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(71) Applicant: **Lloyd, John George
98000 Monte Carlo (MC)**

(72) Inventors:
• **Jongsma, Bastiaan
De Bilt 3731 JP (NL)**
• **Storey, Piers Christian
Cheshire, WA14 2SG (GB)**
• **Lloyd, John George
Monte Carlo, MC98000 (MC)**

(74) Representative: **Atkinson, Ralph et al
Atkinson & Company
Intellectual Property Limited
10 Fitzroy Square
London W1T 5HP (GB)**

(54) **Body protection**

(57) A body protection assembly is disclosed for protecting a human body from injury due to an impact. An internal planar structure (102) defines the shape of the apparatus and an outer layer of a flexible sheet material (105) has a shape defined by the internal planar structure. The internal planar structure is constructed from a plu-

rality of cells such that, in response to an impact, the cells at the position of an impact region deform to absorb kinetic energy. Furthermore, the outer layer of flexible sheet material extends the size of the impact region so as to increase the number of cells that absorb this kinetic energy.

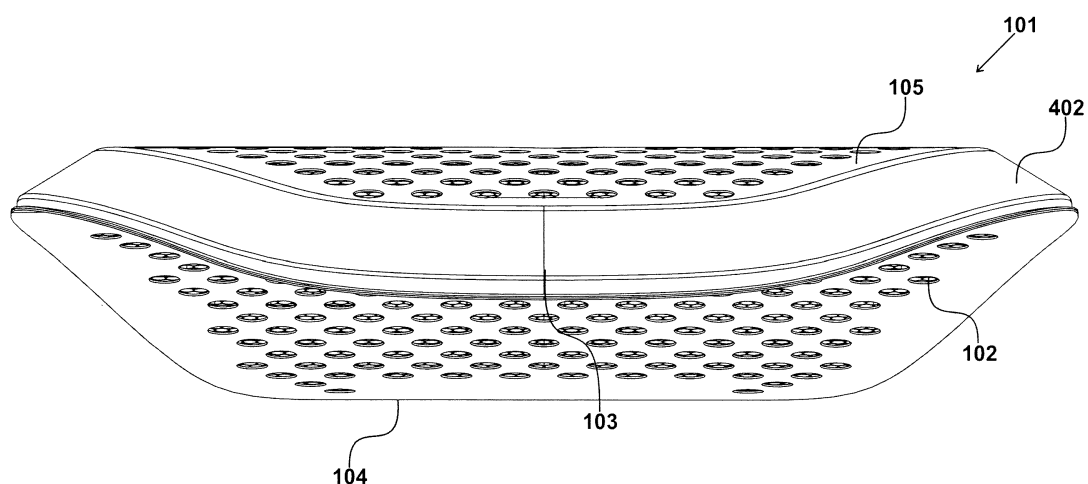


Fig. 1

Description

[0001] The present invention relates to a body protection apparatus for absorbing the energy of an impact. The present invention also relates to a method of fabricating a body protection apparatus for absorbing the energy of an impact.

[0002] Devices for protecting the human body against injury are known. For example, it is known to provide a back protector for motorcyclists such that, in the event of an accident or a fall, injuries to a rider's spine can be reduced or eliminated.

[0003] The requirements for a spine protector of this type may be identified as follows. The device should be resilient, in that it should retain its shape so as to remain at its required location and so as to retain its mechanical integrity. However, upon receiving an impact of sufficient energy, the device should absorb this energy. Furthermore, in order to be useable in most environments, the device should be breathable to facilitate heat transfer, to ensure that a user does not become too hot and uncomfortable.

[0004] According to an aspect of the present invention, there is provided a body protection apparatus for absorbing the energy of an impact, comprising: an internal planar structure constructed from a plurality of open cells configured to deform under load; and an outer layer of a flexible sheet material arranged to overlie a surface of the internal planar structure, wherein: the outer layer of flexible material is held in place relative to the internal planar structure such that the outer layer of flexible material increases the area of energy absorption under impact.

[0005] In an embodiment, the internal planar structure is a honeycomb material comprising a plurality of tubular open cells arranged normally to the surface to be impacted.

[0006] According to a second aspect of the present invention, there is provided a method of fabricating a body protection apparatus for absorbing the energy of an impact, comprising the steps of: constructing an internal planar structure from a plurality of open cells configured to deform under load; and arranging an outer layer of a flexible material to overlie a surface of said internal planar structure; wherein the outer layer of flexible material is held in place relative to the internal planar structure such that the outer layer of flexible material increases the area of energy absorption.

[0007] In an embodiment, the method includes the further step of forming holes in said flexible material.

[0008] The invention will now be described by way of example only with reference to the accompanying drawings, of which:

Figure 1 shows a body protection apparatus;
Figure 2 shows an internal planar structure of the apparatus identified in Figure 1;
Figure 3 shows an example of an outer layer of flex-

ible sheet material;

Figure 4 shows an alternative view of the apparatus identified in Figure 1;

Figure 5 shows the apparatus in an outer cover for attachment to a user;

Figure 6 shows the apparatus of Figure 1 deployed within a jacket;

Figure 7 illustrates the apparatus of Figure 1 in use;

Figure 8 shows a first stage in a method of fabricating a body protection assembly;

Figure 9 shows a second stage in said assembly;

Figure 10 shows a third stage in said assembly;

Figure 11 shows an alternative jacket with pockets for receiving protection devices; and

Figure 12 shows a glove with pockets for receiving protection devices.

Figure 1

[0009] A body protection apparatus **101** is shown in Figure 1, for protecting a human body from injury due to an impact. The apparatus has an internal planar structure **102** defining the shape of the apparatus. The internal planar structure is therefore substantially rigid but does allow a degree of flexibility. Thus, in an embodiment, pressure may be applied to a bottom **103** of the apparatus and to a top **104** of the apparatus resulting in a degree of curvature being introduced. In this way, when fitted, the apparatus will flex to a degree in order to accommodate the particular shape of a user and to accommodate user movements.

[0010] An outer layer of a flexible sheet material **105** is provided having a shape defined by the internal planar structure. The internal planar structure **102** is itself made up from a plurality of cells. Cells at the position of an impact region deform to absorb kinetic energy. In addition, the outer layer of the flexible sheet material draws additional cells into the impact region. In this way, the outer layer extends the size of the impact region so as to increase the number of cells that absorb the kinetic energy. It is then possible for the apparatus to absorb a substantial degree of kinetic energy before the overall integrity of the apparatus breaks down.

Figure 2

[0011] Internal planar structure **102** is shown in Figure 2. Region **201** is shown enlarged at **202**. In this embodiment, cells, such as cell **203**, are tubes, with each tube being welded to at least one other tube. A material of this type is described in European patent publication EP 1 694 152 (US 8,082,599).

[0012] In this embodiment, each cell comprises a tube and the tubes are arranged in close packed arrays, such that the gap between adjacent tubes is minimised. Each tube may have a diameter of between two millimetre and nine millimetre (2mm - 9mm) and a thickness of between zero point one millimetre and zero point seven five milli-

metre (0.10mm - 0.75mm). A typical tube length is between ten millimetre and twenty five millimetre (10mm-25mm). In this configuration, a progressive buckling failure mode is achieved and a global fracture is avoided if a sufficient number of the tubes are included in the process of material deformation.

[0013] In previous applications of the material, it is known to encase the material within a solid outer shell, such as that provided by a motorcyclist's helmet. In this way, the integrity of the apparatus is maintained by the outer shell and the presence of the outer shell ensures that the impact region is extended over a substantially large number of collapsing cells. In the present embodiment, such a shell is not available and the rigidity and structure of the apparatus are provided by the cellular material itself.

[0014] Experiments have shown that when used alone, the material may fracture upon the application of a relatively modest impact; given that the progressive buckling property is not observed. However, further experiments have shown that by the inclusion of an outer layer of a flexible sheet material, it is possible to bring a sufficient number of collapsing cells within the influence of the impact, thereby dissipating impact energy without causing a catastrophic failure.

[0015] Thus, in an embodiment, the cells are tubes and each tube is welded to at least one other tube. However, in alternative embodiments, alternative structures could be deployed, such as a honey-comb structure, provided that progressive buckling occurs upon impact and the region of buckling is extended by the presence of the planar structure.

Figure 3

[0016] An example of an outer layer 301 of a flexible sheet material is shown in Figure 3. In an embodiment, the flexible material covers the upper or outer face of the apparatus; this being the impact side of the apparatus. In an alternative embodiment, flexible material of the type shown in Figure 3 covers both the front face and the rear face of the internal planar structure.

[0017] In an embodiment, a layer of adhesive 302 is provided between the internal planar structure and the flexible material. Thus, in an embodiment, a sub-assembly of the apparatus will be constructed as a plurality of layers. A first layer 301 provides a rear flexible material face that is covered by a layer of adhesive 302. The internal planar structure 102 is then applied, followed by a further layer of adhesive and a front flexible material cover.

Figure 4

[0018] In an embodiment, a subassembly 404 (constructed from the plurality of layers previously described) is surrounded by an outer rim 402. In an embodiment, the outer rim 402 is constructed from a plastics material

and is configured to hold the edges of the layers in place.

[0019] In an embodiment, an edge 402 is chamfered, as shown in Figure 1.

[0020] In an embodiment, the flexible material 301 is a breathable material, knitted or woven from a yarn. Thus, in this way, at modest expense, it is possible to produce an assembly that has the required mechanical properties, while at the same time presenting holes for breathability and heat transfer.

[0021] In an alternative embodiment, the outer layer 301 is a flexible plastic sheet material. To facilitate heat transfer, the flexible sheet material 301 is provided with a plurality of holes 403. In an embodiment, the holes are as large as possible, to enhance breathability, while maintaining sufficient material to retain the required mechanical characteristics.

[0022] In the example shown in Figure 4, the overall shape of the apparatus has been configured to allow the apparatus to be deployed for protection against spinal injury. In this application, a vertical axis 404 is positioned over the spine of a user and a horizontal axis 405 is placed at the position of the shoulders.

Figure 5

[0023] In an embodiment, the apparatus of Figure 4 may be surrounded by an outer cover 501 and the assembly may include attachments 502 for attaching the apparatus into position over the spine of a user. In an embodiment, the attachments may take the form of shoulder straps 502 and a waist belt 503. In the example of Figure 5, the apparatus is totally self contained and its functionality is directed exclusively towards providing protection.

Figure 6

[0024] In an alternative configuration, the apparatus of Figure 4 may be included at a location 601 within a jacket 602. The apparatus may be included during the manufacture of the jacket 602 or the jacket 602 may be provided with a pocket allowing the apparatus to be inserted and, if necessary, subsequently removed or replaced.

[0025] The example of Figure 6 shows the apparatus deployed in a motorcyclist's jacket 602. However, it should be appreciated that the apparatus could be included in many other forms of clothing, such as clothing for off road cycling or skiing. In many of these sporting applications, it is appreciated that the devices should be lightweight, flexible and breathable; while at the same time exhibiting sufficient strength in order to absorb energy when an impact occurs. Further examples are described with reference to Figures 8 to 12.

Figure 7

[0026] The configuration illustrated in Figure 6 facilitates a method for protecting a body while receiving an

impact. As shown in Figure 7, a user has fallen from a motorcycle **701** resulting in the user making impact with tarmac **702**. The resulting accident could leave the user severely injured but the impact has been received at the position of the body protection apparatus.

[0027] In response to this, the body protection apparatus absorbs kinetic energy by deforming cells at the position of a region of energy absorption. The apparatus is configured to draw-in additional cells into the region of energy absorption. Thus, in this way, the outer layer extends the size of the impact region so as to increase the number of cells that absorb kinetic energy.

[0028] The cells form a solid planar structure that defines the shape of the body protection apparatus. In addition, the planar structure has an impact surface in contact with an outer layer of flexible material having a shape defined by the solid structure to perform the step of extending the impact region, thereby drawing-in additional cells.

[0029] It should be appreciated that following an impact of the type shown in Figure 7, plastic deformation to the solid planar structure occurs due to the progressive buckling of the cells. In many applications, an apparatus strong enough to absorb an impact of this type would tend to be uncomfortable and introduce further problems in terms of heat dissipation. However, in an embodiment, a user's body may experience satisfactory heat transfer due to the outer layer being constructed from a breathable material. As shown in Figure 4, this breathability may be achieved by the presence of a plurality of holes in the sheet material.

Figure 8

[0030] A method of fabricating a body protection assembly is shown in Figures 8 through 10 and alternative applications for the assembly are illustrated in Figures 11 and 12.

[0031] To fabricate the assembly, an internal structure **801** is constructed from a plurality of cells, such that the structure is configured to deform in an area of energy absorption upon receiving an impact.

[0032] In an embodiment, the internal structure is constructed by extruding tubes with an internal circumference of a first material and an outer circumference of a second material, in which the second material has a lower melting point than the inner material. Predetermined lengths of the extruded tubes are then cut and arranged into the planar structure of Figure 8. Heat is then applied to melt a portion of the outer circumferences without melting respective inner circumferences. In this embodiment, further machining is performed in order to create a chamfered edge **802**.

[0033] The tubes may have an outer diameter of between two millimetre and nine millimetre (2mm - 9mm) and each tube may have a thickness of less than seven hundred and fifty micrometre (750µm).

Figure 9

[0034] Having constructed the internal structure **802**, an outer layer of a flexible material **901** is attached to the internal structure. The purpose of the outer layer of flexible material is to bring more of the cells into a region of energy absorption when an impact occurs, thereby increasing the area of energy absorption.

Figure 10

[0035] An assembly of layers, consisting of a first flexible material, a layer of adhesive, the internal structure, a further layer of adhesive and a second flexible material is surrounded by an outer rim **1001** of a plastics material. The outer rim holds the layers of the assembly in place and maintains the overall mechanical integrity of the apparatus.

[0036] The apparatus shown in Figure 10 may be produced to various sizes, facilitating many different types of application. The apparatus of Figure 10 may be seen as a general purpose protector, suitable for application in various places; unlike the protector of Figure 4 that has been designed for a specific type of application.

Figure 11

[0037] An alternative jacket **1101** is shown in Figure 11. The jacket has been constructed with a plurality of pockets configured to receive protection devices of the type shown in Figure 10.

Figure 12

[0038] A glove **1201** is shown in Figure 12, again including pockets for receiving protection devices of the type shown in Figure 10. Thus, it can be seen, that the size of the protection device shown in Figure 10 may vary significantly, thereby allowing deployment in many different configurations.

Claims

1. A body protection apparatus for absorbing the energy of an impact, **characterised by:**

an internal planar structure constructed from a plurality of open cells configured to deform under load; and
an outer layer of a flexible sheet material arranged to overlie a surface of the internal planar structure, wherein:

the outer layer of flexible material is held in place relative to the internal planar structure such that the outer layer of flexible material increases the area of energy absorption un-

- der impact.
2. The body protection apparatus of claim 1, wherein the outer flexible layer is held in place relative to the internal planar structure at its edges. 5
 3. The body protection apparatus of claim 1 or claim 2, wherein the outer layer of flexible material is attached to the internal planar structure to hold the layers in place. 10
 4. The body protection apparatus of claims 1 to 3, further comprising a layer of adhesive between said internal planar structure and said flexible material to attach the flexible material in place. 15
 5. The body protection apparatus of claims 1 to 4, wherein said internal planar structure is a honeycomb material comprising a plurality of tubular open cells arranged normally to the surface to be impacted. 20
 6. The apparatus of claim 5, wherein each of said tubular cells is welded to at least one other of said tubes. 25
 7. The apparatus of claims 1 to 6, configured to protect against spinal injury.
 8. The apparatus of claim 7, including attachments for attaching the apparatus into position over the spine of a user. 30
 9. The apparatus of claims 1 to 8, wherein said apparatus is configured to be received within an item of clothing or a wearable item of luggage. 35
 10. The apparatus of any of claims 1 to 9, wherein said outer layer of flexible material covers both a front surface and a rear surface of said internal planar structure. 40
 11. The apparatus of any of claims 1 to 10, further comprising an outer rim surrounding an edge of the apparatus. 45
 12. The apparatus of any of claims 1 to 11, wherein said outer layer of flexible material is a breathable material knitted or woven from a yarn 50
 13. The apparatus of any of claims 1 to 12, wherein said outer layer of flexible material is a plastic sheet material.
 14. The apparatus of claim 13, wherein said outer layer of plastic sheet material includes a plurality of holes. 55
 15. A method of fabricating a body protection apparatus

for absorbing the energy of an impact, **characterised by** the steps of:

constructing an internal planar structure from a plurality of open cells configured to deform under load; and
 arranging an outer layer of a flexible material to overlie a surface of said internal planar structure; wherein
 the outer layer of flexible material is held in place relative to the internal planar structure such that the outer layer of flexible material increases the area of energy absorption under impact.

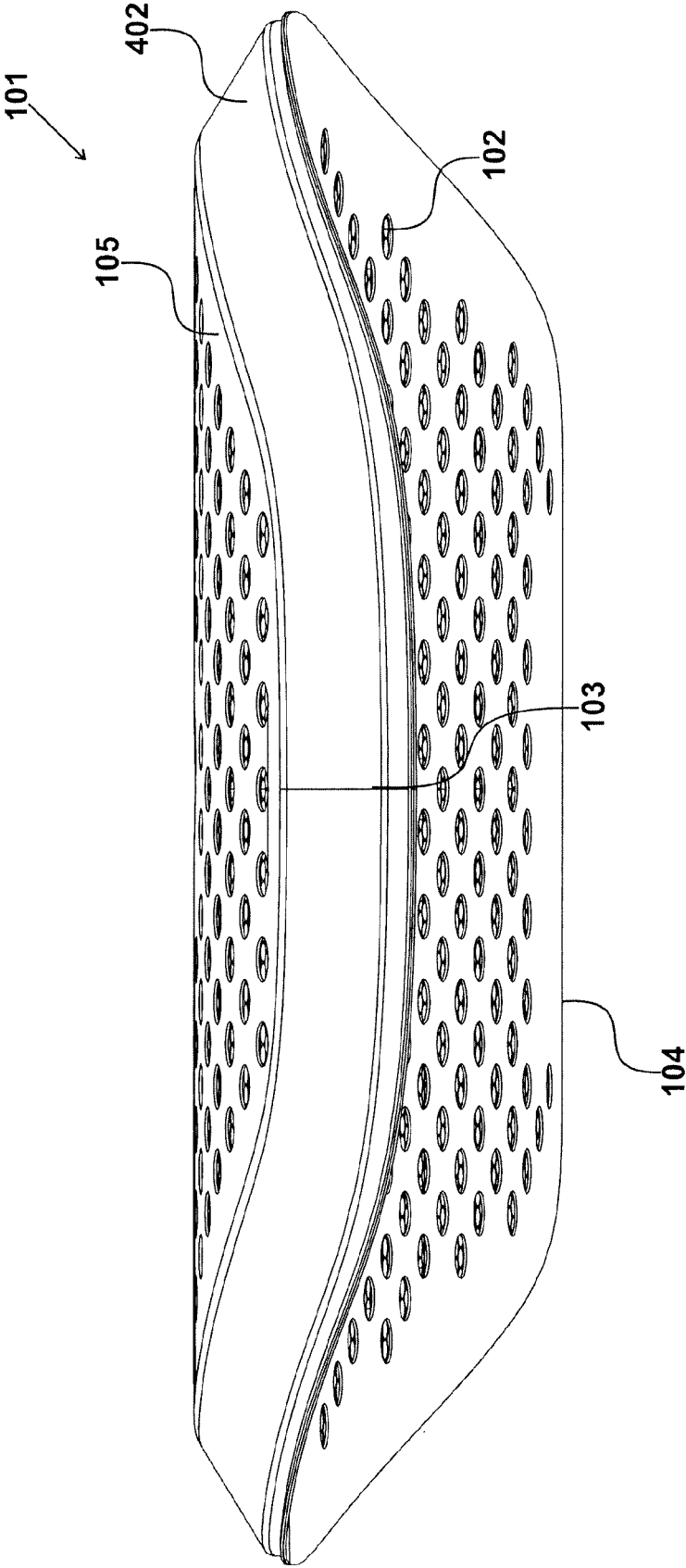
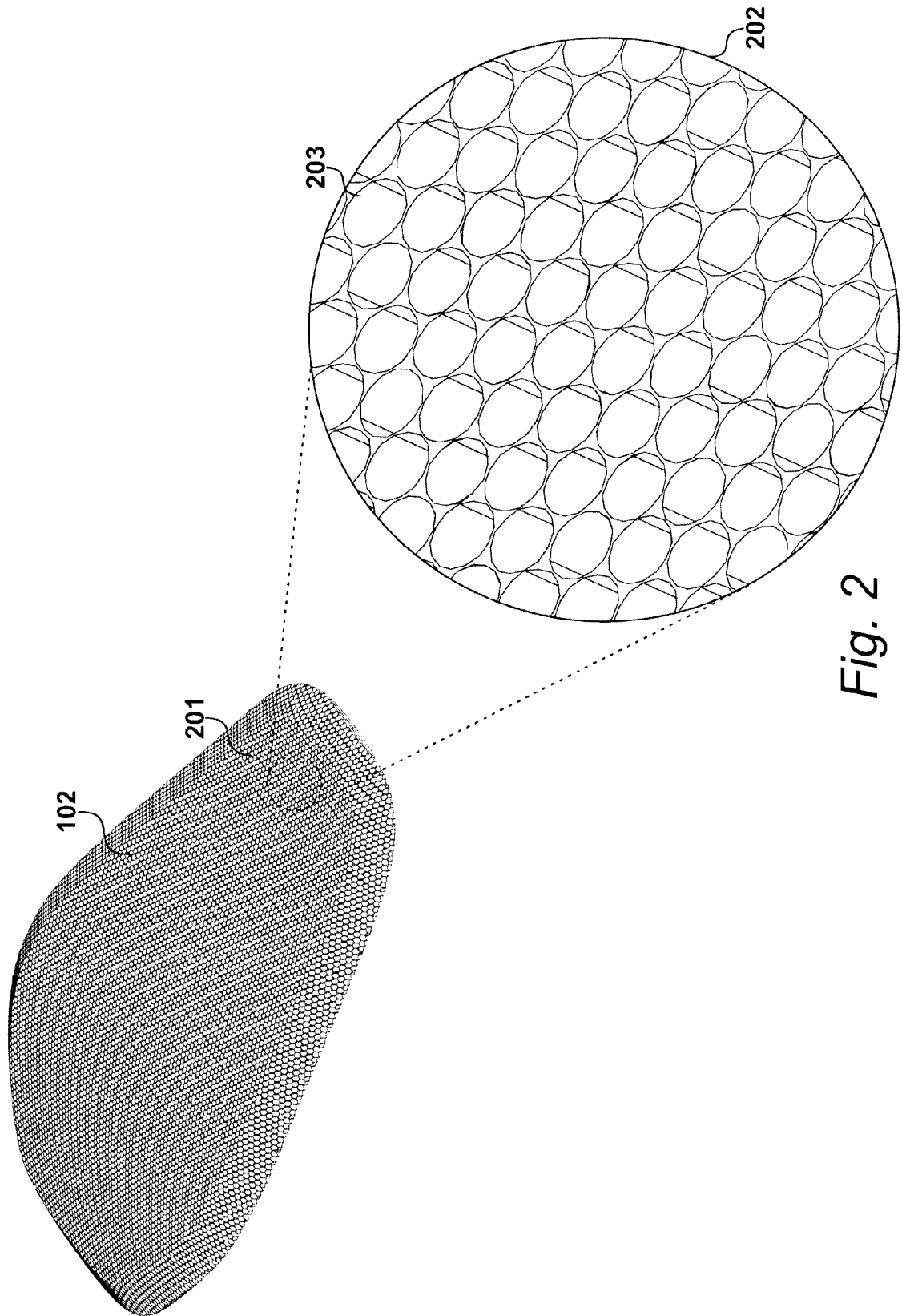


Fig. 1



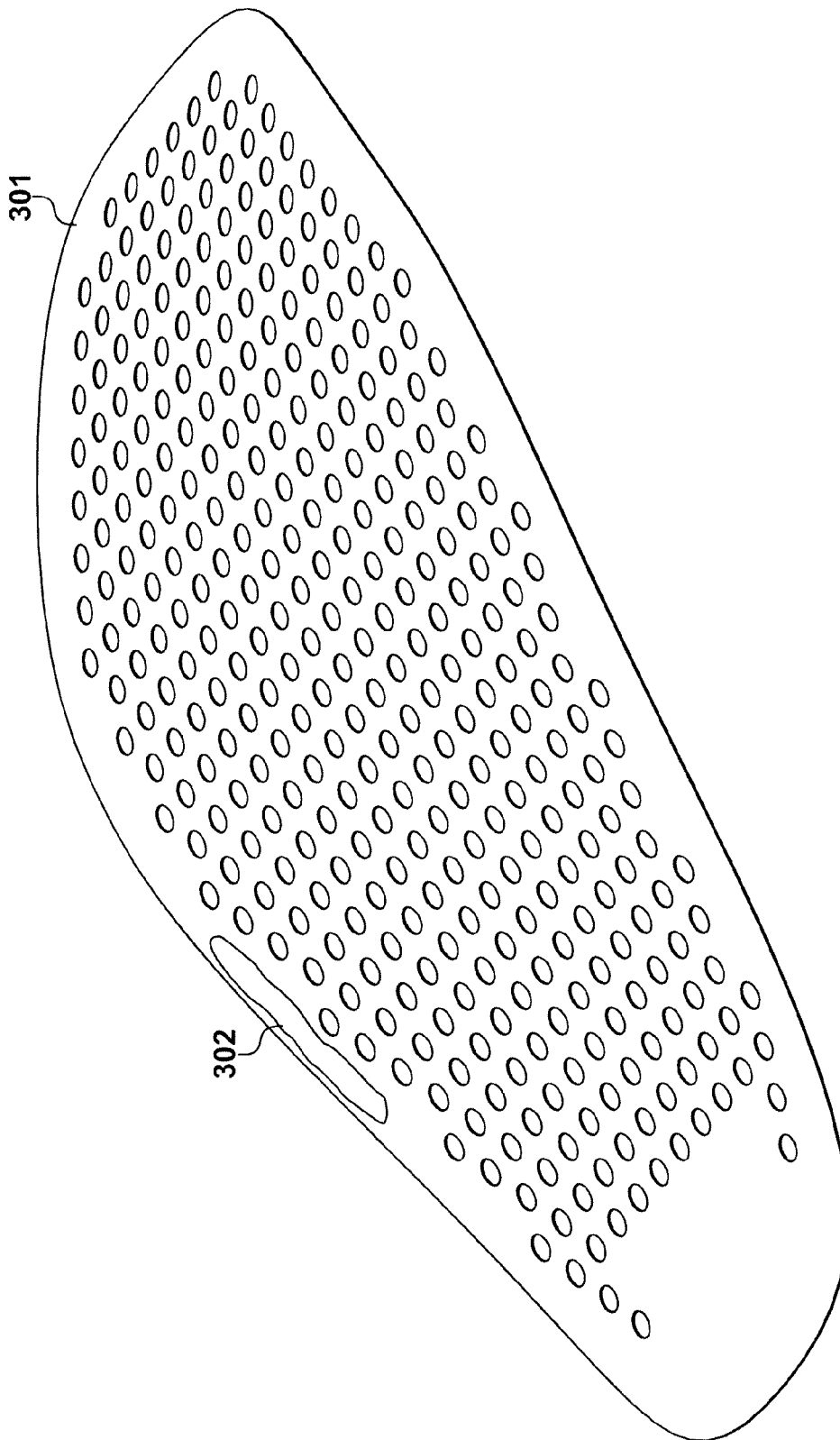


Fig. 3

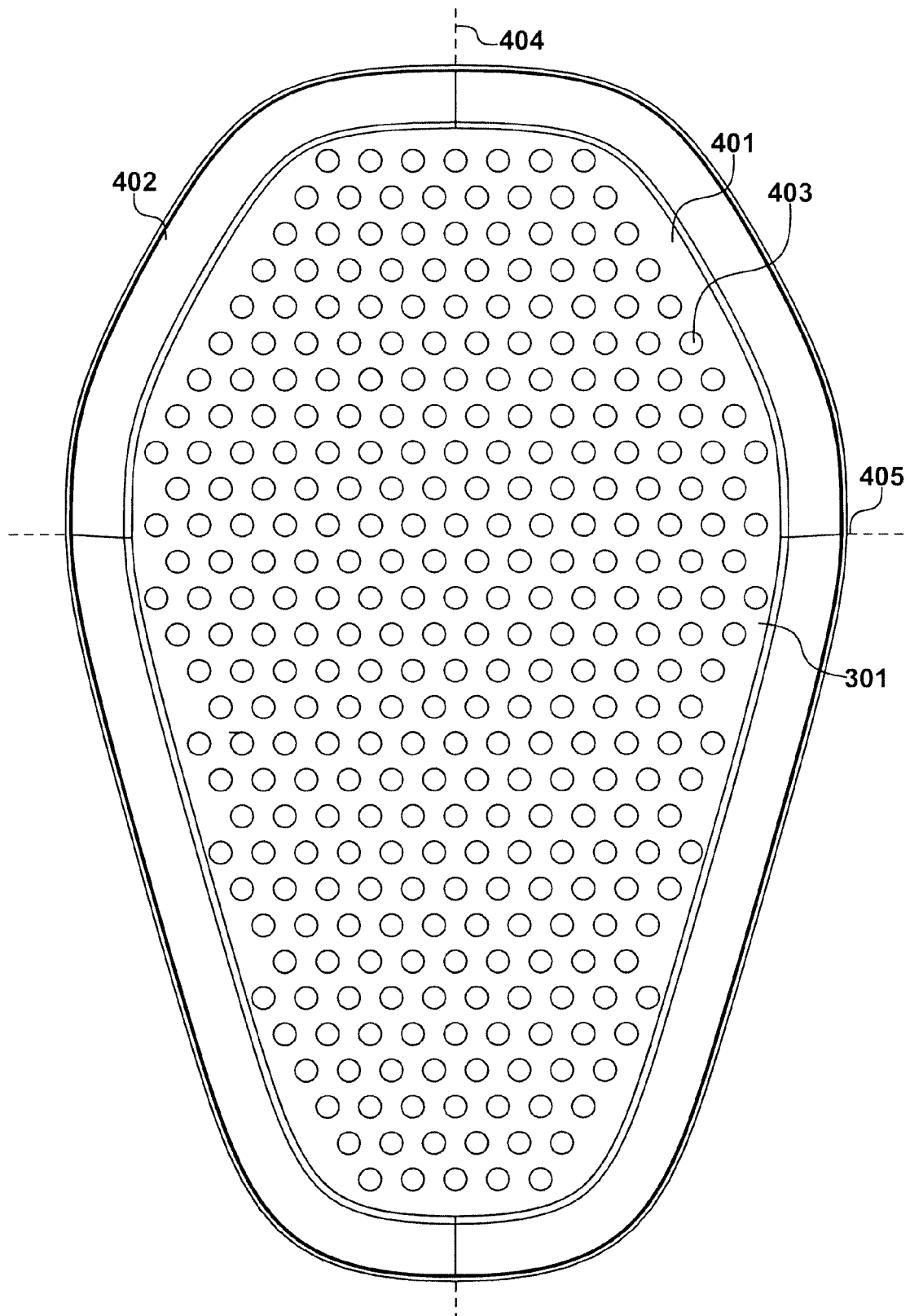


Fig. 4

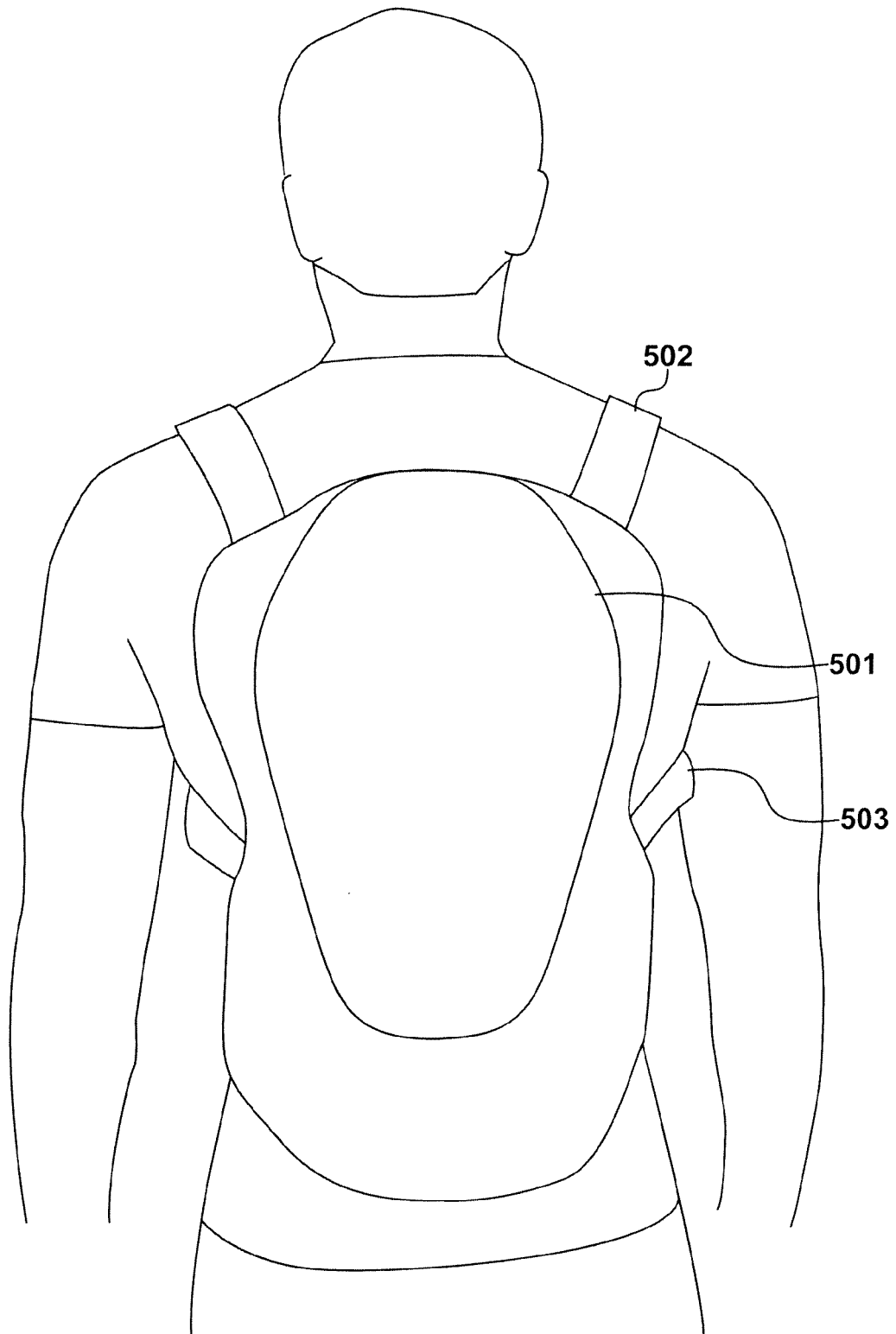


Fig. 5

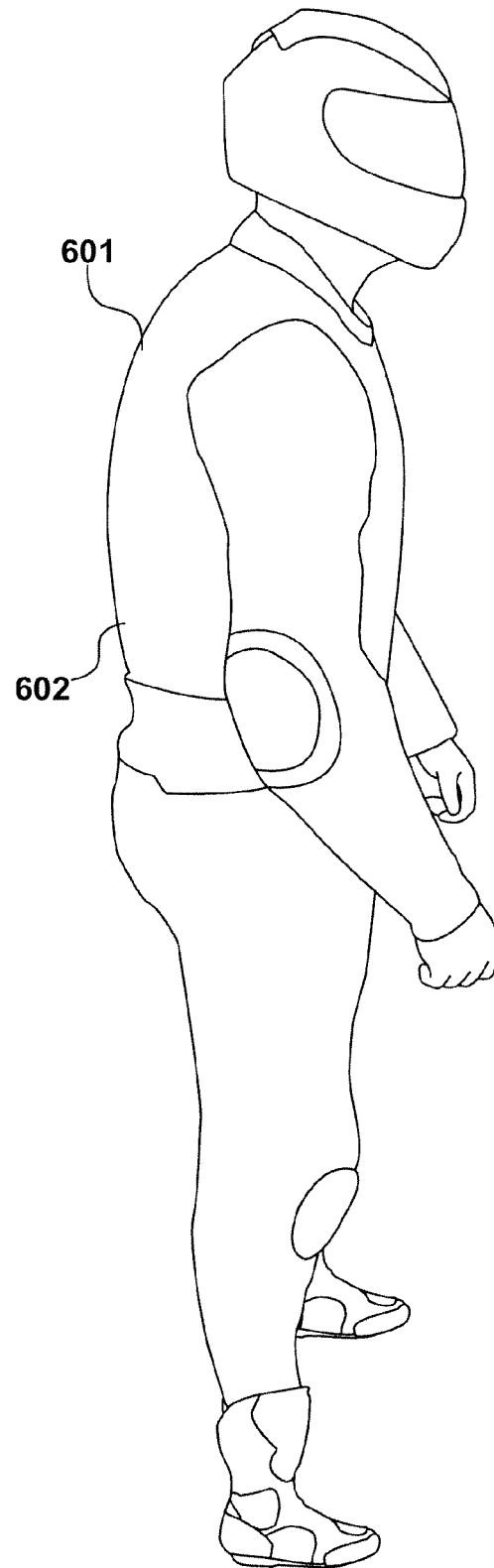


Fig. 6

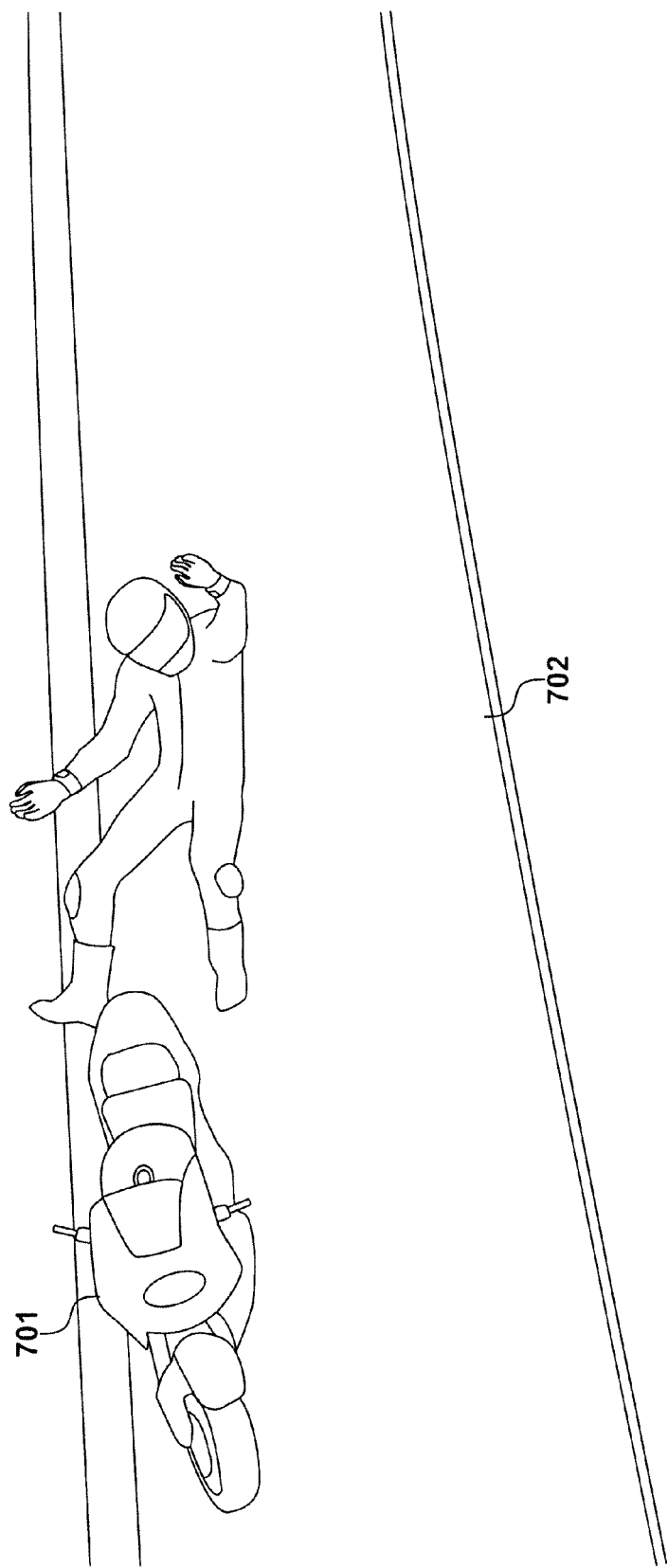


Fig. 7

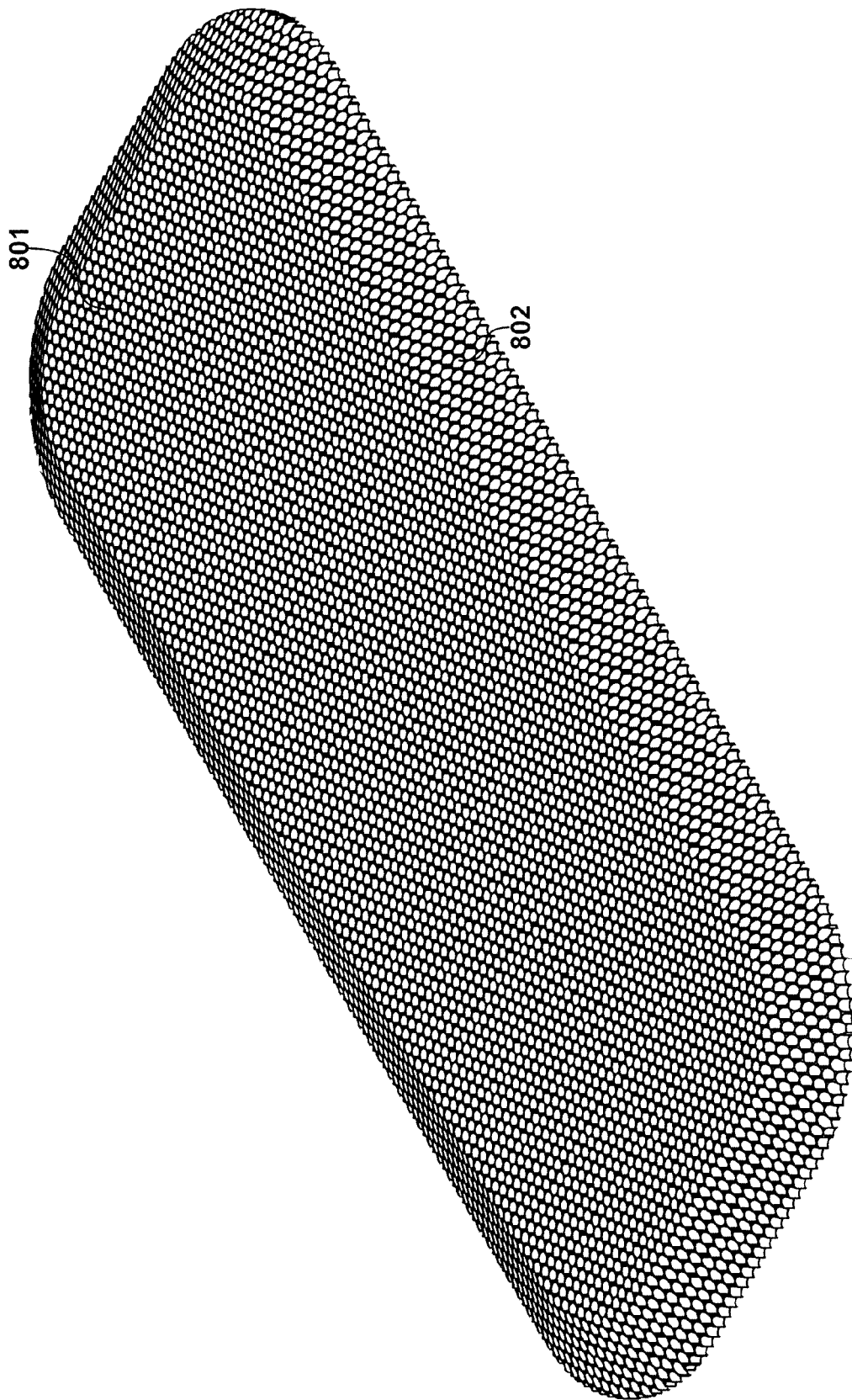


Fig. 8

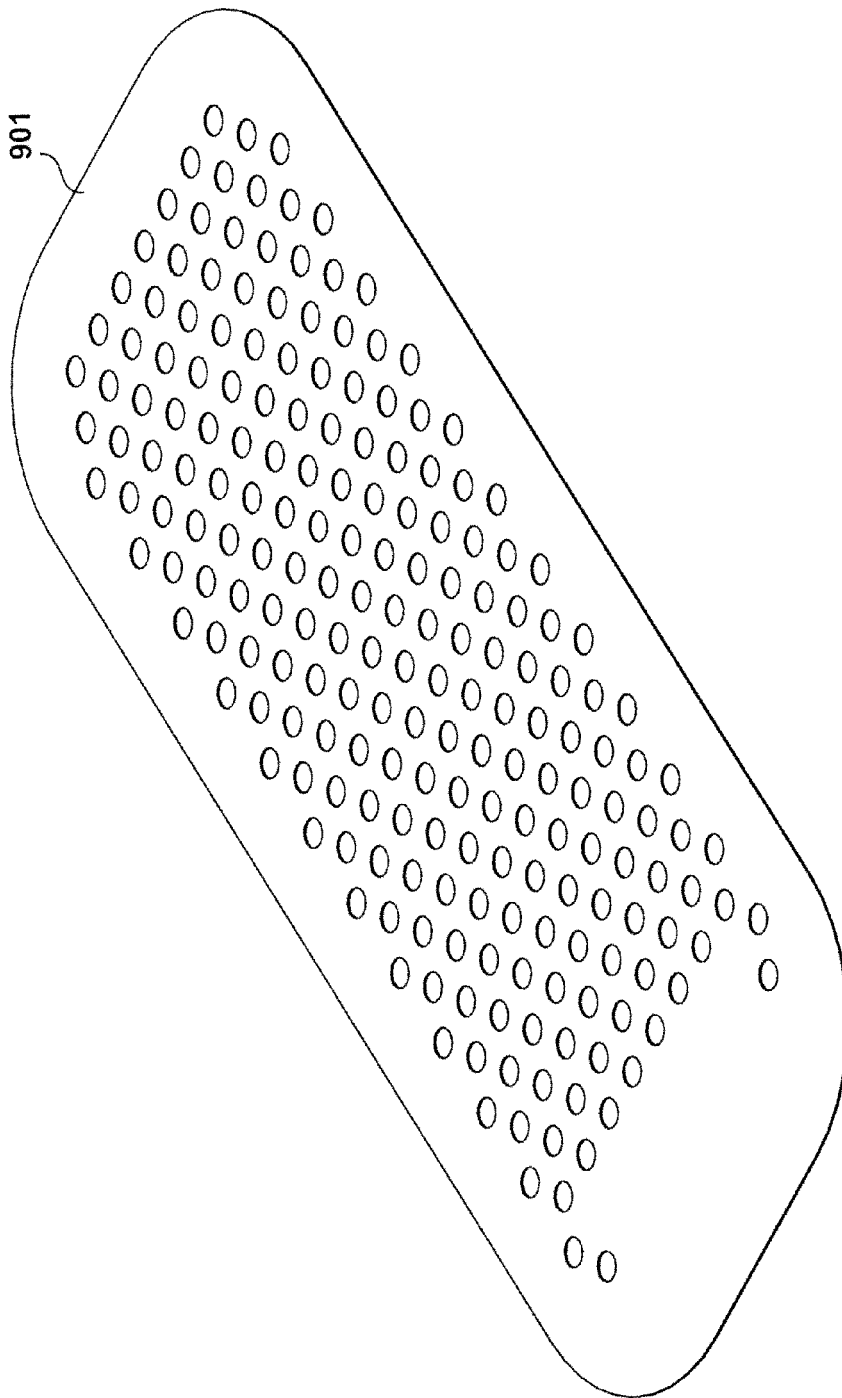


Fig. 9

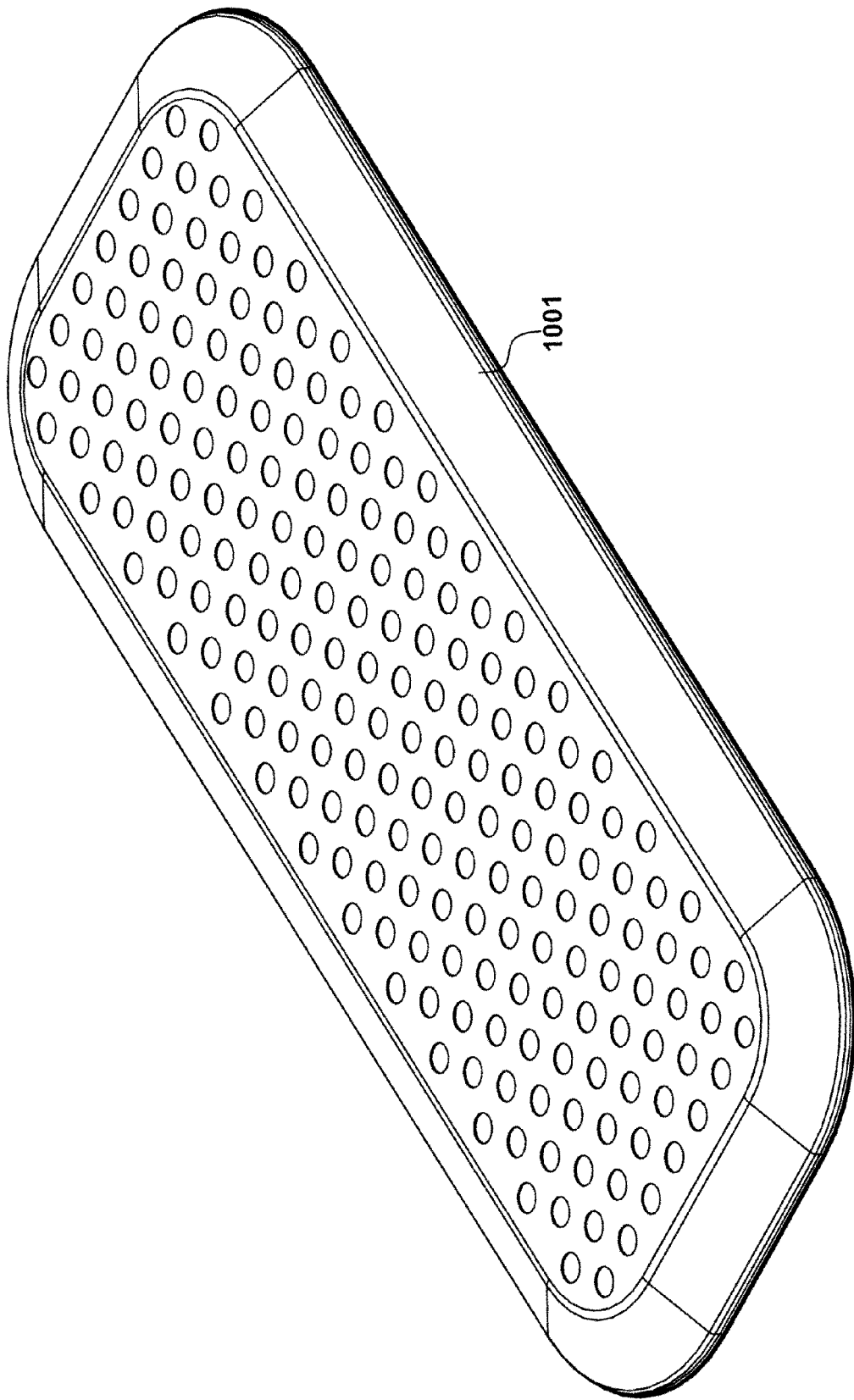


Fig. 10

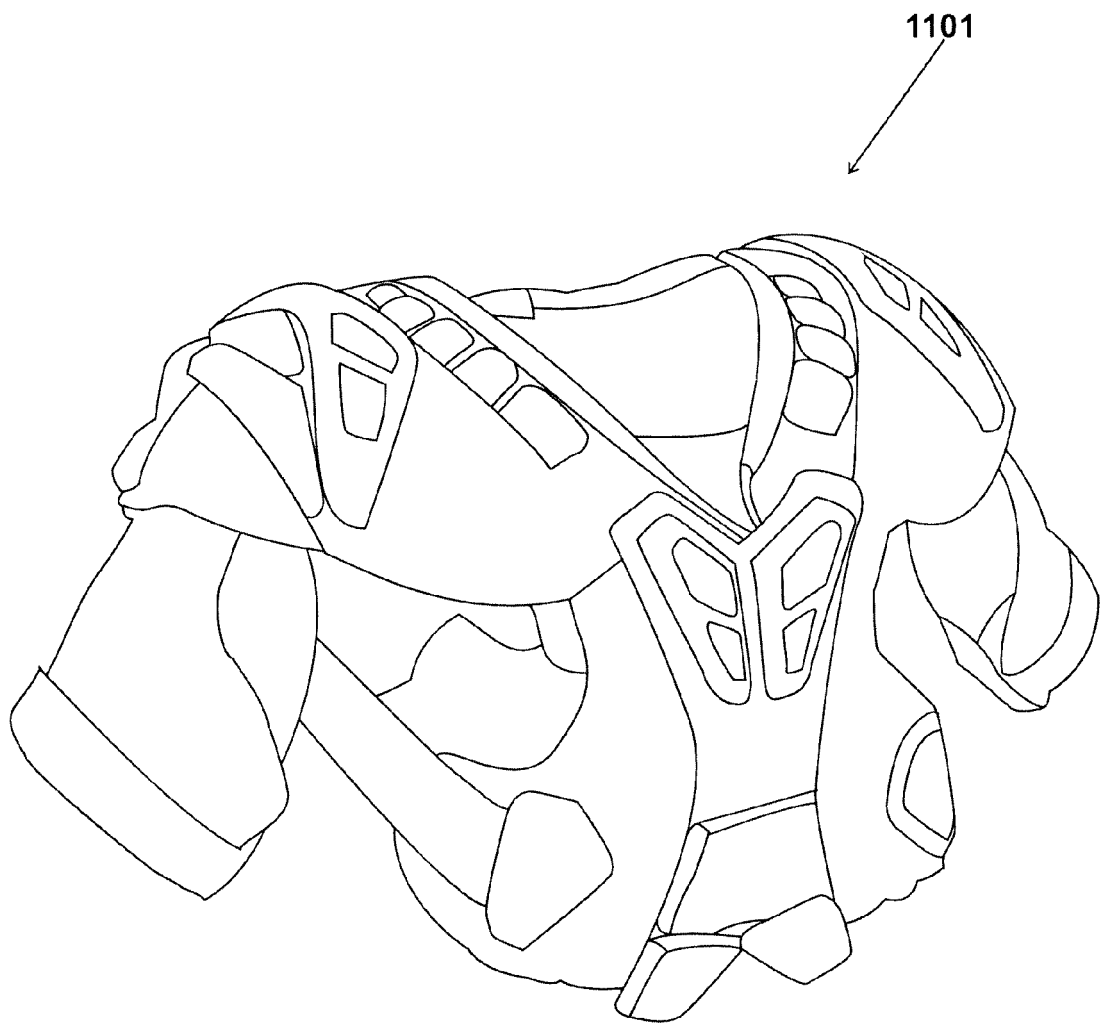


Fig. 11

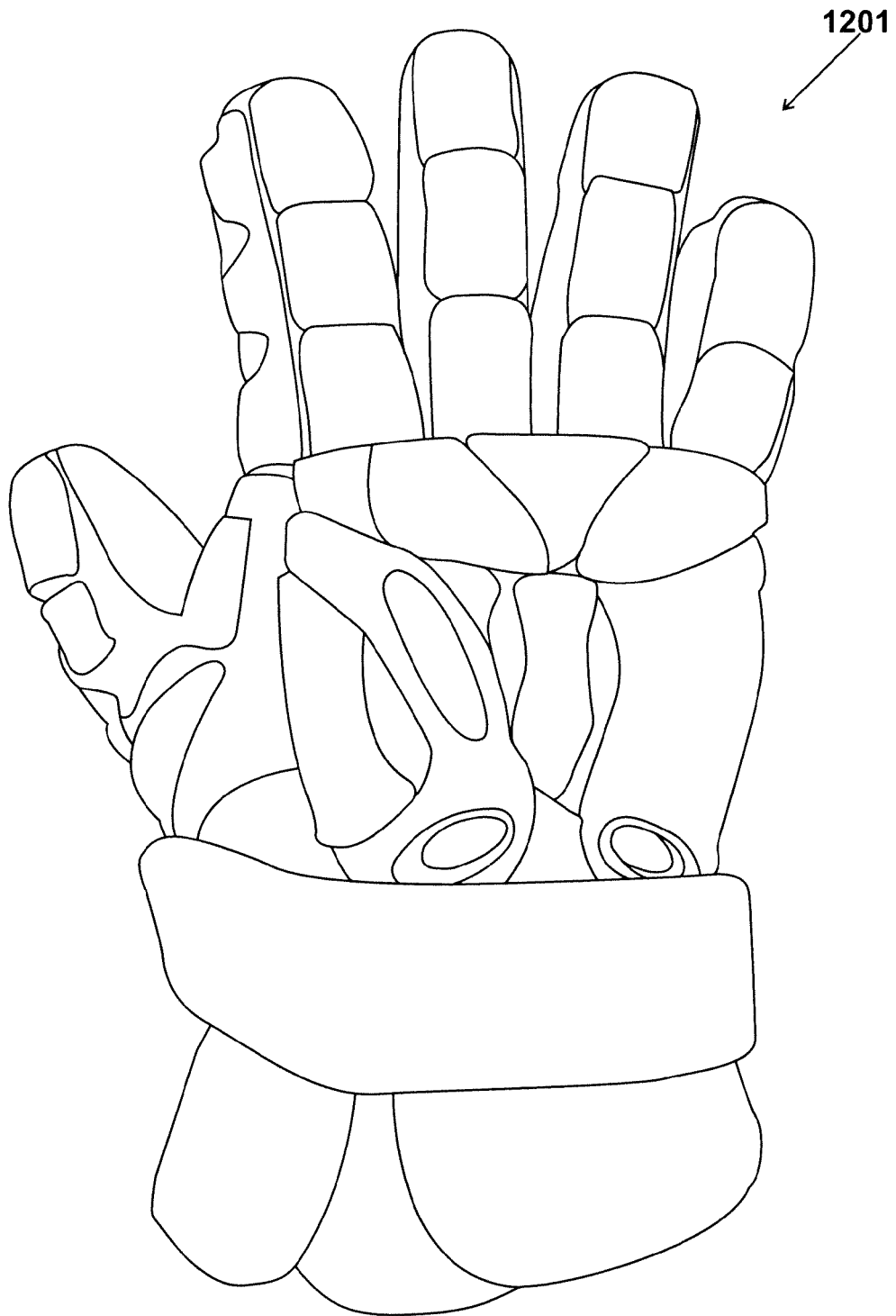


Fig. 12



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Place of search The Hague		Date of completion of the search 2 June 2015	Examiner Simpson, Estelle
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