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(54) **OUTSOLE LUGS ALIGNED WITH METATARSAL BONES**

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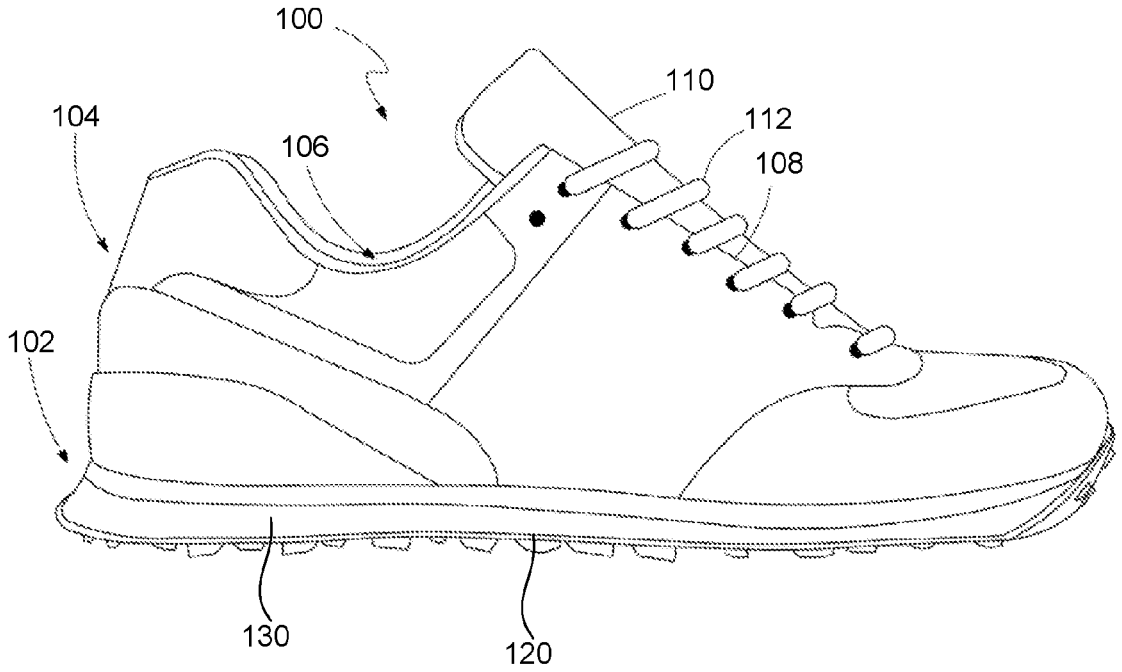
(57) **ABSTRACT**

A running shoe includes an upper, a foot cavity defined in part by the upper and having a foot cavity length starting at a rearmost heel surface and ending at a frontmost toe surface of the foot cavity. The running shoe further includes an outsole including one or more metatarsal lugs, and a midsole. The metatarsal lug is disposed on the outsole under a corresponding metatarsal bone of a user when the user is wearing the running shoe and has a center disposed at a center point corresponding to a location between 65% and 67% of the foot cavity length.



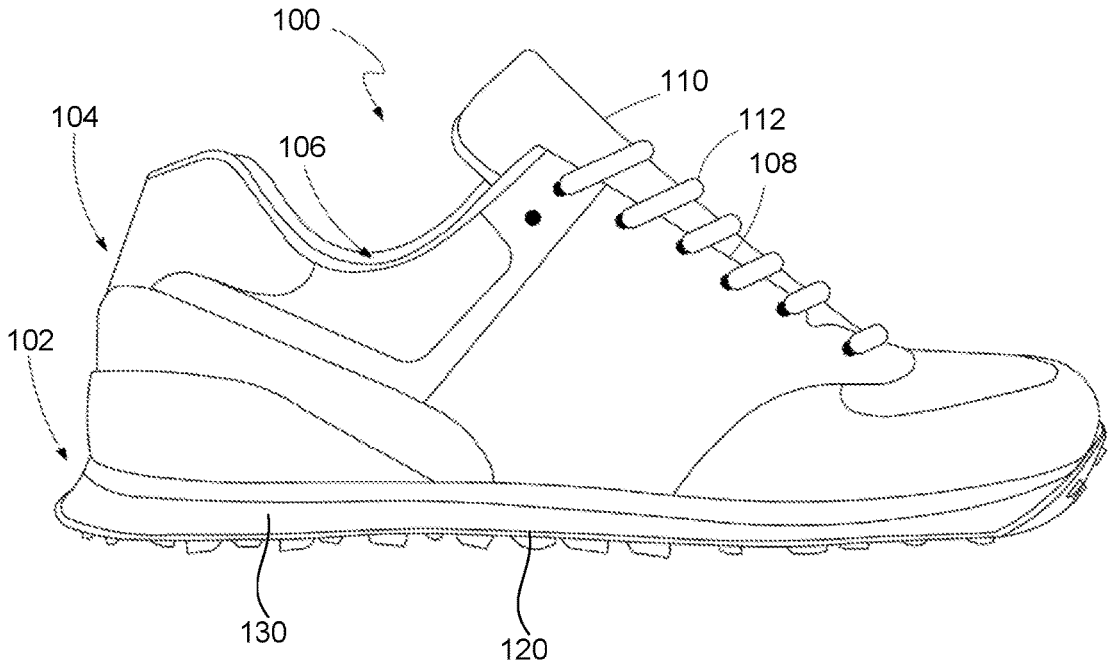


Fig. 1A

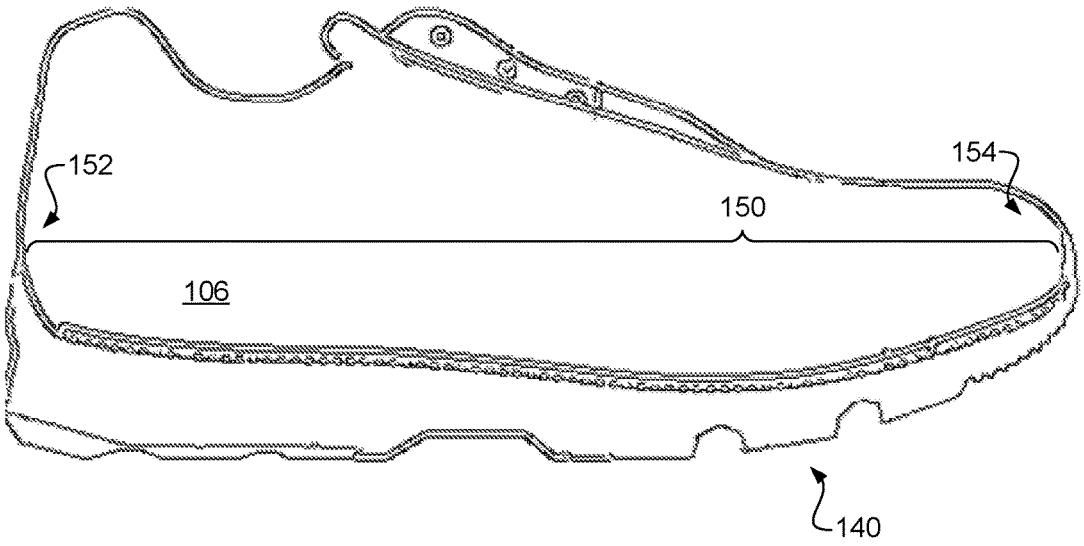


Fig. 1B

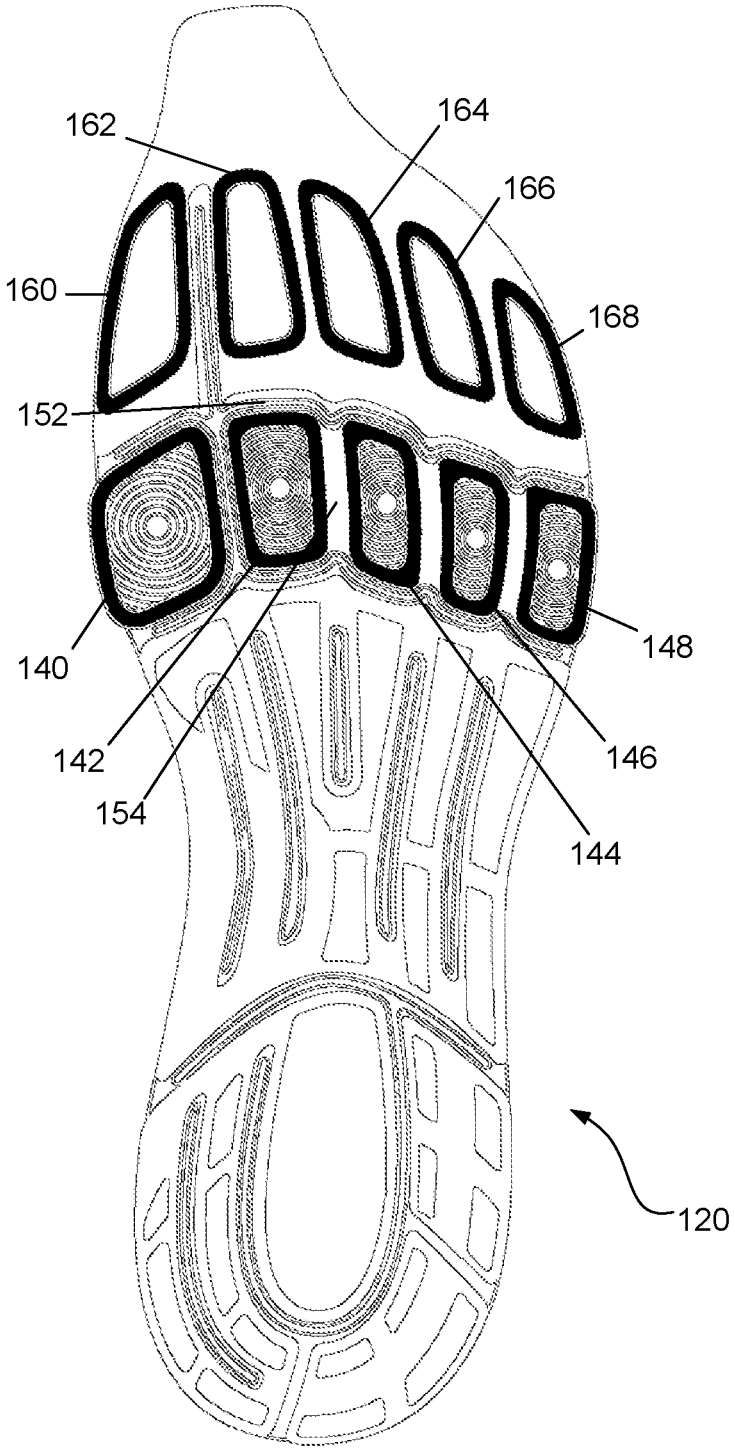


Fig. 2

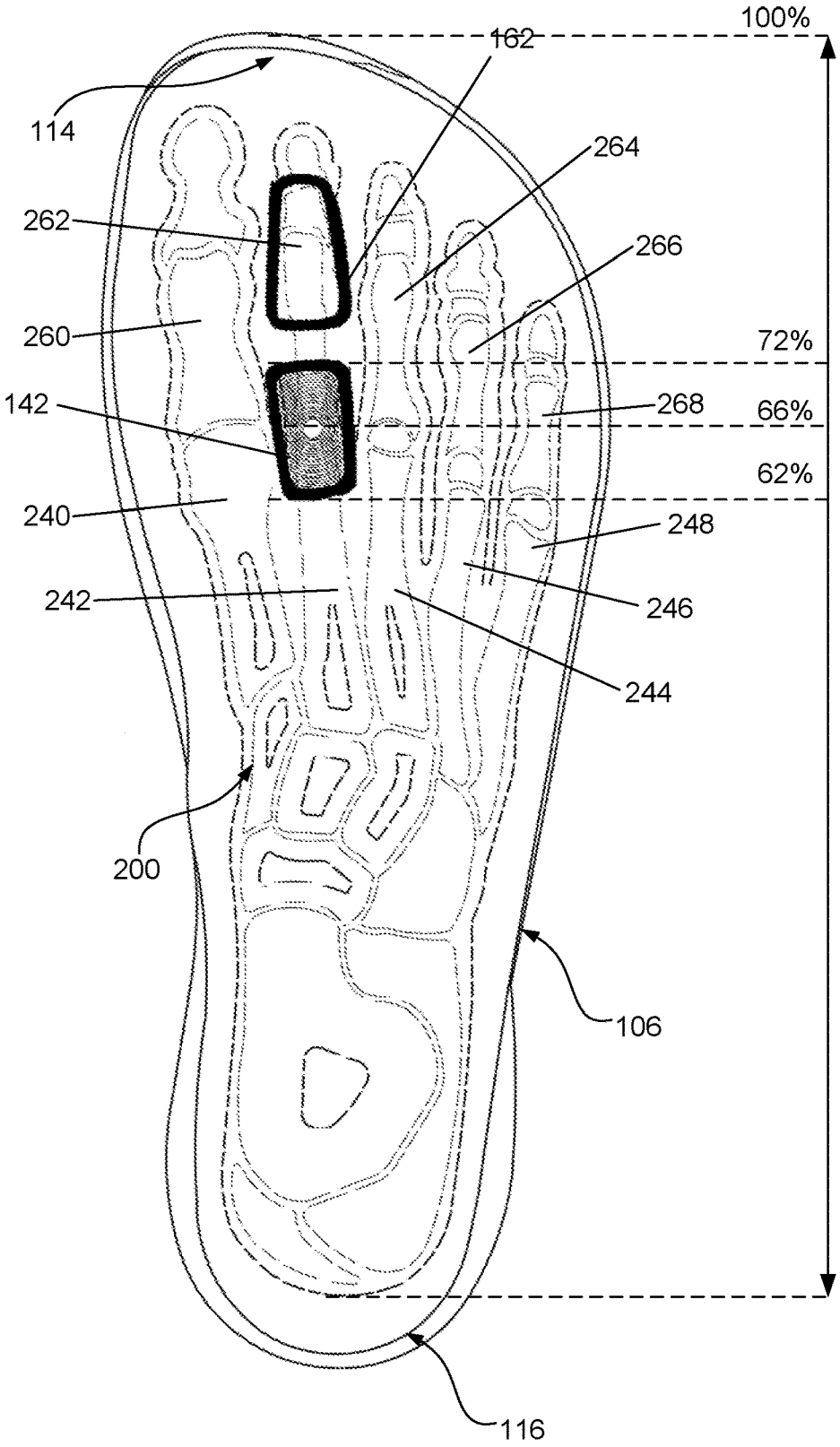

100%
162
114
264
262
266
260
72%
142
268
66%
62%
240
248
242
246
244
200
106
116

Fig. 3

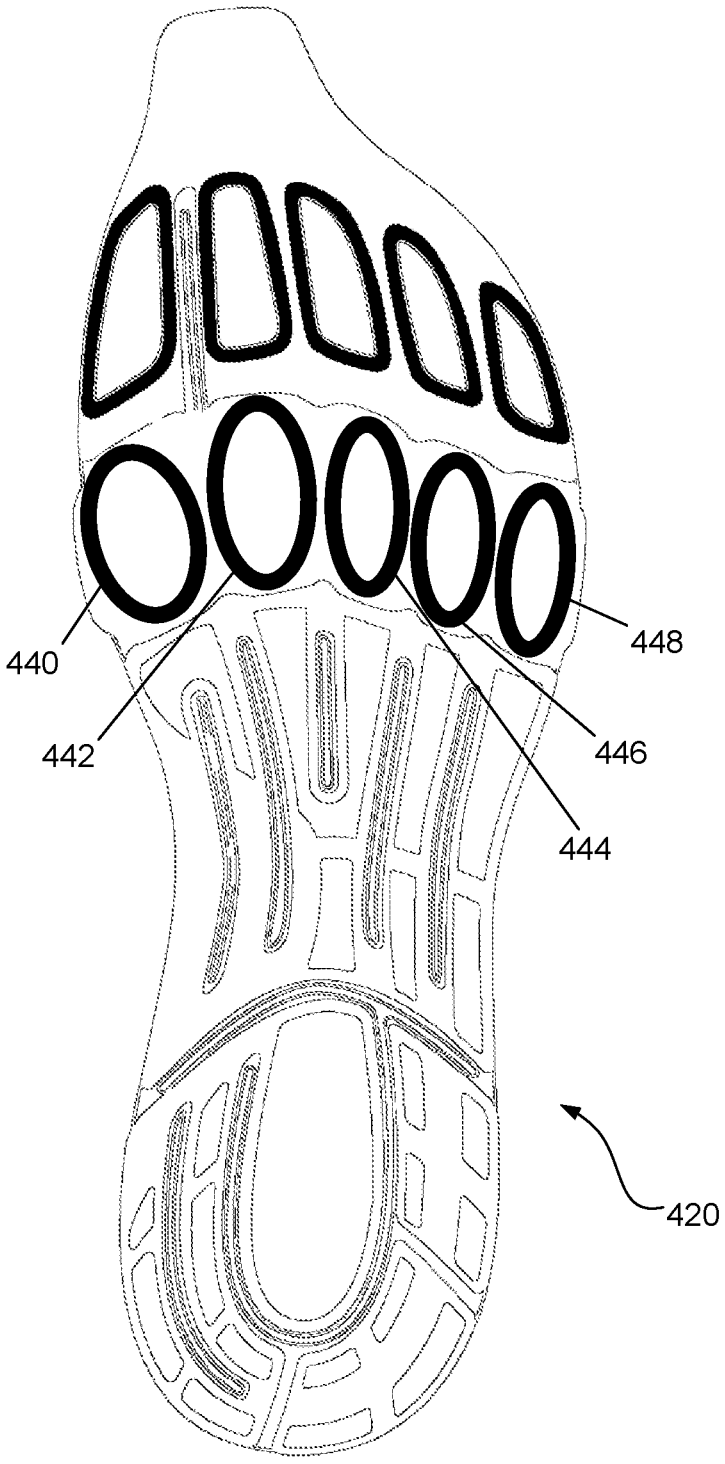


Fig. 4

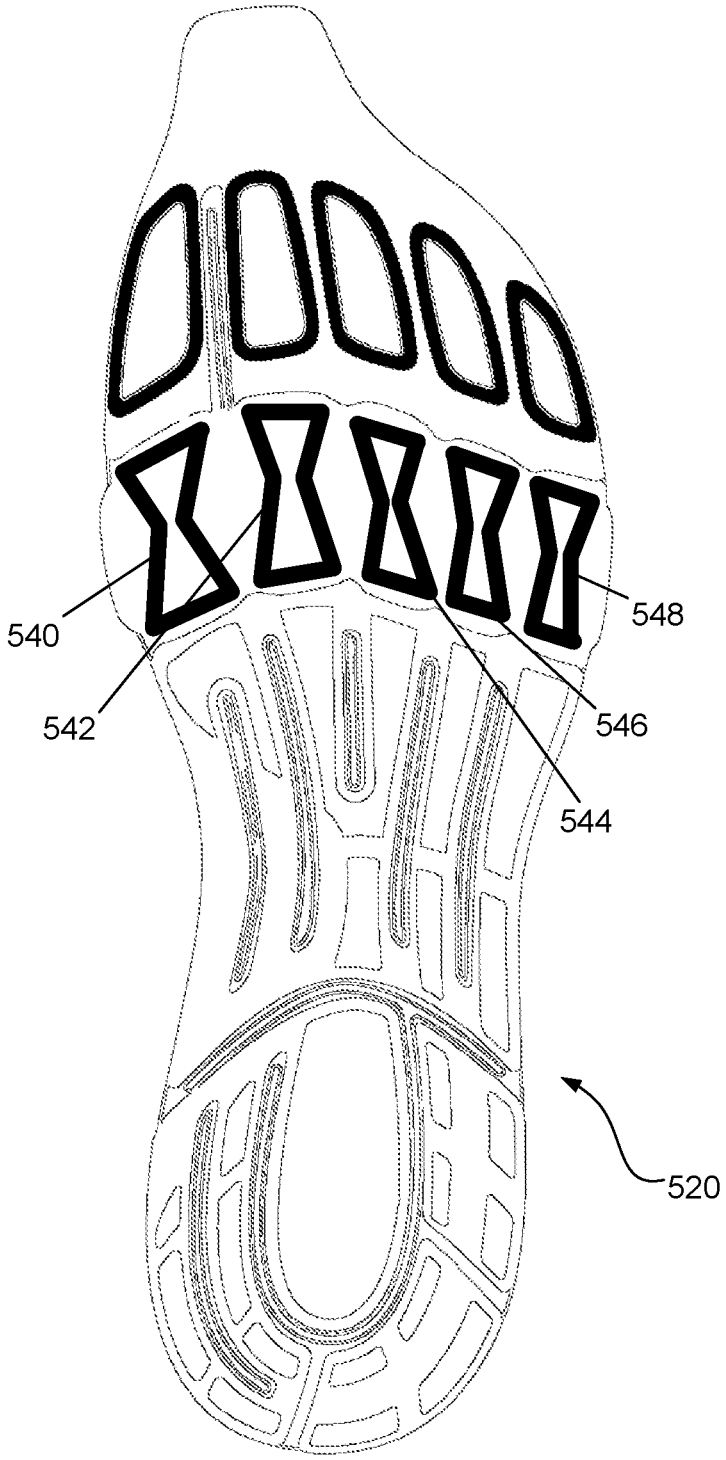


Fig. 5

OUTSOLE LUGS ALIGNED WITH METATARSAL BONES

BACKGROUND

[0001] Athletic shoes can be used in variety of circumstances and for a variety of purposes. Depending on the intended use of a shoe, it can be constructed differently or include different components than other types of shoes.

[0002] Running shoes can be constructed for multiple types of running environments and types of running. Often road running shoes are constructed for running on pavement and other surfaces that are generally flat. These types of running shoes tend to be light weight and flexible. Additionally, they include insulation to cushion or stabilize feet during repetitive strides on hard, even surfaces.

[0003] Cross-training shoes are constructed for workouts that include both aerobic and anaerobic types of activities. The soles of these shoes are often configured to maintain more contact with the ground to provide stability.

[0004] Trail-running shoes are often constructed for off-road routes that are rugged where the runner can encounter various obstacles such as puddles, mud, rocks, roots, and so forth. These shoes conventionally include aggressive treads for improved traction and are fortified to add stability and support. Generally, the outsole of the shoe extends substantially beyond the edges of the shoe's upper to provide the additional stability.

[0005] Sometimes, running shoes can include one or more outsole elements that are intended to distribute loads on the underside of the shoe experienced during activities. These elements can be stiffer or thicker than surrounding portions of the outsole in order to effectively distribute the loads. However, these portions are often one large inflexible piece, which can be incompatible with the natural flexibility of the foot. For example, the outsole may not have sufficient flexibility at locations under the joints or gaps between bones in the foot. In some cases, shoes can include a plurality of outsole portions, with each portion corresponding to, for example, a metatarsal bone of the foot, in an attempt to provide a more natural flexibility to the outsole. However, these portions are often imprecisely aligned with the foot, which can lead to a loss of comfort, a reduction of efficient load transfer, and even an increased risk of injury.

[0006] Some types of non-running shoes, such as heavy duty shoes, utility shoes, work shoes, hiking boots, and so forth include lug soles. Lug soles are thick and designed with deep indentations to improve stability and traction. The lugs of these soles vary from V-shaped to diamond shaped indentations. Lug soles are most frequently found on boots, including fishing, hunting, logging, hiking, and work boots.

[0007] One example of a shoe outsole that includes a plurality of lugs is disclosed in U.S. Pat. No. 9,149,087 to Abshire. Abshire discloses an outsole having five lugs, each lug corresponding to one of the five metatarsal bones of the foot. However, the positions of these lugs are not precisely defined, and can only be "partially positioned under" a metatarsal bone of the user. Further, the edges of the lugs can not correspond to the natural points of flexure of the user's foot. This reference is herein incorporated by reference for all that it contains.

SUMMARY

[0008] In one embodiment, a running shoe includes an upper, a foot cavity defined at least in part by an inside surface of the upper, including a frontmost toe surface, a rearmost heel surface, and a foot cavity length starting at the rearmost heel surface and ending at the front most toe surface. The shoe further includes an outsole, including a first metatarsal lug disposed under a first metatarsal bone of a user when the user is wearing the shoe, the first metatarsal lug including a center disposed at a center point corresponding to a first location between 65% and 67% of the foot cavity length, and a midsole.

[0009] The first metatarsal lug can further include a toe-facing edge disposed at an edge point corresponding to a second location between 71% and 73% of the foot cavity length.

[0010] The first metatarsal lug can further include a heel-facing edge disposed at an edge point corresponding to a third location between 61% and 63% of the foot cavity length.

[0011] An edge of the first metatarsal lug can define, in part, a flexure recess defined in the outsole and transversely orientated with respect to the foot cavity length.

[0012] The first metatarsal lug can be located near an adjacent metatarsal lug that is mechanically isolated and separated from the first metatarsal lug along a second flexure recess defined in the outsole, wherein the second flexure recess can align with the foot cavity length.

[0013] The outsole can further include a first phalange lug disposed substantially adjacent to a toe-facing edge of the first metatarsal lug and disposed under a first phalange bone of the user when the user is wearing the shoe, a third flexure recess between a toe-facing edge of the first metatarsal lug and the first phalange lug, wherein the first metatarsal lug and first phalange lug are mechanically isolated relative to each other.

[0014] The shoe can further include a second metatarsal lug disposed under a second metatarsal bone of the user when the user is wearing the shoe, including a center disposed at a center point corresponding to a fourth location between 65% and 67% of the foot cavity length, a toe-facing edge disposed at an edge point corresponding to a fifth location between 71% and 73% of the foot cavity length, a heel-facing edge disposed at an edge point corresponding to a sixth location between 61% and 63% of the foot cavity length.

[0015] The shoe can further include a third, fourth, and fifth metatarsal lug, wherein one of the metatarsal lugs corresponds to each metatarsal bone of the user's foot.

[0016] The outsole can further include a second phalange lug disposed substantially adjacent to the toe-facing edge of the second metatarsal lug and disposed under a second phalange bone of the user when the user is wearing the shoe, and a fourth flexure recess between the toe-facing edge of the second metatarsal lug and the second phalange lug, wherein the second metatarsal lug and the second phalange lug are mechanically isolated with respect to one another and to the metatarsal lug.

[0017] The outsole can further include a fifth flexure recess between the first metatarsal lug and the second metatarsal lug, and wherein the first metatarsal lug and the second metatarsal lug are mechanically isolated relative to each other.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] The accompanying drawings illustrate various embodiments of the present apparatus and are a part of the

specification. The illustrated embodiments are merely examples of the present apparatus and do not limit the scope thereof

[0019] FIG. **1**A illustrates a side view of an example of a shoe in accordance with the present disclosure.

[0020] FIG. **1**B illustrates a cross-sectional side view of an example of a shoe in accordance with the present disclosure.

[0021] FIG. **2** illustrates a bottom view of an example of an outsole in accordance with the present disclosure.

[0022] FIG. **3** illustrates a bottom view of an example of an outsole in accordance with the present disclosure.

[0023] FIG. **4** illustrates an example of a metatarsal lug in accordance with the present disclosure.

[0024] FIG. **5** illustrates an example of a metatarsal lug in accordance with the present disclosure.

DETAILED DESCRIPTION

[0025] For purposes of this disclosure, the term "aligned" means parallel, substantially parallel, or forming an angle of less than 35.0 degrees. For purposes of this disclosure, the term "transverse" means perpendicular, substantially perpendicular, or forming an angle between 55.0 and 125.0 degrees. Also, for purposes of this disclosure, the term "length" means the longest dimension of an object. Additionally, for purposes of this disclosure, the term "width" means the dimension of an object from side to side. Often, the width of an object is transverse the object's length.

[0026] For the purposes of this disclosure, the phrase "mechanically isolated" generally refers to a characteristic of a load being applied one object having at least a reduction load in the other object. Thus, when two lugs are mechanically isolated, a load applied to the first lug cannot be loaded to the second lug or the load applied to the second lug is significantly diminished. A first and second adjacent lug can be mechanically isolated from one another when they are separated by a flexure recess that allows the outsole to bend between the first and second lugs.

[0027] FIG. **1**A depicts an example of a running shoe **100**. In this example, the running shoe **100** includes a sole **102** and an upper **104** connected to the sole **102**. The sole **102** and the upper **104** collectively form a foot cavity **106** that receives a foot of the user. The upper **104** includes a slit or an opening **108** that enables the size of the foot cavity **106** to vary while the user inserts or removes their foot. A tongue **110** is connected to the upper **104** near the end of the slit **108**. The tongue **110** fills the gap defined by the slit **108** when the user is wearing the running shoe **100**. Multiple eyelets **112** are formed in the upper **104** adjacent to the slit **108** through which a lace **112** passes in a desired lacing pattern. The lace **112** can be loosened to enable the foot cavity to be expanded while a user inserts or removes their foot, and can be tightened when the running shoe **100** is worn by the user to secure the user's foot within the foot cavity **106** of the shoe **100**.

[0028] The foot cavity **106** can include a sock liner that lines portions of the foot cavity **106**. Also, the side walls of the foot cavity **106** can include other types of cushioning that reduce the jarring impacts when the user's shoe strikes the running surface and holds the upper snuggly against the user's feet throughout the running motion. In some cases, the cushioning lines the entire surface of the foot cavity's wall. In other examples, the cushioning lines just a subset of the foot cavity **106**. As described further herein, the foot cavity **106** can have a foot cavity length that starts at a rearmost heel surface of the foot cavity and extends to a frontmost toe surface of the foot cavity **106**.

[0029] In the example depicted in FIG. **1**, the running shoe's upper **104** is configured as a low top profile wherein the upper **104** terminates at or below the user's ankle. The low top profile **116** provides the running shoe with a lower weight and provides the user additional movement.

[0030] The sole **102** includes an outsole **120** having a desired tread or pattern on its lowermost surface for engagement with a running surface. As described further herein, the tread can include a plurality of lugs that are positioned to correspond to the metatarsal and phalange bones of the human foot. The outsole **120** can additionally include a toe bumper or toe guard providing some protection for the users toes as well as providing an ergonomic traction surface associated with a runner rolling up onto and pushing off of their toes while they run.

[0031] The sole **102** additionally includes a midsole **130** positioned about the outsole **120**. The midsole **130** is configured to provide cushioning and shock absorbing to the runner. In one embodiment, the midsole can be configured of ethyl vinyl acetate (EVA). Above the midsole **130** can be a foot plate, also referred to herein as a stone guard.

[0032] The sole **102** can further include an insole above the stone guard or foot plate. The insole provides a foundation on which a user's foot presses when wearing the shoe **100**. The sock liner of the shoe can rest on the insole. The insole can provide some cushioning, but also provides structure and torsional stability to the shoe. In some embodiments, the sole can include an optional shock absorbing layer placed between the insole and the stone guard.

[0033] FIG. **1**B depicts an example of a shoe **100** taken at a cross-sectional cut through the foot cavity **106**. The foot cavity **106** includes a foot cavity length **150** that starts at a rearmost heel surface **152** and ends at a frontmost toe surface **154**. The first metatarsal lug **140** can be located at **66.0** percent of the foot cavity length **150** measured from the rearmost heel surface **152**.

[0034] FIG. **2** depicts a bottom view of an example outsole **120** including metatarsal lugs **140**, **142**, **144**, **146**, **148** and phalange lugs **160**, **162**, **164**, **166**, **168** according to an embodiment of the disclosure. In this embodiment, each of the metatarsal lugs **140**, **142**, **144**, **146**, **148** corresponds to one of the five metatarsal bones of the human foot, as described further herein with respect to FIG. **3**. Similarly, in this embodiment, each of the phalange lugs **160**, **162**, **164**, **166**, **168** corresponds to one of the five phalange bones of the human foot, as described further herein with respect to FIG. **3**. The metatarsal lugs can have an approximately rectangular shape, although other shapes are expressly contemplated, and can each have an independently selected length of from about 20 mm to about 30 mm, or a length of about 25 mm. The metatarsal lugs can have substantially the same widths, or each of the lugs can have an independently selected width. In this example, the width of any one of the lugs can correspond to the width of a metatarsal bone and be from about 20 mm to about 10 mm. The metatarsal lugs can have substantially the same thickness, or each of the lugs can have an independently selected thickness. In this example, the thickness of any one of the lugs can be from about 1 mm to about 3 mm, 5 mm, or another appropriate thickness. A metatarsal lug can exert a characteristic of having a greater stiffness than other, non-lug portions of the outsole **120**. A metatarsal lug can be formed of a material having a greater

stiffness than the material of the non-lug portions of the outsole **120**, and/or the metatarsal lug can have a thickness greater than the non-lug portions of the outsole **120** that causes the lugs to have a greater stiffness.

[0035] The phalange lugs can have an approximately trapezoidal shape, although other shapes are expressly contemplated, and can each have an independently selected length of from about 20 mm to about 50 mm. In this example, the width of any one of the lugs can correspond to the width of a phalange bone and be from about 20 mm to about 10 mm. The phalange lugs can have substantially the same thickness, or each of the lugs can have an independently selected thickness. In this example, the thickness of any one of the lugs can be from about 1 mm to about 3 mm, 5 mm, or another appropriate thickness.

[0036] The outsole **120** further includes one or more flexure recess, which can be defined in part by at least one edge of a metatarsal and/or phalange lug. For example, a toe-facing edge of the second metatarsal lug **142** can define in part a flexure recess **152**. The flexure recess **152** can be transversely oriented with respect to the foot cavity length of the shoe **100**. A lateral edge of the second metatarsal lug **142** can define, in part, a flexure recess **154**. The flexure recess **154** can be aligned with the foot cavity length of the shoe **100**.

[0037] A flexure recess, for example flexure recesses **152**, **154**, can be an indented or recessed portion of the outsole, and can have a depth of from about 0.5 mm to about 1 mm, 2 mm, 3 mm, 4 mm, or 5 mmm. A flexure recess, for example flexure recesses **152**, **154**, can have a width of from about 0.5 mm to about 3 mm, 5 mm, or 10 mm. In some embodiments, a flexure recess can have a width corresponding to a distance between adjacent bones of the foot, for example, adjacent phalange and metatarsal bones. As described herein, the flexure recess provides for enhanced flexure and flexibility of the outsole **120** at the position of the flexure recess. The flexure recess can further separate the lugs and allow for portions of the outsole **120** adjacent to one another, for example first metatarsal lug **140** and second metatarsal lug **142** to be substantially mechanically isolated from one another. That is, a load exerted on the first metatarsal lug **140** cannot be transferred to the second metatarsal lug **142**, or can be transferred to the second metatarsal lug **142** to a significantly lesser extent. In this example, the edges of each of the metatarsal lugs **140**, **142**, **144**, **146**, **148** define, in part, a plurality of flexure recesses, such that each of the metatarsal lugs can be substantially mechanically isolated from one another and from other adjacent portions of the outsole **120**. In some embodiments, and in this example, a flexure recesses can be connected to one or more other flexure recesses.

[0038] FIG. **3** depicts a diagrammatic bottom view of the foot cavity **106** of an example shoe **100** and the position of the second metatarsal lug **142** and second phalange lug **162** with respect to the bones of the human foot **200** when a user is wearing the shoe **100**. The foot cavity **106** of the shoe **100** is defined in part by the interior surface of the upper **104**, and includes a frontmost interior toe surface **114**, and a rearmost interior heel surface **116**. A foot cavity length can be defined as the length between the heel surface **116** and the toe surface **114**. In some examples, each metatarsal bone can have a corresponding foot cavity length, which can be defined as the length of an imaginary reference line passing through the length of the metatarsal bone and extending between the toe surface **114** and the heel surface **116**.

[0039] As can be seen in FIG. **3**, the human foot includes five metatarsal bones; a first metatarsal bone **240**, a second metatarsal bone **242**, a third metatarsal bone **244**, a fourth metatarsal bone **246**, and a fifth metatarsal bone **248**. Each of the metatarsal lugs is disposed under a corresponding metatarsal bone of the user when the user is wearing the shoe. For simplicity and ease of understanding, only the location of the second metatarsal lug **142**, disposed under the second metatarsal **242**, is illustrated in FIG. **3**.

[0040] The second metatarsal lug **142** includes a center disposed at a center point corresponding to a location 66% of the foot cavity length. In some embodiments, the center point can correspond to a location between 65.9% and 66.1% of the foot cavity length, between 65.75% and 66.25% of the foot cavity length, between 65.5% and 66.5% of the foot cavity length, or between 65% and 67% of the foot cavity length. Each of the first, and third through fifth metatarsal lugs **140**, **144**, **146**, **148** similarly include a center disposed at a center point corresponding to a location 66% of the foot cavity length. In some embodiments, the center points of each of the first, and third through fifth metatarsal lugs **140**, **144**, **146**, **148** can correspond to a location between 65.9% and 66.1% of the foot cavity length, between 65.75% and 66.25% of the foot cavity length, between 65.5% and 66.5% of the foot cavity length, or between 65% and 67% of the foot cavity length.

[0041] In this example, each metatarsal lug can include a toe-facing edge or terminus. The toe-facing edge can be transversely oriented with respect to the foot cavity length, and can define, in part, a flexure recess, as described herein. Each toe-facing edge is disposed at an edge point corresponding to a location 72% of the foot cavity length. In some embodiments, the edge point can correspond to a location between 71.9% and 72.1% of the foot cavity length, between 71.75% and 72.25% of the foot cavity length, between 71.5% and 72.5% of the foot cavity length, or between 71% and 73% of the foot cavity length.

[0042] In this example, each metatarsal lug can include a heel-facing edge or terminus. The heel-facing edge can be transversely oriented with respect to the foot cavity length, and can define in part a flexure recess, as described herein. Each toe-facing edge is disposed at an edge point corresponding to a location 62% of the foot cavity length. In some embodiments, the edge point can correspond to a location between 61.9% and 62.1% of the foot cavity length, between 61.75% and 62.25% of the foot cavity length, between 61.5% and 62.5% of the foot cavity length, or between 61% and 63% of the foot cavity length.

[0043] As described further herein, the locations of the center, toe-facing edge, and heel-facing edge of the each of the lugs in relation to the foot cavity length serves to properly align each lug with respect to the corresponding metatarsal bone of the user's foot when the user is wearing the shoe. The position of each metatarsal lug as described herein can allow for the outsole **120** to flex at positions, such as the flexure recesses described herein, corresponding to the joints or gaps between the bones of the user's foot, and can allow for loads exerted on the outsole to be optimally transferred to the foot in order to maximize comfort and prevent injury. Further, even a small variance in position outside of the above-described locations can result in a misalignment of the lugs and flexure ridges with the

anatomy of the foot, leading to a reduction of comfort, injury prevention, and the ability of the outsole to optimally transfer loads to the foot.

[0044] As can be seen in FIG. **3**, the human foot also includes five phalange bones; a first phalange bone **260**, a second phalange bone **262**, a third phalange bone **264**, a fourth phalange bone **266**, and a fifth phalange bone **268**. Each of the phalange lugs is disposed under a corresponding phalange bone of the user when the user is wearing the shoe. For simplicity and ease of understanding, only the location of the second phalange lug **162**, disposed under the second phalange **262**, is illustrated in FIG. **3**.

[0045] The second phalange lug **162** is disposed substantially adjacent to the toe-facing edge of the second metatarsal lug **142**. The second phalange lug and the second metatarsal lug **142** can be spaced apart on the outsole **120** by a flexure recess, for example as shown in FIG. **2**. The second phalange lug **162** and the second metatarsal lug **142** can thus be mechanically isolated from one another. Similarly, each of the first phalange lug **160**, third phalange lug **164**, fourth phalange lug **166**, and fifth phalange lug **168** can be disposed substantially adjacent to the first metatarsal lug **140**, third metatarsal lug **144**, fourth metatarsal lug **146**, and fifth metatarsal lug **148**, respectively. Each of the phalange lugs can be separated from the corresponding adjacent metatarsal lugs by a flexure recess.

[0046] FIG. **4** depicts an example of an outsole **420** including metatarsal lugs **440**, **442**, **444**, **446**, **448** according to an embodiment of the disclosure. As illustrated, in some embodiments the metatarsal lugs **440**, **442**, **444**, **446**, **448** can have an approximately ovoid shape.

[0047] FIG. **5** depicts an example of an outsole **520** including metatarsal lugs **540**, **542**, **544**, **546**, **548** according to an embodiment of the disclosure. As illustrated, in some embodiments the metatarsal lugs **540**, **542**, **544**, **546**, **548** can have an irregular shape, such as an approximately hourglass shape.

GENERAL DESCRIPTION

[0048] In general, the present disclosure provides users with a running shoe having an outsole that includes a plurality of metatarsal lugs which can serve to stiffen the outsole at the location of the lugs and appropriately distribute loads experienced by the outsole to the midsole and the user's foot. Each metatarsal lug can correspond to one of the metatarsal bones of the user's foot and can be disposed on the outsole under the corresponding metatarsal bone when the user is wearing the shoe. For example, a first metatarsal lug can correspond to and be disposed under a first metatarsal bone of the user's foot. Each metatarsal lug can be surrounded by one or more flexure recesses, that can be defined, in part, by an edge of a metatarsal lug. These flexure recesses can allow for the lugs to move relatively independently of one another on the outsole so that each metatarsal lug can be mechanically isolated from each other metatarsal lug via the outsole. In some embodiments, mechanical force can still be transferred between metatarsal lugs via the midsole; however the flexure recesses can still substantially reduce the amount of force transferred between metatarsal lugs. In some embodiments, the outsole can further include a plurality of phalange lugs, where each phalange lug can correspond to and be disposed under one of the phalange bones of the user's foot when the user is wearing the shoe. In some cases, each phalange lug can be substantially adjacent to a corresponding metatarsal lug and can be spaced apart therefrom on the outsole by one or more flexure recesses.

[0049] In order to achieve the effects described herein, each of the metatarsal lugs must be precisely positioned with respect to the metatarsal bones and joints of the user's foot. In some embodiments, the position of each metatarsal lug on the outsole of the shoe can be determined relative to the foot cavity of the shoe. For example, the foot cavity can be defined, in part, by an interior surface of the upper of the shoe and can be bounded by a frontmost interior toe surface and a rearmost interior heel surface. A foot cavity length can be defined as the distance of a reference line running between points on each surface. In some embodiments, each metatarsal bone of the user's foot can have a corresponding foot cavity length, where the reference line used to determine the foot cavity length runs through the metatarsal bone, for example by running through the length of the metatarsal bone. In some embodiments, the position and/or size of each metatarsal lug can thus be described by its placement at one or more points along the foot cavity length, for example as described herein with respect to FIG. **3**.

[0050] The positions of the center and toe-facing terminus of each metatarsal lug with respect to the foot cavity length as described herein provide for the alignment of the metatarsal lugs with the corresponding metatarsal bones of the foot, the alignment of the flexure recesses surrounding the lugs with the joints between the metatarsal bones and phalange bones, and with the gaps between adjacent metatarsal bones.

[0051] The location of the lugs at these positions allows the outsole to flex or bend with the natural flexure points of the user's foot. In this way, the positioning of the lugs as described herein can allow for loads exerted on the outsole to be optimally transferred to the foot while still allowing for the natural movement and flexure of the foot, in order to maximize comfort and prevent injury. Further, even a small variance in position outside of the above-described locations can result in a misalignment of the lugs and flexure ridges with the anatomy of the foot, leading to a reduction of comfort, injury, and the ability of the outsole to optimally transfer loads to the foot. For example, the misalignment of even one metatarsal lug can lead to a noticeable reduction in comfort and function of the shoe as described herein.

[0052] The metatarsal lugs can be sized according to the positions of the center and toe-facing terminus as described herein. In some examples, the metatarsal lugs can have an approximately rectangular shape corresponding to the approximate size of a metatarsal bone. Other shapes are expressly contemplated, and in some examples, a metatarsal lug can be circular, ovoid, or irregularly shaped. Each metatarsal lug can have a thickness greater than an adjacent non-lug portion of the outsole, and/or can be formed of a material having a greater stiffness than an adjacent non-lug portion of the outsole. However, in other embodiments, a lug can be formed of the same material as the outsole. Accordingly, in some embodiments, a metatarsal lug can have a characteristic of having a stiffness greater than a stiffness of an adjacent non-lug portion of the outsole. In some cases, this increased stiffness of the lug portions of the outsole can provide for efficient transfer of loads to the midsole and ultimately to the user's foot, increased comfort, and/or

increased impact resistance. In some embodiments, a lug of the outsole can be formed of a polymer material, such as a hard rubber material.

[0053] A shoe including a plurality of metatarsal lugs of the present disclosure can include a variety of other components and features. For example, the running shoe of the present systems and methods can include a sole that is made up of at least two distinct layers, including the outsole and the midsole. The outsole can be configured to contact a running surface (e.g., the ground). The outsole can be made of a hard, abrasion resistant material that resists wear, provides traction, and provides flexibility.

[0054] In some embodiments, the outsole can include a rubber compound with a high carbon content at the heel and in the toe box area. The outsole can be constructed with studs, ridges or other tread structures to provide traction on slippery surfaces, such as wet grass or slick pavement. In some examples, the outsole can include transverse grooves in the toe box area so that the running shoe is more flexible in the toe box area when the user's weight is loaded against the ball of the user's foot while the heel is raised off of the ground. Generally, the wider the outsole, the greater stability the outsole provides the foot. Although, a wide outsole can also increase the weight of the shoe. In some examples, the running shoe can include an outsole that is just as wide or has a width that is less than **5.0** percent greater than width of other corresponding sections of the shoe (e.g., corresponding sections of the midsole or upper).

[0055] The midsole of the sole is located above the outsole. The midsole is made of a material that provides cushioning while also providing stability. In some embodiments, the total height of the midsole and outsole under the heel can be about 1.0 inch and the total height of the midsole and outsole under the toe box can be about 0.6 inches. The difference in sole thickness between the heel and toe box can reduce the strain on the user's Achilles tendon. This drop in the height of the sole from the heel to the toe box can affect how the user's foot strikes the ground. In some cases, the heel drop can range from 4 mm to 10 mm.

[0056] The midsole can be constructed of various materials to provide cushioning. In some cases, the midsole is made of ethyl vinyl acetate (EVA) or polyurethane. EVA is a copolymer of ethylene and vinyl acetate with microscopic air bubbles formed within the material, making it lightweight while providing a good amount of cushioning. Polyurethane also has a microscopic air bubble structure like EVA, but is generally firmer and more resistant to compression than EVA.

[0057] In some embodiments where a shoe includes a sole having a foot plate or stone guard disposed above the outsole, the plate can include a plurality of portions sized to correspond to each of the metatarsal lugs. In some embodiments, each of the portions of the plate can be spaced apart from one another, for example, by a distance corresponding to the widths of the flexure recesses separating the lugs of the outsole. In some embodiments, the size and positions of the portions of the foot plate can be substantially similar to the size and positions of the metatarsal lugs of the outsole.

[0058] The shoe can further include an upper attached to the sole. In some embodiments, the upper can be made of a combination of lightweight nylon to reduce the running shoe's weight. However, a variety of other materials can be used to form the upper. The upper of a running shoe can also incorporate a heel counter that is commonly stiffer than in other athletic shoes to help control excessive pronation or supination during running.

[0059] In some embodiments, the upper can be formed of waterproof fabric. This prevents water from entering the shoe through the upper. The tongue of the running shoe can also include a waterproof fabric. In some circumstances the waterproof fabric of the tongue has the same characteristics as the waterproof fabric incorporated into the upper. In some embodiments, the waterproof fabric can be located on the underside of the tongue and on the inside of the upper adjacent the foot cavity. In some embodiments, the waterproof fabric of the upper is located on the outside of the upper. In some embodiments, the tongue can be connected to the upper along the tongue's edges with a gusset. The gusset can also be lined with the waterproof material. In some cases, the gusset's waterproof fabric is located on the inside surface that is adjacent to the foot cavity. In other examples, the gusset's waterproof fabric is located on the outside surface of the gusset.

[0060] In some cases, the waterproof fabric is small enough to exclude water particles that would come from the ambient environment such as water from rain, mud puddles, or other sources while enabling water to move from the inside of the shoe to the outside through a diffusive mechanism. The diffusive water transport mechanism allows some water to be removed from the inside of the running shoe or from the inside layers of the running shoe.

[0061] The waterproof fabric that forms the protective exterior also includes a second, convective water transport mechanism. The convective water transport mechanism is enabled due to the waterproof fabric being air permeable such that a small amount of air passes through the waterproof fabric. This additional air circulation accelerates the removal of water moisture inside the foot cavity or water moisture inside the upper's insulation in the inside layer. Convective mass transport works largely via advection or the transport of water through air motion. The convective mass transfer does not require sweat build up. The waterproof fabric can transport air out of the shoe when the user's foot is inserted into the shoe or not.

[0062] Any appropriate type of running shoe, trail-running shoe, or cross-training shoe can be used in accordance with the principles described herein. In one example, the shoe can include a low-top profile where the upper terminates just below the user's ankle. While a low-top upper can provide less lateral stability, the shoe is lighter. In other examples, the shoe includes a high-top profile. In this example, the running shoe includes an upper that extends over the user's ankle. Other types of shoes, including non-athletic shoes, can also incorporate the principles, features, or aspects disclosed herein.

What is claimed is:

1. A running shoe, comprising:

an upper;

a foot cavity defined at least in part by an inside surface of the upper, including a frontmost toe surface, a rearmost heel surface, and a foot cavity length starting at the rearmost heel surface and ending at the frontmost toe surface;

a midsole; and

an outsole, including a first metatarsal lug located on an exterior of the outsole to be located under a first metatarsal bone of a user when the user is wearing the

shoe, the first metatarsal lug having a center disposed at a center point corresponding to a first location between 65% and 67% of the foot cavity length.

2. The running shoe of claim **1**, wherein the first metatarsal lug further comprises a toe-facing edge disposed at an edge point corresponding to a second location between 71% and 73% of the foot cavity length.

3. The running shoe of claim **1**, wherein the first metatarsal lug further comprises a heel-facing edge disposed at an edge point corresponding to a third location between 61% and 63% of the foot cavity length.

4. The running shoe of claim **1**, wherein an edge of the first metatarsal lug defines, in part, a flexure recess defined in the outsole, the flexure recess being transversely orientated with respect to the foot cavity length.

5. The running shoe of claim **1**, wherein the first metatarsal lug is located adjacent to a second metatarsal lug that is mechanically isolated and separated from the first metatarsal lug along a second flexure recess defined in the outsole;

wherein the second flexure recess is aligned with the foot cavity length.

6. The running shoe of claim **1**, wherein the outsole further comprises:

a first phalange lug disposed substantially adjacent to a toe-facing edge of the first metatarsal lug and disposed under a first phalange bone of the user when the user is wearing the shoe;

a third flexure recess between a toe-facing edge of the first metatarsal lug and the first phalange lug; and

wherein the first metatarsal lug is mechanically isolated from the first phalange lug.

7. The running shoe of claim **1**, further comprising a second metatarsal lug disposed under a second metatarsal bone of the user when the user is wearing the shoe, comprising:

a center disposed at a center point corresponding to a fourth location between 65% and 67% of the foot cavity length;

a toe-facing edge disposed at an edge point corresponding to a fifth location between 71% and 73% of the foot cavity length; and

a heel-facing edge disposed at an edge point corresponding to a sixth location between 61% and 63% of the foot cavity length.

8. The running shoe of claim **7**, further comprising a third, fourth, and fifth metatarsal lug, wherein one of each of the first, second, third, fourth, and fifth metatarsal lugs corresponds to each metatarsal bone of the user's foot.

9. The running shoe of claim **8**, wherein the outsole further comprises:

a second phalange lug disposed substantially adjacent to the toe-facing edge of the second metatarsal lug and disposed under a second phalange bone of the user when the user is wearing the shoe; and

a fourth flexure recess between the toe-facing edge of the second metatarsal lug and the second phalange lug;

wherein the second metatarsal lug is mechanically isolated relative to the second phalange lug and the metatarsal lug.

10. The running shoe of claim **6**, wherein the outsole further comprises a fifth flexure recess between the first metatarsal lug and the second metatarsal lug; and

wherein the first metatarsal lug is mechanically isolated relative to the second metatarsal lug.

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