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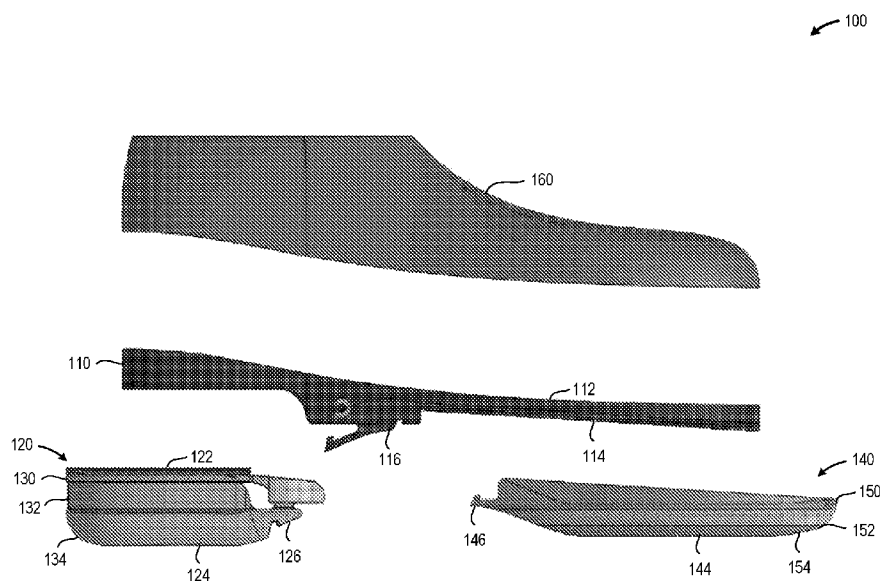


FIG. 1

(57) **Abstract:** The present disclosure is directed to systems and methods of forming a modular footwear sole. The modular sole includes a midsole layer having a first attachment fixture disposed on at least a portion of the lower surface of the midsole layer. A heel member includes a deformable heel layer that includes a plurality of deformable elements having the same or different mechanical properties. The heel member includes a second attachment fixture that couples to the first attachment fixture. An outsole member includes a deformable outsole layer that includes a plurality of deformable elements having the same or different mechanical properties. The outsole member includes a third attachment fixture that couples to the first attachment fixture. The deformable elements may be selected based on a user's foot pressure map.

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MODULAR FOOTWEAR SOLE SYSTEMS AND METHODS

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CROSS REFERENCE TO RELATED APPLICATION

The present application claims the benefit of U.S. Prov. Appln. Serial No. 63/107,875 filed 10-30-2020, the teachings of which are hereby incorporated by reference in its entirety.

TECHNICAL FIELD

The present disclosure relates to footwear, more specifically to footwear featuring replaceable sole portions.

BACKGROUND

Running shoes, today, have two major flaws. The first is their longevity; in particular, running shoes tend to both wear through the heel's tread as well as see significant decay in the performance of any shock absorption features in the heel. For these reasons, runners tend to change running shoes often (for instance every 200 miles). Note that an average good quality pair of running shoes ranges between \$150 and \$200. The second problem stems from the fact that running shoes are mass produced and, therefore, their performance – especially in terms of shock absorption – might not be ideal for a specific individual.

BRIEF DESCRIPTION OF THE DRAWINGS

Features and advantages of various embodiments of the claimed subject matter will become apparent as the following Detailed Description proceeds, and upon reference to the Drawings, wherein like numerals designate like parts, and in which:

FIG 1 depicts an exploded view of an illustrative footwear system that includes a flexible midsole member that includes a first attachment fixture to which a heel member and/or an outsole member may be coupled, in accordance with at least one embodiment described herein;

5 FIG 2 depicts an exploded perspective view of an illustrative modular sole, in accordance with at least one embodiment described herein;

FIG 3 depicts a number of perspective views of an illustrative modular sole, in accordance with at least one embodiment described herein;

10 FIG 4 depicts an illustrative system useful for selecting a deformable heel portion and a deformable outsole portion to provide a modular sole based on user biometric data, in accordance with at least one embodiment described herein;

FIG 5 depicts an illustrative system useful for selecting a deformable heel portion and a deformable outsole portion to provide a modular sole based on user biometric data, in accordance with at least one embodiment described herein;

15 FIG 6 depicts an illustrative system useful for selecting a deformable heel portion and a deformable outsole portion to provide a modular sole based on user biometric data, in accordance with at least one embodiment described herein;

FIG 7 depicts an illustrative system in which a modular sole that includes a deformable heel portion and a deformable outsole portion has been configured based on
20 user biometric data, such as a foot pressure map, in accordance with at least one embodiment described herein;

FIG 8 depicts an illustrative system useful for selecting a deformable heel portion and a deformable outsole portion to provide a modular sole based on user having a pronating fore-foot strike, in accordance with at least one embodiment described herein;

25 FIG 9 depicts an illustrative system useful for selecting a deformable heel portion and a deformable outsole portion to provide a modular sole 100 based on user having a supinating fore-foot strike, in accordance with at least one embodiment described herein;

FIG 10 depicts an illustrative system useful for selecting a deformable heel portion and a deformable outsole portion to provide a modular sole based on user having a pronating heel strike, in accordance with at least one embodiment described herein;

FIG 11 depicts an illustrative system useful for selecting a deformable heel portion and a deformable outsole portion to provide a modular sole based on user having a supinating heel strike, in accordance with at least one embodiment described herein;

FIG 12 depicts an illustrative system useful for selecting a deformable heel portion and a deformable outsole portion to provide a modular sole based on user having a pronating stance, in accordance with at least one embodiment described herein;

FIG 13 depicts an illustrative system useful for selecting a deformable heel portion and a deformable outsole portion to provide a modular sole based on user having a supinating stance, in accordance with at least one embodiment described herein;

FIG 14 depicts a high level flow diagram of an illustrative method of forming a modular sole, in accordance with at least one embodiment described herein; and

FIG 15 depicts a high level flow diagram of an illustrative method of forming footwear having a modular sole, in accordance with at least one embodiment described herein.

Although the following Detailed Description will proceed with reference being made to illustrative embodiments, many alternatives, modifications and variations thereof will be apparent to those skilled in the art.

DETAILED DESCRIPTION

The systems and methods described herein beneficially provide a footwear system that enables a wearer to selectively replace portions of the sole of the footwear. In particular, the footwear systems and methods described herein include a flexible midsole that includes an attachment fixture positioned on the lower surface of the flexible midsole. The attachment fixture permits the attachment of a heel to a first portion of the attachment fixture and an outsole to a second portion of the attachment fixture. The heel

features a layered construction that includes an upper heel portion and a lower heel portion separated by a deformable heel portion. Similarly, the outsole features a layered construction that includes an upper outsole portion and a lower outsole portion separated by a deformable outsole portion. The deformable portion of either or both the heel and
5 the outsole may incorporate a plurality of deformable elements to provide desired material properties and stiffness.

In some instances, the plurality of deformable elements may be selected such that each deformable element includes a similar physical configuration and is fabricated using one or more materials. Such construction may provide uniform material properties and
10 stiffness. By altering the physical configuration and/or the composition of the plurality of deformable elements, heels and/or outsoles may be manufactured having differing material properties with low, medium, or high stiffness.

In other instances, each of the plurality of deformable elements may be selected such that each deformable element has a specific physical configuration to provide a
15 specific stiffness and material properties. By tailoring each of the deformable elements to provide a specific material property and stiffness, the heel and/or outsole may be custom tailored to an individual's foot structure and stride.

A footwear apparatus is provided. The footwear apparatus includes: a flexible midsole member having an upper surface and a lower surface, the flexible midsole
20 member including a first attachment fixture disposed on the lower surface; a heel member having a second attachment fixture to engage at least a first portion of the first attachment fixture, the second attachment fixture to maintain the heel member proximate the lower surface of the flexible midsole member. The heel member may include: an upper heel portion; a lower heel portion; and a deformable heel portion disposed between the upper
25 portion and the lower portion. The footwear apparatus may also include: an outsole member having a third attachment fixture to engage at least a second portion of the first attachment fixture, the third attachment fixture to maintain the outsole member proximate the lower surface of the flexible midsole member. The outsole member may include: an

upper outsole portion; a lower outsole portion; and a deformable outsole portion disposed between the upper portion and the lower portion.

A footwear assembly method is provided. The method may include: forming a first attachment fixture on at least a portion of a lower surface of a flexible midsole member, coupling a heel member to a first portion of the lower surface of the flexible midsole member, the heel member having a second attachment fixture to engage at least a first portion of the first attachment fixture. The heel member may include: an upper heel portion, a lower heel portion, and a deformable heel portion disposed between the upper portion and the lower portion. The method may further include: coupling an outsole member to a second portion of the lower surface of the flexible midsole member, the outsole member having a third attachment fixture to engage at least a second portion of the first attachment fixture. The outsole member may include: an upper outsole portion; a lower outsole portion; and a deformable outsole portion disposed between the upper portion and the lower portion.

FIG 1 depicts an elevation, exploded view, of an illustrative footwear system 100 that includes a flexible midsole member 110 that includes a first attachment fixture 112 to which a heel member 120 and/or an outsole member 140 may be coupled, in accordance with at least one embodiment described herein. As depicted in FIG 1, an upper footwear portion 160 may be coupled to the flexible midsole member 110. The flexible midsole member 110 includes an upper surface 112 and lower surface 114. A first attachment fixture 116 may disposed, positioned, or otherwise incorporated into at least a portion of the lower surface 114 of the flexible midsole member 110.

The flexible midsole member 110 may be fabricated using one or more materials. For example, the forward portion of the flexible midsole member 110 (*i.e.*, the portion of the flexible midsole member 110 extending from in front of the first attachment fixture 116 to the toe portion of the flexible midsole member 110) may be fabricated using a first material having a first set of material properties and the rear portion of the flexible midsole member 110 (*i.e.*, the portion of the flexible midsole member 110 extending from behind the first attachment fixture 116 to the heel portion of the flexible midsole

member 110) may be fabricated using a second material having a second set of material properties at least some of which differ (*i.e.*, is greater than or less than) from the first set of material properties. In embodiments, the flexible midsole member 110 may have a uniform or non-uniform thickness. In embodiments, the first attachment fixture 116 may
5 be fabricated using a different material than the flexible midsole member 110.

The heel member 120 includes an upper surface 122, a lower surface 124, and a second attachment fixture 126. The second attachment fixture 126 may couple to a first portion of the first attachment fixture 116 on the lower surface of the flexible midsole member 110. In embodiments, when the heel member 120 couples to the flexible midsole
10 member 110, all or a portion of the upper surface 122 of the heel member 120 is disposed proximate at least a portion of the lower surface 114 of the flexible midsole member 110. The heel member 120 incorporates a layered construction that includes an upper heel portion 130 and a lower heel portion 134 separated by a deformable heel portion 132. In embodiments, the lower heel portion 134 may include any number or combination of
15 grooves, recesses, embossments, patterns, or similar to achieve a desired friction and/or traction between the heel member 120 and a surface that the heel member 120 contacts. For example, where footwear 100 includes an athletic or running shoe, the heel member 120 may include a pattern conducive to performing the athletic activity or running.

In embodiments, the second attachment fixture 126 permits the detachable
20 attachment of the heel member 120 to the flexible midsole member 110. Such an arrangement beneficially permits the replacement of the typically high-wear heel member 120 with a replacement heel member 120. In such embodiments, the second attachment fixture 126 may include any number and/or combination of physical clips, latches, hooks, threaded fasteners, barbed fasteners, chemical adhesives, thermally activated adhesives,
25 or similar useful for detachably attaching the heel member 120 to the flexible midsole member 110. In other embodiments, the second attachment fixture 126 permits the permanent attachment of the heel member 120 to the flexible midsole member 110 (*e.g.*, non-removeable without destruction of either or both the heel member 120 and/or the flexible midsole member 110). In such embodiments, the second attachment fixture may

include any number and/or combination of non-removeable fasteners, chemically activated adhesives, thermally activated adhesives, and similar.

The outsole member 140 includes an upper surface 142, a lower surface 144, and a third attachment fixture 146. The third attachment fixture 146 may couple to a second
5 portion of the first attachment fixture 116 on the lower surface of the flexible midsole member 110. In embodiments, when the outsole member 140 couples to the flexible midsole member 110, all or a portion of the upper surface 142 of the outsole member 140 is disposed proximate at least a portion of the lower surface 114 of the flexible midsole member 110. In embodiments, the outsole member 140 includes a layered construction
10 that includes at least an upper outsole portion 150 and a lower outsole portion 154 separated by a deformable outsole portion 152. In embodiments, the lower outsole portion 154 may include any number or combination of grooves, recesses, embossments, patterns, or similar to achieve a desired friction and/or traction between the outsole member 140 and a surface that the outsole member 140 contacts. For example, where
15 footwear 100 includes an athletic or running shoe, the outsole member 140 may include a pattern conducive to performing the athletic activity or running.

In embodiments, the third attachment fixture 146 permits the detachable attachment of the outsole member 140 to the flexible midsole member 110. Such an arrangement beneficially permits the replacement of the typically high-wear outsole
20 member 140 with a replacement outsole member 140. In such embodiments, the third attachment fixture 146 may include any number and/or combination of physical clips, latches, hooks, threaded fasteners, barbed fasteners, chemical adhesives, thermally activated adhesives, or similar useful for detachably attaching the outsole member 140 to the flexible midsole member 110. In other embodiments, the third attachment fixture 146
25 permits the permanent attachment of the outsole member 140 to the flexible midsole member 110 (*e.g.*, non-removeable without destruction of either or both the outsole member 140 and/or the flexible midsole member 110). In such embodiments, the third attachment fixture 146 may include any number and/or combination of non-removeable fasteners, chemically activated adhesives, thermally activated adhesives, and similar.

The upper footwear portion 160 may include any type of currently available and/or future developed footwear. Non-limiting examples of such footwear includes but is not limited to athletic footwear, business footwear, formal footwear, informal footwear, and/or casual footwear.

5 FIG 2 depicts an exploded perspective view of an illustrative modular sole 200, in accordance with at least one embodiment described herein. As depicted in FIG 2, one or more surface features 202 may be disposed, formed, or otherwise incorporated into the lower surface of a rear portion of the flexible midsole member 110. Similarly, one or more surface features 204 may be disposed, formed, or otherwise incorporated into the
10 lower surface of a front portion of the flexible midsole member 110. In embodiments, the one or more surface features 202 include a plurality of evenly or unevenly spaced ridges disposed, formed, or otherwise incorporated into the lower surface of the rear portion of the flexible midsole member 110. In other embodiments, the one or more surface features 202 may include any number and/or combination of geometric patterns such as circles,
15 ovals, triangles, polygons, and similar. In embodiments, the one or more surface features 204 include a plurality of evenly or unevenly spaced ridges disposed, formed, or otherwise incorporated into the lower surface of the front portion of the flexible midsole member 110. In other embodiments, the one or more surface features 204 may include any number and/or combination of geometric patterns such as circles, ovals, triangles,
20 polygons, and similar.

 In embodiments, one or more surface features 212 are disposed, formed, or otherwise incorporated into at least a portion of the upper surface 122 of the heel member 120. In such embodiments, the one or more surface features 212 are complimentary to the one or more surface features 202 formed into the lower surface of a rear portion of the
25 flexible midsole member 110. In at least some implementations, the one or more surface features 212 may be formed integral with the upper heel portion 130. In embodiments, the one or more surface features 212 include a plurality of evenly or unevenly spaced ridges disposed, formed, or otherwise incorporated into the upper surface of at least a portion of the upper heel portion 130. In other embodiments, the one or more surface

features 212 may include any number and/or combination of geometric patterns such as circles, ovals, triangles, polygons, and similar.

In embodiments, one or more surface features 214 are disposed, formed, or otherwise incorporated into at least a portion of the upper surface 142 of the outsole member 140. In such embodiments, the one or more surface features 214 are complimentary to the one or more surface features 204 formed into at least a portion of the lower surface of a front portion of the flexible midsole member 110. In at least some implementations, the one or more surface features 214 may be formed integral with the upper outsole portion 150. In embodiments, the one or more surface features 214 include a plurality of evenly or unevenly spaced ridges disposed, formed, or otherwise incorporated into the upper surface of at least a portion of the upper outsole portion 150. In other embodiments, the one or more surface features 214 may include any number and/or combination of geometric patterns such as circles, ovals, triangles, polygons, and similar.

FIG 3 depicts a number of perspective views of an illustrative modular sole 300, in accordance with at least one embodiment described herein. As depicted in FIG 3, the deformable heel portion 132 may include a plurality of deformable elements 302A-302n (collectively, “deformable elements 302”). Similarly, the outsole layer 152 may include a plurality of deformable elements 312A-312n (collectively, “deformable elements 312”).

In embodiments, the deformable elements 302 may include any number and/or combination of flexible members. The deformable elements 302 included in the deformable heel portion 132 may be arranged to form a regular or irregular pattern between the upper heel portion 130 and the lower heel portion 134. The deformable elements 302 may include deformable gas filled members, deformable spring members, deformable linear or non-linear spring-mass dampers, deformable elastomeric elements, or any combination thereof. In embodiments, the deformable elements 302 may each have the same or similar mechanical characteristics. In other embodiments, the deformable elements 302 may each have a different mechanical characteristics. In embodiments, the deformable elements 302 may have similar mechanical characteristics

and may be evenly distributed between the upper heel portion 130 and the lower heel portion 134.

In some implementations, the deformable elements 302 may be selected such that the heel member 120 may have a number of standard levels of stiffness and material properties. In some implementations, the deformable elements 302 may be selected based upon the forces exerted on the modular sole 300 by the foot of the wearer. For example, in locations having high compression (*e.g.*, where a user's heel strikes the heel member 120) a greater number of deformable elements 302 may be positioned compared to locations having lower compression (*e.g.*, about the periphery of the user's heel) where a lesser number of relatively softer deformable elements 302 may be positioned.

In embodiments, the deformable elements 312 may include any number and/or combination of flexible members. The deformable elements 312 included in the deformable outsole portion 152 may be arranged to form a regular or irregular pattern between the upper outsole portion 150 and the lower outsole portion 154. The deformable elements 312 may include deformable gas filled members, deformable spring members, deformable linear or non-linear spring-mass dampers, deformable elastomeric elements, or any combination thereof. In embodiments, the deformable elements 312 may each have the same or similar mechanical properties. In other embodiments, the deformable elements 312 may each have a different mechanical properties. In embodiments, the deformable elements 312 may have similar mechanical properties and may be evenly distributed between the upper outsole portion 130 and the lower outsole portion 134.

In some implementations, the deformable elements 312 may be selected such that the outsole member 140 may have a number of standard levels of stiffness and material properties. In some implementations, the deformable elements 312 may be selected based upon the forces exerted on the modular sole 300 by the foot of the wearer. For example, in locations having high compression (*e.g.*, in the area of the user's ball) a greater number of deformable elements 312 may be positioned compared to locations having lower compression (*e.g.*, in the area of the user's arch) where a lesser number of relatively softer deformable elements 312 may be positioned.

FIG 4 depicts an illustrative system 400 useful for selecting a deformable heel portion 132 and a deformable outsole portion 152 to provide a modular sole 100 based on user biometric data, in accordance with at least one embodiment described herein. As depicted in FIG 4, biometric data, such as a user's foot pressure map 402 may be used to select an appropriate number, stiffness, and/or pattern of the deformable elements 302 included in the deformable heel portion 132 and an appropriate number, stiffness, and/or pattern of the deformable elements 312 included in the deformable outsole portion 152. The three dimensional plot 410 includes a plot of stiffness 412 of each of the deformable elements 302 as a function of x-y location 414, 416 within the deformable heel portion 132 and within the deformable outsole portion 152.

FIG 5 depicts an illustrative system 500 useful for selecting a deformable heel portion 132 and a deformable outsole portion 152 to provide a modular sole 100 based on user biometric data, in accordance with at least one embodiment described herein. As depicted in FIG 5, the deformable elements 302 included in the deformable heel portion 132 and the deformable elements 312 included in the deformable outsole portion 152 may, in some implementations include a regularly spaced field (*e.g.*, regularly or evenly spaced deformable elements 302, 312 – the distance between the elements does not vary within a defined tolerance or positional deviation limit) of linear or non-linear resonators 502A-502n arranged in a matrix having a number of rows 510 and a number of columns 520. In other embodiments, the deformable elements 302 included in the deformable heel portion 132 and/or the deformable elements 312 included in the deformable outsole portion 152 may be arranged in an irregularly spaced field (*e.g.*, irregularly or unevenly spaced deformable elements 302, 312 – the distance between the elements varies). In embodiments, the linear or non-linear resonators 502A-502n may have the same or different mechanical properties (*e.g.*, damping) across the deformable heel portion 132. In embodiments, the linear or non-linear resonators 502A-502n may have the same or different mechanical properties (*e.g.*, damping) across the deformable outsole portion 152.

FIG 6 depicts an illustrative system 600 useful for selecting a deformable heel portion 132 and a deformable outsole portion 152 to provide a modular sole 100 based on user biometric data, in accordance with at least one embodiment described herein. As depicted in FIG 6, biometric data, such as a user's foot pressure map 602 may be used to select an appropriate number, stiffness, and/or pattern of the deformable elements 302 included in the deformable heel portion 132 and an appropriate number, stiffness, and/or pattern of the deformable elements 312 included in the deformable outsole portion 152. The three dimensional plot 610 includes a plot of stiffness 612 of each of the deformable elements 302 as a function of x-y location 614, 616 within the deformable heel portion 132 and within the deformable outsole portion 152.

FIG 7 depicts an illustrative system 700 in which a modular sole 100 that includes a deformable heel portion 132 and a deformable outsole portion 152 has been configured based on user biometric data, such as a foot pressure map 702, in accordance with at least one embodiment described herein. As depicted in FIG 7, biometric data, such as a user's foot pressure map 702 may be used to select an appropriate number, stiffness, and/or pattern of the deformable elements 302 included in the heel portion 120 affixed to the flexible midsole member 110 and an appropriate number, stiffness, material properties, and/or pattern of the deformable elements 312 included in the outsole portion 140 affixed to the flexible midsole member 110.

FIG 8 depicts an illustrative system 800 useful for selecting a deformable heel portion 132 and a deformable outsole portion 152 to provide a modular sole 100 based on user having a pronating fore-foot strike, in accordance with at least one embodiment described herein. As depicted in FIG 8, the foot pressure map 802 indicates the user strikes relatively harder on the inside portion of the ball of the foot and relatively lighter on the heel. Thus, based on the plot 810, a field of relatively stiffer deformable elements 312 are included where the user's foot strike occurs – the portion of the deformable outsole portion 152 along the user's big toe. As depicted in FIG 8, and evident in plot 810, a field of relatively softer deformable elements 302 are included in the deformable heel portion 132 of the heel member 120.

FIG 9 depicts an illustrative system 900 useful for selecting a deformable heel portion 132 and a deformable outsole portion 152 to provide a modular sole 100 based on user having a supinating fore-foot strike, in accordance with at least one embodiment described herein. As depicted in FIG 9, the foot pressure map 902 indicates the user strikes relatively harder on the outside portion of the ball of the foot 904 and relatively lighter on the heel. Thus, based on the plot 910, a field of relatively stiffer deformable elements 312 are included where the user's foot strike occurs – the portion of the deformable outsole portion 152 proximate the user's little toe 904. Also as depicted in FIG 9, and evident in plot 910, a field of relatively softer deformable elements 302 are included in the deformable heel portion 132 of the heel member 120.

FIG 10 depicts an illustrative system 1000 useful for selecting a deformable heel portion 132 and a deformable outsole portion 152 to provide a modular sole 100 based on user having a pronating heel strike, in accordance with at least one embodiment described herein. As depicted in FIG 10, the foot pressure map 1002 indicates the user strikes relatively harder on the heel and relatively lighter strike on the ball of the foot. Thus, based on the plot 1010, a field of relatively stiffer deformable elements 302 are included proximate the location 1004 where the user's heel strike occurs – the portion of the deformable heel portion 132 proximate the user's heel 1004. Also as depicted in FIG 10, and evident in plot 1010, a field of relatively softer deformable elements 312 are included in the deformable outsole portion 152 of the outsole member 140.

FIG 11 depicts an illustrative system 1100 useful for selecting a deformable heel portion 132 and a deformable outsole portion 152 to provide a modular sole 100 based on user having a supinating heel strike, in accordance with at least one embodiment described herein. As depicted in FIG 11, the foot pressure map 1102 indicates the user strikes relatively harder at a location 1104 on the heel and relatively lighter strike on the ball of the foot. Thus, based on the plot 1110, a field of relatively stiffer deformable elements 302 are included proximate the location 1104 where the user's heel strike occurs – the portion of the deformable heel portion 132 proximate the user's heel 1104. Also as depicted in FIG 11, and evident in plot 1110, a field of relatively softer

deformable elements 312 are included in the deformable outsole portion 152 of the outsole member 140.

FIG 12 depicts an illustrative system 1200 useful for selecting a deformable heel portion 132 and a deformable outsole portion 152 to provide a modular sole 100 based on user having a pronating stance, in accordance with at least one embodiment described herein. As depicted in FIG 12, the foot pressure map 1202 indicates that, when standing, the user places relatively greater pressure at a first location 1204 on the inside portion of the ball of the foot and a second location 1206 on the heel. Thus, based on the plot 1210, a field of relatively stiffer deformable elements 302 are included proximate the location 1206 where pressure is placed on the user's heel and a field of relatively stiffer deformable elements 312 are included proximate the location 1204 where pressure is placed on the ball of the user's foot. Also as depicted in FIG 12, and evident in plot 1210, a field of relatively softer deformable elements 302 are included in the areas of the deformable heel portion 132 and a field of relatively softer deformable elements 312 are included in the areas of the deformable outsole portion 152 where the user's foot exerts a relatively lower pressure when standing.

FIG 13 depicts an illustrative system 1300 useful for selecting a deformable heel portion 132 and a deformable outsole portion 152 to provide a modular sole 100 based on user having a supinating stance, in accordance with at least one embodiment described herein. As depicted in FIG 13, the foot pressure map 1302 indicates that, when standing, the user places relatively greater pressure at a first location 1304 on the outside portion of the ball of the foot and a second location 1306 on the heel. Thus, based on the plot 1310, a field of relatively stiffer deformable elements 302 are included proximate the location 1306 where pressure is placed on the user's heel and a field of relatively stiffer deformable elements 312 are included proximate the location 1304 where pressure is placed on the ball of the user's foot. Also as depicted in FIG 13, and evident in plot 1310, a field of relatively softer deformable elements 302 are included in the areas of the deformable heel portion 132 and a field of relatively softer deformable elements 312 are

included in the areas of the deformable outsole portion 152 where the user's foot exerts a relatively lower pressure when standing.

FIG 14 depicts a high level flow diagram of an illustrative method 1400 of forming a modular sole, in accordance with at least one embodiment described herein.

5 The modular sole includes a flexible midsole layer 110 having a first attachment fixture 116, a heel member 120 having a second attachment fixture 126 that couples to at least a portion of the first attachment fixture 116, and an outsole member 140 having a third attachment fixture 146 that couples to at least a portion of the first attachment fixture 116. The method 1400 commences at 1402.

10 At 1404, the first attachment fixture 116 is formed in, on, about, or across at least a portion of the lower surface 114 of the flexible midsole layer 110. In embodiments, the first attachment fixture 116 includes a first attachment portion to which the heel member 120 may be permanently affixed and/or detachably attached. In embodiments, the first attachment fixture 116 may include a second attachment portion to which the outsole
15 member 140 may be permanently affixed and/or detachably attached.

At 1406, a second attachment fixture 126 on the heel member 120 couples to at least a portion of the first attachment fixture 116. After coupling to the first attachment fixture 116, the heel member 120 is disposed proximate at least a portion of the lower surface 114 of the flexible midsole layer 110. In embodiments, one or more surface
20 features 212 disposed, formed, incorporated, or otherwise attached to at least a portion of the upper surface 122 of the heel member 120 may engage one or more complimentary surface features 202 disposed, formed, incorporated, or otherwise attached to at least a portion of the lower surface 114 of the flexible midsole layer 110. In embodiments, the heel member 120 is permanently affixed to the flexible midsole layer 110. In other
25 embodiments, the heel member 120 is detachably attached to the flexible midsole layer 110.

At 1408, a third attachment fixture 146 on the outsole member 140 couples to at least a portion of the first attachment fixture 116. After coupling to the first attachment fixture 116, the outsole member 140 is disposed proximate at least a portion of the lower

surface 114 of the flexible midsole layer 110. In embodiments, one or more surface features 214 disposed, formed, incorporated, or otherwise attached to at least a portion of the upper surface 142 of the outsole member 140 may engage one or more complimentary surface features 204 disposed, formed, incorporated, or otherwise
5 attached to at least a portion of the lower surface 114 of the flexible midsole layer 110. In embodiments, the outsole member 140 is permanently affixed to the flexible midsole layer 110. In other embodiments, the outsole member 140 is detachably attached to the flexible midsole layer 110. The method 1400 concludes at 1410.

FIG 15 depicts a high level flow diagram of an illustrative method 1500 of
10 forming footwear having a modular sole, in accordance with at least one embodiment described herein. A footwear upper 160 may be affixed or otherwise permanently or detachably attached to at least a portion of the upper surface 112 of the flexible midsole layer 110. In embodiments, the detachable attachment of the footwear upper 160 to the flexible midsole layer 110 beneficially permits changing the type, style, color, or
15 decoration of the footwear upper 160 to accommodate the user's needs or wishes. For example, to participate in an athletic event, a user may detachably attach an athletic shoe upper 160 to the flexible midsole layer 110 and to attend a formal event, the user may detach the athletic shoe upper 160 from the flexible midsole layer 110 and attach a formal shoe upper to the flexible midsole layer 110. The method 1500 commences at 1502.

20 At 1504, a footwear upper 160 is permanently or detachably attached to at least a portion of the upper surface 112 of the flexible midsole layer 110. In embodiments, the footwear upper 160 may be permanently affixed via stitching, fasteners, thermally activated adhesives, chemically activated adhesives, or any combination thereof. In embodiments, the footwear upper 160 may be detachably attached to the flexible midsole
25 layer 110 using removable fasteners, latches, or similar removable attachment devices. The method 1500 concludes at 1506.

As used in this application and in the claims, a list of items joined by the term "and/or" can mean any combination of the listed items. For example, the phrase "A, B and/or C" can mean A; B; C; A and B; A and C; B and C; or A, B and C. As used in this

application and in the claims, a list of items joined by the term “at least one of” can mean any combination of the listed terms. For example, the phrases “at least one of A, B or C” can mean A; B; C; A and B; A and C; B and C; or A, B and C.

Thus, the present disclosure is directed to systems and methods of forming a modular footwear sole. The modular sole includes a flexible midsole layer having a first attachment fixture disposed on at least a portion of the lower surface of the flexible midsole layer. A heel member includes a deformable heel layer that includes a plurality of deformable elements having the same or different mechanical properties. The heel member includes a second attachment fixture that couples to the first attachment fixture. An outsole member includes a deformable outsole layer that includes a plurality of deformable elements having the same or different mechanical properties. The outsole member includes a third attachment fixture that couples to the first attachment fixture. The deformable elements may be selected based on a user’s foot pressure map.

The terms and expressions which have been employed herein are used as terms of description and not of limitation, and there is no intention, in the use of such terms and expressions, of excluding any equivalents of the features shown and described (or portions thereof), and it is recognized that various modifications are possible within the scope of the claims. Accordingly, the claims are intended to cover all such equivalents. Various features, aspects, and embodiments have been described herein. The features, aspects, and embodiments are susceptible to combination with one another as well as to variation and modification, as will be understood by those having skill in the art. The present disclosure should, therefore, be considered to encompass such combinations, variations, and modifications.

Reference throughout this specification to “one embodiment” or “an embodiment” means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment. Thus, appearances of the phrases “in one embodiment” or “in an embodiment” in various places throughout this specification are not necessarily all referring to the same embodiment. Furthermore, the

particular features, structures, or characteristics may be combined in any suitable manner in one or more embodiments.

WHAT IS CLAIMED:

1. A footwear apparatus, comprising:

a midsole member having an upper surface and a lower surface, the midsole member including a first attachment fixture disposed on the lower surface;

5 a heel member having a second attachment fixture to engage at least a first portion of the first attachment fixture, the second attachment fixture to maintain the heel member proximate the lower surface of the midsole member;

wherein the heel member includes:

an upper heel portion;

10 a lower heel portion; and

a deformable heel portion disposed between the upper portion and the lower portion;

an outsole member having a third attachment fixture to engage at least a second portion of the first attachment fixture, the third attachment fixture to maintain the outsole member proximate the lower surface of the midsole member;

wherein the outsole member includes:

an upper outsole portion;

a lower outsole portion; and

20 a deformable outsole portion disposed between the upper portion and the lower portion.

2. The footwear apparatus of claim 1, further comprising:

an upper portion couplable to the upper surface of the midsole member.

25 3. The footwear apparatus of claim 1 wherein the deformable heel portion comprises a plurality of deformable elements.

4. The footwear apparatus of claim 3 wherein the plurality of deformable elements comprise a plurality of linear or non-linear spring-mass dampers.

5. The footwear apparatus of claim 3 wherein the plurality of deformable elements comprise a plurality of deformable elements, each of the plurality of deformable elements formed using a material having the same mechanical properties.

5

6. The footwear apparatus of claim 3 wherein the plurality of deformable elements comprise a plurality of deformable elements, at least two of the plurality of deformable elements formed using materials having different mechanical properties.

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7. The footwear apparatus of claim 1 wherein the second attachment fixture permits the detachable attachment of the heel member to the lower surface of the midsole member.

15

8. The footwear apparatus of claim 1:
wherein the upper surface of the heel member includes a plurality of surface features; and

wherein the lower surface of the midsole member includes a plurality of surface features complimentary to the surface features on upper surface of the heel member.

20

9. The footwear apparatus of claim 1 wherein the deformable outsole portion comprises a plurality of deformable elements.

25

10. The footwear apparatus of claim 9 wherein the plurality of deformable elements comprise a plurality of linear and non-linear spring-mass dampers.

25

11. The footwear apparatus of claim 9 wherein the plurality of deformable elements comprise a plurality of deformable elements, each of the plurality of deformable elements formed using a material having the same mechanical properties.

12. The footwear apparatus of claim 9 wherein the plurality of deformable elements comprise a plurality of deformable elements, at least two of the plurality of deformable elements formed using materials having different mechanical properties.

5 13. The footwear apparatus of claim 1 wherein the third attachment fixture permits the detachable attachment of the outsole member to the lower surface of the midsole member.

10 14. The footwear apparatus of claim 1:
wherein the upper surface of the outsole member includes a plurality of surface features; and
wherein the lower surface of the midsole member includes a plurality of surface features complimentary to the surface features on upper surface of the outsole member.

15 15. A method of forming a footwear sole, the method comprising:
forming a first attachment fixture on at least a portion of a lower surface of a midsole member;
coupling a heel member to a first portion of the lower surface of the midsole member, the heel member having a second attachment fixture to engage at least a first
20 portion of the first attachment fixture;

wherein the heel member includes:
an upper heel portion;
a lower heel portion; and
a deformable heel portion disposed between the upper portion and the
25 lower portion;

coupling an outsole member to a second portion of the lower surface of the midsole member, the outsole member having a third attachment fixture to engage at least a second portion of the first attachment fixture;

wherein the outsole member includes:

an upper outsole portion;
a lower outsole portion; and
a deformable outsole portion disposed between the upper portion and the lower portion.

5

16. The method of claim 15, further comprising:
coupling an upper shoe portion to at least a portion of an upper surface of the midsole member.

10

17. The method of claim 15 wherein coupling the heel member to the first portion of the lower surface of the midsole member further comprises:
coupling the heel member to the first portion of the lower surface of the midsole member, wherein the deformable heel portion comprises a plurality of deformable elements.

15

18. The method of claim 15 wherein coupling the heel member to the first portion of the lower surface of the flexible midsole member, wherein the deformable heel portion includes the plurality of deformable elements further comprises:
coupling the heel member to the first portion of the lower surface of the midsole member, wherein the plurality of deformable elements comprise a plurality of linear or non-linear spring-mass dampers.

20

19. The method of claim 15 wherein coupling the heel member to the first portion of the lower surface of the midsole member, wherein the deformable heel portion includes the plurality of deformable elements further comprises:

25

coupling the heel member to the first portion of the lower surface of the flexible midsole member, wherein the plurality of deformable elements comprise a plurality of deformable elements, each of the plurality of deformable elements formed using a material having the same mechanical properties.

20. The method of claim 15 wherein coupling the heel member to the first portion of the lower surface of the midsole member, wherein the deformable heel portion includes the plurality of deformable elements further comprises:

5 coupling the heel member to the first portion of the lower surface of the flexible midsole member, wherein the plurality of deformable elements comprise a plurality of deformable elements, at least two of the plurality of deformable elements formed using materials having a different mechanical properties.

10 21. The method of claim 15 wherein coupling the heel member to the first portion of the lower surface of the flexible midsole member further comprises:

detachably attaching the heel member to the lower surface of the flexible midsole member via the second attachment fixture.

15 22. The method of claim 15 wherein coupling the heel member to the first portion of the lower surface of the midsole member further comprises:

engaging a plurality of surface features disposed across at least a portion of the upper surface the heel member with a corresponding plurality of surface features disposed across at least a portion of the first portion of the lower surface of the midsole member.

20 23. The method of claim 15 wherein coupling the outsole member to the second portion of the lower surface of the midsole member further comprises:

coupling the outsole member to the second portion of the lower surface of the flexible midsole member, wherein the deformable outsole portion comprises a plurality of deformable elements.

24. The method of claim 23 wherein coupling the outsole member to the second portion of the lower surface of the midsole member further comprises:

coupling the outsole member to the second portion of the lower surface of the flexible midsole member, wherein the plurality of deformable elements comprise a plurality of linear or non-linear spring-mass dampers.

5 25. The method of claim 23 wherein coupling the outsole member to the second portion of the lower surface of the midsole member further comprises:

 coupling the outsole member to the second portion of the lower surface of the midsole member, wherein the plurality of deformable elements comprise a plurality of deformable elements, each of the plurality of deformable elements formed using a
10 material having the same mechanical properties.

 26. The method of claim 23 wherein coupling the outsole member to the second portion of the lower surface of the midsole member further comprises:

 coupling the outsole member to the second portion of the lower surface of the
15 midsole member, wherein the plurality of deformable elements comprise a plurality of deformable elements, at least two of the plurality of deformable elements formed using materials having different mechanical properties.

 27. The method of claim 15 wherein coupling the outsole member to the
20 second portion of the lower surface of the midsole member further comprises:

 detachably attaching the outsole member to the second portion of the lower surface of the midsole member via the third attachment fixture.

 28. The method of claim 15 wherein coupling the outsole member to the
25 second portion of the lower surface of the midsole member further comprises:

 engaging a plurality of surface features disposed across at least a portion of the upper surface the outsole member with a corresponding plurality of surface features disposed across at least a portion of the second portion of the lower surface of the midsole member.

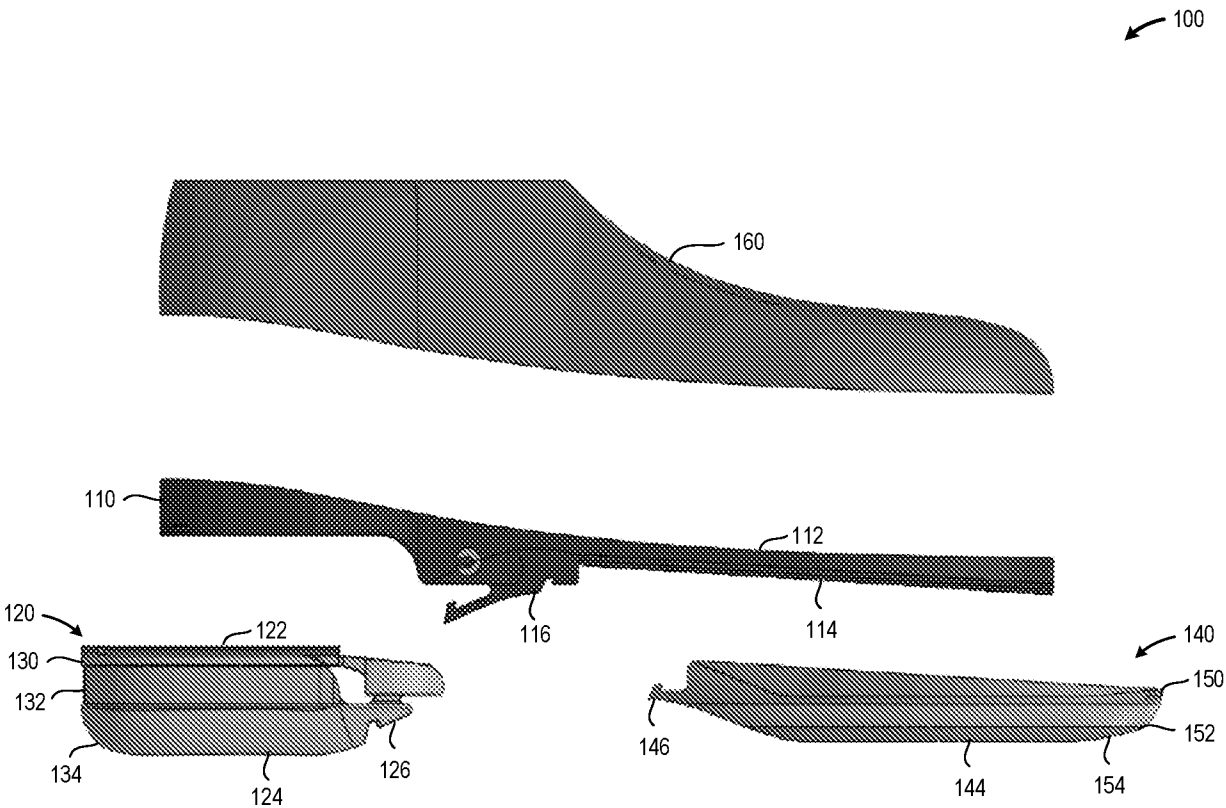


FIG. 1

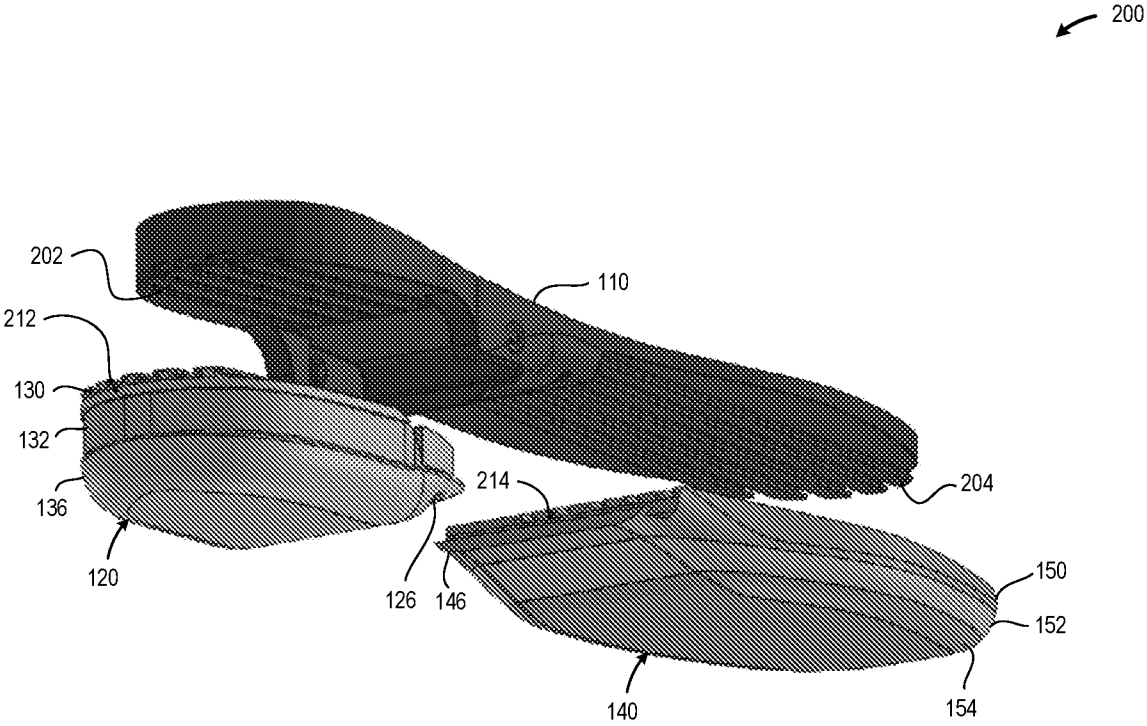


FIG. 2

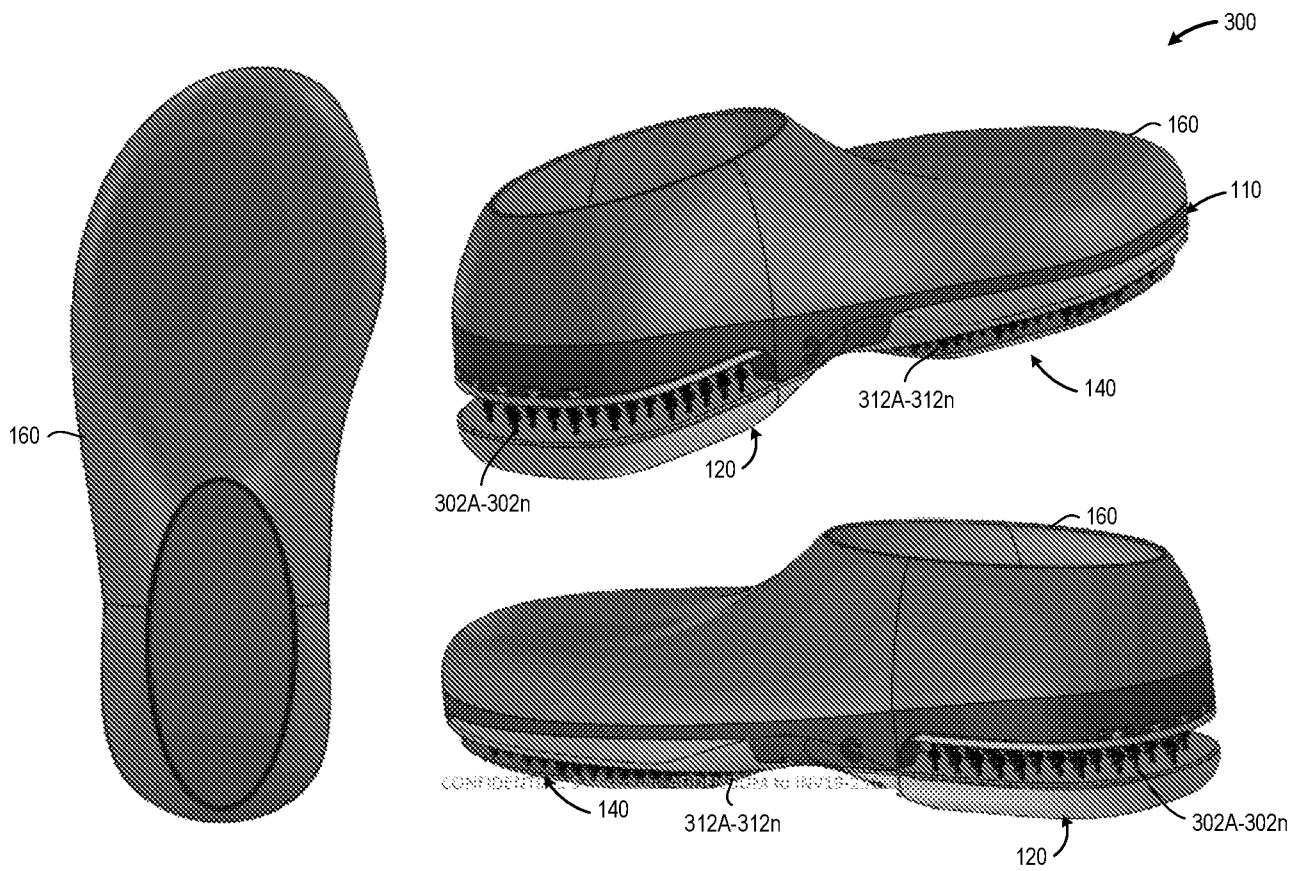


FIG. 3

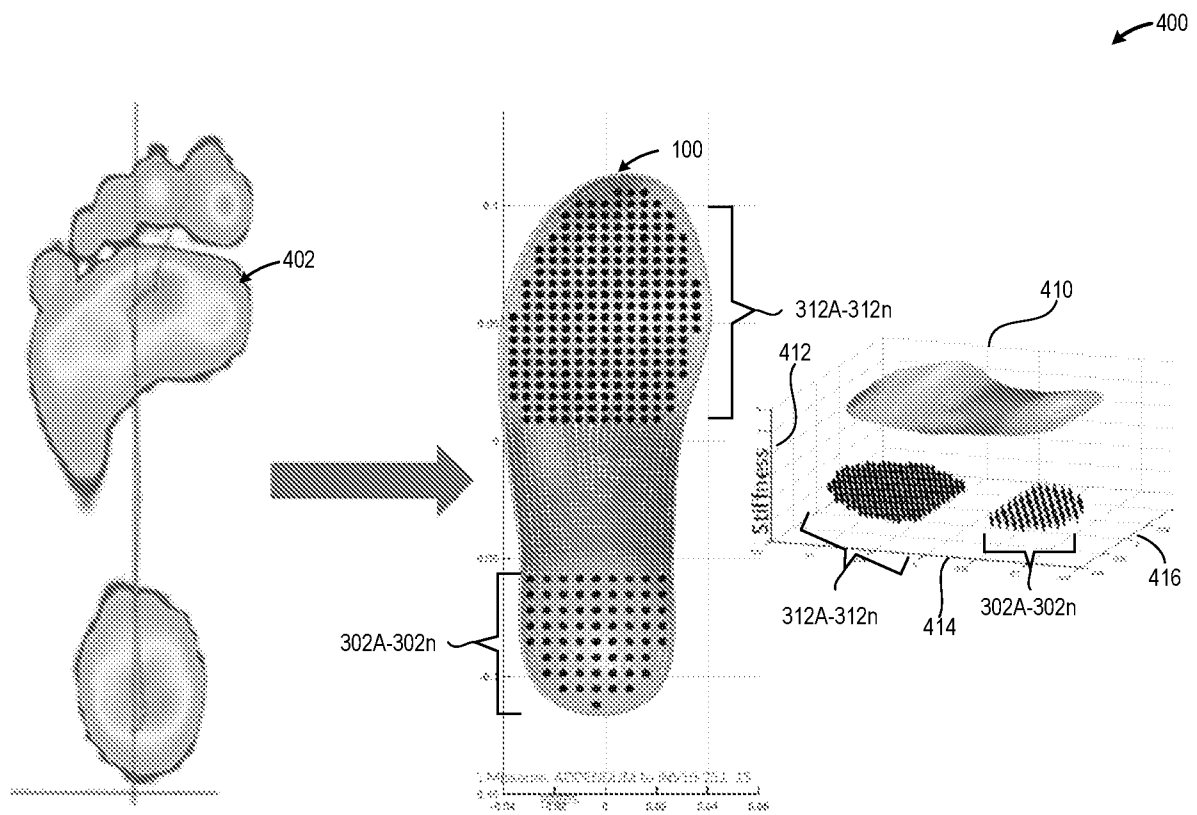


FIG. 4

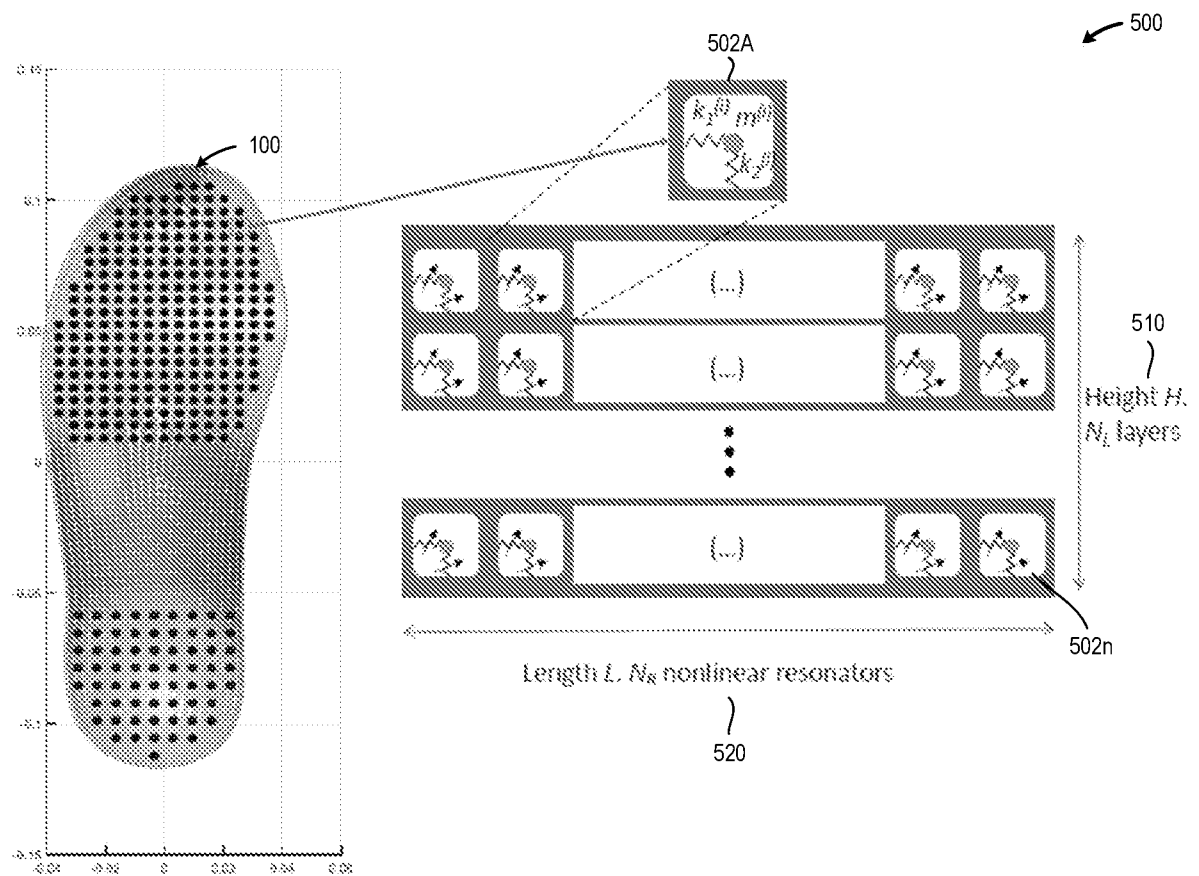


FIG. 5

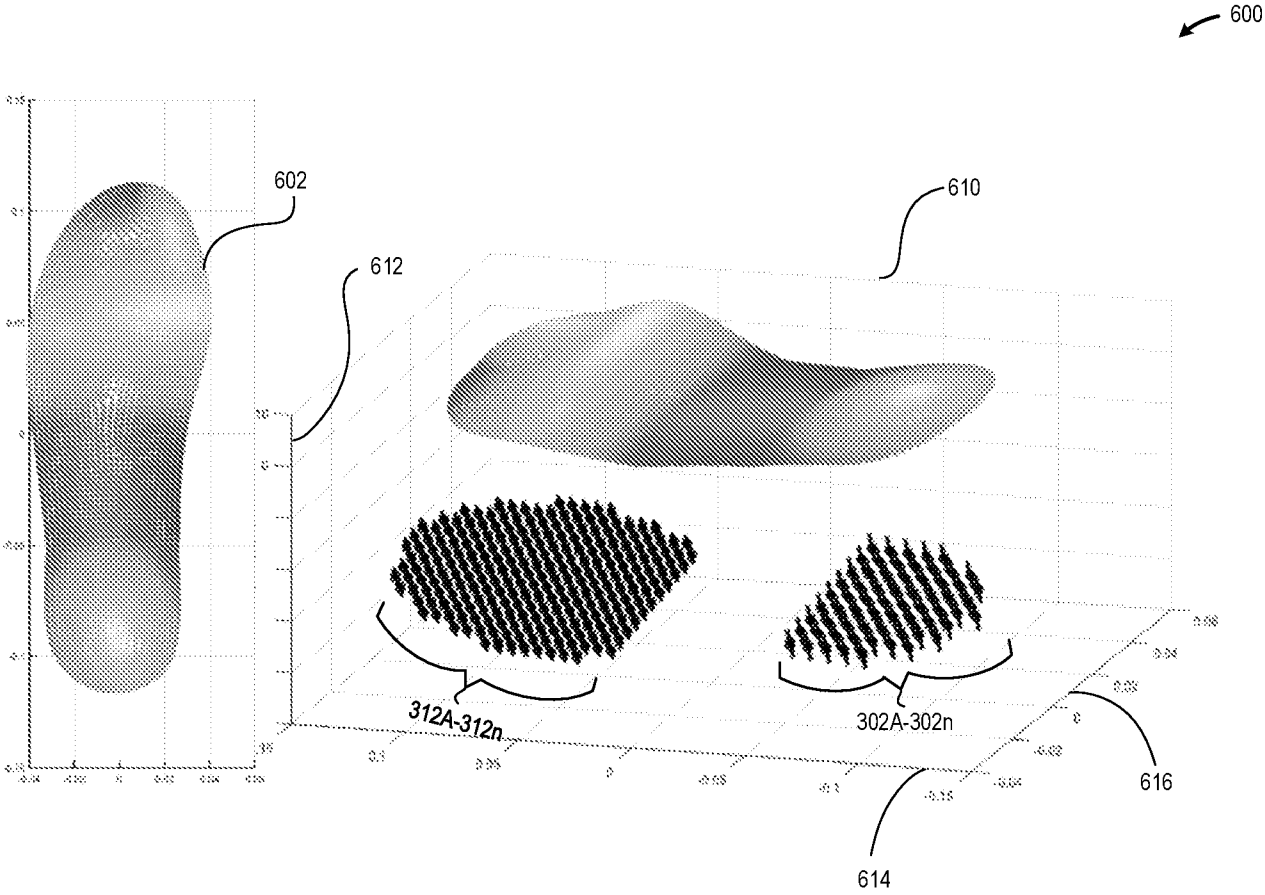


FIG. 6

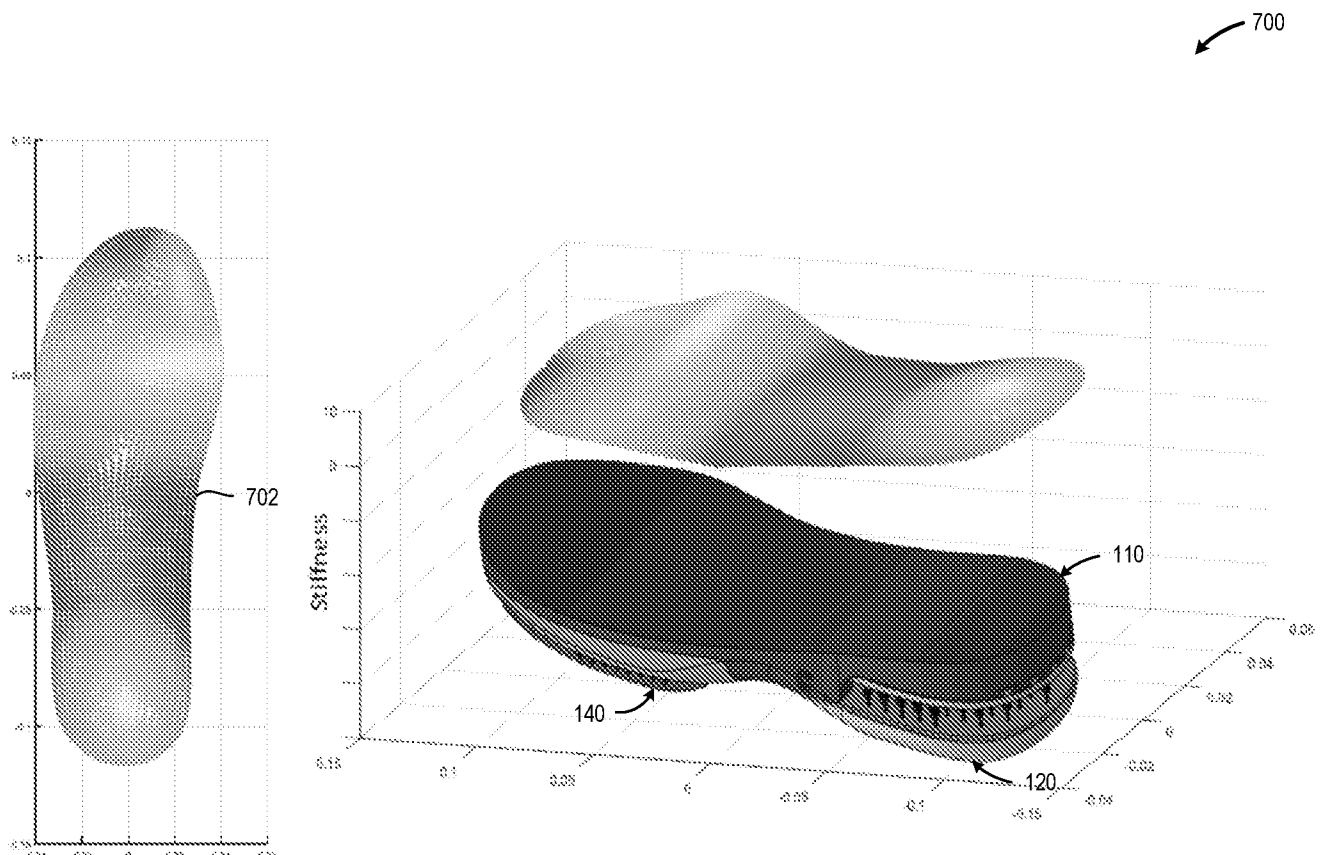


FIG. 7

800

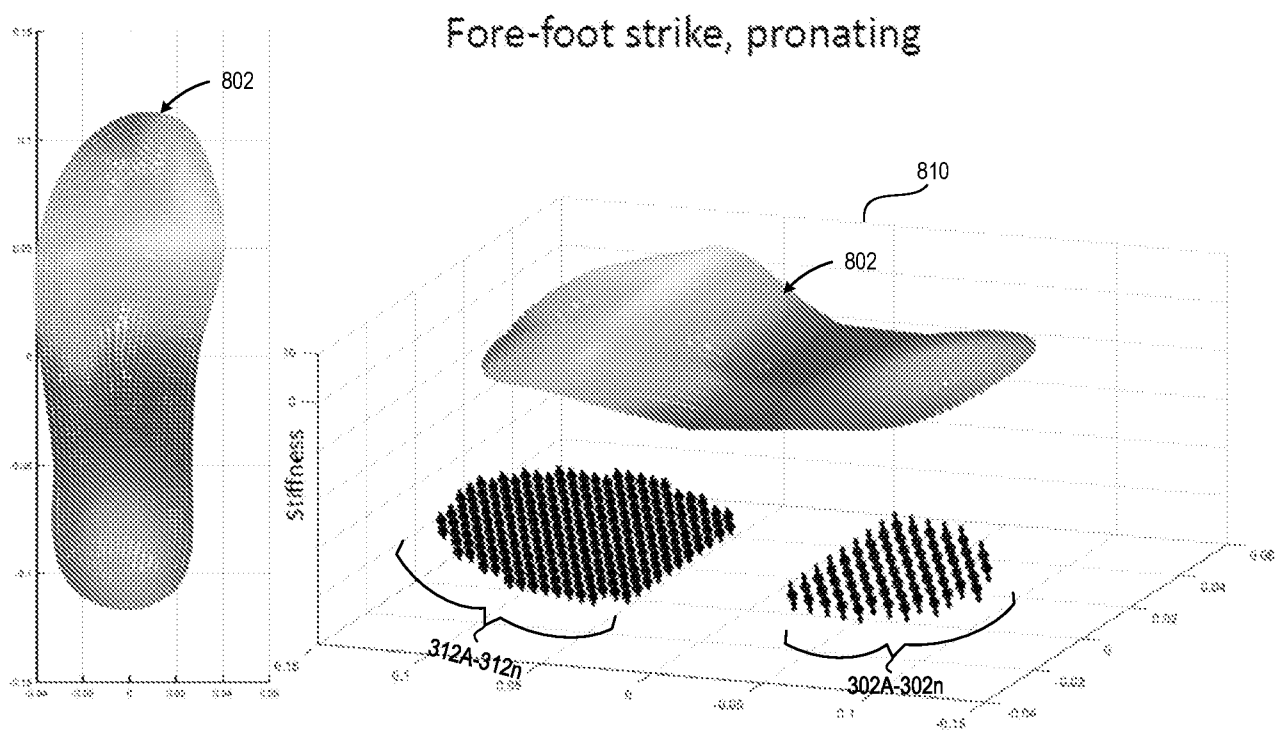


FIG. 8

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900

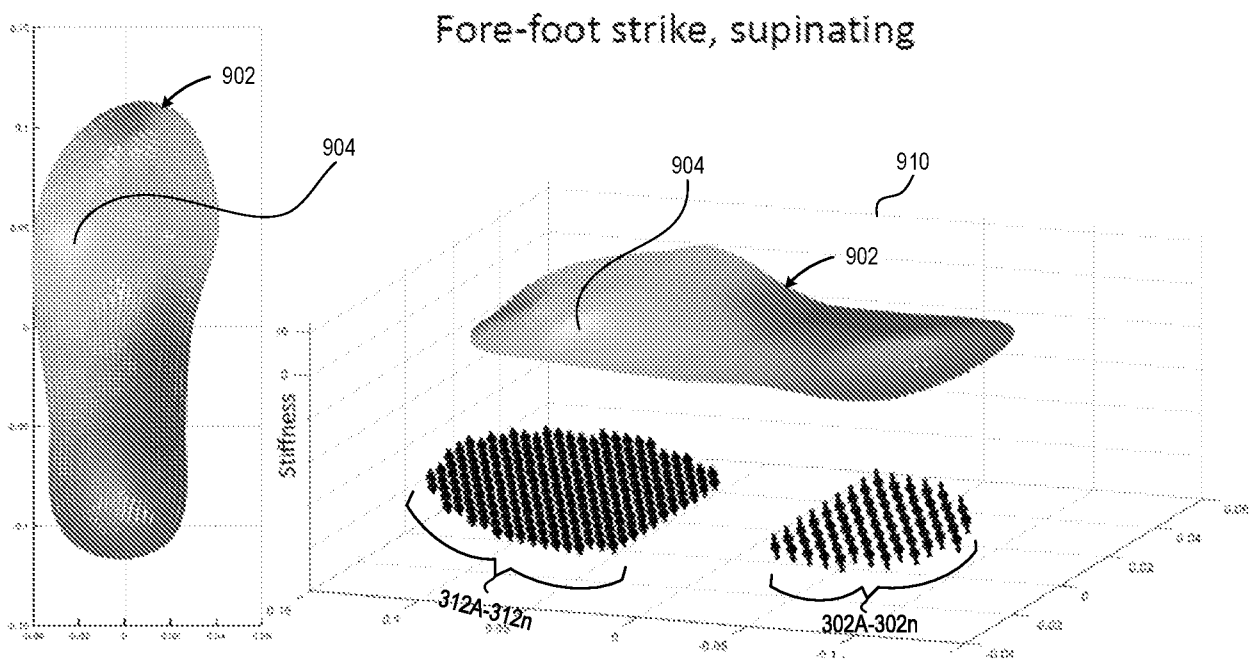


FIG. 9

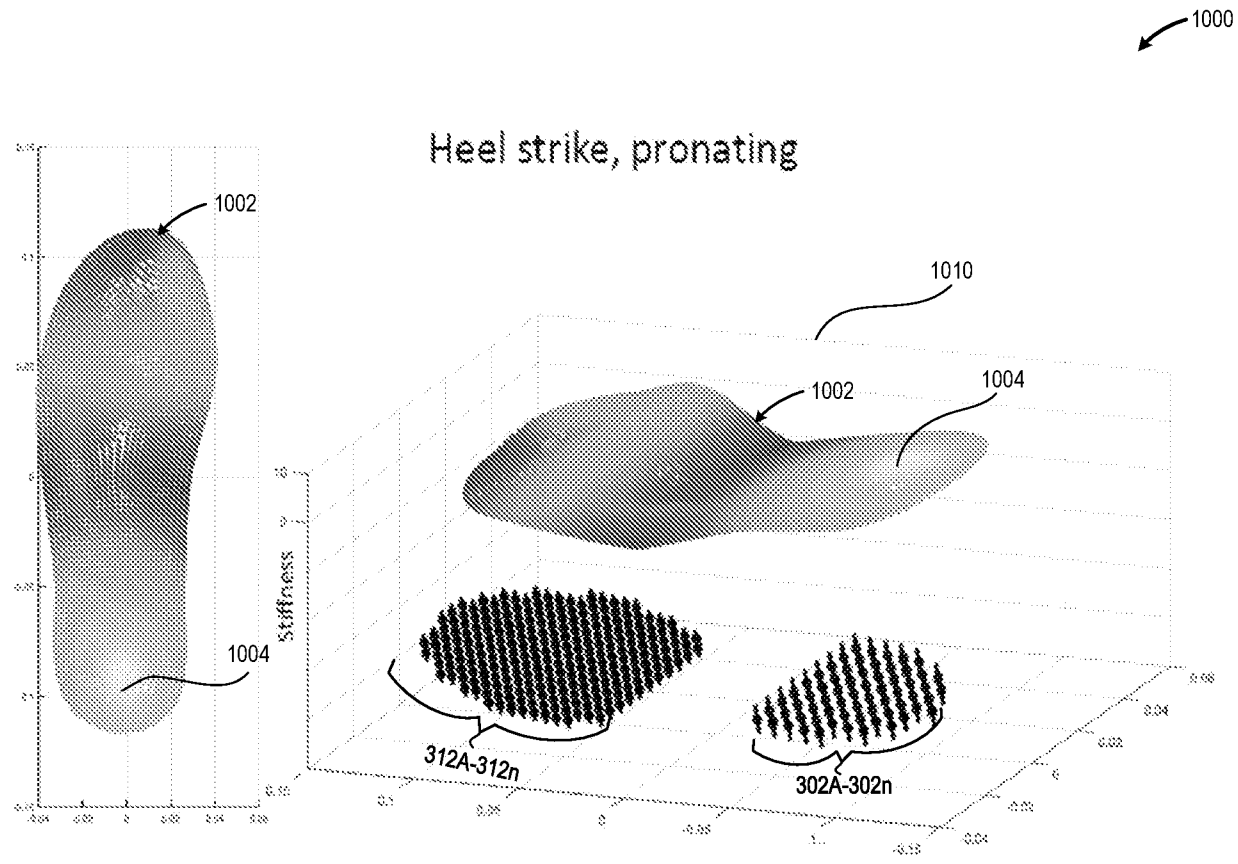


FIG. 10

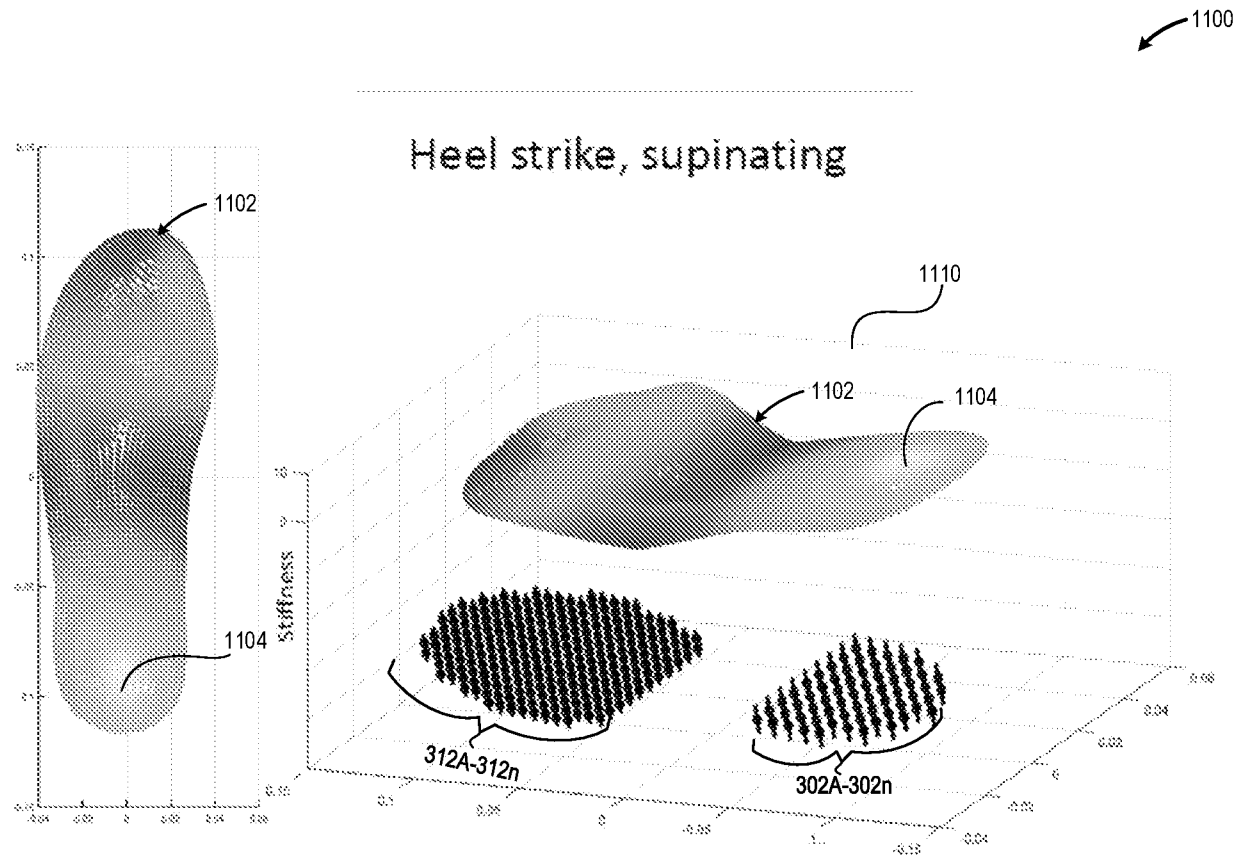


FIG. 11

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1200

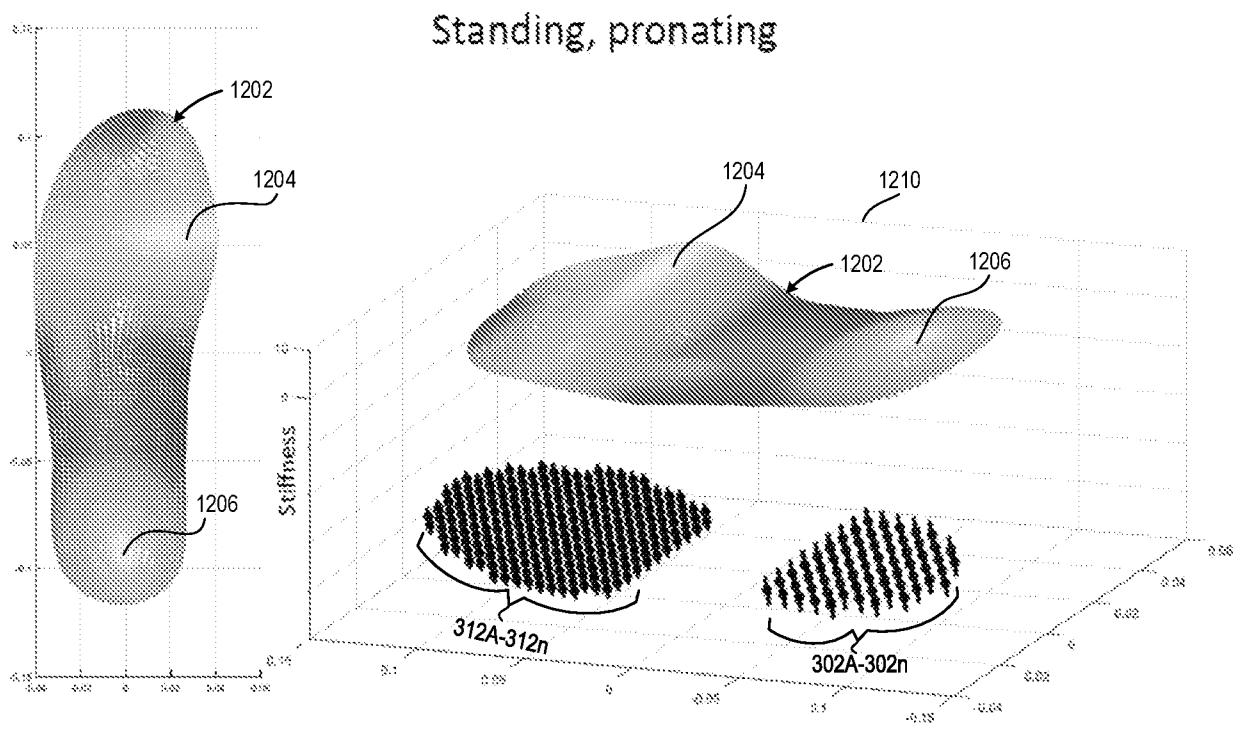


FIG. 12

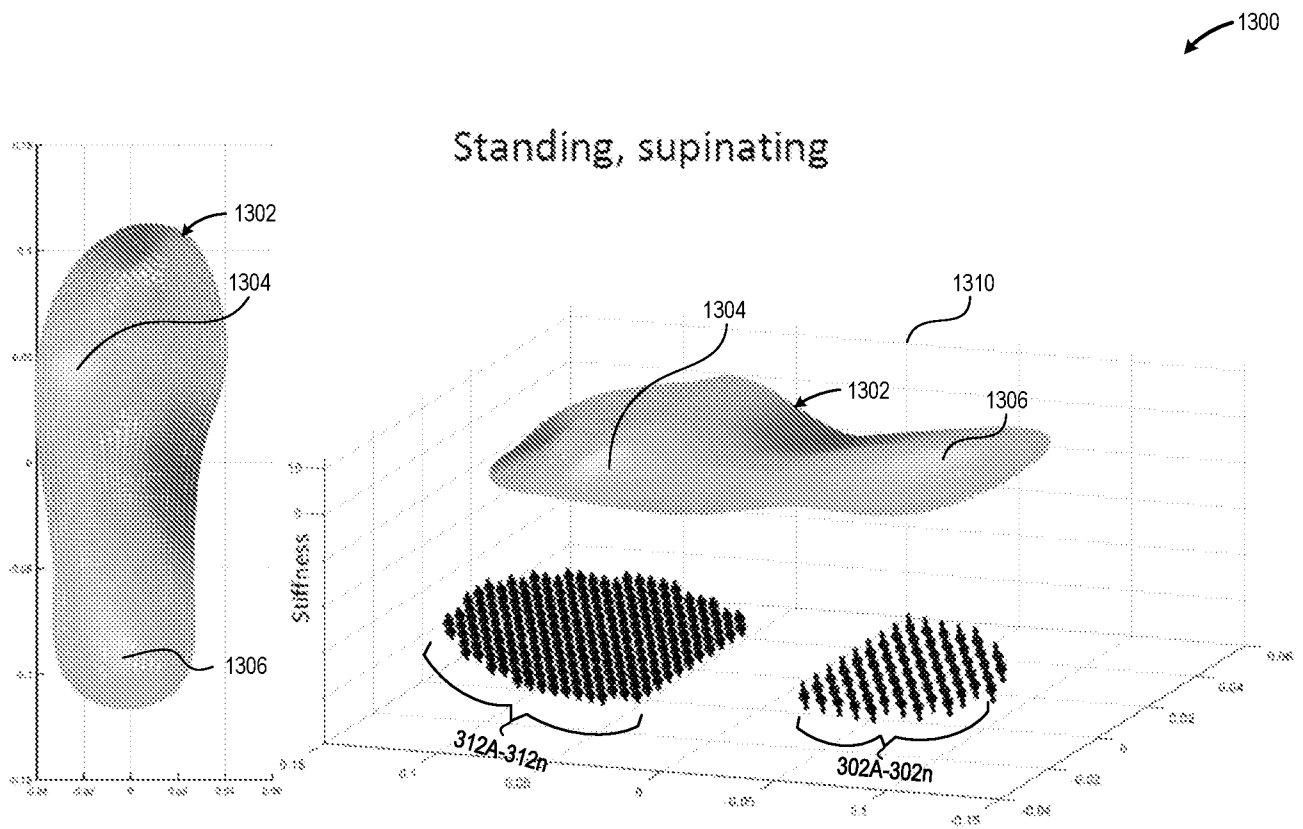


FIG. 13

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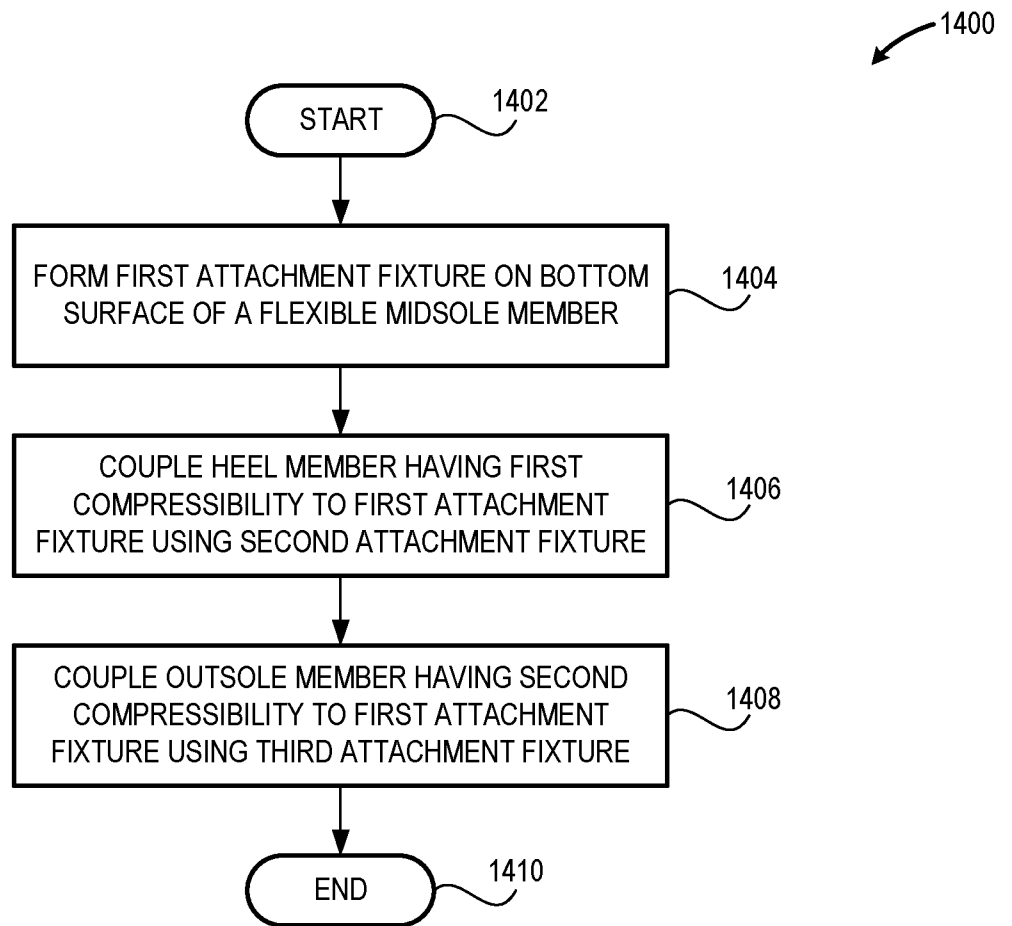


FIG. 14

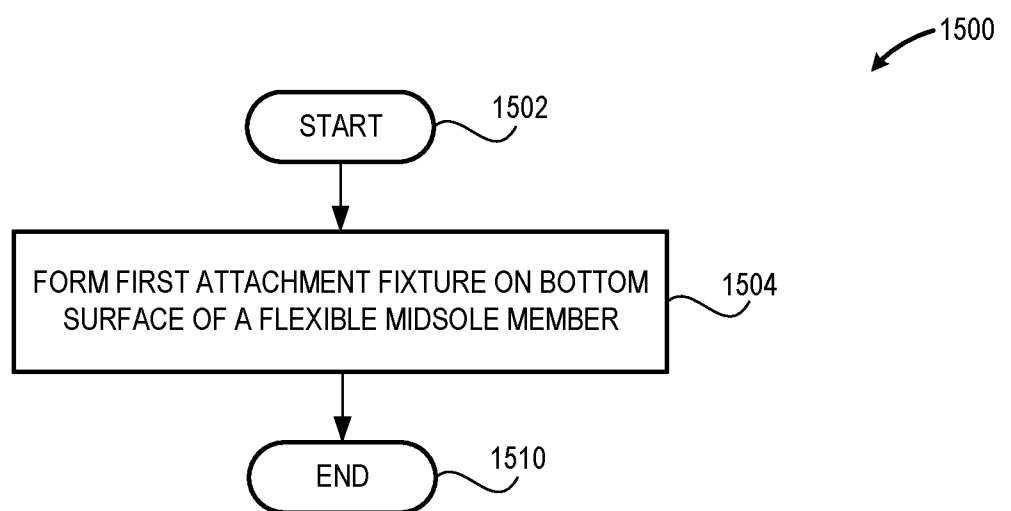


FIG. 15

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2021/057438

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - A43B 13/36; A43B 3/24; A43B 13/12; A43B 13/14; A43B 13/18; A43B 13/22 (2021.01)

CPC - A43B 13/36; A43B 3/244; A43B 3/246; A43B 13/125; A43B 13/14; A43B 13/18; A43B 13/183; A43B 13/223; A43B 13/26; A43B 13/28; A43C 13/02 (2021.08)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

see Search History document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

see Search History document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

see Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2006/0021260 A1 (KIM) 02 February 2006 (02.02.2006) entire document	1-3, 5, 7-9, 11, 13-17, 19, 21-23, 25, 27, 28
Y	US 2013/0074364 A1 (LIM) 28 March 2013 (28.03.2013) entire document	1-3, 5, 7-9, 11, 13-17, 19, 21-23, 25, 27, 28
A	US 2011/0232127 A1 (CHANEY et al) 29 September 2011 (29.09.2011) entire document	1-28
A	US 2,640,283 A (JOSES) 02 June 1953 (02.06.1953) entire document	1-28
A	US 6,389,712 B1 (SCHELLING) 21 May 2002 (21.05.2002) entire document	1-28

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

* Special categories of cited documents:

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search

29 December 2021

Date of mailing of the international search report

FEB 01 2022

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