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(54) **KNEE SUPPORT SYSTEM**

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(57) **ABSTRACT**

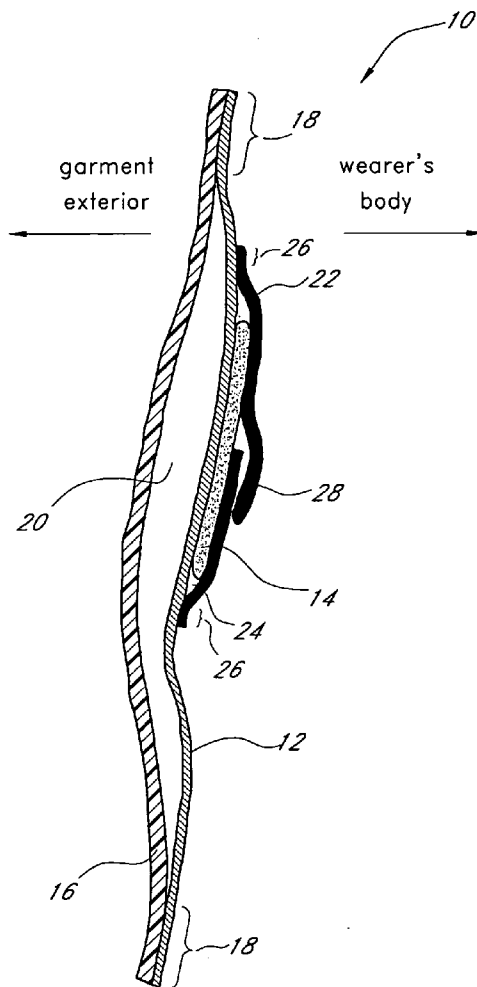
A jacket comprises an exterior layer. The jacket further comprises an inner liner layer that is substantially coextensive with the exterior layer. The inner liner layer has an interior surface and an exterior surface. The inner liner layer exterior surface is secured to the exterior layer along a seam. The jacket further comprises a plurality of flexible covers secured to the inner liner layer. The plurality of flexible covers forming a corresponding plurality of pockets. Each of the plurality of pockets includes a corresponding padding member positioned therein.

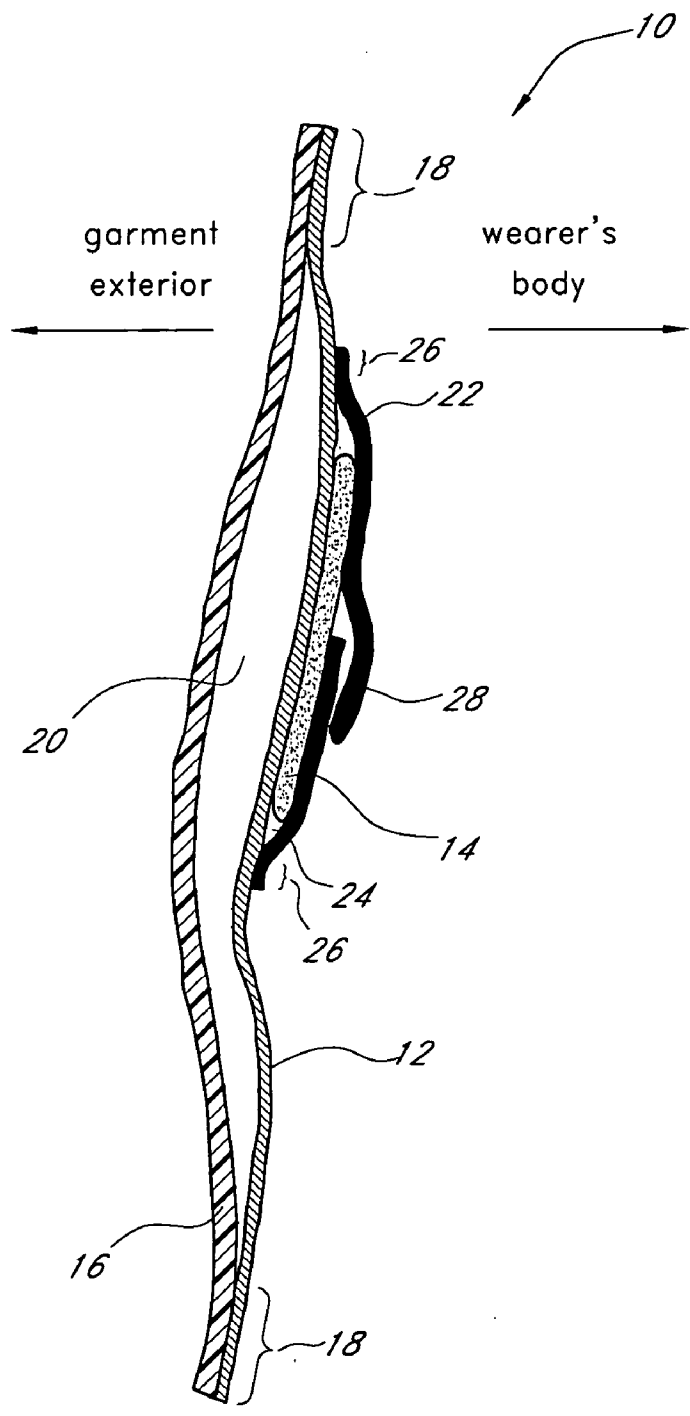
(21) Appl. No.: **11/402,551**

(22) Filed: **Apr. 12, 2006**

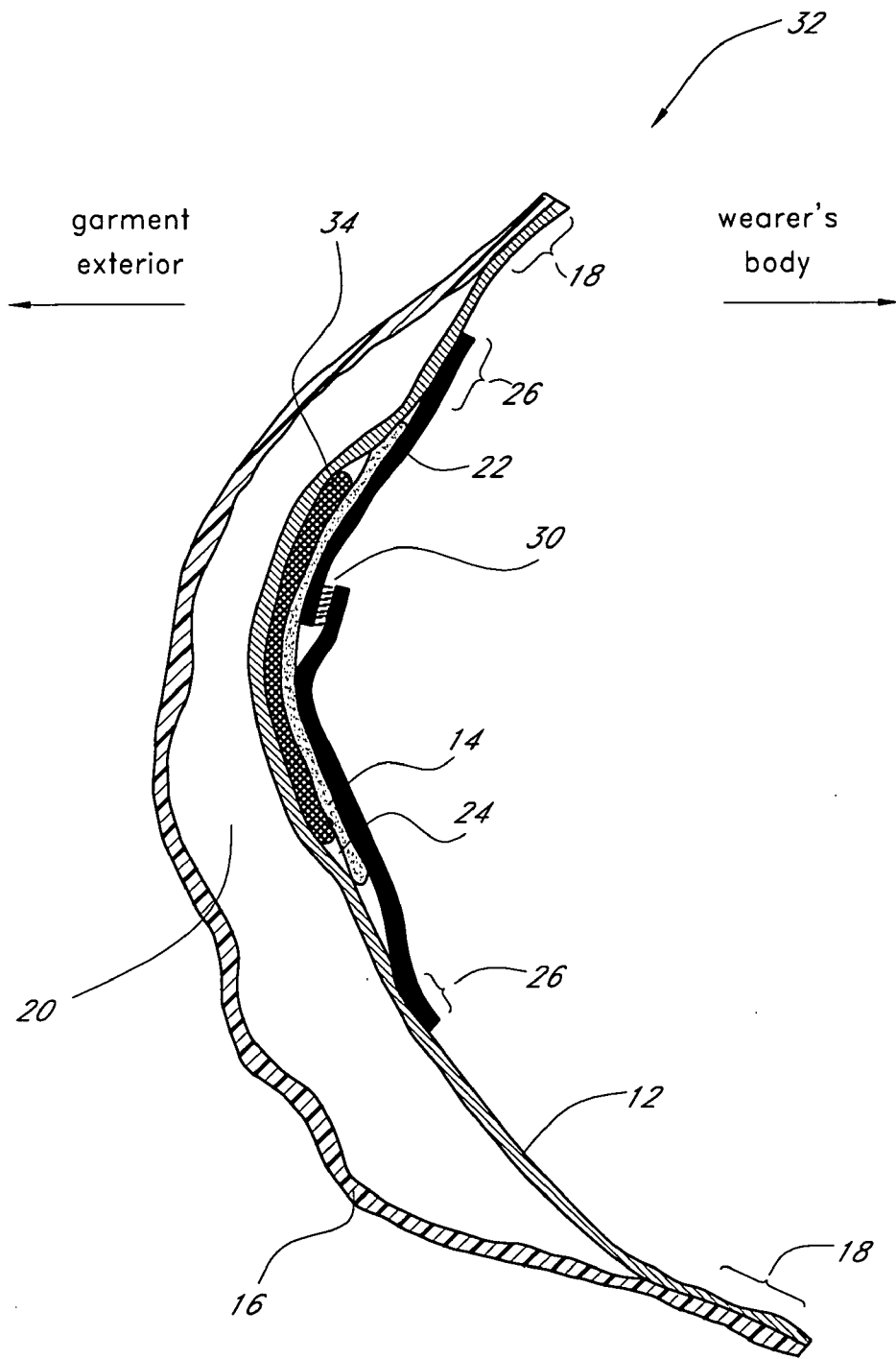
**Related U.S. Application Data**

(60) Provisional application No. 60/690,105, filed on Jun. 13, 2005.

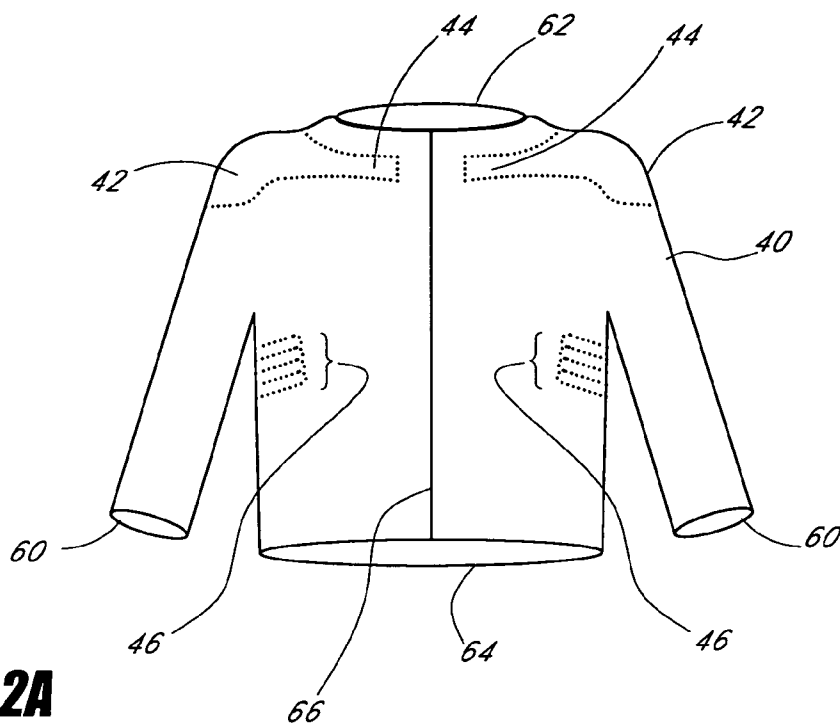




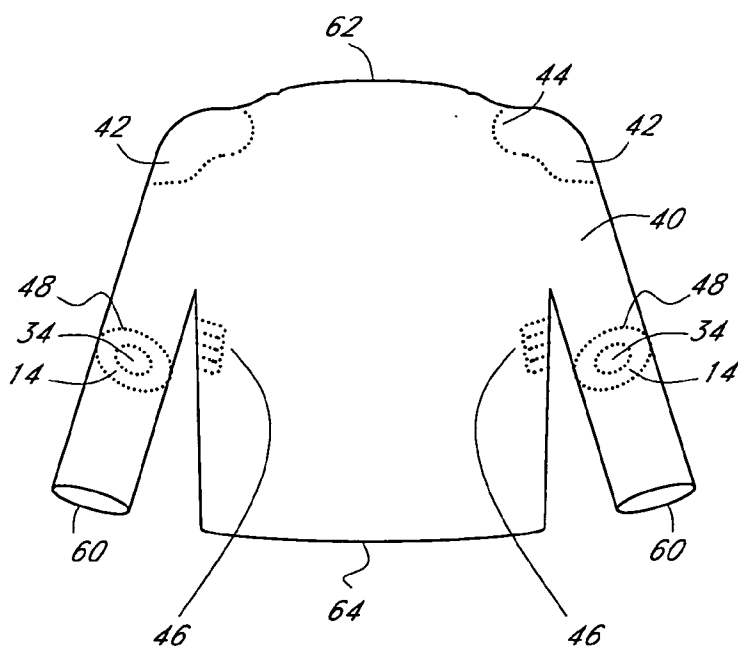
**FIG. 1A**



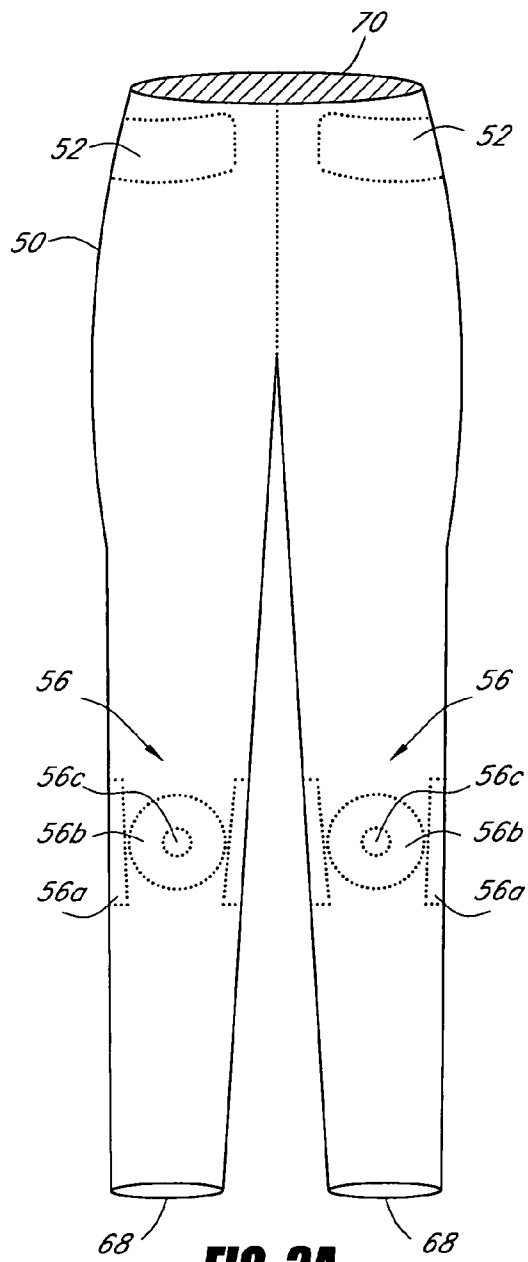
**FIG. 1B**



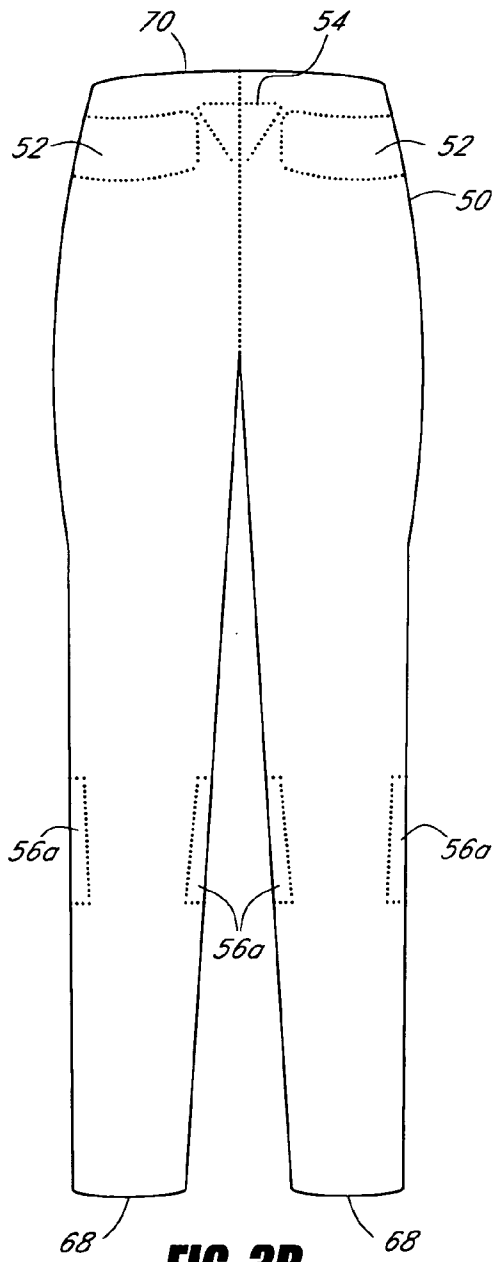
**FIG. 2A**



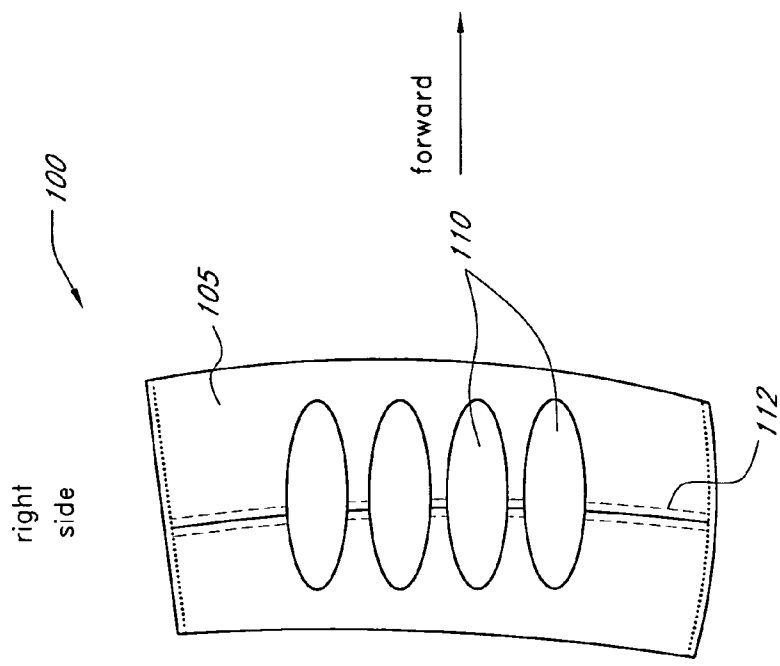
**FIG. 2B**



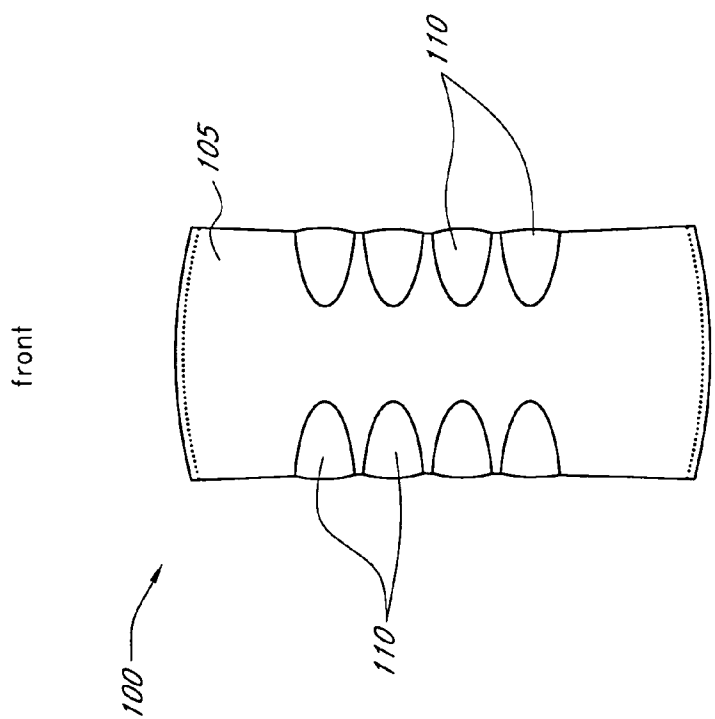
**FIG. 3A**



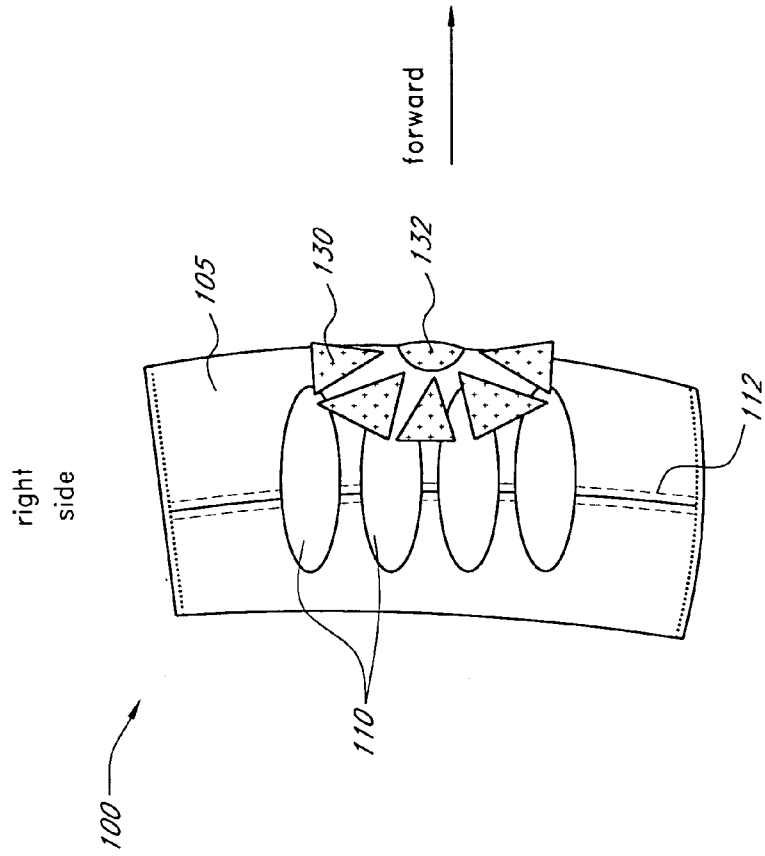
**FIG. 3B**



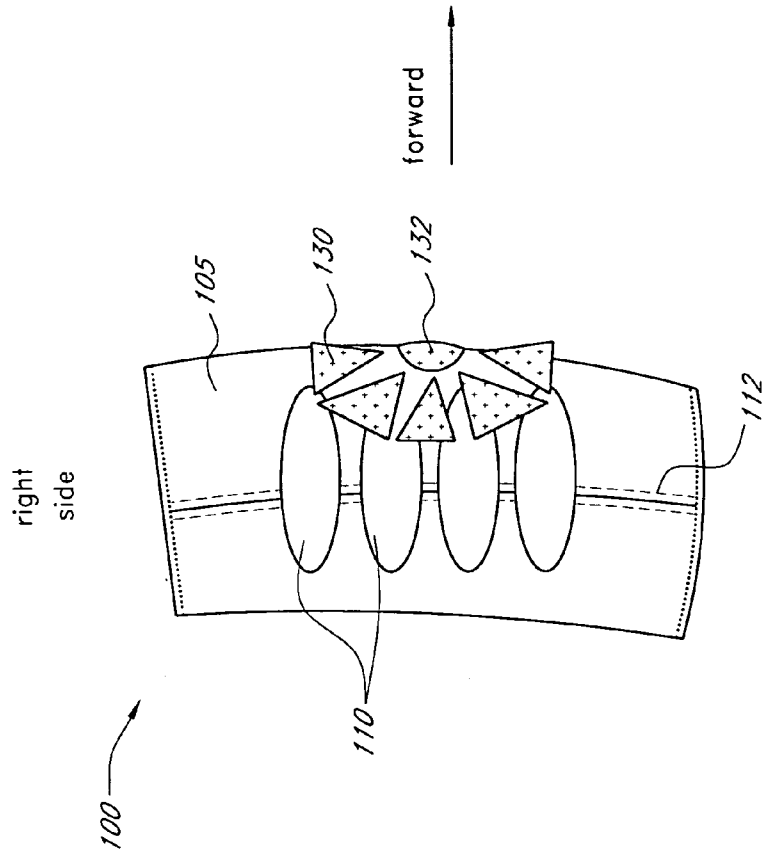
**FIG. 4B**



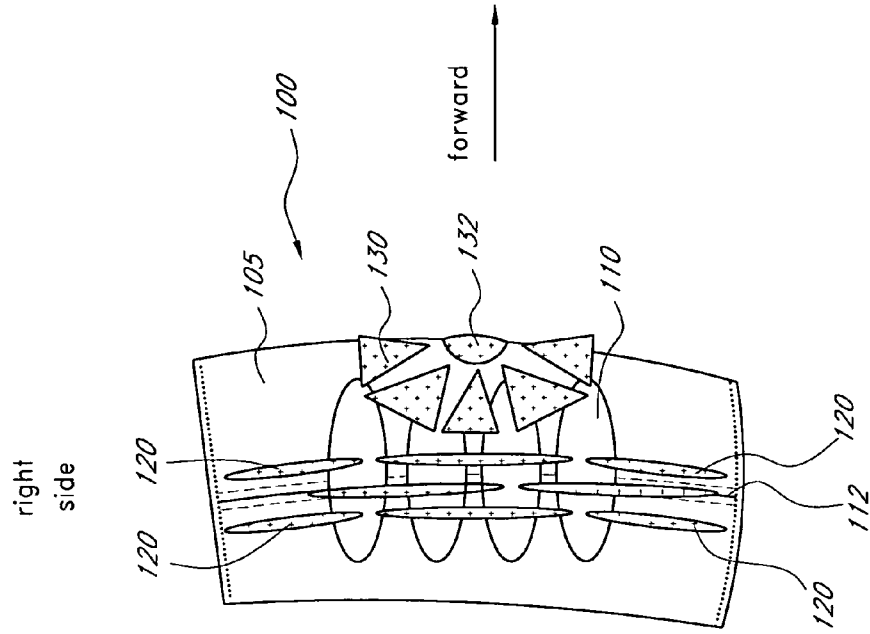
**FIG. 4A**



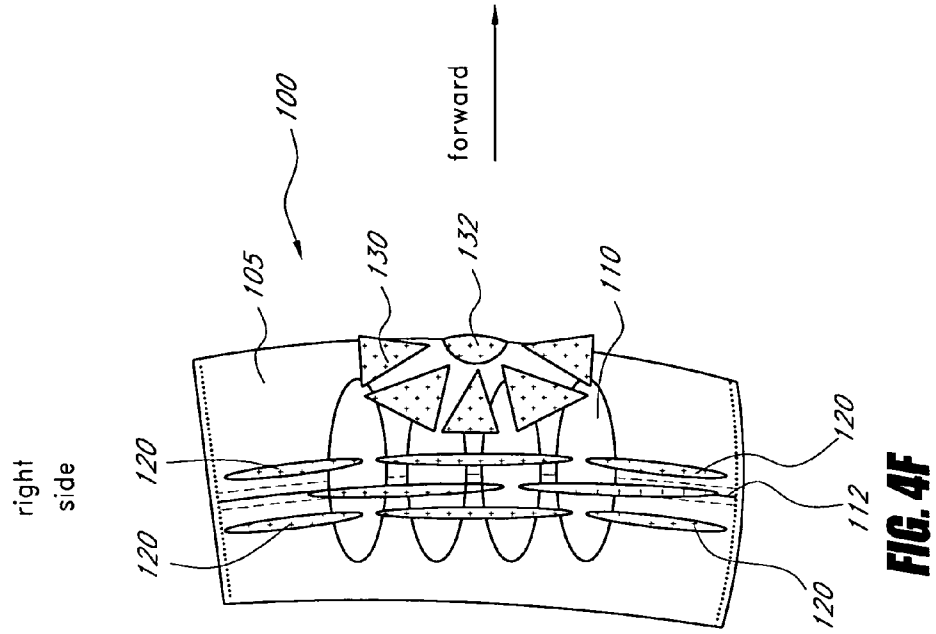
**FIG. 4C**



**FIG. 4D**

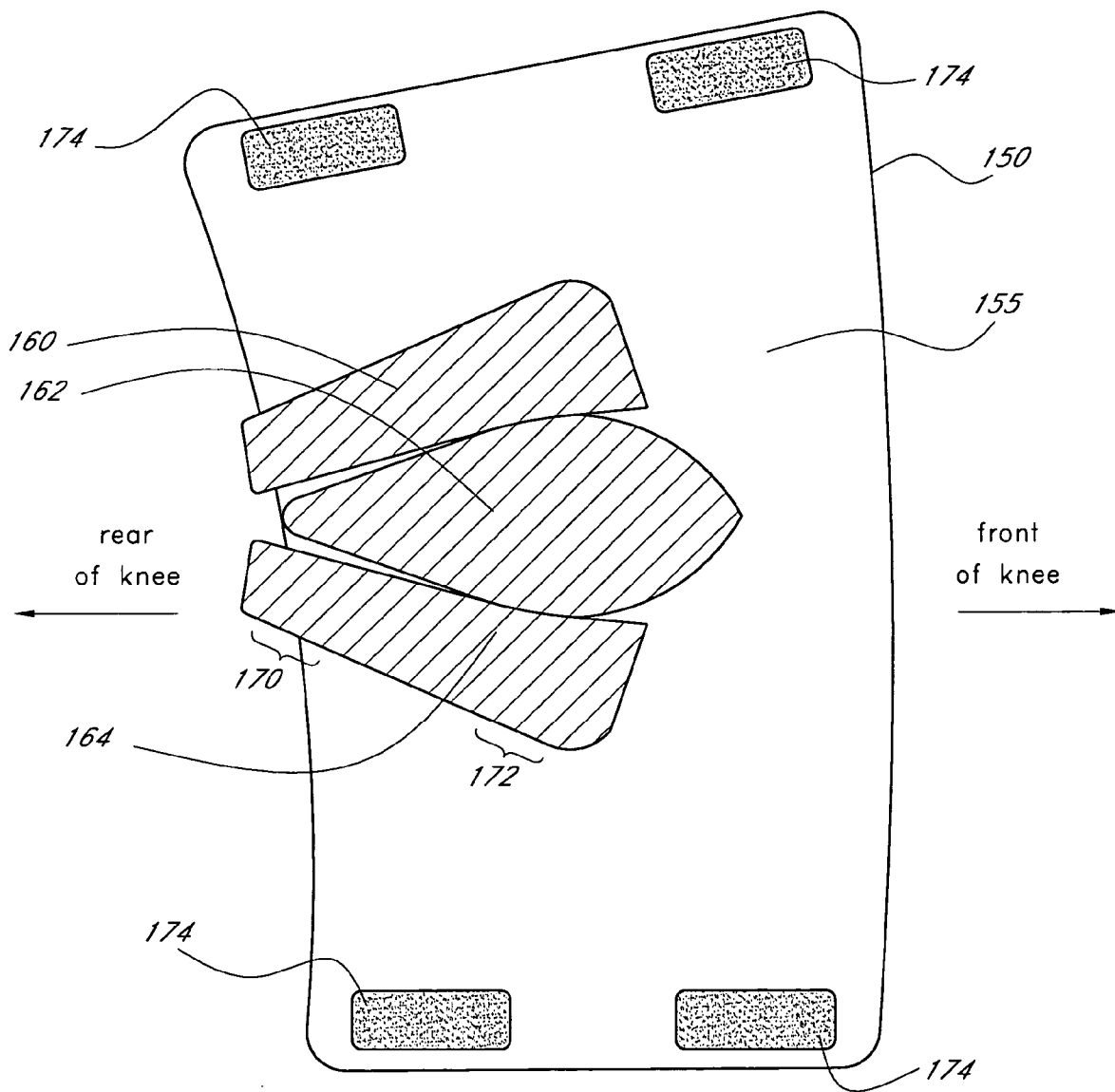


**FIG. 4E**

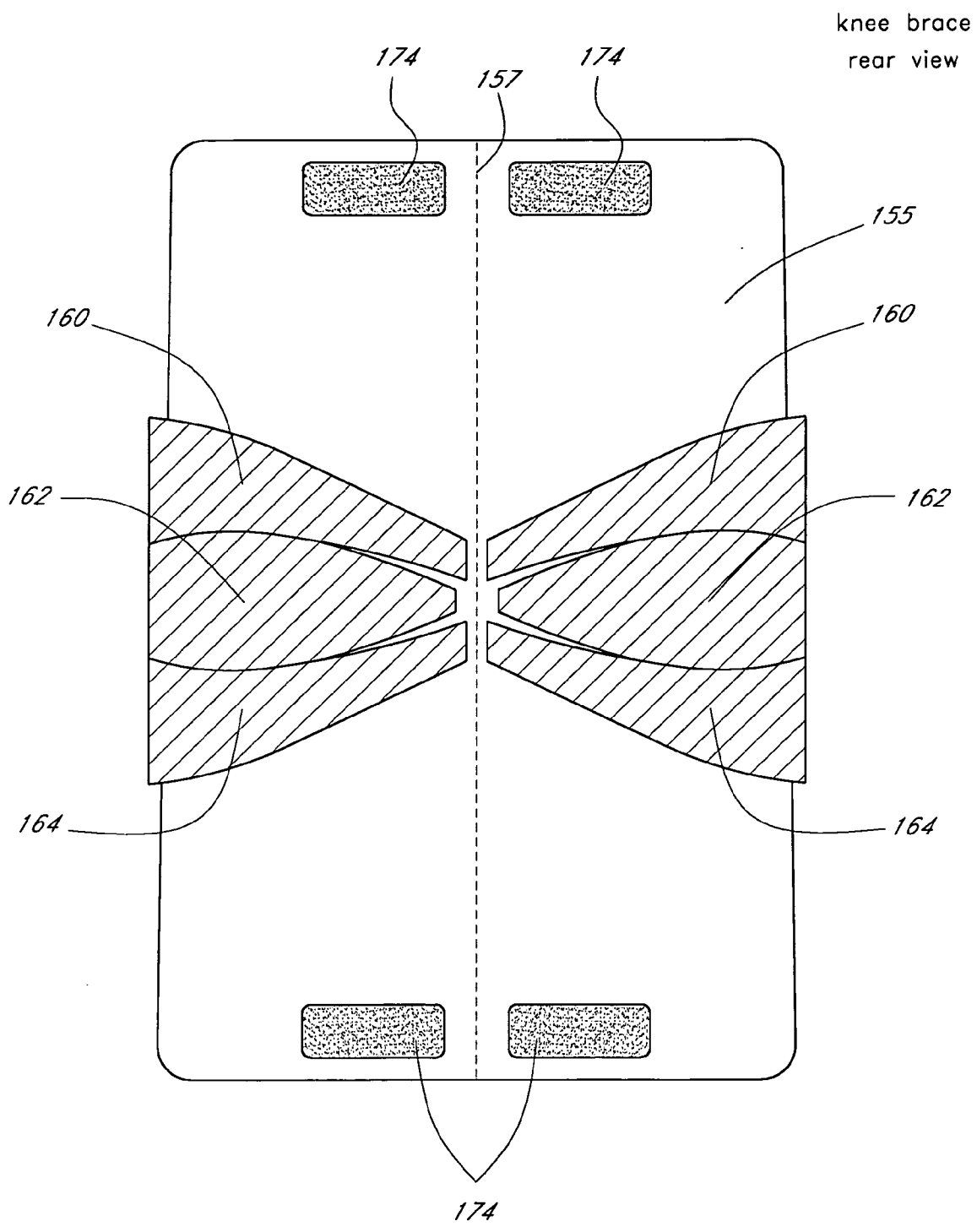


**FIG. 4F**

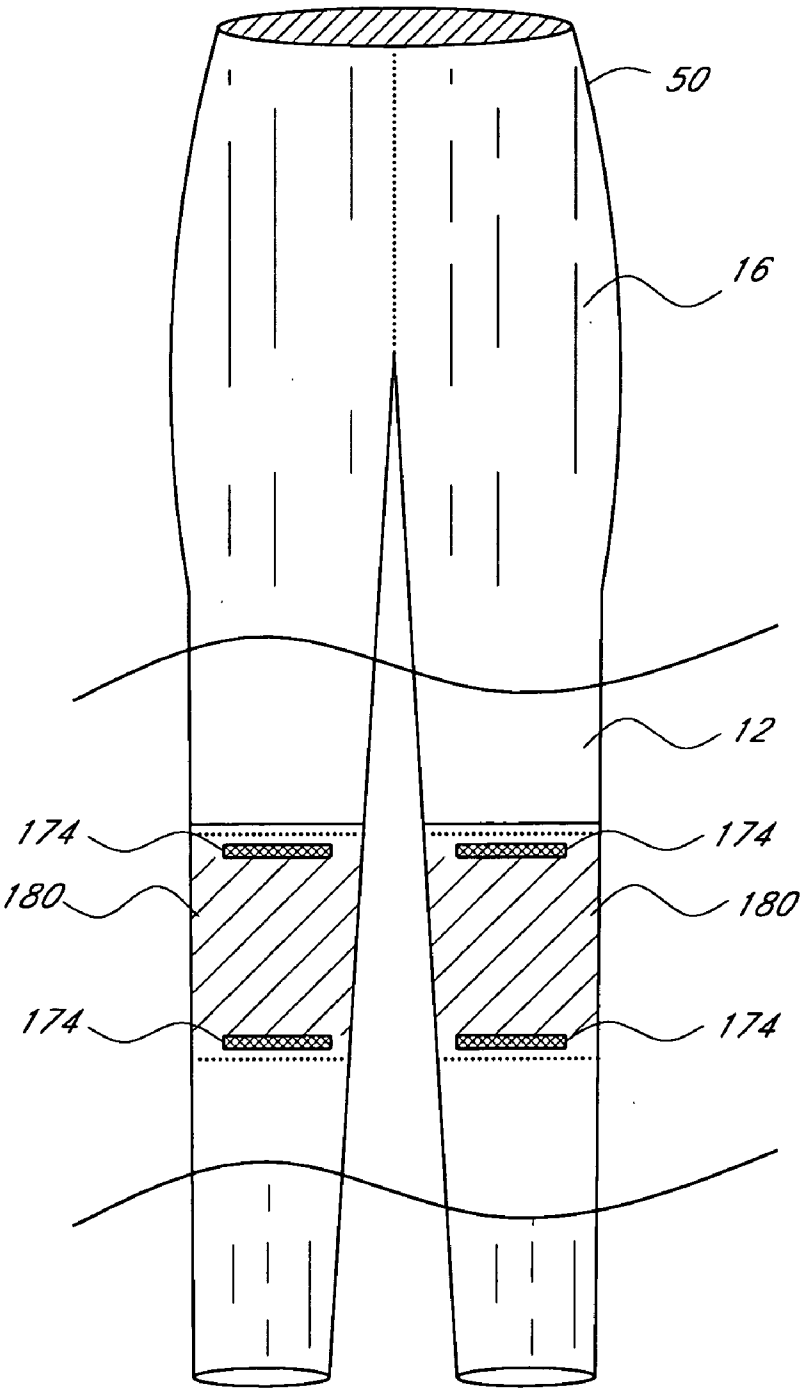




**FIG. 5A**



**FIG. 5B**



**FIG. 6**

## KNEE SUPPORT SYSTEM

### CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Patent Application No. 60/690,105 (filed 13 Jun. 2005), the entire disclosure of which is hereby incorporated by reference herein.

### FIELD OF THE INVENTION

[0002] The present invention relates generally to equipment and apparel used during sporting activities, and more particularly to sporting equipment and apparel having beneficial protection and support characteristics.

### BACKGROUND OF THE INVENTION

[0003] Participants in many sporting activities are often subject to jarring impacts resulting from falls, collisions with objects, or even collisions with other participants. Sporting activities that involve participants moving at high speeds, such as skiing, snowboarding and ice skating, have the potential to be particularly dangerous in this respect. To mitigate the adverse effects of such impacts, a wide variety of protective equipment has been developed. Such protective equipment includes both rigid structural devices such as helmets and shin guards, as well as soft form-fitting padded garments, such as padded pants and jackets. Often, protective equipment is specifically designed for use in a particular sporting activity, such as a baseball catcher's chest protector or a hockey goalie's protective padding.

[0004] Furthermore, sports injuries are often sustained not only from jarring impacts, but also from overextending the natural capabilities of a participant's joints, muscles, or other anatomy. For example, significant injury often results when joints such as the knee joint are overextended or over-flexed. To reduce the likelihood of such injuries, braces and other orthopaedic devices have been developed that are intended to restrict the motion of a joint.

### BRIEF SUMMARY OF THE INVENTION

[0005] Conventional protective equipment designed to insulate an athlete from impact injuries often comprises bulky padding elements that are attached either directly to the athlete's body, or to a garment worn by the athlete. While such equipment is usable to protect against impact injuries, significant disadvantages exist. For example, many athletes find that such equipment is uncomfortable to wear, is bulky and unsightly, and is unduly restrictive of the athlete's movement. This is especially so for many orthopaedic devices designed to protect against joint injuries, such as knee injuries, since conventional devices often include hardware that is heavy, unsightly, expensive and uncomfortable to wear. Thus, in accordance with the foregoing, improved protective equipment and apparel has been developed to help mitigate and/or prevent injuries sustained by participants in sporting activities.

[0006] In one embodiment of the present invention, a jacket comprises an exterior layer. The jacket further comprises an inner liner layer that is substantially coextensive with the exterior layer. The inner liner layer has an interior surface and an exterior surface. The inner liner layer exterior surface is secured to the exterior layer along a seam. The

jacket further comprises a plurality of flexible covers secured to the inner liner layer. The plurality of flexible covers forming a corresponding plurality of pockets. Each of the plurality of pockets includes a corresponding padding member positioned therein.

[0007] In another embodiment of the present invention, a trousers comprises an exterior layer having a trunk portion that is connected to an elongate leg portion. The trousers further comprises an interior layer that is attached to the exterior layer along a seam that is at least disposed around a waist opening of the trunk portion. The trousers further comprises a pocket mounted on the interior layer. The pocket does not contact the exterior layer. The trousers further comprises a padding member positioned within the pocket.

[0008] In another embodiment of the present invention, a garment comprises an outer layer having an interior surface and an exterior surface. The garment further comprises an inner layer having an interior surface and an exterior surface. The inner layer exterior surface is attached to the outer layer interior surface along a seam. The garment further comprises a pocket formed on the inner layer interior surface. The garment further comprises a padding member positioned within the pocket. The pocket includes an opening through which the padding member is removable.

[0009] In another embodiment of the present invention, a knee support device comprises an expandable sleeve configured to be positioned over a knee. The expandable sleeve has an exterior surface with a forward portion, a rearward portion opposite the forward portion, and side portions extending between the forward and rearward portions. The knee support device further comprises a central padding element that is attached to the expandable sleeve exterior surface, and that has a narrow region and a wide region opposite the narrow region. The central padding element narrow region is attached to the exterior surface rearward portion. The central padding element wide region is attached to one of the exterior surface side portions. The knee support device further comprises an upper peripheral padding element, at least a portion of which is attached to the rearward portion of the expandable sleeve exterior surface. The upper peripheral padding element is positioned in contact with an upper edge of the central padding element. The knee support further comprises a lower peripheral padding element, at least a portion of which is attached to the rearward portion of the expandable sleeve exterior surface. The lower peripheral padding element is positioned in contact with a lower edge of the central padding element.

[0010] In another embodiment of the present invention, a knee support device comprises a hollow sleeve configured to be positioned over a knee. The hollow sleeve includes a forward portion, a rearward portion opposite the forward portion, and left and right side portions extending between the forward and rearward portions. The left and right side portions are substantially equidistant from a sleeve central axis. The knee support device comprises a left primary padding element at least partially disposed over the left side portion of the hollow sleeve. The left primary padding element has a narrow region and a wide region opposite the narrow region. The knee support device further comprises a right primary padding element at least partially disposed over the right side portion of the hollow sleeve. The right

primary padding element has a narrow region and a wide region opposite the narrow region. The knee support device further comprises a plurality of secondary padding elements that contact at least one of the left or right primary padding elements. The secondary padding elements are disposed in pairs that are symmetrically positioned about the sleeve central axis.

[0011] In another embodiment of the present invention, an apparatus comprises a tubular sleeve configured to be positioned around a knee. The tubular sleeve has an exterior surface with a forward portion, a rearward portion opposite the forward portion, and left and right side portions extending between the forward and rearward portions. The apparatus further comprises a first layer of left side padding elements positioned on the left side portion of the tubular sleeve. The apparatus further comprises a first layer of right side padding elements positioned on the right side portion of the tubular sleeve. The apparatus further comprises a kneecap protection element positioned on the forward portion of the exterior surface. The apparatus further comprises a plurality of radial padding elements that are radially positioned around the kneecap protection element. A first portion of the radial padding elements are positioned over the first layer of left side padding elements. A second portion of the radial padding elements are positioned over the first layer of right side padding elements.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0012] Example embodiments of the performance equipment and apparel disclosed herein are illustrated in the accompanying drawings, which are for illustrative purposes only. The drawings comprise the following figures, in which like numerals indicate like parts.

[0013] **FIG. 1A** is a cross-sectional view of an example embodiment of a portion of a garment including protective padding.

[0014] **FIG. 1B** is a cross-sectional view of an example embodiment of a portion of a garment including protective padding and a protective shell.

[0015] **FIG. 2A** is a schematic front view of an example embodiment of a jacket that includes protective padding elements.

[0016] **FIG. 2B** is a schematic rear view of the jacket of **FIG. 2A**.

[0017] **FIG. 3A** is a schematic front view of an example embodiment of a trousers that includes protective padding elements.

[0018] **FIG. 3B** is a schematic rear view of the trousers of **FIG. 3A**.

[0019] **FIG. 4A** is a front view of an example embodiment of a knee support device including a first layer of peripheral padding elements.

[0020] **FIG. 4B** is a side view of the knee support device of **FIG. 4A**.

[0021] **FIG. 4C** is a front view of the knee support device of **FIG. 4A**, further including an array of front padding elements.

[0022] **FIG. 4D** is a side view of the knee support device of **FIG. 4C**.

[0023] **FIG. 4E** is a front view of the knee support device of **FIG. 4C**, further including a second layer of peripheral padding elements.

[0024] **FIG. 4F** is a side view of the knee support device of **FIG. 4E**.

[0025] **FIG. 5A** is a side view of an example embodiment of a knee support device having a central padding element positioned between peripheral padding elements.

[0026] **FIG. 5B** is a rear view of the knee support device of **FIG. 5A**.

[0027] **FIG. 6** is a partial cutaway front view of an example embodiment of a trousers that includes a knee support device.

#### DETAILED DESCRIPTION OF THE INVENTION

[0028] Disclosed herein are various embodiments of protective equipment and apparel having features that are particularly useful in reducing the risk of injury associated with sporting activities, such as skiing, snowboarding, skating, and the like. For example, in certain embodiments a garment is provided with an inner liner layer having padding elements secured thereto. The padding elements are positioned in the garment at locations that correspond to portions of the anatomy that are particularly vulnerable to impact injuries, such as the knees, elbows, shoulders and hips. In other embodiments a knee support device is provided that provides resistance to potentially damaging movement of a knee joint. The knee support device is optionally integrated into a trousers that includes padding elements.

[0029] **FIG. 1A** illustrates a cross-sectional view of a portion of a multilayered garment **10** that includes an inner liner layer **12** that is configured to be worn adjacent to a wearer's body, and an exterior layer **16** that provides the outer surface of the multilayered garment **10**. The inner liner layer **12** and the exterior layer **16** are secured together at one or more seams **18** that are positioned at appropriate locations on the multilayered garment **10**. In one embodiment, the positioning of the seams **18** depends on the portion of the body over which the multilayered garment **10** is to be worn, such as the upper body (for example, for a jacket), the lower body (for example, for a trousers), the feet (for example, for socks), the hands (for example, for gloves) or the head (for example, for a beanie).

[0030] Example techniques used to secure the inner liner layer **12** and the exterior layer **16** together include sewing, stitching, gluing, and chemically bonding, although other techniques are used in other embodiments, such as the use of a zipper or a hook-and-loop type fastener. Optionally, multiple seams **18** are configured to form an enclosed region **20** between the inner liner layer **12** and the exterior layer **16**, as illustrated in **FIG. 1A**. In a modified embodiment, the seams **18** are releasable, such as provided by a hook-and-loop attachment system, thereby allowing the inner liner layer **12** to be separated from the exterior layer **16**.

[0031] The inner liner layer **12** and the exterior layer **16** have properties that are tailored to the application in which the multilayered garment **10** is intended to be used, among

other things. For example, where the multilayered garment **10** is intended to be used during snow sports, such as skiing and snowboarding and the like, the exterior layer **16** is provided with a waterproof or water resistant surface that is lightweight and breathable, but that also provides the wearer with protection from wind chill and other inclement weather. Examples of materials that are used to form the exterior layer **16** include polyurethane-coated polyester and/or nylon, although other materials and coatings are used in other embodiments. Likewise, examples of materials that are used to form the inner liner layer **12** include polyester, fleece, elastic mesh and other materials that are particularly well suited to be worn against interior clothing layers, or against the skin.

[0032] Still referring to **FIG. 1A**, a flexible cover **22** is attached to the inner liner layer **12** so as to form a pocket **24** in which a padding element **14** is positioned. In an example embodiment, the flexible cover **22** comprises a lightweight material that is capable of being sewn or otherwise affixed to the inner liner layer **12** at seams **26**. For instance, in one embodiment the flexible cover **22** comprises the same material as the inner liner layer **12**, although different materials are used for the flexible cover **22** and the inner liner layer **12** in other embodiments. In one embodiment, the flexible cover **22** comprises an elastic textile, such as an elastic mesh material. The flexible cover **22** optionally includes an opening, such as provided by the flap **28** illustrated in **FIG. 1A**. In an example embodiment, pockets **24** are formed in regions of the garment that are particularly susceptible to collisions, such as the elbows, the shoulders, the ribs, the clavicle, the tailbone, the knees, the hips, and other regions of the body.

[0033] In an example embodiment, the padding element **14** is a flexible high density open- or closed-cell polyurethane material, such as is available from Rogers Corporation (Rogers, CT) under the brand name PORON®. Polyurethane padding advantageously resists deformation over time, and decreases the peak force exerted on a body when used to cushion an impact. For example, in one embodiment the padding element **14** is capable of decreasing the peak force exerted on a body by at least about 10% as compared to an unpadded impact, more preferably by at least about 30% as compared to an unpadded impact, and most preferably by at least about 50% as compared to an unpadded impact. Polyurethane padding provides these mechanical properties without being excessively bulky or heavy, which is particularly advantageous for sporting apparel applications.

[0034] Other padding materials are used in other embodiments, such as shape memory foams or viscoelastic foams that are capable of form-fitting to the wearer's body and at least partially absorbing the mechanical shock associated when an impact occurs with another object. For example, in certain embodiments the padding material is disposed in a pouch filled with a shock absorbing material, such as a viscoelastic gel or a fluid, such as air. In modified embodiments, the padding element **14** comprises a laminated element having a plurality of layers of different materials. For example, in one such embodiment the padding element **14** is a layered element that comprises an inner viscoelastic foam layer positioned toward the wearer's body and an outer polyurethane layer positioned toward the garment exterior. In certain embodiments the padding element is formed by an injection molding process. In still other embodiments, the

padding material includes one or more spring elements formed therein, such as a metallic spring element.

[0035] In certain embodiments wherein the pocket **24** includes an opening, such as the flap **28** illustrated in **FIG. 1A**, the padding element **14** is removable from the pocket **24**. This configuration advantageously allows the padding element **14** to be replaced if worn, if a different size padding element is desired, or if the garment **10** is to be washed without washing the padding element **14**. While the pocket **24** is illustrated with a flapped opening **FIG. 1A**, other types of openings are used in other embodiments, such as the hook-and-loop opening **30** illustrated in **FIG. 1B**. In modified embodiments, such as embodiments wherein the pocket **24** does not include an opening, the padding element **14** is secured within the pocket **24**, such as by being affixed to the inner liner layer **12** and/or the flexible cover **22**. In such embodiments, the padding element is secured by using an adhesive, by sewing, or by another technique. This configuration advantageously reduces the likelihood that the padding element **14** has excessive movement within the pocket **24**, or becomes folded onto itself, or is otherwise disturbed in the pocket **24**.

[0036] Referring again to **FIG. 1B**, a modified multilayered garment **32** is illustrated that includes a rigid shell **34** that is positioned in the pocket **24** with the padding element **14**. In the illustrated embodiment, the rigid shell **34** is coupled to the exterior side of the padding element **14**. In other embodiments the rigid shell is placed elsewhere within the pocket **24**, such as on the interior side of the padding element **14**, or within the padding element **14**. The rigid shell **34** is configured to provide additional protection for regions of the body that are particularly susceptible to damaging impacts, such as the knees and the elbows. In such embodiments the rigid shell **34** has a shape that approximates the shape of the underlying anatomy that is to be protected. As illustrated, the rigid shell **34** is configured to cover a smaller area than the padding element **14** in certain embodiments, thereby preventing the garment **32** from becoming excessively heavy due to the rigid shell **34**. In one embodiment that rigid shell **34** comprises a molded plastic element, although other materials are used in other embodiments.

[0037] As set forth herein, the pockets **24** and the padding elements **14** are included in a garment in regions that are particularly susceptible to injury during sporting activities. For example, **FIGS. 2A and 2B** illustrate front and rear views (respectively) of an example jacket **40** that includes padding elements in a shoulder region **42**, a clavicle region **44**, a rib region **46**, and an elbow region **48**. The padding elements in the elbow region **48** optionally include both a larger padding element **14**, and a smaller rigid shell **34**. In the illustrated example embodiment, the padding elements in the rib region **46** are optionally provided in the form of multiple parallel elongate elements, thereby allowing the jacket **40** to retain substantial flexibility in the rib region **46**, thus helping to avoid giving the jacket an unduly bulky or rigid feel to the wearer, and helping to avoid giving the jacket a padded outward appearance. In modified embodiments, additional padding elements are positioned in other regions of the jacket **40**, such as the lumbar region, or fewer padding elements are used. However, regardless of how many padding elements are used, positioning the padding elements **14** in pockets **24** that are secured to the inner liner layer **12** advantageously helps to prevent to padding ele-

ments from moving substantially from the respective body regions for which they are intended to protect.

[0038] **FIGS. 3A and 3B** illustrate front and rear views (respectively) of an example trousers **50** that includes padding elements in a hips region **52**, a tailbone region **54**, and a knee region **56**. The padding elements in the knee region **56** optionally include lateral padding elements **56a**, frontal padding elements **56b**, and a kneecap rigid shell **56c**. As with the jacket **40**, additional padding elements are optionally positioned in other regions of the trousers **50**, such as the buttocks region, or fewer padding elements are used.

[0039] In one embodiment, the inner liner layer **12** is substantially coextensive with the exterior layer **16**, such that the seams **18** joining these layers are at least positioned around openings in the garment. For example, for the jacket **40** illustrated in **FIGS. 2A and 2B**, the seams **18** in such an embodiment are at least located around the wrist openings **60**, around the neck opening **62**, around the waist opening **64**, and along the chest opening **66**. For the trousers **50** illustrated in **FIGS. 3A and 3B**, the seams **18** in such an embodiment are at least located around the ankle openings **68** and around the waist opening **70**. In these embodiments, additional seams are optionally positioned elsewhere in the garment to provide further durability.

[0040] In certain embodiments, the trousers includes a knee support device that provides resistance to potentially damaging movement of a knee joint, as well as to impacts against a knee joint. **FIGS. 4A-4F** illustrate example embodiments of a knee support device **100** that is compatible with the trousers disclosed herein, or that is usable independently of a trousers. The knee support device **100** comprises a tubular sleeve **105** configured to be positioned over the wearer's knee. In an example embodiment the tubular sleeve **105** comprises an expandable and structurally supportive material, such as neoprene foam or polyurethane foam, thereby allowing the sleeve **105** to fit snugly over the knee, and to resist twisting, sliding or other movement away from the wearer's knee joint. The tubular sleeve **105** optionally includes adjustable straps that allow the knee support device **100** to be placed on the wearer with an adjustable tightness. In such embodiments, the straps include hook-and-loop type fasteners, snaps, buckles or other mechanisms that allow the tightness of the straps to be adjusted.

[0041] The sleeve **105** has attached thereto one or more layers of padding elements that are configured to protect the knee against damaging impacts and/or to restrict potentially damaging movements of the knee. Rapid movement of the knee into certain positions has the potential to damage the tendons, ligaments and other anatomy of the knee. In contrast, slower movement of the knee into the same position is often accomplished without causing such damage.

[0042] **FIG. 4A** provides a front view of a knee support device **100** that includes a first layer of lateral padding elements **110** that are positioned on lateral regions of the tubular sleeve **105**. In an example embodiment, the lateral padding elements **110** comprise an open- or closed-cell polyurethane foam, although other padding materials, such as viscoelastic shock absorbing materials, are used in other embodiments. The lateral padding elements **110** are secured to the tubular sleeve **105** using an adhesive, although other attachment mechanisms are used in other embodiments, such as by sewing, by using a hook-and-loop type attach-

ment system, or by stapling. The lateral padding elements **110** are shaped and positioned to contact and compress against each other as the knee is flexed, thereby providing resistance to rapid flexing of the knee and/or to over-flexing of the knee. This reduces the likelihood that these movements cause injury to the knee anatomy, such as injury to the anterior cruciate ligament. The lateral padding elements **110** also advantageously provide the lateral portion of the knee with protection from impact injuries.

[0043] **FIG. 4B** illustrates a side view of the knee support device **100** of **FIG. 4A**, with the front of the knee support device **100** facing to the right. A plurality of lateral padding elements **110** are positioned on the side of the sleeve **105**. Although four lateral padding elements **110** are illustrated on each side of the knee support device **100** in **FIGS. 4A and 4B**, more or fewer padding elements are used in other embodiments. In the example embodiment illustrated in **FIG. 4B**, the knee support device **100** includes a seam **112** at which one or more pieces of expandable material are joined to form the tubular sleeve **105**.

[0044] As described herein, in certain embodiments the knee support device **100** includes more than one layer of padding elements. For example, **FIG. 4C** illustrates a front view of the knee support device **100** of **FIG. 4A**, further including a second layer of front radial padding elements **130** that are positioned radially around a kneecap protection element **132**. In an example embodiment, the radial padding elements **130** and the kneecap protection element **132** comprise the same material as the lateral padding elements **110**, although other protective materials and/or padded materials are used in other embodiments. For example, in a modified embodiment the kneecap protection element **132** includes a rigid shell, such as the rigid shell **34** illustrated in **FIG. 1B**. The rigid shell is optionally configured to extend below the knee, such as to the wearer's shin, thereby providing additional impact protection to the shin as well as the kneecap. The radial padding elements **130** are affixed to the tubular sleeve **105** and/or the lateral padding elements using an adhesive, although other techniques for affixing these elements are used in other embodiments.

[0045] The orientation and shape of the radial padding elements **130** are configured to protect the frontal portion of the knee from impact injuries without significantly restricting knee movement. For example, in the illustrated embodiment the radial padding elements **130** have a triangular shape whereby a narrow portion of the triangle is oriented toward the kneecap protection element **132**, and a wide portion of the triangle is oriented in the opposite direction. **FIG. 4D** illustrates a side view of the knee support device **100** of **FIG. 4C**, with the front of the knee support device **100** facing to the right.

[0046] In certain embodiments, as illustrated in **FIG. 4E**, a third layer of lateral support elements **120** are positioned over the tubular sleeve **105** and/or the lateral padding elements **110**. In certain embodiments, the lateral support elements **120** comprise a padding material, such as a neoprene padding or a polyurethane padding. In such embodiments the lateral support elements **120** provide additional resistance to rapid flexing of the knee and/or to over-flexing of the knee, and additional protection against impact injuries. In a modified embodiment, the lateral support elements **120** comprise a more rigid structure, such as a flexible

plastic or metallic element. The flexible plastic or metallic elements are optionally enclosed in a sheath that is affixed to the sleeve 105 and/or the lateral padding elements 110. The lateral support elements 120 are configured to advantageously reduce potentially damaging lateral movement of the knee.

[0047] FIG. 4F shows a side view of the knee support device of FIG. 4E, with the front of the knee support device 100 facing to the right, and indicates that in an example embodiment the lateral support elements 120 are positioned in three rows that are substantially parallel to the seam 112. More rows or fewer rows of lateral support elements 120 are used in other embodiments. Additionally, in other embodiments the lateral support elements 120 are configured to extend substantially uninterrupted across the length of the tubular sleeve 105.

[0048] The example embodiments illustrated in FIGS. 4A-4F illustrate example embodiments of a knee support device 100 having one or more layers of lateral padding elements 110, lateral support elements 120, radial padding elements 130, and kneecap protection elements 132. However, other embodiments comprise other padding elements that are positioned on the sleeve using other configurations. For example, FIG. 5A is a side view of a modified knee support device 150 with the front of the knee support device 150 facing to the right, and FIG. 5B is a rear view of the modified knee support device 150 of FIG. 5A. The modified knee support device 150 comprises a tubular sleeve 155 having a plurality of padding elements attached thereto. The padding elements include a pair of upper padding elements 160 that are separated from each other, a pair of central padding elements 162 that are separated from each other, and a pair of lower padding elements 164 that are separated from each other. In an example embodiment, the padding elements are secured to the tubular sleeve 155 using an adhesive, although other securing methods are used in other embodiments.

[0049] Still referring to the example embodiment illustrated in FIGS. 5A and 5B, the pairs of padding elements are shaped and positioned in a substantially symmetrical configuration about a center axis 157 of the tubular sleeve 155. Furthermore, the pairs of padding elements are relatively narrow in a rear-facing region 170 of the tubular sleeve 155, and are relatively wide in a side-facing region 172 of the tubular sleeve 155. The upper, central and lower padding elements contact each other in the side-facing region 172 of the tubular sleeve 155, but are separated from each other in the rear-facing region 170 of the tubular sleeve 155. The pairs of padding elements extend between the rear-facing region 170 and the side-facing region 155 of the tubular sleeve in the illustrated configuration. The relative positions, sizes and shapes of the padding elements cause the element to become compressed against each other in the rear-facing region 170 of the modified knee support device when the knee is flexed. This advantageously provides a resistance to knee flexion that is relatively small when the knee is slightly bent, but that increases as the knee is bent to larger angles.

[0050] As disclosed herein, the knee support device 100 is optionally configured to be used with the trousers 50 disclosed herein. For instance, as shown in the example embodiment illustrated in FIGS. 5A and 5B, the knee

support device 150 includes fasteners 174, such as hook-and-loop type fasteners, that are usable to secure the knee support device 150 to a corresponding fastener included on the inner liner layer 12 of the trousers 50. An example embodiment of this configuration is illustrated in FIG. 6, which shows a partial cutaway front view of a trousers 50 having an exterior layer 16 and an inner liner layer 12. A knee support device 180 is secured to the inner liner layer 12 using fasteners 174. In a modified embodiment, an upper portion of the knee support device 180 is secured to the inner liner layer 12, and a lower portion of the knee support device 180 is secured to an inner portion of the exterior layer 16. In certain embodiments, the exterior layer 16 of the trousers 50 optionally includes a closable opening, such as a zippered opening, in the knee region of the trousers that is used to access a knee support device 180 positioned therein, regardless of whether the knee support device 180 is coupled to the trousers 50, or is simply placed over the wearer's knee.

[0051] The improved protective equipment and apparel disclosed herein has been developed to help mitigate and/or prevent injuries sustained by participants in sporting activities. For example, the padded garments disclosed herein help to cushion portions of the anatomy that are particularly vulnerable to impact injuries, such as the knees, elbows, shoulders and hips. Placing the padding elements on an interior liner layer instead of directly on the wearer's body, or directly on the garment exterior body, reduces both interference with the wearer's motion and the bulky appearance of a padded garment. Other protective equipment disclosed herein includes a variety of knee support devices that are configured to restrict knee movements that have the potential to damage the knee anatomy. For example, in certain embodiments positioning a flexible sleeve having compressible padding elements over the knee joint provides resistance to large angle and/or rapid knee flexing.

#### SCOPE OF THE INVENTION

[0052] While the foregoing detailed description discloses several embodiments of the present invention, it should be understood that this disclosure is illustrative only and is not limiting of the present invention. It should be appreciated that the specific configurations and operations disclosed can differ from those described above, and that the methods described herein can be used in contexts other than sporting equipment and apparel.

I claim:

1. A knee support device comprising:

an expandable sleeve configured to be positioned over a knee, the expandable sleeve having an exterior surface with a forward portion, a rearward portion opposite the forward portion, and side portions extending between the forward and rearward portions;

a central padding element that is attached to the expandable sleeve exterior surface, and that has a narrow region and a wide region opposite the narrow region, wherein the central padding element narrow region is attached to the exterior surface rearward portion, and wherein the central padding element wide region is attached to one of the exterior surface side portions;

an upper peripheral padding element, at least a portion of which is attached to the rearward portion of the expand-



able sleeve exterior surface, wherein the upper peripheral padding element is positioned in contact with an upper edge of the central padding element; and

a lower peripheral padding element, at least a portion of which is attached to the rearward portion of the expandable sleeve exterior surface, wherein the lower peripheral padding element is positioned in contact with a lower edge of the central padding element.

2. The device of claim 1, further comprising an adjustable strap positioned around a portion of the expandable sleeve.

3. The device of claim 1, wherein the expandable sleeve comprises a material selected from the group consisting of neoprene and polyurethane.

4. The device of claim 1, wherein:

the upper peripheral padding element has a narrow region and a wide region opposite the narrow region;

the upper peripheral padding element narrow region is attached to the exterior surface rearward portion; and

the upper peripheral padding element wide region is attached to one of the exterior surface side portions.

5. The device of claim 1, wherein the upper peripheral padding element is positioned in contact with the upper edge of the central padding element over the exterior surface side portion, but not over the exterior surface rearward portion.

6. The device of claim 1, wherein the central padding element, the upper peripheral padding element, and the lower peripheral padding element comprise polyurethane.

7. The device of claim 1, further comprising a trousers having a trunk portion connected to an elongate leg portion, wherein the expandable sleeve is attached to the elongate leg portion of the trousers.

8. A knee support device comprising:

a hollow sleeve configured to be positioned over a knee, the hollow sleeve including a forward portion, a rearward portion opposite the forward portion, and left and right side portions extending between the forward and rearward portions, wherein the left and right side portions are substantially equidistant from a sleeve central axis;

a left primary padding element at least partially disposed over the left side portion of the hollow sleeve, the left primary padding element having a narrow region and a wide region opposite the narrow region;

a right primary padding element at least partially disposed over the right side portion of the hollow sleeve, the right primary padding element having a narrow region and a wide region opposite the narrow region; and

a plurality of secondary padding elements that contact at least one of the left or right primary padding elements, wherein the secondary padding elements are disposed in pairs that are symmetrically positioned about the sleeve central axis.

9. The knee support device of claim 8, wherein each of the secondary padding elements has a narrow region and a wide region opposite the narrow region, the narrow region being positioned over the rearward portion of the hollow sleeve.

10. The knee support device of claim 8, further comprising a trousers having a trunk portion connected to an elongate leg portion, wherein the hollow sleeve is coupled to the elongate leg portion of the trousers.

11. The knee support device of claim 8, further comprising a first plurality of fasteners positioned along an upper edge portion of the hollow sleeve, and a second plurality of fasteners positioned along a lower edge portion of the hollow sleeve.

12. The knee support device of claim 8, wherein the left primary padding element, the right primary padding element and the plurality of secondary padding elements comprise polyurethane.

13. The knee support device of claim 8, wherein the left primary padding element narrow region and the right primary padding element narrow region are positioned over the rearward portion of the hollow sleeve.

14. The knee support device of claim 8, wherein the left primary padding element and the right primary padding element are symmetrically positioned on opposite sides of the sleeve central axis.

15. An apparatus comprising:

a tubular sleeve configured to be positioned around a knee, the tubular sleeve having an exterior surface with a forward portion, a rearward portion opposite the forward portion, and left and right side portions extending between the forward and rearward portions;

a first layer of left side padding elements positioned on the left side portion of the tubular sleeve;

a first layer of right side padding elements positioned on the right side portion of the tubular sleeve;

a kneecap protection element positioned on the forward portion of the exterior surface; and

a plurality of radial padding elements that are radially positioned around the kneecap protection element, wherein a first portion of the radial padding elements are positioned over the first layer of left side padding elements, and a second portion of the radial padding elements are positioned over the first layer of right side padding elements.

16. The apparatus of claim 15, wherein the first layer of left side padding elements and the first layer of right side padding elements both comprise a plurality of oval-shaped padding elements that extend between the exterior surface forward portion and the exterior surface rearward portion.

17. The apparatus of claim 15, wherein the tubular sleeve comprises a material selected from the group consisting of neoprene and polyurethane.

18. The apparatus of claim 15, further comprising:

a second layer of left side padding elements that are positioned over the first layer of left side padding elements; and

a second layer of right side padding elements that are positioned over the first layer of right side padding elements.

19. The apparatus of claim 15, wherein each of the plurality of radial padding elements have a triangular shape.

20. The apparatus of claim 15, further comprising a rigid shell positioned over the kneecap protection element, wherein the kneecap protection element comprises polyurethane.

21. The apparatus of claim 15, wherein the kneecap protection element comprises a rigid shell.