



US 20070101617A1

(19) **United States**

(12) **Patent Application Publication**
Brewer et al.

(10) **Pub. No.: US 2007/0101617 A1**

(43) **Pub. Date: May 10, 2007**

(54) **FOOTWEAR SOLE ASSEMBLY HAVING
SPRING MECHANISM**

Publication Classification

(51) **Int. Cl.**
A43B 13/00 (2006.01)

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(52) **U.S. Cl.** **36/103**

(57) **ABSTRACT**

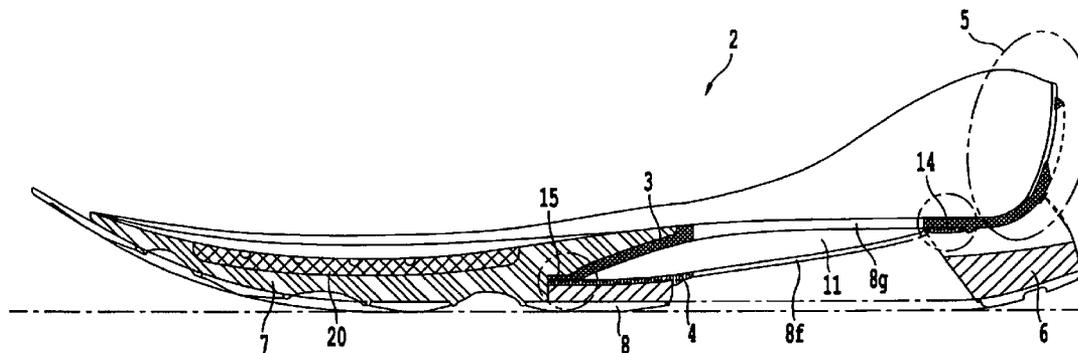
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A sole assembly which includes a heel cradle configured to cradle a heel of a human foot when the human foot is rested within the heel cradle, a rigid upper plate including a first part connected to the heel cradle and a second part located farther from the heel cradle than is the first part, a lower plate including a first part of which is connected to the first part of the upper plate and including a second part which is connected to the second part of the upper plate, an oblong gap located between the upper plate and lower plate and between the first and second parts of the upper and lower plates. A sole assembly including an upper plate and a lower plate stiffer than the upper plate and attached to the upper plate so as to form an oblong gap. Also, a shoe including the sole assembly.

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(21) Appl. No.: **11/270,526**

(22) Filed: **Nov. 10, 2005**



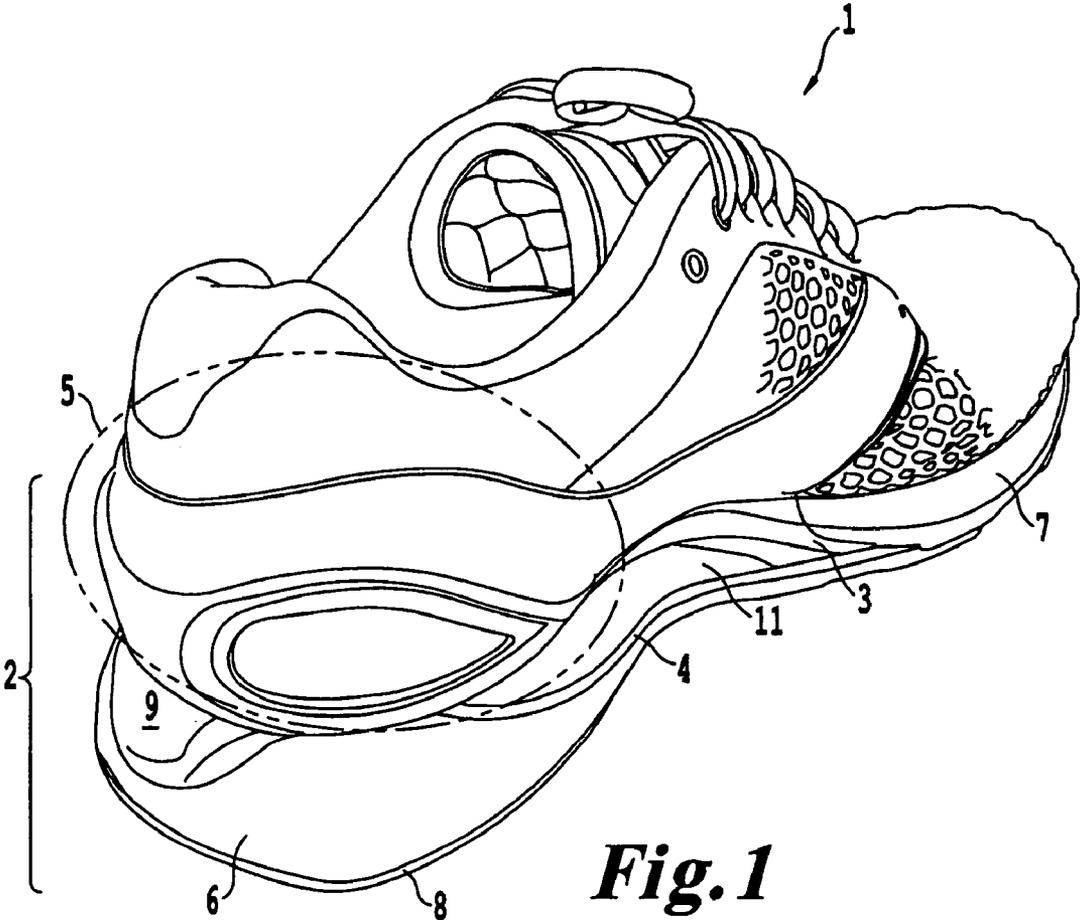


Fig. 1

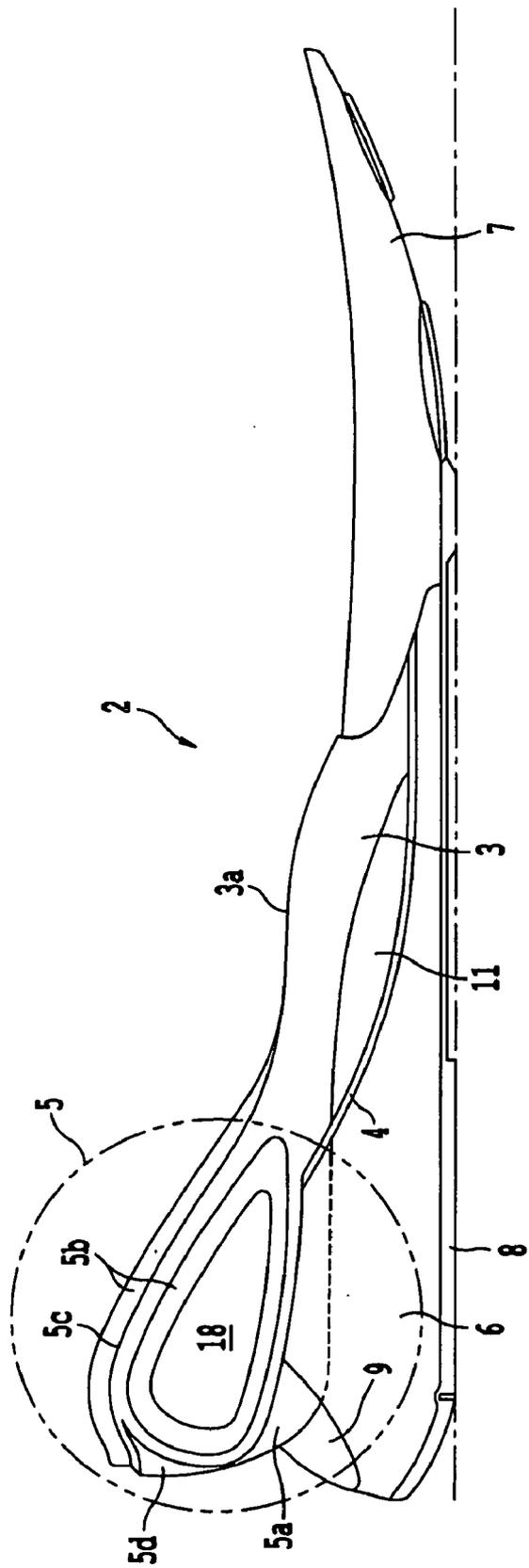


Fig. 2

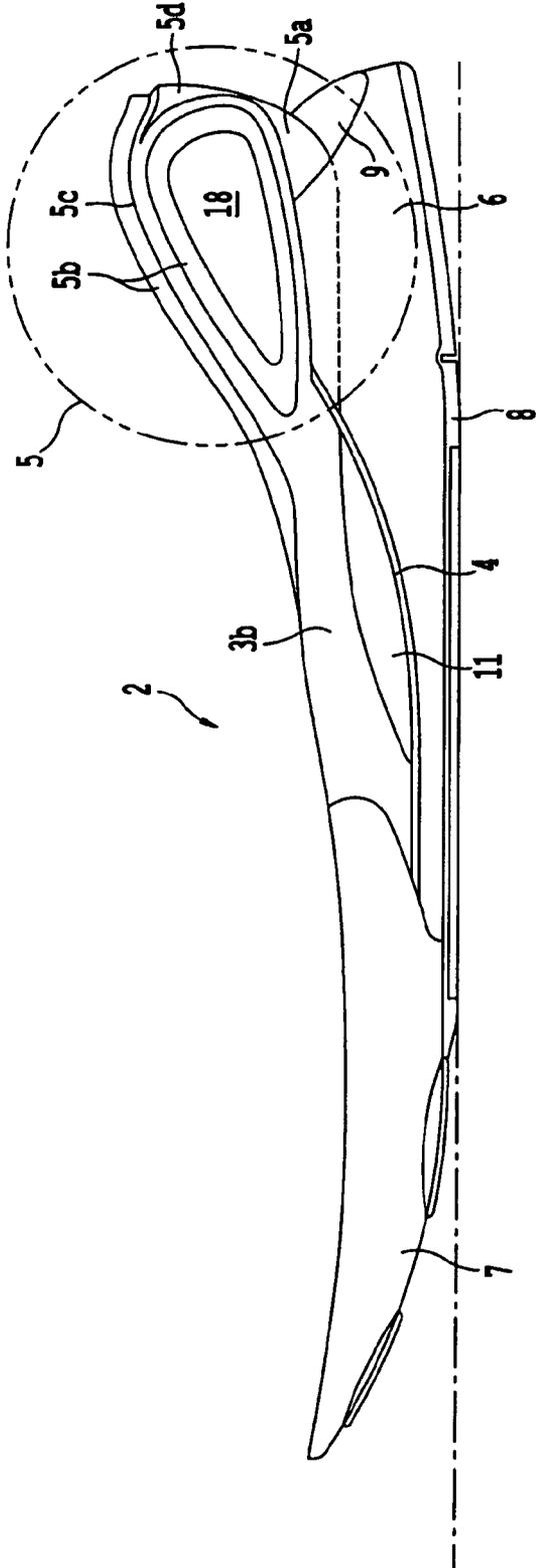


Fig.3

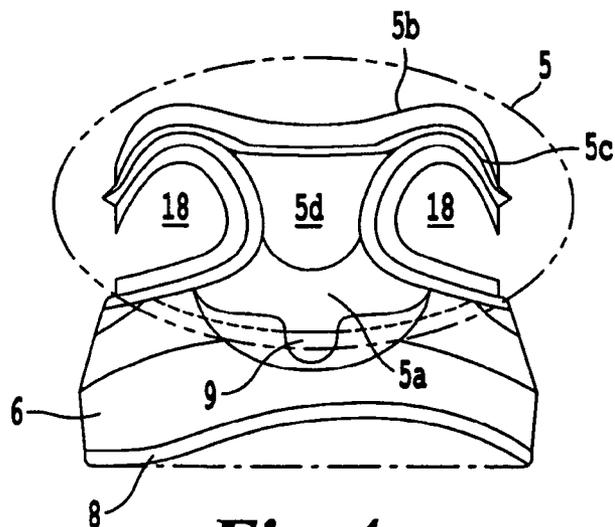


Fig. 4

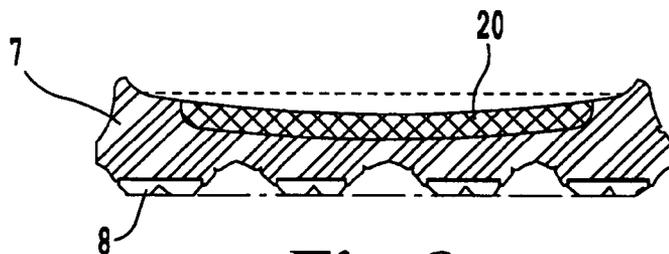


Fig. 8

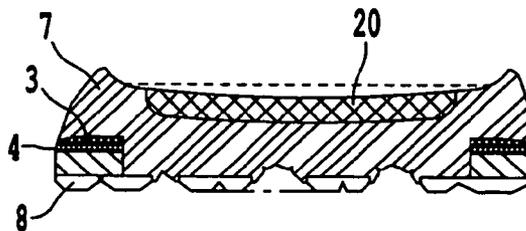
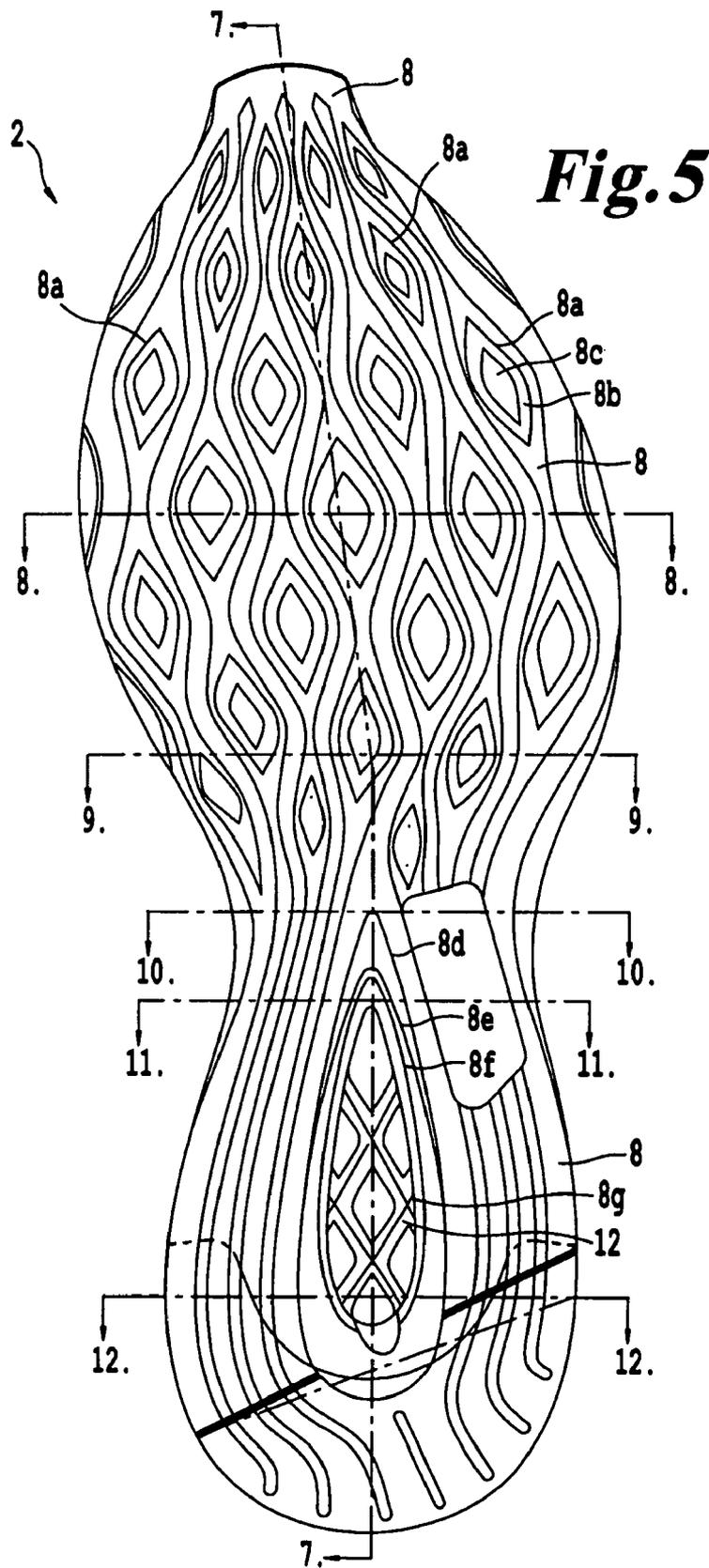


Fig. 9



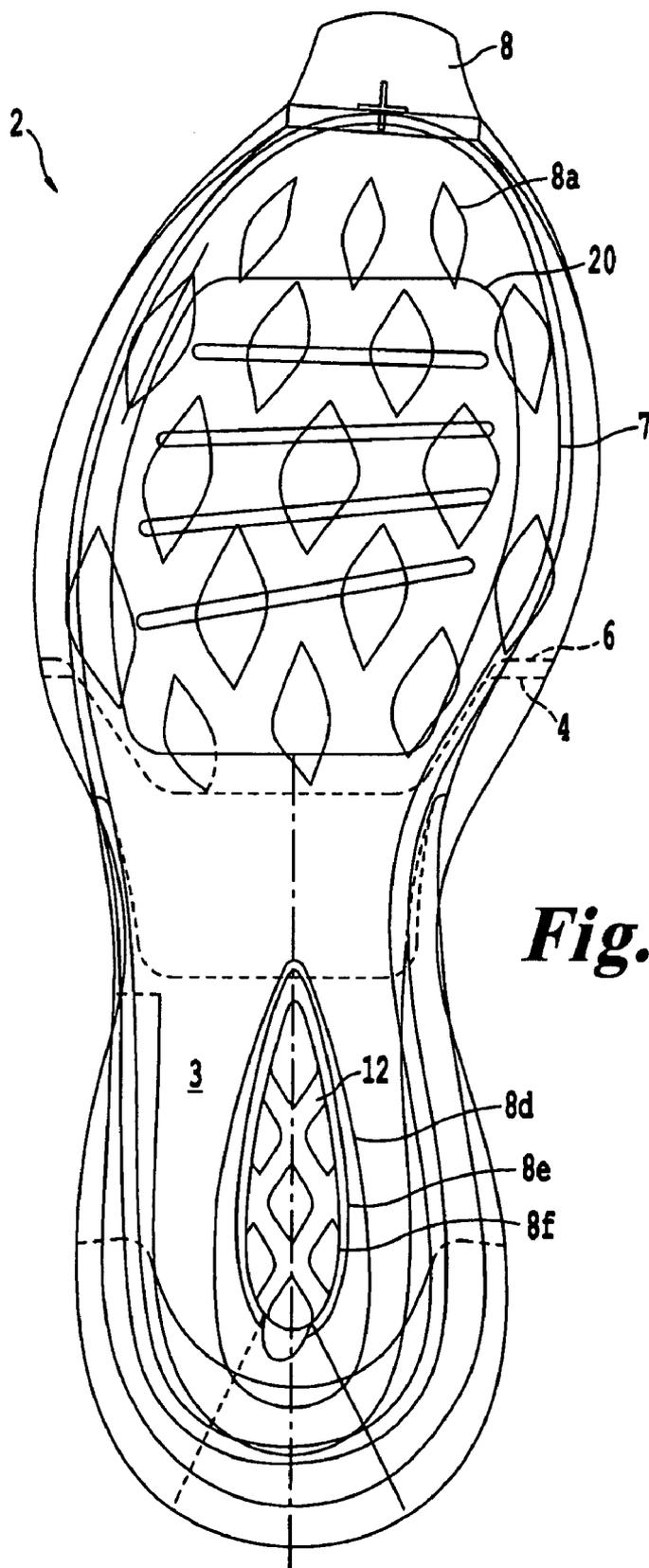


Fig. 6

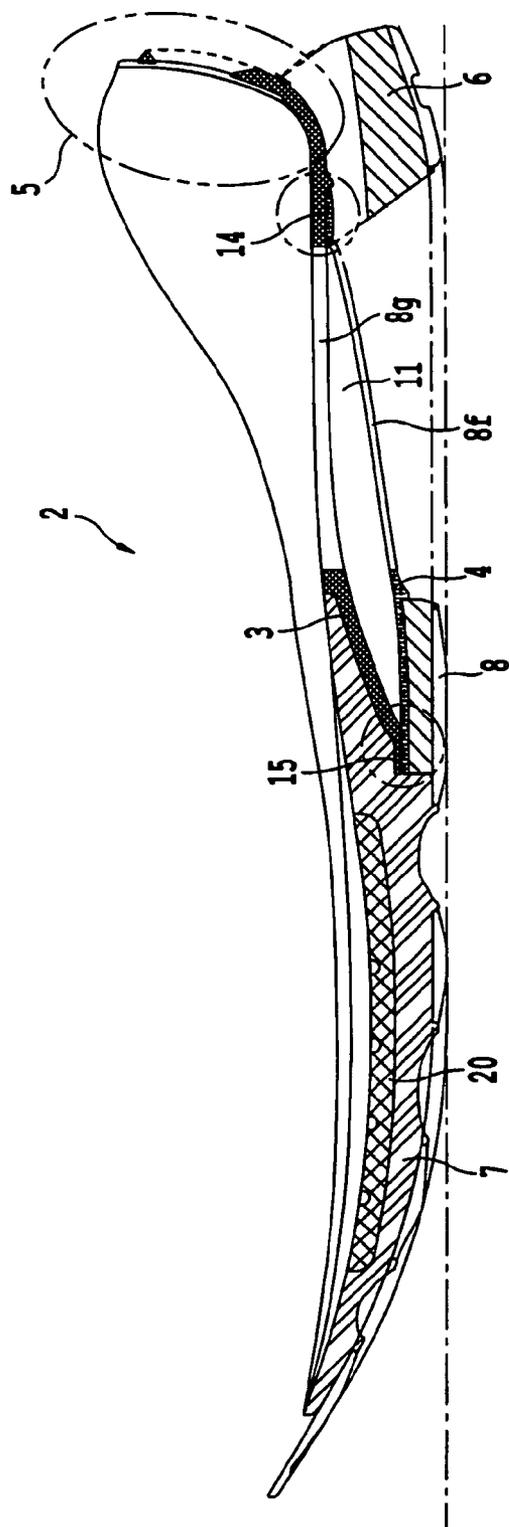


Fig. 7

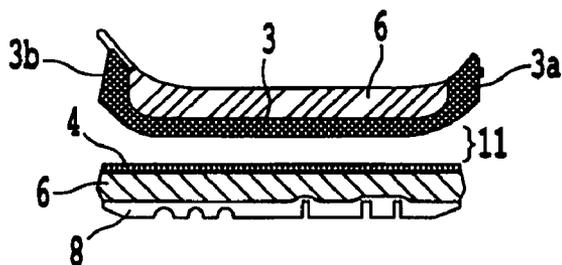


Fig. 10

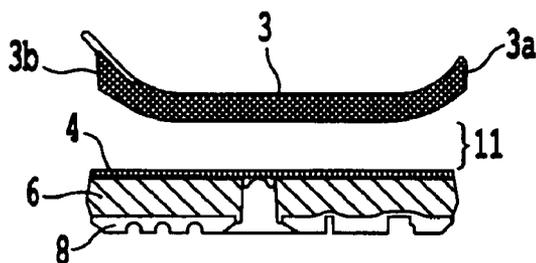


Fig. 11

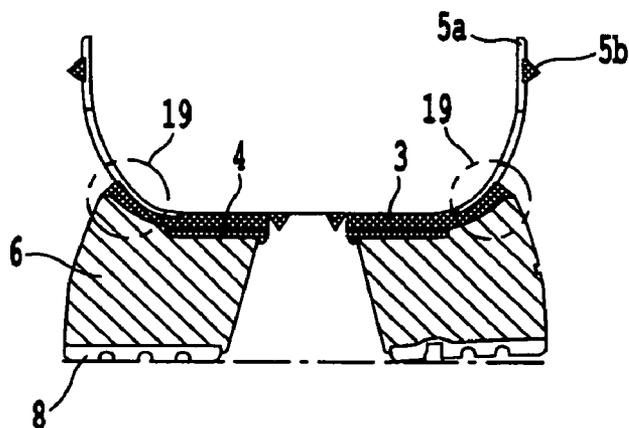


Fig. 12

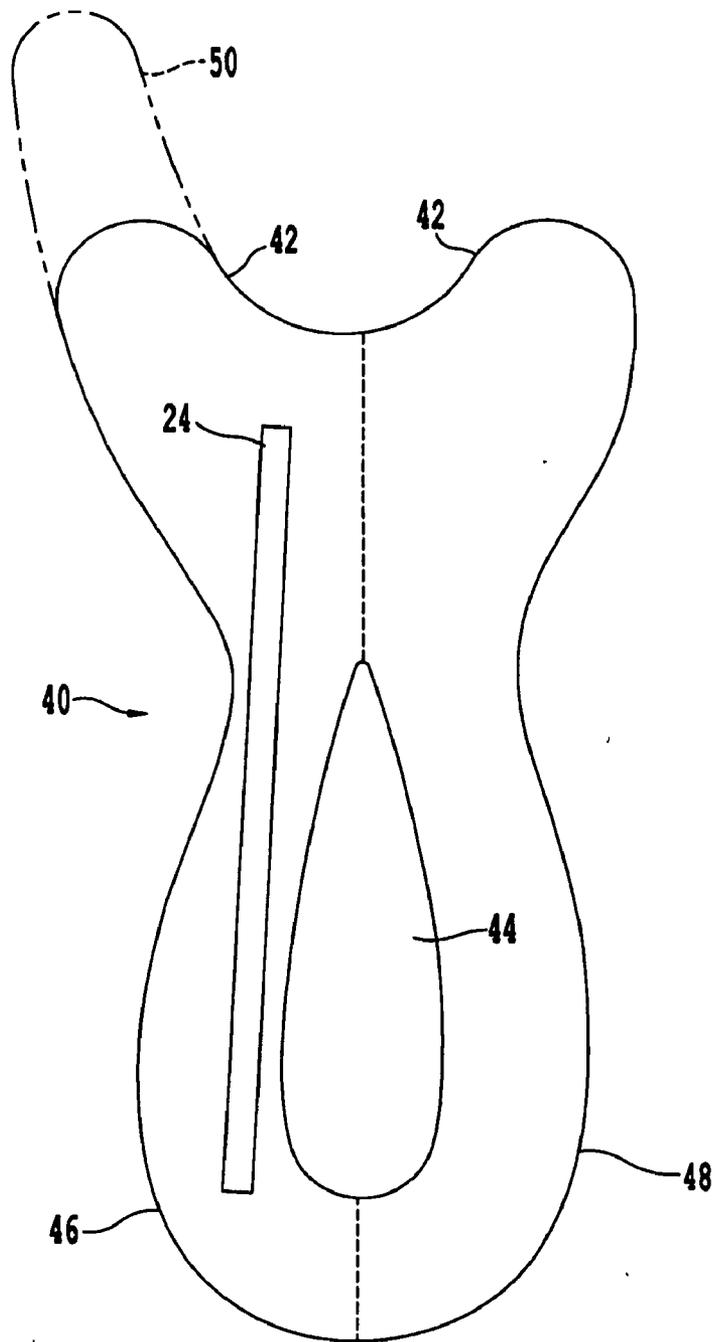


Fig. 13

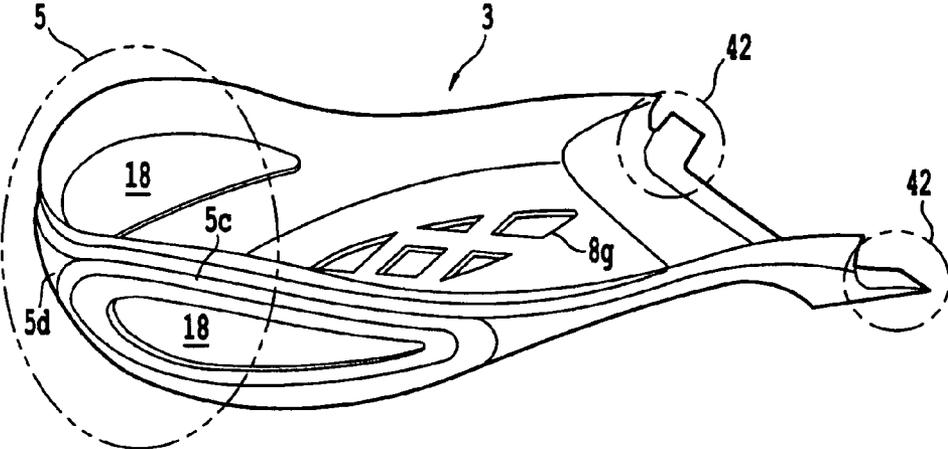


Fig. 14

FOOTWEAR SOLE ASSEMBLY HAVING SPRING MECHANISM

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a device that supports a person's foot, and more specifically, to a shoe sole assembly having a spring mechanism for storing and releasing mechanical energy during the gait cycle.

[0003] 2. Discussion of the Background

[0004] Footwear has often incorporated various methods of absorbing impact energy generated while a person walks or runs. Specifically, sponges or cushion materials are often used to absorb and dissipate energy throughout the wearer's gait cycle. However, in order to achieve sufficient cushioning, a large amount of cushioning material that substantially covers the entire plantar region of the shoe may be necessary. This creates a thick and heavy sole structure that adds weight to the shoe and prevents air flow to the plantar region of the wearer's foot. Cushion material may also become compacted over time and lose its cushioning effect, and does very little to store energy for use during the gait cycle.

[0005] Shoe makers have also created "through-holes" in the cushion material that extend from the lateral to medial sides of the shoe sole in order to reduce the weight of the shoe. However, as these conventional through-holes are typically mere vacancies created in the cushion material, they do not provide effective air flow to the plantar region of the wearer's foot. Moreover, conventional through-holes do not provide a structure for effectively storing mechanical energy.

[0006] Various spring elements have been used in footwear in an attempt to store impact energy for use during the gait cycle. For example, U.S. Pat. No. 6,449,878 discloses a spring assembly including a first spring element that extends over a large area of the shoe sole, and a second spring element attached to the first element in a midfoot region but spaced from and opposing the first element in a heel region of the shoe. The opposing first and second spring elements form a tension spring in the heel region of the shoe. However, this spring assembly is complex and requires large and highly resilient components that are too heavy to be of practical use for most shoes, particularly athletic shoes.

[0007] While simple and light-weight plastic-type assemblies have been implemented into footwear, these structures have generally been used to provide rigidity to certain regions of the sole and cannot efficiently store and release energy during the gait cycle. For example, U.S. Patent Publication 2003/0005600A1 discloses a plastic shank member embedded in a midfoot region of a shoe sole. The shank member is a substantially rigid sheet of material closed to form an oblong cross sectional shape. Placement of the shank member in the midfoot region of the midsole provides greater rigidity to this area of the midsole so that the forefoot of the midsole is more bendable. However, the shank is not disclosed as a spring element for storing and releasing energy during gait.

[0008] Furthermore, the present inventors have recognized that when any type of energy storage device is implemented in footwear, foot placement within the shoe

during contact with the ground is important to realizing a spring effect. Moreover, if the foot is improperly placed relative to the energy storage device, the device may interfere with the natural sequence of pressure distribution of the foot during the footstep, thus resulting in foot discomfort. For example, in the heel area, the heel of the foot tends to break contact or at least reduce pressure on the heel portion of the sole of the shoe when the foot is lifted. Accordingly, the heel of the foot may drift within the shoe and not impact the sole of the shoe in the optimum location for cushion effect and energy storage. Conventional shoes have not recognized this importance of heel placement, and thus have not provided comfortable and efficient energy storage mechanisms.

SUMMARY OF THE INVENTION

[0009] Accordingly, one object of the present invention is to address at least some of the above described and/or other problems of conventional footwear.

[0010] Another object of the present invention is to provide a simple, light-weight footwear spring element for effectively storing and releasing energy during the gait cycle.

[0011] Yet another object of the present invention is to provide a footwear mechanism for effectively positioning the wearer's heel in relation to a sole spring element in order to enhance efficient storage of energy in the spring at impact. Any of these and/or other objects can be provided by a sole assembly according to the present invention.

[0012] According to one aspect of the present invention, a sole assembly is disclosed including: a heel cradle configured to cradle a heel of a human foot when the human foot is rested within the heel cradle, a rigid upper plate including a first part connected to the heel cradle and a second part located farther from the heel cradle than is the first part, a lower plate including a first part which is connected to the first part of the upper plate and including a second part which is connected to the second part of the upper plate, an oblong gap located between the upper plate and lower plate and between the first and second parts of the upper and lower plates shaped such that a gap dimension between the upper and lower plates in a first direction, measured from the first part of the upper plate to the second part of the upper plate, is greater than a gap dimension between the upper and lower plates in a second direction which is perpendicular to the first direction.

[0013] According to another aspect of the present invention, a shoe is disclosed including: an upper portion; and a sole assembly including, a heel cradle configured to cradle a heel of a human foot when the human foot is rested within the heel cradle, a rigid upper plate including a first part connected to the heel cradle and a second part located farther from the heel cradle than is the first part, a lower plate including a first part which is connected to the first part of the upper plate and including a second part which is connected to the second part of the upper plate, an oblong gap located between the upper plate and lower plate and between the first and second parts of the upper and lower plates shaped such that a gap dimension between the upper and lower plates in a first direction, measured from the first part of the upper plate to the second part of the upper plate, is

greater than a gap dimension between the upper and lower plates in a second direction which is perpendicular to the first direction.

[0014] According to another aspect of the invention, a sole assembly is disclosed including: an outsole located on a side of the sole assembly and configured to support the sole assembly, a cushion material located next to the outsole, a means for cradling a heel of a human foot when the human foot is rested within the means for cradling, and a means for storing energy generated during walking connected to the means for cradling.

[0015] According to another aspect of the invention, a sole assembly is disclosed including: a rigid upper plate including a first part and a second part and having a first stiffness, a lower plate having a second stiffness greater than the first stiffness and including a first part which is connected to the first part of the upper plate and including a second part which is connected to the second part of the upper plate, an oblong gap located between the upper plate and lower plate and between the first and second parts of the upper and lower plates shaped such that a gap dimension between the upper and lower plates in a first direction, measured from the first part of the upper plate to the second part of the upper plate, is greater than a gap dimension between the upper and lower plates in a second direction which is perpendicular to the first direction.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] A more complete appreciation of the invention and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

[0017] FIG. 1 is a perspective view of a shoe incorporating a sole assembly and heel cradle according to one non-limiting embodiment of the present invention;

[0018] FIG. 2 shows the medial side of a sole assembly according to one exemplary embodiment of the present invention;

[0019] FIG. 3 shows the lateral side of a sole assembly according to one exemplary embodiment of the present invention;

[0020] FIG. 4 shows the back of a sole assembly according to one exemplary embodiment of the present invention;

[0021] FIG. 5 shows the bottom of a sole assembly including the outsole and various cross-section lines according to one exemplary embodiment of the present invention;

[0022] FIG. 6 shows the top of a sole assembly without the shoe upper according to one exemplary embodiment;

[0023] FIG. 7 shows a cross-section along line 7 of the sole assembly shown in FIG. 5;

[0024] FIG. 8 depicts a cross-section along line 8 of the sole assembly shown in FIG. 5;

[0025] FIG. 9 depicts a cross-section along line 9 of the sole assembly shown in FIG. 5;

[0026] FIG. 10 depicts a cross-section along line 10 of the sole assembly shown in FIG. 5;

[0027] FIG. 11 depicts a cross-section along line 11 of the sole assembly shown in FIG. 5;

[0028] FIG. 12 depicts a cross-section along line 12 of the sole assembly shown in FIG. 5;

[0029] FIG. 13 shows a top view of a bottom plate according to one exemplary embodiment of the present invention; and

[0030] FIG. 14 shows a perspective view of an upper plate and heel cradle according to one exemplary embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0031] Referring now to the drawings, wherein like reference numerals designate identical or corresponding parts throughout the several views, FIG. 1 is a perspective view of a shoe incorporating a sole assembly according to one non-limiting embodiment of the present invention. As seen in this figure, the shoe includes an upper 1 attached to a sole assembly 2. The upper is preferably made of durable sheets of non-elastic material such as leather, canvas, synthetic material or any other upper material known to those skilled in the art of shoes. In a preferred embodiment, the upper is a breathable nylon mesh material reinforced with outer layer regions of nylon netting. The upper 1 may be attached to the sole assembly 2 by stitching, adhesion or any other method known in the art.

[0032] In the embodiment of FIG. 1, the sole assembly 2 includes a spring mechanism having an upper plate 3 and a lower plate 4 in contact with one another to form a gap 11 through the sole assembly 2. Also included is a heel cradle structure 5, and rear and front cushion materials 6 and 7 respectively. In the embodiment of FIG. 1, the rear cushion material 6 includes a through hole 9 that works with the gap 11 to facilitate air flow to the bottom portion of the sole assembly as will be further described below. An outsole 8 is formed on a bottom portion of the cushion materials 6, 7 as will also be discussed below.

[0033] FIG. 2 and 3 show a medial and lateral side respectively of the sole assembly 2 shown in FIG. 1. As seen in these figures, the upper plate 3 and a lower plate 4 are connected to one another so as to form an oblong shaped gap 11 that extends as a hole from the lateral to medial side of the sole assembly 2. The upper plate 3 is concave facing downward and extends longitudinally from a heel region to a metatarsal region of the sole assembly 2, while the lower plate 4 is concave facing upward and connects to the upper plate 3 at the heel and metatarsal regions respectively. However, in alternative embodiments the upper and/or lower plates may be flat or concave in the opposite direction, and may be further contoured to fit the shape of a human foot. Further the upper plate 3 and lower plate 4 may be attached by any of various methods, such as, for example, by adhesive, heat bonding, ultrasonic welding or mechanical connection etc.

[0034] In the embodiment of FIGS. 2 and 3, the gap 11 extends approximately 10.5 cm longitudinally along the sole assembly 2, and is approximately 1.2 cm high at a middle point of the gap, however dimensions of the gap vary according to the size of the sole assembly 2, and/or according to the spring effects desired. In one embodiment, the gap

is approximately 25-35% of the length of the sole assembly 2. Preferably, the length of the gap (not considering curvature) is from approximately 100 mm to 130 mm, and the height is from approximately 5 mm to 14 mm.

[0035] In the embodiment of FIGS. 1-3, the upper plate 3 is more flexible than the lower plate 4. Specifically, the upper plate 3 has a thickness of approximately 3 mm, and is formed with medial and lateral sidewalls 3a and 3b that provide some rigidity to the upper plate 3, while the lower plate 4 is approximately 1.5 mm thick and generally planar along a transverse cross section. However, the upper plate 3 is made of a relatively flexible material such as thermoplastic polyurethane (TPU), while the bottom plate is made of a stiffer material such as carbon fiber or KEVLAR® (poly-paraphenylene terephthalamide) etc., which have a higher tensile strength and flexural modulus. The present inventors have discovered that the softer TPU used in the upper plate 3, provides a cushioning effect while the more rigid carbon fiber lower plate 4 provides excellent energy storage characteristics. In alternative embodiments, the thickness, structural design and/or the material composition of the plates may be varied to provide upper and lower plates having the same or different stiffness properties. Further the upper and/or lower plate can be designed to have localized stiffness properties as will be further described below.

[0036] One benefit of using carbon fiber in the plates, especially the lower plate 4, is that because the carbon fiber is very strong and stiff, the lower plate 4 can provide the desired spring effect with a reduced thickness relative to other materials. Thus, the vertical dimension of gap 11 is increased without increasing the overall height of the sole assembly 2. This increase allows a greater range of travel between the upper plate 3 and the lower plate 4 within a given overall height of the sole assembly 2. In other words, with one or both plates made of a high stiffness material such as carbon fiber, the range of travel between the plates can be maintained while the sole assembly can be made shorter in height than would be possible with other materials.

[0037] In the embodiment of FIGS. 1-3, the heel cradle 5 is integrally formed with the upper plate 3, and the lower plate 4 connects to a middle region of the heel cradle 5. Thus, a portion of the upper plate 3 extends beyond the contact point with the lower plate to form a cantilevered portion 5a, which is contoured to cup or cradle the wearer's heel. As seen by the dashed lines in FIGS. 2 and 3, the rear cushion material 6 overlaps the bottom of the cantilevered portion 5a in order to provide support for the portion 5a. The heel cradle 5 also includes a substantially flat and flexible strip portion 5b that is in flush contact with an outer surface of the upper 1 of the shoe to provide comfortable support for the heel, while a more rigid portion 5c overlaps the strip 5b and is made integral with the upper plate 4 to provide reinforcement of the strip 5b.

[0038] As best seen in FIG. 4, the rear portion of the heel cradle 5 includes a rigid wall 5d that is integral with the cantilevered part 5a and the reinforcing portion 5c. The wall 5d provides strong support for the heel at impact during, for example, running. The portions 5a, 5c and 5d of the heel cradle are preferably made of the same material as the upper plate 3. The reinforcing portion 5c (and strip 5b beneath it) extend from the rigid wall 5d along the lateral and medial sidewalls of the upper 1, and are contoured to approach the

upper plate 3 as they run forward toward a midfoot region of the sole assembly 2. Thus, side portions of the heel cradle 5 include an opening 18, which can allow some air flow through the upper 1 to the heel region of the shoe interior. In the embodiment of FIGS. 1-4 and 14, the heel cradle 5 extends approximately 3.7 cm up the sidewall of the upper 1 at a maximum, and extends approximately 7 cm along the sidewalls from a rear of the upper 1. It is to be understood, however, that the portion of the heel cradle 5 overlapping the upper 1 can have varying dimensions for different size shoes and for different shoe types, as long as the overall heel cradle structure 5 supports the heel to enhance centering of the wearer's heel during use.

[0039] The addition of the heel cradle 5 can enhance the effect of the spring mechanism by improving a position of the wearer's heel as the heel of the foot lifts and descends during walking or running. The present inventors have realized that by consistently centering the heel of the foot in relation to the sole assembled, the upper plate 3 and lower plate 4 more efficiently store and release energy during gait. Furthermore, proper positioning of the heel allows the sole assembly 2 to smoothly accommodate the natural gait of the wearer and to provide support where needed. To achieve proper positioning of the heel of the foot, the heel cradle 5 is typically added to the shoe on the outside of the upper 1 as shown in FIGS. 1-4; however, the heel cradle 5 may be formed inside or as an integral part of the heel region of the upper 1.

[0040] Further in the non-limiting embodiment shown in FIGS. 1-4 and 14, the heel cradle 5 is an integral part of the upper plate 3. One benefit of this arrangement is that the heel cradle 5 not only centers the heel of the foot on the upper plate 3, but flexes as the upper plate 3 flexes. In another non-limiting embodiment, the heel cradle 5 may be a separate component and attached to the upper plate 3 via any of the various joining processes discussed above regarding connecting the plate. Additionally, the heel cradle 5 may be made of a different material than the upper plate 3. Accordingly, the stiffness of the heel cradle 5 may be made different from the plates by changing the material or by changing the dimensions of the heel cradle 5.

[0041] As shown in FIG. 14, the heel cradle 5 may include openings on the sides to provide ventilation to the heel region. Additionally, in embodiments where the heel cradle 5 is external to the upper 1, the heel cradle may provide an aesthetically pleasing design. In the embodiment shown in FIGS. 4 and 14, the area between the openings 18 and above rigid wall 5d is slightly lower in height than the area above openings 18. This enhances the fit of the heel cradle 5 to the Achilles tendon area of the heel.

[0042] As seen in FIGS. 1-4, the rear cushion 6 supports the upper plate 3 and heel cradle 5 in the heel area, and supports the lower plate 4 from the heel to approximately midfoot, while front cushion 7 supports the forefoot. Cushion material 6,7 is preferably made of a resilient, shock-absorbing material such as, for example, ethylene vinyl acetate (EVA). Rear cushion gap 9 is provided to support the cantilevered portion of the upper plate 3 and heel cradle 5. The presence of the rear cushion gap 9 may improve the flexibility of the heel of the shoe while decreasing the weight of the shoe and improving air flow directly around the heel of the foot as will be further described below. In some

non-limiting embodiments, the rear cushion gap 9 may not be present, may be shaped differently than as shown in FIG. 4, or may include multiple smaller gaps.

[0043] The rear cushion 6 is coupled to the front cushion material 7 to provide a planar surface for attaching the outsole 8. The outsole 8 is preferably implemented as a layer of deformable rubber material that contacts the ground when the shoe is in use, and preferably includes treads that are designed to grip a variety of ground surfaces. As seen in FIGS. 2-4 the outsole 8 is shown as curved along a contour provided by the sole assembly 2. Such contouring accommodates a natural human gait by providing a smooth flow from heel to toe as the foot twists during walking or running. Details of the outsole 8 are discussed below.

[0044] The present inventors have discovered that the sole assembly of the exemplary embodiment of FIGS. 1-4 provides a simple and light-weight footwear spring element for effectively storing and releasing energy during the gait cycle. Further the heel cradle can effectively position the wearer's heel in relation to the sole spring element in order to enhance efficient storage of energy in the spring at impact. It is to be understood, however, that the spring mechanism may be used to provide improved spring characteristics without the need for the heel cradle, and the heel cradle can enhance the energy storage and release characteristics of springs other than that shown in FIGS. 1-4. Still further use of the absorbing material 6, 7 can absorb and dissipate impact shock during heel strike, and operate to dampen the spring effect of the spring mechanism of the sole assembly 2.

[0045] Specifically, prior to heel impact of the gait cycle when the heel is not in contact with the ground, the heel cradle 5 can provide lateral support for the heel and maintain a substantially center position of the heel on the sole assembly 2. A downward force created from heel contact to the midstance portion of the gait cycle is applied to the upper plate 3. This causes the upper plate 3 to deflect in elastic deformation downward toward the lower plate 4, thus storing the energy of the applied load. This stored energy is then released during the windlass phase of the gait cycle when the foot locks into place and moves from midstance to toe off. This creates a natural propulsion sensation to the wearer. The absorbing material functions to absorb and disperse shock forces in order to cushion the foot during this gait cycle, and can further dampen the spring effect of the spring element to provide a smoother feel.

[0046] FIG. 5 shows a bottom surface of a sole assembly in accordance with an embodiment of the present invention. As seen in this figure, cross-section lines 7-12 are shown to define the cross-section planes of FIGS. 7-12 respectively. As also seen in FIG. 5, the outsole 8 is substantially continuous from the rear to the front of the sole assembly 2. However, in other embodiments, the outsole could be two or more separate parts, e.g., a rear part and a front part separated by a gap or flexion area. The outsole 8 includes a tread portion (designated by number 8), which can be made of various tough, flexible materials such as, for example, carbon rubber, and is designed to provide gripping of various surfaces. In the embodiment of FIG. 5, the tread portion 8 is implemented as a substantially planar sheet of rubber having serpentine raised edges and grooves that extend in a longitudinal direction.

[0047] The tread portion 8 includes a plurality of small holes 8a therein at a forefoot region of the sole assembly, and a larger hole 8d extending from the heel to midfoot region of the sole assembly 2. In the embodiment of FIG. 5, the tread holes 8a correspond to holes 8b in the absorbing material 7 to provide front ventilation holes 8c in the bottom of the shoe to permit air flow to the forefoot interior of the shoe. Similarly, the hole 8d corresponds to hole 8e provided in the rear cushion 6, hole 8f provided in lower plate 4 and hole 8g provided in upper plate 3, such that a heel ventilation hole 12 allows air flow to an interior of the shoe. Although the holes are shown in FIGS. 5 and 6 as having a teardrop shape, other shapes are possible. Additionally, not all of the upper plate 3, lower plate 4, or rear cushion 6 need to have similarly shaped holes. Furthermore, as shown in FIG. 14, the holes may have a mesh or reinforcing structure added.

[0048] FIG. 6 shows a top surface of the sole assembly 2 at the interior of the shoe. As seen in this figure, the sole assembly 2 includes an outsole 8 having a front cushion 6 provided at a forefoot region thereof, and a rear cushion 7, lower plate 4 and upper plate 3 sequentially stacked on a heel to mid-foot region of the outsole 8. As also seen in FIG. 6, the ventilation holes 8b and 12 extend to the interior of the shoe. The ventilation holes 8c and 12 preferably include a screen or mesh material that permits air flow into the shoe while keeping debris from entering the interior of the shoe. Thus, the sole assembly of FIGS. 5 and 6, is designed to permit substantial air flow from an exterior of the shoe to a plantar region of the wearer's foot. This is further enhanced by the cushion gap 9 in the absorbing material 6 and the gap 11 in the spring mechanism, which allow free flow of air around the heel portion of the shoe and to the ventilation hole 12. Further ventilation holes 8a and 12 reduce the weight of the sole assembly, while enhancing the performance characteristics of the shoe by guiding the heel to center strike upon impact.

[0049] FIGS. 7-12 show various cross sections of the sole assembly of FIGS. 1-6 in accordance with one embodiment. FIG. 7 shows a longitudinal cross section of the sole assembly of FIG. 5. As seen in FIG. 7, the upper plate 3 is formed of TPU depicted by a diagonal cross sectional marking, while the lower plate 4 is formed from carbon fiber depicted by a vertical-horizontal cross sectional marking. Areas 14 and 15 show a contact region of the upper and lower plate at a heel and mid-foot region respectively. Further, the upper and lower plates include a break at this cross section due to the hole 8g in the upper plate 3 and the hole 8f in the lower plate 4. As also seen in this figure, the absorbing material 7 at the metatarsal region of the forefoot includes a cavity having a second absorbing or cushioning material 20 provided therein. In one non-limiting embodiment, cushioning material 7 and 20 preferably have different durometer hardness ratings. However, in a preferred embodiment, the cushioning material 7 and 20 are comprised of the same material.

[0050] FIG. 8 shows a cross-section of the outsole 8 taken along the section-line as defined in FIG. 5. As shown in FIG. 8, the first foam material 20 provides a cushion across the metatarsal region of the foot. Below the first foam material 20 is forefoot absorbing material 7 and the outsole 8. In one non-limiting embodiment, the upper plate 3 and lower plate 4 do not extend to the cross-section shown in FIG. 8. By not placing the plates in the region of this cross-section, natural

flexure at the ball of the foot occurs independently of the upper plate 3 and lower plate 4. In another non-limiting embodiment, the upper plate 3 and lower plate 4 are formed such that they are present in the metatarsal region, but are structured to allow flexure at the ball of the foot as needed. It should be noted that the upper plate 3 and lower plate 4 may be made longer or shorter depending on the particular needs of the wearer. In some cases, the plates may be made shorter and moved closer to the heel of the sole assembly 2. In other cases, the plates may be moved forward, either by lengthening the plates relative to the length of the sole assembly 2 or by moving the plates themselves forward.

[0051] FIG. 9 shows a cross-section of the outsole 8 taken at the section-line as defined in FIG. 5. In this view, the first foam material 20, absorbing material 7, and outsole 8 are present as shown in FIG. 8. However, as section-line of FIG. 9 is closer to the middle of the outsole 8 than section-line of FIG. 8, upper plate 3 and lower plate 4 are shown on the right and left sides of the outsole 8. In this non-limiting embodiment, the upper plate 3 and lower plate 4 are Y-shaped or have extended parts on their right and left edges as shown in exemplary FIGS. 13 and 14, which will be discussed further below. Thus, in the cross-section depicted in FIG. 9, only the extended parts appear. The upper plate 3 and lower plate 4 plate make contact in the region of section-line of FIG. 9. As discussed above, the plates may be attached through various methods, including mechanical attachment.

[0052] As also by a comparison of FIGS. 8 and 9, the sole assembly 2, upper plate 3 and lower plate 4 are thinner towards a center of the shoe. Alternatively, the upper plate 3 and lower plate 4 may have uniform widths as measured horizontally across the shoe. When the widths and thicknesses of the plates are uniform, the plates may easily be formed by simple extrusion. However, in order to enhance response of the plates as a foot travels from heel to toe during a footstep, the plates typically have a varying width (and possibly thickness as discussed below) along their length. In addition to altering the performance of the plates during deflection, such curvature allows the plates to fit beneath the contours of the foot and enhances aesthetic appeal.

[0053] FIG. 10 shows a cross-section taken at the line as defined in FIG. 5. In this non-limiting embodiment, the upper plate 3 is shown as having a concave shape pointing upward to form sidewalls 3a and 3b which can prevent the foot from slipping from side to side. A comparison of FIGS. 9 and 10 shows that the upper plate 3 and lower plate 4 have separated and have formed the beginning areas of the gap 11. Additionally, foam material 6 is shown, which makes up the rear cushion 6 shown in FIGS. 1-4.

[0054] FIG. 11 shows a cross-section taken at the section-line as shown in FIG. 5. As this section-line is further back from the front of the shoe than is section-line of FIG. 10, the vertical dimension of gap 11 is larger. Additionally, the concavity of the upper plate 3 has decreased. Finally, FIG. 12 shows a cross-section taken at the section-line as shown in FIG. 5. Although other locations are possible, an optional rear cushion cavity 9 is shown in approximately the center of the shoe. The presence of the rear cushion cavity 9 allows more flexion in the center of the upper plate 3, especially if the upper plate cavity 12 and lower plate cavity 10 are present, and permits air flow as previously described.

[0055] Further shown in FIG. 12 are the vertical protrusions 19 present on the upper plate 3. In this embodiment, the vertical protrusions 19 are the remnants of the concave-upward parts of the upper plate 3. However, the vertical protrusions may be formed separately from the concave-upward parts of the upper plate 3. In fact, it is not necessary for any other part of the upper plate 3 to be concave upward in order for the upper plate 3 to include the vertical protrusions 19.

[0056] The sole assembly of FIGS. 1-12 has been described as having a neutrally-positioned plate that generally allows for the high-arched, rigid foot-type to apply consistent pressure through the gait cycle and receive the maximum cushioning and spring effect. In this embodiment, the material and thickness of each of the upper plate 3 and lower plate 4 is substantially constant and symmetrical across a respective plate to provide little variation in stiffness properties across a respective plate. However, alternative embodiments may be implemented to accommodate different foot types. For example, an asymmetric design to give greater support on the medial (inside) portion of the shoe to better support a medium-arched semi-flexible foot as it pronates inward. Similarly, maximum support on the medial side of the shoe may be needed to support an extremely flexible and low-arched foot type. The medial side material would need to be very stiff and noticeably less flexible, as the general body-type for this kind of foot-type is much larger, thus exerting more pressure on the spring device. The stiffness would eliminate the potential for collapse in the midfoot.

[0057] Such asymmetrical levels of stiffness can reduce foot pronation. For example, human feet naturally rotate or roll inward during walking, i.e., the feet pronate. Over-pronation occurs when the arch of a human foot collapses upon weight bearing. Problems associated with over-pronation include soft-tissue inflammation and joint stress. To avoid over-pronation, shoes with augmented arch supports have been designed. However, the augmentation may undesirably add to the overall weight and height of the shoe. Additionally, as the augmentation is typically designed merely to prevent collapse of the arch of the foot, the augmentation does not efficiently store energy during walking or running. Thus, rather than augmenting the arch of a shoe with thicker padding which in turn would increase the weight and height of the shoe, a particular part of the foot such as, for example, the arch area of the foot, may be preferentially supported by altering the stiffness characteristics of the plates, either by changing plate geometry or by changing materials.

[0058] FIG. 13 shows a general shape of the upper plate 3 and lower plate 4 in accordance with an embodiment of the present invention. As seen in this figure, the plate 40 includes front wings 42 and a through hole 44, which generally divide the plate 40 into a medial side 46 and lateral side 48 having a boundary indicated by the vertical dashed lines in the figure. In one non-limiting embodiment, a portion or all of the medial side 46 of the plate 40 may be made of stiffer material than a portion of the lateral side 48. For example, part of the medial side of the plate may be fabricated from carbon fiber or other material while the remainder of the plate may be made of relatively more flexible TPU. In one non-limiting embodiment, the carbon fiber may comprise one or more separate inserts 24 attached

or placed inside the plate as shown in FIG. 13. The insert 24 may be replaceable to enable one to customize the shoe for a particular wearer or use. Provisional Application Ser. No. 60/709792 discloses various methods of measuring a characteristic of the wearer in order to determine a footwear component such as insert 24 suitable for the wearer. This provisional application is hereby incorporated herein in its entirety. In another non-limiting embodiment, the inserts may be integrally formed into the plate during the manufacture of the plate.

[0059] Various methods of stiffening particular portions of the plates exist. If the stiffness of the plate depends largely on the number of fibers present in the material, such as it typically does with fiber-glass or carbon fiber materials, the density of the fibers in a part of the plate may be increased or reduced during manufacture to affect the stiffness in a particular area. In yet another non-limiting embodiment, the chemical composition of the plate may be altered in various parts such that the stiffness changes.

[0060] Further, the thickness of the plate 40 may be increased on the medial side 46. As the stiffness of a cross-section of a plate is proportional to the cube of the thickness of the plate, even a small change in the thickness of the plate will have a large effect on the overall stiffness of the plate. Thus, grooves, ribs, and plates with gradually varying thicknesses may be used to affect the localized stiffness of the upper plate 3 or lower plate 4 or both. Still further, the medial side may be asymmetrical in shape as shown by the phantom wing extension 50 on the medial side, which may stiffen this area.

[0061] As shown in FIG. 13 wings 42 are typically positioned on the medial and lateral sides of the plate 40. In FIG. 14, the wings 42 are shown on the upper plate 3 as slightly tapered protrusions extending toward the toe area. Thus, the wings 42 enhance stability of the sole assembly 2 by stiffening the outer portions of the sole assembly, but add less weight than would a shape in which the area between the wings 42 is filled with material. Accordingly, the stiffness of the metatarsal region can be enhanced with little added material. Wings 42 added to the lower plate 4 achieve similar results. Additionally, the tapering shape of the wings 42 in the vertical direction provides enhanced ability to attach the lower plate 4 and upper plate 3 to the rest of the sole assembly 2, i.e., the taper provides a fillet shape in the connection area.

[0062] In addition to asymmetry of the upper and lower plates themselves, the spring assembly may be positioned differently within the sole assembly to accommodate different foot types. For example, moving the spring mechanism forward or back may change a performance characteristic of the sole assembly. For example, a smaller system that is closer to the heel may work better for a mild overpronator. As another example, moving the system forward may create the best forefoot cushioning in a shoe. Still further, material and design variations may be implemented to provide a lower midsole height.

[0063] Clearly, numerous modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described herein.

1. A sole assembly comprising:

a heel cradle configured to cradle a heel of a human foot when the human foot is rested within the heel cradle;

an upper plate including a first part connected to the heel cradle and a second part located farther from the heel cradle than is the first part;

a lower plate including a first part which is connected to the first part of the upper plate and including a second part which is connected to the second part of the upper plate;

an oblong gap located between the upper plate and lower plate and between the first and second parts of the upper and lower plates shaped such that a gap dimension between the upper and lower plates in a first direction, measured from the first part of the upper plate to the second part of the upper plate, is greater than a gap dimension between the upper and lower plates in a second direction which is perpendicular to the first direction.

2. The sole assembly of claim 1, further comprising at least one insert attached to at least one of the upper plate and lower plate.

3. The sole assembly of claim 2, wherein the at least one insert is located in the lower plate.

4. The sole assembly of claim 3, wherein the at least one insert includes a material with a stiffness greater than a stiffness of a material comprising the lower plate.

5. The sole assembly of claim 4, wherein the at least one insert comprises at least one of carbon fiber and poly-paraphenylene terephthalamide.

6. The sole assembly of claim 4, wherein the insert is located nearer to a medial side of the lower plate than to a lateral side.

7. The sole assembly of claim 1, wherein the upper plate and lower plate are comprised of different materials.

8. The sole assembly of claim 7, wherein the lower plate comprises carbon fiber.

9. The sole assembly of claim 7, wherein the lower plate comprises poly-paraphenylene terephthalamide.

10. The sole assembly of claim 1, wherein the heel cradle comprises a different material than the upper plate.

11. The sole assembly of claim 1, wherein the heel cradle and upper plate are a continuous piece of material.

12. The sole assembly of claim 11, wherein the heel cradle is vented.

13. The sole assembly of claim 12, wherein the heel cradle is partially directly supported by the upper plate and partially directly supported by a cushion material.

14. The sole assembly of claim 1, wherein the upper plate is asymmetrical about a vertical plane that passes through a center of the heel cradle and a center of a toe of the sole assembly.

15. The sole assembly of claim 14, wherein the lower plate is asymmetrical about a vertical plane that passes through a center of the heel cradle and a center of a toe of the sole assembly.

16. The sole assembly of claim 15, wherein the lower plate has vertical protrusions that support walls of the heel cradle.

17. The sole assembly of claim 1, wherein the lower plate includes a cavity.

18. The sole assembly of claim 17, wherein the upper plate includes a cavity at least partially overlapping the cavity of the lower plate.

19. The sole assembly of claim 1, wherein a medial side of the lower plate is stiffer than a lateral side of the lower plate.

20. The sole assembly of claim 19, wherein a medial side of the upper plate is stiffer than a lateral side of the upper plate.

21. The sole assembly of claim 1, wherein the thickness of the upper plate varies from a portion of a medial side to a portion of a lateral side.

22. The sole assembly of claim 21, wherein the thickness of the lower plate varies from a portion of a medial side to a portion of a lateral side.

23. A shoe comprising:

an upper portion; and

a sole assembly including,

a heel cradle configured to cradle a heel of a human foot when the human foot is rested within the heel cradle;

an upper plate including a first part connected to the heel cradle and a second part located farther from the heel cradle than is the first part;

a lower plate including a first part which is connected to the first part of the upper plate and including a second part which is connected to the second part of the upper plate;

an oblong gap located between the upper plate and lower plate and between the first and second parts of the upper and lower plates shaped such that a gap dimension between the upper and lower plates in a first direction, measured from the first part of the upper plate to the second part of the upper plate, is greater than a gap dimension between the upper and lower plates in a second direction which is perpendicular to the first direction.

24. A sole assembly comprising:

an outsole located on a side of the sole assembly and configured to support the sole assembly;

a cushion material located next to the outsole,

means for cradling a heel of a human foot when the human foot is rested within the means for cradling; and

means for storing energy generated during walking connected to the means for cradling.

25. A sole assembly comprising:

an upper plate including a first part and a second part and having a first stiffness;

a lower plate having a second stiffness greater than the first stiffness and including a first part which is connected to the first part of the upper plate and including a second part which is connected to the second part of the upper plate,

an oblong gap located between the upper plate and lower plate and between the first and second parts of the upper and lower plates shaped such that a gap dimension between the upper and lower plates in a first direction, measured from the first part of the upper plate to the second part of the upper plate, is greater than a gap dimension between the upper and lower plates in a second direction which is perpendicular to the first direction.

26. The sole assembly of claim 25, wherein the upper plate and lower plate are comprised of different materials.

27. The sole assembly of claim 26, wherein the upper plate comprises TPU and the lower plate comprises carbon fiber.

28. The sole assembly of claim 26, wherein the upper plate comprises TPU and the lower plate comprises poly-paraphenylene terephthalamide.

29. The sole assembly of claim 26, wherein the upper plate has a greater thickness in the vertical direction than the lower plate.

30. The sole assembly of claim 29, wherein the thickness of the upper plate is 3 mm and the thickness of the lower plate is 1.5 mm.

31. The sole assembly of claim 26, wherein the lower plate includes an insert.

32. The sole assembly of claim 31, wherein the insert is disposed on a medial side of the lower plate and comprises a material having a different stiffness than material of the lower plate.

33. The sole assembly of claim 25, wherein the upper plate and lower plate include wings projecting toward a toe region of the sole assembly.

34. The sole assembly of claim 33, wherein a wing on a medial side of the upper and lower plates is longer than a wing on a lateral side.

35. The sole assembly of claim 25, wherein the lower plate includes a cavity.

36. The sole assembly of claim 35, wherein the upper plate includes a cavity at least partially overlapping the cavity of the lower plate.

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