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(54) **ARTICULATED PROTECTIVE APPARATUS**

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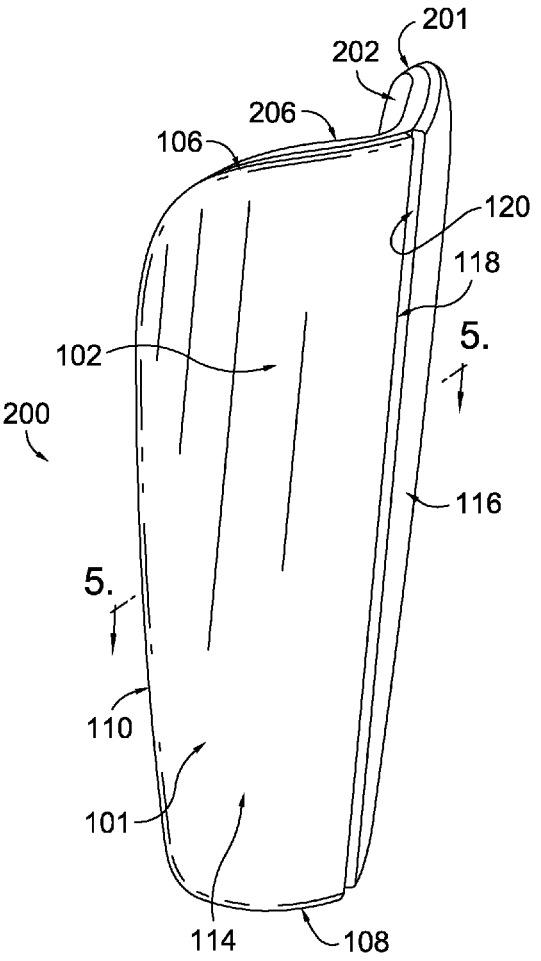
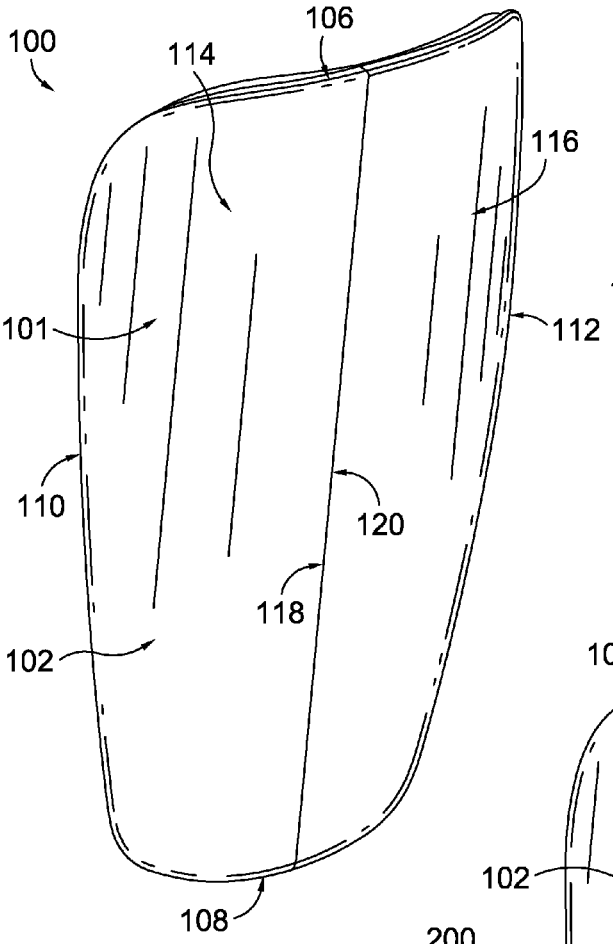
(57) **ABSTRACT**

Aspects of the present invention relate to a protective apparatus that is comprised of an impact shell and an impact attenuating structure. The impact shell includes two discrete portions that are moveably hinged to one another to conform to the underlying protected portion, such as an athlete's shin region. The protective apparatus also utilizes an impact attenuating structure that functions to attenuate an impact force as well as serve as a hinge between the two-part shell. Additional aspects include a puncture prevention element that is positioned between the two shell portions to resist impalement at the hinge junction formed between the two shell portions. Further, additional aspects utilize one or more channels on a posterior surface of the impact attenuating structure to aid in guiding the articulation of the impact attenuating structure in a location related to the shell articulation joint.




100
114
106
116
101
112
110
120
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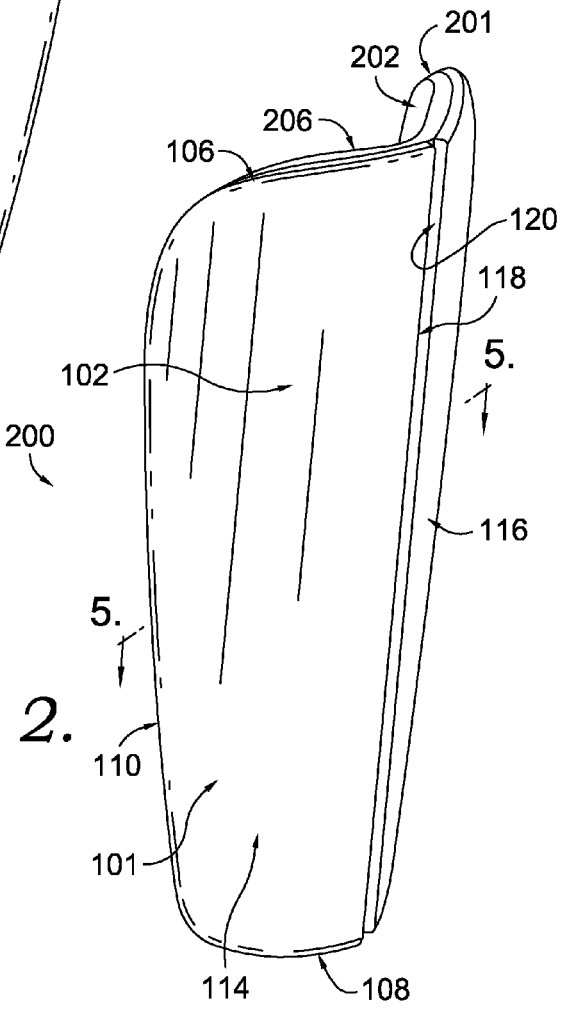
108

FIG. 1.


201
202
206
106
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118
102
5.
200
116
5.
110
101
114
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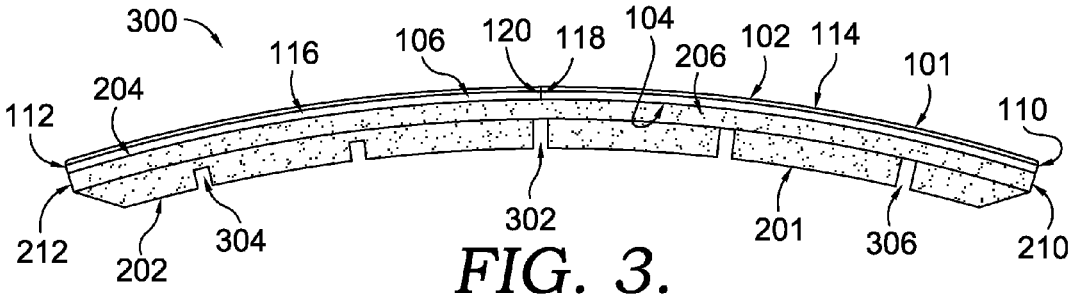
FIG. 2.


300
116
106
120
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101
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304
302
201
306
210

FIG. 3.

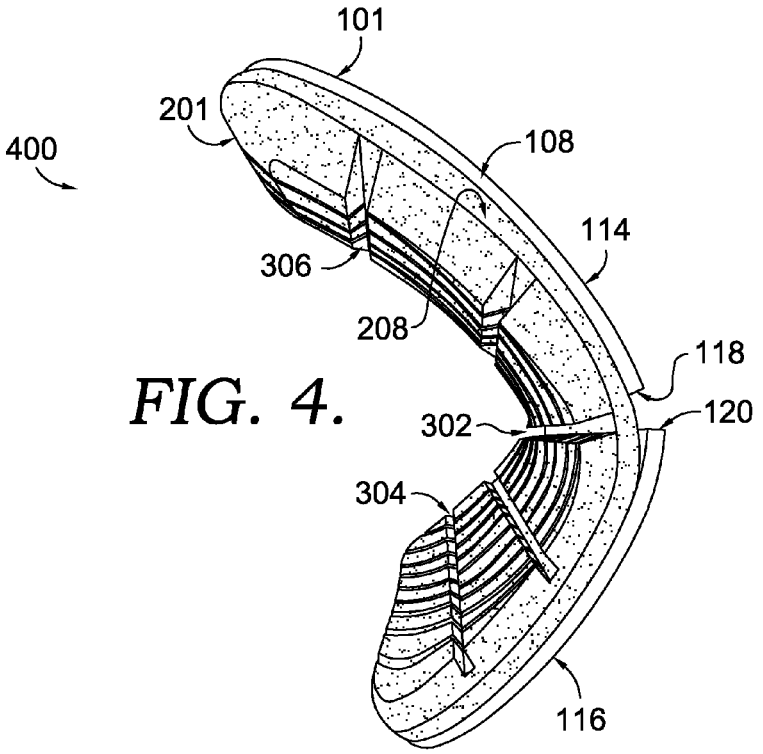
101
201
400
108
114
306
208
118
120
302
304
116

FIG. 4.

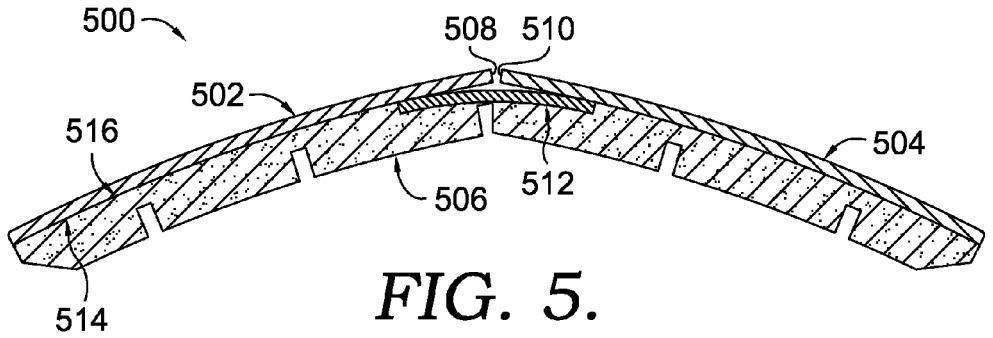

FIG. 5.

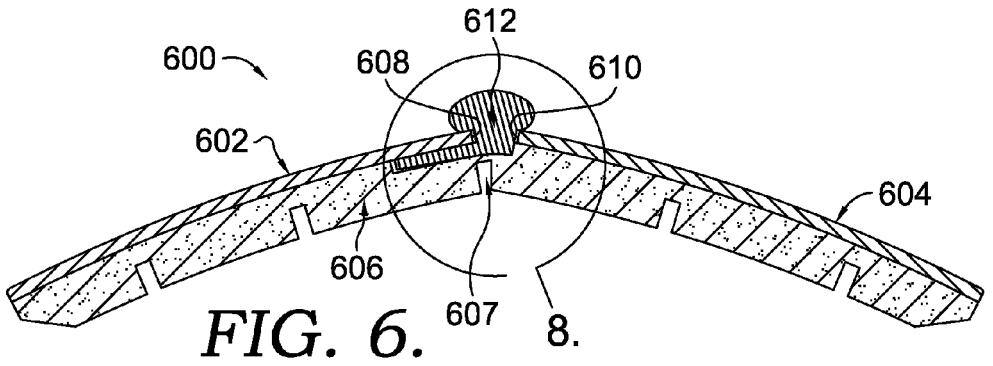

FIG. 6.

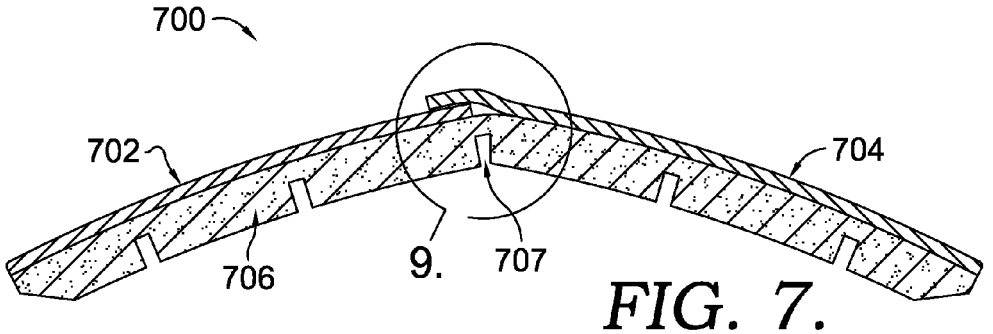

FIG. 7.

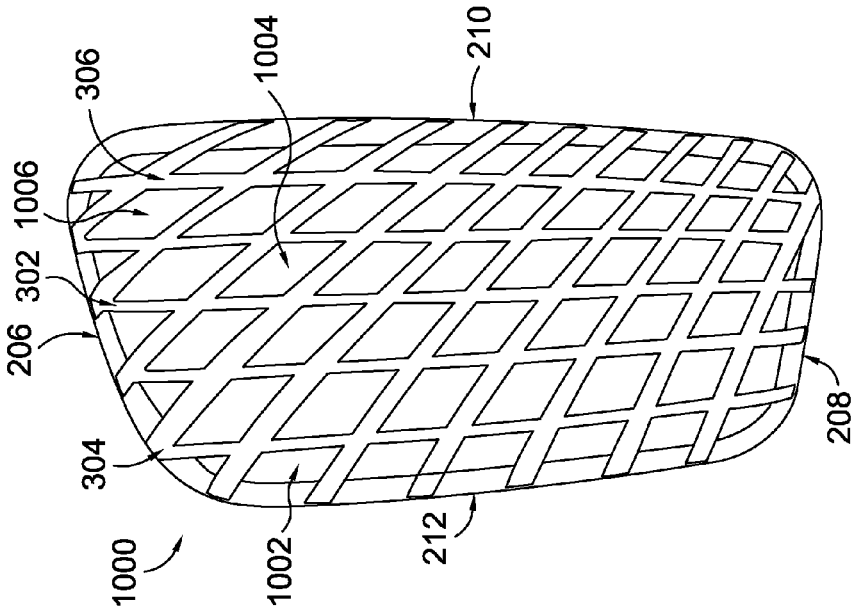

FIG. 10.

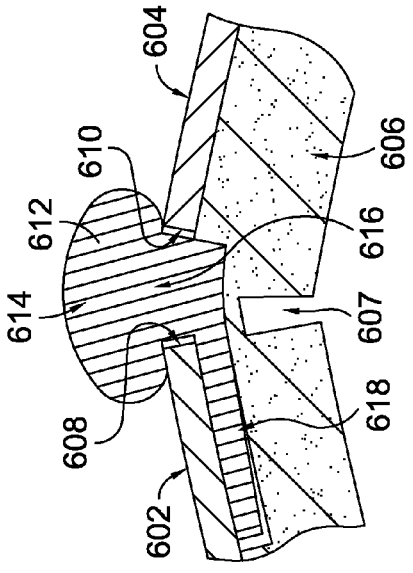

FIG. 8.

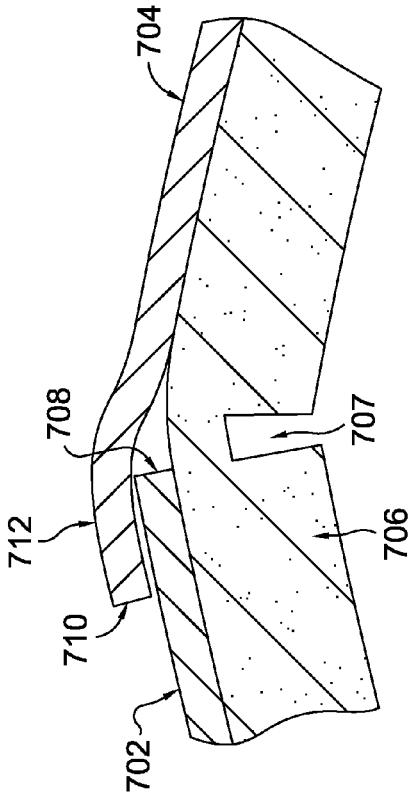

FIG. 9.

ARTICULATED PROTECTIVE APPARATUS

BACKGROUND

[0001] A protective apparatus, such as a shin guard or other padded elements, are traditionally used to limit an impact force experienced by a person or an object. Some examples of protective apparatus rely on foam-like materials that are placed between a protected surface and a point of impact. As part of some certification and testing plans, a protective apparatus must exhibit an ability to resist a puncture. A puncture force may be exerted by a cleat or spike on an opposing player's footwear, for example. However, because a foam-like material may not provide the level of puncture prevention desired, a rigid shell may be used in combination with the foam-like material. However, the rigid shell is not conducive to fitting a variety of wearers not adapting to the desired fit of the wearer.

SUMMARY

[0002] Aspects of the present invention relate to a protective apparatus that is comprised of an impact shell and an impact attenuating structure. The impact shell includes two discrete portions that are moveably hinged to one another to conform to the underlying protected portion, such as an athlete's shin region. The protective apparatus also utilizes an impact attenuating structure that functions to attenuate an impact force as well as serve as a hinge between the two-part shell. Additional aspects may include a puncture prevention element that is positioned between the two shell portions to resist impalement at the hinge junction formed between the two shell portions. Further, additional aspects may utilize one or more channels on a posterior surface of the impact attenuating structure to aid in guiding the articulation of the impact attenuating structure in a location related to the shell articulation joint.

[0003] This Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0004] Illustrative embodiments of the present invention are described in detail below with reference to the attached drawing figures, which are incorporated by reference herein and wherein:

[0005] FIG. **1** illustrates an exemplary protective apparatus, in accordance with aspects of the present invention;

[0006] FIG. **2** illustrates a side perspective of an articulated protective apparatus exposing the articulation joint between the medial shell element and the lateral shell element, in accordance with aspects of the present invention;

[0007] FIG. **3** illustrates a top-down view of an articulated protective apparatus, in accordance with aspects of the present invention;

[0008] FIG. **4** illustrates an exemplary bottom-up perspective of an articulated protective apparatus in an articulated configuration, in accordance with aspects of the present invention;

[0009] FIG. **5** illustrates a cross sectional view of an articulated protective apparatus along the cutline **5-5** of FIG. **2**, in accordance with aspects of the present invention;

[0010] FIG. **6** illustrates a cross sectional view of an articulated protective apparatus along a similar cutline as that depicted in FIG. **5**, in accordance with aspects of the present invention;

[0011] FIG. **7** illustrates a shell overlap puncture prevention arrangement for an articulated protection apparatus, in accordance with aspects of the present invention;

[0012] FIG. **8** is an illustration of a puncture prevention element, in accordance with aspects of the present invention;

[0013] FIG. **9** illustrates a focused view of the articulated protection apparatus of FIG. **7**, in accordance with aspects of the present invention; and

[0014] FIG. **10** illustrates a posterior surface of an impact attenuating structure in accordance with aspects of the present invention.

DETAILED DESCRIPTION

[0015] The subject matter of embodiments of the present invention is described with specificity herein to meet statutory requirements. However, the description itself is not intended to limit the scope of this patent. Rather, the inventors have contemplated that the claimed subject matter might also be embodied in other ways, to include different elements or combinations of elements similar to the ones described in this document, in conjunction with other present or future technologies.

[0016] Aspects of the present invention relate to a protective apparatus that is comprised of an impact shell and an impact attenuating structure. The impact shell includes two discrete portions that are moveably hinged to one another to conform to the underlying protected portion, such as an athlete's shin region. The protective apparatus also utilizes an impact attenuating structure that functions to attenuate an impact force as well as serve as a hinge between the two-part shell. Additional aspects include a puncture prevention element that is positioned between the two shell portions to resist impalement at the hinge junction formed between the two shell portions. Further, additional aspects utilize one or more channels on a posterior surface of the impact attenuating structure to aid in guiding the articulation of the impact attenuating structure in a location related to the shell articulation joint.

[0017] Accordingly, in one aspect, the present invention provides an articulated protective apparatus. The articulated protective apparatus includes an impact shell having an anterior surface, an opposite posterior surface, a medial edge, an opposite lateral edge, a superior edge, and an opposite inferior edge. The impact shell further comprises a medial shell element extending from the superior edge to the inferior edge and from the medial edge to a medial hinge edge. The impact shell further comprises a lateral shell element extending from the superior edge to the inferior edge and from the lateral edge to a lateral hinge edge. The medial shell element is physically independent of the lateral shell element. The articulated apparatus is further comprised of an impact attenuating structure having a posterior surface, an opposite anterior surface, a medial edge, an opposite lateral edge, a superior edge, and an opposite inferior edge. The impact attenuating structure anterior surface is directly coupled to the posterior surface of the impact shell near a portion of the medial shell element and also near a portion of the lateral shell element.

[0018] In another aspect, the present invention provides an articulated protective apparatus having a two-part impact shell. The two-part shell is comprised of an anterior surface and an opposite posterior surface and a medial edge, an opposite lateral edge, a superior edge, and an opposite inferior edge. The two-part impact shell also is formed from a medial shell element extending from the superior edge to the inferior edge and from the medial edge to a medial hinge edge. The two-part shell is also formed from a lateral shell element extending from the superior edge to the inferior edge and from the lateral edge to a lateral hinge edge. The articulated protective apparatus also includes an impact attenuating structure having a posterior surface, an opposite anterior surface, a medial edge, an opposite lateral edge, a superior edge, and an opposite inferior edge. The impact attenuating structure anterior surface is coupled to the posterior surface of the impact shell proximate a portion of the medial shell element and proximate a portion of the lateral shell element. The impact attenuating structure includes a channel extending from the superior edge to the inferior edge of the impact attenuating structure on the posterior surface. Additionally, the articulated protection apparatus includes a puncture prevention element coupled with the impact attenuating structure on the impact attenuating structure anterior surface proximate the channel.

[0019] A third aspect of the present invention also provides an articulated protective apparatus comprising a two-part impact shell having an anterior surface and an opposite posterior surface. The posterior surface is curved toward the anterior surface between a medial edge and an opposite lateral edge. The two-part impact shell is comprised of (1) a medial shell element extending from the superior edge to the inferior edge and from the medial edge to a medial hinge edge and (2) a lateral shell element extending from the superior edge to the inferior edge and from the lateral edge to a lateral hinge edge. Further, the articulated protective apparatus includes an impact attenuating structure having a posterior surface and an anterior surface. The impact attenuating structure anterior surface is coupled to the posterior surface of the impact shell near a portion of the medial shell element and also near a portion of the lateral shell element. The impact attenuating structure is comprised of (1)

[0020] a hinge channel extending from the superior edge to the inferior edge of the impact attenuating structure on the posterior surface corresponding proximately with the lateral hinge edge; (2) a lateral channel extending from the superior edge to the inferior edge of the impact attenuating structure on the posterior surface between the lateral edge and the hinge channel; and (3) a medial channel extending from the superior edge to the inferior edge of the impact attenuating structure on the posterior surface between the medial edge and the hinge channel. The lateral channel is recessed into the impact attenuating structure a greater amount than the medial channel.

[0021] Having briefly described an overview of embodiments of the present invention, a more detailed description follows.

[0022] The protective apparatus is contemplated as providing protection to one or more portions of a body or object. For example, it is contemplated that a protective apparatus implementing one or more aspects provided herein may be utilized to provide protection (e.g., puncture prevention) and/or force damping functions to a variety of body parts. Examples include, but are not limited to, shin guards, knee pads, hip pads, abdominal pads, chest pads, shoulder pads, arm pads, and elbow pads. Therefore, it is contemplated that aspects provided herein may be useful in a variety of situations at a variety of locations.

[0023] A protective apparatus, as provided herein, is an article for reducing an effect of an impact force on an associated portion of a wearer. For example, a shin guard utilizing features discussed herein may reduce the perception of energy imparted on the shin region of a user through the use of the protective apparatus. This change in perception may be accomplished in a variety of ways. For example, the energy applied at a point of impact may be distributed over a greater surface area, such as through a rigid/semi-rigid impact shell. Further, it is contemplated that a dissipating/absorbing material (i.e., an impact attenuating structure) may provide a compressive function for absorbing and/or dissipating a portion of the impact force. Aspects of the present invention look to provide at least some of the advantages of a protective apparatus (e.g., energy distribution and energy absorption) while reducing some of the disadvantages associated with a traditional non-conforming rigid portions of a protective apparatus.

[0024] FIG. **1** illustrates an exemplary protective apparatus **100**, in accordance with aspects of the present invention. The protective apparatus **100** is depicted as a shin guard having an impact shell **101** (also referred to as a "shell" herein) that has an anterior surface **102**, which is a surface more forward from the wearer when in an as-worn position than an opposite posterior surface (identified as posterior surface **104** in FIG. **3** hereinafter). The posterior surface of the shell **101** is typically closer to the wearer when in an as-worn position than the anterior surface **102**. The shell **101** is also defined by a perimeter that is formed from a superior edge **106**, a medial edge **112**, an inferior edge **108**, and a lateral edge **110**.

[0025] As can be appreciated by one of skill in the art, a shin guard may be produced in a right-leg orientation and a left-leg orientation. Therefore, while one or more orientations are depicted, it is contemplated that concepts similar to those discussed and depicted may be translated to the opposite orientation. Stated differently, while a right shin guard may be discussed herein, it is contemplated that a left shin guard having a mirror-image orientation is also contemplated. Further, human anatomical relational terms are used herein (e.g., medial, lateral, superior, inferior, posterior, and anterior) as general locational terms for reference. However, it is contemplated that alternative aspects may be implemented that are contrary to the terms meaning with respect to a human body. Stated differently, a medial edge of a protective apparatus is contemplated, in an exemplary aspect, of being located proximate a lateral relative location on the wearer, for example.

[0026] Returning to the shell **101**, it is contemplated that a medial shell element **116** and a separate lateral shell element **114** form the shell **101**, at least in part. For example, it is contemplated that the medial shell element **116** and the lateral shell element **114** are the only two elements forming the entirety of the shell **101**, in an exemplary aspect. In this example, the medial shell element **116** and the lateral shell element **114** are connected by a flexible joint allowing for the shell to articulate about the joint (e.g., hinge). In an alternative aspect, it is contemplated that three or more elements may be used in conjunction to form the totality of the shell.

[0027] The medial shell element **116** is comprised of a medial hinge edge **120** that is opposite the medial edge **112** previously discussed with the shell **101** in the entirety. The

medial shell element **116** extends from the superior edge **106** to the opposite inferior edge **108** and between the medial edge **112** and the medial hinge edge **120**. A posterior surface and an anterior surface of the medial shell element **116** form a portion of the respective posterior and anterior surfaces **102** of the shell **101**.

[0028] Similarly, the lateral shell element **114** is comprised of a lateral hinge edge **118** that is opposite the lateral edge **110** previously discussed with the shell **101** in the entirety. The lateral shell element **114** extends from the superior edge **106** to the opposite inferior edge **108** and between the lateral edge **110** and the lateral hinge edge **118**. A posterior surface and an anterior surface of the lateral shell element **114** form a portion of the respective posterior and anterior surfaces **102** of the shell **101**.

[0029] The lateral hinge edge **118** and the medial hinge edge **120** define a physical separation between the lateral shell element **114** and the medial shell element **116**, which allows for the shell **101** to flex and articulate as if hinged proximate the separation between the lateral hinge edge **118** and the medial hinge edge **120**. This hinge (e.g., articulation joint) allows for a rigid or semi-rigid shell to conform to the shape of the wearer and to move with changes to the underlying form of the wearer (e.g., flexing of a calf muscle, differences in sock/sheath material thickness). Consequently, a common shell geometry may be offered to a variety of different consumers having different sizing needs as the hinged shell can adapt by articulating or bending while still having a functional shell.

[0030] A shell is contemplated as being constructed from a number of materials, such as polymer-based materials, infused materials (e.g., carbon-fiber, fiberglass, and aramids), natural materials, metals, and the like. Additionally, it is contemplated that the shell may be constructed from a rapid manufacturing process such as an additive (e.g., laser sintering, polymer deposition) or reductive process. Additionally, it is contemplated that a shell may be constructed from a carbon fiber material comprised of carbon fiber and binders (e.g., resins) to form a durable light-weight material.

[0031] The shell is contemplated to provide several functional attributes to the protective apparatus. For example, a force distribution function may be desired. As a result, a rigid or semi-rigid material that is able to distribute a focused force across a larger surface area may be implemented. Similarly, it is contemplated that the shell functions to prevent a puncture. In an exemplary aspect, an opponent may have a cleat or spike on the underside of a shoe that could puncture an inappropriately selected material. As a result, a material, such as those listed above, may be utilized in the shell to resist impalement of the wearer. The prevention of impalement by implementing puncture resistant materials, elements, and geometries will be discussed in greater detail hereinafter with respect to the hinge region formed between the medial shell element **116** and the lateral shell element **114**.

[0032] While not identified explicitly in FIG. **1**, it is contemplated that an impact attenuating structure, such as a padded element, is coupled to the posterior surface of the shell **101**. As will be discussed in greater detail hereinafter, the impact attenuating structure may serve several functions. For example, the impact attenuating structure may dissipate and attenuate an impact force experienced by the shell. Further, the impact attenuating structure may serve as a flexible hinge member between the medial shell element **116** and the lateral shell element **114**. As a flexible hinge member, the impact attenuating structure allows the articulated protective apparatus to flex while maintain a spatial and relative relationship between the different shell elements.

[0033] FIG. **2** illustrates a side perspective of an articulated protective apparatus **200** exposing the articulation joint between the medial shell element **116** and the lateral shell element **114**, in accordance with aspects of the present invention. As discussed with respect to FIG. **1** above, the shell **101** is comprised of the superior edge **106**, the inferior edge **108**, the lateral edge **110**, the lateral hinge edge **118**, the medial hinge edge **120**, the lateral shell element **114**, and the medial shell element **116**. Additionally depicted is an impact attenuating structure **201** having a posterior surface **202** and an anterior surface along with a superior edge **206**.

[0034] As illustrated, a hinge is formed between the medial hinge edge **120** of the medial shell element **116** and the lateral hinge edge **118** of the lateral shell element **114**. In this example, a gap is less pronounces as the curvature of the posterior surface of the shell **101** is extended in the direction of the anterior surface of the shell **101**. Stated differently, as the diameter of a curve of the shell **101** is reduced, a gap expands between the medial shell element **116** and the lateral shell element **114** at the hinge to allow for the articulation of the elements for reducing the curve diameter.

[0035] Also depicted in FIG. **2** is a cutline **5-5** extending horizontally through the articulated protective apparatus **200** from the lateral edge **110** to the medial edge. The cutline view is illustrated in FIG. **5** hereinafter.

[0036] FIG. **3** illustrates a top-down view of an articulated protective apparatus **300**, in accordance with aspects of the present invention. In an exemplary aspect, the articulated protective apparatus **300** is similar to that which was discussed with respect to FIG. **1** and FIG. **2** hereinabove. As previously discussed the articulated protective apparatus **300** is comprised of a shell **101** and an impact attenuating structure **201**. The shell **101** is formed with a lateral edge **110**, a superior edge **106**, a medial edge **112** and an inferior edge (not identified in FIG. **3**). Further, the shell **101** is comprised of a medial shell element **116** and a lateral shell element **114**. The medial shell element is defined as extending between the medial edge **112** and a medial hinge edge **120**. The lateral shell element **114** is defined as extending between the lateral edge **110** and a lateral hinge edge **118**. Further, the shell **101** has a posterior surface **104** and an anterior surface **102**.

[0037] The impact attenuating structure **201** is comprised of an anterior surface **204** and a posterior surface **202**. Further the impact attenuating structure **201** is comprised of a superior edge **206**, a medial edge **212**, and a lateral edge **210**. As illustrated, it is contemplated that a continuous impact attenuating structure **201** extends across both the medial shell element **116** and the lateral shell element **114**. Therefore, the impact attenuating structure **201** is functional to provide a flexible coupling between the medial shell element **116** and the lateral shell element **114**. As illustrated, the lateral edge **210** substantially aligns with the lateral edge **110** and the medial edge **212** substantially aligns with the medial edge **112**. However, it is contemplated that the shell **101** may extend past one or more edges (e.g., superior, inferior, medial, lateral) of the impact attenuating structure **201** and/or the impact attenuating structure **201** may extend past one or more edges (e.g., superior, inferior, medial, lateral) of the shell **101**, in exemplary aspects.

[0038] The impact attenuating structure **201** is also comprised of a number of channels (e.g., grooves, recesses) along

at least the posterior surface **202**. The channels, as illustrated in greater detail in FIG. **10** hereinafter, may extend in any direction, for any length, at any depth, and at any geometry. In an exemplary aspect, a hinge channel **302** extends from the superior edge **206** downwardly towards an inferior edge of the impact attenuating structure **201**. In an exemplary aspect, the hinge channel is substantially parallel with at least one of the medial hinge edge **120** and/or the lateral hinge edge **118**. Similarly, it is contemplated that the hinge channel **302** is substantially aligned with and positioned proximate to an articulation joint between the medial shell element **116** and the lateral shell element **114**. The hinge channel **302**, in an exemplary aspect, provides a crease line along the impact attenuating structure **201** that is more prone to bending than non-channel portions of the impact attenuating structure **201** proximate the articulation joint. Therefore, the hinge channel **302** serves as a hinge for the medial shell element **116** and the lateral shell element **114**. Stated differently, the impact attenuating structure **201** proximate the hinge channel **302** serves as an articulating member to which the shell elements are coupled, but remain physically independent of one another.

[0039] In addition to the hinge channel **302**, a medial channel **304** and a lateral channel **306** are also depicted. The medial channel **304** and the lateral channel **306** may also extend from the superior edge to the inferior edge of the impact attenuating structure **201** in a substantially parallel manner to the hinge channel **302**. It is contemplated that the medial channel **304** may recess into the impact attenuating structure **201** a first amount, the hinge channel **302** may extend into the impact attenuating structure **201** a second amount, as depicted. In this example, the medial channel **304** may recess into the impact attenuating structure **201** a lesser amount than the hinge channel **302**. Similarly, the lateral channel **306** may recess a third amount into the impact attenuating structure **201**. It is contemplated that the first amount, the second amount, and the third amount are different amounts. Further, it is contemplated that first amount is different from the second amount and the third amount, wherein the second amount and the third amount are substantially similar amounts.

[0040] The degree of recess of a channel may be altered to accomplish a variety of goals. For example, it is contemplated that the medial channel **304** is more closely oriented to the wearer's tibia bone (i.e., shin) in an as-worn position. Therefore, the reduction in the channel depth increases a volume of impact attenuating material that is effective for attenuating an impact force across the tibia. The greater degree of recess of the hinge channel **302** may allow for the impact attenuating structure **201** to articulate at the hinge channel with greater ease than a shallower recess depth. Further, the greater depth of the hinge channel **302** and the lateral channel **306** may provide for greater ventilation along the wearer's body and a reduction in weight from a reduction in material of the impact attenuating structure **201**.

[0041] As will be discussed with FIG. **10** hereinafter, it is contemplated that additional or fewer channels may be incorporated within the impact attenuating structure **201** on either the posterior and/or anterior surfaces to accomplish one or more of the functional characteristics (e.g., flexibility, weight reduction, protection, ventilation) provided herein.

[0042] The impact attenuating structure may be formed from a variety of materials. For example, it is contemplated that a foam-like material is utilized. Similarly, it is contemplated that an elastomeric polymer may be utilized. Further, it is contemplated that a combination of materials may be utilized in the formation of the impact attenuating structure. For example, a foam core may be maintained between outer layers of a polyurethane-like material to provide a resilient, flexible, washable, and wearable impact attenuating structure material. While specific examples of materials are provided herein, it is contemplated that additional impact attenuating materials may be implemented in one or more portions of the impact attenuating structure **201**.

[0043] FIG. **4** depicts an exemplary bottom-up perspective of an articulated protective apparatus **400** in an articulated configuration, in accordance with aspects of the present invention. The articulated protective apparatus **400** is comprised of a shell **101** formed from a medial shell element **116** and a lateral shell element **114**. The medial shell element **116** terminates proximate the lateral shell element **114** at a medial hinge edge **120**. The lateral shell element **114** terminates proximate the medial shell element **116** at a lateral hinge edge **118**.

[0044] The articulated protective apparatus **400** is further comprised of an impact attenuating structure **201** that is comprised of a number of channels, such as a medial channel **304**, a lateral channel **306**, and a hinge channel **302**. As depicted, the hinge channel **302** provides an articulating joint between the medial shell element **116** and the lateral shell element **114**.

[0045] As depicted in FIG. **4**, it is contemplated that the medial shell element **116** is coupled with the impact attenuating structure **201** in a manner that allows a portion of the medial shell element **116** to deflect away from the impact attenuating structure **201**. Stated differently, the portion of the medial shell element **116** coupled with the impact attenuating structure **201** may be positioned away from the medial hinge edge **120**. It is contemplated that this offset in coupling allows for a greater portion of the impact attenuating structure to serve as an articulation point, which reduces strain and stress on the components during an articulation. However, while the offset coupling is depicted, it is contemplated that the medial shell element may be coupled with the impact attenuating structure **201** at/near the medial hinge edge **120**, in an exemplary aspect. While the discussion related to offset coupling is directed to the medial portion, it is contemplated that the lateral portions may equally apply. Further, it is contemplated that both the medial and lateral portions may utilize an offset coupling or only one may utilize an offset coupling.

[0046] The coupling between two or more portions may be accomplished using known techniques, such as adhesives and mechanical fasteners. For example, it is contemplated that, but not limited to, glue, epoxy, heat-set adhesive and the like may be applied to one or more portions to be permanently or temporarily coupled. Mechanical fasteners include, but are not limited to, stitching, snaps, rivets, interlocking elements, hook-and-loop fasteners, pockets, and the like. Further, it is contemplated that one or more coupling options may be combined to couple a first portion (e.g., shell element) with a second portion (e.g., impact attenuating structure). In an exemplary aspect, the impact shell and the impact attenuating structure are coupled with an epoxy that forms a permanent bond between the features.

[0047] FIG. **5** depicts a cross sectional view of an articulated protective apparatus **500** along the cutline **5-5** of FIG. **2**, in accordance with aspects of the present invention. In particular, the protective apparatus **500** is comprised of a shell having a medial shell element **502** and a lateral shell element

504, an impact attenuation structure **506**, and a puncture prevention element **512**. The puncture prevention element **512** is positioned at least along a hinge joint defined by a medial hinge edge **508** and a lateral hinge edge **510** of the shell. As illustrated, the puncture prevention element **512** is positioned between an anterior surface **516** of the shell and a posterior surface **514** of the impact attenuation structure **506**.

[0048] In an exemplary aspect, the puncture prevention element **512** is formed from a material that is resistant to impalement (e.g., woven, knit, webbing, mesh). For example, a ballistic-type material, such as a nylon, aramid fiber-based materials (e.g., Poly-paraphenylene terephthalamide), carbon-based materials, and other natural and synthetic materials. For example, it is contemplated that a woven textile made from one or more fiber materials listed above may form a puncture resistant layer that could reduce the potential of impalement through the articulation joint formed between shell portions. Stated differently, the puncture prevention element provides a barrier to impalement at a location formed between the medial hinge edge **508** and the lateral hinge edge **510**. As the medial shell element **502** and the lateral shell element **504** are articulated about the articulation joint, the protection from impalement offered by the shell is reduced along the articulation joint; therefore, a secondary puncture protection element is utilized along at least that location.

[0049] Therefore, it is contemplated that the puncture prevention element **512** extends between the medial shell element **502** and the lateral shell element **504**. It is contemplated that the puncture prevention element **512** extends all of the way from a superior edge to an inferior edge of the shell and/or the impact attenuation structure **506**. Further, it is contemplated that the puncture prevention element **512** extends from a medial edge to a lateral edge of the shell and/or the impact attenuation structure **506**. Further, as depicted, the puncture prevention element **512** is contemplated as extending to a location between the medial hinge edge **508** and the medial edge and also extending from a location between the lateral hinge edge **510** and the lateral edge.

[0050] In an exemplary aspect, the puncture prevention element **512** is coupled with the impact attenuation structure **506** along the anterior surface **516**. In an alternative aspect, it is contemplated that the puncture prevention element **512** is coupled with the medial shell element **502** and the lateral shell element **504**. Further, it is contemplated that the puncture prevention element **512** is coupled with both the impact attenuation structure **506** and the shell. Further, as previously discussed, the utilization of offset bonding may be utilized in one or more aspects in connection with the puncture prevention element **512**.

[0051] While not depicted, it is contemplated that the puncture prevention element **512** may also (or in the alternative) be coupled proximate the shell anterior surface. It is contemplated that the impact attenuation structure **506** is maintained between the puncture prevention element **512** and the wearer in order to provide an impalement absorption depth. For example, it is contemplated that the puncture prevention element **512** may stretch, even slightly, in the direction of the impalement force. Because of this stretch, the puncture prevention element **512** may be spaced from the wearer's skin to provide a zone in which the puncture prevention element **512** may absorb the impalement force.

[0052] FIG. **6** depicts a cross sectional view of an articulated protective apparatus **600** along a similar cutline as that depicted in FIG. **5**, in accordance with aspects of the present invention. In particular, the protective apparatus **600** is comprised of a shell having a medial shell element **602** and a lateral shell element **604**, an impact attenuation structure **606**, and a puncture prevention element **612**. The puncture prevention element **612** is positioned at least along a hinge joint defined by a medial hinge edge **608** and a lateral hinge edge **610** of the shell. As illustrated, the puncture prevention element **612** is positioned on an anterior surface of the impact attenuation structure **606** between the medial shell element **602** and the lateral shell element **604**.

[0053] In an exemplary aspect, the puncture prevention element **612** is formed from an elastomeric material. For example, a thermoplastic polyurethane may form the puncture prevention element **612** and be maintained within the articulation joint to fill the gap formed by the articulating shell elements. For example, it is contemplated that the puncture prevention element **612** is elastic in nature to expand/contract to fill a changing articulation joint size. Additionally (or in the alternative) it is contemplated that the puncture prevention element **612** comprises a cap region (**614** in FIG. **8** hereinafter) that covers a portion of the anterior surface of both the medial shell element **602** and the lateral shell element **604** along the hinge joint. As the cap region may be sized to extend over the hinge junction regardless of the gap created between the shell elements during a deflection (e.g., bending), the puncture prevention element **612** may not need to dynamically adjust in size as the coverage provided by the cap region may prevent an impalement regardless of the hinge joint deflection size/amount. Other materials are contemplated (e.g., silicone rubber, polypropylene) for forming the puncture prevention element **612**.

[0054] The puncture prevention element **612** may be couple directly to the medial hinge edge **608** and the lateral hinge edge **610** such that when the two edges extend away from one another during an articulation, the puncture prevention element **612** stretches to fill the widening void. Further, it is contemplated that the puncture prevention element **612** contracts during a reduced deflection to allow the return of the shell elements to a pre-articulation position. The puncture prevention element **612** may also (or in the alternative) be coupled directly with the anterior surface of the impact attenuation structure **606**. Further, it is contemplated that the puncture prevention element **612** is maintained in a desired location absent an adhesive or other bonding agent. Instead, as will be discussed in greater detail in FIG. **8**, one or more flange portions may extend between the shell and the impact attenuating portion to effectively maintain the puncture prevention element **612** within the articulation joint.

[0055] FIG. **6** also depicts a hinge channel **607**. The hinge channel **607** is substantially aligned with the puncture prevention element **612**, which is also aligned with a hinge joint between the medial hinge edge **608** and the lateral hinge edge **610**, in this exemplary aspect.

[0056] FIG. **6** depicts a focus region **8**, which is highlighted in FIG. **8** hereinafter. FIG. **8** is an illustration of the puncture prevention element **612**, in accordance with aspects of the present invention. As discussed with respect to FIG. **6**, FIG. **8** depicts the medial shell element **602**, the lateral shell element **604**, the impact attenuation structure **606**, the hinge channel **607**, the medial hinge edge **608**, and the lateral hinge edge **610**. In particular, FIG. **8** demonstrates the puncture prevention element **612** comprised of a cap portion **614**, a stem portion **616** and a flange portion **618**. It is contemplated that

the puncture prevention element **608** may extend the length of the hinge junction (e.g., superior edge to inferior edge).

[0057] The cap portion **614** is depicted as having a particular size and geometry; however, it is contemplated that the cap may have any size and/or shape. For example, it is contemplated that the features of the cap portion **614** that are near the anterior surfaces of the medial shell element **602** and the lateral shell element **604** may be rounded in the cross-sectional direction, in an exemplary aspect. The cap portion **614** provides at least two functional advantages. The first advantage is an adjustable hinge joint cover capable of deflecting impalement to the hinge joint regardless of a reasonable articulation-caused separation of the shell elements. A second advantage of the cap portion is to provide a resistance to dislodgement of the puncture prevention element **612**. As the cap portion **614** is sized with a greater medial-to-lateral width than the hinge joint, the cap portion resists a posterior movement of the puncture prevention element **612**.

[0058] The stem portion **616** extends in a posterior direction from the cap portion **614**. The stem portion **616** extends between the medial hinge edge **608** and the lateral hinge edge **610** forming the hinge joint. The length of the stem portion may be equal, slightly greater than, or slightly less than the thickness of the shell elements proximate the hinge joint. Stated differently, the stem portion may provide a tying element between the cap portion **614** and the flange **618**.

[0059] The flange **618** is depicted as extending in a first direction (e.g., medial shell direction in this example). However, it is contemplated that the flange may extend in the opposite direction or both the medial and lateral direction. Therefore, while a backwards "L"-shaped stem and flange combination is depicted, it is contemplated that an upside down "T"-shaped stem and flange combination may be implemented. Further, it is contemplated that an "L"-shaped stem and flange combination may also be utilized. Further, it is contemplated that one or more portion of the stem **616** may be coupled with one or more portions of the shell and/or the impact attenuating structure (with or without a flange **618**). Further, it is contemplate that one or more portions of the flange **618** may be couple with one or more portions of the shell and/or the impact attenuating structure to additionally (or alternatively) secure the puncture prevention element **612** in a desired position.

[0060] FIG. **8** depicts a portion of the impact attenuation structure **606** removed proximate the medial shell element **602** to accommodate the flange **618**. However, it is contemplated that the impact attenuation structure **606** may not incorporate a recessed portion that accommodates the flange **618**. Instead, it is contemplated that the flange **618** is merely inserted between an impact attenuation structure **606** anterior surface and the posterior surface of the medial shell element **602**, in an exemplary aspect.

[0061] FIG. **7** depicts a shell overlap puncture prevention arrangement for an articulated protection apparatus **700**, in accordance with aspects of the present invention. The articulated protection apparatus **700** is comprised of a shell having a medial shell element **704** and a lateral shell element **702**. The medial shell element **704** overlaps the lateral shell element **702** at an articulation joint that will be discussed in greater detail at FIG. **9** hereinafter. The overlapping of the lateral shell element **702** by the medial shell element **704** allows the shell elements to be physically separate from one another and therefore able to articulate in the posterior direction while still preventing impalement through the articulation joint. Consequently, an impact attenuating structure **706** may be protected from impalement by this overlapping configuration. The focus region **9** of FIG. **6** identifies region of focus depicted in FIG. **9** hereinafter.

[0062] FIG. **9** depicts the articulated protection apparatus of FIG. **7** with the medial shell element **704**, the lateral shell element **702**, the impact attenuating structure **706**, a medial hinge edge **710**, a lateral hinge edge **708**, an overlap shell portion **712**, and a hinge channel **707**. While the medial shell element **704** is depicted as overlapping the lateral shell element **702**, it is contemplated that the lateral shell element **702** may overlap the medial shell element **704** in an exemplary aspect.

[0063] As depicted, the medial shell element **704** curves in an anterior direction as it approaches the lateral hinge edge **708** allowing the overlap shell portion **712** to overlap the anterior surface of the lateral shell element **702**. Further, while the medial hinge edge is depicted as a perpendicular surface to the medial shell element anterior and posterior surfaces, it is contemplated that an angled medial hinge edge may be utilized to deflect an incoming object. Stated differently, it is contemplated that the medial hinge edge may be angled to provide a ramp-like effect to deflect a force originating from a lateral side, in an exemplary aspect.

[0064] FIG. **10** illustrates a posterior surface of an impact attenuating structure **1000** in accordance with aspects of the present invention. The impact attenuating structure **1000** is comprised of a superior edge **206**, an inferior edge **208**, a medial edge **212**, and a lateral edge **210**. Additionally, a number of channels (e.g., recessed regions) are also depicted. For example, a hinge channel **302**, a medial channel **304**, and a lateral channel **306** are depicted. Also illustrated are a number of formations, such as element **1002**, **1004**, and **1006**. The elements generally extend to the posterior surface and are defined, in part, by the various channels recessed below the impact attenuating structure **1000** posterior surface.

[0065] As previously discussed, it is contemplated that one or more channels may be recessed a different amount from a posterior surface than other channel. For example, it is contemplated that the medial channel **304**, which may be positioned proximate the tibia bone of a wearer when in an as-worn position, may have a lesser amount of recess from the impact attenuating structure **1000** posterior surface than the hinge channel **302** and/or the lateral channel **306**. As previously discussed, the variations in depth for the channels may be utilized to provide specific functions, such as desired impact attenuation, ventilation, weight, balance, feel, fit, and the like.

[0066] In an exemplary aspect, the channels of the impact attenuating structure **1000** that run approximately from the superior edge **206** to the inferior edge **208** on a medial side of the hinge channel **302** are recessed into the impact attenuating structure **1000** to a lesser degree than those channels that run approximately from the superior edge **206** to the inferior edge **208** on a lateral side of the hinge channel **302**. As the medial side of the impact attenuating structure **1000** is positioned over the tibia region of a wearer when in an as-worn position, a greater degree of impact attenuation is desired in this region, in an exemplary aspect.

[0067] While the concepts provided herein discuss the concept of an articulated protection apparatus and depict a shin guard in particular, it is contemplated that this concept extends to all types of force attenuation applications. Additionally, the term "proximate" has been used herein. Proxi-

mate is a spatial term that is intended to reflect a locational sense of being close to, near, approximately at, and the like.

The invention claimed is:

1. An articulated protective apparatus comprising:

an impact shell having an anterior surface, an opposite posterior surface, a medial edge, an opposite lateral edge, a superior edge, and an opposite inferior edge;

the impact shell further comprising:

(1) a medial shell element extending from the superior edge to the inferior edge and from the medial edge to a medial hinge edge; and

(2) a lateral shell element extending from the superior edge to the inferior edge and from the lateral edge to a lateral hinge edge;

(3) the medial shell element is physically independent of the lateral shell element; and

an impact attenuating structure having a posterior surface, an opposite anterior surface, a medial edge, an opposite lateral edge, a superior edge, and an opposite inferior edge, the impact attenuating structure anterior surface directly coupled to the posterior surface of the impact shell proximate a portion of the medial shell element and proximate a portion of the lateral shell element.

2. The articulated protective apparatus of claim **1**, wherein the impact shell is formed from at least one material selected from the following:

a) a polymer-based material; or

b) a resin and fiber material.

3. The articulated protective apparatus of claim **1**, wherein the medial shell element overlaps the lateral shell element proximate the lateral hinge edge.

4. The articulated protective apparatus of claim **1** further comprising a puncture prevention element proximate the medial hinge edge and the lateral hinge edge.

5. The articulated protective apparatus of claim **4**, wherein the puncture prevention element is positioned between the impact attenuating structure anterior surface and the impact shell posterior surface proximate the medial hinge edge and the lateral hinge edge.

6. The articulated protective apparatus of claim **4**, wherein the puncture prevention element is formed from a woven material.

7. The articulated protective apparatus of claim **4**, wherein the puncture prevention element is positioned between the medial hinge edge and the lateral hinge edge proximate the impact attenuating structure anterior surface.

8. The articulated protective apparatus of claim **7**, wherein the puncture prevention element is formed from a thermoplastic polyurethane material.

9. The articulated protective apparatus of claim **4**, wherein the puncture prevention element is coupled directly to the medial shell element and the lateral shell element.

10. The articulated protective apparatus of claim **4**, wherein the puncture prevention element is not directly coupled with the medial shell element or the lateral shell element.

11. The articulated protective apparatus of claim **4**, wherein the puncture prevention element is directly coupled with the impact attenuating structure anterior surface.

12. The articulated protective apparatus of claim **1**, wherein the impact attenuating structure is further comprised of a channel extending from the impact attenuating structure superior edge to the impact attenuating structure inferior edge on the impact attenuating structure posterior surface.

13. The articulated protective apparatus of claim **12**, wherein the channel is substantially parallel with the medial hinge edge and the lateral hinge edge.

14. The articulated protective apparatus of claim **13**, wherein the channel is positioned on the impact attenuating structure on the posterior surface in a location corresponding proximate with a location of the medial hinge edge and a location of the lateral hinge edge on the anterior surface of the impact attenuating structure.

15. The articulated protective apparatus of claim **1**, wherein the posterior surface and the anterior surface of the impact attenuating structure are formed from a thermoplastic polyurethane material with a foam material maintained between the posterior surface and the anterior surface.

16. An articulated protective apparatus comprising:

a two-part impact shell having an anterior surface and an opposite posterior surface and a medial edge, an opposite lateral edge, a superior edge, and an opposite inferior edge;

the two part impact shell further comprising:

(1) a medial shell element extending from the superior edge to the inferior edge and from the medial edge to a medial hinge edge; and

(2) a lateral shell element extending from the superior edge to the inferior edge and from the lateral edge to a lateral hinge edge;

an impact attenuating structure having a posterior surface, an opposite anterior surface, a medial edge, an opposite lateral edge, a superior edge, and an opposite inferior edge, the impact attenuating structure anterior surface coupled to the posterior surface of the impact shell proximate a portion of the medial shell element and proximate a portion of the lateral shell element;

the impact attenuating structure comprising a channel extending from the superior edge to the inferior edge of the impact attenuating structure on the posterior surface; and

a puncture prevention element coupled with the impact attenuating structure on the impact attenuating structure anterior surface proximate the channel.

17. The articulated protective apparatus of claim **16**, wherein the puncture prevention element is formed from a woven material.

18. The articulated protective apparatus of claim **16**, wherein the puncture prevention element is coupled with the medial shell element and the lateral shell element.

19. The articulated protective apparatus of claim **16**, wherein the impact attenuating structure is further comprised of:

(1) a medial channel having a first amount of recess from the impact attenuating structure posterior surface, the medial channel between the medial edge and the channel, and

(2) a lateral channel having a second amount of recess from the impact attenuating structure posterior surface, the lateral channel between the lateral edge and the channel, the first amount of recess is less than the second amount of recess.

20. An articulated protective apparatus comprising:

a two-part impact shell having an anterior surface and an opposite posterior surface, the posterior surface curved toward the anterior surface between a medial edge and an opposite lateral edge;

the two-part impact shell comprised of:

(1) a medial shell element extending from the superior edge to the inferior edge and from the medial edge to a medial hinge edge; and

(2) a lateral shell element extending from the superior edge to the inferior edge and from the lateral edge to a lateral hinge edge;

an impact attenuating structure having a posterior surface and an anterior surface, the impact attenuating structure anterior surface coupled to the posterior surface of the impact shell proximate a portion of the medial shell element and proximate a portion of the lateral shell element;

the impact attenuating structure comprising:

(1) a hinge channel extending from the superior edge to the inferior edge of the impact attenuating structure on the posterior surface corresponding proximately with the lateral hinge edge;

(2) a lateral channel extending from the superior edge to the inferior edge of the impact attenuating structure on the posterior surface between the lateral edge and the hinge channel;

(3) a medial channel extending from the superior edge to the inferior edge of the impact attenuating structure on the posterior surface between the medial edge and the hinge channel; and

(4) the lateral channel recessing into the impact attenuating structure a greater amount than the medial channel.

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