. The shoe sole (28) as set forth in claims 1-23, wherein said substantially uniform thickness (S) of said shoe sole (28), as measured in about frontal plane cross sections, extends through at least part of said at least one contoured side portion (28a) of at least 45 degrees.

25. The shoe sole (28) as set forth in claims 1-24, wherein said substantially uniform thickness (S) of the shoe sole (28), as measured in about frontal plane cross sections, extends through at least part of said at least one contoured side portion (28a) of at least 90 degrees;

whereby the amount of any shoe sole con-

toured side (28a) that is provided said shoe sole (28) is sufficient to maintain lateral stability of said wearer's foot (27) throughout the most extreme range of sideways motion, including at least 90 degrees of inversion and eversion; said lateral stability being like that of said wearer's foot (27) when bare.

26. The shoe sole (28) as set forth in claims 1-25, wherein said substantially uniform thickness (S) of said shoe sole (28), when measured in about frontal plane cross sections, extends through at least part of said at least one contoured side portion (28a) of 120 degrees;

whereby the amount of any shoe sole contoured side (28a) that is provided said shoe sole (28) is sufficient to maintain lateral stability of said wearer's foot (27) throughout the most extreme range of sideways motion, said lateral stability being like that of said wearer's foot (27) when bare.

27. The shoe sole (28) as set forth in claims 1-26, wherein said lower ground-contacting surface (31) of said shoe sole (28) is connected to said upper surface (30) by a non-load-bearing surface (53a) forming an outside edge of said shoe sole (28);

when measured in about frontal plane cross sections, the distance between any point on said outside edge surface (53a) and the closest point of said upper surface (30) of the shoe sole is less than the previously defined substantially uniform thickness (S) of the load-bearing portions of the shoe sole;

said lesser distance is reduced gradually, starting from the thickness of the load-bearing portions, so that said outside edge (53a) tapers gradually from said lower ground-contacting surface (31) to said upper foot-contacting surface (30) thereby avoiding the creation of any sharp edge for said shoe sole (28) to pivot on unstably when tilted sideways to an extreme.

28. The shoe sole (28) as set forth in claims 1-27, wherein at least part of said at least one contoured portion (28) in a given frontal plane cross section is substantially constructed using a mathematical approximation in the form of a part of a ring with substantially the same thickness (r) as that of said shoe sole thickness (S) of said about frontal plane cross section;

in said given about frontal plane cross section, at least a part of said upper, foot sole-contacting surface (30) of the shoe sole (28) is constructed as a relatively smaller circle defining an inner surface of said ring, which is made with an appropriate radius (r') and center (115) to coincide approximately with at least a part of

said contoured surface (30) of said sole (29) the wearer's foot (27);

and at least a part of said lower, ground-contacting surface (31) of said shoe sole (28) is constructed as a relatively larger circle defining an outer surface of said ring, which is made, while substantially maintaining same said center of rotation (115), by a radius (r'+r) increased by an amount (r) substantially equal to the thickness (S) of said shoe sole (28) in said given about frontal plane cross section.

29. The shoe sole (28) as set forth in claims 1-28, wherein said outer surface (31) of said shoe sole (28) has a plurality of cleats affixed to it;

the surface (63) to which said cleats (61) are affixed becomes load-bearing on any said ground (43) sufficiently soft for said cleats to penetrate the ground fully, thereby obtaining their traction benefit; consequently, that load-bearing surface (63) is defined as the lower, ground-contacting surface (31) for purposes of measuring said shoe sole thickness (S).

30. The shoe sole (28) as set forth in claims 1-29, wherein at least a part of the curved structure of said contoured side portion (28a), such as a tread pattern (60) of the said ground-contacting surface (31), is approximated by using at least one straight line segments (110) to construct at least a portion of said curve, when measured in about frontal plane cross sections.

31. The shoe sole (28) as set forth in claims 1-30, wherein said at least one sole portion (28b) and said at least one contoured side portion (28a) are integrally formed into a unitary shoe sole structure (28).

32. The shoe sole (28) as set forth in claims 1-31, wherein said shoe sole (28) comprises at least a midsole (127) and an outer sole (128).

33. The shoe sole (28) as set forth in claims 1-32, wherein said shoe sole (28) comprises at least three layers: an insole, said midsole (127) and said outer sole (128).

34. The shoe sole (28) as set forth in claims 1-33, wherein said forefoot area (126) of said shoe sole (28) comprises at least said insole and said outer sole (128).

35. The shoe sole (28) as set forth in claims 1-34, wherein said at least one sole portion (28b) and said at least one side portion (28a) of said shoe sole (28) are sufficient to maintain the load-bearing portion of the sole (29) of the wearer's foot (27) at

about a constant distance (S) from the ground (43), when measured in about frontal plane cross sections, said constant distance being said thickness (S) of said shoe sole (28), even when said shoe (20) is tilted to the side by natural lateral foot motion on said ground (43) such as pronation or supination, whether routine or extreme.

36. The shoe sole (28) as set forth in claims 1-35, wherein at least a part of a lower surface of a midsole (127) and a corresponding at least part of an upper surface of an outer sole (128) are substantially flat planes, with at least a part of the shoe sole side (28a) contours being formed by the shape of said outer sole (128), so that the two soles (127, 128) can be easily and conventionally joined in the manufacturing assembly process.
37. The shoe sole (28) as set forth in claims 1-36, wherein a shoe upper (21) is connected to said shoe sole (28).

Patentansprüche

1. Schuhsohle (28) für einen Schuh (20) oder andere Schuhwaren, wie ein Straßen- oder Sportschuh, mit:

einer oberen Fläche (30, 30a, 30b), die im wesentlichen der natürlichen Form von zumindest einem Teil einer Sohle (29) eines Fußes (27) von einem Träger entspricht, wobei die Form zumindest einen Teil des gewichttragenden Abschnitts von zumindest einem gekrümmten Seitenbereich der Fußsohle (29) umfaßt; und

einer unteren Fläche (31), die mit dem Boden Kontakt hat; und

zumindest einem Sohlenabschnitt (28b), der die obere Fläche (30b) umfaßt, und zumindest einem natürlich angepaßten Seitenabschnitt (28a), der mit dem Sohlenabschnitt (28b) und der oberen Fläche (30a) verbunden ist, die im wesentlichen der Form des zugehörigen Seitenbereichs der Sohle (29) des Fußes (27) entspricht;

wobei die Schuhsohle (28) eine veränderliche Dicke (S) hat, wenn etwa in Sagittalebene-Querschnitten gemessen wird;

dadurch gekennzeichnet, daß der Sohlenabschnitt (28b) und der angepaßte Seitenabschnitt (28a) eine im wesentlichen gleichbleibende Dicke (S) haben, wenn etwa in Frontalebene-Querschnitten gemessen wird; die Schuhsohlendicke (S) als etwa der kürzeste Abstand zwischen jedem Punkt auf etwa der oberen Fläche (30), die mit dem Fuß Kontakt hat, und dem nächstliegenden Punkt auf etwa der unteren Fläche (31) definiert ist, die

mit dem Boden Kontakt hat, wenn etwa in Frontalebene-Querschnitten gemessen wird; und die im wesentlichen gleichbleibende Dicke (S) unterschiedlich ist, wenn zumindest in zwei verschiedenen Frontalebene-Querschnitten gemessen wird, wobei die Schuhsohle (28) zumindest einen angepaßten Seitenabschnitt (28a) mit im wesentlichen gleichbleibender Dicke (S) von zumindest 20° hat, so daß zumindest zwei unterschiedliche Dicken (S) des zumindest einen angepaßten Seitenabschnitts (28a) vorhanden sind, wenn in den beiden verschiedenen Frontalebene-Querschnitten gemessen wird.

2. Schuhsohle (28) nach Anspruch 1, bei der die Schuhsohlendicke (S) in einem Fersenbereich (125) größer ist als die in einem Vorderfußbereich (126).
3. Schuhsohle (28) nach Anspruch 1 oder 2, bei der die Schuhsohle (28) aus einem nachgiebigen Material besteht, das eine ausreichende Nachgiebigkeit hat, um im wesentlichen zu erreichen, daß sich die Fußsohle (29) des Trägers unter einer Last des Körpergewichts in der gleichen Art natürlich abflacht, als wenn die Fußsohle (29) direkt auf dem Boden (43) lastet;

wobei unter der Last des Körpergewichts durch die Nachgiebigkeit der Fußsohle (29) erreicht wird, daß die gewichttragende Fläche (30) der Schuhsohle (28) und die damit in Kontakt stehende gewichttragende Fläche der Fußsohle (29) im wesentlichen parallel zu der Fläche des Bodens (43) verlaufen, wenn in Frontalebene-Querschnitten gemessen wird; und wobei durch die Nachgiebigkeit der Schuhsohle (28) außerdem erreicht wird, daß die obere Fläche (30) der Schuhsohle (28), die zumindest den angepaßten Seitenabschnitt (28a) umfaßt, sich im wesentlichen ständig der sich verändernden Form der Fußsohle (29) des Trägers anpaßt, sogar dann, wenn sich die Fußsohle auf natürliche Art und Weise unter der Last des Körpergewichts abflacht.

4. Schuhsohle (28) nach einem der Ansprüche 1 bis 3, bei der der angepaßte Seitenabschnitt (28a) von zumindest 20° mit zumindest einem Sohlenabschnitt (28b) verbunden ist, der sich im wesentlichen nahe der Metatarsalknochenköpfe (96) des Fußes des Trägers befindet.
5. Schuhsohle (28) nach einem der Ansprüche 1 bis 4, bei der der angepaßte Seitenabschnitt (28a) von zumindest 20° mit zumindest einem Sohlenabschnitt (28b) verbunden ist, der sich im wesentlichen nahe einer Basis des fünften

Metatarsalknochens (97) des Fußes des Trägers befindet.

6. Schuhsohle (28) nach einem der Ansprüche 1 bis 5, bei der der angepaßte Seitenabschnitt (28a) von
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zumindest 20° mit zumindest einem Sohlenabschnitt (28b) verbunden ist, der sich im wesentlichen nahe einer seitlichen Tuberositas des Kalkaneus (95) des Fußes (27) des Trägers befindet. 10
7. Schuhsohle (28) nach einem der Ansprüche 1 bis 6, bei der der angepaßte Seitenabschnitt (28a) von
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zumindest 20° mit zumindest einem medialen Sohlenabschnitt (28b) verbunden ist, der sich im wesentlichen nahe einer Basis des Kalkaneus (95) des Fußes (27) des Trägers befindet. 20
8. Schuhsohle (28) nach einem der Ansprüche 1 bis 7, bei der der angepaßte Seitenabschnitt (28a) von
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zumindest 20° mit zumindest einem Sohlenabschnitt (28b) verbunden ist, der sich im wesentlichen nahe der Metatarsalknochenköpfe (96) des Fußes (27) des Trägers befindet. 25
9. Schuhsohle (28) nach einem der Ansprüche 1 bis 8, bei der der angepaßte Seitenabschnitt (28a) von
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zumindest 20° mit zumindest einem Sohlenabschnitt (28b) verbunden ist, der sich im wesentlichen nahe des Kopfes des ersten distalen Phalanx (98) des Fußes (27) des Trägers befindet. 35
10. Schuhsohle (28) nach einem der Ansprüche 1 bis 9, bei der zumindest ein wesentlicher Teil des
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zumindest einen Sohlenabschnitts (28b) mit dem zumindest einen angepaßten Seitenabschnitt (28a) verbunden ist. 40
11. Schuhsohle (28) nach einem der Ansprüche 1 bis 10, bei der zumindest zwei angepaßte Seitenab-
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schnitte (28a), die einen Abschnitt, der sich im wesentlichen nahe des ersten Metatarsalknochenkopfes (96) befindet, und einen Abschnitt umfassen, der sich im wesentlichen nahe der ersten distalen Phalanx (98) befindet, durch einen Bereich
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getrennt sind, der direkt zwischen diesen liegt und keinen angepaßten Seitenabschnitt (28a) hat. 50
12. Schuhsohle (28) nach einem der Ansprüche 1 bis 11, bei der zumindest zwei angepaßte Seitenab-
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schnitte (28a) durch einen Bereich getrennt sind, der direkt zwischen diesen liegt und einen Sohlenabschnitt (28b) umfaßt, der mit einem angepaßten Seitenabschnitt verbunden ist, der eine Dicke hat, die kleiner ist als die Dicke des Sohlenabschnitts (28b); wobei die Dicke des angepaßten Seitenab-
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schnitts (28a) und die des Sohlenabschnitts (28b) in Frontalebene-Querschnitten gemessen wird.

13. Schuhsohle (28) nach einem der Ansprüche 1 bis 12, bei der zumindest ein Teil der oberen Fläche (30b) des zumindest einen Sohlenabschnitts (28b) im wesentlichen der natürlichen Form der Sohle (29) des gewichttragenden Fußes (27) des Trägers entspricht.

14. Schuhsohle (28) nach einem der Ansprüche 1 bis 13, bei der zumindest ein Teil der oberen Fläche (30b) des zumindest einen Sohlenabschnitts (28b) im wesentlichen der natürlichen Form der Unterseite der Sohle (29) des Fußes (27) des Trägers entspricht, wenn dieser nicht unter einer Last steht.

15. Schuhsohle (28) nach einem der Ansprüche 1 bis 14, bei der zumindest in dem Bereich des Kalkaneus (95) zumindest ein Teil der oberen Fläche (30b) des zumindest einen Sohlenabschnitts (28b) im wesentlichen der natürlichen Form der Unterseite der Sohle (29) des Fußes (27) des Trägers entspricht, wenn dieser nicht unter einer Last steht.

16. Schuhsohle (28) nach einem der Ansprüche 1 bis 15, bei der zumindest ein Teil der oberen Fläche (30b) des zumindest einen Sohlenabschnitts (28b) im wesentlichen eben ist.

17. Schuhsohle (28) nach einem der Ansprüche 1 bis 16, bei der die angepaßten Seitenabschnitte (28a) ausreichend sind, um eine Seitenstabilität des Fußes (27) des Trägers über dessen gesamten Bereich der seitwärts gerichteten Pronations- und Supinationsbewegung auf eine Weise aufrechtzuhalten, die im wesentlichen gleich der des nackt auf dem Boden (43) stehenden Fußes (27) des Trägers ist;

wobei eine feste Seitenstabilität durch einen einfachen Vergleichstest demonstriert werden kann, der von dem Träger durchgeführt wird, der eine Inversionsbewegung des Knöchels simulieren kann, während er eine unbewegliche Stellung einnimmt;

wobei erstens der Fuß (27) des Trägers ohne Schuh eine seitliche Inversionsbewegung bis zum äußersten 20°-Grenzwert des Bewegungsbereichs eines subtalaren oberen Sprunggelenks des Fußes des Trägers durchführt, um die feste Seitenstabilität zu demonstrieren;

zweitens die gleiche Inversionsbewegung von dem Träger wiederholt wird, der einen Schuh mit einer Schuhsohle (28) trägt, die die angepaßten Seitenabschnitte (28a) mit im wesentlichen gleichbleibender Dicke (s) enthält, um die im wesentlichen gleiche feste Seitenstabilität zu demonstrieren;

und drittens im Gegensatz dazu die gleiche Inversionsbewegung sehr vorsichtig von dem

Träger wiederholt wird, der einen Schuh mit einer herkömmlichen Schuhsohle (22) trägt, um das Fehlen der Seitenstabilität festzustellen.

18. Schuhsohle (28) nach einem der Ansprüche 1 bis 17, bei der die Dichte des zumindest einen angepaßten Seitenabschnitts (28a) größer ist als die Dichte des Materials, das für den Sohlenabschnitt (28b) verwendet wird, um die erhöhte Druckbelastung während der Inversionsbewegung und der Eversionsbewegung des Fußes auszugleichen.

19. Schuhsohle (28) nach einem der Ansprüche 1 bis 18, bei der zumindest der angepaßte Seitenabschnitt (28a) von zumindest 30° mit einem Fersenbereich (125) des Sohlenabschnitts (28b) verbunden ist;

und die im wesentlichen gleichbleibende Dicke (S) der Schuhsohle (28) im Fersenbereich (125) mit einem angepaßten Seitenabschnitt (28a) von zumindest 30°, bei Messung in einem Frontalebene-Querschnitt, verschieden von der im wesentlichen gleichbleibenden Dicke (S) der Schuhsohle in dem Vorderfußbereich (126) ist, die sich über den zumindest einen angepaßten Seitenabschnitt (28a) von zumindest 30° erstreckt, ebenfalls bei Messung etwa in Frontalebene-Querschnitten.

20. Schuhsohle (28) nach einem der Ansprüche 1 bis 19, bei der die im wesentlichen gleichbleibende Dicke (S) der Schuhsohle (28) sich über zumindest einen angepaßten Seitenabschnitt (28a) erstreckt, durch den eine direkte Abstützung zwischen der Sohle (29) des Fußes (27) und dem Boden (43) über eine Seitwärtsneigung von zumindest 45° erreicht wird;

die gleichbleibende Dicke (S) der Schuhsohle (28) in zumindest zwei unterschiedlichen Frontalebene-Querschnitten verschieden ist, wobei die Schuhsohle (28) einen angepaßten Seitenabschnitt (28a) von zumindest 45° hat, so daß zumindest zwei verschiedene Dicken (S) der angepaßten Seitenabschnitte (28a) vorhanden sind, wenn etwa in Frontalebene-Querschnitten gemessen wird; wobei die Dicke (S) des zumindest einen angepaßten Seitenabschnitts (28a) in zumindest einem Frontalebene-Querschnitt nahe einer Ferse der Metatarsalknochen (96) des Trägers und die Dicke (S) eines anderen angepaßten Seitenabschnitts (28a) in zumindest einem anderen etwa Frontalebene-Querschnitt nahe einer Basis des fünften Metatarsalknochens (97) des Trägers gemessen wird.

21. Schuhsohle (28) nach einem der Ansprüche 1 bis 20, bei der die im wesentlichen gleichbleibende Dicke (S) der Vorderfußes (126) der Schuhsohle (28) in zumindest zwei verschiedenen Frontalebene-Querschnitten unterschiedlich ist, wobei die Schuhsohle (28) zumindest einen angepaßten Seitenabschnitt (28a) mit einer im wesentlichen gleichbleibenden Dicke hat, der sich über eine Seitwärtsneigung von zumindest 45° erstreckt, so daß zumindest zwei verschiedene Dicken (S) der angepaßten Seitenabschnitte (28a) im Vorderfußbereich (126) der Schuhsohlen vorhanden sind, wenn etwa in Frontalebene-Querschnitten gemessen wird.

22. Schuhsohle (28) nach einem der Ansprüche 1 bis 21, bei der die Schuhsohle, wenn etwa in Frontalebene-Querschnitten gemessen wird, eine im wesentlichen gleichbleibende Dicke (S) in allen Teilen der Schuhsohle (28) hat, die eine direkte Abstützung zwischen der das Gewicht des Trägers aufnehmenden Sohle (29) des Fußes (27) und dem Boden (43) bilden;

der direkt das Gewicht tragende Abschnitt der Schuhsohle (28) sowohl einen Bereich des zumindest einen Sohlenabschnitts (28b) und einen Bereich des zumindest einen angepaßten Seitenabschnitts (28a) umfaßt, der direkt Gewicht aufnimmt, wenn die Schuhsohle (28) auf dem Boden (43) von einer aufrechten Position zur Seite geneigt wird; die im wesentlichen gleichbleibende Dicke der Schuhsohle (28) sich über zumindest einen angepaßten Seitenabschnitt (28a) erstreckt, der bei einer Seitwärtsneigung von zumindest 20° die direkte Abstützung zwischen der Sohle (29) des Fußes (27) und dem Boden (43) bewirkt;

wobei, wenn etwa in Frontalebene-Querschnitten gemessen wird, die im wesentlichen gleichbleibende Dicke (S) der Schuhsohle (28), die insbesondere den angepaßten Seitenabschnitt (28a) umfaßt, eine Seitenstabilität des Fußes (27) auf der Schuhsohle (28) aufrechterhält, ähnlich der, wenn der Fuß (27) nackt auf dem Untergrund (43) steht, speziell während einer Pronations- und einer Supinationsbewegung, die stattfindet, wenn die Schuhsohle (28) Kontakt mit dem Boden (43) hat.

23. Schuhsohle (28) nach einem der Ansprüche 1 bis 22, bei der die im wesentlichen gleichbleibende Dicke (S) der Schuhsohle (28), wenn etwa in Frontalebene-Querschnitten gemessen wird, sich über zumindest einen Teil des zumindest einen angepaßten Seitenabschnitts (28a) von zumindest 30° erstreckt.

24. Schuhsohle (28) nach einem der Ansprüche 1 bis 23, bei der die im wesentlichen gleichbleibende Dicke (S) der Schuhsohle (28), wenn etwa in Frontalebene-Querschnitten gemessen wird, sich über zumindest einen Teil des zumindest einen angepaßten Seitenabschnitts (28a) von zumindest 45° erstreckt.

25. Schuhsohle (28) nach einem der Ansprüche 1 bis 24, bei der die im wesentlichen gleichbleibende Dicke (S) der Schuhsohle (28), wenn etwa in Frontalebene-Querschnitten gemessen wird, sich über zumindest einen Teil des zumindest einen angepaßten Seitenabschnitts (28a) von zumindest 90° erstreckt;

wobei der Anteil des angepaßten Seitenabschnitts (28a) der Schuhsohle, durch den die Schuhsohle (28) gebildet ist, ausreichend ist, um eine Seitenstabilität des Fußes (27) des Trägers über den äußersten Bereich der zur Seite gerichteten Bewegung aufrechterhält, einschließlich von zumindest 90° der Inversion und der Eversion; wobei die Seitenstabilität ähnlich der des nackten Fußes (27) des Trägers ist.

26. Schuhsohle (28) nach einem der Ansprüche 1 bis 25, bei der die im wesentlichen gleichbleibende Dicke (S) der Schuhsohle (28), wenn etwa in Frontalebene-Querschnitten gemessen wird, sich über zumindest einen Teil des zumindest einen angepaßten Seitenabschnitts (28a) von 120° erstreckt;

wobei der Anteil des angepaßten Seitenabschnitts (28a) der Schuhsohle, durch den die Schuhsohle (28) gebildet ist, ausreichend ist, um die Seitenstabilität des Fußes (27) des Trägers über den äußersten Bereich der zur Seite gerichteten Bewegung aufrechtzuerhalten; wobei die Seitenstabilität ähnlich der des nackten Fußes (27) des Trägers ist.

27. Schuhsohle (28) nach einem der Ansprüche 1 bis 26, bei der die untere Fläche (31) der Schuhsohle (28), die mit dem Boden Kontakt hat, mit der oberen Fläche (30) durch eine kein Gewicht tragende Fläche (53a) verbunden ist, die eine äußere Kante der Schuhsohle (28) bildet;

wobei, wenn etwa in Frontalebene-Querschnitten gemessen wird, der Abstand zwischen einem Punkt auf der äußeren Kantenfläche (53a) und dem nächstliegenden Punkt der oberen Fläche (30) der Schuhsohle kleiner ist als die vorstehend definierte, im wesentlichen gleichbleibende Dicke (S) der gewichttragenden Bereiche der Schuhsohle; sich der kleinere Abstand ausgehend von der Dicke des gewichttragenden Abschnitts allmählich vermindert, so daß sich die äußere Kante (53a) allmählich von der unteren Fläche

(31), die mit dem Boden Kontakt hat, zu der oberen Fläche (30) verjüngt, die mit dem Fuß Kontakt hat, wodurch für die Schuhsohle (28) die Bildung von scharfen Kanten verhindert wird, um sie in den instabilen Bereich schwenken zu können, wenn sie extrem zur Seite geneigt wird.

28. Schuhsohle (28) nach einem der Ansprüche 1 bis 27, bei der zumindest ein Teil des zumindest einen angepaßten Abschnitts (28) in einem vorgegebenen Frontalebene-Querschnitt im wesentlichen unter Verwendung einer mathematischen Näherung konstruiert ist, und zwar in der Form eines Teils eines Ringes, der eine Dicke (r) hat, die im wesentlichen gleich der Schuhsohlendicke (S) in dem Frontalebene-Querschnitt ist;

wobei in dem vorgegebenen Frontalebene-Querschnitt zumindest ein Teil der oberen Fläche (30) der Schuhsohle (28), die mit dem Fuß Kontakt hat, als ein relativ kleiner Kreis konstruiert ist, durch den eine Innenfläche des Ringes bestimmt ist, der einen passenden Radius (r') und einen Mittelpunkt (115) hat, um ungefähr mit zumindest einem Teil der angepaßten Fläche (30) der Sohle (29) des Fußes (27) des Trägers übereinzustimmen;

und wobei zumindest ein Teil der unteren Fläche (31) der Schuhsohle (28), die mit dem Boden Kontakt hat, als ein relativ großer Kreis konstruiert ist, durch den eine Außenfläche des Ringes bestimmt ist, der im wesentlichen den gleichen Mittelpunkt (115) hat und durch einen Radius ($r' + r$) gebildet ist, der um einen Wert (r) größer ist, der im wesentlichen gleich der Dicke (S) der Schuhsohle (28) in dem vorgegebenen Frontalebene-Querschnitt ist.

29. Schuhsohle (28) nach einem der Ansprüche 1 bis 28, bei der die äußere Fläche (31) der Schuhsohle (28) eine Anzahl von daran angebrachten Vorsprüngen aufweist;

die Fläche (63), an der die Vorsprünge (61) angebracht sind, das Gewicht auf irgendeinem Boden (43) trägt, der weich genug ist, damit die Vorsprünge vollständig in den Boden eindringen können, wodurch sie ihren Reibungsvorteil erreichen; wobei zum Messen der Schuhsohlendicke (S) folglich die gewichttragende Fläche (63) als die untere Fläche (31), die mit dem Boden Kontakt hat, definiert ist.

30. Schuhsohle (28) nach einem der Ansprüche 1 bis 29, bei der zumindest ein Teil der gekrümmten Struktur des angepaßten Seitenabschnitts (28a), wie beispielsweise ein Sohlenprofil (60) der mit dem Boden in Kontakt stehenden Fläche (31),

angenähert ist, indem zumindest ein gerades Liniensegment (110) verwendet wird, um zumindest einen Bereich der Kurve auszubilden, wenn etwa in Frontalebene-Querschnitten gemessen wird.

31. Schuhsohle (28) nach einem der Ansprüche 1 bis 30, bei der zumindest ein Sohlenabschnitt (28b) und der zumindest eine angepaßte Seitenabschnitt (28a) integriert zu einer einteiligen Schuhsohlenstruktur (28) ausgebildet sind.

32. Schuhsohle (28) nach einem der Ansprüche 1 bis 31, bei der die Schuhsohle (28) zumindest eine Mittelsohle (127) und eine Außensohle (128) enthält.

33. Schuhsohle (28) nach einem der Ansprüche 1 bis 32, bei der die Schuhsohle (28) zumindest drei Schichten aufweist: eine Brandsohle, die Mittelsohle (127) und die Außensohle (128).

34. Schuhsohle (28) nach einem der Ansprüche 1 bis 33, bei der der Vorderfußbereich (126) der Schuhsohle (28) zumindest die Brandsohle und die Außensohle (128) enthält.

35. Schuhsohle (28) nach einem der Ansprüche 1 bis 34, bei der zumindest ein Sohlenabschnitt (28b) und der zumindest eine Seitenabschnitt (28a) der Schuhsohle (28) ausreichend sind, um den gewichttragenden Bereich der Sohle (29) des Fußes (27) des Trägers bei einem etwa konstanten Abstand (S) von dem Boden (43) zu halten, wenn etwa in Frontalebene-Querschnitten gemessen wird, wobei der konstante Abstand die Dicke (S) der Schuhsohle (28) ist, und zwar auch dann, wenn der Schuh (20) durch eine natürliche seitliche Fußbewegung auf dem Boden (43) geneigt wird, wie bei einer normalen oder extremen Pronation oder Supination.

36. Schuhsohle (28) nach einem der Ansprüche 1 bis 35, bei der zumindest ein Teil einer unteren Fläche einer Mittelsohle (127) und zumindest ein zugehöriger Teil einer oberen Fläche einer Außensohle (128) im wesentlichen ebene Flächen sind, wobei zumindest ein Teil der Konturen des Schuhsohlenseitenabschnitts (28a) durch die Form der Außensohle (128) gebildet ist, so daß die beiden Sohlen (127, 128) bei der Herstellung einfach und auf herkömmliche Weise miteinander verbunden werden können.

37. Schuhsohle (28) nach einem der Ansprüche 1 bis 36, bei der ein Schuhoberteil (21) mit der Schuhsohle (28) verbunden ist.

Revendications

1. Semelle de chaussure (28) pour une chaussure

(20) ou autre article chaussant, tel qu'une chaussure de ville ou de sport, comprenant :

une surface supérieure (30, 30a, 30b) qui épouse sensiblement la forme naturelle d'au moins une partie de la plante de pied (29) du pied (27) du porteur, ladite forme comprenant au moins une partie de la portion supportant la charge d'au moins un côté courbe de la plante de pied (29) ; et

une surface inférieure (31) de contact avec le sol ; et

au moins une portion de semelle (28b) comprenant ladite surface supérieure (30b) et au moins une portion latérale (28a) profilée au profil naturel, qui se raccorde à ladite portion de semelle (28b) et à ladite surface supérieure (30a) en épousant sensiblement la forme du côté correspondant de la plante de pied (29) dudit pied (27) ;

dans laquelle ladite semelle de chaussure (28) possède une épaisseur (S) variable, mesurée dans des sections planes à peu près sagittales ;

caractérisée en ce que ladite portion de semelle (28b) et ladite portion latérale profilée (28a) ont une épaisseur (S) sensiblement uniforme, mesurée dans des sections planes à peu près frontales ; ladite épaisseur (S) de la semelle de la chaussure est définie par à peu près la distance la plus courte entre un point quelconque quelque part sur ladite surface supérieure (30) de contact avec le pied, et le point le plus proche quelque part sur ladite surface inférieure (31) de contact avec le sol, mesurée dans des coupes planes frontales et en ce que, ladite épaisseur (S) sensiblement uniforme est différente lorsqu'elle est mesurée dans au moins deux coupes planes frontales distinctes, la semelle (28) de la chaussure possédant au moins une dite portion latérale profilée (28a) d'épaisseur (S) sensiblement uniforme d'au moins 20 degrés, de sorte qu'il y a au moins deux épaisseurs (S) différentes de ladite au moins une portion latérale profilée (28a), mesurées dans lesdites coupes planes à peu près frontales distinctes.

2. Semelle de chaussure (28) selon la revendication 1, dans laquelle ladite épaisseur (S) de la semelle de chaussure est plus grande dans une région de talon (125) que dans une région d'avant-pied (126).

3. Semelle de chaussure (28) selon la revendication 1 ou 2, dans laquelle ladite semelle de chaussure (28) est faite d'une matière non rigide possédant une flexibilité suffisante pour permettre sensiblement à ladite plante de pied (29) du porteur de

s'aplatir naturellement sous une charge de poids du corps de la même façon que lorsque ladite plante de pied (29) transmet directement la charge sur le sol (43) ;

en conséquence, sous ladite charge du poids du corps, la flexibilité de ladite plante de pied (29) permet à la surface (30) supportant la charge de ladite semelle (28) de la chaussure et à la surface supportant la plante de pied (29) qui est en contact avec elle de se placer sensiblement parallèlement à la surface dudit sol (43), considéré dans des coupes planes frontales ;

et la flexibilité de ladite semelle de chaussure (28) permet aussi à ladite surface supérieure (30) de la semelle de chaussure (28), y compris au moins ladite portion latérale profilée (30a) d'épouser sensiblement continuellement la forme changeante de la plante de pied (29) du porteur, même lorsque ladite plante du pied s'aplatit d'une façon naturelle sous ladite charge du poids du corps.

4. Semelle de chaussure (28) selon les revendications 1 à 3, dans laquelle ladite portion latérale profilée (28a) d'au moins 20 degrés se raccorde à au moins une portion de semelle (28b) sensiblement proche des têtes des métatarses (96) du pied du porteur.

5. Semelle de chaussure (28) selon les revendications 1 à 4, dans laquelle ladite portion latérale profilée (28a) d'au moins 20 degrés se raccorde à au moins une portion de semelle (28b) sensiblement proche d'une base du cinquième métatarse (97) du pied du porteur.

6. Semelle de chaussure (28) selon les revendications 1 à 5, dans laquelle ladite portion latérale profilée (28a) d'au moins 20 degrés se raccorde à au moins une portion (28b) de la semelle qui est sensiblement proche d'une tubérosité latérale du calcaneum (95) du pied (27) du porteur.

7. Semelle de chaussure (28) selon les revendications 1 à 6, dans laquelle ladite portion latérale profilée (28a) d'au moins 20 degrés se raccorde à au moins une portion médiane (28b) de la semelle sensiblement proche d'une base du calcaneum (95) du pied (27) du porteur.

8. Semelle de chaussure (28) selon les revendications 1 à 7, dans laquelle ladite portion latérale profilée (28a) d'au moins 20 degrés se raccorde à au moins une portion (28b) de la semelle sensiblement proche de la tête des métatarses (96) dudit pied (27) du porteur.

9. Semelle de chaussure (28) selon les revendications

1 à 8, dans laquelle ladite portion latérale profilée (28a) d'au moins 20 degrés se raccorde à au moins une portion (28b) de la semelle qui est sensiblement proche de la tête de la première phalange distale (98) du pied (27) du porteur.

10. Semelle de chaussure (28) selon les revendications 1 à 9, dans laquelle au moins une grande partie de ladite au moins une portion (28b) de la semelle se raccorde à au moins une portion latérale profilée (28a).

11. Semelle de chaussure (28) selon les revendications 1 à 10, dans laquelle au moins deux portions latérales profilées (28a), y compris une portion sensiblement proche de la tête du premier métatarse (96) et une portion sensiblement proche de la première phalange distale (98) sont séparées par une région située directement entre elles qui ne comporte pas de portion latérale profilée (28a).

12. Semelle de chaussure (28) selon les revendications 1 à 11, dans laquelle au moins deux dites portions latérales profilées (28a) sont séparées par une zone située directement entre elles et ayant une portion de semelle (28b) qui se raccorde à un côté profilé qui a une épaisseur qui est plus faible que l'épaisseur de ladite portion de semelle (28b) ;

les épaisseurs de ladite portion latérale profilée (28a) et de ladite portion de semelle (28b) étant mesurées dans des coupes planes frontales.

13. Semelle de chaussure (28) selon les revendications 1 à 12, dans laquelle au moins une partie de la surface supérieure (30b) de ladite au moins une portion de semelle (28b) épouse sensiblement les profils naturels de ladite plante de pied (29) dudit pied (27) supportant la charge dudit porteur.

14. Semelle de chaussure (28) selon les revendications 1 à 13, dans laquelle au moins une partie de ladite surface supérieure (30b) de ladite au moins une portion de semelle (28b) épouse sensiblement le profil naturel de la face inférieure de ladite plante de pied (29) dudit pied (27) du porteur lorsqu'elle n'est pas sous une charge.

15. Semelle de chaussure (28) selon les revendications 1 à 14, dans laquelle, dans au moins la région calcaneale (95), au moins une partie de ladite surface supérieure (30b) de ladite au moins une portion (28b) de la semelle épouse sensiblement le profil naturel de la face inférieure de la plante de pied (29) dudit pied (27) du porteur lorsqu'il n'est pas sous une charge.

16. Semelle de chaussure (28) selon les revendications

1 à 15, dans laquelle au moins une partie de ladite surface supérieure (30b) de ladite au moins une portion (28b) de la semelle est sensiblement plate.

17. Semelle de chaussure (28) selon les revendications 1 à 16, dans laquelle lesdites portions latérales profilées (28a) sont suffisantes pour maintenir la stabilité latérale dudit pied (27) du porteur sur toute la gamme des mouvements latéraux de pronation et supination d'une façon sensiblement équivalente à celle du pied (27) du porteur lorsqu'il est nu sur le sol (43) ;

cette ferme stabilité latérale peut être démontrée par un simple test de comparaison relative fait par ledit porteur, qui peut simuler une entorse de la cheville par inversion commune lorsqu'il se tient debout dans une position immobile ;

premièrement ledit pied (27) déchaussé du porteur est basculé latéralement en inversion jusqu'à la limite extrême de 20 degrés de l'intervalle de mouvement de l'articulation subtalare de la cheville dudit pied du porteur pour démontrer une ferme stabilité latérale ;

deuxièmement, le même mouvement d'inversion est répété par le pied chaussé dudit porteur avec la semelle de chaussure (28) possédant des portions latérales profilées (28a) avec une épaisseur (s) sensiblement uniforme pour démontrer la ferme stabilité latérale sensiblement équivalente ;

et, troisièmement, au contraire, le même mouvement d'inversion est de nouveau répété, très prudemment, par le porteur chaussé avec une semelle de chaussure classique quelconque (22) pour démontrer le grave manque de stabilité latérale.

18. Semelle de chaussure (28) selon les revendications 1 à 17, dans laquelle la densité de ladite au moins une portion latérale profilée (28a) est plus grande que la densité de la matière utilisée dans ladite portion de semelle (28b), pour compenser la plus forte charge de pression pendant le mouvement d'inversion et d'éversion dudit pied.

19. Semelle de chaussure (28) selon les revendications 1 à 18, dans laquelle ladite au moins une portion latérale profilée (28a) d'au moins 30 degrés se raccorde à une portion de talon (125) de ladite portion de semelle (28b) ;

et ladite épaisseur (S) sensiblement uniforme de ladite semelle de chaussure (28) dans ladite région de talon (125) munie d'une portion latérale profilée (28a) d'au moins 30 degrés, mesurée dans une coupe plane frontale, est différente de ladite épaisseur (S) sensiblement

uniforme de ladite semelle de chaussure dans ladite région d'avant-pied (126) qui s'étend sur ladite au moins une portion latérale profilée (28a) d'au moins 30 degrés, également mesurée dans des coupes planes à peu près frontales.

20. Semelle de chaussure (28) selon les revendications 1 à 19, dans laquelle ladite épaisseur sensiblement uniforme (S) de ladite semelle de chaussure (28) s'étend sur au moins une portion latérale profilée (28a) en donnant un appui structurel direct entre ladite plante de pied (29) dudit pied (27) et ledit sol (43) sur toute une amplitude d'inclinaison latérale d'au moins 45 degrés ;

ladite épaisseur uniforme (S) de ladite semelle de chaussure (28) est différente dans au moins deux coupes planes frontales distinctes, dans laquelle ladite semelle de chaussure (28) a une portion latérale profilée (28a) d'au moins 45 degrés, de sorte qu'il y a au moins deux épaisseurs (S) différentes desdites portions latérales profilées (28a), mesurées dans des coupes planes à peu près frontales ;

l'épaisseur (S) de ladite au moins une portion latérale profilée (28a) est mesurée avec au moins une coupe plane frontale prise à proximité des têtes des métatarses (96) du porteur et l'épaisseur (S) d'une autre portion latérale profilée (28a) est mesurée dans au moins une autre coupe plane à peu près frontale prise à proximité d'une base du premier métatarse (97) du porteur.

21. Semelle de chaussure (28) selon les revendications 1 à 20, dans laquelle ladite épaisseur (S) sensiblement uniforme dudit avant-pied (126) de la semelle de chaussure (28) est différente dans au moins deux coupes planes frontales distinctes, dans laquelle ladite semelle de chaussure (28) a au moins une portion latérale profilée (28a) ayant une épaisseur sensiblement uniforme qui s'étend sur une inclinaison latérale d'au moins 45 degrés, de sorte qu'il y a au moins deux épaisseurs (s) différentes desdites portions latérales profilées (28a) dans ladite zone d'avant-pied (126) de la semelle de chaussure, mesurées dans des coupes planes à peu près frontales.

22. Semelle de chaussure (28) selon les revendications 1 à 21, dans laquelle la semelle de chaussure a ladite épaisseur (S) sensiblement uniforme, mesurée dans des coupes planes à peu près frontales, dans toutes les parties de ladite semelle de chaussure (28), pour donner un appui structurel direct entre ladite plante de pied (29) supportant la charge dudit pied (27) dudit porteur et ledit sol (43) ;

ladite portion supportant la charge directe de ladite semelle de chaussure (28) comprend aussi bien une partie quelconque de ladite au moins une portion de semelle (28b) et une portion quelconque de ladite au moins une portion latérale profilée (28a) qui deviennent directement support de charge lorsque ladite semelle de chaussure (28) appuyée sur ledit sol (43) est inclinée latéralement en s'éloignant d'une position verticale ;

ladite épaisseur sensiblement uniforme de ladite semelle de chaussure (28) s'étend sur au moins une dite portion latérale profilée (28a) en établissant un appui structurel direct entre ladite plante de pied (29) dudit pied (27) et ledit sol (43) sur une inclinaison latérale d'au moins 20 degrés ;

de sorte que, mesurée dans des coupes planes à peu près frontales, ladite épaisseur (S) sensiblement uniforme de ladite semelle de chaussure (28), qui inclut spécialement ladite portion latérale profilée (28a), maintient la stabilité latérale dudit pied (27) sur ladite semelle de chaussure (28) de la même façon que lorsque ledit pied (27) est nu sur le sol (43) spécialement pendant les mouvements latéraux de pronation et supination qui se produisent lorsque ladite semelle de chaussure (28) est en contact avec ledit sol (43).

23. Semelle de chaussure (28) selon les revendications 1 à 22, dans laquelle ladite épaisseur (S) sensiblement uniforme de ladite semelle de chaussure (28), mesurée dans des coupes planes à peu près frontales, s'étend sur au moins une partie de ladite au moins une portion latérale profilée (28a) d'au moins 30 degrés.

24. Semelle de chaussure (28) selon les revendications 1 à 23, dans laquelle ladite épaisseur (S) sensiblement uniforme de ladite semelle de chaussure (28), mesurée dans des coupes planes à peu près frontales, s'étend sur au moins une partie de ladite au moins une portion latérale profilée (28a) d'au moins 45 degrés.

25. Semelle de chaussure (28) selon les revendications 1 à 24, dans laquelle ladite épaisseur (S) sensiblement uniforme de ladite semelle de chaussure (28), mesurée dans des coupes planes à peu près frontales, s'étend sur au moins une partie de ladite au moins une portion latérale profilée (28a) d'au moins 90 degrés ;

de sorte que la dimension d'un quelconque côté profilé (28a) de la semelle de chaussure qui est prévue dans ladite semelle de chaussure (28) est suffisante pour maintenir la stabilité latérale dudit pied (27) du porteur dans toute l'étendue de l'intervalle le plus extrême de mouvement latéral, y

compris au moins 90 degrés d'inversion et d'éversion ; ladite stabilité latérale étant analogue à celle dudit pied (27) du porteur lorsqu'il est nu.

26. Semelle de chaussure (28) selon les revendications 1 à 25, dans laquelle ladite épaisseur (S) sensiblement uniforme de ladite semelle de chaussure (28), mesurée dans des coupes planes à peu près frontales, s'étend sur au moins une partie de ladite au moins une portion latérale profilée (28a) de 120 degrés ;

de sorte que la dimension d'un quelconque côté profilé (28a) de la semelle de chaussure qui est prévue dans ladite semelle de chaussure (28) est suffisante pour maintenir la stabilité latérale dudit pied (27) du porteur dans toute l'étendue de l'intervalle le plus extrême de mouvement latéral ; ladite stabilité latérale étant analogue à celle d'un pied (27) du porteur lorsqu'il est nu.

27. Semelle de chaussure (28) selon les revendications 1 à 26, dans laquelle ladite surface inférieure (31), de contact avec le sol, de ladite semelle de chaussure (28) est reliée à ladite surface supérieure (30) par une surface (53a) ne supportant pas la charge, qui forme un bord extérieur de ladite semelle de chaussure (28) ;

mesurée dans des coupes planes à peu près frontales, la distance entre un point quelconque de ladite surface de bord extérieur (53a) et le point le plus proche de ladite surface supérieure (30) de la semelle de chaussure est inférieure à l'épaisseur (S) sensiblement uniforme définie plus haut des portions supportant la charge de la semelle de chaussure ;

ladite distance inférieure se réduit progressivement, en partant de l'épaisseur des portions supportant la charge, de sorte que ledit bord extérieur (53a) est en pente progressive depuis ladite surface inférieure (31) de contact avec le sol jusqu'à ladite surface supérieure (30) de contact avec le pied, en évitant ainsi la création d'une arête vive qui permettrait à ladite semelle de chaussure (28) de pivoter sur cette arête de façon instable lorsqu'elle est inclinée latéralement à un degré extrême.

28. Semelle de chaussure (28) selon les revendications 1 à 27, dans laquelle, dans une coupe plane frontale donnée, au moins une partie de ladite au moins une portion profilée (28) est sensiblement construite sur la base d'une approximation mathématique de la forme d'une partie d'un anneau ayant une épaisseur (r) sensiblement égale à ladite épaisseur (S) de la semelle de chaussure, dans ladite coupe plane à peu près frontale :

dans ladite coupe plane à peu près frontale

donnée, au moins une partie de ladite surface supérieure (30) de contact avec la plante de pied, de la semelle de chaussure (28) est construite sous la forme d'un cercle relativement plus petit qui définit une surface intérieure dudit anneau qui est formée avec un rayon (r') approprié et un centre (115) pour coïncider approximativement avec au moins une partie de ladite surface profilée (30) de ladite plante de pied (29) du pied (27) du porteur ;

et au moins une partie de ladite surface inférieure (31), de contact avec le sol, de ladite semelle de chaussure (28) est construite sous la forme d'un cercle relativement plus grand qui définit une surface extérieure dudit anneau et qui est formée, tout en conservant sensiblement le même centre de rotation (115) avec un rayon ($r'+r$) augmenté d'une quantité (r) sensiblement égale à l'épaisseur (S) de ladite semelle de chaussure (28) dans ladite coupe plane à peu près frontale donnée.

29. Semelle de chaussure (28) selon les revendications 1 à 28, dans laquelle ladite surface extérieure (31) de ladite semelle de chaussure (28) porte une pluralité de crampons fixés à cette semelle ;

la surface (63) à laquelle lesdits crampons (61) sont fixés devient support de charge sur un sol (43) quelconque suffisamment souple pour que lesdits crampons pénètrent entièrement dans le sol, en tirant ainsi parti de leur avantage de traction ; en conséquence, cette surface supportant la charge (63) est définie en tant que surface inférieure (31), de contact avec le sol, pour la mesure ladite épaisseur (S) de la semelle de chaussure.

30. Semelle de chaussure (28) selon les revendications 1 à 29, dans laquelle au moins une partie de la structure courbe de ladite portion latérale profilée (28a), telle qu'une sculpture de semelle (60) de ladite surface (31), de contact avec le sol, est construite par approximation en utilisant au moins un segment de ligne droite (110) pour construire au moins une portion de ladite courbe, mesurée dans des coupes planes à peu près frontales.

31. Semelle de chaussure (28) selon les revendications 1 à 30, dans laquelle au moins une portion (28b) de la semelle et ladite au moins une portion latérale profilée (28a) sont formées en une seule pièce pour constituer une structure unitaire de semelle de chaussure (28).

32. Semelle de chaussure (28) selon les revendications 1 à 31, dans laquelle ladite semelle de chaussure (28) comprend au moins une semelle intercalaire (127) et une semelle extérieure (128).

33. Semelle de chaussure (28) selon les revendications 1 à 32, dans laquelle ladite semelle de chaussure (28) comprend au moins trois couches : une première, ladite semelle intercalaire (127) et ladite semelle extérieure (128).

34. Semelle de chaussure (28) selon les revendications 1 à 33, dans laquelle ladite zone d'avant-pied (126) de ladite semelle de chaussure (28) comprend au moins ladite première et ladite semelle extérieure (128).

35. Semelle de chaussure (28) selon les revendications 1 à 34, dans laquelle ladite au moins une portion de semelle (28b) et ladite au moins une portion latérale (28a) de ladite semelle de chaussure (28) sont suffisantes pour maintenir la portion supportant la charge de la plante de pied (29) du pied (27) du porteur à une distance (S) à peu près constante du sol (43), mesurée dans des coupes planes à peu près frontales, ladite distance constante étant ladite épaisseur (S) de ladite semelle de chaussure (28), même lorsque ladite chaussure (20) est inclinée vers le côté par un mouvement latéral naturel du pied sur ledit sol (43), tel que la pronation ou la supination, soit de routine, soit extrême.

36. Semelle de chaussure (28) selon les revendications 1 à 35, dans laquelle au moins une partie d'une surface inférieure d'une semelle intercalaire (127) et au moins une partie, qui lui correspond, d'une surface supérieure d'une semelle extérieure (128) sont des plans sensiblement plats, au moins une partie des profils latéraux (28a) de la semelle de chaussure étant formée par la forme de ladite semelle extérieure (128), de sorte que les deux semelles (127, 128) peuvent être assemblées facilement et de la façon classique dans le processus d'assemblage de la fabrication.

37. Semelle de chaussure (28) selon les revendications 1 à 36, dans laquelle un dessus (21) de Chaussure est assemblé à ladite semelle de chaussure (28).

FIG. 1
(PRIOR ART)

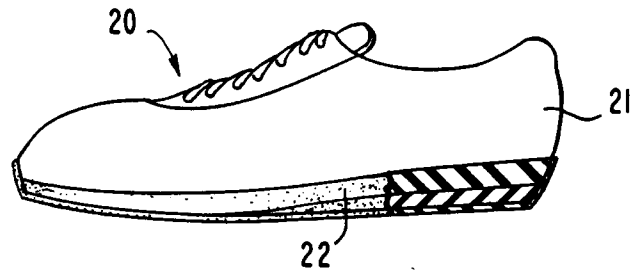


FIG. 2A
(PRIOR ART)

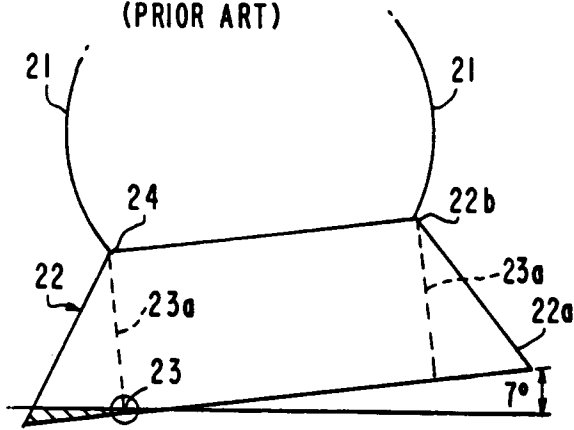


FIG. 2

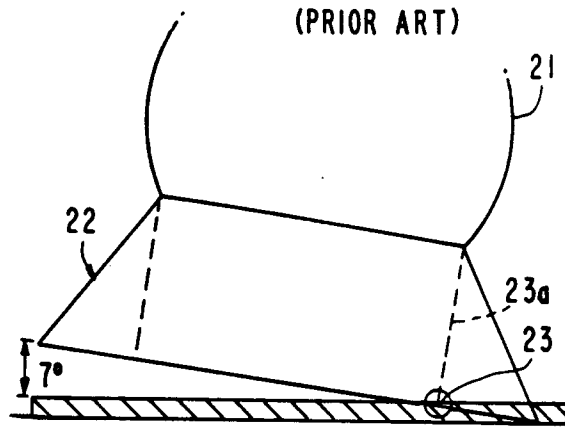


FIG. 2B
(PRIOR ART)

FIG. 2C

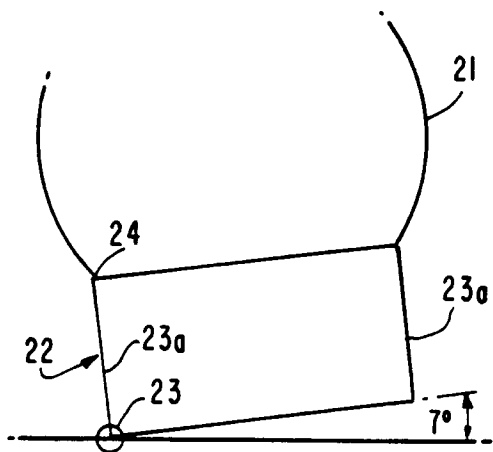


FIG. 2D

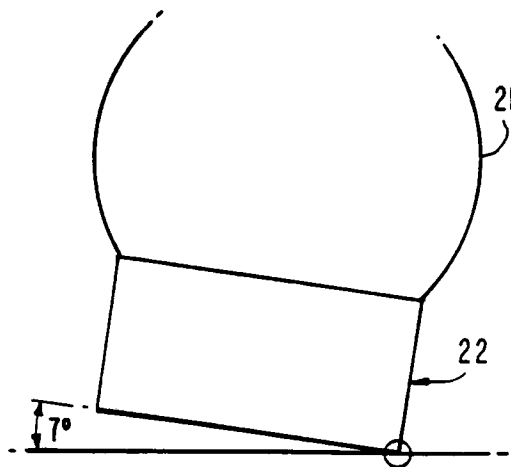


FIG. 3

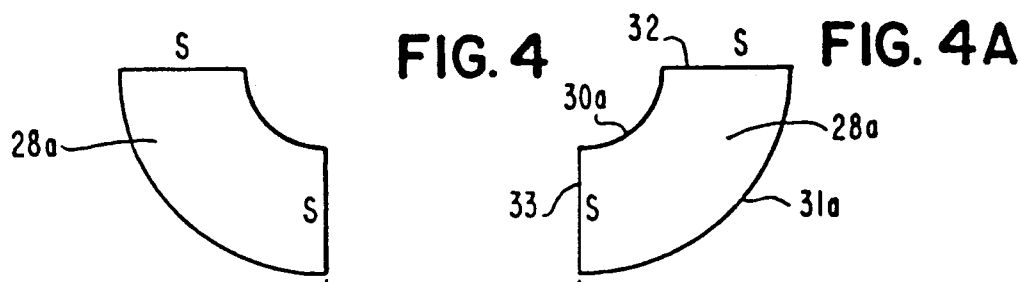
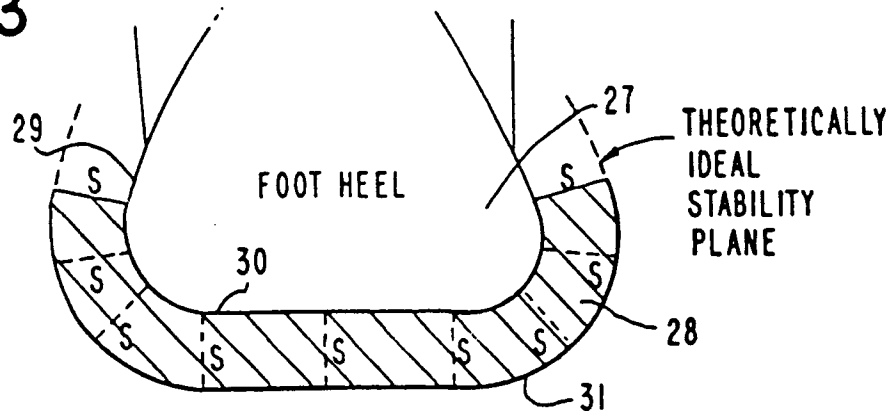


FIG. 4B

FIG. 4A

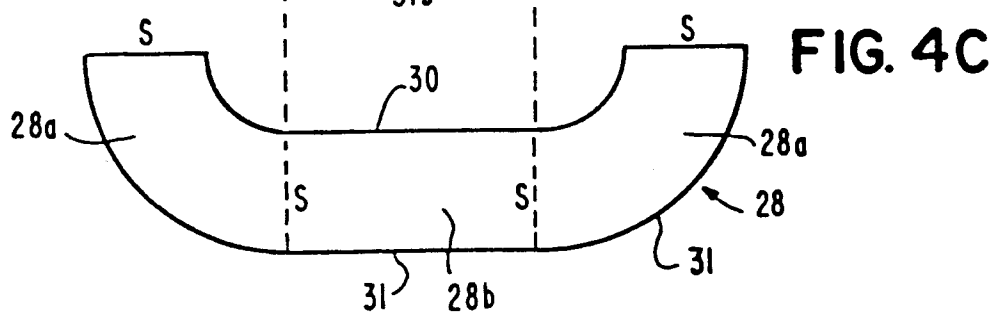


FIG. 4C

FIG. 4D

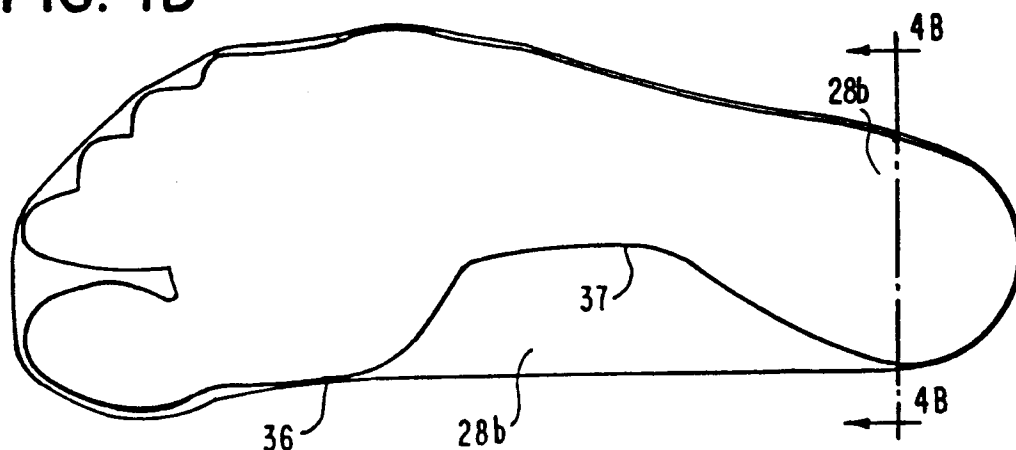


FIG. 5

FIG. 5A

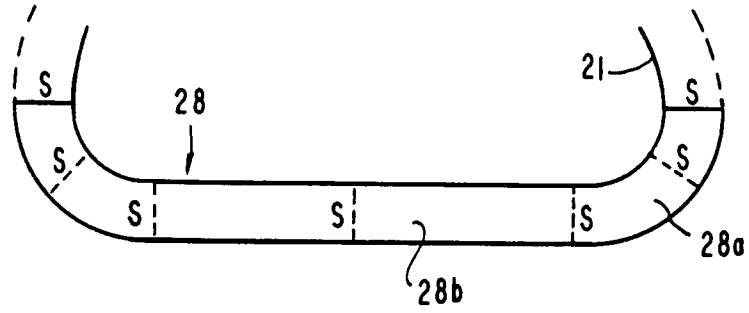


FIG. 5B

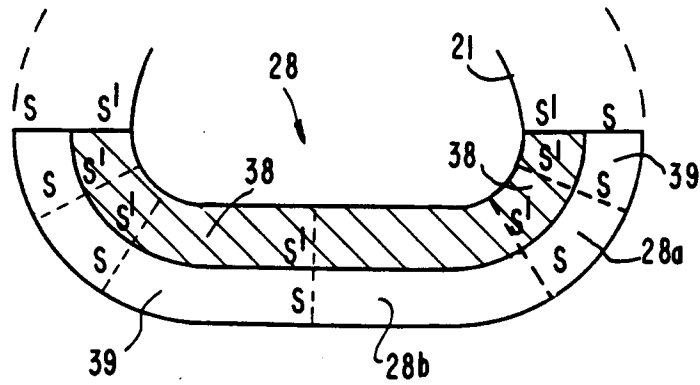


FIG. 6

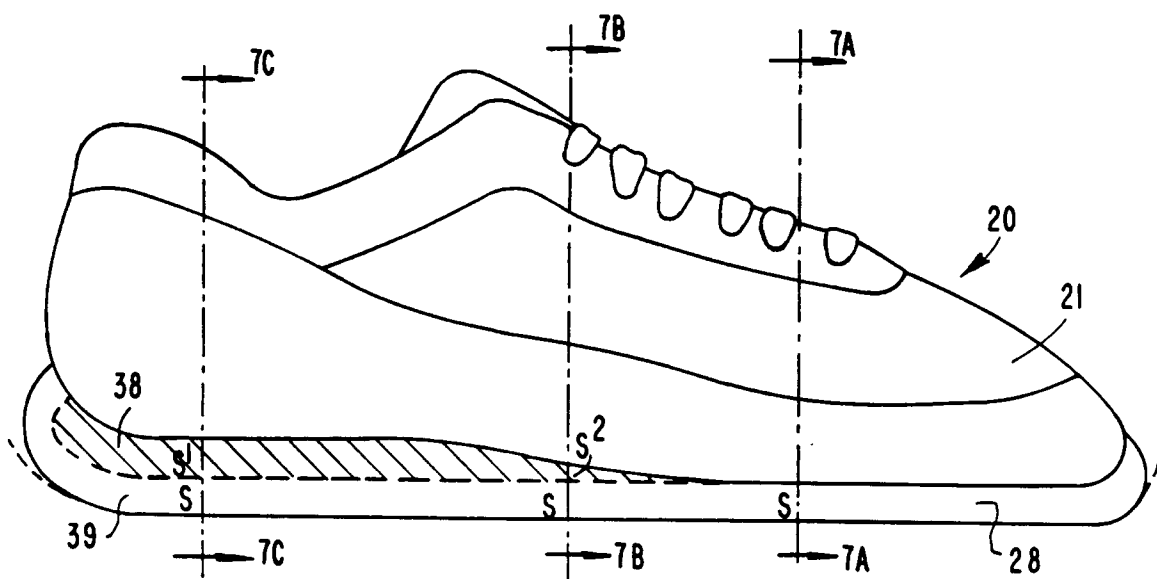


FIG. 7A

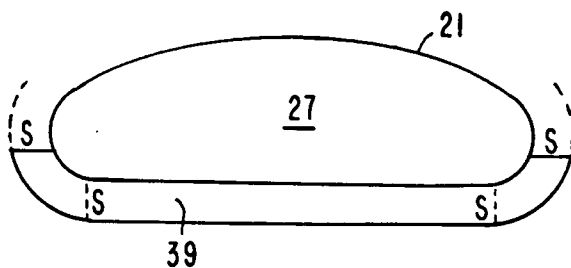


FIG. 7

FIG. 7D

FIG. 7B

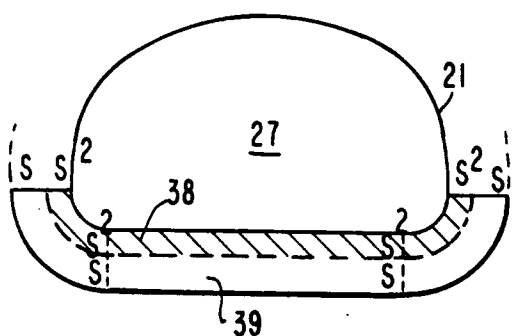


FIG. 7C

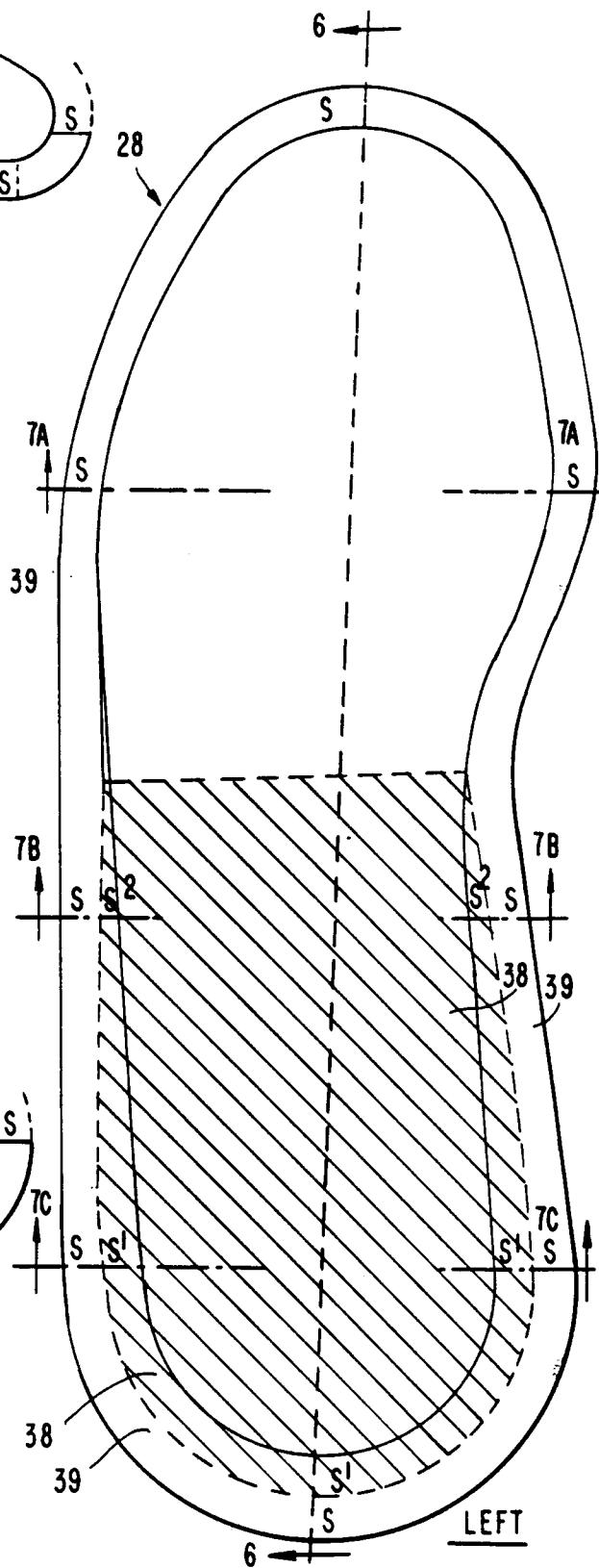
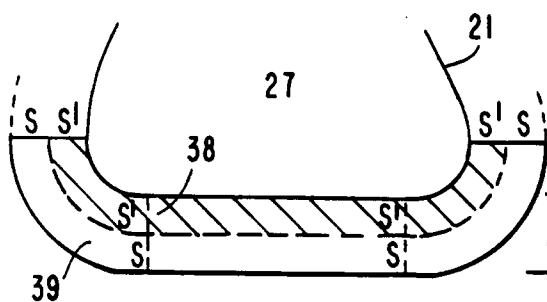


FIG. 8

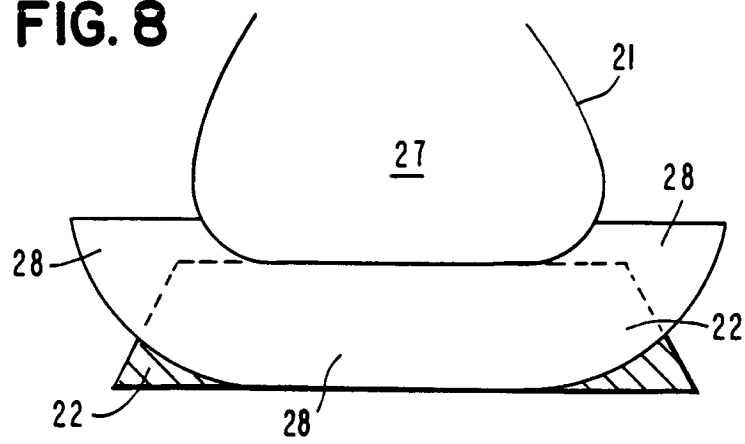


FIG. 9

FIG. 9A

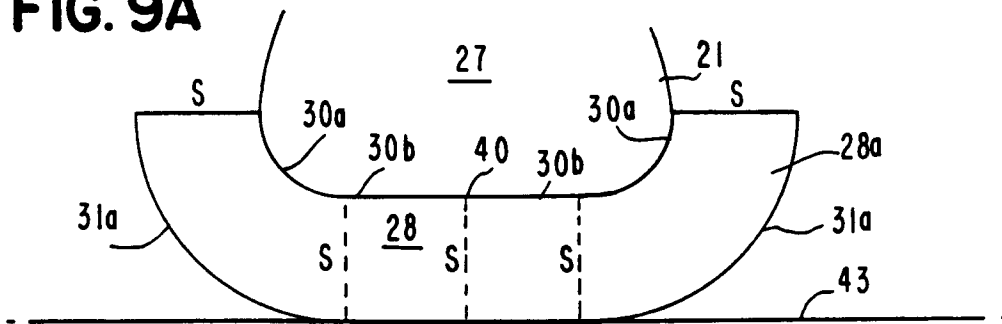


FIG. 9B

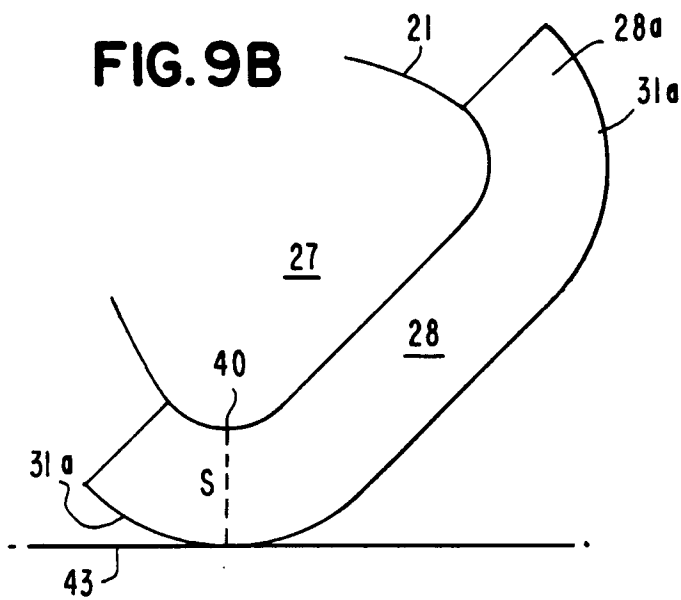


FIG. 9C

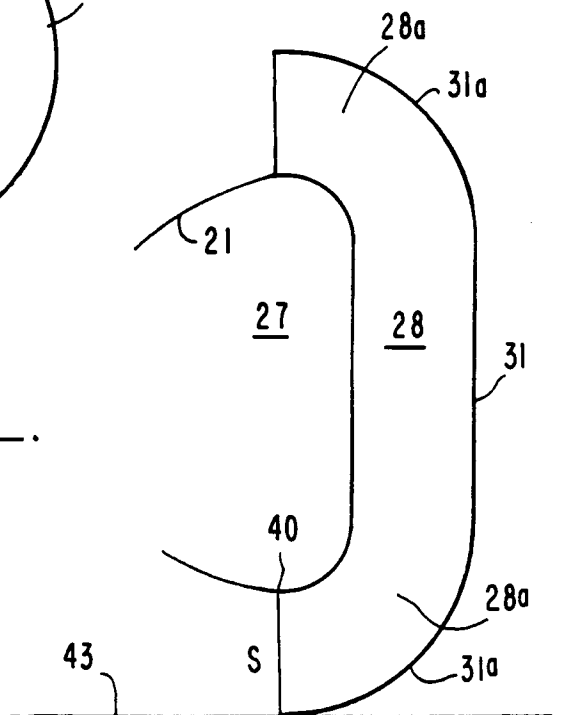


FIG. 10

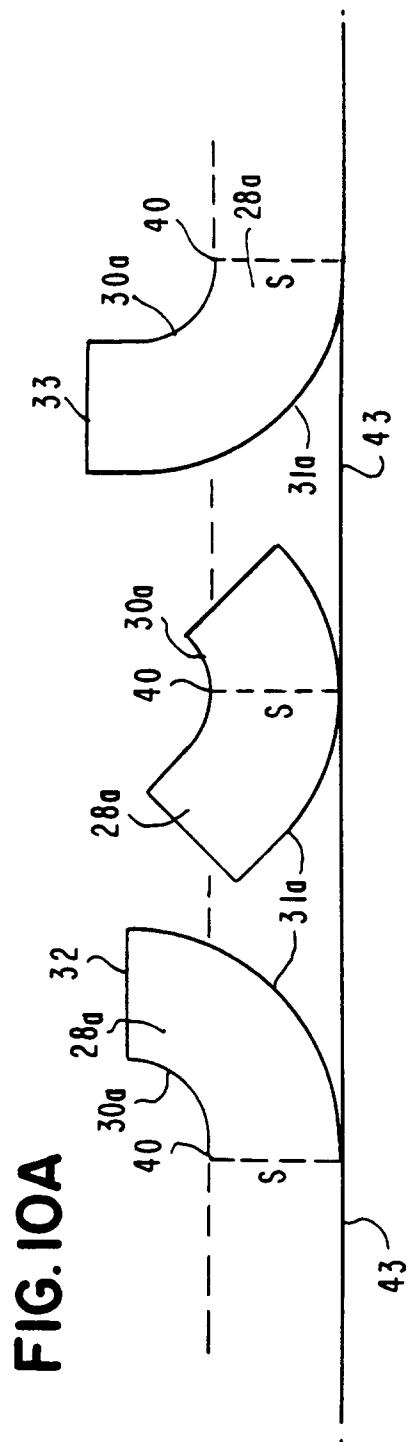


FIG. 10B

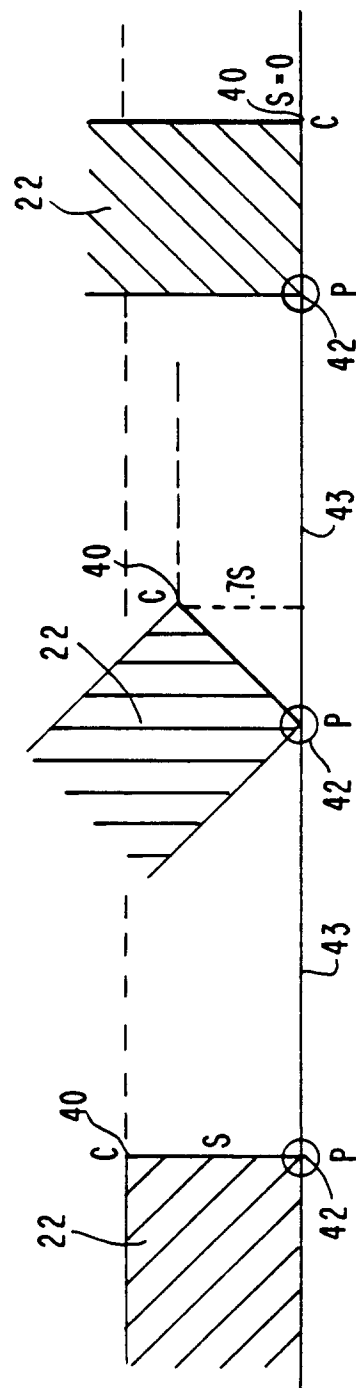


FIG. II

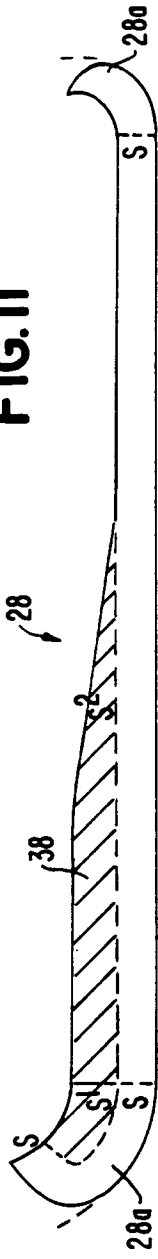


FIG. IIB



FIG. IIC

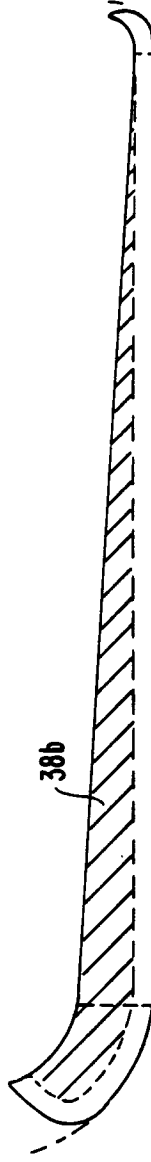


FIG. IID

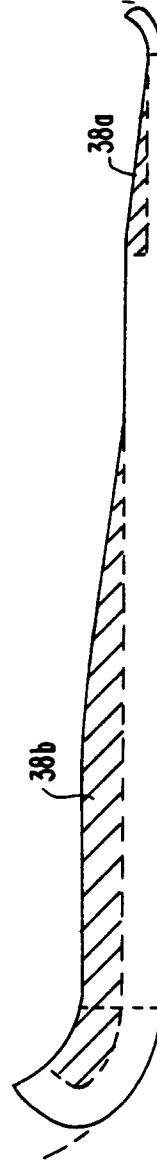


FIG. IIE

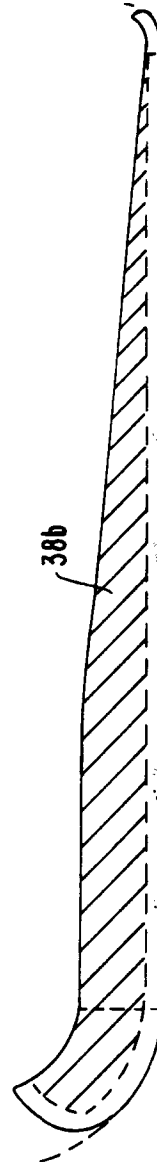


FIG.12A

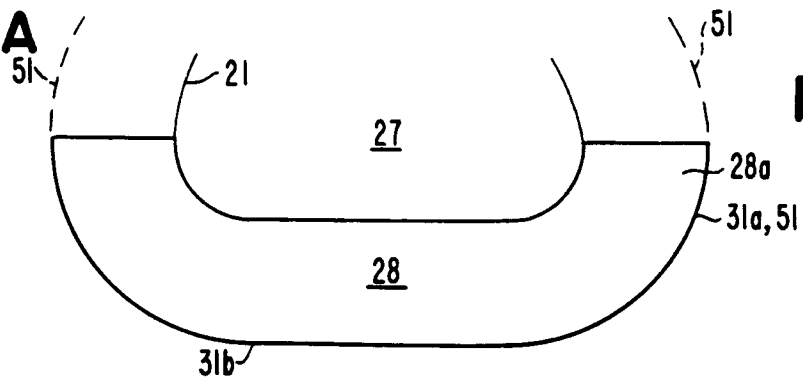


FIG.12

FIG.12B

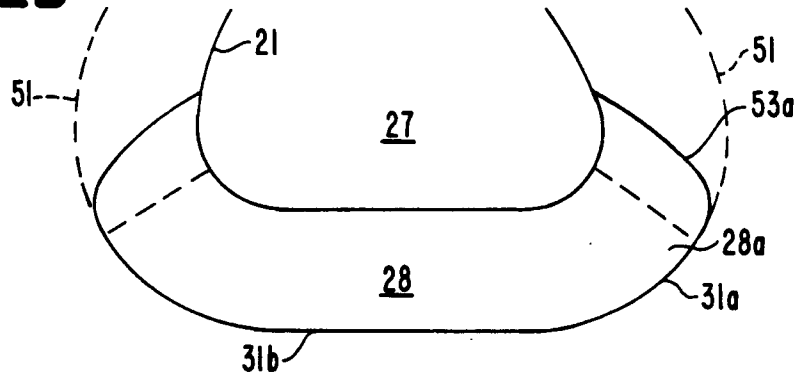


FIG.12C

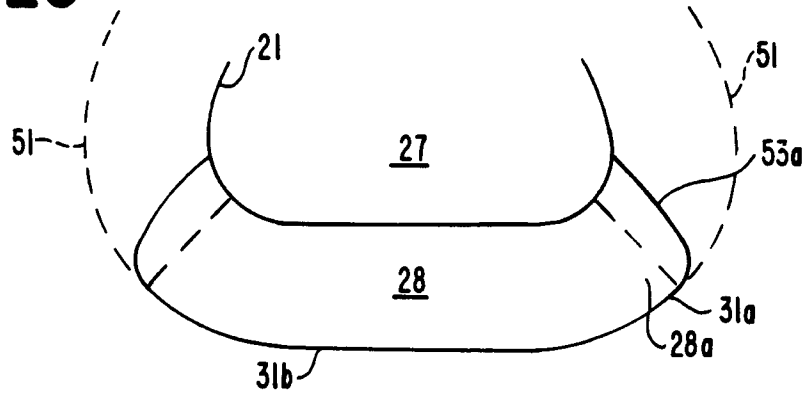


FIG.12D

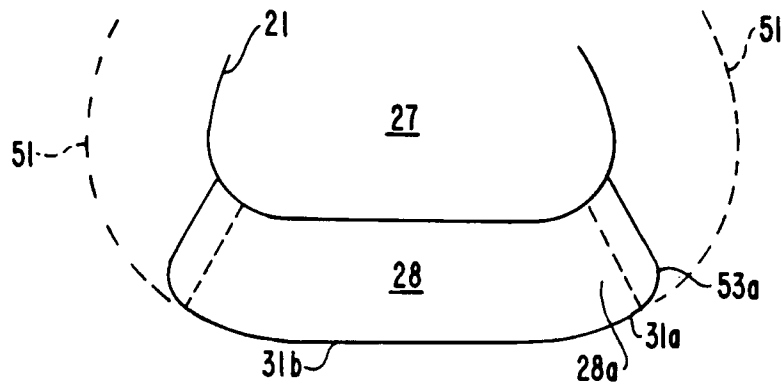


FIG.13

FIG.13A

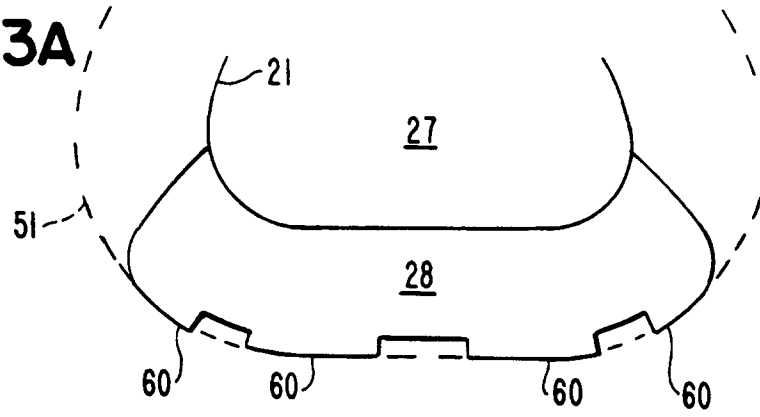


FIG.13B

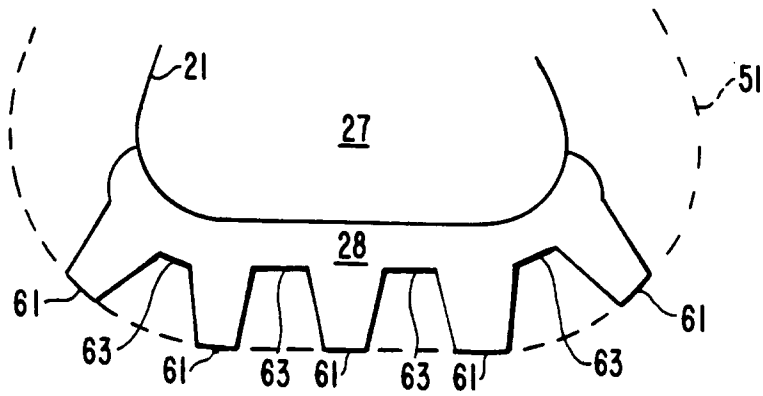


FIG.13C

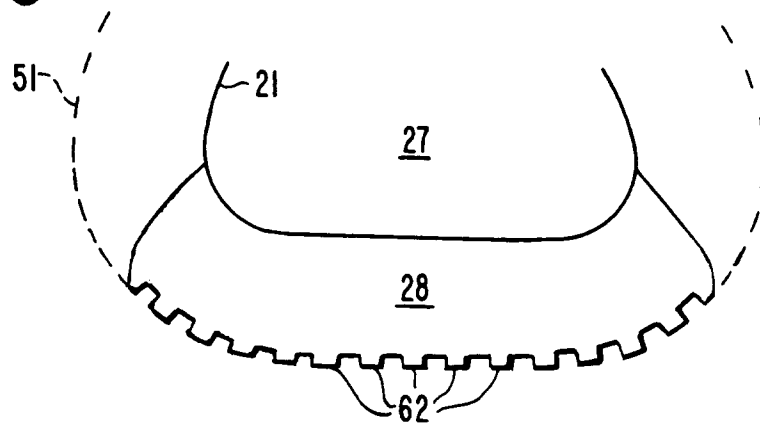


FIG. 14

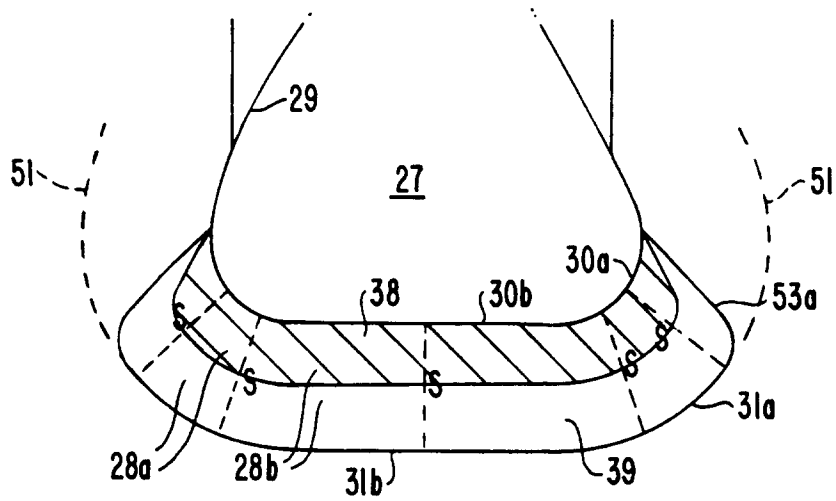


FIG. 15

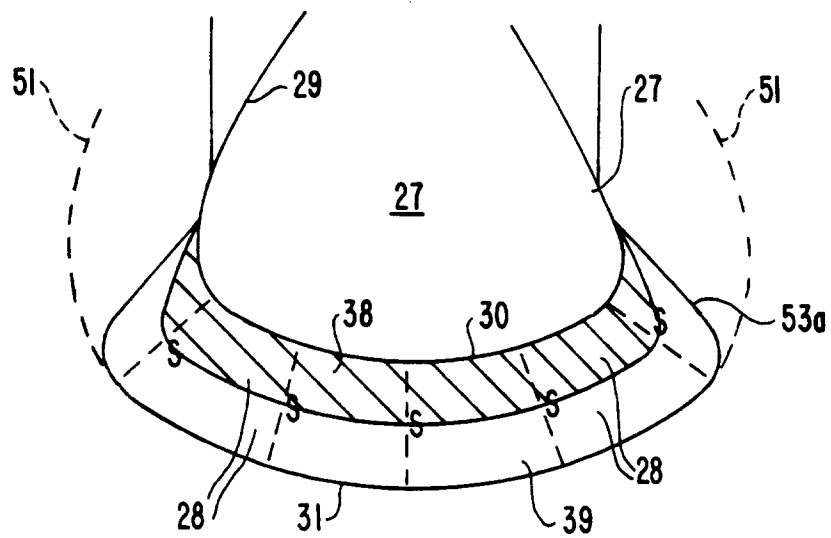


FIG. 16

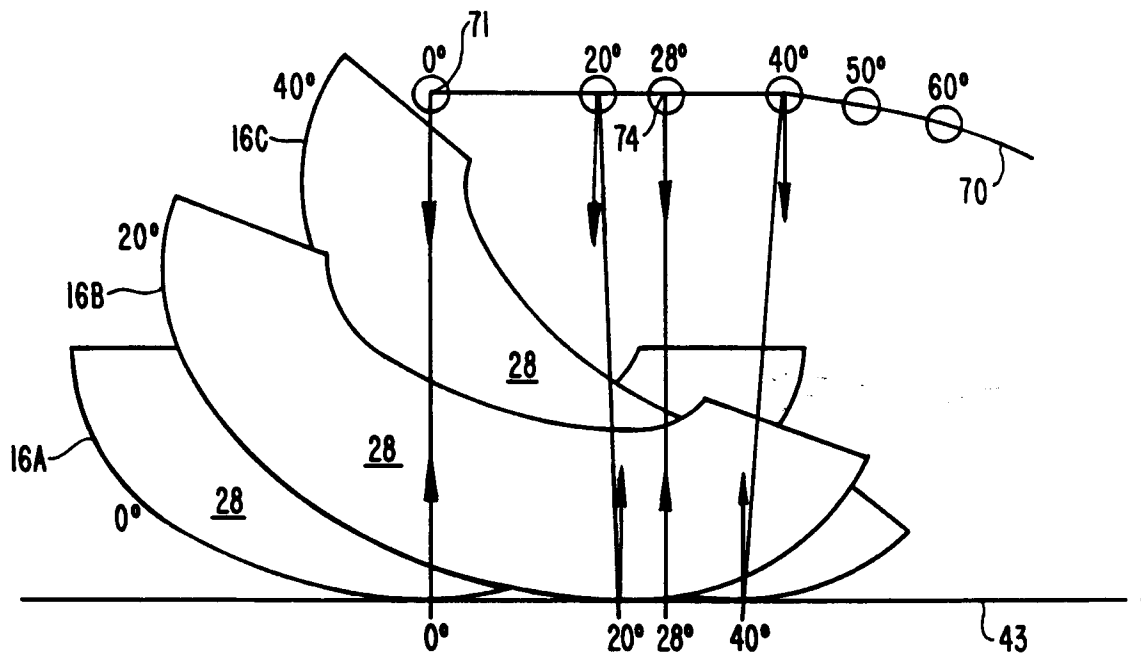


FIG. 17

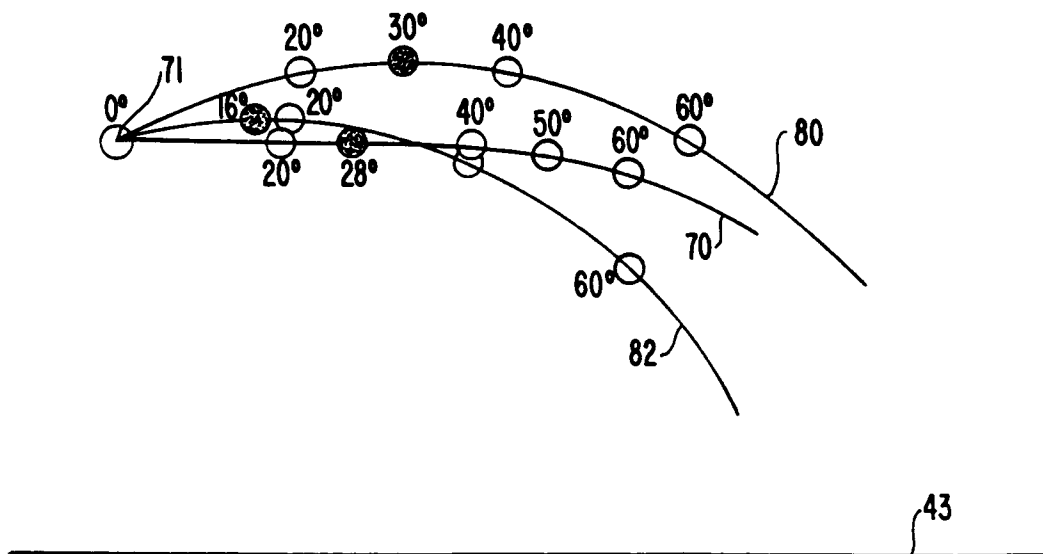


FIG. 18

FIG. 18A

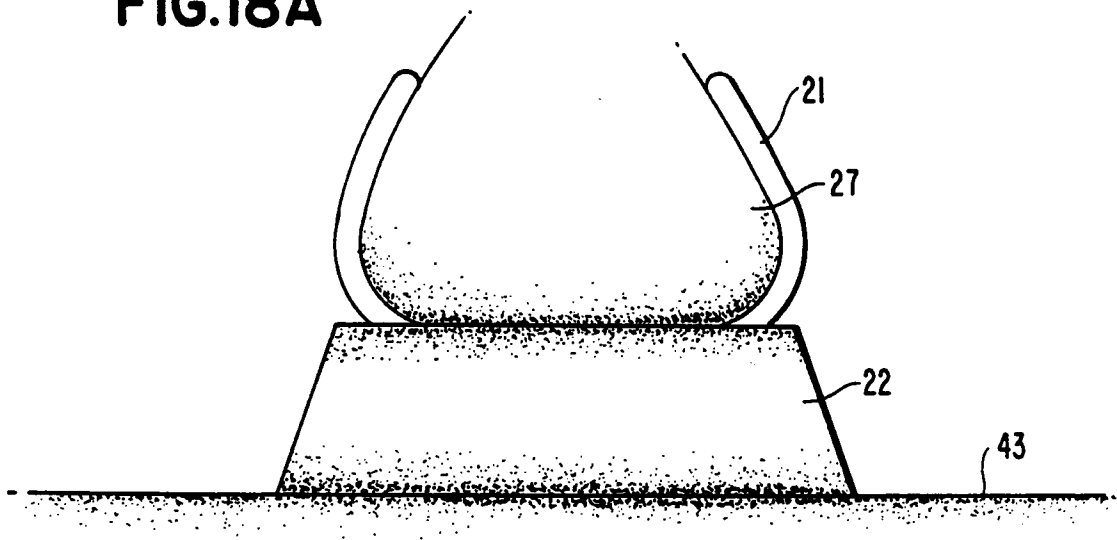


FIG. 18B

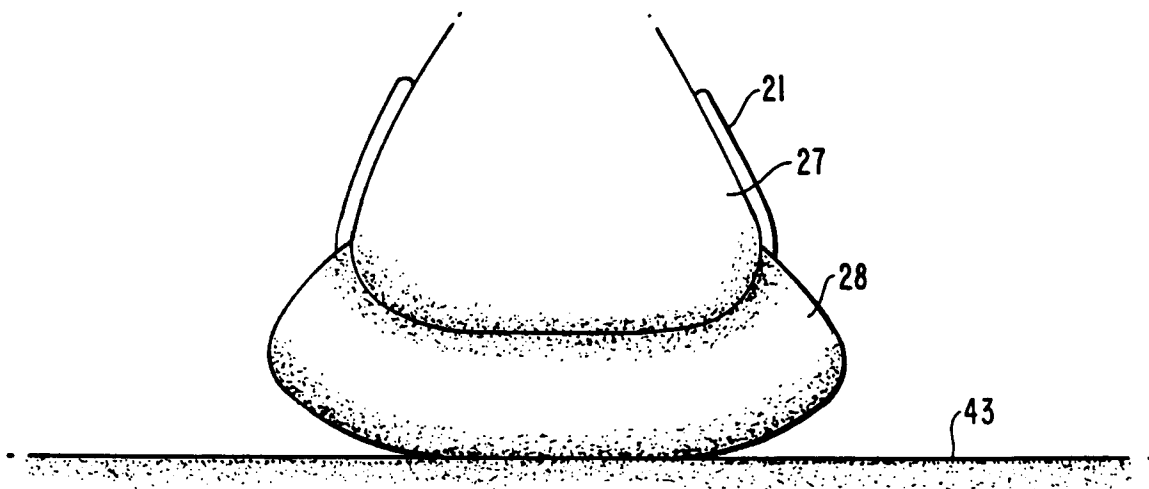


FIG. 19A

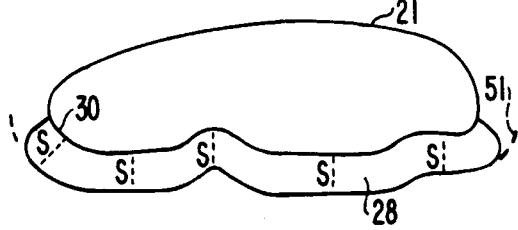


FIG. 19

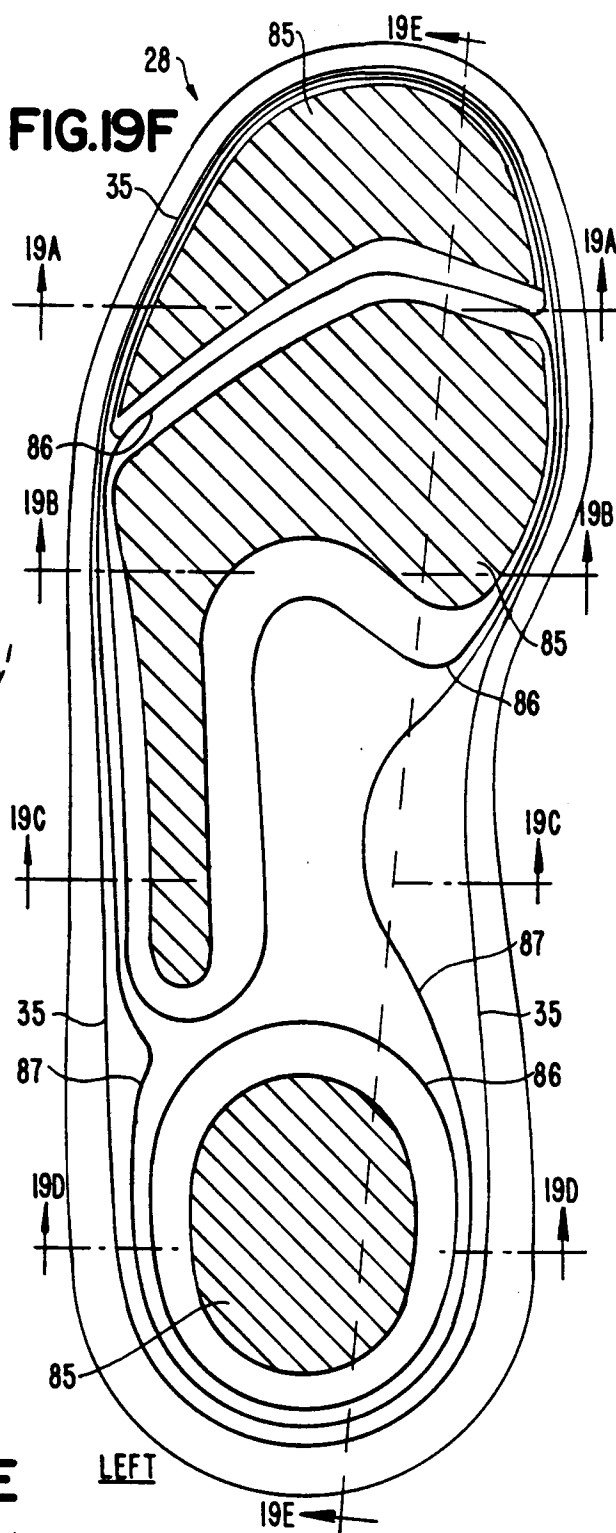


FIG. 19B

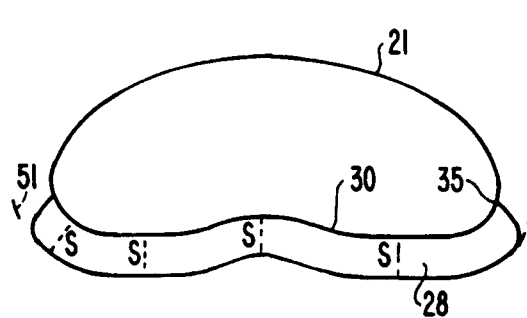


FIG. 19C

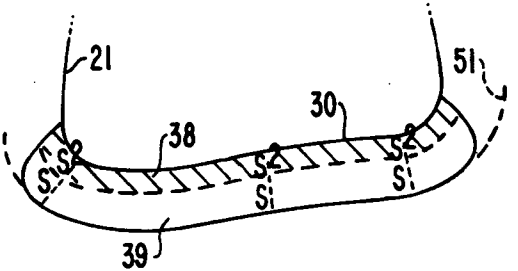


FIG. 19D

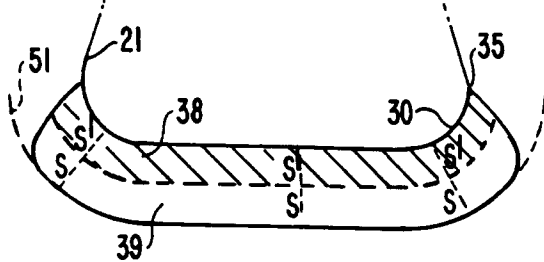
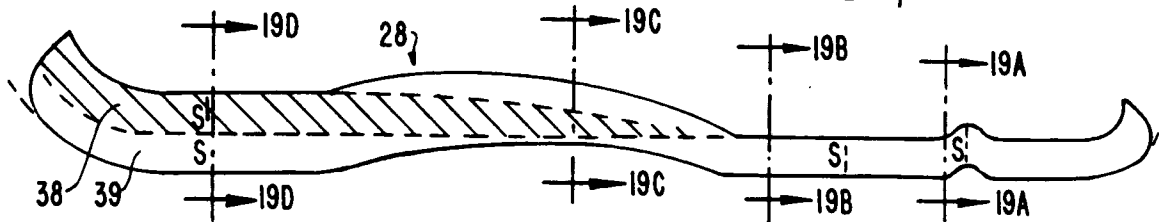


FIG. 19E



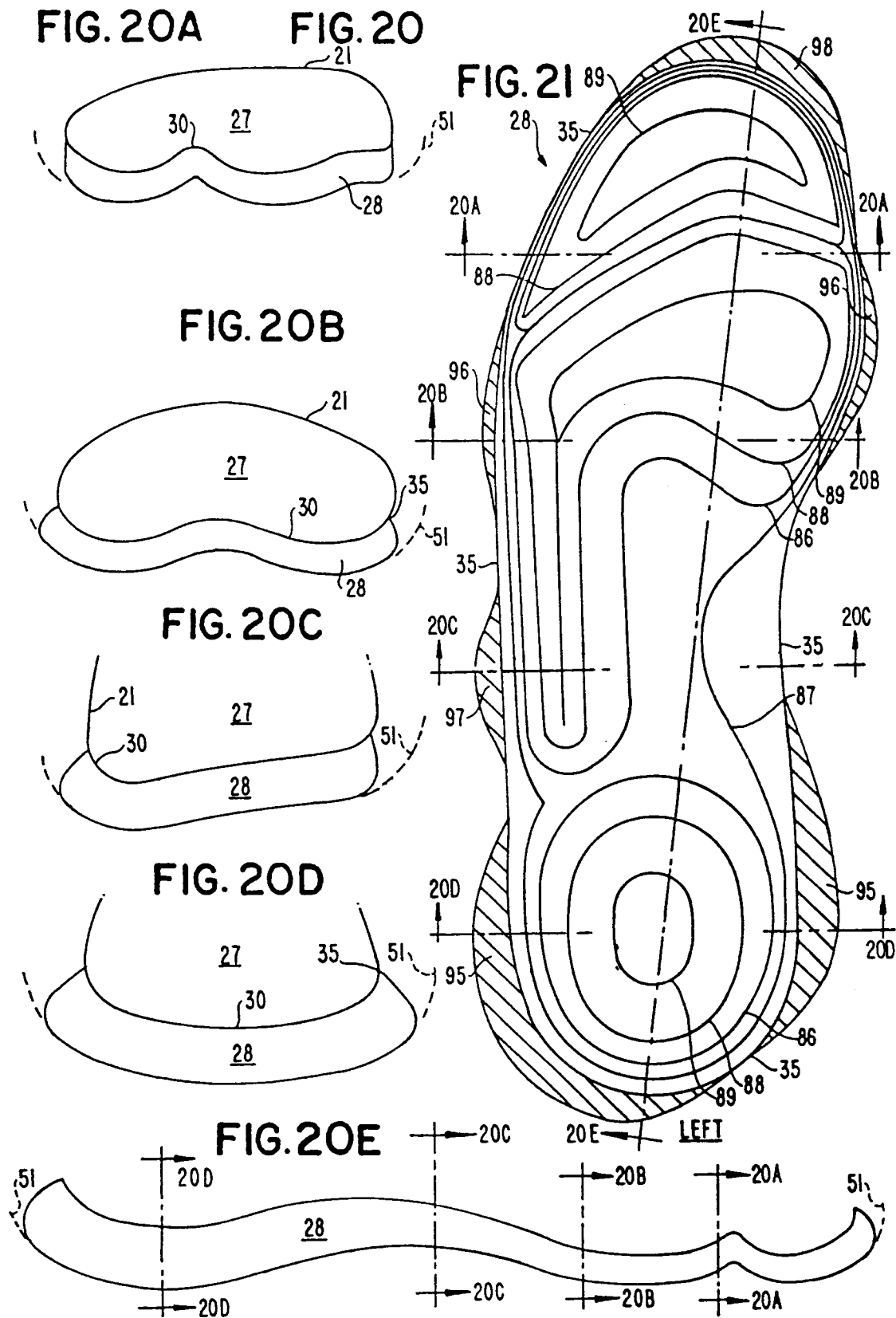


FIG. 22

FIG. 22A

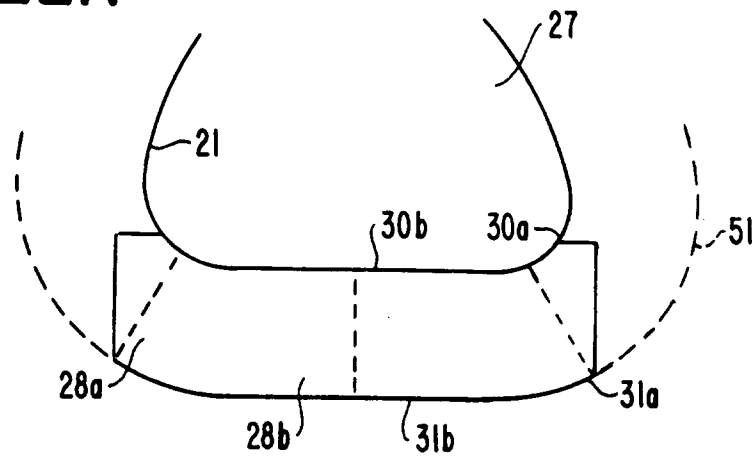


FIG. 22B

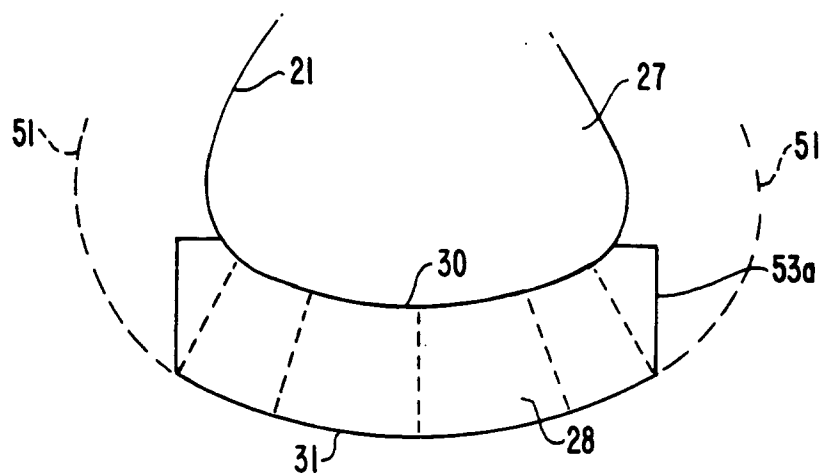


FIG. 23

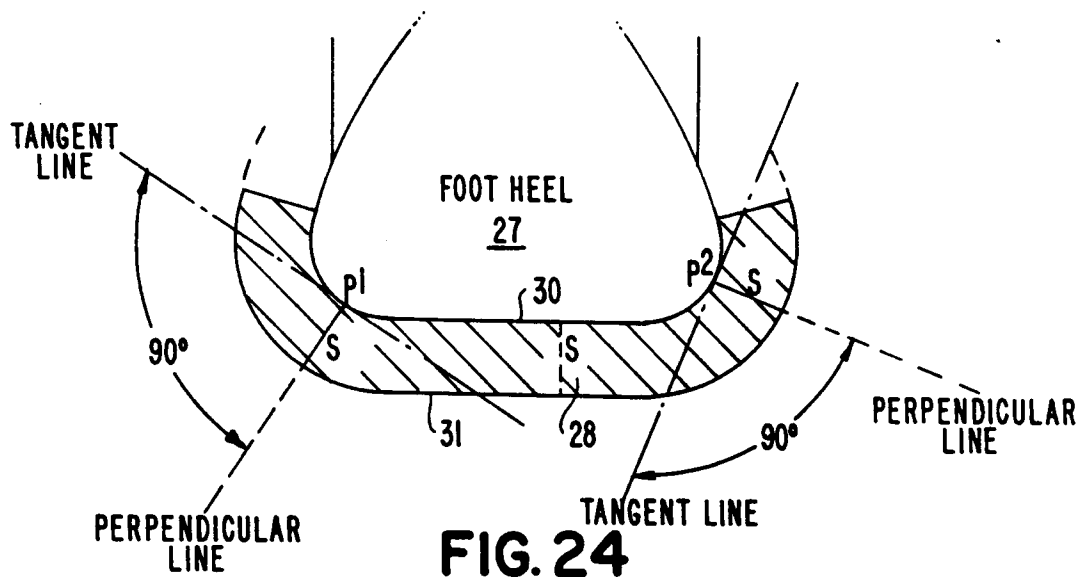


FIG. 24

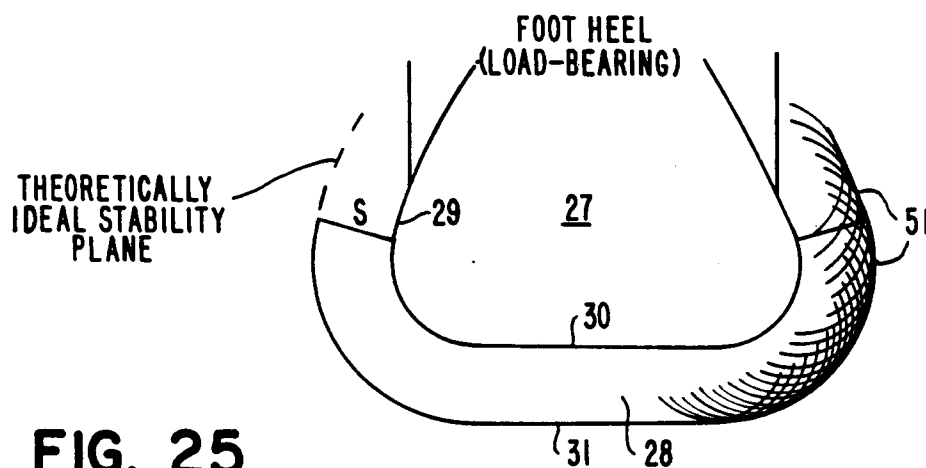


FIG. 25

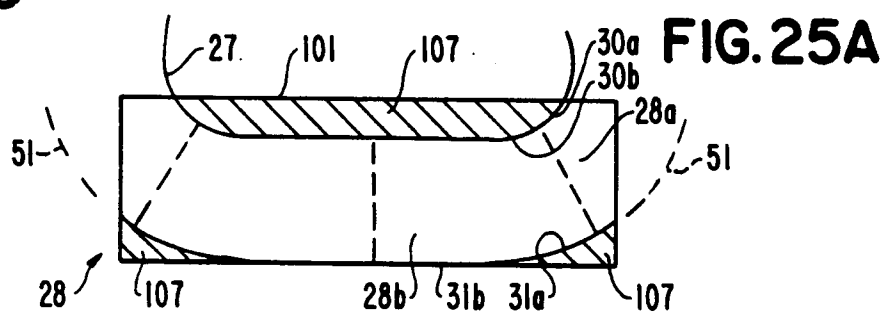


FIG. 25A

FIG. 25B

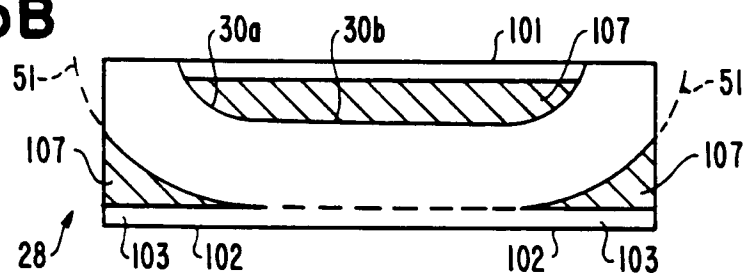


FIG.26

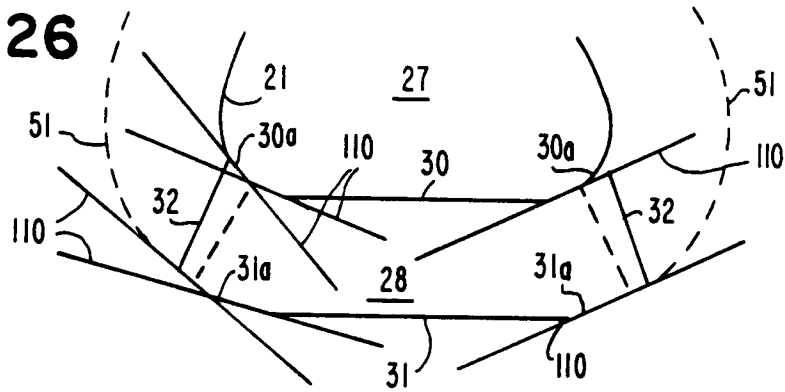


FIG. 27

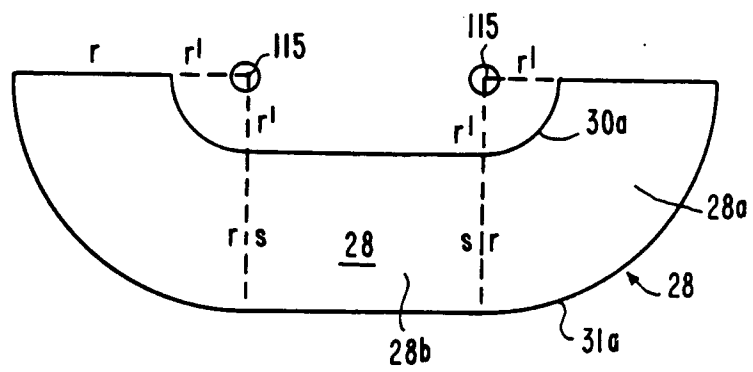


FIG. 28A

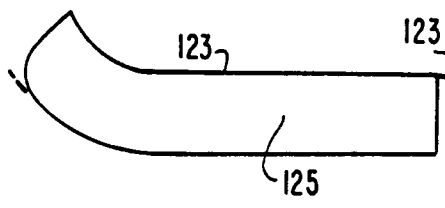


FIG. 28

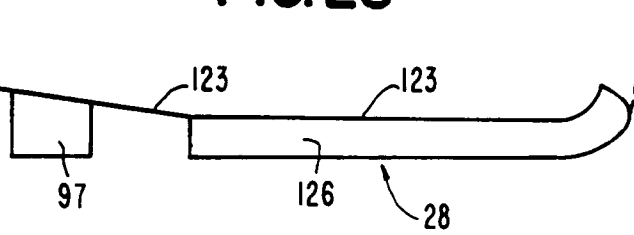


FIG. 28B

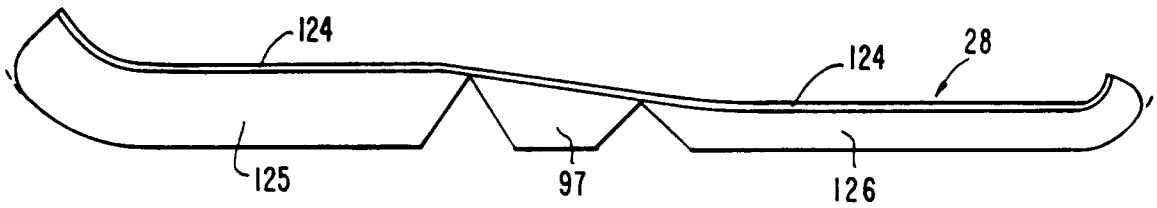


FIG. 28C

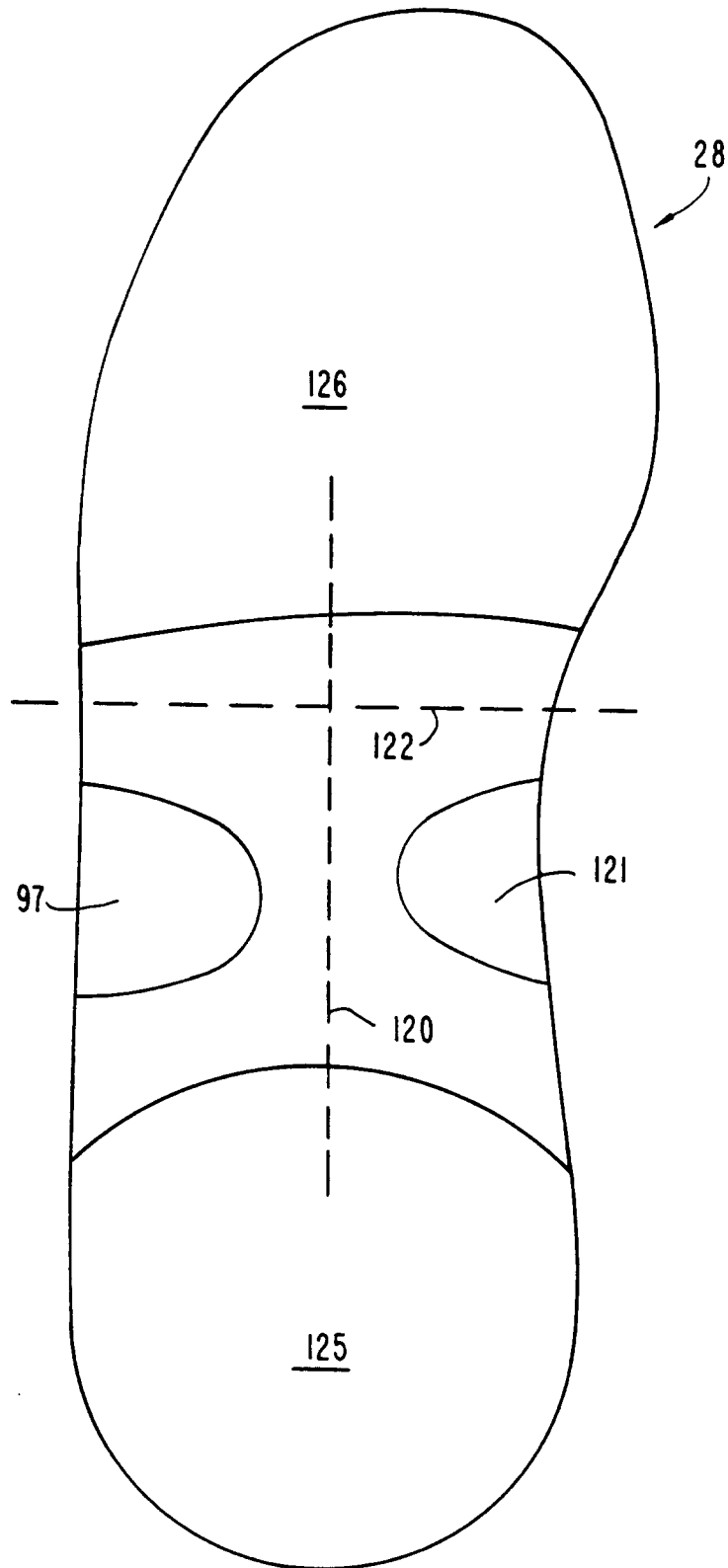


FIG. 29A

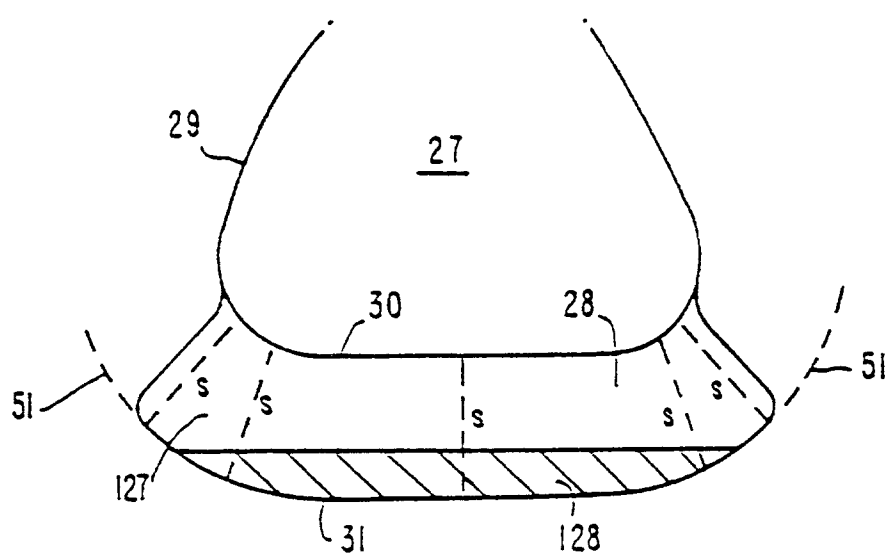


FIG.29B

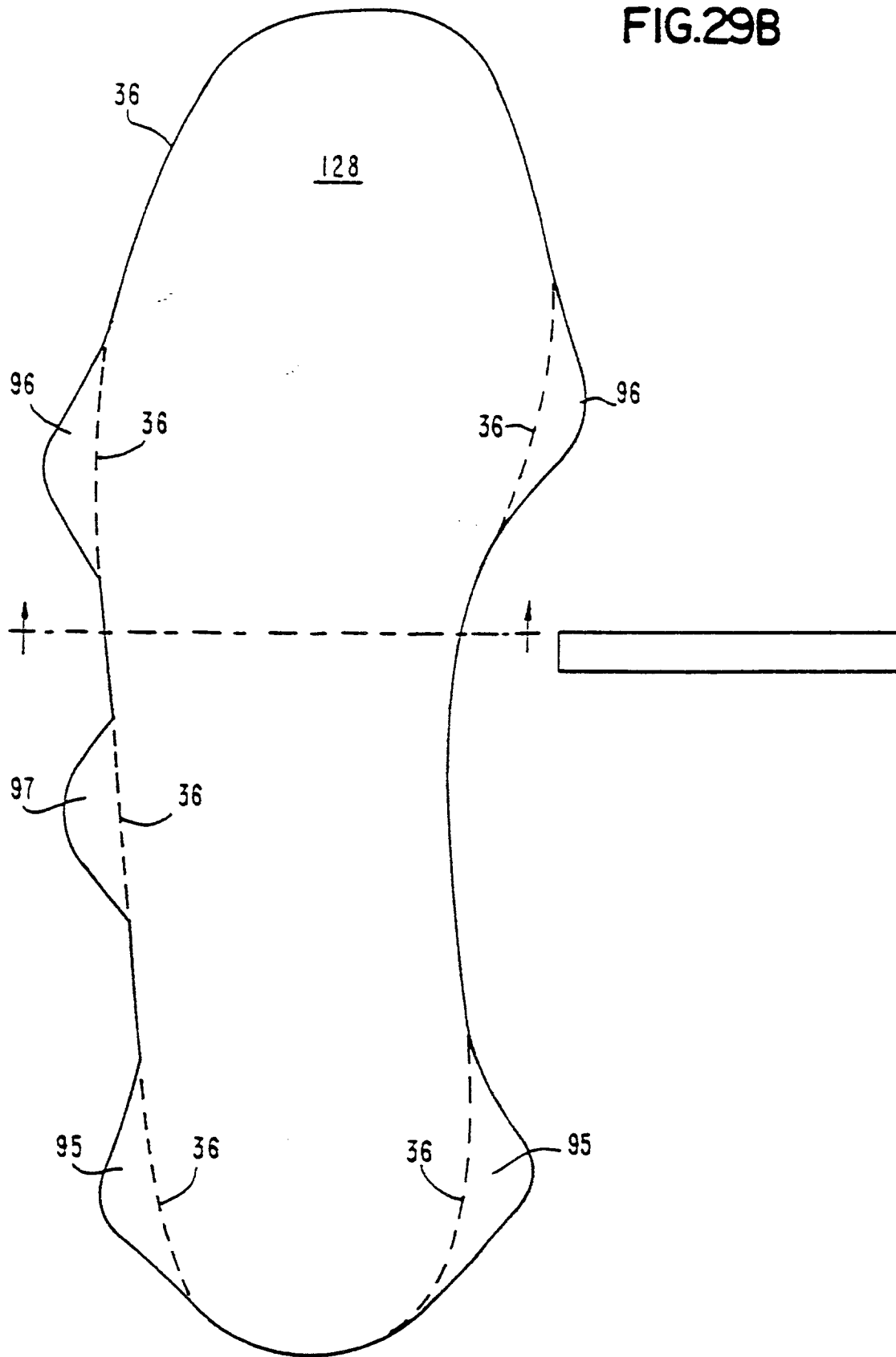


FIG. 30

FIG. 30A

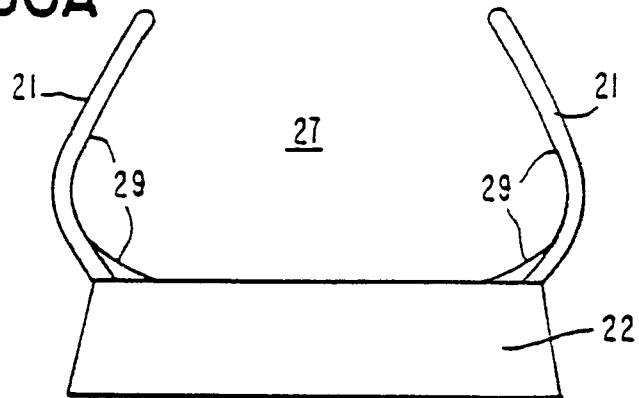


FIG. 30B

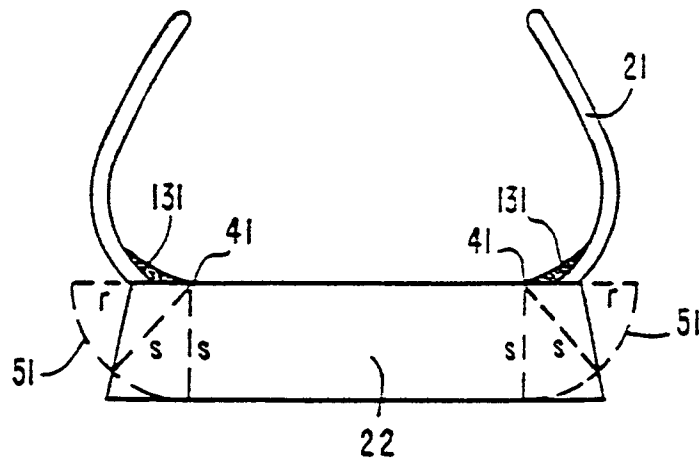


FIG. 30C

