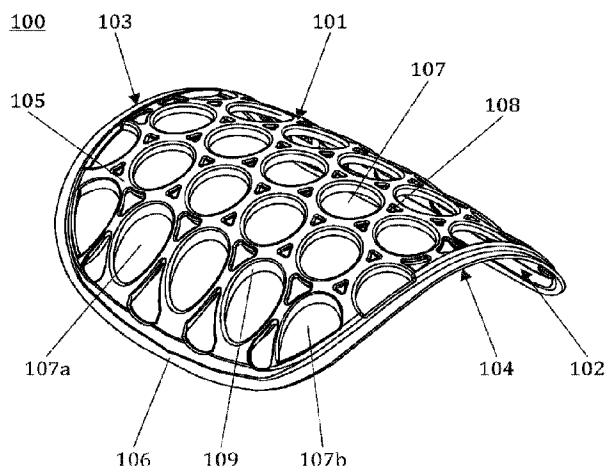




(86) Date de dépôt PCT/PCT Filing Date: 2020/01/27
(87) Date publication PCT/PCT Publication Date: 2020/08/06
(45) Date de délivrance/Issue Date: 2023/11/14
(85) Entrée phase nationale/National Entry: 2021/07/29
(86) N° demande PCT/PCT Application No.: FI 2020/000002
(87) N° publication PCT/PCT Publication No.: 2020/157372
(30) Priorité/Priority: 2019/02/01 (FI20197015)

(51) Cl.Int./Int.Cl. *A41D 13/015* (2006.01),
A41D 13/05 (2006.01), *A63B 71/08* (2006.01)
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(54) Titre : STRUCTURE DE PROTECTION POUR VETEMENTS ET EQUIPEMENT DE PROTECTION
(54) Title: A PROTECTIVE STRUCTURE FOR PROTECTIVE GARMENTS AND EQUIPMENT



(57) **Abrégé/Abstract:**

The invention is a protective structure (100) for protective garments and equipment. The protective structure is flat curved plate like object which comprises a mesh structure (105) having a multitude of holes (107). The holes in the mesh structure or the parts of the holes in the mesh structure have rim structures (109) extending towards the user when the protective structure is in use and between the rim structures are channels. The channels improve air circulation beneath the protective structure and the rim structures enhances the impact spreading and elasticity of the protective structure. A continuous border frame (106) surrounds the mesh structure. The protective structure has a first surface (101) and a second surface (102), and the second surface is towards the user of the protective structure when the protective structure is in use.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property

Organization

International Bureau

(43) International Publication Date

06 August 2020 (06.08.2020)



(10) International Publication Number

WO 2020/157372 A1

(51) International Patent Classification:

A41D 13/015 (2006.01)*A63B 71/08* (2006.01)*A41D 13/05* (2006.01)

(21) International Application Number:

PCT/FI2020/000002

(22) International Filing Date:

27 January 2020 (27.01.2020)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

20197015

01 February 2019 (01.02.2019) FI

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(81) Designated States (unless otherwise indicated, for every

kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every

kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK,

(54) Title: A PROTECTIVE STRUCTURE FOR PROTECTIVE GARMENTS AND EQUIPMENT

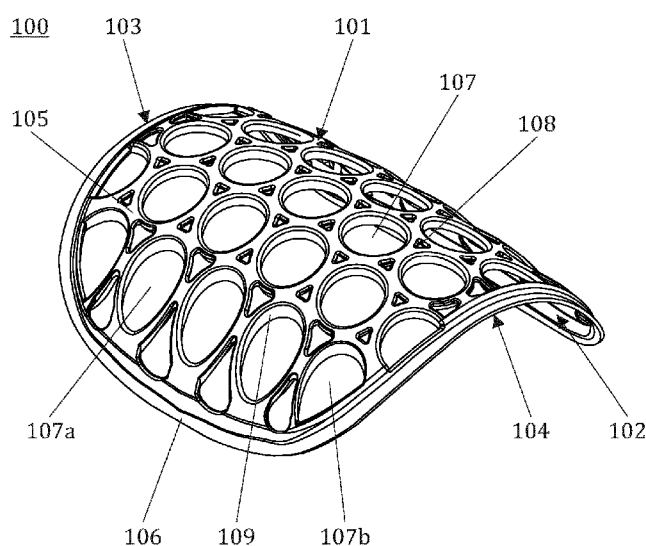


FIG. 1

(57) **Abstract:** The invention is a protective structure (100) for protective garments and equipment. The protective structure is flat curved plate like object which comprises a mesh structure (105) having a multitude of holes (107). The holes in the mesh structure or the parts of the holes in the mesh structure have rim structures (109) extending towards the user when the protective structure is in use and between the rim structures are channels. The channels improve air circulation beneath the protective structure and the rim structures enhances the impact spreading and elasticity of the protective structure. A continuous border frame (106) surrounds the mesh structure. The protective structure has a first surface (101) and a second surface (102), and the second surface is towards the user of the protective structure when the protective structure is in use.

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EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV,
MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,
TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW,
KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

A protective structure for protective garments and equipment

The invention relates to a protective structure for protective garments and equipment, comprising a first surface, a second surface, a curved mesh structure having a multitude of holes extending from the first surface to the second surface, and a
 5 border frame surrounding the mesh structure at least partly, and the protective structure is configured to be positioned in a garments in a such way that the second surface is towards the user of the garment, and the material of the protective structure is rigid.

10 BACKGROUND

Many sporting and safety garments and equipment feature protective structures. Protective structures are present e.g. in ice hockey leg shields, breast and shoulder shields and in pants and safety garments that protect users from falls and high impacts. The protective structures are fairly stiff structures that are usually made of
 15 a plastic material, the purpose of the protective structures being receiving shocks and distributing the energy of the shock over a wider area.

Protective structures for protective garments and equipment have traditionally been made from sheet-like material by die-cutting and forming the die-cut piece by to a desired shape by subjecting it to heat. Also, the sheet-like material is bent during
 20 die-cutting in order to improve the stiffness of the piece. Also, openings have been made in the piece during die-cutting in order to lighten the piece. Plastic has normally been the material of choice. Such protective structures have been used in the outer surface of sporting equipment e.g. ice hockey leg shields or inside the sporting equipment, wedged between softer protective structures such as foamed
 25 plastics. The purpose of the protective structure is to receive shocks and impacts from the outside and to distribute their energy over a wider area. The protective structure and its material should be substantially rigid for maintaining the shape of the protective structure. However, the protective structure should bend when receiving impacts for distributing energy over a wider area.

30 A protective structure made of sheet-like material by die-cutting becomes fairly heavy. The thickness of the material is the same throughout the whole piece and the ability of the piece to distribute shocks effectively over a wider area remains rather limited. The described protective structure also traps heat and prevents air from circulating under the protective structure, causing discomfort and fatigue.

Following publications address some of these problems.

Patent publication FI103862 shows a protective pad for a garment equipped with separate protective pads that are inserted into pockets. Each protective pad is composed of a flexible cellular protective pad material, which retains its shape and
 5 comprises interconnected walls which extend from an outer surface to an inner surface of the protective pad, said walls having a width in the direction of the surface of the pad which is smaller than the height of the wall in the thickness direction of the protective pad. The walls form cells with a closed periphery such that between the walls of the cells there remain holes extending through the pad. The
 10 pad is made from a sheet-like cellular material by cutting the material into a shape having the appropriate contour. The width of the walls increases from the outer surface towards the inner surface of the pad. The pad can be manufactured e.g. by injection moulding or by producing a cellular sheet, where cells needed for the pad are on a big sheet. The height of the walls, i.e. the thickness of the pad, is the
 15 same on the whole area of the pad.

Patent publication FI124192 shows a protective structure comprising at least in one direction a curved support rib structure of a material that is suited for injection moulding. The thickness of the support rib structure varies in a direction perpendicular to a surface formed by the support rib structure so that the thickness is
 20 greater at the middle of the support rib structure compared to the material thickness at the edges of the support rib structure. This kind of structure improves impact energy distribution and makes the whole structure lighter.

However, there is a clear need for improving protective structures for protective garments and equipment. It would be especially beneficial if the weight could be
 25 reduced and air circulation in the protective structure could be improved. If these goals can be achieved, there can also be other uses for the protective structures, in addition to sporting equipment.

BRIEF DESCRIPTION

30 The object of the invention is a solution that can significantly reduce the disadvantages and drawbacks of the prior art. In particular, the object of the invention is a solution where a is provided a light protective structure with improved air circulation properties.

The objects of the invention are attained with a device that is characterised by what is stated in the independent patent claim. Some advantageous embodiments of the invention are disclosed in the dependent claims.

5 The invention is a protective structure for protective garments and equipment. The protective structure is a flat curved plate like an object that comprises a mesh structure having a multitude of holes. The holes in the mesh structure or the parts of the holes in the mesh structure have rim structures extending towards the user when the protective structure is in use and between the rim structures are channels. The channels improve air circulation beneath the protective structure and the rim structures enhances impact-spreading and the elasticity of the protective structure. A continuous border frame surrounds the mesh structure. The protective structure has a first surface and a second surface, and the second surface is towards the user of the protective structure when the protective structure is in use.

15 If it is mentioned that some part of the protective structure is higher than some other part of the protective structure, then a situation where the protective structure is laying on a surface with the first surface down is described. Also, when some direction or surface or part is referred to by 'outer', it is meant that it is away from the user when the protective structure is in use.

20 In one embodiment of the invention is a protective structure for protective garments and equipment, comprising a first surface, a second surface, a curved mesh structure having a multitude of holes extending from the first surface to the second surface, and a border frame surrounding the mesh structure at least partly, and the protective structure is configured to be positioned in a garments or equipment in a such way that the second surface is towards the user of the garments or equipment, and the material of the protective structure is rigid. The term rigid means here that the protective structure maintains its form in a normal use. Impacts may bend the protective structure. In one advantageous embodiment of the invention, the edges of the holes in the mesh structure have rim structures extending towards the second surface from the mesh structure and the rim structure has a top side, an inner side and an outer side, and between the rim structures are channels formed by the sides of the rim structures and the mesh structure, and the top sides of the rim structures form at least part of the second surface, and the heights of the rim structures are greater at the middle of the mesh structure compared to the heights of the rim structures at the edge of the mesh structure.

In one embodiment of the protective structure, the rim structures are separate from each other. This feature allows the channels to be continuous and the elasticity of the protective structure is enhanced and its impact-distribution properties are improved.

- 5 In a second embodiment of the protective structure, the rim structures are continuous at holes which do not touch the border frame. This means that the rim structures surround the holes that are not delimited by the edge of the mesh structure. This feature guides the air circulation and improves the impact durability of the protective structure.
- 10 In a third embodiment of the protective structure, the thickness of the border frame is less than the distance between the first surface and the second surface at the edge of the mesh structure. This feature provides an arrangement that can be used for fixing the protective structure to garments or fixing some material to the protective structure. Also, this diminishes the weight of the protective structure.
- 15 In a fourth embodiment of the protective structure, at least one of the curvature radiuses of the second surface is greater than the corresponding curvature radius of the first surface.

- 20 In a fifth embodiment of the protective structure, the holes are circular or elliptical or at least partly circular or elliptical. The holes are partly circular or elliptical where the border frame limits them. Circular shapes are found to be durable and they spread the impact forces efficiently.

- 25 In a sixth embodiment of the protective structure, the centre points of three adjacent holes form an equilateral triangle of a triangle, the sides of which differ from each other in length by 20% at most. This kind of placement of the holes yields a durable and light mesh structure.

- 30 In a seventh embodiment of the protective structure, there is a ventilation hole opening between three adjacent holes to the channels between the rim structures. This hole ventilates the channel between the rim structures. Also, it has been found that they further lessen the stress forces. Furthermore, they reduce the total mass of the protective structure.

In an eight embodiment of the protective structure, the border frame is configured in such a way that at least a cushioning and a supporting fabric layer can be fixed to the border frame. In a ninth embodiment of the protective structure, the cushion-

ing and the supporting fabric layer are configured to be fixed to the border frame in such a way that the middle parts of the cushioning and the supporting fabric layer are separate from the second surface.

5 In a tenth embodiment of the protective structure, at least some of the holes have a collar structure on the inner side of the rim structure, and the upper side of the collar structure is on the same level as the first surface.

In an eleventh embodiment of the protective structure, at least some of the holes have a collar structure on the inner side of the rim structure, and the upper side of the collar structure is on the same level as the second surface.

10 In a twelfth embodiment of the protective structure, the mesh structure and the border frame are of a material or material composition that is suited for injection moulding.

15 In a thirteenth embodiment of the protective structure, the mesh structure and the border frame are coated with a material containing metallic particles. In a fourteenth embodiment of the protective structure, the metallic part is made of metallic material having a microstructure which is fine-grained with an average grain size between 2 and 5,000 nm. This feature improves the impact resistance of the protective structure.

20 In a fifteenth embodiment of the protective structure, the open surface area of the mesh structure, i.e. total area of the holes, is at least 60% of the total area of the mesh structure in its entirety. This makes the protective structure light and at the same time durable.

25 In a sixteenth embodiment of the protective structure, the diameters of the holes are between 2 and 7 cm. Bigger holes do not provide any more protection from direct hits and using smaller holes increases the mass of the protective structure and impairs air circulation.

It is an advantage of the invention that it provides a protective structure that is light and has efficient air circulation.

30 Using the protective structure significantly improves impact-spreading and thus diminishes the probability of injuries. It also makes for a product that has no complex parts, so that it is easier to manufacture and maintain than devices according to known techniques.

One advantage of the invention is that it is quite durable and retains its form but is still elastic when receiving impacts. The protective structure can also be easily and quickly integrated in different kinds of garments and equipment.

5 It is a further advantage of the invention that additional devices, such as sensors, can be easily integrated in the protective structure. Also, the invention makes it possible, due its lightness and efficient air circulation, to use the protective structure for example in safety garments for elderly people.

DESCRIPTIONS OF THE FIGURES

10 In the following, the invention is described in detail. The description refers to the accompanying drawings, in which

Figure 1 shows an example of a protective structure according to an embodiment,

15 Figure 2 shows the protective structure presented in Figure 1 as seen from one end,

Figure 3 shows a second example of a protective structure according to an embodiment,

Figure 4 shows the protective structure presented in Figure 1 as seen from below,

20 Figure 5 shows a third example of a protective structure according to an embodiment,

Figure 6 shows the protective structure presented in Figure 5 as seen from below,

25 Figure 7 shows a fourth example of a protective structure according to an embodiment as seen from below,

Figure 8 shows the protective structure presented in Figure 7 as seen from the side, and

Figure 9 shows a fifth example of a protective structure according to an embodiment as seen from below.

DETAILED DESCRIPTIONS OF THE FIGURES

The embodiments in the following description are given as examples only and someone skilled in the art can carry out the basic idea of the invention also in
 5 some other way than what is described in the description. Though the description may refer to a certain embodiment or embodiments in several places, this does not mean that the reference would be directed towards only one described embodiment or that the described characteristic would be usable only in one described
 10 embodiment. The individual characteristics of two or more embodiments may be combined and new embodiments of the invention may thus be provided.

Figure 1 shows an embodiment of a protective structure 100. The protective structure is a plate-like construct having a first surface 101 and a second surface 102 and a first end 103 and a second end 104. The protective structure is configured in
 15 such a way that when the protective structure is in use, i.e. it is installed in a garment or equipment and the user is wearing it, the second surface is towards the user. The protective structure is curved in a such way that the body part to be protected is partly surrounded by the protective structure. The curvature of the protective structure in the embodiment in Figure 1 affect only one direction, but the curvature can affect many different directions. The protective structure could e.g. take
 20 the form of a hemisphere, a half ellipse or any combination of these. Choosing the correct curvature depends on where the protective structure is to be placed and how the impact forces are to be distributed. The material of the protective structure is rigid, which means that it retains its form during normal use. The shaping of the protective structure provides some elasticity for distributing impact forces.

25 The protective structure 100 comprises a mesh structure 105 and a border frame 106. The mesh structure has a multitude of holes 107 extending from the first surface 101 to the second surface 102. Between the holes are rib structures which function as a frame for the mesh structure. The border frame surrounds the mesh structure at least partly. In this embodiment the border frame is a flat shelf. The
 30 border frame serves to support the mesh structure and in some embodiments it also serves as a platform for fixing the protective structure to a garment or equipment. Also, in some embodiments the border frame can be used for attaching cushioning to the second surface. Some supporting fabric layers can be fixed to the border frame, too. The holes on the mesh structure have some kind of geometrical
 35 shape. In this embodiment holes are circular or elliptical or partly circular or

elliptical. Of course, in some embodiments they can be rectangular or take some other form. It must be noted that shapes of the holes can vary in different parts of the mesh structure. The border frame delimits the mesh structure in such a way that some of the holes 107a are whole and some holes 107b are incomplete, i.e. they are truncated. In some embodiments the thickness of the border frame is less than the distance between the first surface and the second surface at the edge of the mesh structure.

The edges of the holes 107 on the mesh structure 105 have rim structures 109 extending towards the second surface 102 from the mesh structure, i.e. the rim structures are towards the user when the protective structure 100 is in use. The rim structure is a wall-like construct and has a top side, an inner side and an outer side. Between the rim structures are channels which can be used, for example, for guiding air currents in the horizontal direction in relation to the protective structure, i.e. inside the protective structure. The channels are formed by the sides of the rim structures and the mesh structure, and in more particular the outer sides of the rim structures and the lower surfaces of the rib structures (i.e. surface of the rib structure that is towards the second surface). The channels are open to the second surface 102. The height of the rim structure is the distance from the first surface 101 to the top side of the rim structure, i.e. the height is measured in the hole. The inner side is towards the hole that the rim structure is surrounding. The top sides of the rim structures form at least part of the second surface, i.e. the thickness of the mesh structure is the vertical distance from the first surface to the top side of the rim structure. The heights of the rim structures are greater at the middle of the mesh structure compared to the heights of the rim structures at the edge of the mesh structure. This means that the thickness of the mesh structure is greater at the middle of the mesh structure compared to the thickness of the mesh structure at the edge of the mesh structure. The first surface and the second surface have curvature radiuses. In some embodiments one of the curvature radiuses of the second surface is greater than the corresponding curvature radiuses of the first surface. The term 'corresponding' means here that they are on top of each other and have the same direction.

In some embodiments the rim structures 109 are separate from each other. The mesh structure frame (rib structure) between the holes 107 can be interpreted as a beam having a U-shaped groove. The walls of the groove are rim structures of the two adjacent holes and the bottom of the groove is the rib structure between the two same adjacent holes. These grooves form the channel network in the protec-

tive structure. Preferably the protective structure is configured in such a way that there is free space inside the channels when the protective structure is in use.

The rim structures 109 are continuous at holes 107a that do not touch the border frame 106, i.e. the rim structure completely surrounds the hole. The holes that are
 5 delimited by the border frame may have rim structures that end at the point where the edge of the hole meets the border frame.

When the protective structure 100 is manufactured by injection moulding the usage of raw material can be minimized compared to a protective structure manufactured by die-cutting. There is always a rather big wastage when pieces of a desired size and form are die-cut from a uniform sheet with the die-cut technique.
 10 Injection moulding makes it is also possible to optimize the thickness of the mesh structure 105 so that sufficient stiffness and strength are achieved with a minimum of material. Injection moulding makes elaborate designs possible and thus shape whole protective structure in the desired way. The mesh structure can thus be as
 15 aesthetical pleasing as desired. Suitable materials for injection moulding are all plastic materials as well as plastic materials that are reinforced, for example carbon fibre. The material must naturally be of such a variety that it achieves sufficient hardness after curing. The protective structure can be manufactured from such a plastic grade or such a composite of a plastic and a reinforcing material
 20 that are best suited for each application. For enhancing the hardness of the protective structure the mesh structure and the border frame can be coated with a material containing metallic particles. This prevents cracks and fracture formation. Thus lighter and softer materials can be used. The best results are achieved when the metallic particles are metallic material having a microstructure which is fine-grained with an average grain size between 2 and 5,000 nm. The coating improves the properties of the protective structure, allowing it to be made lighter.
 25

It must be noted that the protective structure 100 can be non-symmetrical. For example, the width of the protective structure can be greater near the first end 103 than near the second end 104.

30 In the embodiment described in the Figure 1 the holes 107 are positioned on the mesh structure 105 in such a way that they are interleaved to cover as much area as possible and still keep the frame of the mesh structure solid, i.e. the rib structures between holes should not become too narrow. In some embodiments the centre points of three adjacent holes form an equilateral triangle of a triangle, the
 35 sides of which differ from each other in length by 20% at most. The length of the

sides may vary because of the shapes of the holes and the geometry (curvature) of the mesh structure.

In some embodiments there is a ventilation hole 108 between three adjacent holes opening to the channels between the rim structures 109. Of course, there can be
 5 other embodiments in which the ventilation holes are positioned differently, in case the holes are placed in some other formation. For example, the centres of the holes may form an equidistant grid and the ventilation holes may be at the middle points of the squares formed by four adjacent holes. Of course, there can be ventilation holes in other places as well. For example, in the embodiment of the Figure
 10 1 there are also some ventilation holes near the border frame 106. The ventilation holes are for lightening the whole protective structure 100 and for guiding air currents in the channels.

The mesh structure 105 forms a cell-like structure having a large open surface. The large open surface contributes to making the protective structure 100 light-
 15 weight. In some embodiments the rib structures can be dimensioned so that the width of the rib structures in the direction of the surface of the support structure is smaller than the height of the rim structure 109. By varying the height of the rim structures it is possible to regulate the stiffness and rigidity of the protective structure in the direction perpendicular to the surface of the protective structure. On the
 20 other hand, the rib structure can be kept narrow in the direction of the surface of the protective structure in order to achieve a large open area. Also, a large open area makes the air permeability of the protective structure especially high. In some embodiments the open surface area of the mesh structure is at least 60% of the total area of the mesh structure. The open area comprises both the holes 107 and
 25 the ventilation holes 108. Of course, the open area may be even larger, but this is the smallest limit, and below that the protective structure 100 becomes heavy and sweaty in use.

The protective structure 100 can thus on the other hand be made light, but still stiff and rigid enough. The stiffness of the protective structure can be regulated also by
 30 changing the size of the mesh structure 105.

The amount of material used in the mesh structure 105 can be optimized in relation to the stiffness by varying the thickness of the mesh structure in a direction perpendicular to the first surface 101 formed by the mesh structure so that the material thickness is greater at the middle of the mesh structure compared to the
 35 thickness at the edges of the mesh structure. More material can be concentrated

in those parts of the mesh structure where the benefit in relation to the stiffness is the greatest. By concentrating more material in the middle of the mesh structure the middle part of the mesh structure will become stiffer and the edges more flexible. In consequence, the middle part of the mesh structure can withstand impacts and transfer impact energy to the edges of the protective structure 100 more efficiently. The more flexible edge parts of the protective structure also contribute to the suitability of the protective structure in some equipment, improving user comfort. The rim structures 109 can be for improving this.

In some embodiments the diameters of the holes 107a positioned wholly in the mesh structure are between 2 and 7 cm, i.e. these constitute the holes that not delimited by the border frame 106. If the diameters are larger, i.e. the holes are bigger, the projectiles may penetrate the protective structure 100. These impacts may be, for example, strikes by hockey pucks.

Figure 2 shows the protective structure 100 presented in Figure 1 as seen from the direction of the second end 104. The protective structure has a longitudinal axis on the first surface from the middle point of the second end to the middle point of the first end. The protective structure is curved in such a way that if the longitudinal axis is considered as the top of the protective structure, the edges of the protective structure parallel to the longitudinal axis are lower than the longitudinal axis. The thickness of the border frame 106 is less than the distance between the first surface and the second surface at the edge of the mesh structure. In some embodiments there may be a step at the edge of the mesh structure 105.

Figure 3 shows a second embodiment of a protective structure 300 having a first surface 301 and a second surface and the first end 303 and the second end 304. The protective structure comprises a mesh structure 305 and a border frame 306. The mesh structure has a multitude of holes 307 extending from the first surface 301 to the second surface. Between the holes are rib structures which function as a frame of the mesh structure. On the mesh structure between adjacent holes 307 are ventilation holes.

Figure 4 shows the protective structure 300 presented in Figure 3 as seen from the side. The outermost point of the mesh structure 305 sets a top level that is parallel to the longitudinal axis between the first end and the second end. The border frame 306 curves upwards (i.e. towards the top level of the protective structure) at the first end 303 and at the second end 304. This kind of design ensures an ideal anatomical fit for the protective structure.

Figure 5 shows a third embodiment of a protective structure 500 having a first surface 501 and a second surface 502 and the first end 503 and the second end 504. The protective structure comprises a mesh structure 505 and a border frame 506. The mesh structure has a multitude of holes 507 extending from the first surface

5 501 to the second surface. Between the holes are rib structures that form the frame of the mesh structure and one surface of the rib structures forms the outer surface of the protective structure, i.e. the first surface 501. The other surface of the rib structures is towards the second surface. The protective structure is slightly curved. The middle point, i.e. the top point of the mesh structure is located higher

10 than the border frame (i.e. the top point is vertically farthest from the border frame plane). Even the slightly outward (i.e. the direction away from the user of the protective structure when the protective structure is in use) curvature of the mesh structure is beneficial, because a curved structure spreads impact forces more efficiently than a flat surface.

15 Figure 6 shows the protective structure 500 presented in Figure 5 as seen from below, i.e. from the direction of the second surface 502. The holes 507 are surrounded by rim structures 509. The rim structures are wall-like structures, and they extend towards the second surface. The rim structures have inner walls that are towards the centre of the hole, the outer wall and the top side. The top sides of the

20 rim structures form at least part of the second surface 502. It must be noted that the second surface is partly virtual, i.e. there is no continuous material surface that would form the second surface.

Between the rim structures 509 are channels 510. The channels forms passages that are delimited by the rim structures (the outer walls of the rim structures), the

25 surfaces of the rib structures which are towards the second surface and the second surface 502 (i.e. the plane between the top sides of the adjacent rim structures). At the edges of the mesh structure 505 the border frame 506 delimits the channel network. In some embodiments there may be some openings or grooves in the border frame that connect outer areas to the channels when the protective

30 structure 500 is in use. There are ventilation holes 508 on the rib structures connecting the channel to the first surface 501. In this example the ventilation holes are situated between three adjacent holes 507 the centre points of which form a triangle. The ventilation holes serve to enhance air circulation. Also, they further decrease the total weight of the protective structure 500. Furthermore, careful po-

35 sitioning and shaping the ventilation holes allows for guiding and spreading the stress and impact forces of a strike on the protective structure. Also, the ventilation

holes improve elasticity of the protective structure and prevent shearing forces on the rib structures.

Figure 7 shows a fourth embodiment of a protective structure 700 as seen from below, i.e. from the direction of the second surface 702. The protective structure comprises a mesh structure 705 and a border frame 706. In the mesh structure is a multitude of holes 707. There are rim structures 709 which circle the holes in the mesh structure and channels 710 between the rim structures. The rim structure comprises an inner wall, an outer wall and a top side. In this embodiment there is a collar structure 711 on the inner wall of the rim structure. The collar structure has a first collar surface and a second collar surface that are approximately parallel to the first surface and to the second surface near the collar structure. In addition, the collar structure has a side surface that is parallel to the inner wall of the rim structure. The side surface defines the height of the collar structure. The height of the collar structure is less than the height of the rim structure, i.e. the distance between the first surface and the top side of the rim structure (the second surface). In some cases the collar structures may serve to increase the stiffness of the outer surface of the mesh structure (i.e. the first surface). Also, if some form of cushioning is used under the protective structure, i.e. between the second surface and the user, the collar structures can serve to prevent the cushioning from bulging out of the hole. In some embodiments the collar structure is positioned in such a way that the first collar surface forms a part of the first surface, i.e. the outer side of the mesh structure 705. This means that the diameter of the hole 707 on the first surface is less than the diameter of the hole on the second surface. In that case the collar structures do not form any steps on the first surface. Naturally, there are embodiments where the collar structures are positioned differently.

Figure 8 shows the protective structure 700 presented in Figure 7 as seen from the side as a cross section. The rim structure 709 circles the hole 707 extending downwards, i.e. towards the second surface 702. The collar structure 711 circles the hole and extends towards the middle point of the hole. Between the rim structures are channels 710 which form a channel network. The first collar surfaces are parallel and in the same level as the first surface 701 near the first collar surface. This means that the first surface is continuous, i.e. there are no sharp angles, and the curvature of the first surface is smooth. It must be noted that the first surface is partly virtual at the holes. In some embodiments the collar structure (the second collar surface) is in the same level as the second surface.

Figure 9 shows a fifth embodiment of a protective structure 900. The protective structure has a first surface 901 and a second surface 902. The protective structure comprises a mesh structure 905 and a border frame 906. The protective structure further comprises a cushioning layer 912 and a supporting fabric layer 913. The border frame is configured in such a way that the cushioning and the supporting fabric layer can be fixed to the border frame. The fixing can be, for example, done by knitting, stapling, gluing or similar means. In some embodiments the supporting fabric layer is used to stretch the protective structure. In that case the mesh structure is tensioned and the protective structure, in addition to spreading the impact, also recoils from the impacts.

The mesh structure 905 effectively transfers the energy of an impact to the mesh structure from the firm crossing points of the mesh structure parts into every direction of the protective structure. The mesh structure can also be designed so that some projectile hitting the mesh structure transfers impact energy through the mesh structure into a cushioning layer 912 underneath the mesh structure. The cushioning could be for example a plastic foam structure or some such. The mesh structure and especially the rim structures will thus penetrate a certain distance into the cushioning whereas the energy of the impact is absorbed into the cushioning.

Some advantageous embodiments of the device according to the invention have been described above. The invention is however not limited to the embodiments described above, but the inventive idea can be applied in numerous ways within the scope of the claims.

Patent claims

1. A protective structure (100; 300; 500; 700; 900) for protective garments and equipment, comprising a first surface (101; 301; 501; 701; 901), a second surface (102; 502; 702; 902), a curved mesh structure (105; 305; 505; 705; 905) having a multitude of holes (107, 107a, 107b; 307; 507; 707) extending from the first surface to the second surface, and a border frame (106; 306; 506; 706; 906) surrounding at least a part of the mesh structure, and the protective structure is configured to be positioned in a garment or equipment in such a way that the second surface is towards the user of the garment or equipment, and a material of the protective structure is rigid, **characterised** in that the holes on the mesh structure are surrounded at least partly by wall-like rim structures (109; 509; 709) extending towards the second surface from the mesh structure and the rim structure has a top side, an inner side and an outer side, and between the rim structures are channels (510; 710) formed by the sides of the rim structures and the mesh structure, and the top sides of the rim structures form at least part of the second surface, and heights of the rim structures are greater in a middle of the mesh structure compared to the heights of the rim structures at an edge of the mesh structure, and the protective structure further comprises a ventilation hole (108; 508) between three adjacent holes (107, 107a, 107b; 307; 507; 707) and the ventilation hole is open to the channels (510; 710) between the rim structures (109; 509; 709).
2. The protective structure (100; 300; 500; 700; 900) according to claim 1, **characterised** in that the rim structures (109; 509; 709) are separate from each other.
3. The protective structure (100; 300; 500; 700; 900) according to claims 1 or 2, **characterised** in that the rim structures (109; 509; 709) are continuous at holes (107, 107a; 307; 507; 707) that are not connected to the border frame (106; 306; 506; 706; 906).
4. The protective structure (100; 300; 500; 700; 900) according to any one of claims 1 to 3, **characterised** in that a thickness of the border frame (106; 306; 506; 706; 906) is less than a distance between the first surface (101; 301; 501; 701; 901) and the second surface (102; 502; 702; 902) at the edge of the mesh structure (105; 305; 505; 705; 905).

5. The protective structure (100; 300; 500; 700; 900) according to any one of claims 1 to 4, **characterised** in that at least one of curvature radiuses of the second surface (102; 502; 702; 902) is greater than corresponding curvature radiuses of the first surface (101; 301; 501; 701; 901).

6. The protective structure (100; 300; 500; 700; 900) according to any one of claims 1 to 5, **characterised** in that the holes (107, 107a, 107b; 307; 507; 707) are circular or elliptical or at least partly circular or elliptical.

7. The protective structure (100; 300; 500; 700; 900) according to claim 6, **characterised** in that centre points of three adjacent holes (107, 107a, 107b; 307; 507; 707) form an equilateral triangle or a triangle, sides of which differ from each other in length by 20% at most.

8. The protective structure (100; 300; 500; 700; 900) according to any one of claims 1 to 7, **characterised** in that the protective structure further comprises a cushioning layer (912) and a supporting fabric layer (913), and the cushioning (912) and the supporting layer of fabric (913) are fixed to the border frame (106; 306; 506; 706; 906).

9. The protective structure (100; 300; 500; 700; 900) according to claim 8, **characterised** in that the cushioning (912) and the supporting fabric layer (913) are fixed to the to the border frame (106; 306; 506; 706; 906) in such a way that middle parts of the cushioning and the support layer are separate from the second surface (102; 502; 702; 902).

10. The protective structure (100; 300; 500; 700; 900) according to any one of claims 1 to 9, **characterised** in that at least some of the holes (107, 107a, 107b; 307; 507; 707) have a collar structure (711) at the inner side of the rim structure (109; 509; 709), and an upper side of the collar structure is on a same level as the first surface (101; 301; 501; 701; 901).

11. The protective structure (100; 300; 500; 700; 900) according to any one of claims 1 to 9, **characterised** in that at least some of the holes (107, 107a, 107b; 307; 507; 707) have a collar structure (711) at the inner side of the rim structure (109; 509; 709), and an upper side of the collar structure is on a same level as the
5 second surface (102; 502; 702; 902).

12. The protective structure (100; 300; 500; 700; 900) according to any one of claims 1 to 11, **characterised** in that the mesh structure (105; 305; 505; 705; 905) and the border frame (106; 306; 506; 706; 906) are of a material or composite material that is suited for injection moulding.
10

13. The protective structure (100; 300; 500; 700; 900) according to any one of claims 1 to 12, **characterised** in that the mesh structure (105; 305; 505; 705; 905) and the border frame (106; 306; 506; 706; 906) are coated with a material containing metallic particles.
15

14. The protective structure (100; 300; 500; 700; 900) according to claim 13, **characterised** in that the material of the protective structure is a metallic material having a microstructure that is fine-grained with an average grain size between 2
20 and 5,000 nm.

15. The protective structure (100; 300; 500; 700; 900) according to any one of claims 1 to 14, **characterised** in that an open surface area of the mesh structure (105; 305; 505; 705; 905) is at least 60% of a total area of the mesh structure.
25

16. The protective structure (100; 300; 500; 700; 900) according to any one of claims 1 to 15, **characterised** in that diameters of the holes (107, 107a; 307; 507; 707) situated wholly in the mesh structure (105; 305; 505; 705; 905) are between 2 and 7 cm.

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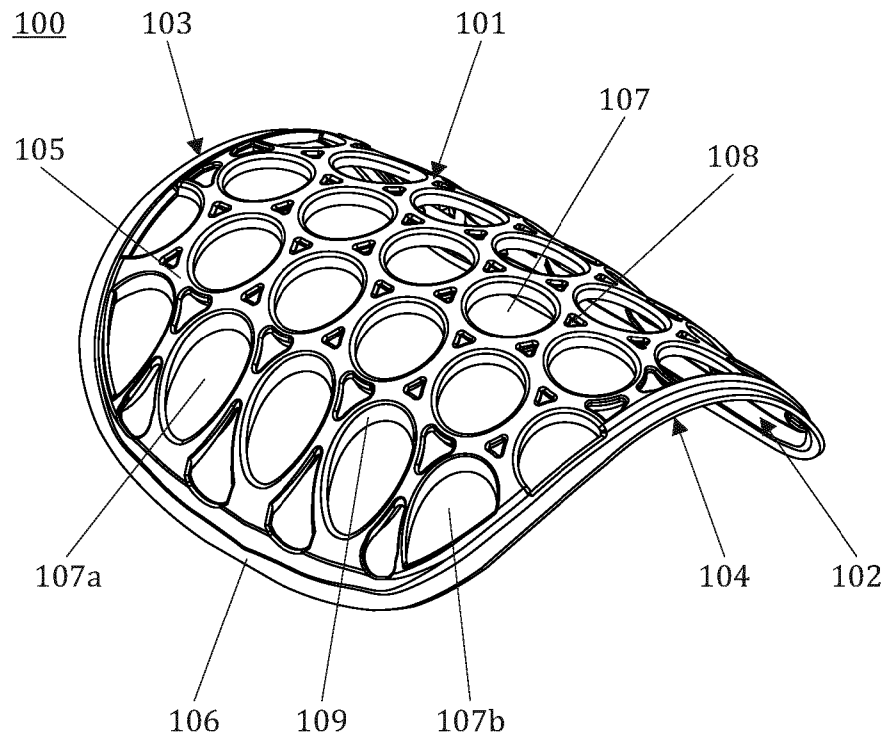


FIG. 1

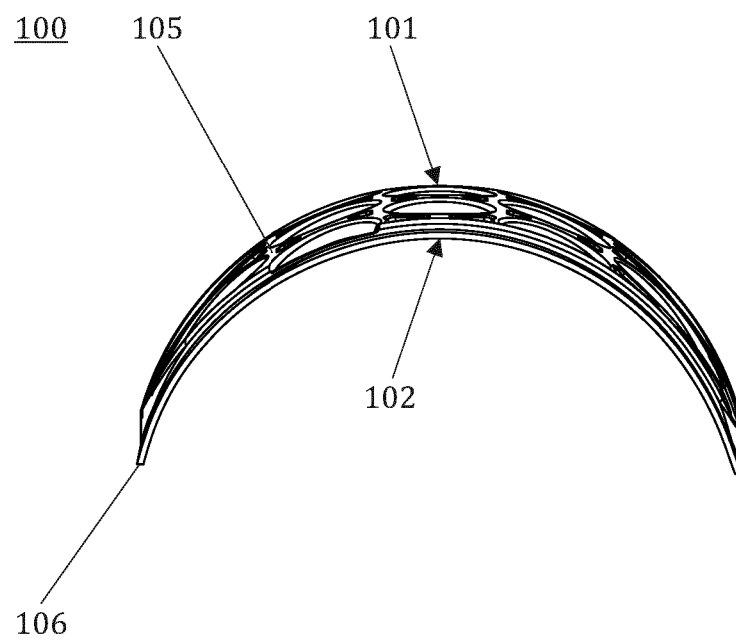


FIG. 2

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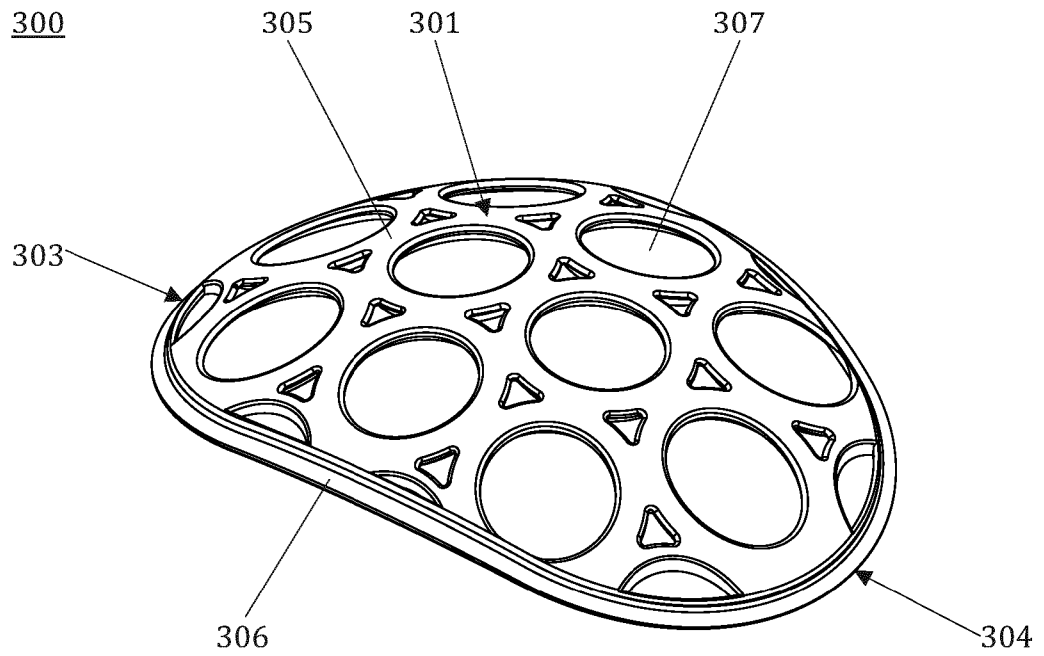


FIG. 3

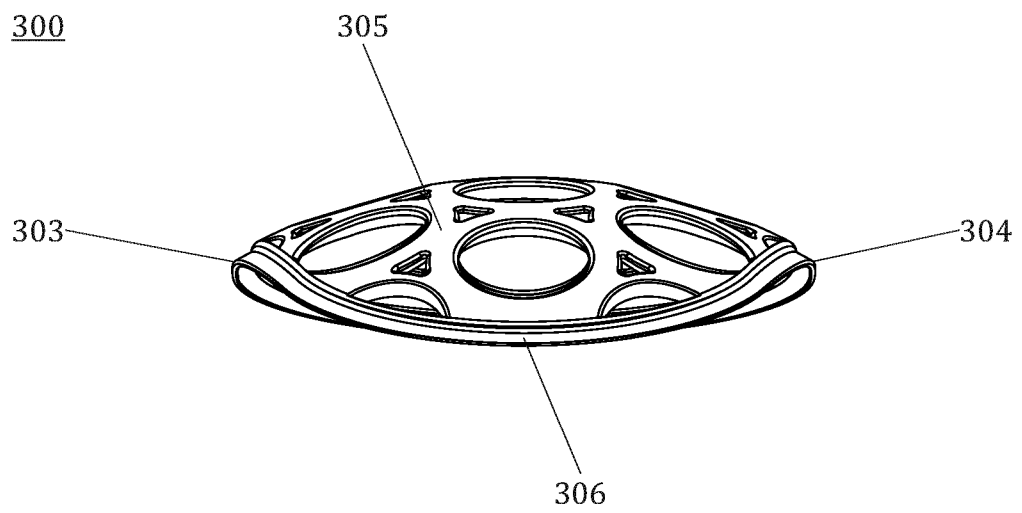


FIG. 4

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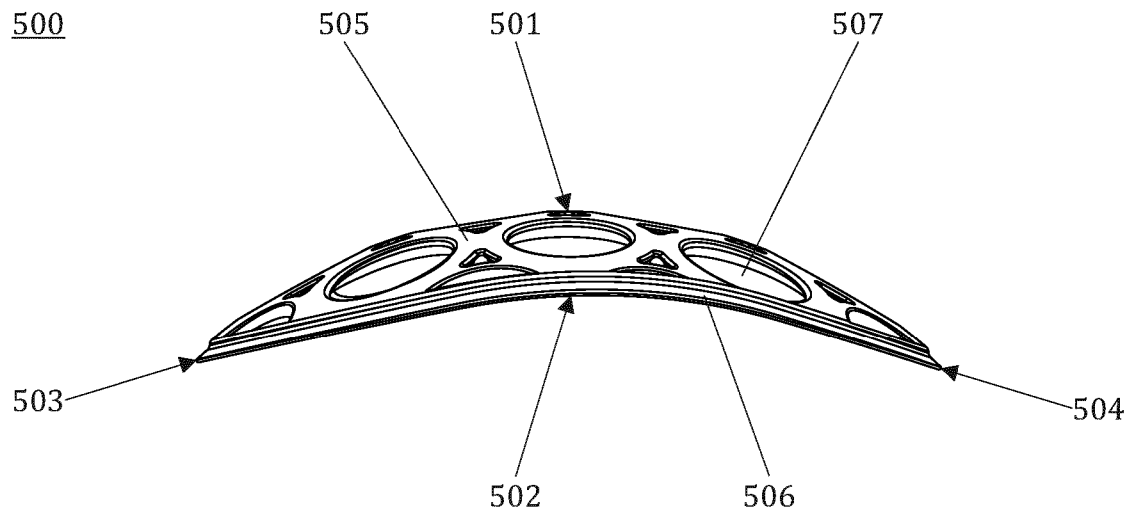


FIG. 5

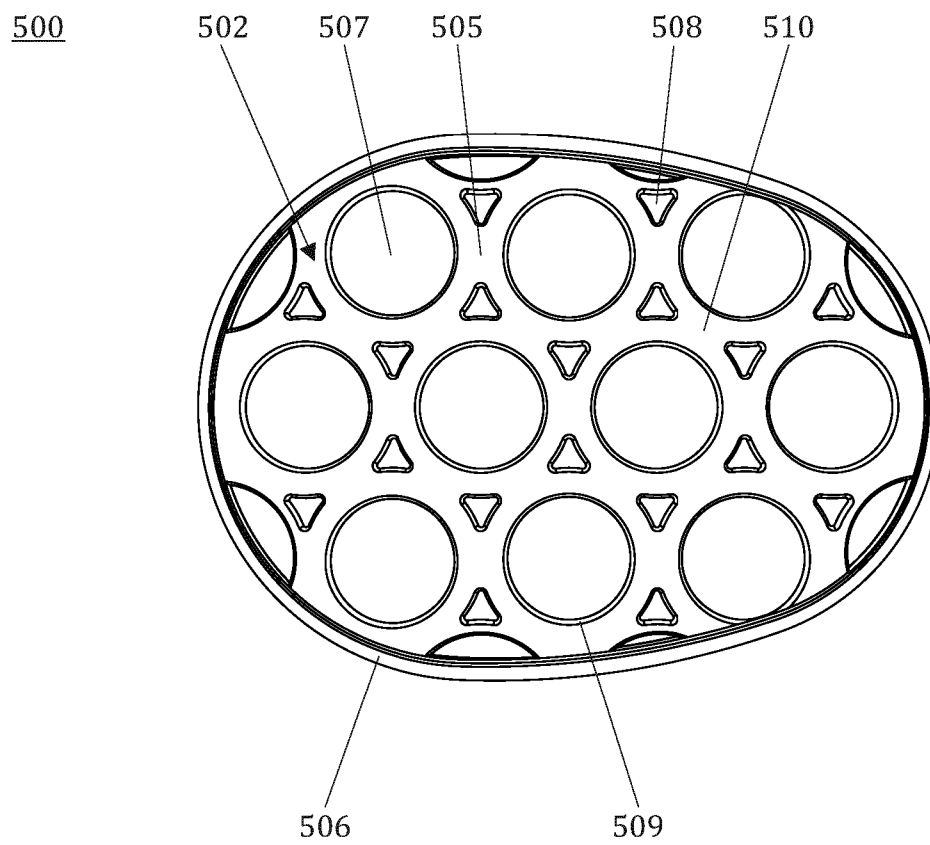


FIG. 6

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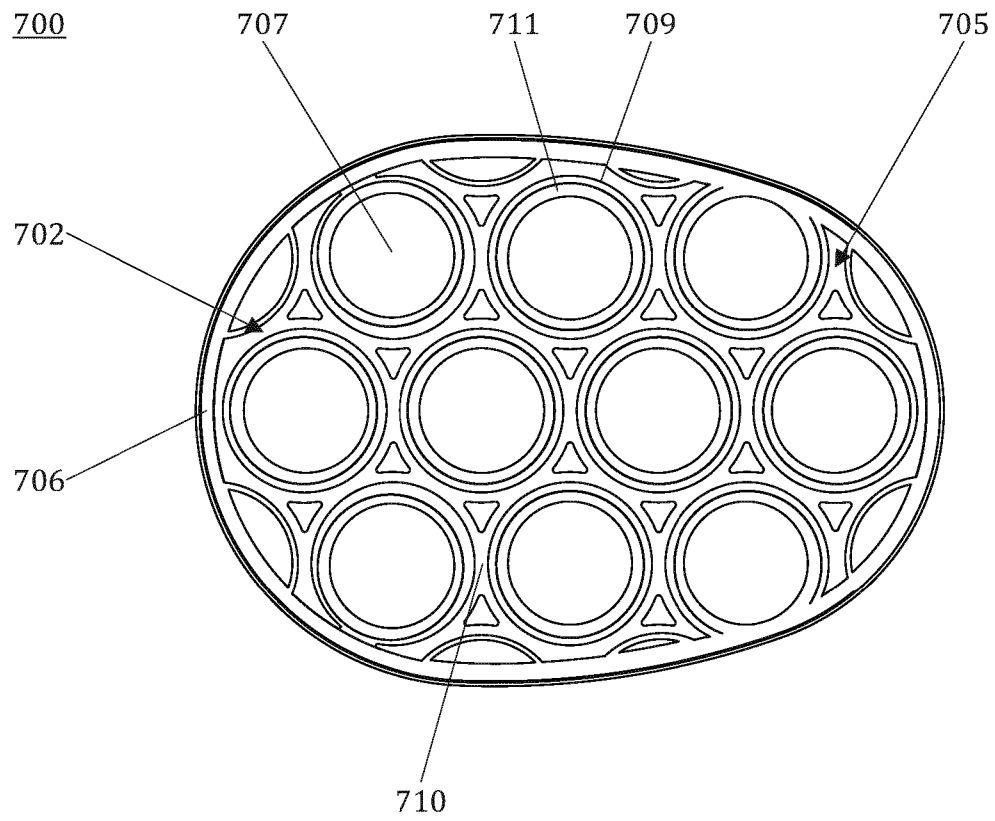


FIG. 7

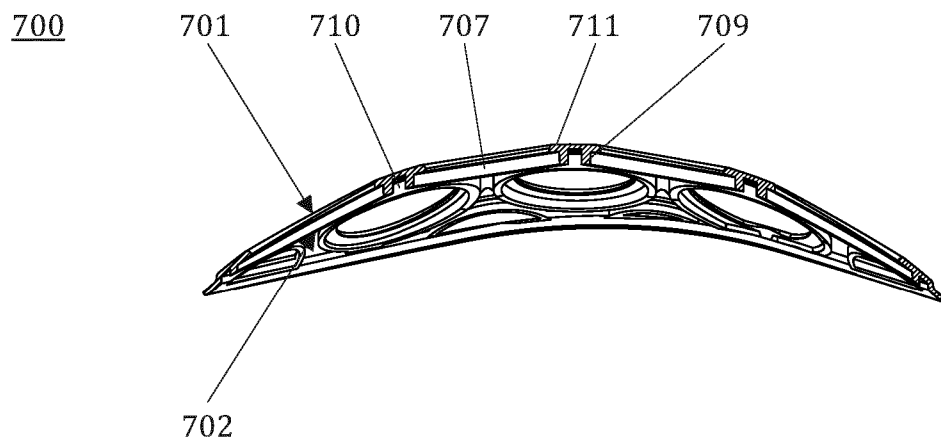


FIG. 8

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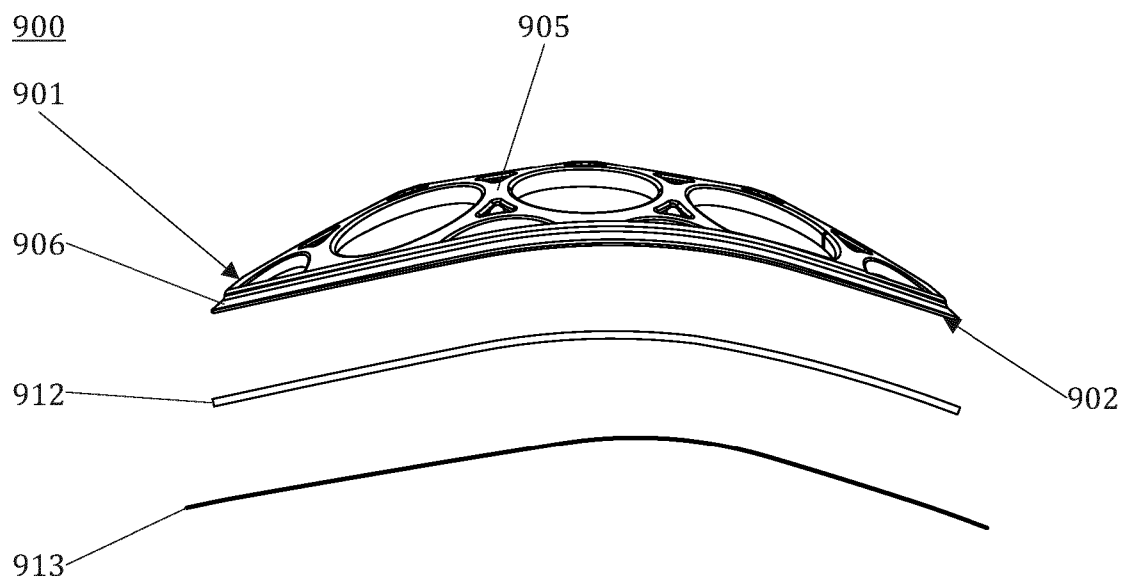


FIG. 9

