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(71)(72) Applicant and Inventor: ELLIS, Frampton, E., III [US/US]; 2895 South Abingdon Street, Suite B-2, Arlington, VA 22206 (US).

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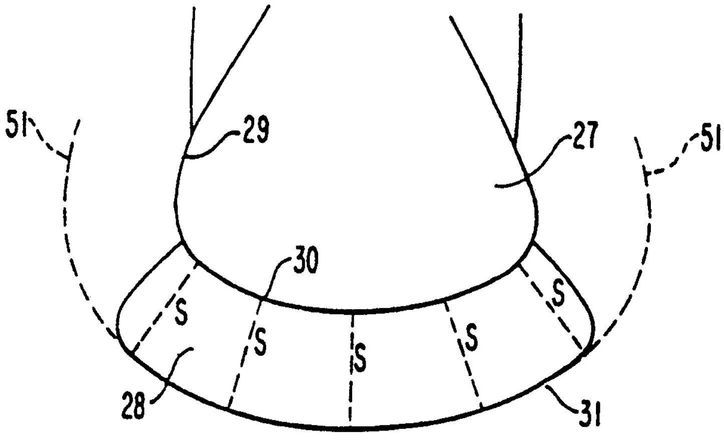

(57) Abstract

In its simplest conceptual form, the applicant's invention is the structure of a conventional shoe sole that has been modified by having its sides bent up so that their inner surface (30) conforms to a shape nearly identical but slightly smaller than the shape of the outer surface (29) of the sides of the foot (27) sole of the wearer (instead of the shoe sole sides conforming to the ground (43) by paralleling it, as is conventional). The shoe sole sides are sufficiently flexible to bend out easily when the shoes are put on the wearer's feet (27) and therefore the shoe soles (28) gently hold the sides of the wearer's foot (27) sole when on, providing the equivalent of custom fit in a mass-produced shoe sole (28). This invention can be applied to shoe sole (27) structures based on a theoretically ideal stability plane (51) as a basic concept, especially including structures exceeding that plane (51). The theoretically ideal stability plane (51) is defined as the plane of the surface of the bottom (31) of the shoe sole (28), wherein the shoe sole (28) conforms to the natural shape of the wearer's foot sole (29), particulary its sides, and has a constant thickness (5) in frontal or transverse plane cross sections.

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SHOES SOLE STRUCTURES

BACKGROUND OF THE INVENTION

This invention relates generally to the structure of soles of shoes and other footwear, including soles of street shoes, hiking boots, sandals, slippers, and moccasins. More specifically, this invention relates to the structure of athletic shoe soles, including such examples as basketball and running shoes.

More particularly, in it simplest conceptual form, this invention is the structure of a conventional shoe sole that has been modified by having its sides bent up so that their inner surface conforms to a shape nearly identical but slightly smaller than the shape of the outer surface of the sides of the foot sole of the wearer (instead of the shoe sole sides conforming to the ground by paralleling it, as is conventional). The shoe sole sides are sufficiently flexible to bend out easily when the shoes are put on the wearer's feet and therefore the shoe soles gently hold the sides of the wearer's foot sole when on, providing the equivalent of custom fit in a mass-produced shoe sole.

Still more particularly, this invention relates to variations in the structure of such soles using a theoretically ideal stability plane as a basic concept, especially including structures exceeding that plane.

This application clarifies and expands the applicant's recently filed U.S. Application No. 07/680,134, filed April 3, 1991.

The applicant has introduced into the art the concept of a theoretically ideal stability plane as a structural basis for shoe sole designs. The theoretically ideal stability plane was defined by the applicant in previous copending applications as the plane of the surface of the bottom of the shoe sole, wherein the shoe sole conforms to the natural shape of the wearer's foot sole, particularly its sides, and has a constant thickness in frontal or transverse plane cross sections. Therefore, by definition, the theoretically ideal stability plane is the surface plane of the bottom of the shoe sole that parallels the surface of the wearer's foot sole in transverse or frontal plane cross sections.

The theoretically ideal stability plane concept as implemented into shoes such as street shoes and athletic shoes is presented in U.S. Patent Number 4,989,349, issued February 5, 1991; and pending U. S. application Nos. 07/239,667, filed September 2, 1988; 07/400,714, filed August 30, 1989; 07/416,478, filed October 3, 1989; 07/424,509, filed October 20, 1989; 07/463,302, filed January 10, 1990; 07/469,313, filed January 24, 1990; 07/478,579, filed February 8, 1990; 07/539,870, filed June 18, 1990; and 07/608,748, filed November 5, 1990. PCT applications have been filed to date on all of the applicant's pending cases with priority dates more than one year older than this application.

This new invention is a modification of the inventions disclosed and claimed in the earlier applications and develops the application of the concept of the theoretically ideal stability plane to other shoe structures. Each of the applicant's applications is built directly on its predecessors and therefore all possible combinations of inventions or their component elements with other inventions or elements in prior and subsequent applications have always been specifically intended by the applicant. Generally, however, the applicant's applications are generic at such a fundamental level that it is not possible as a practical matter to describe every embodiment combination that offers substantial improvement over the existing art, as the length of this description of only some combinations will testify.

The purpose of this application is to specifically describe some of the most important combinations, especially those that constitute optimal ones, that exist between the applicant's U.S. Patent Application No. 07/400,714, filed August 30, 1989, and subsequent patents filed by the applicant, particularly U.S. No. 07/416,478, filed October 3, 1989.

BRIEF SUMMARY OF THE INVENTION

In its simplest conceptual form, the applicant's invention is the structure of a conventional shoe sole that has been modified by having its sides bent up so that their inner surface conforms to a shape nearly identical but slightly smaller than the shape of the outer surface of the foot sole of the wearer (instead of the shoe sole sides being flat on the ground, as is conventional). This concept is like that described in Fig. 3 of the applicant's 07/239,667 application; for the applicant's fully contoured design described in Fig. 15 of the '667 application, the entire shoe sole -- including both the sides and the portion directly underneath the foot -- is bent up to conform to a shape nearly identical but slightly smaller than the contoured shape of the unloaded foot sole of the wearer, rather than the partially flattened load-bearing foot sole shown in Fig. 3.

This theoretical or conceptual bending up must be accomplished in practical manufacturing without any of the puckering distortion or deformation that would necessarily occur if such a conventional shoe sole were actually bent up simultaneously along all of its the sides; consequently, manufacturing techniques that do not require any bending up of shoe sole material, such as injection molding manufacturing of the shoe sole, would be required for optimal results and therefore is preferable.

It is critical to the novelty of this fundamental concept that <u>all layers</u> of the shoe sole are bent up around the foot sole. A small number of both street and athletic shoe soles that are commercially available are naturally contoured to a limited extent in that <u>only their bottom soles</u>, which are about one quarter to one third of the total thickness of the entire shoe sole, are wrapped up around portions of the wearers' foot soles; the remaining soles layers, including the insole, midsole and heel lift (or heel) of such shoe soles, constituting over half of the thickness of the entire shoe sole, remains flat, conforming to the ground rather than the wearers' feet. (At the other extreme, some shoes in the existing art have flat midsoles and bottom soles, but have insoles that conform to the wearer's foot sole.)

Consequently, in existing contoured shoe soles, the total shoe sole thickness of the contoured side portions, including every layer or portion, is <u>much less</u> than the total thickness of the sole portion directly underneath the foot, whereas in the applicant's shoe sole inventions the shoe sole thickness of the contoured side portions are the <u>same as or at least similar to</u> the thickness of the sole portion directly underneath the foot.

This major and conspicuous structural difference between the applicant's underlying concept and the existing shoe sole art is paralleled by a similarly dramatic functional difference between the two: the aforementioned equivalent or similar thickness of the applicant's shoe sole invention maintains intact the firm lateral stability of the wearer's foot, that stability as demonstrated when the foot is unshod and tilted out laterally in inversion to the extreme limit of the normal range of motion of the ankle joint of the foot. The sides of the applicant's shoe sole invention extend sufficiently far up the sides of the wearer's foot sole to maintain the lateral stability of the wearer's foot when bare.

In addition, the applicant's shoe sole invention maintains the natural stability and natural, uninterrupted motion of the wearer's foot when bare throughout its normal range of sideways pronation and supination motion occurring during all load-bearing phases of locomotion of the wearer, including when the wearer is standing, walking, jogging and running, even when the foot is tilted to the extreme limit of that normal range, in contrast to unstable and inflexible conventional shoe soles, including the partially contoured existing art described above. The sides of the applicant's shoe sole invention extend sufficiently far up the sides of the wearer's foot sole to maintain the natural stability and uninterrupted motion of the wearer,s foot when bare. The exact thickness and material density of the shoe sole sides and their specific contour will be determined empirically for individuals and groups using standard biomechanical techniques of gait analysis to determine those combinations that best provide the barefoot stability described above.

Finally, the shoe sole sides are sufficiently flexible to bend out easily when the shoes are put on the wearer's feet and therefore the shoe soles gently hold the sides of the wearer's foot sole when on, providing the equivalent of custom fit in a mass-produced shoe sole. In general, the applicant's preferred shoe sole embodiments include the structural and material flexibility to deform in parallel to the natural deformation of the wearer's foot sole as if it were bare and unaffected by any of the abnormal foot biomechanics created by <u>rigid</u> conventional shoe sole.

At the same time, the applicant's preferred shoe sole embodiments are sufficiently firm to provide the wearer's foot with the structural support necessary to maintain normal pronation and supination, as if the wearer's foot were bare; in contrast, the excessive softness of many of the shoe sole materials used in shoe soles in the existing art cause instability in the form of abnormally excessive foot pronation and supination.

BRIEF DESCRIPTION OF THE DRAWINGS

Figs. 1 through 9 are from prior copending applications of the applicant, with some new textual specification added.

Fig. 10 is the applicant's custom fit design utilizing downsized flexible contoured shoe sole sides in combination with a thickness greater than the theoretically ideal stability plane.

Fig. 11 is the same custom fit design in combination with shoe sole side portions having a material with greater density than the sole portion.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figs. 1A-C illustrate, in frontal or transverse plane cross sections in the heel area, the applicant's concept of the theoretically ideal stability plane applied to shoe soles.

Fig. 1A is Fig. 8A in the applicant's U.S. Patent Application No.07/400,714 and Fig. 15 in his 07/239,667 Application. Fig. 1A shows a fully contoured shoe sole design that follows the natural contour of all of the foot sole, 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 as shown in Fig. 1B and flatten just as the human foot bottom is slightly round unloaded but flattens under load. Therefore, the shoe sole material must be of such composition as to allow the natural deformation following that of the foot.

Fig. 1B is Fig. 8B of the '714 application and shows the same fully contoured design when upright, under normal load (body weight) and therefore deformed naturally in a manner very closely paralleling the natural deformation under the same load of the foot. An almost identical portion of the foot sole that is flattened in deformation is also flatten in deformation in the shoe sole. Fig. 1C is Fig. 8C of the '714 application and shows the same design when tilted outward 20 degrees laterally, the normal barefoot limit; with virtually equal accuracy it shows the opposite foot tilted 20 degrees inward, in fairly severe pronation. As shown, the deformation of the shoe sole 28 again very closely parallels that of the foot, even as it tilts.

In its simplest conceptual form, the applicant's Fig 1 invention is the structure of a conventional shoe sole that has been modified by having its sides bent up so that their inner surface conforms to the shape of the outer surface of the foot sole of the wearer (instead of the shoe sole sides being flat on the ground, as is conventional); this concept is like that described in Fig. 3 of the applicant's 07/239,667 application. For the applicant's fully contoured design, the entire shoe sole -- including both the sides and the portion directly underneath the foot -- is bent up to conform to the shape of the unloaded foot sole of the wearer, rather than the partially flattened load-bearing foot sole shown in Fig. 3.

This theoretical or conceptual bending up must be accomplished in practical manufacturing without any of the puckering distortion or deformation that would necessarily occur if such a conventional shoe sole were actually bent up simultaneously along all of its the sides; consequently, manufacturing techniques that do not require any bending up of shoe sole material, such as injection molding manufacturing of the shoe sole, would be required for optimal results and therefore is preferable.

It is critical to the novelty of this fundamental concept that <u>all layers</u> of the shoe sole are bent up around the foot sole. A small number of both street and athletic shoe soles that are commercially available are naturally contoured to a limited extent in that <u>only their bottom soles</u>, which are about one quarter to one third of the total thickness of the entire shoe sole, are wrapped up around portions of the wearers' foot soles; the remaining sole layers, including the insole, the midsole and the heel lift (or heel) of such shoe soles, constituting over half of the thickness of the entire shoe sole, remains flat, conforming to the ground rather than the wearers' feet.

Consequently, in existing contoured shoe soles, the shoe sole thickness of the contoured side portions is <u>much less</u> than the thickness of the sole portion directly underneath the foot, whereas in the applicant's shoe sole inventions the shoe sole thickness of the contoured side portions are the same as the thickness of the sole portion directly underneath the foot.

This major and conspicuous structural difference between the applicant's underlying concept and the existing shoe sole art is paralleled by a similarly dramatic functional difference between the two: the aforementioned equivalent or similar thickness of the applicant's shoe sole invention maintains intact the firm lateral stability of the wearer's foot, as demonstrated when the foot is unshod and tilted out laterally in inversion to the extreme limit of the normal range of motion of the ankle joint of the foot; in a similar demonstration in a conventional shoe sole, the wearer's foot and ankle are unstable. The sides of the applicant's shoe sole invention extend sufficiently far up the sides of the wearer's foot sole to maintain the lateral stability of the wearer's foot when bare.

In addition, the applicant's shoe sole invention maintains the natural stability and natural, uninterrupted motion of the wearer's foot when bare throughout its normal range of sideways pronation and supination motion occurring during all load-bearing phases of locomotion of the wearer, including when said wearer is standing, walking, jogging and running, even when said foot is tilted to the extreme limit of that normal range, in contrast to unstable and inflexible conventional shoe soles, including the partially contoured existing art described above. The sides of the applicant's shoe sole invention extend sufficiently far up the sides of the wearer's foot sole to maintain that natural stability and uninterrupted motion.

For the Fig. 1 shoe sole invention, the amount of any shoe sole side portions coplanar with the theoretically ideal stability plane is determined by the degree of shoe sole stability desired and the shoe sole weight and bulk required to provide said stability; the amount of said coplanar contoured sides that is provided said shoe sole being sufficient to maintain intact the firm stability of the wearer's foot throughout the range of foot inversion and eversion motion typical of the use for which the shoe is intended and also typical of the kind of wearer - such as normal or excessive pronator - for which said shoe is intended.

As mentioned earlier, Fig. 1A is Fig. 15 in the applicant's 07/239,667 Application; however, it does not show the heel lift 38 which is included in the original Fig. 15. That heel lift is shown with constant frontal or transverse plane thickness, since it is oriented conventionally in alignment with the frontal or transverse plane and perpendicular to the long axis of the shoe sole; consequently, the thickness of the heel lift decreases uniformly in the frontal or transverse plane between the heel and the forefoot when moving forward along the long axis of the shoe sole. However, the conventional heel wedge, or toe taper or other shoe sole thickness variations in the sagittal plane along the long axis of the shoe sole, can be located at an angle to the conventional alignment.

For example, the heel wedge can be rotated inward in the horizontal plane so that it is located perpendicular to the subtalar axis, which is located in the heel area generally about 20 to 25 degrees medially, although a different angle can be used base on individual or group testing; such a orientation may provide better, more natural support to the subtalar joint, through which critical pronation and supination motion occur. The applicant's theoretically ideal stability plane concept would teach that such a heel wedge orientation would require constant shoe sole thickness in a vertical plane perpendicular to the chosen subtalar joint axis, instead of the frontal plane.

Fig. 2 is Fig. 9 of the '714 application and shows, in frontal or transverse plane cross section in the heel area, the preferred relative density of the shoe sole, including the insole as a part, order to maximize the shoe sole's ability to deform naturally following the natural deformation of the foot sole. Regardless of how many shoe sole layers (including insole) or laminations of differing material densities and flexibility are used in total, the softest and most flexible material 147 should be closest to the foot sole, with a progression through less soft 148 to the firmest and least flexible 149 at the outermost shoe sole layer, the bottom sole. This arrangement helps to avoid the unnatural side lever arm/torque problem mentioned in the previous several figures.

Fig. 3, which is a frontal or transverse plane cross section at the heel, is Fig. 10 from the applicant's copending U. S. Patent Application No. 07/400,714, filed August 30, 1989. Fig. 3 illustrates that the applicant's naturally contoured shoe sole sides can be made to provide a fit so close as to approximate a custom fit. By molding each mass-produced shoe size with sides that are bent in somewhat from the position 29 they would normally be in to conform to that standard size shoe last, the shoe soles so produced will very gently hold the sides of each individual foot exactly. Since the shoe sole is designed as described in connection with Fig. 2 (Fig. 9 of the applicant's copending application No. 07/400,714) to deform easily and naturally like that of the bare foot, it will deform easily to provide this designed-in custom fit. The greater the flexibility of the shoe sole sides, the greater the range of individual foot size. This approach applies to the fully contoured design described here in Fig. 1A (Fig. 8A of the '714 application) and in Fig. 15, United States Patent Application 07/239,667 (filed 02 September 1988), as well, which would be even more effective than the naturally contoured sides design shown in Fig. 3.

Besides providing a better fit, the intentional undersizing of the flexible shoe sole sides allows for simplified design of shoe sole lasts, since they can be designed according to the simple geometric methodology described in the textual specification of Fig. 27, United

States Application 07/239,667 (filed 02 September 1988). That geometric approximation of the true actual contour of the human is close enough to provide a virtual custom fit, when compensated for by the flexible undersizing from standard shoe lasts described above.

Expanding on the '714 Application, a flexible undersized version of the fully contoured design described in Fig. 1A (and 8A of the '714 application) can also be provided by a similar geometric approximation. As a result, the undersized flexible shoe sole sides allow the applicant's shoe sole inventions based on the theoretically ideal stability plane to be manufactured in relatively standard sizes in the same manner as are shoe uppers, since the flexible shoe sole sides can be built on standard shoe lasts, even though conceptually those sides conform closely to the specific shape of the individual wearer's foot sole, because the flexible sides bend to conform when on the wearer's foot sole.

Fig. 3 shows the shoe sole structure when not on the foot of the wearer; the dashed line 29 indicates the position of the shoe last, which is assumed to be a reasonably accurate approximation of the shape of the outer surface of the wearer's foot sole, which determines the shape of the theoretically ideal stability plane 51. Thus, the dashed lines 29 and 51 show what the positions of the inner surface 30 and outer surface 31 of the shoe sole would be when the shoe is put on the foot of the wearer. Numbering with the figures in this application is consistent with the numbering used in prior applications of the applicant.

The Fig. 3 invention provides a way make the inner surface 30 of the contoured shoe sole, especially its sides, conform very closely to the outer surface 29 of the foot sole of a wearer. It thus makes much more practical the applicant's earlier underlying naturally contoured designs shown in Figs. 1A-C. The shoe sole structures shown in Fig. 1, then, are what the Fig. 3 shoe sole structure would be when on the wearer's foot, where the inner surface 30 of the shoe upper is bent out to virtually coincide with the outer surface of the foot sole of the wearer 29 (the figures in this and prior applications show one line to emphasize the conceptual coincidence of what in fact are two lines; in real world embodiments, some divergence of the surface, especially under load and during locomotion would be unavoidable).

In its simplest conceptual form, the applicant's invention is the structure of a conventional shoe sole that has been modified by having its sides bent up so that their inner surface conforms to a shape nearly identical but slightly smaller than the shape of the outer surface of the foot sole of the wearer (instead of the shoe sole sides being flat on the ground, as is conventional); this concept is like that described in Fig. 3 of the applicant's 07/239,667 application. For the applicant's fully contoured design described in Fig. 15 of the '667 application, the entire shoe sole -- including both the sides and the portion directly underneath the foot -- is bent up to conform to a shape nearly identical but slightly smaller than the contoured shape of the unloaded foot sole of the wearer, rather than the partially flattened load-bearing foot sole shown in Fig. 3.

This theoretical or conceptual bending up must be accomplished in practical manufacturing without any of the puckering distortion or deformation that would necessarily occur if such a conventional shoe sole were actually bent up simultaneously along all of its the sides; consequently, manufacturing techniques that do not require any bending up of shoe sole material, such as injection molding manufacturing of the shoe sole, would be required for optimal results and therefore is preferable.

It is critical to the novelty of this fundamental concept that <u>all layers</u> of the shoe sole are bent up around the foot sole. A small number of both street and athletic shoe soles that are commercially available are naturally contoured to a limited extent in that <u>only their bottom soles</u>, which are about one quarter to one third of the total thickness of the entire shoe sole, are wrapped up around portions of the wearers' foot soles; the midsole and heel lift (or heel) of such shoe soles, constituting over half of the thickness of the entire shoe sole, remains flat, conforming to the ground rather than the wearers' feet. (At the other extreme, some shoes in the existing art have flat midsoles and bottom soles, but have insoles that conform to the wearer's foot sole.)

Consequently, in existing contoured shoe soles, the shoe sole thickness of the contoured side portions is <u>much less</u> than the thickness of the sole portion directly underneath the foot, whereas in the applicant's shoe sole inventions the shoe sole thickness of the contoured side portions are the <u>same as</u> the thickness of the sole portion directly underneath the foot.

This major and conspicuous structural difference between the applicant's underlying concept and the existing shoe sole art is paralleled by a similarly dramatic functional difference between the two: the aforementioned equivalent thickness of the applicant's shoe sole invention maintains intact the firm lateral stability of the wearer's foot, as demonstrated when the foot is unshod and tilted out laterally in inversion to the extreme limit of the normal range of motion of the ankle joint of the foot; in a similar demonstration in a conventional shoe sole, the wearer's foot and ankle are unstable. The sides of the applicant's shoe sole invention extend sufficiently far up the sides of the wearer's foot sole to maintain the lateral stability of the wearer's foot when bare.

In addition, the applicant's shoe sole invention maintains the natural stability and natural, uninterrupted motion of the wearer's foot when bare throughout its normal range of sideways pronation and supination motion occurring during all load-bearing phases of locomotion of the wearer, including when the wearer is standing, walking, jogging and running, even when said foot is tilted to the extreme limit of that normal range, in contrast to unstable and inflexible conventional shoe soles, including the partially contoured existing art described above. The sides of the applicant's shoe sole invention extend sufficiently far up the sides of the wearer's foot sole to maintain the natural stability and uninterrupted motion of the wearer's foot when bare.

For the Fig. 3 shoe sole invention, the amount of any shoe sole side portions coplanar with the theoretically ideal stability plane is determined by the degree of shoe sole stability desired and the shoe sole weight and bulk required to provide said stability; the amount of said coplanar contoured sides that is provided said shoe sole being sufficient to maintain intact the firm stability of the wearer's foot throughout the range of foot inversion and eversion motion typical of the use for which the shoe is intended and also typical of the kind of wearer - such as normal or excessive pronator - for which said shoe is intended.

The shoe sole sides of the Fig. 3 invention are sufficiently flexible to bend out easily when the shoes are put on the wearer's feet and therefore the shoe soles gently hold the sides of the wearer's foot sole when on, providing the equivalent of custom fit in a mass-produced shoe sole. In general, the applicant's preferred shoe sole embodiments include the structural and material flexibility to deform in parallel to the natural deformation of the wearer's foot sole as if it were bare and unaffected by any of the abnormal foot biomechanics created by <u>rigid</u> conventional shoe sole.

At the same time, the applicant's preferred shoe sole embodiments are sufficiently firm to provide the wearer's foot with the structural support necessary to maintain normal pronation and supination, as if the wearer's foot were bare; in contrast, the excessive softness of many of the shoe sole materials used in shoe soles in the existing art cause abnormal foot pronation and supination.

Fig. 3 is a frontal or transverse plane cross section at the heel, so the structure is shown at one of the essential structural support and propulsion elements, as specified by applicant in his copending 07/239,667 application in its Fig. 21 specification. 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; the essential propulsion element is the head of the first distal phalange 98. The Fig. 3 shoe sole structure can be abbreviated along its sides to only the essential structural support and propulsion elements, like Fig. 21 of the '667 application. The Fig. 3 design can also be abbreviated underneath the shoe sole to the same essential structural support and propulsion elements, as shown in Fig. 28 of the '667 Application.

As mentioned earlier regarding Fig. 1A, the applicant has previously shown heel lifts with constant frontal or transverse plane thickness, since it is oriented conventionally in alignment with the frontal or transverse plane and perpendicular to the long axis of the shoe sole. However, the heel wedge (or toe taper or other shoe sole thickness variations in the sagittal plane along the long axis of the shoe sole) can be located at an angle to the conventional alignment in the Fig. 3 design.

For example, the heel wedge can be rotated inward in the horizontal plane so that it is located perpendicular to the subtalar axis, which is located in the heel area generally about 20 to 25 degrees medially, although a different angle can be used base on individual or group testing; such a orientation may provide better, more natural support to the subtalar joint, through which critical pronation and supination motion occur. The applicant's theoretically ideal stability plane concept would teach that such a heel wedge orientation would require constant shoe sole thickness in a vertical plane perpendicular to the chosen subtalar joint axis, instead of the frontal plane.

The sides of the shoe sole structure described under Fig. 3 can also be used to form a slightly less optimal structure: a conventional shoe sole that has been modified by having its sides bent up so that their inner surface conforms to shape nearly identical but slightly larger than the shape of the outer surface of the foot sole of the wearer, instead of the shoe sole sides being flat on the ground, as is conventional. Clearly, the closer the sides are to the shape of the wearer's foot sole, the better as a general rule, but any side position between flat on the ground and conforming like Fig. 3 to a shape slightly smaller than the wearer's shape is both possible and more effective than conventional flat shoe sole sides. And in some cases, such as for diabetic patients, it may be optimal to have relatively loose shoe sole sides providing no conforming pressure of the shoe sole on the tender foot sole; in such cases, the shape of the flexible shoe uppers, which can even be made with very elastic materials such as lycra and spandex, can provide the capability for the shoe, including the shoe sole, to conform to the shape of the foot.

As discussed earlier by the applicant, the critical functional feature of a shoe sole is that it deforms under a weight-bearing load to conform to the foot sole just as the foot sole deforms to conform to the ground under a weight-bearing load. So, even though the foot sole and the shoe sole may start in different locations - the shoe sole sides can even be conventionally flat on the ground - the critical functional feature of both is that they both conform under load to parallel the shape of the ground, which conventional shoes do not, except when exactly upright. Consequently, the applicant's shoe sole invention, stated most broadly, includes any shoe sole - whether conforming to the wearer's foot sole or to the ground or some intermediate position, including a shape much smaller than the wearer's foot sole - that deforms to conform to the theoretically ideal stability plane, which by definition itself deforms in parallel with the deformation of the wearer's foot sole under weight-bearing load.

Of course, it is optimal in terms of preserving natural foot biomechanics, which is the primary goal of the applicant, for the shoe sole to conform to the foot sole when on the foot, not just when under a weight-bearing load. And, in any case, all of the essential structural support and propulsion elements previously identified by the applicant in discussing Fig. 3 must be supported by the foot sole.

To the extent the shoe sole sides are easily flexible, as has already been specified as desirable, the position of the shoe sole sides before the wearer puts on the shoe is less important, since the sides will easily conform to the shape of the wearer's foot when the shoe is put on that foot. In view of that, even shoe sole sides that conform to a shape more than slightly smaller than the shape of the outer surface of the wearer's foot sole would function in accordance with the applicant's general invention, since the flexible sides could bend out easily a considerable relative distance and still conform to the wearer's foot sole when on the wearer's foot.

Fig. 4 is Fig. 4 from the applicant's copending U.S. Patent Application No. 07/416,478, filed October 3, 1989. Fig. 4 illustrates, in frontal or transverse plane cross section in the heel area, the applicant's new invention of shoe sole side thickness increasing beyond the theoretically ideal stability plane to increase stability somewhat beyond its natural level. The unavoidable trade-off resulting is that natural motion would be restricted somewhat and the weight of the shoe sole would increase somewhat.

Fig. 4 shows a situation wherein the thickness of the sole at each of the opposed sides is thicker at the portions of the sole 31a by a thickness which gradually varies continuously from a thickness (s) through a thickness (s+s1), to a thickness (s+s2).

These designs recognize that lifetime use of existing shoes, the design of which has an inherent flaw that continually disrupts natural human biomechanics, has produced thereby actual structural changes in a human foot and ankle to an extent that must be compensated for. Specifically, one of the most common of the abnormal effects of the inherent existing flaw is a weakening of the long arch of the foot, increasing pronation. These designs therefore modify the applicant's preceding designs to provide greater than natural stability and should be particularly useful to individuals, generally with low arches, prone to pronate excessively, and could be used only on the medial side. Similarly, individuals with high arches and a tendency to over supinate and lateral ankle sprains would also benefit, and the design could be used only on the lateral side. A shoe for the general population that compensates for both weaknesses in the same shoe would incorporate the enhanced stability of the design compensation on both sides.

The new design in Fig. 4 (like Figs. 1 and 2 of the '478 application) allows the shoe sole to deform naturally closely paralleling the natural deformation of the barefoot under load; in addition, shoe sole material must be of such composition as to allow the natural deformation following that of the foot.

The new designs retain the essential novel aspect of the earlier designs; namely, contouring the shape of the shoe sole to the shape of the human foot. The difference is that the shoe sole thickness in the frontal plane is allowed to vary rather than remain uniformly constant. More specifically, Fig. 4 (and Figs. 5, 6, 7, and 11 of the '478 application) show, in frontal plane cross sections at the heel, that the shoe sole thickness can increase beyond the theoretically ideal stability plane 51, in order to provide greater than natural stability. Such variations (and the following variations) can be consistent through all frontal plane cross sections, so that there are proportionately equal increases to the theoretically ideal stability plane 51 from the front of the shoe sole to the back, or that the thickness can vary, preferably continuously, from one frontal plane to the next.

The exact amount of the increase in shoe sole thickness beyond the theoretically ideal stability plane is to be determined empirically. Ideally, right and left shoe soles would be custom designed for each individual based on an biomechanical analysis of the extent of his or her foot and ankle disfunction in order to provide an optimal individual correction. If epidemiological studies indicate general corrective patterns for specific categories of individuals or the population as a whole, then mass-produced corrective shoes with soles incorporating contoured sides exceeding the theoretically ideal stability plane would be possible. It is expected that any such mass-produced corrective shoes for the general population would have thicknesses exceeding the theoretically ideal stability plane by an amount up to 5 or 10 percent, while more specific groups or individuals with more severe disfunction could have an empirically demonstrated need for greater corrective thicknesses on the order of up to 25 percent more than the theoretically ideal stability plane. The optimal contour for the increased thickness may also be determined empirically.

As described in the '478 Application, in its simplest conceptual form, the applicant's Fig. 4 invention is the structure of a conventional shoe sole that has been modified by having its sides bent up so that their inner surface conforms to a shape of the outer surface of the foot sole of the wearer (instead of the shoe sole sides conforming to the ground by paralleling it, as is conventional); this concept is like that described in Fig. 3 of the applicant's 07/239,667 application. For the applicant's fully contoured design described in Fig. 15 of the '667 application, the entire shoe sole -- including both the sides and the portion directly underneath the foot -- is bent up to conform to a shape nearly identical but slightly smaller than the contoured shape of the unloaded foot sole of the wearer, rather than the partially flattened load-bearing foot sole shown in Fig. 3.

This theoretical or conceptual bending up must be accomplished in practical manufacturing without any of the puckering distortion or deformation that would necessarily occur if such a conventional shoe sole were actually bent up simultaneously along all of its the sides; consequently, manufacturing techniques that do not require any bending up of shoe sole material, such as injection molding manufacturing of the shoe sole, would be required for optimal results and therefore is preferable.

It is critical to the novelty of this fundamental concept that <u>all layers</u> of the shoe sole are bent up around the foot sole. A small number of both street and athletic shoe soles that are commercially available are naturally contoured to a limited extent in that <u>only their bottom soles</u>, which are about one quarter to one third of the total thickness of the entire shoe sole, are wrapped up around portions of the wearers' foot soles; the midsole and heel lift (or heel) of such shoe soles, constituting over half of the thickness of the entire shoe sole, remains flat, conforming to the ground rather than the wearers' feet. (At the other extreme, some shoes in the existing art have flat midsoles and bottom soles, but have insoles that conform to the wearer's foot sole.)

Consequently, in existing contoured shoe soles, the shoe sole thickness of the contoured side portions is <u>much less</u> than the thickness of the sole portion directly underneath the foot, whereas in the applicant's shoe sole inventions the shoe sole thickness of the contoured side portions are the <u>at least similar to</u> the thickness of the sole portion directly underneath the foot.

This major and conspicuous structural difference between the applicant's underlying concept and the existing shoe sole art is paralleled by a similarly dramatic functional difference between the two: the aforementioned similar thickness of the applicant's shoe sole invention maintains intact the firm lateral stability of the wearer's foot, as demonstrated when the foot is unshod and tilted out laterally in inversion to the extreme limit of the normal range of motion of the ankle joint of the foot; in a similar demonstration in a conventional shoe sole, the wearer's foot and ankle are unstable. The sides of the applicant's shoe sole invention extend sufficiently far up the sides of the wearer's foot sole to maintain the lateral stability of the wearer's foot when bare.

In addition, the applicant's shoe sole invention maintains the natural stability and natural, uninterrupted motion of the wearer's foot when bare throughout its normal range of sideways pronation and supination motion occurring during all load-bearing phases of locomotion of the wearer, including when the wearer is standing, walking, jogging and running, even when said foot is tilted to the extreme limit of that normal range, in contrast to unstable and inflexible conventional shoe soles, including the partially contoured existing art described above. The sides of the applicant's shoe sole invention extend sufficiently far up the sides of the wearer's foot sole to maintain the natural stability and uninterrupted motion of the wearer's foot when bare. The exact thickness of the shoe sole sides and their specific contour will be determined empirically for individuals and groups using standard biomechanical techniques of gait analysis to determine those combinations that best provide the barefoot stability described above.

For the Fig. 4 shoe sole invention, the amount of any shoe sole side portions coplanar with the theoretically ideal stability plane is determined by the degree of shoe sole stability desired and the shoe sole weight and bulk required to provide said stability; the amount of said coplanar contoured sides that is provided said shoe sole being sufficient to maintain intact the firm stability of the wearer's foot throughout the range of foot inversion and eversion motion typical of the use for which the shoe is intended and also typical of the kind of wearer - such as normal or excessive pronator - for which said shoe is intended.

In general, the applicant's preferred shoe sole embodiments include the structural and material flexibility to deform in parallel to the natural deformation of the wearer's foot sole as if it were bare and unaffected by any of the abnormal foot biomechanics created by <u>rigid</u> conventional shoe sole.

At the same time, the applicant's preferred shoe sole embodiments are sufficiently firm to provide the wearer's foot with the structural support necessary to maintain normal pronation and supination, as if the wearer's foot were bare; in contrast, the excessive softness of many of the shoe sole materials used in shoe soles in the existing art cause abnormal foot pronation and supination.

As mentioned earlier regarding Fig. 1A, the applicant has previously shown heel lifts with constant frontal or transverse plane thickness, since it is oriented conventionally in alignment with the frontal or transverse plane and perpendicular to the long axis of the shoe sole. However, the heel wedge (or toe taper or other shoe sole thickness variations in the sagittal plane along the long axis of the shoe sole) can be located at an angle to the conventional alignment in the Fig. 4 design.

For example, the heel wedge can be located perpendicular to the subtalar axis, which is located in the heel area generally about 20 to 25 degrees medially, although a different angle can be used base on individual or group testing; such a orientation may provide better, more natural support to the subtalar joint, through which critical pronation and supination motion occur. The applicant's theoretically ideal stability plane concept would teach that such a heel wedge orientation would require constant shoe sole thickness in a vertical plane perpendicular to the chosen subtalar joint axis, instead of the frontal plane.

Fig. 5 is Fig. 5 in the applicant's copending U.S. Patent Application No. 07/416,478 and shows, in frontal or transverse plane cross section in the heel area, a variation of the enhanced fully contoured design wherein the shoe sole begins to thicken beyond the theoretically ideal stability plane 51 somewhat offset to the sides.

Fig. 6 is Fig. 10 in the applicant's copending '714 Application and shows, in frontal or transverse plane cross section in the heel area, that similar variations in shoe midsole (other portions of the shoe sole area not shown) density can provide similar but reduced effects to the variations in shoe sole thickness described previously in Figs. 4 and 5. The major advantage of this approach is that the structural theoretically ideal stability plane is retained, so that naturally optimal stability and efficient motion are retained to the maximum extent possible.

The '714 Application showed midsole only, since that is where material density variation has historically been most common. Density variations can and do, of course, also occur in other layers of the shoe sole, such as the bottom sole and the inner sole, and can occur in any combination and in symmetrical or asymmetrical patterns between layers or between frontal or transverse plane cross sections.

The major and conspicuous structural difference between the applicant's underlying concept and the existing shoe sole art is paralleled by a similarly dramatic functional difference between the two: the aforementioned similar thickness of the applicant's shoe sole invention maintains intact the firm lateral stability of the wearer's foot, as demonstrated when the foot is unshod and tilted out laterally in inversion to the extreme limit of the normal range of motion of the ankle joint of the foot; in a similar demonstration in a conventional shoe sole, the wearer's foot and ankle are unstable. The sides of the applicant's shoe sole invention extend sufficiently far up the sides of the wearer's foot sole to maintain the lateral stability of the wearer's foot when bare.

In addition, the applicant's shoe sole invention maintains the natural stability and natural, uninterrupted motion of the wearer's foot when bare throughout its normal range of sideways pronation and supination motion occurring during all load-bearing phases of locomotion of the wearer, including when the wearer is standing, walking, jogging and running, even when said foot is tilted to the extreme limit of that normal range, in contrast to unstable and inflexible conventional shoe soles, including the partially contoured existing art described above. The sides of the applicant's shoe sole invention extend sufficiently far up the sides of the wearer's foot sole to maintain the natural stability and uninterrupted motion of the wearer's foot when bare. The exact material density of the shoe sole sides will be determined empirically for individuals and groups using standard biomechanical techniques of gait analysis to determine those combinations that best provide the barefoot stability described above.

For the Fig. 6 shoe sole invention, the amount of any shoe sole side portions coplanar with the theoretically ideal stability plane is determined by the degree of shoe sole stability desired and the shoe sole weight and bulk required to provide said stability; the amount of said coplanar contoured sides that is provided said shoe sole being sufficient to maintain intact the firm stability of the wearer's foot throughout the range of foot inversion and eversion motion typical of the use for which the shoe is intended and also typical of the kind of wearer - such as normal or excessive pronator - for which said shoe is intended.

In general, the applicant's preferred shoe sole embodiments include the structural and material flexibility to deform in parallel to the natural deformation of the wearer's foot sole as if it were bare and unaffected by any of the abnormal foot biomechanics created by <u>rigid</u> conventional shoe sole.

At the same time, the applicant's preferred shoe sole embodiments are sufficiently firm to provide the wearer's foot with the structural support necessary to maintain normal pronation and supination, as if the wearer's foot were bare; in contrast, the excessive softness of many of the shoe sole materials used in shoe soles in the existing art cause abnormal foot pronation and supination.

As mentioned earlier regarding Fig. 1A, the applicant has previously shown heel lifts with constant frontal or transverse plane thickness, since it is oriented conventionally in alignment with the frontal or transverse plane and perpendicular to the long axis of the shoe sole. However, the heel wedge (or toe taper or other shoe sole thickness variations in the sagittal plane along the long axis of the shoe sole) can be located at an angle to the conventional alignment in the Fig. 4 design.

For example, the heel wedge can be located perpendicular to the subtalar axis, which is located in the heel area generally about 20 to 25 degrees medially, although a different angle can be used base on individual or group testing; such a orientation may provide better, more natural support to the subtalar joint, through which critical pronation and supination motion occur. The applicant's theoretically ideal stability plane concept would teach that such a heel wedge orientation would require constant shoe sole thickness in a vertical plane perpendicular to the chosen subtalar joint axis, instead of the frontal plane.

Fig. 7 is Fig. 14B of the applicant's '714 Application and shows, in frontal or transverse plane cross sections in the heel area, embodiments like those in Fig. 4 through 6 but wherein a portion of the shoe sole thickness is decreased to less than the theoretically ideal stability plane. It is anticipated that some individuals with foot and ankle biomechanics that have been degraded by existing shoes may benefit from such embodiments, which would provide less than natural stability but greater freedom and motion, and less shoe sole weight and bulk. Fig. 7 shows a embodiment like the fully contoured design in Fig. 5, but with a show sole thickness decreasing with increasing distance from the center portion of the sole.

Fig. 8 is Fig. 13 of the '714 Application and shows, in frontal or transverse plane cross section, a bottom sole tread design that provides about the same overall shoe sole density variation as that provided in Fig. 6 by midsole density variation. The less supporting tread there is under any particular portion of the shoe sole, the less effective overall shoe density there is, since the midsole above that portion will deform more easily than if it were fully supported.

Fig. 8 from the '714 is illustrative of the applicant's point that bottom sole tread patterns, just like midsole or bottom sole or inner sole density, directly affect the actual structural support the foot receives from the shoe sole. Not shown, but a typical example in the real world, is the popular "center of pressure" tread pattern, which is like a backward horseshoe attached to the heel that leaves the heel area directly under the calcaneus unsupported by tread, so that all of the weight bearing load in the heel area is transmitted to outside edge treads. Variations of this pattern are extremely common in athletic shoes and are nearly universal in running shoes, of which the 1991 Nike 180 model and the Avia "cantilever" series are examples.

The applicant's '714 shoe sole invention can, therefore, utilize bottom sole tread patterns like any these common examples, together or even in the absence of any other shoe sole thickness or density variation, to achieve an effective thickness greater than the theoretically ideal stability plane, in order to achieve greater stability than the shoe sole would otherwise provide, as discussed earlier under Figs. 4-6.

The applicant's shoe sole invention maintains intact the firm lateral stability of the wearer's foot, that stability as demonstrated when the foot is unshod and tilted out laterally in inversion to the extreme limit of the normal range of motion of the ankle joint of the foot. The sides of the applicant's shoe sole invention extend sufficiently far up the sides of the wearer's foot sole to maintain the lateral stability of the wearer's foot when bare.

In addition, the applicant's shoe sole invention maintains the natural stability and natural, uninterrupted motion of the wearer's foot when bare throughout its normal range of sideways pronation and supination motion occurring during all load-bearing phases of locomotion of the wearer, including when the wearer is standing, walking, jogging and running, even when the foot is tilted to the extreme limit of that normal range, in contrast to unstable and inflexible conventional shoe soles, including the partially contoured existing art described above. The sides of the applicant's shoe sole invention extend sufficiently far up the sides of the wearer's foot sole to maintain the natural stability and uninterrupted motion of the wearer,s foot when bare. The exact thickness and material density of the bottom sole tread, as well as the shoe sole sides and their specific contour, will be determined empirically for individuals and groups using standard biomechanical techniques of gait analysis to determine those combinations that best provide the barefoot stability described above.

Fig. 9 is Fig. 9 from the applicant's copending U.S. Patent Application No.07/463,302, filed January 10, 1990. Fig. 9A shows, also in cross sections at the heel, a naturally contoured shoe sole design that parallels as closely as possible the overall natural cushioning and stability system of the barefoot (described in Fig. 8 of the '302 Application), including a cushioning compartment

161 under support structures of the foot containing a pressure-transmitting medium like gas, gel, or liquid, like the subcalcaneal fat pad under the calcaneus and other bones of the foot.

The function of the subcalcaneal fat pad is not met satisfactorily with existing proprietary cushioning systems, even those featuring gas, gel or liquid as a pressure transmitting medium. In contrast to those artificial systems, the new design shown is Fig. 9 conforms to the natural contour of the foot and to the natural method of transmitting bottom pressure into side tension in the flexible but relatively non-stretching (the actual optimal elasticity will require empirical studies) sides of the shoe sole.

Existing cushioning systems like Nike Air or Asics Gel do not bottom out under moderate loads and rarely if ever do so even partially under extreme loads; the upper surface of the cushioning device remains suspended above the lower surface. In contrast, the new design in Fig. 9 provides firm support to foot support structures by providing for actual contact between the lower surface 165 of the upper midsole 147 and the upper surface 166 of the bottom sole 149 when fully loaded under moderate body weight pressure.

The applicant's Fig. 9 invention can be combined with the Fig. 3 invention, although the combination is not shown; the Fig. 9 invention can be combined with Figs. 10 and 11 below. Also not shown, but useful combinations, is the applicant's Figs. 3, 10 and 11 inventions with all of the applicant's deformation sipes inventions, the first of a sequence of applications on various embodiments of that sipes invention is U.S. No. 07/424,509, filed October 20, 1989, and with his inventions based on other sagittal plane or long axis shoe sole thickness variations described in U.S. Application No. 07/469,313, filed January 24, 1990.

All of the applicant's shoe sole invention mentioned immediately above maintain intact the firm lateral stability of the wearer's foot, that stability as demonstrated when the wearer's foot is unshod and tilted out laterally in inversion to the extreme limit of the normal range of motion of the ankle joint of the foot; in a similar demonstration in a conventional shoe sole, the wearer's foot and ankle are unstable. The sides of the applicant's shoe sole invention extend sufficiently far up the sides of the wearer's foot sole to maintain the lateral stability of the wearer's foot when bare.

In addition, the applicant's invention maintains the natural stability and natural, uninterrupted motion of the foot when bare throughout its normal range of sideways pronation and supination motion occurring during all load-bearing phases of locomotion of the wearer, including when said wearer is standing, walking, jogging and running, even when the foot is tilted to the extreme limit of that normal range, in contrast to unstable and inflexible conventional shoe soles, including the partially contoured existing art described above. The sides of the applicant's shoe sole invention extend sufficiently far up the sides of the wearer's foot sole to maintain the natural stability and uninterrupted motion of the wearer's foot when bare. The exact material density of the shoe sole sides will be determined empirically for individuals and groups using standard biomechanical techniques of gait analysis to determine those combinations that best provide the barefoot stability described above.

For the shoe sole combination inventions list immediately above, the amount of any shoe sole side portions coplanar with the theoretically ideal stability plane is determined by the degree of shoe sole stability desired and the shoe sole weight and bulk required to provide said stability; the amount of said coplanar contoured sides that is provided said shoe sole being sufficient to maintain intact the firm stability of the wearer's foot throughout the range of foot inversion and eversion motion typical of the use for which the shoe is intended and also typical of the kind of wearer - such as normal or as excessive pronator - for which said shoe is intended.

Finally, the shoe sole sides are sufficiently flexible to bend out easily when the shoes are put on the wearer's feet and therefore the shoe soles gently hold the sides of the wearer's foot sole when on, providing the equivalent of custom fit in a mass-produced shoe sole. In general, the applicant's preferred shoe sole embodiments include the structural and material flexibility to deform in parallel to the natural deformation of the wearer's foot sole as if it were bare and unaffected by any of the abnormal foot biomechanics created by <u>rigid</u> conventional shoe sole.

At the same time, the applicant's preferred shoe sole embodiments are sufficiently firm to provide the wearer's foot with the structural support necessary to maintain normal pronation and supination, as if the wearer's foot were bare; in contrast, the excessive softness of many of the shoe sole materials used in shoe soles in the existing art cause abnormal foot pronation and supination.

Fig. 10 is new with this application and is a combination of the shoe sole structure concepts of Fig. 3 and Fig. 4; it combines the custom fit design with the contoured sides greater than the theoretically ideal stability plane. It would apply as well to the Fig 7 design with contoured sides less than the theoretically ideal stability plane, but that combination is not shown. It would also apply to the Fig. 8 design, which shows a bottom sole tread design, but that combination is also not shown.

While the Fig. 3 custom fit invention is novel for shoe sole structures as defined by the theoretically ideal stability plane, which specifies constant shoe sole thickness in frontal or transverse plane, the Fig. 3 custom fit invention is also novel for shoe sole structures with sides that exceed the theoretically ideal stability plane: that is, a shoe sole with thickness greater in the sides than underneath the foot. It would also be novel for shoe sole structures with sides that are less than the theoretically ideal stability plane, within the parameters defined in the '714 application. And it would be novel for a shoe sole structure that provides stability like the barefoot, as described in Figs. 1 and 2 of the '714 application.

In its simplest conceptual form, the applicant's invention is the structure of a conventional shoe sole that has been modified by having its sides bent up so that their inner surface conforms to a shape nearly identical but slightly smaller than the shape of the outer surface of the foot sole of the wearer (instead of the shoe sole sides conforming to the ground by paralleling it, as is conventional); this concept is like that described in Fig. 3 of the applicant's 07/239,667 application. For the applicant's fully contoured design described in Fig. 15 of the '667 Application, the entire shoe sole -- including both the sides and the portion directly underneath the foot -- is bent up to conform to a shape nearly identical but slightly smaller than the contoured shape of the unloaded foot sole of the wearer, rather than the partially flattened load-bearing foot sole shown in Fig. 3.

This theoretical or conceptual bending up must be accomplished in practical manufacturing without any of the puckering distortion or deformation that would necessarily occur if such a conventional shoe sole were actually bent up simultaneously along all of its the sides; consequently, manufacturing techniques that do not require any bending up of shoe sole material, such as injection molding manufacturing of the shoe sole, would be required for optimal results and therefore is preferable.

It is critical to the novelty of this fundamental concept that <u>all layers</u> of the shoe sole are bent up around the foot sole. A small number of both street and athletic shoe soles that are commercially available are naturally contoured to a limited extent in that only their bottom soles, which are about one quarter to one third of the total thickness of the entire shoe sole, are wrapped up around portions of the wearers' foot soles; the midsole and heel lift (or heel) of such shoe soles, constituting over half of the thickness of the entire shoe sole, remains flat, conforming to the ground rather than the wearers' feet. (At the other extreme, some shoes in the existing art have flat midsoles and bottom soles, but have insoles that conform to the wearer's foot sole.)

Consequently, in existing contoured shoe soles, the total shoe sole thickness of the contoured side portions is much less than the total thickness of the sole portion directly underneath the foot, whereas in the applicant's shoe sole Fig. 10 invention the shoe sole thickness of the contoured side portions are the at least similar to the thickness of the sole portion directly underneath the foot.

This major and conspicuous structural difference between the applicant's underlying concept and the existing shoe sole art is paralleled by a similarly dramatic functional difference between the two: the aforementioned similar thickness of the applicant's shoe sole invention maintains intact the firm lateral stability of the wearer's foot, that stability as demonstrated when the wearer's foot is unshod and tilted out laterally in inversion to the extreme limit of the normal range of motion of the ankle joint of the foot; in a similar demonstration in a conventional shoe sole, the wearer's foot and ankle are unstable. The sides of the applicant's shoe sole invention extend sufficiently far up the sides of the wearer's foot sole to maintain the lateral stability of the wearer's foot when bare.

In addition, the applicant's invention maintains the natural stability and natural, uninterrupted motion of the foot when bare throughout its normal range of sideways pronation and supination motion occurring during all load-bearing phases of locomotion of the wearer, including when said wearer is standing, walking, jogging and running, even when the foot is tilted to the extreme limit of that normal range, in contrast to unstable and inflexible conventional shoe soles, including the partially contoured existing art described above. The sides of the applicant's shoe sole invention extend sufficiently far up the sides of the wearer's foot sole to maintain the natural stability and uninterrupted motion of the wearer's foot when bare. The exact thickness and material density of the shoe sole sides and their specific contour will be determined empirically for individuals and groups using standard biomechanical techniques of gait analysis to determine those combinations that best provide the barefoot stability described above.

For the Fig. 10 shoe sole invention, the amount of any shoe sole side portions coplanar with the theoretically ideal stability plane is determined by the degree of shoe sole stability desired and the shoe sole weight and bulk required to provide said stability; the amount of said coplanar contoured sides that is provided said shoe sole being sufficient to maintain intact the firm stability of the wearer's foot throughout the range of foot inversion and eversion motion typical of the use for which the shoe is intended and also typical of the kind of wearer - such as normal or as excessive pronator - for which said shoe is intended.

Finally, the shoe sole sides are sufficiently flexible to bend out easily when the shoes are put on the wearer's feet and therefore the shoe soles gently hold the sides of the wearer's foot sole when on, providing the equivalent of custom fit in a mass-produced shoe sole. In general, the applicant's preferred shoe sole embodiments include the structural and material flexibility to deform in parallel to the natural deformation of the wearer's foot sole as if it were bare and unaffected by any of the abnormal foot biomechanics created by rigid conventional shoe sole.

At the same time, the applicant's preferred shoe sole embodiments are sufficiently firm to provide the wearer's foot with the structural support necessary to maintain normal pronation and supination, as if the wearer's foot were bare; in contrast, the excessive softness of many of the shoe sole materials used in shoe soles in the existing art cause abnormal foot pronation and supination.

As mentioned earlier regarding Fig. 1A and Fig. 3, the applicant has previously shown heel lift with constant frontal or transverse plane thickness, since it is oriented conventionally in alignment with the frontal or transverse plane and perpendicular to the long axis of the shoe sole. However, the heel wedge (or toe taper or other shoe sole thickness variations in the sagittal plane along the long axis of the shoe sole) can be located at an angle to the conventional alignment in the Fig. 10 design.

For example, the heel wedge can be located perpendicular to the subtalar axis, which is located in the heel area generally about 20 to 25 degrees medially, although a different angle can be used base on individual or group testing; such a orientation may provide better, more natural support to the subtalar joint, through which critical pronation and supination motion occur. The applicant's theoretically ideal stability plane concept would teach that such a heel wedge orientation would require constant shoe sole thickness in a vertical plane perpendicular to the chosen subtalar joint axis, instead of the frontal plane.

Besides providing a better fit, the intentional undersizing of the flexible shoe sole sides allows for simplified design of shoe sole lasts, since the shoe last needs only to be approximate to provide a virtual custom fit, due to the flexible sides. As a result, the undersized flexible shoe sole sides allow the applicant's Fig. 10 shoe sole invention based on the theoretically ideal stability plane to be manufactured in relatively standard sizes in the same manner as are shoe uppers, since the flexible shoe sole sides can be built on standard shoe lasts, even though conceptually those sides conform to the specific shape of the individual wearer's foot sole, because the flexible sides bend to so conform when on the wearer's foot sole.

Fig. 10 shows the shoe sole structure when not on the foot of the wearer; the dashed line 29 indicates the position of the shoe last, which is assumed to be a reasonably accurate approximation of the shape of the outer surface of the wearer's foot sole, which determines the shape of the theoretically ideal stability plane 51. Thus, the dashed lines 29 and 51 show what the positions of the inner surface 30 and outer surface 31 of the shoe sole would be when the shoe is put on the foot of the wearer.

The Fig. 10 invention provides a way make the inner surface 30 of the contoured shoe sole, especially its sides, conform very closely to the outer surface 29 of the foot sole of a wearer. It thus makes much more practical the applicant's earlier underlying naturally contoured designs shown in Figs. 4 and 5. The shoe sole structures shown in Fig. 4 and 5, then, are what the Fig. 10 shoe sole structure would be when on the wearer's load-bearing foot, where the inner surface 30 of the shoe upper is bent out to virtually coincide with the outer surface of the foot sole of the wearer 29 (the figures in this and prior applications show one line to emphasize the conceptual coincidence of what in fact are two lines; in real world embodiments, some divergence of the surface, especially under load and during locomotion would be unavoidable).

The sides of the shoe sole structure described under Fig. 10 can also be used to form a slightly less optimal structure: a conventional shoe sole that has been modified by having its sides bent up so that their inner surface conforms to shape nearly identical but slightly larger than the shape of the outer surface of the foot sole of the wearer, instead of the shoe sole sides being flat on the ground, as is conventional. Clearly, the closer the sides are to the shape of the wearer's foot sole, the better as a general rule, but any side position between flat on the ground and conforming like Fig. 10 to a shape slightly smaller than the wearer's shape is both possible and more effective than conventional flat shoe sole sides. And in some cases, such as for diabetic patients, it may be optimal to have relatively loose shoe sole sides providing no conforming pressure of the shoe sole on the tender foot sole; in such cases, the shape of the flexible shoe uppers, which can even be made with very elastic materials such as lycra and spandex, can provide the capability for the shoe, including the shoe sole, to conform to the shape of the foot.

As discussed earlier by the applicant, the critical functional feature of a shoe sole is that it deforms under a weight-bearing load to conform to the foot sole just as the foot sole deforms to conform to the ground under a weight-bearing load. So, even though the foot sole and the shoe sole may start in different locations - the shoe sole sides can even be conventionally flat on the ground - the critical functional feature of both is that they both conform under load to parallel the shape of the ground, which conventional shoes do not, except when exactly upright. Consequently, the applicant's shoe sole invention, stated most broadly, includes any shoe sole - whether conforming to the wearer's foot sole or to the ground or some intermediate position, including a shape much smaller than the wearer's foot sole - that deforms to conform to a shape at least similar to the theoretically ideal stability plane, which by definition itself deforms in parallel with the deformation of the wearer's foot sole under weight-bearing load.

Of course, it is optimal in terms of preserving natural foot biomechanics, which is the primary goal of the applicant, for the shoe sole to conform to the foot sole when on the foot, not just when under a weight-bearing load. And, in any case, all of the essential structural support and propulsion elements previously identified by the applicant earlier in discussing Fig. 3 must be supported by the foot sole.

To the extent the shoe sole sides are easily flexible, as has already been specified as desirable, the position of the shoe sole sides before the wearer puts on the shoe is less important, since the sides will easily conform to the shape of the wearer's foot when the shoe is put on that foot. In view of that, even shoe sole sides that conform to a shape more than slightly smaller than the shape of the outer surface of the wearer's foot sole would function in accordance with the applicant's general invention, since the flexible sides could bend out easily a considerable relative distance and still conform to the wearer's foot sole when on the wearer's foot.

Fig. 11 is new with this application and is a combination of the shoe sole structure concepts of Fig. 3 and Fig. 6; it combines the custom fit design with the contoured sides having material density variations that produce an effect similar to variations in shoe sole thickness shown in Figs. 4, 5, and 7; only the midsole is shown. The density variation pattern shown in Fig. 2 can be combined with the type shown in Fig. 11. The density pattern can be constant in all cross sections taken along the long the long axis of the shoe sole or the pattern can vary.

The applicant's Fig. 11 shoe sole invention maintains intact the firm lateral stability of the wearer's foot, that stability as demonstrated when the wearer's foot is unshod and tilted out laterally in inversion to the extreme limit of the normal range of motion of the ankle joint of the foot; in a similar demonstration in a conventional shoe sole, the wearer's foot and ankle are unstable. The sides of the applicant's shoe sole invention extend sufficiently far up the sides of the wearer's foot sole to maintain the lateral stability of the wearer's foot when bare.

In addition, the applicant's invention maintains the natural stability and natural, uninterrupted motion of the foot when bare throughout its normal range of sideways pronation and supination motion occurring during all load-bearing phases of locomotion of the wearer, including when said wearer is standing, walking, jogging and running, even when the foot is tilted to the extreme limit of that normal range, in contrast to unstable and inflexible conventional shoe soles, including the partially contoured existing art described above. The sides of the applicant's shoe sole invention extend sufficiently far up the sides of the wearer's foot sole to maintain the natural stability and uninterrupted motion of the wearer's foot when bare. The exact material density of the shoe sole sides will be determined empirically for individuals and groups using standard biomechanical techniques of gait analysis to determine those combinations that best provide the barefoot stability described above.

For the Fig. 11 shoe sole invention, the amount of any shoe sole side portions coplanar with the theoretically ideal stability plane is determined by the degree of shoe sole stability desired and the shoe sole weight and bulk required to provide said stability; the amount of said coplanar contoured sides that is provided said shoe sole being sufficient to maintain intact the firm stability of the wearer's foot throughout the range of foot inversion and eversion motion typical of the use for which the shoe is intended and also typical of the kind of wearer - such as normal or as excessive pronator - for which said shoe is intended.

Finally, the shoe sole sides are sufficiently flexible to bend out easily when the shoes are put on the wearer's feet and therefore the shoe soles gently hold the sides of the wearer's foot sole when on, providing the equivalent of custom fit in a mass-produced shoe sole. In general, the applicant's preferred shoe sole embodiments include the structural and material flexibility to deform in parallel to the natural deformation of the wearer's foot sole as if it were bare and unaffected by any of the abnormal foot biomechanics created by <u>rigid</u> conventional shoe sole.

At the same time, the applicant's preferred shoe sole embodiments are sufficiently firm to provide the wearer's foot with the structural support necessary to maintain normal pronation and supination, as if the wearer's foot were bare; in contrast, the excessive softness of many of the shoe sole materials used in shoe soles in the existing art cause abnormal foot pronation and supination.

As mentioned earlier regarding Fig. 1A and Fig. 3, the applicant has previously shown heel lift with constant frontal or transverse plane thickness, since it is oriented conventionally in alignment with the frontal or transverse plane and perpendicular to the long axis of the shoe sole. However, the heel wedge (or toe taper or other shoe sole thickness variations in the sagittal plane along the long axis of the shoe sole) can be located at an angle to the conventional alignment in the Fig. 10 design.

For example, the heel wedge can be located perpendicular to the subtalar axis, which is located in the heel area generally about 20 to 25 degrees medially, although a different angle can be used base on individual or group testing; such a orientation may provide better, more natural support to the subtalar joint, through which critical pronation and supination motion occur. The applicant's theoretically ideal stability plane concept would teach that such a heel wedge orientation would require constant shoe sole thickness in a vertical plane perpendicular to the chosen subtalar joint axis, instead of the frontal plane.

Besides providing a better fit, the intentional undersizing of the flexible shoe sole sides allows for simplified design of shoe sole lasts, since the shoe last needs only to be approximate to provide a virtual custom fit, due to the flexible sides. As a result, the undersized flexible shoe sole sides allow the applicant's

Fig. 10 shoe sole invention based on the theoretically ideal stability plane to be manufactured in relatively standard sizes in the same manner as are shoe uppers, since the flexible shoe sole sides can be built on standard shoe lasts, even though conceptually those sides conform to the specific shape of the individual wearer's foot sole, because the flexible sides bend to so conform when on the wearer's foot sole.

Besides providing a better fit, the intentional undersizing of the flexible shoe sole sides allows for simplified design of shoe sole lasts, since they can be designed according to the simple geometric methodology described in the textual specification of Fig. 27, United States Application 07/239,667 (filed 02 September 1988). That geometric approximation of the true actual contour of the human is close enough to provide a virtual custom fit, when compensated for by the flexible undersizing from standard shoe lasts described above.

A flexible undersized version of the fully contoured design described in Fig. 11 can also be provided by a similar geometric approximation. As a result, the undersized flexible shoe sole sides allow the applicant's shoe sole inventions based on the theoretically ideal stability plane to be manufactured in relatively standard sizes in the same manner as are shoe uppers, since the flexible shoe sole sides can be built on standard shoe lasts, even though conceptually those sides conform closely to the specific shape of the individual wearer's foot sole, because the flexible sides bend to conform when on the wearer's foot sole.

Fig. 11 shows the shoe sole structure when not on the foot of the wearer; the dashed line 29 indicates the position of the shoe last, which is assumed to be a reasonably accurate approximation of the shape of the outer surface of the wearer's foot sole, which determines the shape of the theoretically ideal stability plane 51. Thus, the dashed lines 29 and 51 show what the positions of the inner surface 30 and outer surface 31 of the shoe sole would be when the shoe is put on the foot of the wearer.

The Fig. 11 invention provides a way make the inner surface 30 of the contoured shoe sole, especially its sides, conform very closely to the outer surface 29 of the foot sole of a wearer. It thus makes much more practical the applicant's earlier underlying naturally contoured designs shown in Fig. 1A-C and Fig. 6. The shoe sole structure shown in Fig. 61, then, is what the Fig. 11 shoe sole structure would be when on the wearer's foot, where the inner surface 30 of the shoe upper is bent out to virtually coincide with the outer surface of the foot sole of the wearer 29 (the figures in this and prior applications show one line to emphasize the conceptual coincidence of what in fact are two lines; in real world embodiments, some divergence of the surface, especially under load and during locomotion would be unavoidable).

The sides of the shoe sole structure described under Fig. 11 can also be used to form a slightly less optimal structure: a conventional shoe sole that has been modified by having its sides bent up so that their inner surface conforms to shape nearly identical but slightly larger than the shape of the outer surface of the foot sole of the wearer, instead of the shoe sole sides being flat on the ground, as is conventional. Clearly, the closer the sides are to the shape of the wearer's foot sole, the better as a general rule, but any side position between flat on the ground and conforming like Fig. 11 to a shape slightly smaller than the wearer's shape is both possible and more effective than conventional flat shoe sole sides. And in some cases, such as for diabetic patients, it may be optimal to have relatively loose shoe sole sides providing no conforming pressure of the shoe sole on the tender foot sole; in such cases, the shape of the flexible shoe uppers, which can even be made with very elastic materials such as lycra and spandex, can provide the capability for the shoe, including the shoe sole, to conform to the shape of the foot.

As discussed earlier by the applicant, the critical functional feature of a shoe sole is that it deforms under a weight-bearing load to conform to the foot sole just as the foot sole deforms to conform to the ground under a weight-bearing load. So, even though the foot sole and the shoe sole may start in different locations - the shoe sole sides can even be conventionally flat on the ground - the critical functional feature of both is that they both conform under load to parallel the shape of the ground, which conventional shoes do not, except when exactly upright. Consequently, the applicant's shoe sole invention, stated most broadly, includes any shoe sole - whether conforming to the wearer's foot sole or to the ground or some intermediate position, including a shape much smaller than the wearer's foot sole - that deforms to conform to the theoretically ideal stability plane, which by definition itself deforms in parallel with the deformation of the wearer's foot sole under weight-bearing load.

Of course, it is optimal in terms of preserving natural foot biomechanics, which is the primary goal of the applicant, for the shoe sole to conform to the foot sole when on the foot, not just when under a weight-bearing load. And, in any case, all of the essential structural support and propulsion elements previously identified by the applicant earlier in discussing Fig. 3 must be supported by the foot sole.

To the extent the shoe sole sides are easily flexible, as has already been specified as desirable, the position of the shoe sole sides before the wearer puts on the shoe is less important, since the sides will easily conform to the shape of the wearer's foot when the shoe is put on that foot. In view of that, even shoe sole sides that conform to a shape more than slightly smaller than the shape of the outer surface of the wearer's foot sole would function in accordance with the applicant's general invention, since the flexible sides could bend out easily a considerable relative distance and still conform to the wearer's foot sole when on the wearer's foot.

The applicant's shoe sole inventions described in Figs. 4, 10 and 11 all attempt to provide structural compensation for actual structural changes in the feet of wearers that have occurred from a lifetime of use of existing shoes, which have a major flaw that has been identified and described earlier by the applicant. As a result, the biomechanical motion of even the wearer's barefeet have been degraded from what they would be if the wearer's feet had not been structurally changed. Consequently, the ultimate design goal of the applicant's inventions is to provide un-degraded barefoot motion. That means to provide wearers with shoe soles that compensate for their flawed barefoot structure to an extent sufficient to provide foot and ankle motion equivalent to that of their barefeet if never shod and therefore not flawed. Determining the biomechanical characteristics of such un-flawed barefeet will be difficult, either on an individual or group basis. The difficulty for many groups of wearers will be in finding un-flawed, never-shod barefoot from similar genetic groups, assuming significant genetic differences exist, as seems at least possible if not probable.

The ultimate goal of the applicant's invention is to provide shoe sole structures that maintain the natural stability and natural, uninterrupted motion of the foot when bare throughout its normal range of sideways pronation and supination motion occurring during all load-bearing phases of locomotion of a wearer who has never been shod in conventional shoes, including when said wearer is standing, walking, jogging and running, even when the foot is tilted to the extreme limit of that normal range, in contrast to unstable and inflexible conventional shoe soles.

WHAT IS CLAIMED IS:

1. A sole construction for shoes and other footwear, including both street and athletic shoes, comprising:

a sole having a flat sole portion including a foot support surface, a contoured side portion merging with said sole portion and conforming to the shape of the sides of the foot sole of a wearer, and a uniform thickness in transverse plane cross sections;

said thickness being defined as the shortest distance between any point on an upper, foot sole-contacting surface of said shoe sole and a lower, ground-contacting surface of said shoe sole;

said thickness varying in the sagittal plane and being greater in the heel area than in the forefoot area;

said thickness of the contoured side portion equaling and therefore varying directly with the thickness of the sole portion in transverse plane cross sections.

2. The sole construction as set forth in claim 1, wherein said shoe sole is of such a construction that said shoe sole deforms under load and flattens just as does the foot sole of a wearer under load and wherein the material of said shoe sole is of such composition as to allow deformation following that of said foot sole; whereby said structure maintains intact the firm lateral stability of the wearer's foot, as demonstrated when said foot is unshod and tilted out laterally in inversion to the extreme limit of the normal range of motion of the ankle joint of said foot.

3. The shoe sole construction as set forth in claim 1, wherein said contoured side portion is located only at a plurality of essential support and propulsion elements, including the base and lateral tuberosity of the calcaneus, the head of the first and fifth metatarsals, the base of the fifth metatarsal, and the head of the first distal phalange to provide said shoe sole with flexibility paralleling the foot sole flexibility of a wearer;

whereby said shoe sole maintains the natural stability and natural, uninterrupted motion of said foot when bare throughout its normal range of sideways pronation and supination motion occurring when said wearer is standing, walking, jogging, and running, even when said foot is tilted to the extreme limit of said range, in contrast to unstable and inflexible conventional shoe soles.

4. The sole construction as set forth in claim 1, wherein a heel wedge is oriented along a subtalar joint axis of the foot instead of a long axis of the shoe sole.

5. The sole construction as set forth in claim 1, wherein the amount of any shoe sole contoured side portions that is provided said shoe sole is sufficient to maintain intact the firm lateral stability of the wearer's foot, as demonstrated when said foot is unshod and tilted out laterally in inversion to the extreme limit of the range of motion of the ankle joint of said foot.

6. The sole construction as set forth in claim 1, wherein the amount of any shoe sole side portions coplanar with the theoretically ideal stability plane is determined by the degree of shoe sole stability desired and the shoe sole weight and bulk required to provide said stability; the amount of said coplanar contoured sides that is provided said shoe sole being sufficient to maintain intact the firm stability of the wearer's foot throughout the range of foot inversion and eversion motion typical of the use for which said shoe is intended.

7. The sole construction as set forth in claim 1, wherein said shoe sole is composed of layers of material having a progression of densities, with the greatest density at the outermost layer and the least density at the innermost layer.

8. A sole construction for shoes and other footwear, including both street and athletic shoes, comprising:

a sole having a flat sole portion including a foot support surface, a contoured side portion merging with said sole portion and an inner surface of said side portion conforming to a shape similar to the shape of the outer surface of the sides of a shoe last approximating a foot sole of the wearer, and a uniform thickness in transverse plane cross sections;

said thickness being defined as the shortest distance between any point on an upper, foot sole-contacting surface of said shoe sole and a lower, ground-contacting surface of said shoe sole;

said thickness varying along the long axis of the shoe sole and being greater in the heel area than in the forefoot area;

said thickness of the contoured side portion equaling and therefore varying directly with the thickness of the sole portion in transverse plane cross sections.

9. The sole construction as set forth in claim 8, wherein the shoe sole sides are sufficiently flexible to bend out easily when the shoes are put on the wearer's feet and therefore the shoe soles gently hold the sides of the wearer's foot sole when on, providing the equivalent of custom fit in a mass-produced shoe sole.

10. The sole construction as set forth in claim 8, wherein at least a part of said contoured side portion is determined in frontal plane cross section in a mathematically precise manner by using a section of a ring with a thickness equaling the shoe sole thickness to approximate the natural contour of the side of the foot sole of a wearer and maintain exactly the thickness of the shoe sole portion.

11. The sole construction as set forth in claim 8, wherein a density of a material composing said contoured side portion is greater than a density of a material composing said flat sole portion.

12. The sole construction as set forth in claim 8, wherein said contoured sides are positioned only at essential structural support and propulsion elements; said essential structural elements are the base and lateral tuberosity of the calcaneus, the first and fifth heads of the metatarsals, and the base of the fifth metatarsal; said essential propulsion element is the head of the first distal phalange.

13. The sole construction as set forth in claim 8, wherein said shoe sole is of such a construction that said shoe sole deforms under load and flattens just as does the foot sole of a wearer under load and wherein the material of said shoe sole is of such composition as to allow deformation following that of said foot sole; whereby said structure maintains intact the firm lateral stability of the wearer's foot, as demonstrated when said foot is unshod and tilted out laterally in inversion to the extreme limit of the range of motion of the ankle joint of said foot.

14. A sole construction for shoes and other footwear, including both street and athletic shoes, comprising:

a sole having a flat sole portion including a foot support surface, a contoured side portion merging with said sole portion and an inner surface of said side portion conforming to a shape similar to the shape of the outer surface of the sides of a shoe last approximating a foot sole of the wearer, and a side portion thickness at least similar to a flat sole portion thickness in transverse plane cross sections;

said thickness being defined as the shortest distance between any point on an upper, foot sole-contacting surface of said shoe sole and a lower, ground-contacting surface of said shoe sole;

said thickness varying along the long axis of the shoe sole and being greater in the heel area than in the forefoot area;

said thickness of the contoured side portion equaling and therefore varying directly with the thickness of the sole portion in transverse plane cross sections.

15. The sole construction as set forth in claim 14, wherein said contoured side portion thickness is greater than said flat sole portion thickness.

16. The sole construction as set forth in claim 14, wherein said contoured side portion thickness is less than said flat sole portion thickness.

17. The sole construction as set forth in claim 14, wherein a heel wedge is oriented along a subtalar joint axis of the foot instead of a long axis of the shoe sole.

18. The sole construction as set forth in claim 14, wherein the shoe sole sides are sufficiently flexible to bend easily when the shoes are put on the wearer's feet and therefore the shoe soles gently hold the sides of the wearer's foot sole when on, providing the equivalent of custom fit in a mass-produced shoe sole.

19. The sole construction as set forth in claim 14, wherein said shoe sole is of such a construction that said shoe sole deforms under load and flattens just as does the foot sole of a wearer under load and wherein the material of said shoe sole is of such composition as to allow deformation following that of said foot sole; whereby said structure maintains intact the firm lateral stability of the wearer's foot, as demonstrated when said foot is unshod and tilted out laterally in inversion to the extreme limit of the range of motion of the ankle joint of said foot.

20. The sole construction as set forth in claim 14, wherein the amount of any shoe sole contoured side portions that is provided said shoe sole is sufficient to maintain intact the firm lateral stability of the wearer's foot, as demonstrated when said foot is unshod and tilted out laterally in inversion to the extreme limit of the range of motion of the ankle joint of said foot.

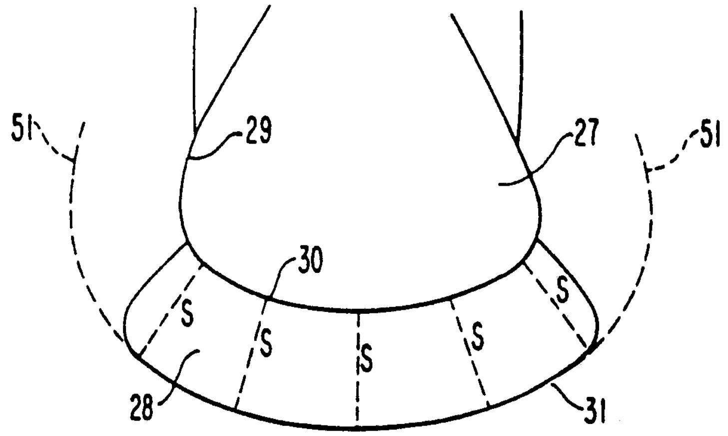

FIG. 1A

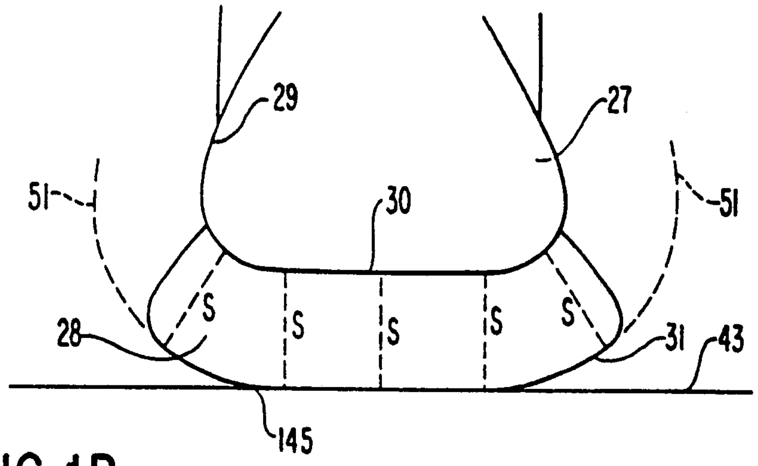

FIG. 1B

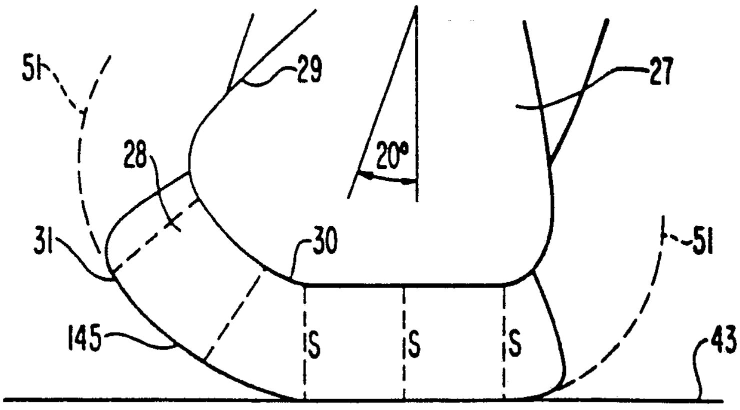

FIG. 1C

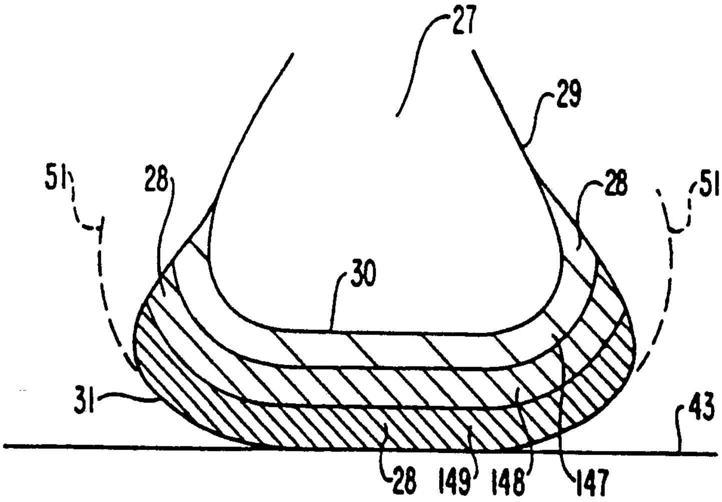
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FIG. 2

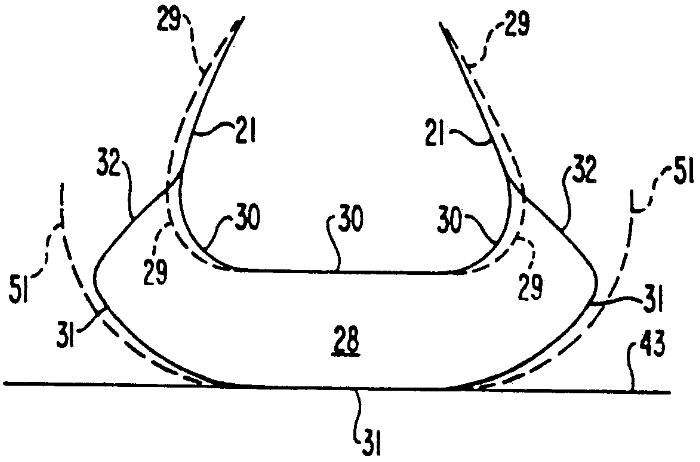
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FIG. 3

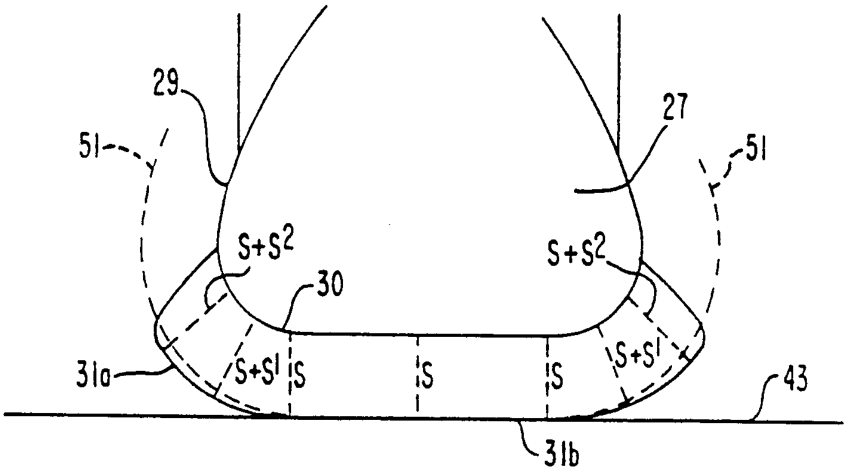
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FIG. 4

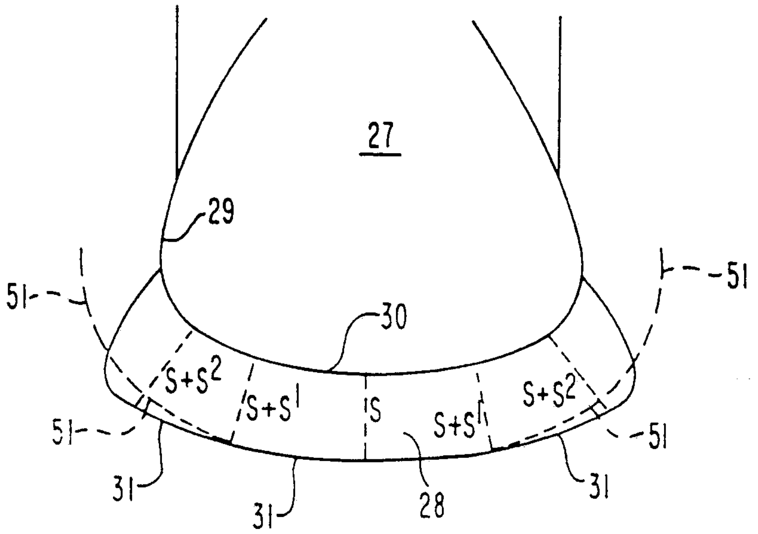
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FIG. 5

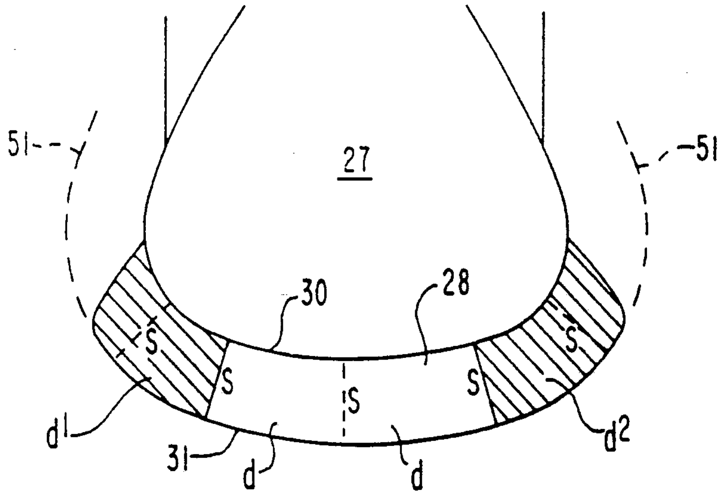

FIG. 6

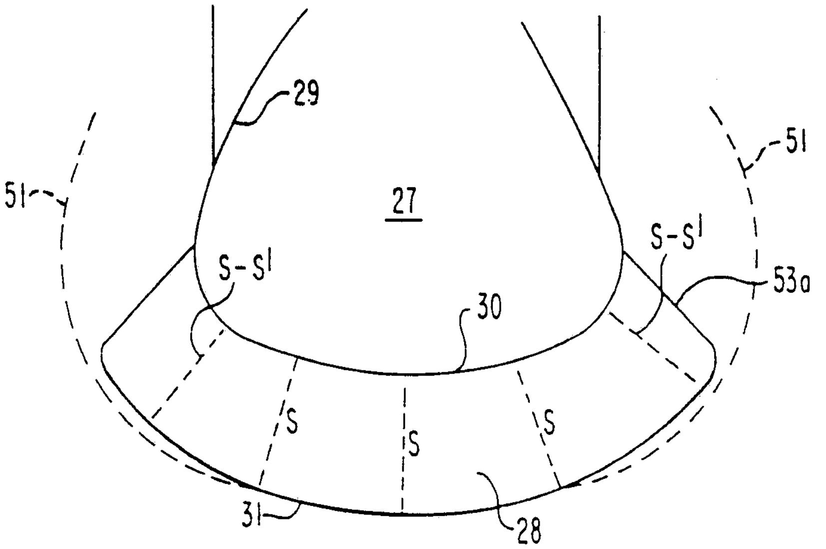

FIG. 7

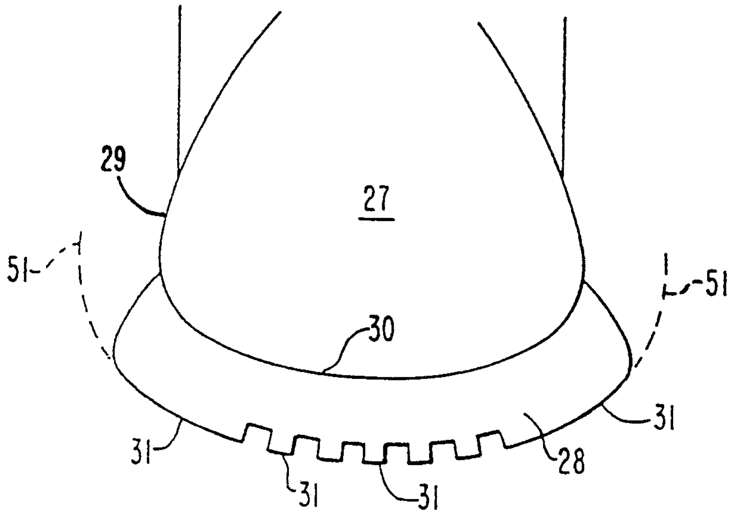

FIG. 8

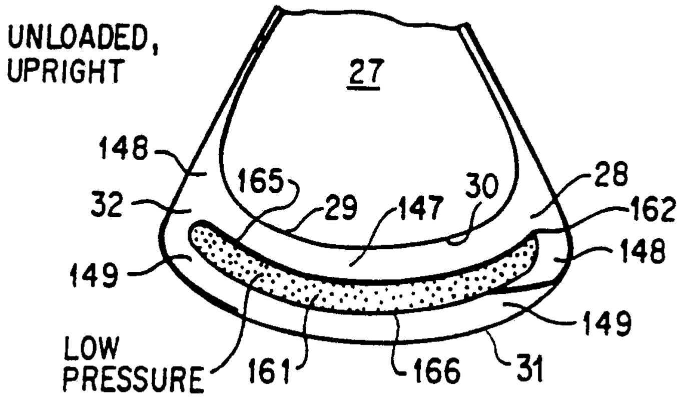

FIG. 9

SUBSTITUTE SHEET

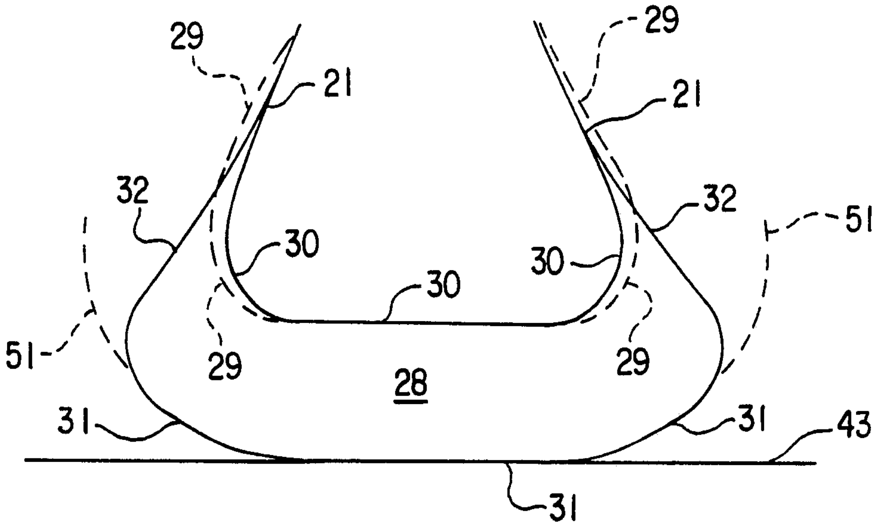
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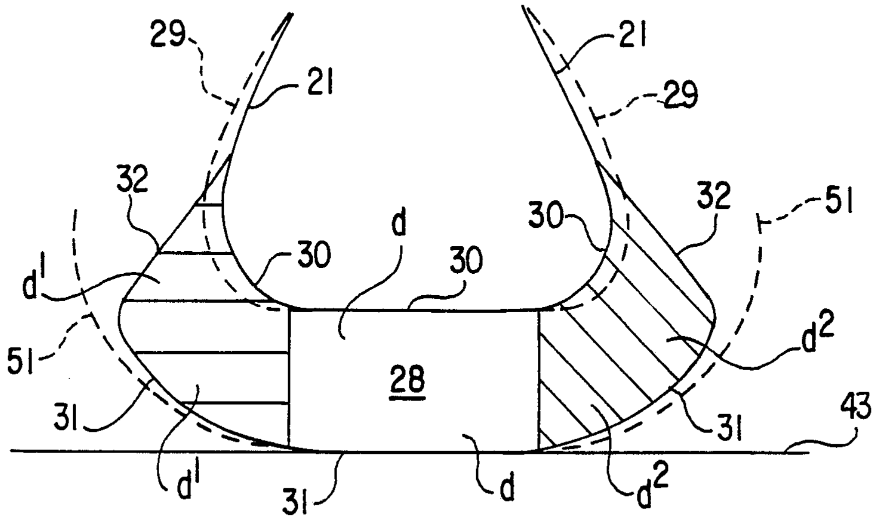
FIG. 10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d2
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d2

FIG. 11

INTERNATIONAL SEARCH REPORT

International Application No. PCT/US92/03032

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[3]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC (5): A43B 13/00
US CL : 36/25R

II. FIELDS SEARCHED

Minimum Documentation Searched[4]

Classification System	Classification Symbols
U.S.	36/25R, 30R, 31, 32R, 88, 91, 114, 129

Documentation Searched other than Minimum Documentation to the extent that such Documents are included in the Fields Searched[5]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[14]

Category*	Citation of Document,[16] with indication, where appropriate, of the relevant passages[17]	Relevant to Claim No. [18]
Y	US, A 4,989,349 (ELLIS) 05 February 1991, See whole reference.	1-20
Y	US, A 4,083,125 (BENSELER ET AL) 11 April 1978, See whole reference.	1-20
Y	GB, A 764,956 (BREVITT) 02 January 1957, See figure 2.	1-20
Y	DE, A 1,290,844 (CONINENTAL) 13 March 1969, See figure 10.	2,9,18
A	US, A 288,127 (SHEPARD) 06 November 1883, See whole reference.	1-20
A	US, A 4,715,133 (HARTJES ET AL) 29 December 1987, See whole reference.	7,11
A	US, A 4,858,340 (PASTERNAK) 22 August 1989, See whole reference.	1-20
Y	US, A 4,455,765 (SJOWARD) 26 June 1984, See whole reference.	7,11
A	US, A 4,398,357 (BATRA) 16 August 1983, See whole reference.	7,11

* Special categories of cited documents:[15]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search[2] 06 JUNE 1992	Date of Mailing of this International Search Report[2] 18 AUG 1992
International Searching Authority[1] ISA/US	Signature of Authorized Officer[20] M. D. PATTERSON

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

A	US, A 4,366,634 (GIESE ET AL) 04 January 1983, See whole reference.	7,11

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE[1]

1. ☐ Claim numbers _, because they relate to subject matter (1) not required to be searched by this Authority, namely:

2. ☐ Claim numbers _, because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out (1), specifically:

3. ☐ Claim numbers _, because they are dependent claims not drafted in accordance with the second and third sentences of PCT Rule 6.4(a).

VI. ☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING[2]

This International Searching Authority found multiple inventions in this international application as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.
2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:
3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:
4. ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Search Authority did not invite payment of any additional fee.

Remark on protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.