Abstract:

Title: FOOTWEAR HAVING A FILLED FLEX-FRAME MIDSOLE

An article of footwear may include a midsole having a flex-frame defining a plurality of cells. Some or all of the cells may be substantially filled with a foam material. The flex-frame may be made of a solid material having a greater stiffness than the foam material. The flex-frame may be unitary in construction.
INTRODUCTION
Work boots, athletic shoes, and other types of footwear may be designed and constructed from materials that make the footwear highly resistant to wear and tear. For example, the shoes may be designed to include thick outsoles and/or thick midsoles. Such features may be constructed from rubber and/or other protective materials to improve the durability of the shoes. However, known designs and materials may lead to shoes having an increased mass, a relatively low level of responsiveness, and/or a relatively low rate of energy return. Any or all of these issues may contribute to discomfort and fatigue for a user.

SUMMARY
Footwear according to the present teachings overcomes the drawbacks described above by incorporating a midsole that includes a flex-frame having a plurality of spring-like cells. Some or all of the cells may be substantially filled (e.g., with a high-rebound foam). Benefits of this approach may include lighter weight, higher responsiveness, and a high rate of energy return.

The present disclosure provides systems, apparatuses, and methods relating to an article of footwear comprising an upper; and a sole portion coupled to the upper and including an outsole and a midsole; the midsole including a resiliently-flexible kinematic frame having a plurality of cells, and a foam at least partially surrounding the frame; wherein the frame comprises a solid material having a greater stiffness than the foam.

In some embodiments, a sole for an article of footwear may include a midsole including a plurality of cells each defining an internal volume and mechanically coupled to form a unitary resilient frame; and a compressible foam surrounding the
plurality of cells and filling the internal volume of at least one of the cells; wherein the resilient frame has a higher stiffness than the foam.

In some embodiments, an article of footwear may include an upper; and a sole coupled to the upper, the sole including a plurality of molded spring-like cells integrated into a single layer to form a flexibly resilient kinematic frame, each cell extending at least partially across a width of the sole; wherein an interior volume of each cell is substantially filled with a compressible foam material.

Features, functions, and advantages may be achieved independently in various embodiments of the present disclosure, or may be combined in yet other embodiments, further details of which can be seen with reference to the following description and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a side elevation view of an illustrative article of footwear including a midsole having a flex-frame substantially filled with foam, in accordance with aspects of the present disclosure.

Fig. 2 is an isometric partial cutaway view of a portion of the midsole of Fig. 1, with the foam partially removed to show the flex-frame.

Fig. 3 is a side elevation view of an illustrative article of footwear having a midsole similar to that shown in Fig. 1.

Fig. 4 is a side elevation view of an illustrative article of footwear having a flex-frame midsole substantially filled with foam, with the flex-frame midsole including reverse direction kinematic springs.

Fig. 5 is a side elevation view of an illustrative article of footwear including another example of a substantially filled flex-frame midsole.

Fig. 6 is a side elevation view of an illustrative article of footwear including a substantially filled flex-frame midsole having generally evenly spaced kinematic springs.

Fig. 7 is a side elevation view of an illustrative article of footwear having a substantially filled flex-frame, wherein the flex-frame comprises a midsole and an outsole portion of the footwear.

Fig. 8 is a side elevation view of an illustrative article of footwear including a midsole having a substantially filled flex-frame with a discontinuous upper portion.
Fig. 9 is a side elevation view of an illustrative article of footwear including a midsole having a substantially filled flex-frame with discontinuous upper and lower portions.

DESCRIPTION

Overview

Various aspects and examples of footwear having filled flex-frame midsoles, as well as related methods, are described below and illustrated in the associated drawings. Unless otherwise specified, an article of footwear and/or its various components may, but are not required to, contain at least one of the structure, components, functionality, and/or variations described, illustrated, and/or incorporated herein. Furthermore, unless specifically excluded, the process steps, structures, components, functionalities, and/or variations described, illustrated, and/or incorporated herein in connection with the present teachings may be included in other similar devices and methods, including being interchangeable between disclosed embodiments. The following description of various examples is merely illustrative in nature and is in no way intended to limit the disclosure, its application, or uses. Additionally, the advantages provided by the examples and embodiments described below are illustrative in nature and not all examples and embodiments provide the same advantages or the same degree of advantages.

In the following descriptions, various direction- or orientation-related terms, such as up, down, vertical, horizontal, width, height, and the like are used when describing features and aspects of footwear. Unless indicated otherwise, these terms are intended to be understood in the context of an article of footwear, the sole of which is supported on a generally planar surface (e.g., a floor). The force of gravity is assumed to be generally normal to this support surface. Accordingly, in this context, "down" is understood as the direction of the force of gravity.

In general, an article of footwear, such as a boot or shoe, according to the present teachings may include a midsole having a kinematic flex-frame co-molded with high-rebound foam (or other suitable high-rebound material). As used herein, the term "kinematic" refers generally to an assembly or device comprising a plurality of mechanical elements capable of relative motion with respect to each other. Each kinematic flex-frame, also referred to as a frame or framework, may be molded as one piece of material having a plurality of cells or spring portions formed by ribs or
other suitable substructures. The flex-frame may be configured to bend and flex elastically as one unit, while also being sufficiently stiff or rigid to support an expected load (e.g., the weight of a user) without collapsing. The flex-frame may be described as structural, in that it may form a structural element of the sole. The flex-frame may be of unitary construction, such that the individual cells or spring elements are attached to form a cohesive whole. In some examples, this may be accomplished by forming or molding the flex-frame as a single piece of material. Weight and pressure may be effectively transferred throughout the flex-frame due to its shape, material qualities, and/or its ability to bend and flex as a complete composition.

Ribs or kinematic spring portions of the flex-frame may be shaped to provide an elastic or spring-like return and motion with each step. Individual cells or spring portions may be compressed and/or expanded, depending on pressure points created by the distribution of weight of the user on different portions of the foot supported by the sole of the footwear. In general, a kinematic frame may have a shape, a material quality or qualities, and/or an ability to bend and flex as a complete unit (e.g., as described above), which enable the kinematic frame to effectively transfer or distribute applied pressure throughout its composition. According to aspects of the present teachings, such a kinematic frame may be supplemented and/or filled with foam or other high-rebound and/or relatively light material, and incorporated into a footwear midsole. High rebound foam or other suitable material may fill or partially fill one or more open cells of the flex-frame to reinforce high-energy return qualities thereof. Such a midsole may be relatively lightweight and responsive, with a high rate of energy return as compared to known midsoles.

The cells (also referred to as chambers) of the flex-frame may have any suitable shape or combination of shapes. For example, cells may have a generally polygonal cross-section, the section being taken along a line generally parallel to a long axis of the sole or footwear. Due to the extent and open-ended nature of the cells, these shapes may be visible on the sides of the soles, as shown in the drawings. In some examples, the cells may have parallelogram-like shapes (e.g., as shown in Figs. 1 and 5), may have generally trapezoidal or slanted trapezoidal shapes (e.g., as shown in Fig. 4), may have substantial crescent-like shapes (e.g., as shown in Fig. 6), may have free-form or rounded shapes (e.g., as shown in Fig. 7), and/or the like, or any combination of these. In some embodiments, different
individual cells may have different shapes, such as circular, triangular, rectangular, and/or any suitable curvilinear and/or rectilinear shape(s). Regardless of the sectional shape, each cell may form a chamber having an interior volume. Each of these chambers may extend width-wise across at least a portion of the sole of the footwear. Each of the chambers may be open at lateral ends and/or at other locations on the perimeter.

Additionally, the cells may be any suitable size or combination of sizes. For example, one or more cells may have a larger vertical height as compared to the height of one or more other cells. For example, one or more cells disposed in toe and/or heel regions of the associated footwear may have larger height(s) than one or more cells disposed in a central arch region of the associated footwear, which may provide for greater energy transfer from relatively high impact regions.

In general, the resilient flex-frame may comprise a solid material having a greater stiffness than the foam. In some embodiments, the flex-frame may be made of nylon. In some examples, the foam used to fill cells of the flex-frame may comprise ethylene-vinyl acetate (EVA) or other relatively high-rebound material or foam, such as polyurethane (PU) or thermoplastic polyurethane (TPU), or the like, and/or a combination of these. The high-rebound material (e.g., foam) may have any material characteristic and/or property suitable for biasing the flex-frame toward a substantially non-compressed (e.g., expanded or rebounded) position. In some examples, the high-rebound material (e.g., EVA and/or PU) may have a density in a range of about 0.8 to about 2.0 pounds per cubic foot (PCF), and/or a durometer level (or hardness) in a range of about 45 to about 65 shore C. However, in some embodiments the high-rebound foam may have other characteristics, such as a suitable density and/or hardness outside of these respective ranges. The high rebound foam may fill and cover the inside and outside of the kinematic frame. The kinematic frame may cross or span (e.g., extend across) the entire width of the sole of the footwear.

In some embodiments, co-molded supplemental foam may disperse the weight on the midsole, which may permit a thickness of the kinematic frame to be optimized (e.g., reduced as compared to known sole flex-frames), while still providing responsiveness and a high rate of energy return. In some embodiments, the thickness may be tailored to a desired function (e.g., a selected responsiveness
and/or energy return). Such an embodiment may provide a lightweight, responsive, and high rate of energy return midsole, as similarly described above.

In some embodiments, the flex-frame may be made of a molded plastic composition, such as one made of nylon or carbon fiber reinforced polymer (also referred to as carbon fiber). EVA or TPU (or other high rebound foam or material) may be directly injected or cemented inside at least one cell defined by the flex-frame. One or more compression spaces (or zones) between adjacent cells may be hollow or partially hollow, or may be filled with foam or other high-rebound material.

In some embodiments, a combination of a nylon flex-frame and molded high-rebound foam (e.g., filling cells of the flex-frame and/or compression zones) may provide improved cushioning (e.g., for a user's foot disposed inside an associated footwear upper) for increased periods of time, without the associated material becoming packed down. In other words, midsoles in accordance with aspects of the present disclosure may prevent significant loss of resiliency over time.

Examples, Components, and Alternatives

The following sections describe selected aspects of exemplary footwear having filled flex-frame midsoles, as well as related systems and/or methods. The examples in these sections are intended for illustration and should not be interpreted as limiting the entire scope of the present disclosure. Each section may include one or more distinct examples, and/or contextual or related information, function, and/or structure.

Illustrative Footwear Example 1

As shown in Figs. 1-3, this section describes an illustrative article of footwear 100. Footwear 100 is an example of footwear having a foam-filled flex-frame, as described in the overview above. Accordingly, corresponding components and aspects may share substantially identical characteristics as described above.

Footwear 100 may include an upper portion 104 and a sole portion 108. Upper portion 104 may include any suitable footwear upper configured to receive a foot of a user and be selectively secured thereto (e.g., by lacing, hook-and-loop fasteners, and/or the like). Sole portion 108 may be coupled (e.g., attached or affixed) to upper portion 104. Sole portion 108 may include any suitable sub-portions or layers, such as an outsole (or outer sole layer) 112, a midsole (or midsole layer)
116, and an interface (or interface layer) 120. The outsole, the midsole, and/or the
interface may extend at least substantially along the entire length of footwear 100. Although sole portion 108 is shown to include a distinct outsole 112, midsole 116, and interface 120, sole portion 108 may additionally, or alternatively, include any other suitable configuration of layer(s). For example, one or more of the sub-portions or layers may be combined into a single structure. In some examples, sole portion 108 may exclude interface 120.

In this example, midsole 116 is coupled to upper portion 104 (e.g., via interface 120, adhesive, sewing, bonding, welding, and/or other mechanisms). Outsole 112 may be disposed opposite upper portion 104 relative to midsole 116. In other words, outsole 112 may be disposed on (or otherwise comprise) a bottom surface of sole portion 108. The outsole may include a plurality of projections, ridges, and/or recesses configured to improve traction, and/or to transfer kinetic energy between the foot of the user and an external surface (e.g., a road, trail, or other surface) via midsole 116. Although the footwear of Fig. 1 includes an outsole that wraps around at least a portion of the toe of the footwear, the footwear of the present disclosure may include any suitable outsole. In some examples, footwear 100 may include an outsole that does not wrap around the toe and/or that may wrap around at least a portion of the heel of the footwear.

Midsole 116 may be configured to store or absorb kinetic energy and return or transfer the stored energy back into the user’s step. For example, midsole 116 may include a kinematic frame (also referred to as a flex-frame or framework) 124 substantially filled with a relatively high-rebound material, such as foam 128. Components of midsole 116 may comprise any suitable materials configured to minimize weight and/or improve transfer of energy back to the user. For example, flex-frame 124 may be made of nylon, carbon fiber reinforced polymer, or any other suitable relatively light resilient material. Foam 128 may be made of EVA, PU, or any other suitable high rebound material. In some embodiments, foam 128 may include a closed-cell foam, which may improve a rebound characteristic of midsole 116, an open-celled foam, which may improve a cushioning characteristic of midsole 116, and/or a combination of closed-cell and open-cell foams.

A substantially resilient member 132 (e.g., made of nylon, carbon fiber, or any other suitable relatively light, resilient material) may form continuous flex-frame 124. Continuous flex-frame 124 may include a plurality of cells, such as cells 136A
through 136H. Resilient member 132 may form a generally continuous base member 140. Base member 140 may extend along a length of footwear 100, e.g., along the entire length of footwear 100. Base member 140 may form a floor portion of each of discrete cells 136A-136H. For example, base member 140 may form a floor portion 140A of cell 136A, a floor portion 140B of cell 136B, a floor portion 140C of cell 136C, and so on.

Resilient member 132 may further include or form a plurality of ribs or kinematic springs, a few of which are indicated respectively at 144, 146, 148, 150, 152, and 154, and a plurality of interconnecting portions (also referred to as upper portions), three of which are indicated respectively at 156, 158, and 160. Pairs of ribs may form opposing side walls of the associated cell, and may be interconnected by an associated interconnecting portion (e.g., forming a ceiling portion of the associated cell). For example, opposing ribs 144 and 146 may extend from floor portion 140B, and may form opposing side walls of cell 136B. Similarly, interconnecting portion 156 may extend between opposing ribs 144 and 146 to form a ceiling portion of cell 136B opposite floor portion 140B.

Floor portion 140C, opposing ribs 148, 150, and upper portion 158 may define cell 136C (e.g., a perimeter thereof). As shown, the other cells may be similarly defined and/or formed. However, in some embodiments, such as the one shown here, cell 136H in a heel portion of midsole 116 may have an open end at a rear of sole 108. For example, cell 136H may have only one defining generally vertical side wall or kinematic spring, rather than two opposing kinematic springs. Similarly, in some embodiments, a cell in a toe portion of midsole 116 (not shown) may also have an open end.

As mentioned above, foam 128 may substantially fill flex-frame 124. More specifically, foam 128 may substantially, generally, or completely fill some or all of cells 136A-136H. Compression zones 162A-162G may be respectively disposed between adjacent cells in midsole 116. For example, side walls of adjacent cells may be spaced apart to define a gap, space, or compression zone therebetween. As shown in Fig. 1, these compression zones may be tapered, such that the side walls of adjacent cells are closer together near the bottom of the compression zone than they are near the top. For example, a compression zone may have a "V" shaped cross section when viewed from a lateral side of the footwear.
One or more of the compression zones may be filled with foam 128 (or other suitable high-rebound material). As shown, each of these compression zones may be filled with foam 128. However, in some embodiments, one or more of these compression zones may be unfilled or hollow. The inclusion of one or more hollow compression zones may reduce a weight of footwear 100. Conversely, one or more filled compression zones may increase energy absorption and return. In some embodiments, such as the one shown in Fig. 1, foam 128 (or another high-rebound material) may also form interface layer 120, which may be coupled to and/or co-molded with the foam filling the compression zones and disposed adjacent upper portion 104. In some embodiments, interface layer 120 may be coupled to and/or co-molded with upper portions of flex-frame 124.

More specifically, as shown in Fig. 2, each of cells 136A-136H may have, substantially enclose, or generally surround a respective volume. For example, cell 136B may have a volume V1, and cell 136C may have a volume V2. A majority of volumes V1 and V2, as well as the other volumes substantially enclosed by the other cells, may be generally filled with foam 128 (or other suitable high-rebound material). In some embodiments, void spaces may be included within one or more of the cells. For example, one or more air pockets may be formed in one or more of the cells.

In Fig. 2, it should be noted that a portion of foam 128 has been removed to depict an exemplary extent of flex-frame 124 and foam 128. For example, flex-frame 124 may extend across an entire width W1 of footwear 100. In some embodiments, flex-frame 124 may extend across less than width W1. For example, in some embodiments, flex-frame 124 (and/or one or more additional similar structures) may extend across a central portion of width W1, and/or one or more lateral side portions of width W1.

Fig. 3 shows a more detailed view of footwear 100. As shown, upper portion 104 of footwear 100 may include laces 164, or any other suitable device or apparatus for securing a user’s foot within upper portion 104. Further, flex-frame 124 may include a rear portion 166. As shown, rear portion 166 may wrap around a rear end of interface layer 120 and extend toward upper portion 104. Such a configuration may improve energy transfer to the user and/or improve an attachment of flex-frame 124 to interface 120.

In an exemplary operation, compression of midsole 116 may result in flex-frame 124 flexing downward and/or laterally. For example, the toe-wardly angled
cells of flex-frame 124 depicted in Fig. 3 may flex downward and toe-ward (i.e., forward) when midsole 116 is compressed. Such a flexing motion may load one or more of the ribs of flex-frame 124 (e.g., with a restorative force). Such flexing may also decrease one or more volumes of respective cells 136A-136H, which may load (e.g., compress) foam 128 in the associated cells and/or compression zones. Such absorption of force over a corresponding distance (or distances) may store associated energy in midsole 116 (e.g., in flex-frame 124 and/or foam 128), which may then be returned to the user, for example, as these loads are released as midsole 116 returns, expands, or rebounds to the position depicted in Fig. 3.

Illustrative Footwear Example 2

As shown in Fig. 4, this section describes another illustrative article of footwear 400. Footwear 400 is an example of footwear having a foam-filled flex-frame, as described in the overview above. Accordingly, corresponding components and aspects may share substantially identical characteristics as described above. Where aspects of footwear 400 are similar to those of footwear 100, corresponding features are labeled with versions of the same reference numbers, but starting with "4" rather than "1." For example, footwear 400 includes an upper portion 404 coupled to a sole portion 408 having an outsole 412, a midsole 416, and an interface portion 420, all generally as described above with respect to elements 104, 108, 112, 116, and 120.

Midsole 416 includes a filled flex-frame 424, which may be similar in structure and/or function to flex-frame 124. Flex-frame 424 may define a plurality of cells, such as cells 436A-436F, which may be substantially filled with a foam 428 (or other suitable high rebound material). One or more compression zones, such as compression zones 462A-462E, between adjacent cells may similarly be filled with a high rebound material (e.g., foam 428).

In contrast to the generally continuous base member 140 of flex-frame 124, flex-frame 424 includes a resilient, generally continuous ceiling member 440. In other words, the cells of flex-frame 424 depend downward from the continuous member of the frame, while the cells of flex-frame 124 extend upward. Ceiling member 416 may form and/or define upper portions of one or more of cells 436A-436F, as well as upper portions of associated compression zones therebetween. Lower portions 440A-440F of flex-frame 424 may form respective bases of cells 436A-436F. Each of
these lower portions may be coupled (e.g., bonded, adhered, and/or the like) to outsole 412. Such a configuration may provide for increased energy return of footwear 400.

Illustrative Footwear Example 3

As shown in Fig. 5, this section describes another illustrative article of footwear 500. Footwear 500 is an example of footwear having a foam-filled flex-frame, as described in the overview above. Accordingly, corresponding components and aspects may share substantially identical characteristics as described above. Where aspects of footwear 500 are similar to those of footwear 100, corresponding features are labeled with versions of the same reference numbers, but starting with "5" rather than "1." For example, footwear 500 includes an upper portion 504 coupled to a sole portion 508 having an outsole 512, a midsole 516, and an interface portion 520, all generally as described above with respect to elements 104, 108, 112, 116, and 120.

Midsole 516 includes a filled flex-frame 524, which may be similar in structure and/or function to flex-frame 124. Flex-frame 524 may define a plurality of cells, such as cells 536A-536K, which may each be substantially filled with a foam 528 (or other suitable high-rebound material). As shown, a continuous upper resilient member 532A and lower resilient member 532B of flex-frame 524 may respectively form a ceiling and a base portion of cells 536A-536K. In contrast to flex-frame 124, which included a base member with cells extending upward, and flex-frame 424, which included a ceiling member with cells extending downward, flex-frame 524 includes both a ceiling and a base member sandwiching the cells.

Ribs of flex-frame 524, two of which are indicated at 544 and 546, may partition a generally enclosed volume between portions 532A and 532B into cells 536A-536K. As shown in Fig. 5, the ribs of flex-frame 524 may be angled heelward (e.g., toward the rear of the footwear) from bottom to top. In other words, the bottom of one (or all) of the ribs may be farther forward than the top of the same rib. In some examples, an angle \( \theta_1 \) formed between a rib and lower member 532B may be about 105 degrees to about 175 degrees, or any other suitable angle. For example, for heelwardly projecting ribs, as shown in Fig. 5, angle \( \theta_1 \) may be in a range of about 115 degrees to about 175 degrees. For toewardly projecting ribs, such as those shown in Figs. 1-4, a corresponding angle may be in a range of about 15 degrees to
about 65 degrees. One or more of the ribs may be substantially concave on an upward-facing surface. Such a configuration (or one or more aspects thereof) may result in a more toe-ward release of energy from midsole 516 to the user.

Illustrative Footwear Example 4

As shown in Fig. 6, this section describes another illustrative article of footwear 600. Footwear 600 is an example of footwear having a foam-filled flex-frame, as described in the overview above. Accordingly, corresponding components and aspects may share substantially identical characteristics as described above. Where aspects of footwear 600 are similar to those of footwear 100, corresponding features are labeled with versions of the same reference numbers, but starting with "6" rather than "1." For example, footwear 600 includes an upper portion 604 coupled to a sole portion 608 having an outsole 612, a midsole 616, and an interface portion 620, all generally as described above with respect to elements 104, 108, 112, 116, and 120.

Midsole 616 includes a filled flex-frame 624, which may be similar in structure and/or function to flex-frame 124 (and others described above). Flex-frame 624 may define a plurality of cells, such as cells 636A-636D (among others). Cells of flex-frame 624 may be substantially filled with a foam 628 (or other suitable high-rebound material).

Flex-frame 624 may include a plurality of ribs (or kinematic springs), a few of which are indicated at 644, 646, and 648. As shown, these ribs may be generally distributed (e.g., evenly spaced) across a length of midsole 616. The ribs may each have a reduced thickness and/or height, as compared to ribs of footwear 100, 400, or 500.

Similar to flex-frame 524, flex-frame 624 may include continuous upper and lower resilient members 632A and 632B forming a respective ceiling and base of the cells of flex-frame 624. In some embodiments (e.g., as shown in Figs. 8 and 9), one or both of portions 632A, 632B may be discontinuous (e.g., having gaps between adjacent ribs). For example, one or more compression spaces or zones, similar to those described above, may be formed between adjacent cells.

In some examples, such as the one depicted in Fig. 6, one or more of the ribs may be generally, substantially, or continually concave in a toe-ward or forward direction. For example, one or more of the ribs may be radiused between upper and
lower members 632A and 632B, such that a greater volume of an associated cell may be disposed in a heelward portion of the cell than in a toeward portion of the cell. In some examples, one or more of the ribs may instead be generally concave in a heelward or rear direction, and/or generally radiused such that a greater volume of an associated cell may be disposed in a toeward portion of the cell than in a heelward portion of the cell. In some examples, such curvature (or various combinations thereof) of one or more of the ribs may be configured to improve energy rebound of footwear 600, improve an associated weight distribution of the user provided by footwear 600 to an external surface, and/or improve a cushioning characteristic of footwear 600.

Illustrative Footwear Example 5

As shown in Fig. 7, this section describes another illustrative article of footwear 700. Footwear 700 is an example of footwear having a foam-filled flex-frame, as described in the overview above. Accordingly, corresponding components and aspects may share substantially identical characteristics as described above. Where aspects of footwear 700 are similar to those of footwear 100, corresponding features are labeled with versions of the same reference numbers, but starting with "7" rather than "1." For example, footwear 700 includes an upper portion 704 coupled to a sole portion 708 having an outsole 712, a midsole 716, and an interface portion 720, all generally as described above with respect to elements 104, 108, 112, 116, and 120.

Midsole 716 includes a filled flex-frame 724, which may be similar in structure and/or function to flex-frame 124 (and others described above). Flex-frame 724 may define a plurality of cells, such as cells 736A-736D (among others).

In contrast to flex-frames 124, 424, 524, and 624 described above, the cells of flex-frame 724 may be formed between a substantially continuous upper / ceiling member 732 above and outsole 712 below. In other words, outsole 712 is integrated with flex-frame 724. Said another way, a lower substantially continuous member of flex-frame 724 may form outsole 712.

Flex-frame 724 may further include a plurality of generally vertical ribs, a few of which are indicated at 744, 746, and 748. The ribs of flex-frame 724, in combination with upper and lower portions 732 and 712, may define the plurality of cells within flex-frame 724. By integrating outsole 712 into flex-frame 724, a more
organic or otherwise generally pleasing visual appearance may be achieved. Further, such integration may improve a structural integrity of footwear 700, and/or reduce a weight of the sole.

While the article of footwear is depicted as a work boot in Figs. 1-7, other types of footwear or shoes (e.g., sandals, athletic shoes, dress shoes, casual shoes, dance shoes, and orthopedic shoes) may include one or more of the structures described herein, such as a substantially foam filled flex-frame.

Illustrative Footwear Example 6

As shown in Fig. 8, this section describes another illustrative article of footwear 800. Footwear 800 is an example of footwear having a foam-filled flex-frame, as described in the overview above. Accordingly, corresponding components and aspects may share substantially identical characteristics as described above. Where aspects of footwear 800 are similar to those of footwear 100, corresponding features are labeled with versions of the same reference numbers, but starting with "8" rather than "1." For example, footwear 800 includes an upper portion 804 coupled to a sole portion 808 having an outsole 812, a midsole 816, and an interface portion 820, all generally as described above with respect to elements 104, 108, 112, 116, and 120.

Midsole 816 includes a filled flex-frame 824, which may be similar in structure and/or function to flex-frame 124 (and others described above). Flex-frame 824 may define a plurality of cells, such as cells 836A-836G (among others). The cells of flex-frame 824 may be substantially filled with a foam 828 (or other suitable high-rebound material). As shown, one or more of the cells of flex-frame 824 may be "open." For example, an entire perimeter of the cell may not be enclosed by the flex-frame. For example, a cell may be defined as an area substantially surrounded by (and/or enclosed by) an associated portion of flex-frame 824. As shown, backward-"C" shaped openings of one or more of the cells of flex-frame 824 may have open mouths facing in an upward and/or toeward (i.e., forward) direction. As shown in Fig. 8, this arrangement may also be described as having upside-down "L"-shaped ribs. Alternatively or additionally, one or more of these backward-"C" shaped openings may face in a downward and/or heelward (i.e., rearward) direction.

As described further above with reference to Fig. 6, an upper and/or lower member of the flex-frame may be discontinuous between adjacent cells. Such
discontinuities may be configured to provide a desired level of cushioning and/or energy rebound. For example, as shown in Fig. 8, upper portion 832A of flex-frame 824 is discontinuous between adjacent cells 836E and 836F (e.g., resulting in those cells being open). Such a discontinuous upper portion 832A may permit foam 828 to be continuous in midsole 816 (and/or throughout midsole 816 and into interface layer 820).

As also shown, flex-frame 824 includes a substantially continuous lower portion 832B. Alternatively and/or additionally, lower portion 832B may include one or more discontinuities, e.g., in a manner similar to upper portion 832A.

Illustrative Footwear Example 7

As shown in Fig. 9, this section describes another illustrative article of footwear 900. Footwear 900 is an example of footwear having a foam-filled flex-frame, as described in the overview above. Accordingly, corresponding components and aspects may share substantially identical characteristics as described above. Where aspects of footwear 900 are similar to those of footwear 100, corresponding features are labeled with versions of the same reference numbers, but starting with "9" rather than "1." For example, footwear 900 includes an upper portion 904 coupled to a sole portion 908 having an outsole 912, a midsole 916, and an interface portion 920, all generally as described above with respect to elements 104, 108, 112, 116, and 120.

Midsole 916 includes a filled flex-frame 924, which may be similar in structure and/or function to flex-frame 124 (and others described above). Flex-frame 924 may define a plurality of cells, such as cells 936A-936E. The cells of flex-frame 924 may be substantially filled with a foam 928 (or other suitable high rebound material).

As shown, one or more of these cells of flex-frame 924 may be of "open" construction, in a manner similar to those of flex-frame 824. For example, flex-frame 924 may include a discontinuous upper portion 932A and/or a discontinuous lower portion 932B. In the example shown in Fig. 9, portions 932A and 932B are both discontinuous resulting in flex-frame 924 comprising a plurality of discrete sections or disconnected parts. As shown Fig. 9, these discrete sections may have substantially "V"- and/or "W"-shaped section profiles, with the "W"-shaped section being disposed in an arch (or central) region of midsole 916. Alternatively, one or more "W"-shaped sections may be disposed in a toe and/or heel region of midsole 916. One or more
"V"-shaped sections may be disposed in an arch region of midsole 916. In some embodiments, the flex-frame may include sections (e.g., discrete or continuous) having other cross-sectional profiles, such as "Z" shapes, "T" shapes, 'I' shapes, or free form shapes.

As indicated, cells 936A, 936B, 936D, and 936E may be respectively defined between opposing portions of adjacent discrete sections of flex-frame 924, and/or between discontinuous upper portion 932A and outsole 912. Cell 936C may be defined between a central portion of the "W"-shaped discrete section of flex-frame 924 and outsole 912. Such a configuration may permit a majority of foam 928 to be continuous in midsole 916 (and/or throughout a majority of midsole 916 and extending from interface layer 920 to outsole 912).

Illustrative Method of Use

The foot of a user may be secured in an article of footwear in accordance with aspects of the present disclosure. The footwear may include a sole having a substantially filled flex-frame. For example, the flex-frame may be substantially filled by foam, such as foam 128, or another high-rebound material. The flex-frame may comprise a midsole and/or a midsole/outsole portion of the footwear. The sole may be attached to an upper of the footwear. Securing the foot in the footwear may include the user substantially securing the foot in the upper. For example, the user may dispose their foot in the upper, and tighten (or otherwise at least temporarily secure the upper to their foot), for example via operation of laces, straps, or other suitable tightening device, which may be included (or coupled to) the upper of the footwear.

The flex-frame may then be substantially compressed, such as when the user is walking. For example, the user may substantially compress the flex-frame by applying pressure to an external surface with their foot via the flex-frame. The flex-frame (and/or the material substantially filling the flex-frame, such as foam 128 or another suitable high-rebound material) may absorb energy transferred to the sole via compression thereof.

Substantial decompression of the flex-frame may then be performed. For example, the user may at least partially remove pressure from the external surface via the flex-frame. Such at least partial removal of pressure (or force) may permit the flex-frame and/or the material substantially filling the flex-frame (e.g., foam 128) to
substantially transfer the absorbed energy to the user. Such a transfer (or return) of energy may improve a responsiveness of the footwear, a cushioning effect imparted to the user's foot by the footwear, and/or a velocity at which the user may travel, among other characteristics. In some examples, decompression of the flex-frame may be aided by expansion of the previously-compressed foam filling.

Additional Examples and Features
This section describes aspects and features of footwear having a filled flex-frame midsole, presented without limitation as a series of paragraphs, some or all of which may be alphanumerically designated for clarity and efficiency. Each of these paragraphs can be combined with one or more other paragraphs, and/or with disclosure from elsewhere in this application, including the materials incorporated by reference in the Cross-References, in any suitable manner. Some of the paragraphs below expressly refer to and further limit other paragraphs, providing without limitation examples of some of the suitable combinations.

AO. An article of footwear comprising:
an upper; and
a sole portion coupled to the upper and including an outsole and a midsole;
the midsole including a resiliently-flexible kinematic frame having a plurality of cells, and a foam at least partially surrounding the frame;
wherein the frame comprises a solid material having a greater stiffness than the foam.

A1. The article of footwear of AO, wherein the solid material of the frame comprises nylon.

A2. The article of footwear of AO, wherein the foam comprises ethylene-vinyl acetate.

A3. The article of footwear of AO, wherein the foam substantially fills an interior of one or more of the cells.
A4. The article of footwear of AO, wherein adjacent cells of the frame are spaced apart, defining a respective compression zone there between, each compression zone being substantially filled with the foam.

A5. The article of footwear of AO, wherein the frame comprises at least one continuous member running along a length of the sole and defining a respective perimeter portion of each of the cells.

A6. The article of footwear of A5, wherein the at least one continuous member forms a respective lower portion of each of the cells.

A7. The article of footwear of A5, wherein the at least one continuous member comprises an upper continuous member and a lower continuous member, and the plurality of cells are formed between the upper and lower continuous members.

A8. The article of footwear of A7, wherein the lower continuous member comprises the outsole.

B0. A sole for an article of footwear, the sole comprising:

   a midsole including a plurality of cells each defining an internal volume and mechanically coupled to form a unitary resilient frame; and

   a compressible foam surrounding the plurality of cells and filling the internal volume of at least one of the cells;

   wherein the resilient frame has a higher stiffness than the foam.

B1. The sole of B0, wherein the frame has sufficient stiffness to support an expected user without collapsing.

B2. The sole of B0, wherein the frame comprises a thermoplastic material.

B3. The sole of B2, wherein the thermoplastic material is nylon.
B4. The sole of BO, wherein the unitary frame is a single, molded piece.

B5. The sole of B4, wherein the foam is co-molded with the frame.

B6. The sole of BO, further comprising an outsole coupled to the midsole.

B7. The sole of BO, wherein the frame comprises at least one lengthwise continuous member joining the plurality of cells.

B8. The sole of BO, wherein adjacent cells are spaced apart along a length of the sole, such that a respective gap is formed between adjacent cells.

B9. The sole of B8, wherein each respective gap between adjacent cells is filled with the foam.

B10. The sole of BO, wherein the plurality of cells are arranged in a single layer of side-by-side cells.

CO. An article of footwear comprising:

an upper; and

a sole coupled to the upper, the sole including a plurality of molded spring-like cells integrated into a single layer to form a flexibly resilient kinematic frame, each cell extending at least partially across a width of the sole;

wherein an interior volume of each cell is substantially filled with a compressible foam material.

C1. The article of footwear of CO, wherein each cell has a polygonal cross section taken along a long axis of the sole.

C2. The article of footwear of CO, wherein the layer of cells are connected by at least one common lengthwise member.
C3. The article of footwear of C2, wherein the at least one common lengthwise member comprises an upper member and the cells depend downward from the upper member.

C4. The article of footwear of C2, wherein the at least one common lengthwise member comprises a lower member and the cells extend upward from the lower member.

C5. The article of footwear of C2, wherein the at least one common lengthwise member comprises an upper member and a lower member, and the cells are formed between the upper and lower members.

C6. The article of footwear of C0, wherein each of the cells is angled forward toward a toe of the footwear, such that an upper portion of each cell is farther forward than a lower portion of the same cell.

C7. The article of footwear of C0, wherein the frame further comprises at least one gap between adjacent cells.

C8. The article of footwear of C7, wherein the at least one gap is substantially filled with the foam.

C9. The article of footwear of C0, wherein a lower portion of the frame comprises an outsole.

D0. A sole for footwear, the sole comprising:
    a flex-frame defining a plurality of cells; and
    foam substantially filling one or more of the cells.

D1. The sole of paragraph D0, wherein the foam generally fills each cell of the plurality of cells.

D2. The sole of paragraph D1, wherein the foam completely fills one or more of the cells.
D3. The sole of paragraph D2, wherein the foam completely fills each cell of the plurality of cells.

D4. The sole of paragraph D0, wherein adjacent cells are spaced apart defining a compression zone therebetween, the compression zone being generally filled with foam.

D5. The sole of paragraph D0, wherein a lower portion of the flex-frame forms an outsole portion of the sole configured to engage an external surface.

E0. Footwear comprising:
an upper for receiving a foot of a user; and
a sole including a midsole and an outsole, the midsole being coupled to the upper, the outsole being disposed opposite the upper relative to the midsole, the outsole being configured to transfer kinetic energy between the foot of the user and an external surface via the midsole, the midsole including a substantially flexible framework defining a plurality of cells, one or more of the cells being substantially filled with foam.

E1. The footwear of paragraph E0, wherein each of the cells has a respective volume, a majority of the volume of each cell being filled with foam.

E2. The footwear of paragraph E1, wherein the entire volume of each cell is generally filled with foam.

E3. The footwear of paragraph E2, wherein the entire volume of each cell in a vertical section of the midsole taken along an elongate axis of the midsole is completely filled with foam.

E4. The footwear of paragraph E0, wherein the foam includes closed-cell foam.

E5. The footwear of paragraph E0, wherein the foam includes open-cell foam.
F0. Footwear comprising:
an upper; and
a sole including a substantially resilient member forming a continuous flex-frame that defines a plurality of cells, at least one of the cells being substantially filled with foam.

F1. The footwear of paragraph F0, wherein adjacent cells are spaced apart to define a compression zone there between, the compression zone being generally filled with foam.

F2. The footwear of paragraph F1, wherein the compression zone and the flex-frame are disposed between the upper and an outsole portion of the footwear.

F3. The footwear of paragraph F2, wherein the compression zone is adjacent the upper.

F4. The footwear of paragraph F2, wherein the compression zone is adjacent the outsole portion of the sole.

F5. The footwear of paragraph F0, wherein the flex-frame and the plurality of cells extend across an entire width of the footwear.

F6. The footwear of paragraph F0, wherein the flex-frame is made of nylon, and the foam is made of ethylene-vinyl acetate (EVA).

GO. A method comprising:
substantially securing a foot of a user in an article of footwear, the footwear including a sole having a substantially foam-filled flex-frame;
substantially compressing the flex-frame, thereby absorbing energy therein;
and
substantially decompressing the flex-frame, thereby transferring the absorbed energy to the user.
G.1. The method of GO, wherein decompression of the flex-frame is aided by expansion of the foam.

**Conclusion**

The disclosure set forth above may encompass multiple distinct examples with independent utility. Although each of these has been disclosed in its preferred form(s), the specific embodiments thereof as disclosed and illustrated herein are not to be considered in a limiting sense, because numerous variations are possible. To the extent that section headings are used within this disclosure, such headings are for organizational purposes only. The subject matter of the invention(s) includes all novel and nonobvious combinations and subcombinations of the various elements, features, functions, and/or properties disclosed herein. The following claims particularly point out certain combinations and subcombinations regarded as novel and nonobvious. Other combinations and subcombinations of features, functions, elements, and/or properties may be claimed in applications claiming priority from this or a related application. Such claims, whether broader, narrower, equal, or different in scope to the original claims, also are regarded as included within the subject matter of the present disclosure.
WHAT IS CLAIMED IS:

1. An article of footwear comprising:
   an upper; and
   a sole portion coupled to the upper and including an outsole and a midsole;
   the midsole including a resiliently-flexible kinematic frame having a plurality of cells, and a foam at least partially surrounding the frame;
   wherein the frame comprises a solid material having a greater stiffness than the foam.

2. The article of footwear of claim 1, wherein the solid material of the frame comprises nylon.

3. The article of footwear of claim 1, wherein the foam comprises ethylene-vinyl acetate.

4. The article of footwear of claim 1, wherein the foam substantially fills an interior of one or more of the cells.

5. The article of footwear of claim 1, wherein the frame comprises at least one continuous member running along a length of the sole and defining a respective perimeter portion of each of the cells.

6. The article of footwear of claim 5, wherein the at least one continuous member forms a respective lower portion of each of the cells.

7. The article of footwear of claim 5, wherein the at least one continuous member comprises an upper continuous member and a lower continuous member, and the plurality of cells are formed between the upper and lower continuous members.
8. A sole for an article of footwear, the sole comprising:
   a midsole including a plurality of cells each defining an internal volume and
   mechanically coupled to form a unitary resilient frame; and
   a compressible foam surrounding the plurality of cells and filling the internal
   volume of at least one of the cells;
   wherein the resilient frame has a higher stiffness than the foam.

9. The sole of claim 8, wherein the frame has sufficient stiffness to
   support an expected user without collapsing.

10. The sole of claim 8, wherein the frame comprises a thermoplastic
    material.

11. The sole of claim 8, wherein the unitary frame is a single, molded
    piece.

12. The sole of claim 8, wherein the frame comprises at least one
    lengthwise continuous member joining the plurality of cells.

13. The sole of claim 8, wherein adjacent cells are spaced apart along a
    length of the sole, such that a respective gap is formed between adjacent cells.

14. The sole of claim 8, wherein the plurality of cells are arranged in a
    single layer of side-by-side cells.

15. An article of footwear comprising:
    an upper; and
    a sole coupled to the upper, the sole including a plurality of molded spring-like
    cells integrated into a single layer to form a flexibly resilient kinematic frame, each
    cell extending at least partially across a width of the sole;
    wherein an interior volume of each cell is substantially filled with a
    compressible foam material.
16. The article of footwear of claim 15, wherein a cross section of each cell taken parallel to a long axis of the sole is generally polygonal.

17. The article of footwear of claim 15, wherein the layer of cells are connected by at least one common lengthwise member.

18. The article of footwear of claim 17, wherein the at least one common lengthwise member comprises an upper member and a lower member, and the cells are formed between the upper and lower members.

19. The article of footwear of claim 15, wherein each of the cells is angled forward toward a toe of the footwear, such that an upper portion of each cell is farther forward than a lower portion of the same cell.

20. The article of footwear of claim 15, wherein a lower portion of the frame comprises an outsole.
A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - A43B 13/18 (2016.01)
CPC - A43B 13/181
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)
IPC(8) Classification(s): A43B 7/14, 13/18, 13/20, 13/22 (2016.01); CPC Classification(s): A43B 7/148, 13/18, 13/181, 13/22, 13/223; USPC Classification(s): (if searched): 36/29, 32, 58.5, 59, 83, 103, 114

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PatSeer (US, EP, WO, JP, DE, GB, CN, FR, KR, ES, AU, IN, CA, INPADOC Data); IP.com; IEEE/IEEEXplore; Google/Google Scholar; EBSCO; Keywords: footwear, shoe, boot, sneaker, rubber-soled w2 show, footgear, galoshes, sole, outsole, midsole, tread, base, intermediate w2 sole, resiliently-flexible w2 kinematic, resilient*, kinematic, flex*, frame, casing, framework, truss, skeleton, cells, opening, aperture, cavity, groove, foam, rubber, polyurethane, open-cell* w2 foam, open-cell, cell* w2 foam, stiff*, durable, strong*

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>X Y</td>
<td>US 2008/0271342 A1 (LUCAS, R J et al.) November 6, 2008; figures 14, 16, 20, 21, 24, 27, 28A; paragraphs [0096], [0097], [0100], [0101], [0103], [0109], [0115], [0117], [0121], [0123]</td>
<td>1-18, 20 *** 19</td>
</tr>
<tr>
<td>A</td>
<td>US 6,769,202 B1 (LUTHI, S et al.) August 3, 2004; figures 1, 5; column 3, lines 20-25, and lines 45-50; column 4, lines 10-15</td>
<td>19</td>
</tr>
</tbody>
</table>

Further documents are listed in the continuation of Box C.

<table>
<thead>
<tr>
<th>I</th>
<th>T</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>Special categories of cited documents:</td>
<td>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</td>
<td>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</td>
</tr>
<tr>
<td>&quot;A&quot; document defining the general state of the art which is not considered to be of particular relevance</td>
<td>&quot;X&quot; 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</td>
<td>&quot;X&quot; 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</td>
</tr>
<tr>
<td>&quot;E&quot; earlier application or patent but published on or after the international filing date</td>
<td>&quot;Y&quot; 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</td>
<td>&quot;Y&quot; 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</td>
</tr>
<tr>
<td>&quot;L&quot; document which may throw doubts on priority claim(s), or which is cited to establish the publication date of another citation or other special reason (as specified)</td>
<td>&quot;Z&quot; member of the same family document</td>
<td>&quot;Z&quot; document member of the same patent family</td>
</tr>
<tr>
<td>&quot;O&quot; document referring to an oral disclosure, use, exhibition or other means</td>
<td>&quot;P&quot; document published prior to the international filing date but later than the priority date claimed</td>
<td></td>
</tr>
</tbody>
</table>

Date of the actual completion of the international search | Date of mailing of the international search report |
---|---|
15 February 2016 (15.02.2016) | 07 MAR 2016 |

Name and mailing address of the ISA/Authorized officer
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents
P.O. Box 1450, Alexandria, Virginia 22313-1450
Facsimile No. 571-273-8300
PCT Helpdesk: 571-272-4300 PCT OPS: 571-272-7774
Shane Thomas

Form PCT/ISA/210 (second sheet) (January 2015)