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(54) **A COMPRESSIBLE LINER FOR IMPACT PROTECTION**

KOMPRIMIERBARE EINLAGE ZUR STOSSDÄMPFUNG

CHEMISAGE COMPRESSIBLE POUR PROTECTION CONTRE LES IMPACTS

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Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to an apparatus and a method for improved impact protection using a compressible liner.

Description of the Art

[0002] Applicant was co-author of a study titled "Improved Shock Absorbing Liner for Helmets", Australian Transport Safety Bureau (ATSB), www.atsb.gov.au, published in July, 2001. In that publication, a combination of low density foam embedded into high density foam was disclosed as one subject of the study. However, the study did not contemplate or discuss the combination of structural elements or method disclosed herein.

[0003] Past research has shown that common single density foam liners used in current helmets are too hard and too stiff to effectively absorb an impact force. A single density foam liner is also limited in its ability to accommodate the variation in strength about the human skull. In addition liners in bicycle helmets for children use liners designed for adult skulls, they do not account for a child's more deformable skull in comparison to an adult. The more deformable skull of a child is less protective of the brain. Incorporated by way of reference is: Corner et al, "Motorcycle and Bicycle Protective Helmets - Requirement Resulting from a Post Crash Study and Experimental Research", Report No. CR 55, 1987, Federal Office of Road Safety, Canberra, Australia and Mohan et al; and "A Biomechanical Analysis of Head Impact Injuries to Children" Vol. 101, 1979, Transactions of the ASME, Journal of Biomechanical Engineering.

[0004] In addition the brain is also susceptible to impact injury against the inside of the skull. The brain is a jelly like soft tissue suspended within the enclosure of the hard skull in a bath of cerebral spinal fluid. Additionally the brain is flexibly supported within the skull by the brain stem and spinal cord at the base of the brain, whilst about the general outer periphery of the brain the dura-mater membrane connects the brain to the skull at various suture points. An impact to the travelling skull may cause the skull to rapidly decelerate whilst the flexibly supported brain continues to travel and impact against the inside of the skull. The impact of the brain against the skull may cause contusions and/or haemorrhaging to the brain. Thus it may be important to decelerate the head appropriately to minimise internal injuries.

[0005] Bone tests for the human skull have indicated that the temporal portion of the skull has a significantly reduced bone strength compared with other portions of the skull. Consequently the temporal portion of the skull is more vulnerable to impact injury compared with other portions of the skull. However, current helmets are not

manufactured with a compressible liner to provide different zones of impact protection about the skull.

[0006] Similarly for other application areas for impact protection such as baby capsules and child safety seats for passenger vehicles, vehicle cabin liners and body armour there are profound deficits in the provision of different zones of impact protection about the human body. The word "baby capsule" in the specification and the claims is taken to include one or more of rear facing infant or baby seats for the seat of a car, reclining rear facing seats for an infant or a baby and seats or capsules for children up to approximately 1 year of age. The word "child safety seat" in the specification and the claims is taken to include one or more of forward facing toddler seats, toddler seats in general, seating for children up to approximately 4 years of age, booster seats/cushions, seats without a backrest and seating in general for children for approximate ages of 4 to 8 years of age. Booster seats may be described as seats without a backrest that are designed so as to raise the seating position of the child so that the sash of the existing adult lap-sash seat-belt appropriately engages the child's shoulder and chest. Toddler seats may be differentiated from booster seats in that they may have an independent five point harness to secure the child to the toddler seat, the toddler seat then being secured to the existing seat or other attachments points within a car or other vehicle.

[0007] Baby capsules and child safety seats may have protective side panels or thigh, torso and head bolsters (or projections or "wings") on the sides of the baby capsule or child safety seats. These side panels or bolsters serve to limit the amount of sideways movement that a baby or child may experience in a side impact. They may also serve to protect the baby or child from impact of a side air bag in the event that the air bag is triggered in a collision. In other terminology the protective side panels may form a protective "channel" about the baby or child.

[0008] Baby capsules and child safety seats typically do not differentiate between the head and the torso of the baby or child in terms of the level of impact protection required. A rear facing baby capsule for a car may be lined with a single density foam liner sufficient to provide impact protection to the baby externally as a whole, but may be insufficient to prevent contusions and/or haemorrhaging to the back of the baby's brain in the event of a head on collision by the car.

[0009] Child safety seats that are typically used for children above an approximate age of one year are commonly constructed of or have liners of polystyrene foam which may be as hard or harder than typical single density polystyrene foam liners used in helmets for adults. Such low compressibility (high stiffness) polystyrene foams do not provide adequate impact protection for children since they are too hard. Child safety seats may also be augmented with a thick liner or structure of a very compressible upholstery or cushioning foam which is so soft and pliable as to provide minimal or nil impact protection to a child. The purpose of such upholstery or cushioning

foam liners or structures is primarily for comfort and appearance.

[0010] None of the prior art provides an entirely satisfactory solution to the problem of providing different levels of appropriate impact protection for the head or to other parts of the body, nor to the ease of manufacture to obtain a more satisfactory impact protection with a compressible liner.

[0011] US 2007/600032 discloses a compressible liner from which may be derived the precharacterizing portion of claim 1 appended hereto.

SUMMARY OF THE INVENTION

[0012] The present invention aims to provide embodiments of a compressible liner for impact protection which overcome or ameliorate the disadvantages of the prior art.

[0013] In one form, the invention provides an apparatus for impact protection for at least a part of a human body comprising: a compressible liner with an inner layer and an outer layer, wherein the inner layer includes a first material of a first compressibility, and the outer layer includes a second material of a second compressibility; and wherein the inner layer has a compressibility greater than that of the outer layer; wherein the inner layer has a contact surface and a first joining surface, wherein the first joining surface includes a plurality of protuberances wherein the outer layer has a second joining surface and an outer surface, wherein the second joining surface includes a plurality of recesses adapted to receive the protuberances of the inner layer; wherein said inner layer is formed of a plurality of inner layer segments; and wherein the plurality of inner layer segments have a first compressibility which is different between inner layer segments.

[0014] Preferably the protuberances are conical. The compressible liner of the invention may be installed within or form for example, a vehicle cabin liner, a baby capsule, a child safety seat, a seat, a head rest or body armour. Preferably, in all applications, the compressible liner may be a removable and replaceable fitting

[0015] Optionally the compressible liner may be formed from one or more outer layer segments and the compressibility between the respective layer segments may differ.

[0016] Optionally one or more of the materials forming the compressible liner may be foam, preferably Expanded Polystyrene (EPS). Alternatively one or more of the materials may be viscoelastic. Preferably the densities of the EPS foam materials may be:

- The inner layer may have a density in the range of 15 to 50 kgm⁻³.
- The outer layer may have a density in the range of 35 to 90 kgm⁻³ or more preferably a density in the range of 35 to 55 kgm⁻³.

- The inner layer may have a density in the range of 25 to 35 kgm⁻³ and outer layer may have a density in the range of 35 to 50 kgm⁻³.
- The inner layer may have a density in the range of 15 to 25 kgm⁻³ and outer layer may have a density in the range of 35 to 45 kgm⁻³.

[0017] Optionally the penetration of one or more protuberances from the inner layer into the outer layer may be in the range of 50 to 100%. Preferably, an apex end of one or more protuberances is contiguous with the outer surface.

[0018] Preferably the distance between adjacent circular bases is in the range of 0 to 20 mm and more preferably in the range of 5 to 15 mm.

[0019] Preferably the diameter of the circular base is in the range of 15 to 22 mm.

[0020] Optionally the compressible liner may have a thickness in the range of 15 to 45 mm, a height of one or more protuberances from the circular base may be in the range of 20 to 25 mm and a distance from the circular base of one or more protuberances to the contact surface may be in the range of 5 to 10 mm.

[0021] In a further form of the invention the inner layer is visible through the outer layer.

[0022] The invention provides a method of impact protection using the aforesaid apparatus for at least a part of the human body, wherein the method provides an initial low resistance to an impact to at least a part of a human body and then progressively increases the level of resistance to the impact to at least a part of the human body, as the impact progresses.

[0023] In a further form, not forming the claimed invention, there may be provided apparatus for impact protection of a least a part of an article, wherein the apparatus includes a compressible liner with a stiffness gradient. The stiffness gradient during an impact varies from a low stiffness adjacent to the article to a higher stiffness through the thickness of the compressible liner. 'Articles' includes goods, animals or anything of value.

[0024] Further forms of the invention are as set out in the appended claims and as apparent from the description.

DISCLOSURE OF THE INVENTION

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] Further preferred embodiments of the invention will now be described with reference to the accompanying drawings, in which:

FIG 1 is a schematic cross-sectional view of the compressible liner in a helmet in an embodiment of the present invention.

FIG 2 is a cross-sectional view taken along the line 2-2 of fig 1.

FIG 3 is a schematic, perspective, part-sectional view of an alternate embodiment of a compressible liner in the helmet embodiment.

FIG 4 is an exploded view of fig 3.

FIG 5 is a schematic cross-sectional view of the compressible liner.

FIG 6 is an alternate embodiment of the compressible liner in fig 5.

FIG 7 is a schematic cross-sectional view of the compressible liner in a portion of a vehicle cabin, in an embodiment of the invention.

FIG 8 is a schematic cut-away illustration of the interior of a civilian passenger car with an installed embodiment of the vehicle cabin liner compressible liner of fig 7.

FIG 9 schematically illustrates, in a perspective view, an example of an embodiment of a baby compressible liner for a baby capsule.

FIG 10 is a schematic perspective view of a child safety seat with a child safety seat compressible liner.

FIG 11 is a schematic of a front elevation view of a protective vest with inserts of a body armour compressible liner.

FIG 12 is a schematic cross-sectional view of a double compressible liner, in an embodiment of the invention. FIG 13 is a schematic view of the inner liner in strip form.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0026] Reference is first made to Figs 1 and 2 which are orthogonal cross-sectional views, schematically showing a first embodiment of a compressible liner 110 installed in a helmet 112 worn by a person 114. The helmet 112 may include a hard outer shell 116 against the outer surface 118 of the compressible liner 110 and also may include a comfort liner 120 against the contact surface 122 of the compressible liner 110. If a comfort liner 120 is present then it is appreciated that the head is immediately adjacent the contact surface 122 via the comfort liner 120. If the comfort liner is not present the contact surface 122 engages the head directly.

[0027] The compressible liner 110 may have a relatively low density foam inner layer 124 fused, adhered or otherwise attached at respective joining surfaces 126 to a relatively high density foam outer layer 128, where the lower density foam is more easily compressed than the

higher density foam. That is, the first material forming the inner layer 124 is more compressible than the second material forming the outer layer 128. The inner layer 124 has many protuberances 130 which project into matching recesses 132 of the outer layer 128 at the joining surface 126. The inner layer 124 has a first region 134 of a relatively uniform thickness layer. Extending radially outwardly from the first region 134 is the multiplicity of protuberances 130 integrally formed with the inner layer 124. The protuberances 130 have apex ends 136 as well as bases 138 having outer peripheries 140 closely spaced from bases 138 of adjacent protuberances 130. The outer peripheries 140 distance may also be considered as the closest distance between adjacent bases 138 of the protuberances 130.

[0028] In an embodiment of the compressible liner 110 the foam material may be expanded polystyrene foam (EPS) where the density of the foam is commonly proportional to a compressibility or a stiffness of the foam, where stiffness has an inverse proportional relationship to compressibility. In a preferred embodiment, the inner layer 124 may have a density of in the range of 20 to 50 kgm^{-3} , (or 1.25 to 3.12 pounds per cubic foot). The outer layer 128 may have a density of in the range of 35 to 90 kgm^{-3} (or 2.18 to 5.62 pounds per cubic foot) and more preferably 35 to 55 kgm^{-3} . In all choices of the respective foam density for the inner layer 124 and outer layer 128, the foam density of the inner layer 124 is less than that of the outer layer 128. In a more preferable embodiment the inner layer 124 foam density may be in the range of 25 to 35 kgm^{-3} and the outer layer 128 foam density may be in the range of 35 to 50 kgm^{-3} . In accordance with the teachings of the present invention, the foam employed may be of any suitable type that permits the desired compressibility or stiffness to be achieved as for the EPS foam embodiment given above and below. In all instances described above and below it will be noted that the first material forming the inner layer 124 has a first compressibility which is greater than the compressibility of the second material forming the outer layer 128, which has a second compressibility.

[0029] The lines 142 represent the boundaries 142 between adjacent segments 144, 146, 148, 150 of the compressible liner 110. The division of the compressible liner 110 into a number of segments as illustrated in fig 1 allows different zones of impact protection to be customised for the helmet 112. For example the rear segment 150 of the compressible liner 110 may be configured and constructed to offer a higher level of impact protection than crown segment 146.

[0030] In fig 2 another example of the division of the compressible liner 110 into a number of segments 210, 212, 214, 216 to provide different zones of impact protection is shown. The temporal segments 210, 216 may be configured and constructed to offer a higher level of impact protection compared to the crown segments 212, 214 due to the higher level of vulnerability of the temporal portions of the skull.

[0031] Fig 3 is a perspective, part-sectional view of an alternate embodiment of the compressible liner 310 with an emphasis to illustrating the protuberances 130 of the inner layer 124. For clarity the portion of the helmet 112 covering the ear is omitted from fig 3. In the embodiment illustrated the protuberances 130 are conical with circular bases 138. In alternate embodiments the conical protuberances may have bases 138 that are polygonal in configuration, for example, trigonal, square, pentagonal, hexagonal, octagonal, etc. Also, if desired, the protuberances 130 may be made frustoconical rather than conical with pointed apexes 136. In yet another embodiment the protuberances may be hemispherical.

[0032] In fig 3 segmentation of compressible liner 310 is again shown with the boundary lines 142. However in this embodiment only the inner layer 124 is segmented whilst the outer layer is not segmented. The segmentation of the inner layer 124, for this embodiment of the compressible liner 310, is described in detail with respect to fig 4.

[0033] Fig 4 is an exploded view of the inner layer 124 and outer layer 128 of fig 3. It can be seen that the outer layer 128 includes a multiplicity of conical recesses 132 sized and configured to receive the protuberances 130 with surface contact in the manner shown in figs 1 and 2. The inner layer 124 may be divided into a number of segments, 410, 412, 414, 416, 418, 420, 422, 424, 426, 428. In the illustrated example 10 segments are given. However alternate examples may have range in number of segments from one (not claimed) to ten with a most preferable number of segments being five. The use of a number of segments 410-428 allows the compressibility or stiffness of the inner layer 124 to be adjusted according to the level of customised impact protection required for a portion or segment of the skull. For example the temporal segments 414, 416 may be more compressible compared with the top of skull segments 418, 420. The temporal sections of the skull being more vulnerable to impact injury than other sections of the skull, bone tests have indicated that the temporal portion of the skull is a half to a third of the strength of other portions of the skull. In another embodiment of the invention the EPS foam densities of the various segments may be as follows: front segments 410, 412 of density 30 kgm^{-3} , temporal segments 414, 416 of density 25 kgm^{-3} , top segments 418, 420 of density 35 kgm^{-3} and rear segments 422, 424, 426, 428 of density 30 kgm^{-3} .

[0034] In accordance with the above, the segments may have circumferential shapes as defined by the boundary lines 142 as illustrated in fig 4 or any other range of circumferential shapes that allows adjoining segments to engage in a close fitting manner along the boundaries 142. The choice of the circumferential shapes of the individual segments being such that when the compressible liner 110 is assembled the segments form a continuous inner layer 124 within the compressible liner 110. For example a segment's planar circumferential shape may be any number of polygonal shapes.

[0035] In yet another embodiment the outer layer 128 may also be segmented (not shown) so that different foam densities may be used about the skull for the outer layer 128. This embodiment may allow for further, independent tailoring of the impact protection about the skull. This embodiment may also be used to provide different levels of protection required between, for example, a child and an adult. The outer layer 128 may be segmented in a similar manner to that described above for the inner layer 124. The planar circumferential shapes of the outer layer 128 segments may or may not correspond to segments of the inner layer. For example the boundary lines 142 for the inner layer 124 and outer layer 128 segments may correspond as shown in figs 1 and 2 or the boundary lines 142 may be discontinuous between the inner layer 124 and the outer layer 128 segments, described in detail with respect to fig 5.

[0036] In still yet another embodiment the density and dimensions of the protuberances 130 and matching recesses 132 and the overall compressible liner dimensions may be varied between segments of the inner layer 124 and/or the outer layer 128 in order to vary the compression or stiffness properties of the compressible liner 110. For example the temporal segments 414, 416 may have conical protuberances 130 of reduced base 138 diameter compared with the other segments of the inner layer 124, however the temporal segments 414, 416 may have a greater areal density of conical protuberances 130 compared with the other segments of the inner layer 124. For example for fig 4 the front segments 410, 412 may together have 23 conical protuberances 130 with a base 138 diameter of 20 mm, the top segments 418, 420 may together have 47 conical protuberances 130 with the base 138 diameter also of 20 mm, the rear segments together may have 39 conical protuberances 130 also with the base 138 diameter of 20 mm whilst the temporal segments may together have 36 conical protuberances 130 but with a base 138 diameter of 15 mm. In addition the range in the outer peripheries 140 distance (or the closest distance between adjacent bases 138) maybe from 0 to 20 mm and more preferably 5 to 15 mm, depending on the segment. Corresponding separations between adjacent apex ends 136 of protuberances 130 may be up to 40 mm with most being between 25 to 35 mm.

[0037] In manufacture typically the outer layer 128 may be formed in one or a number of pieces or segments using moulding techniques. Similarly the inner layer 124 may be formed separately in one or a number of pieces or segments. The pieces of the outer layer 128 and inner layer 124 are then assembled and fused together to form the compressible liner 110 suitable for a helmet or other impact protection application. The dimensions, number and configuration of the protuberances 130 and recesses 132 may be adjusted by a person skilled in the art of fabrication techniques in order to be able to form the compressible liner. For example the angle of the side of the conical protuberances 130 and the shape of the apex end 136 maybe adjusted to enable suitable mould re-

lease properties depending on a particular foam type or other material used.

[0038] Fig 5 is a cross-sectional view of another embodiment of a compressible liner 510 which schematically illustrates the dimensions of the various elements of the compressible liner 110, 310, 510 as well as showing a discontinuous boundary line 142 for segmentation. The dimensions given are by way of example for the various embodiments described above and below. The compressible liner 510 may have a thickness 524 ranging from 20 to 45 mm depending on the application area and/or the portion of the skull to be protected. In a preferred embodiment for a motorcycle helmet the thickness 524 may be 25 mm in the temporal portion of a helmet and 42 mm thick for the top or crown portions of the helmet. For a compressible liner of uniform thickness, the preferred thickness 524 may be in a range from 30 to 35 mm for motorcycle helmets. For helmets for use in horse related sports the thickness 524 of a compressible liner may be reduced to the range of 15 to 25 mm or to a more preferable uniform thickness 524 of 20 mm.

[0039] In fig 5 the outer periphery 140 spacing (between bases 138) is between the two inward pointing arrows. The joining surface 126 of the outer periphery 140 may be flat or radiused. For example the radius of curvature may be in a range from 0 to 2.5 mm or more. Consequently the protuberances 130 may cover the entirety of the radially outward portion of the inner layer 124 or be spaced apart.

[0040] In fig 5 the apex ends 136 of the protuberances 130 are spaced from the outer surface 118 of the outer layer 128 by a spaced region 526. The spaced region 526 may have a thickness in the range of 1 to 5 mm or more. In an alternative embodiment the apex ends 136 of the protuberances 130 of the inner layer 124 may extend to be contiguous with the outer surface 118 of the outer layer 128. For this embodiment the spaced region 526 thickness would effectively be 0 mm.

[0041] The apex end 136 of the protuberance 130 may be pointed (or sharp), rounded off with a radius of curvature in the range of 1 to 2 mm or simply truncated.

[0042] Fig 5 also illustrates an embodiment of the segmented compressible liner 510 where the boundary lines between the inner layer 124 and outer layer 128 segments is discontinuous. The inner layer 124 is divided into two segments 512, 514 by a boundary line 516. Whilst the outer layer 128 is divided into two segments 518, 520 at a different boundary line 522.

[0043] Fig 6 illustrates an example alternate embodiment to fig 5. In fig 6 the space region 526 is increased so that the protuberances 130 project into the outer layer 128 to approximately 50% of the thickness of the outer layer 128. The range in penetration of the protuberances 130 into the outer layer 128 may be from 50 to 100%. The corresponding boundary line 522 between the two segments 518, 520 of the outer layer 128 is extended to correspond to the increased space region 526.

[0044] With reference to figs 5 and 6, the protuberances

130 may have a height from base 138 to apex 136 in the range of approximately 20 to 25 mm. The base 138 of the protuberances 130 may have a diameter or width in the range of approximately 15 to 22 mm.

[0045] In figs 1, 2, 5 and 6 the first region 134 of the inner layer 124 forms a thin layer upon which the bases 138 of the protuberances 130 are linked. The thickness of the first region 134 may range from 5 to 10 mm or more, with the most preferable thickness being 5 mm.

[0046] The compressible liner may be employed with any desired helmet, including motorcycle helmets as well as helmets used by construction personnel, riders of bicycles, horse riders, rodeo riders, football players, baseball players and cricket players.

[0047] In yet another embodiment the compressible liner may be retro-fitted into a helmet in order to improve its impact protection. The retro-fitting of the compressible liner may be to replace all the previous liner in a helmet or just particular sections in a helmet's liner may only be replaced. A partial retro-fitting may be particularly useful for those portions of the liner adjacent to the temporal sections of the skull.

Foam Alternatives

[0048] Alternative materials that may be used for the inner layer 124 and/or outer layer 128 include foams that are elastic. An elastic foam having the property of enabling the compressible liner to elastically compress so that the original dimensions and impact protection performance prior to the impact are restored after the impact. An alternative material to an elastic foam may be a synthetic or natural rubber, either as a continuous solid or as a composite with other materials, for example air, fabric or as designed or selected by a person skilled in the art of shock, vibration or impact absorber design or manufacture.

[0049] Other alternative materials to the foam for the compressible liner may be viscoelastic or thixotropic. Such materials exhibit viscous or liquid behaviour when no force or stress is applied to them, however when a force is applied, such as an impact, the material acts in an elastic fashion exhibiting stiffness to the impacting force. An example of such material is a children's toy commonly known as "silly putty". The inner layer 124 and/or outer layer 128 may be fully or partially viscoelastic. An advantage of the use of viscoelastic materials is that a compressible liner may be constructed that readily conforms to the various skull shapes (or any other body part) present in the human population and may recover after impact sufficiently for the compressible liner to be readily re-used.

Alternate Bicycle or Motorcycle Helmet

[0050] In an alternate embodiment to the compressible liner for a helmet, the outer layer 128 may be replaced by a suitably transparent or translucent material. For ex-

ample the transparent or translucent material may be a viscoelastic jelly or a transparent synthetic rubber material with the appropriate compressible and/or stiffness properties. The outer shell 116 of the helmet may either be absent or a suitably transparent or translucent material. The inner layer 124 may be of an opaque material for example black expanded polystyrene (EPS) foam. Such a helmet may have the striking visual appearance of many visible cones or spikes radiating from the person's head, an aesthetically appealing feature to some bicycle and motorcycle riders, which may still provide impact protection to the wearer of the helmet.

Vehicle Cabin Liner

[0051] Fig 7 schematically illustrates the use of the compressible liner 710 as a vehicle cabin liner (VCL) within a portion of a vehicle cabin carrying people. The VCL compressible liner 710 may be attached via an attachment layer 714 to the vehicle structure 712 that forms the interior of the vehicle cabin (not shown). For car the vehicle structure 712 may be a door pillar, dashboard, ceiling or any structure within the cabin of a car. The use of the VCL compressible liner 710 within a vehicle cabin is of particular interest for side impact collisions of passenger vehicle cars where there is a tendency to a higher proportion of head injuries from the impact of a passenger (or driver) head with the vehicle cabin interior.

[0052] The VCL compressible liner 710 may be permanently affixed to the vehicle structure 712 via the attachment layer 714 adhering to the outer surface 118 of the compressible liner 710. For example attached to side door pillars and windscreen pillars in passenger vehicle cars. Alternatively the VCL compressible liner 710 may be a removable and replaceable fitting which may be retrofitted to existing vehicles. For the removable and replaceable fitting the attachment layer 714 may comprise of a material such as Velcro or incorporate any one of many fastening methods known to a person skilled in the art of interior fittings for vehicles.

[0053] The installation of the VCL compressible liner 710 within a vehicle may further incorporate an optional interior trim liner 716 attached to the contact surface 122 of the VCL compressible liner 710. The interior trim liner 716 may provide aesthetic, tactile and/or sound proofing properties. The interior trim liner 716, or comfort liner, may be made of fabric, cushioning foam, "bubble wrap" plastic and/or a plastic scuff lining.

[0054] Examples of vehicles that may be applicable to the use of the VCL compressible liner 710 include: civilian cars and trucks, military craft such as tanks, aircraft and the like, marine craft and spacecraft. Yet another application area is the seat and head rests of vehicles and in particular aircraft and spacecraft where severe impacts may be encountered by those craft.

[0055] Fig 8 is a cut-away illustration of the interior of a civilian passenger car. Fig 8 schematically shows the application of the VCL compressible liner 710 to provide

different zones of impact protection about the vehicle cabin interior. For example three different zones of protection may be identified, the front and side pillars with the door window sills 810, the rear of the front seats 812 and the dashboard and central console 814. For each of the three zones 810, 812, 814 the outer layer 128 of the VCL compressible liner 710 may be the same stiffness or compressibility whilst the inner layer 124 varies in compressibility between the zones 810, 812, 814 to provide the desired level of impact protection with additional consideration of the day to day wear and tear durability expected of an interior cabin lining for a car.

[0056] In yet another embodiment of the VCL compressible liner 710 (not shown), a zone of impact protection may be further divided. For example the rear of the front seats 812 may have a higher portion with an inner layer 124 segment that may be more compressible than an inner layer 124 segment for a lower portion of the rear of the front seats 812. This arrangement may provide a zone of higher impact protection for the head of an unsecured rear passenger where they are most likely to initially impact on the upper portion of the rear of the front seats 812. The less compressible lower portion of the rear of the front seats 812 allows for an increased durability to scuffing by the feet and legs of rear passengers entering and exiting the rear of the passenger cabin.

[0057] In another example application an embodiment of the compressible liner 110 may be applied to the exterior front surfaces of cars and trucks to aid in the impact protection of pedestrians that may be struck by the car or truck.

Baby Capsules and Child Safety Seats

[0058] Yet another application of the compressible liner within a vehicle is for baby capsules and child safety seats that are typically used in cars, trucks or aircraft.

[0059] A baby capsule or child safety seat (CSS) may incorporate segmented compressible liners according to the location of the torso and head of the baby or child within the baby capsule or CSS so as to offer the appropriate impact protection for those parts of the baby's body. In other words different zones of impact protection within a baby capsule or CSS may be provided. Typically the compressible liner may be added to the interior of the baby capsule or CSS, either as a number of panels to form the complete compressible liner or the compressible liner may be inserted as one unit liner. In another embodiment the compressible liner may form the baby capsule or CSS. In addition the compressible liner may also form the protective side panels or bolsters or in another embodiment may be added to the existing side panels or bolsters of a baby capsule or a child safety seat. Optionally, a comfort liner may also be added to the baby capsule or CSS.

[0060] Fig 9 schematically illustrates, in a perspective view, an example of an embodiment of a baby compressible liner 910 for a baby capsule. A baby capsule 912 is

secured into an adult car seat 914 by the use of the baby capsule base 916 in the adult car seat 914 with rearward securing straps 918 anchoring to a suitable point on the vehicle structure. A baby (not shown) is secured within the removable cradle 920 of the baby capsule 912. Within the cradle 920 the baby compressible liner 910 may be segmented into two zones of impact protection, the baby head zone 922 and a baby torso zone 924. In fig 9 the baby compressible liner 910 is shown as an inserted liner into the structure of the cradle 920. In a preferred embodiment the density of the EPS foam for the baby compressible liner 910 may be in a lower range to that described above for helmets. The inner layer 124 may have density in the range of 15 to 25 kgm⁻³, with an outer layer 128 of density in the range of 35 to 45 kgm⁻³. For increased impact protection for the baby's head, the segments comprising the baby head zone 922 of the baby compressible liner 910 may have EPS densities for the inner and outer layers 124, 128 lower than the segments comprising the baby torso zone 924.

[0061] In yet another embodiment of the baby compressible liner 910, the baby head zone 922 may be shaped in the partial form of a helmet. With reference to fig 4 the baby head zone 922 may be shaped in a form approximated by the rear segments 422, 424, 426, 428 and temporal segments 414, 416, with corresponding segments of the outer layer 128.

[0062] Fig 10 is a perspective view of a CSS 1012 with a CSS compressible liner 1010. Typically the CSS 1012 may have a base 1014 resting upon an adult car seat 914. Upon the base 1014 is the child seat 1016 that typically includes a seat, back rest and side bolsters. The CSS 1012 is secured to the car seat 914 by use of the adult lap sash seat belt (not shown) and/or additional securing straps (not shown) to vehicle anchor points. The CSS compressible liner 1010 may be segmented into two zones for impact protection; the CSS head zone 1018 and the CSS torso zone 1020. Each zone 1018, 1020 may also feature side bolsters (or wings) 1022, 1024 to "channel" or further confine and protect the child. In fig 10 the CSS compressible liner 1010 is shown as an inserted liner onto the structure of the child seat 1016. In a preferred embodiment the density of the EPS foam for the CSS compressible liner 1010 may be as described above for the baby compressible liner 910

Body Armour

[0063] Another application area of an embodiment of the compressible liner 110 is its use in body armour, including protective vests. For sports involving impacts such as motorcycle riding, rodeo riding, football, gridiron, cricket and baseball, body armour in the form of protective vests and pads are often worn about the body. A body armour compressible liner may have an embodiment adapted to impact protection in sports. For example the body armour compressible liner may be a reduced thickness 524 appropriate to the sport, in the range of 5

to 30 mm. Materials selected for the body armour compressible liner may be elastic and robust to enable the compressible liner to be serviceable over many impacts.

[0064] For ballistic body armour an embodiment of the body armour compressible liner may be used in conjunction with ballistic armour. The body armour compressible liner may absorb the impact force of the ballistic armour in its reaction to an impacting projectile.

[0065] Fig 11 is a front elevation view of a protective vest 1112 with inserts of a body armour compressible liner 1110. The protective vest 1112 may have Velcro shoulder tabs 1114 to aid the wearer to put on and take off the protective vest 1112 garment. Chest 1116 and abdominal 1118 compressible liner 1110 segments as panels are shown inserted into the protective vest 1112, where dashed lines 1120 indicate the extent of each segment 1116, 1118 for the front of the protective vest 1112 garment. The abdominal compressible liner 1118 segments may offer a higher level of impact protection compared with the chest compressible liner 1116 segments because the rib cage in the chest offers a level protection for internal organs that is absent for the abdomen.

Protection of High Value Articles

(not forming part of the claimed invention)

[0066] Another application area for the compressible liner may be for the protection of high value articles such as: goods, electronic devices, fragile mechanisms, animals, plants and the like. Examples of the compressible liner may be used protect high value articles in freight transit. Other examples may be incorporated into military craft, aircraft and spacecraft for the protection of sensitive equipment for improved survivability of equipment in the event of a catastrophic impact to the craft.

Performance of the Compressible Liner

[0067] The performance of the compressible liner in the embodiments described above may be further understood in terms of the following descriptions of how the performance of impact protection apparatus and methods are evaluated by those skilled in the art together with the relative performance of the compressible liner. By way of reference and example the following is incorporated herein: "Improved Shock Absorbing Liner for Helmets", Australian Transport Safety Bureau (ATSB), published in July, 2001, www.atsb.gov.au.

[0068] The compressible liner provides an initial low resistance to the impact for the desired part of the human body, for example the skull for a motorcycle helmet when a motorcycle rider's helmet impacts the road surface. As the impact progresses the level of resistance provided by the compressible liner increases in a controlled manner so that controlled deceleration of the skull and brain (continuing the prior example) is occurring throughout the impact. In the following discussion the example em-

bodiment of a compressible liner with an EPS foam material in a motorcycle helmet will be used, however it will be appreciated that similar remarks may be made for all the other embodiments of the compressible liner discussed above and below.

[0069] The particular configuration of the compressible liner with the inner layer 124 and outer layer 128 of materials differing in relative compressibility enables the compressible liner to provide a continuous and gradual variation in compressibility and / or stiffness as the compressible liner is compressed or crushed in an impact.

[0070] The particular configuration of the compressible liner also enables it to be readily manufactured with a reduced overall mass for a helmet, in particular in comparison to single foam density helmets. This is an advantage in reducing the effect of rotational acceleration to the head and the neck during an impact.

Impact -Time Duration (Deceleration Time)

[0071] The compressible liner provides extended controlled compression and crushing so as to extend the time period over which the impact occurs. The human skull or any other body part may then be more gradually decelerated to rest. The crush, or deformation time, for the compressible liner may occur for a time up to and beyond 20% over that for a liner with a single foam density. In other terminology: the impact force translated to the skull is reduced because the deceleration of the skull is slower due to the action of the compressible liner.

Crushing

[0072] Crushing is the penetration into the compressible liner by the skull during an impact. The compression of the compressible liner dissipates the energy of the impact. The compressible liner may crush up to and beyond 10% that of a liner constructed of a single foam density.

Cracking

[0073] Slab and arc cracking during compression of an EPS foam liner are commonly part of impact protection. Arc cracking is a line of circumferential surface cracks about the penetration of the skull into the foam liner. Slab cracking is a full thickness crack through the foam liner in the region of the penetration into the foam liner. Slab cracking is commonly seen in single density foam liners and is to be avoided since impact protection by the foam liner has then begun to fail.

[0074] The compressible liner exhibits no slab cracking during impact tests. Arc cracking is considerably reduced for the compressible liner. The reduction in arc cracking may in part be due to the inner layer 124 making use of lower density foam in comparison to common single density foam liners which commonly use a foam density in the range of 45 to 90 kgm⁻³. Lower density EPS foams

will yield more in a plastic and/or elastic fashion than higher density EPS foams, consequently a lower density foam inner layer 124 is less likely to exhibit arc cracking. In addition the use of lower density foam for the inner layer 124 allows the contact surface 122 of the compressible liner to conform to the skull better than a single density foam liner. Accordingly the impact force is spread more evenly over a greater area of the skull, a desirable feature.

Peak Deceleration (Impact Energy Attenuation or Shock Attenuation, "g-force")

[0075] Australian and New Zealand national standards require that the peak deceleration experienced within a helmet during a type of simulated impact must be less than 300g ("g" being the gravitational acceleration of 9.8ms⁻²). Similar standards exist in North America and Europe. The peak deceleration for the compressible liner in all situations tested was lower than conventional single foam density liners and well below the mandatory national standards requirements for Australia and New Zealand.

Rotational Forces

[0076] The mass of the compressible liner within a helmet may contribute to rotational forces experienced by the head in an accident. It is a safety advantage for the helmet and the compressible liner to be lightweight so as to reduce injuries associated with rotational forces. Helmets with single density foam liners that may perform similarly to the equivalent with a compressible liner, in terms of the other performance tests described above, are significantly larger and heavier. This is because the single density foam liner must be thicker and of a lower single density foam, resulting in extra liner mass as well as a larger and heavier outer shell for the helmet.

[0077] It will be appreciated for the above description that whilst the inner layer 124 is required to be more compressible and/or a lower stiffness than the outer layer 128, the configuration of the protuberances 130 and recesses 132 may be reversed such that the protuberances are associated with the outer layer 128 and the recesses with the inner layer 124. In another example the joining surface 126 may be symmetric such that both the inner layer 124 and the outer layer 128 both have protuberances and recesses in an arrangement that allows engagement of the inner layer 124 to the outer layer 128 at the joining surface 126. However in all configurations, described above and below, the compressibility of the inner layer 124 is more than the compressibility of the outer layer 128. Or in stiffness terms, the stiffness of the inner layer 124 is less than that of the outer layer 128.

[0078] It will also be appreciated that the dimensions, capacities and materials of the compressible liner given above and later are given by way as examples for the embodiments described. Other dimensions, capacities

and materials to those given may also be selected or designed by a person skilled in the art, for example for other impact protection applications.

[0079] Fig 12 schematically illustrates a cross-sectional view of a double compressible liner 1210. The double compressible liner 1210 is an alternate embodiment of the compressible liner 510 shown in fig 5. The double compressible liner 1212 is two compressible liners 510 joined together at the outer surface 118, to form the new join 1212. The double compressible liner 1210 may useful in such applications as contact sports where vigorous body contact between participants is common. In such situations it is desirable that when two participants impact each other that both participants receive the benefits of the initial low resistance of the inner layer 124. Another example is the use of the double compressible liner 1210 between sensitive mechanisms, or articles, so that the two mechanisms both receive the benefit of the inner layer 124. The double compressible liner 1210 may also be segmented (not shown) to provide different zones of impact protection as described above.

[0080] A continuum liner (not shown) may be constructed with similar or superior properties to the compressible liner. The continuum liner may include a liner fabricated in the desired shape, for example a helmet, of a first material. The first material may be highly compressible and / or a low stiffness, for example a viscoelastic jell. It is then desired to produce the effect of decreasing the compressibility (increased stiffness) through the thickness of liner, proceeding in the direction from the inside of the helmet to the outside of the helmet. To apply such an increasing stiffening gradient the first material may be transformed in a continuous fashion to a second material. Where the second material has less compressibility (more stiffness) than the first material and that the second material and first material exist in various proportions throughout the continuum liner so as to produce the desired stiffening gradient.

[0081] The second material may be produced by a number of processes, including:

- Ionising radiation to cross link the molecules of the first material to various degrees of cross linking to form a second material.
- A chemical agent to transform the first material to the second material to various degrees.

[0082] The ionising radiation or chemical agent may be applied to the exterior of the helmet form, or other forms, made of the first material. The level of transformation from the first material to the second material would be carefully controlled by the level of depth attenuation through the thickness of the continuum liner.

[0083] In a similar manner the level of ionising radiation or chemical agent applied about the helmet form of the first material may be controlled to impart different levels zones of impact protection required about the helmet form. For the alternate embodiment with zones of impact

protection the boundary between the segments for each zone may not be a discrete boundary line but a gradient as results from the particular technique used to transform the first material to the second material.

[0084] A different type of bicycle helmet (not shown and not claimed) may be produced without the presence of the outer layer 128. For this helmet the apexes 136 of the protuberances 130 of the inner layer 124 are connected to the outer shell 116. A person skilled in the art of helmet design and manufacture may select a suitable material or materials to form the inner layer 128 so that appropriate safety standards are met for this different bicycle helmet. For example the inner layer 124 EPS foam density may be as described above or transformed into two materials as per the continuum liner described above. In another example (not shown and not claimed), of the different bicycle helmet, the outer shell 116 may be conformal with the outer surface of the inner layer 124 so as to form a hard outer layer in the shape of the conical protuberances.

[0085] The use of a segmented liner, in which zones of different impact protection are provided, can substantially reduce the weight of the liner as compared with a non-segmented construction. Weight saving is possible by using reduced density material where a high resistance to applied force is not required. In the case of a segmented helmet liner, the weight of the helmet may be reduced by up to 20%, which is of considerable benefit to the wearer.

[0086] The liner of the invention may be pierced or apertured to provide areas of no protection, for example to allow ventilation openings. Such an arrangement is particularly useful for helmets and the like.

[0087] In an embodiment of the invention, the inner layer is constituted by a panel in the form of a strip having protuberances or recesses thereon for co-operation into apertures with the other layer. A strip may for example comprise a single row of protuberances, and be moulded with a curvature to suit the other layer, as would be required in for example a helmet.

[0088] Several such strips may form part of an insert and be moulded with a sprue to connect them. The sprue may comprise the layer of material from which the protuberances project, and is typically a single moulding. In one embodiment the sprue extends transversely to the general direction of the strips. This embodiment is particularly suitable for a helmet because the gap between the strips can be aligned with the usual ventilation openings.

[0089] Although the invention has been herein shown and described in what is conceived to be the most practical and preferred embodiments, it is recognized that departures can be made within the scope of the invention, which are not to be limited to the details described herein but are to be accorded the full scope of the appended claims so as to embrace any and all equivalent assemblies, devices and apparatus.

[0090] In this specification, the word "comprising" is to

be understood in its "open" sense, that is, in the sense of "including", and thus not limited to its "closed" sense, that is the sense of "consisting only of". A corresponding meaning is to be attributed to the corresponding words "comprise, comprised and comprises" where they appear.

[0091] It will further be understood that any reference herein to known prior art does not, unless the contrary indication appears, constitute an admission that such prior art is commonly known by those skilled in the art to which the invention relates.

Claims

1. An apparatus for impact protection for at least a part of a human body comprising: a compressible liner (110, 310, 510) with an inner layer (124) and an outer layer (128), wherein the inner layer (124) includes a first material of a first compressibility, and the outer layer (128) includes a second material of a second compressibility; and wherein the inner layer (124) has a compressibility greater than that of the outer layer (128);
wherein the inner layer (124) has a contact surface (122) and a first joining surface, wherein the first joining surface includes a plurality of protuberances (130) wherein the outer layer (128) has a second joining surface and an outer surface (118), wherein the second joining surface includes a plurality of recesses (132) adapted to receive the protuberances (130) of the inner layer;
characterized in that said inner layer (124) is formed of a plurality of inner layer segments (212, 214); and
wherein the plurality of inner layer segments (212, 214) have a first compressibility which is different between inner layer segments.
2. An apparatus according to claim 1 wherein at least part of the contact surface of the inner layer of the compressible liner (110, 310, 510) is adapted to be immediately adjacent or to engage with part of the human body.
3. An apparatus according to claim 1 or claim 2 wherein the protuberances (130) are conical.
4. An apparatus according to any preceding claim wherein said outer layer (128) is formed from one or more outer layer segments (210, 216).
5. An apparatus according to claim 4 wherein the second compressibility is different between outer layer segments (210, 216).
6. An apparatus according to any preceding claim wherein one or more of the first material and the sec-

ond material are viscoelastic or thixotropic.

7. An apparatus according to any preceding claim wherein both the first material and the second material are foam.
8. An apparatus according to claim 7 when dependent on any of claims 1-5, wherein said foam is expanded polystyrene.
9. An apparatus according to claim 8 wherein the first material has a density in the range of 15 to 50 kgm⁻³.
10. An apparatus according to claim 9 wherein the first material has a density in the range of 25 to 35 kgm⁻³ and the second material has a density in the range of 35 to 50 kgm⁻³.
11. An apparatus according to claim 9 wherein the first material has a density in the range of 15 to 25 kgm⁻³ and the second material has a density in the range of 35 to 45 kgm⁻³.
12. An apparatus according to claim 8 where the second material has a density in the range of 35 to 90 kgm⁻³.
13. An apparatus according to claim 12 wherein the second material has a density in the range of 35 to 55 kgm⁻³.
14. An apparatus according to any preceding claim where a penetration of one or more protuberances (130) into the outer layer (128) is in the range of 50 to 100%.
15. An apparatus according to any of claims 1 to 13 wherein an apex of one or more protuberances (130) is contiguous with the outer surface.
16. An apparatus according to any preceding claim wherein the distance between adjacent bases of the protuberances (130) is in the range of 0 to 20 mm.
17. An apparatus according to claim 16 wherein the distance between adjacent bases of the protuberances (130) is in the range of 5 to 15 mm.
18. An apparatus according to any preceding claim wherein the maximum transverse dimension of a base of the protuberances (130) is in the range of 15 to 22 mm.
19. An apparatus according to any preceding claim wherein the compressible liner (110, 310, 510) has a thickness in the range of 15 to 45 mm; a height of one or more protuberances (130) from the base of the respective protuberance is in the range of 20 to 25 mm; and a distance from the base of one or more

protuberances (130) to the contact surface (122) is in the range of 5 to 10 mm.

20. An apparatus according to any preceding claim wherein the inner layer (124) is visible through the outer layer (128). 5
21. An apparatus according to any preceding claim wherein the compressible liner (110, 310, 510) comprises a removable and replaceable fitting. 10
22. An apparatus according to any of claims 1 and 3-21 wherein the compressible liner (110, 310, 510) is installed within or forms: a vehicle cabin liner, a baby capsule, a child safety seat, a seat, a head rest or a body armour. 15
23. An apparatus according to any of claims 1-21 wherein the compressible liner is installed within or forms a helmet. 20
24. An apparatus according to any preceding claim wherein the inner layer (124) comprises a strip from which the protuberances project in a line. 25
25. An apparatus according to claim 24 wherein a plurality of said strips are provided, and connected by a sprue so as to form a one-piece component.
26. A method of impact protection for at least a part of the human body by providing apparatus according to any of claims 1 to 25, said apparatus having: an initial low resistance to an impact to at least a part of a human body; and then progressively increasing the level of resistance to the impact to at least a part of the human body as the impact progresses. 30 35

Patentansprüche

1. Vorrichtung zum Aufprallschutz für mindestens einen Teil eines menschlichen Körpers, umfassend: eine komprimierbare Einlage (110, 310, 510) mit einer Innenschicht (124) und einer Außenschicht (128), wobei die Innenschicht (124) ein erstes Material mit einer ersten Kompressibilität aufweist und die Außenschicht (128) ein zweites Material mit einer zweiten Kompressibilität aufweist und wobei die Innenschicht (124) eine größere Kompressibilität als die Außenschicht (128) hat; 40 45
wobei die Innenschicht (124) eine Kontaktfläche (122) und eine erste Verbindungsfläche hat, wobei die erste Verbindungsfläche eine Vielzahl von Vorsprüngen (130) aufweist, wobei die Außenschicht (128) eine zweite Verbindungsfläche und eine Außenfläche (118) hat, 50
wobei die zweite Verbindungsfläche eine Vielzahl von Vertiefungen (132) aufweist, die zum Aufneh-

men der Vorsprünge (130) der Innenschicht angepasst sind;

dadurch gekennzeichnet, dass die Innenschicht (124) aus einer Vielzahl von Innenschichtsegmenten (212, 214) gebildet ist; und
wobei die Vielzahl von Innenschichtsegmenten (212, 214) eine erste Kompressibilität hat, die sich zwischen den Innenschichtsegmenten unterscheidet.

2. Vorrichtung gemäß Anspruch 1, bei der mindestens ein Teil der Kontaktfläche der Innenschicht der komprimierbaren Einlage (110, 310, 510) dazu angepasst ist, unmittelbar an einen Teil des menschlichen Körpers anzugrenzen oder mit demselben ineinanderzugreifen.
3. Vorrichtung gemäß Anspruch oder Anspruch 2, bei der die Vorsprünge (130) konisch sind.
4. Vorrichtung gemäß einem der vorstehenden Ansprüche, bei der die Außenschicht (128) aus einem oder mehr Außenschichtsegmenten (210, 216) gebildet ist.
5. Vorrichtung gemäß Anspruch 4, bei der die zweite Kompressibilität sich zwischen den Außenschichtsegmenten (210, 216) unterscheidet.
6. Vorrichtung gemäß einem der vorstehenden Ansprüche, bei der eines oder mehrere von dem ersten Material und dem zweiten Material viskoelastisch oder thixotrop sind.
7. Vorrichtung gemäß einem der vorstehenden Ansprüche, bei der sowohl das erste Material als auch das zweite Material Schaumstoff ist.
8. Vorrichtung gemäß Anspruch 7, wenn abhängig von einem der Ansprüche 1 - 5, bei welcher der Schaumstoff expandiertes Polystyrol ist. 40
9. Vorrichtung gemäß Anspruch 8, bei der das erste Material eine Dichte im Bereich von 15 bis 50 kgm⁻³ hat. 45
10. Vorrichtung gemäß Anspruch 9, bei der das erste Material eine Dichte im Bereich von 25 bis 35 kgm⁻³ hat und das zweite Material eine Dichte im Bereich von 35 bis 50 kgm⁻³ hat. 50
11. Vorrichtung gemäß Anspruch 9, bei der das erste Material eine Dichte im Bereich von 15 bis 25 kgm⁻³ hat und das zweite Material eine Dichte im Bereich von 35 bis 45 kgm⁻³ hat. 55
12. Vorrichtung gemäß Anspruch 8, wobei das zweite Material eine Dichte im Bereich von 35 bis 90 kgm⁻³

hat.

13. Vorrichtung gemäß Anspruch 12, bei der das zweite Material eine Dichte im Bereich von 35 bis 55 kgm⁻³ hat.
14. Vorrichtung gemäß einem der vorstehenden Ansprüche, wobei ein Eindringen eines oder mehrerer Vorsprünge (130) in die Außenschicht (128) im Bereich von 50 bis 100% liegt.
15. Vorrichtung gemäß einem der Ansprüche 1 bis 13, bei der eine Spitze eines oder mehrerer Vorsprünge (130) an der Außenfläche anliegt.
16. Vorrichtung gemäß einem der vorstehenden Ansprüche, bei welcher der Abstand zwischen benachbarten Basen der Vorsprünge (130) im Bereich von 0 bis 20 mm liegt.
17. Vorrichtung gemäß Anspruch 16, bei welcher der Abstand zwischen benachbarten Basen der Vorsprünge (130) im Bereich von 5 bis 15 mm liegt.
18. Vorrichtung gemäß einem der vorstehenden Ansprüche, bei der die maximale Querabmessung einer Basis der Vorsprünge (130) im Bereich von 15 bis 22 mm liegt.
19. Vorrichtung gemäß einem der vorstehenden Ansprüche, bei welcher die komprimierbare Einlage (110, 310, 510) eine Dicke im Bereich von 15 bis 45 mm hat; eine Höhe eines oder mehrerer Vorsprünge (130) ab der Basis des jeweiligen Vorsprungs im Bereich von 20 bis 25 mm liegt und ein Abstand von der Basis eines oder mehrerer Vorsprünge (130) zu der Kontaktfläche (122) im Bereich von 5 bis 10 mm liegt.
20. Vorrichtung gemäß einem der vorstehenden Ansprüche, bei der die Innenschicht (124) durch die Außenschicht (128) sichtbar ist.
21. Vorrichtung gemäß einem der vorstehenden Ansprüche, bei der die komprimierbare Einlage (110, 310, 510) einen abnehmbaren und auswechselbaren Einsatz umfasst.
22. Vorrichtung gemäß einem der Ansprüche 2 und 3 - 21, bei der die komprimierbare Einlage (110, 310, 510) in einer Fahrzeuginnenraumverkleidung, einer Babyschale, einem Kinder-Sicherheitssitz, einem Sitz, einer Kopfstütze oder einer Körperpanzerung angebracht ist oder dieselbe beziehungsweise denselben bildet.
23. Vorrichtung gemäß einem der Ansprüche 1 - 21, bei welcher die komprimierbare Einlage in einem Helm

angebracht ist oder denselben bildet.

24. Vorrichtung gemäß einem der vorstehenden Ansprüche, bei der die Innenschicht (124) einen Streifen umfasst, von dem die Vorsprünge in einer Linie vorstehen.
25. Vorrichtung gemäß Anspruch 24, bei der eine Vielzahl der Streifen vorgesehen sind und durch einen Anguss zu einem einstückigen Bauteil verbunden sind.
26. Verfahren zum Aufprallschutz für mindestens einen Teil des menschlichen Körpers durch Bereitstellen einer Vorrichtung gemäß einem der Ansprüche 1 bis 25, wobei die Vorrichtung aufweist: einen anfänglich geringen Widerstand gegen einen Aufprall auf mindestens einen Teil eines menschlichen Körpers und danach fortschreitendes Erhöhen des Widerstandsniveaus gegen den Aufprall auf mindestens einen Teil des menschlichen Körpers, während der Aufprall fortschreitet.

Revendications

1. Dispositif de protection contre les chocs pour au moins une partie d'un corps humain, comprenant : une garniture compressible (110, 310, 510) ayant une couche intérieure (124) et une couche extérieure (128), dans lequel la couche intérieure (124) comprend un premier matériau ayant une première compressibilité, et la couche extérieure (128) comprend un deuxième matériau ayant une deuxième compressibilité ; et dans lequel la couche intérieure (124) a une compressibilité supérieure à celle de la couche extérieure (128) ; dans lequel la couche intérieure (124) a une surface de contact (122) et une première surface de jonction, la première surface de jonction comportant une pluralité de protubérances (130), dans lequel la couche extérieure (128) a une deuxième surface de jonction et une surface extérieure (118), dans lequel la deuxième surface de jonction comporte une pluralité de cavités (132) adaptées pour recevoir les protubérances (130) de la couche intérieure ;
caractérisé en ce que ladite couche intérieure (124) est formée d'une pluralité de segments de couche intérieure (212, 214) ; et dans lequel les segments de couche intérieure (212, 214) ont une première compressibilité qui est différente entre les segments de couche intérieure.
2. Dispositif selon la revendication 1, dans lequel au moins une partie de la surface de contact de la couche intérieure de la garniture compressible (110, 310, 510) est adaptée pour être immédiatement ad-

- jacente à une partie du corps humain ou pour se mettre en contact avec celle-ci.
3. Dispositif selon la revendication 1 ou 2, dans lequel les protubérances (130) sont coniques. 5
 4. Dispositif selon l'une quelconque des revendications précédentes, dans lequel ladite couche extérieure (128) est formée d'un ou de plusieurs segments de couche extérieure (210, 216). 10
 5. Dispositif selon la revendication 4, dans lequel la deuxième compressibilité est différente entre les segments de couche extérieure (210, 216). 15
 6. Dispositif selon l'une quelconque des revendications précédentes, dans lequel un ou plus des premier et deuxième matériaux est viscoélastique ou thixotrope. 20
 7. Dispositif selon l'une quelconque des revendications précédentes, dans lequel le premier matériau et le deuxième matériau sont des mousses.
 8. Dispositif selon la revendication 7 lorsqu'elle dépend de l'une quelconque des revendications 1 à 5, dans lequel ladite mousse est du polystyrène expansé. 25
 9. Dispositif selon la revendication 8, dans lequel le premier matériau a une masse volumique comprise dans l'intervalle de 15 à 50 kgm⁻³. 30
 10. Dispositif selon la revendication 9, dans lequel le premier matériau a une masse volumique comprise dans l'intervalle de 25 à 35 kgm⁻³ et le deuxième matériau a une masse volumique comprise dans l'intervalle de 35 à 50 kgm⁻³. 35
 11. Dispositif selon la revendication 9, dans lequel le premier matériau a une masse volumique comprise dans l'intervalle de 15 à 25 kgm⁻³ et le deuxième matériau a une masse volumique comprise dans l'intervalle de 35 à 45 kgm⁻³. 40
 12. Dispositif selon la revendication 8, dans lequel le deuxième matériau a une masse volumique comprise dans l'intervalle de 35 à 90 kgm⁻³. 45
 13. Dispositif selon la revendication 12, dans lequel le deuxième matériau a une masse volumique comprise dans l'intervalle de 35 à 55 kgm⁻³. 50
 14. Dispositif selon l'une quelconque des revendications précédentes, dans lequel une pénétration d'une ou de plusieurs protubérances (130) dans la couche extérieure (128) est comprise dans l'intervalle de 50 à 100 %. 55
 15. Dispositif selon l'une quelconque des revendications 1 à 13, dans lequel un sommet d'une ou de plusieurs protubérances (130) est contigu avec la surface extérieure.
 16. Dispositif selon l'une quelconque des revendications précédentes, dans lequel la distance entre les bases adjacentes des protubérances (130) est comprise dans l'intervalle de 0 à 20 mm.
 17. Dispositif selon la revendication 16, dans lequel la distance entre les bases adjacentes des protubérances (130) est comprise dans l'intervalle de 5 à 15 mm.
 18. Dispositif selon l'une quelconque des revendications précédentes, dans lequel la dimension transversale maximale d'une base des protubérances (130) est comprise dans l'intervalle de 15 à 22 mm.
 19. Dispositif selon l'une quelconque des revendications précédentes, dans lequel la garniture compressible (110, 310, 510) a une épaisseur comprise dans l'intervalle de 15 à 45 mm ; une hauteur d'une ou de plusieurs protubérances (130) depuis la base de la protubérance respective est comprise dans l'intervalle de 20 à 25 mm ; et une distance de la base de l'une ou de plusieurs protubérances (130) à la surface de contact (122) est comprise dans l'intervalle de 5 à 10 mm.
 20. Dispositif selon l'une quelconque des revendications précédentes, dans lequel la couche intérieure (124) est visible à travers la couche extérieure (128).
 21. Dispositif selon l'une quelconque des revendications précédentes, dans lequel la garniture compressible (110, 310, 510) comprend un raccord amovible et remplaçable.
 22. Dispositif selon l'une quelconque des revendications 1 et 3 à 21, dans lequel la garniture compressible (110, 310, 510) est installée dans ou forme : une garniture de cabine de véhicule, une coque pour bébé, un siège de sécurité pour enfant, un siège, un appui-tête ou un gilet pare-balles.
 23. Dispositif selon l'une quelconque des revendications 1 à 21, dans lequel la garniture compressible est installée dans ou forme un casque.
 24. Dispositif selon l'une quelconque des revendications précédentes, dans lequel la couche intérieure (124) comprend une bande à partir de laquelle les protubérances font saillie en ligne.
 25. Dispositif selon la revendication 24, comportant une pluralité desdites bandes, lesquelles sont reliées en-

tre elles par une carotte afin de former un composant monobloc.

26. Procédé de protection contre les chocs pour au moins une partie du corps humain en fournissant un dispositif selon l'une quelconque des revendications 1 à 25, ledit dispositif ayant : une résistance à un impact initialement faible pour au moins une partie d'un corps humain ; puis le niveau de résistance à l'impact augmentant progressivement pour au moins une partie du corps humain à mesure que l'impact progresse.

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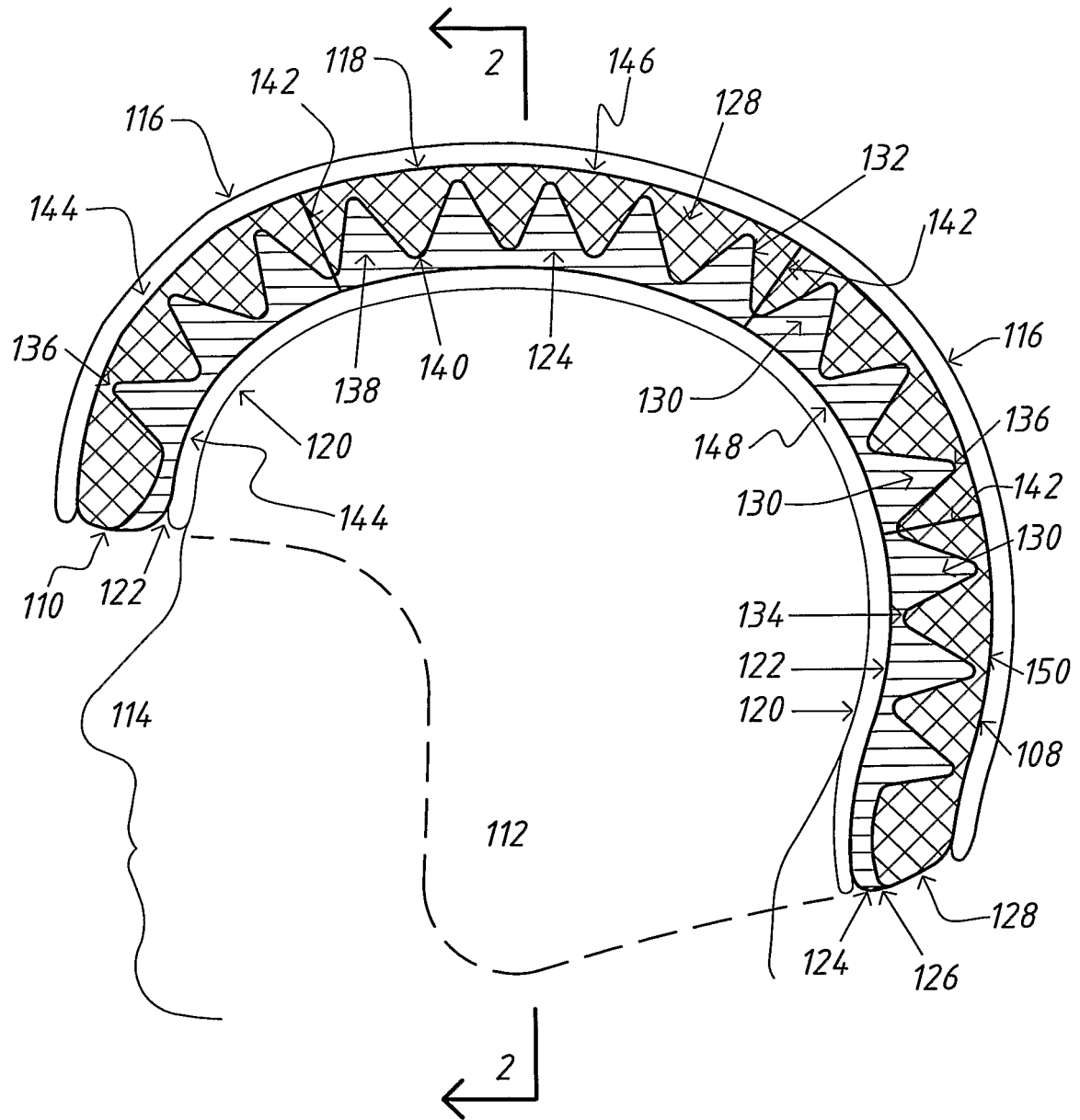


FIG 1/13

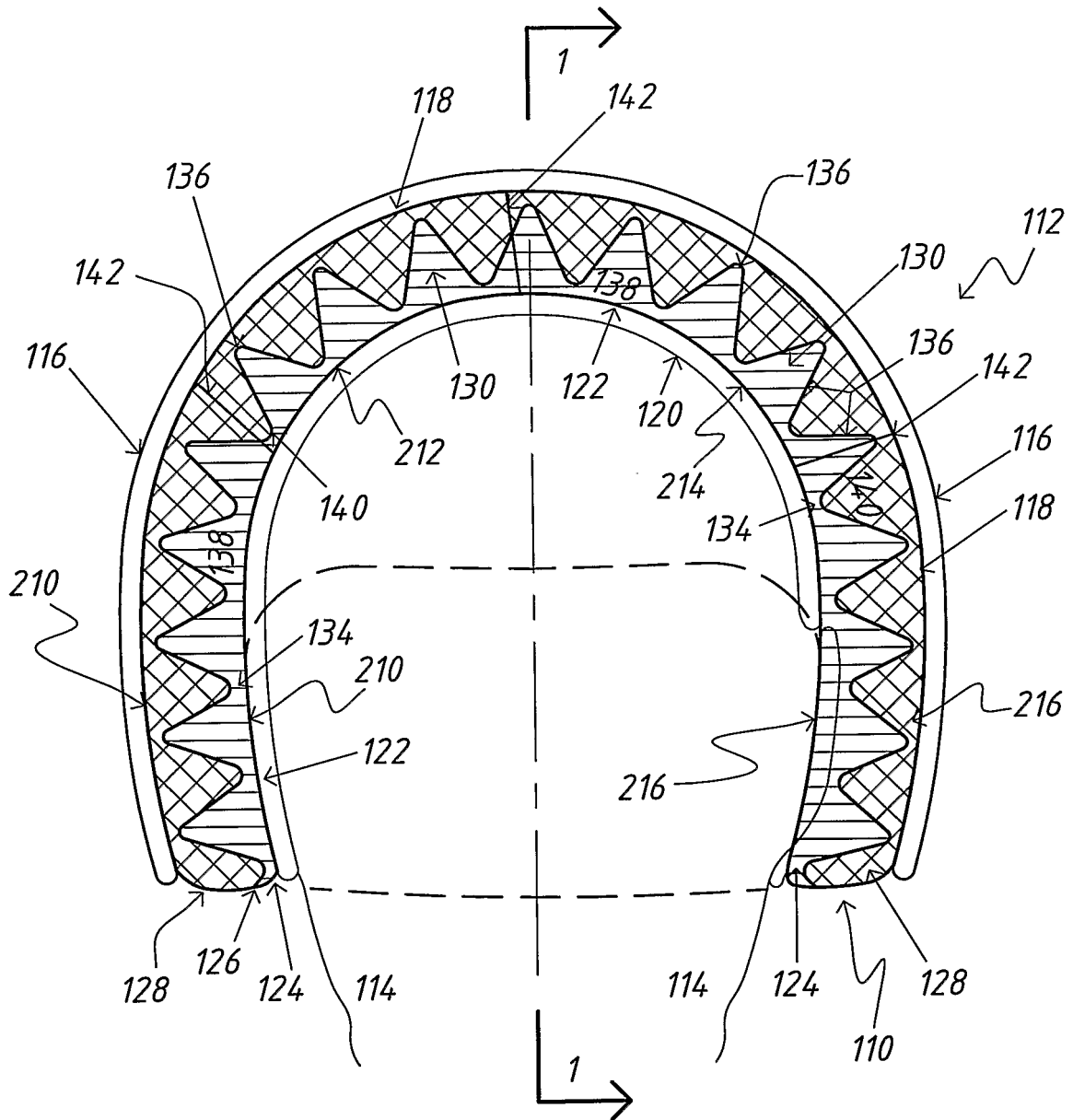


FIG 2/13

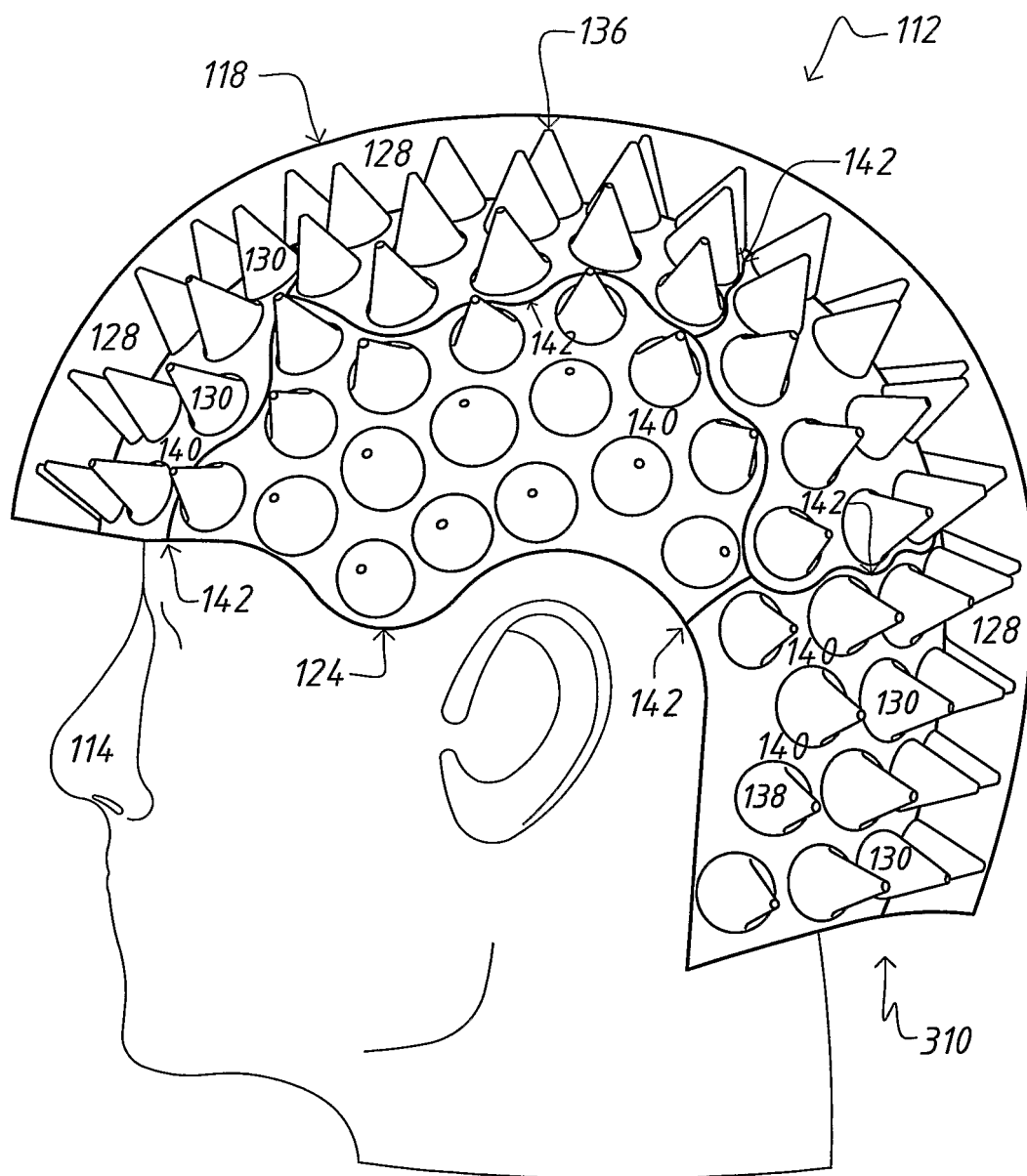


FIG 3/13

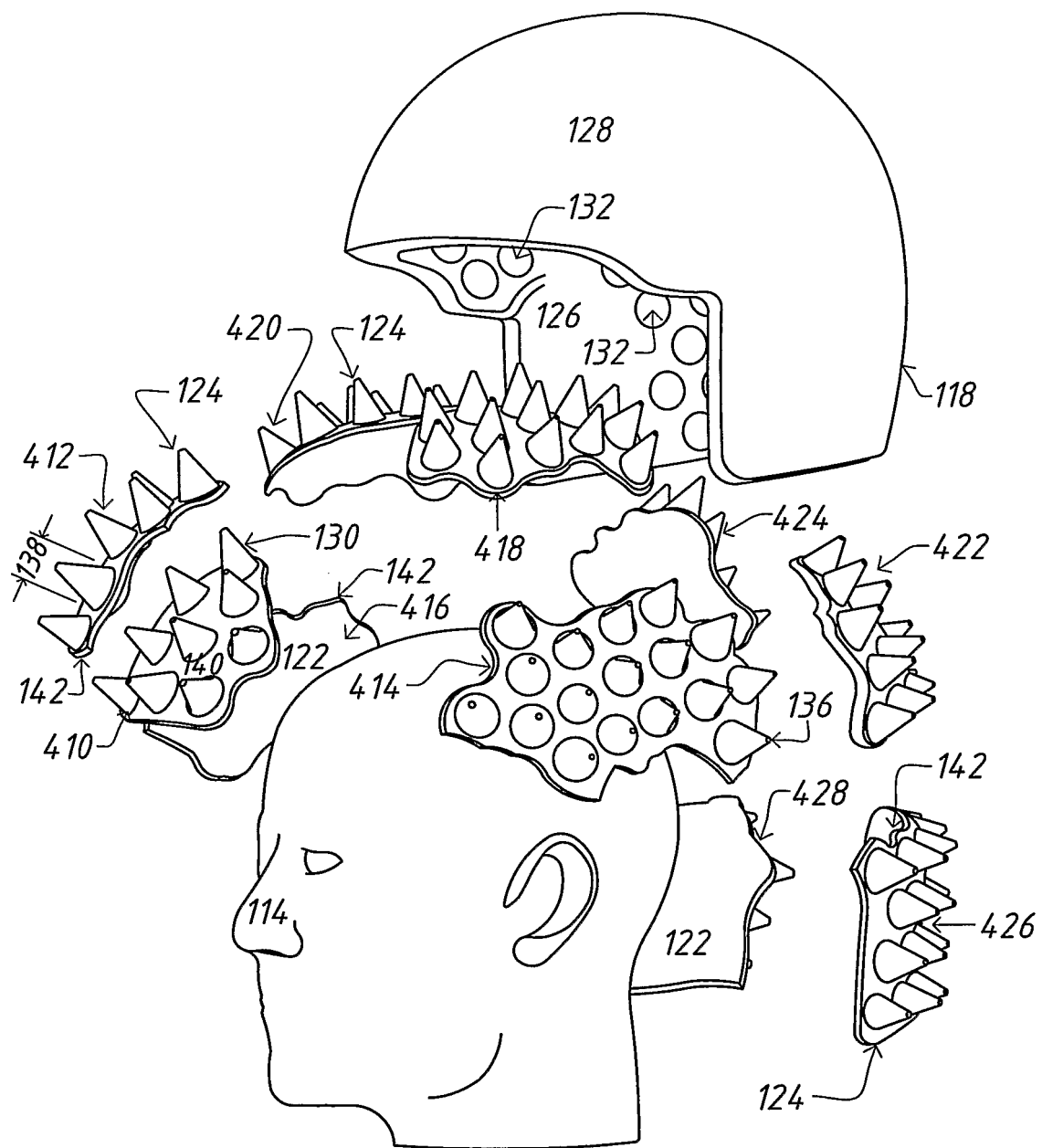


FIG 4/13

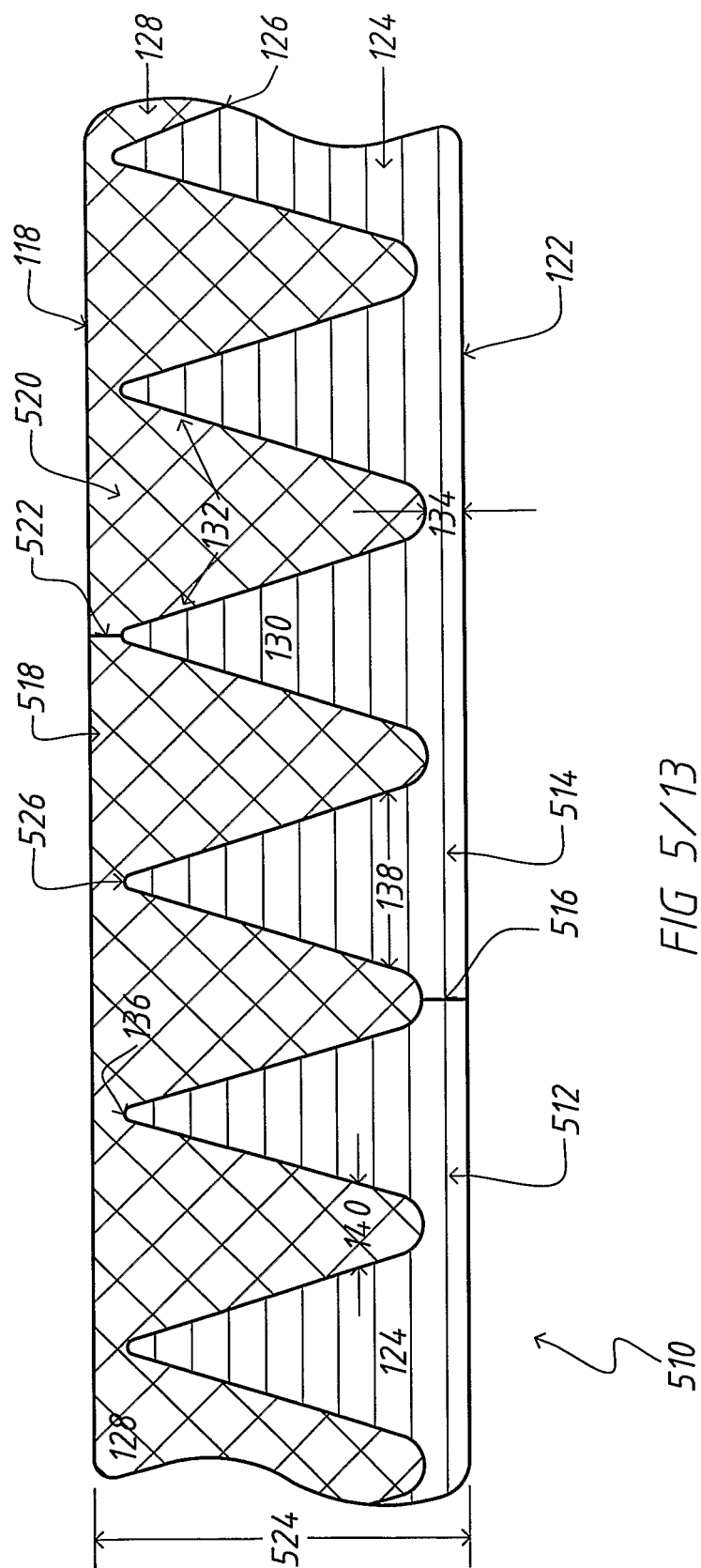


FIG 5/13

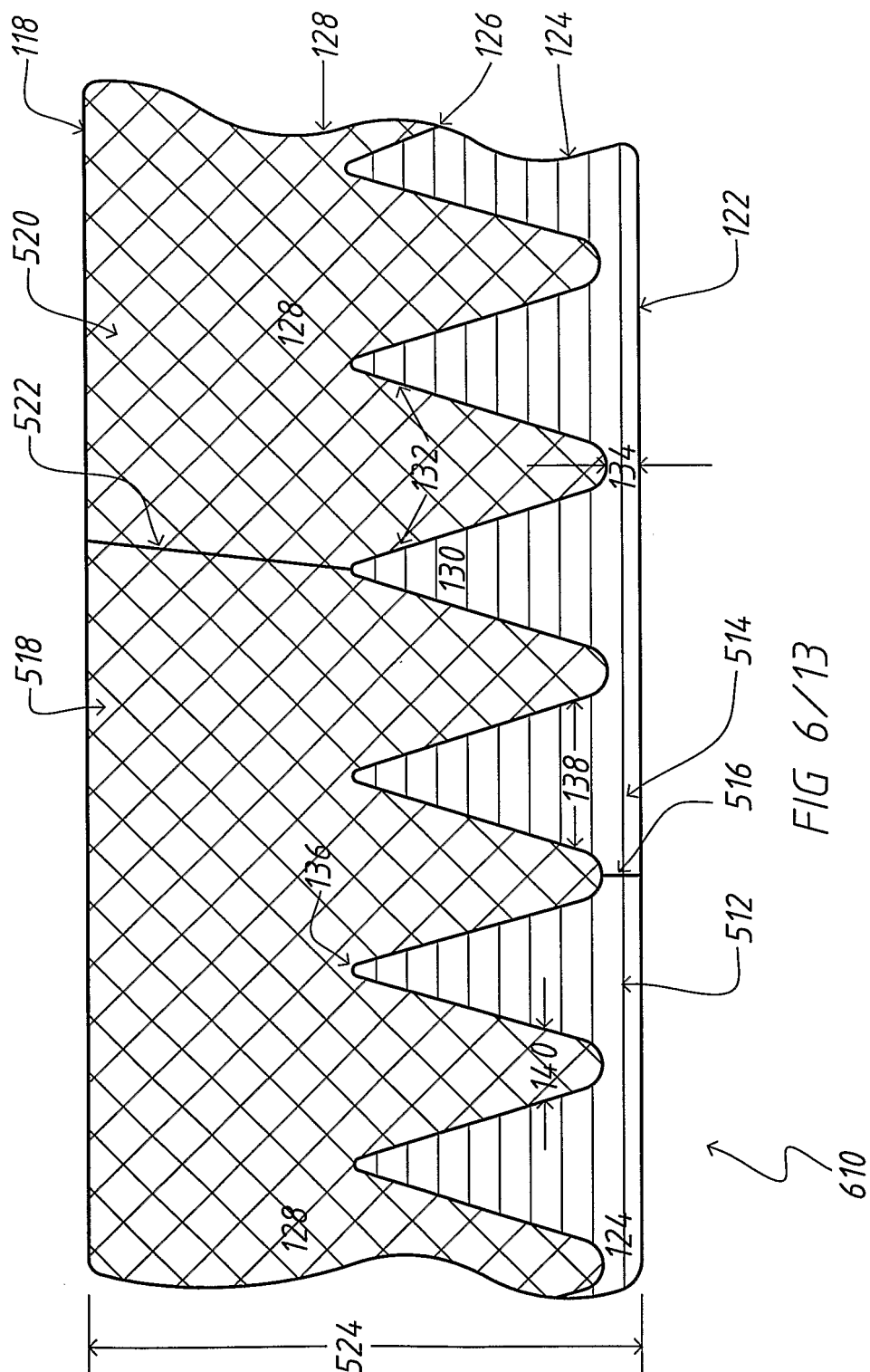


FIG 6/13

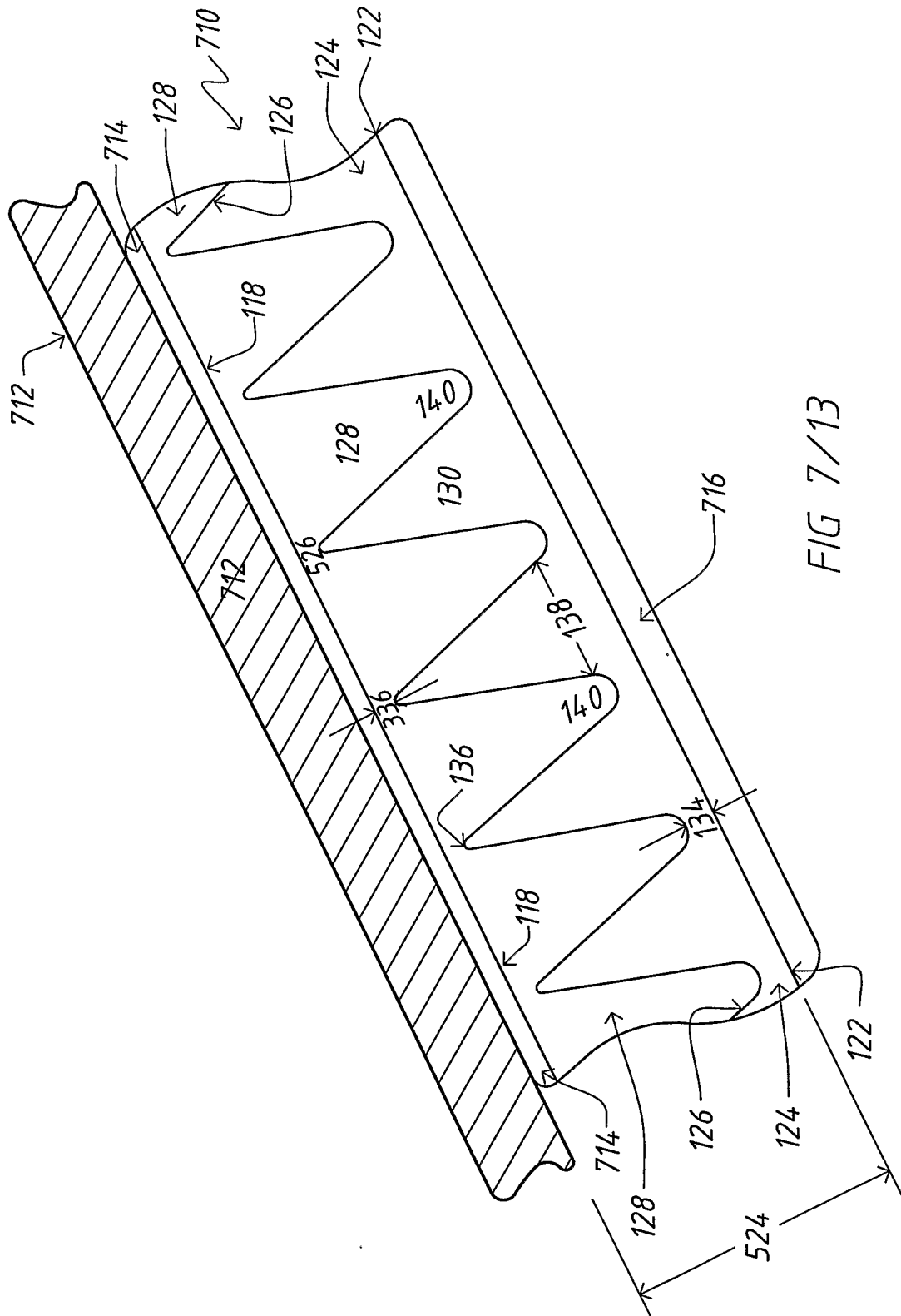


FIG 7/13

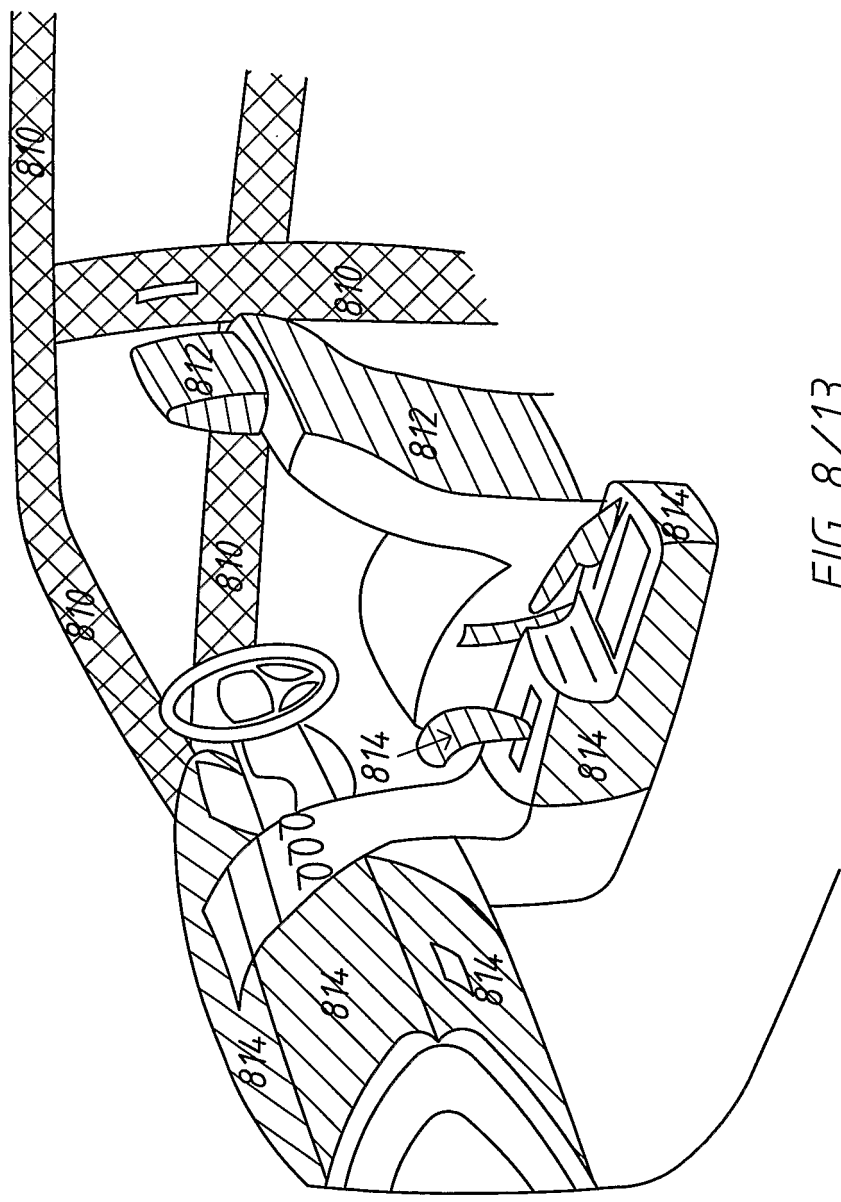


FIG 8/13

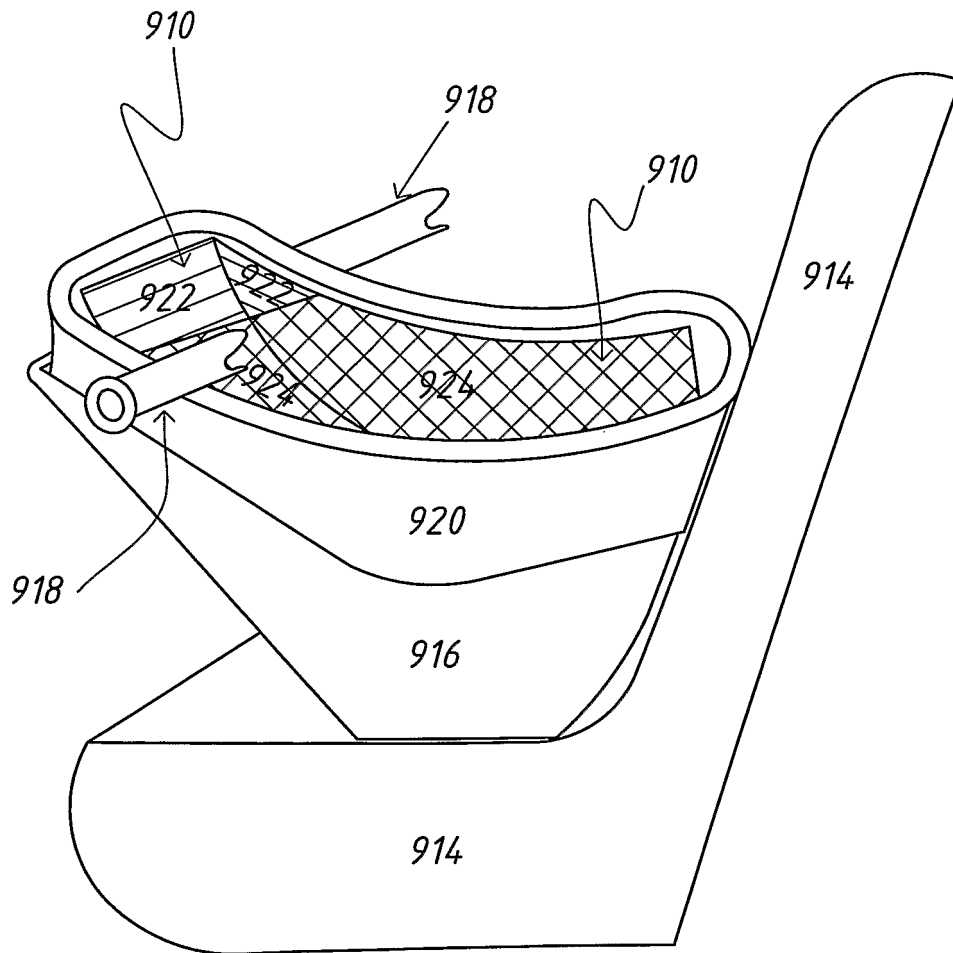


FIG 9/13

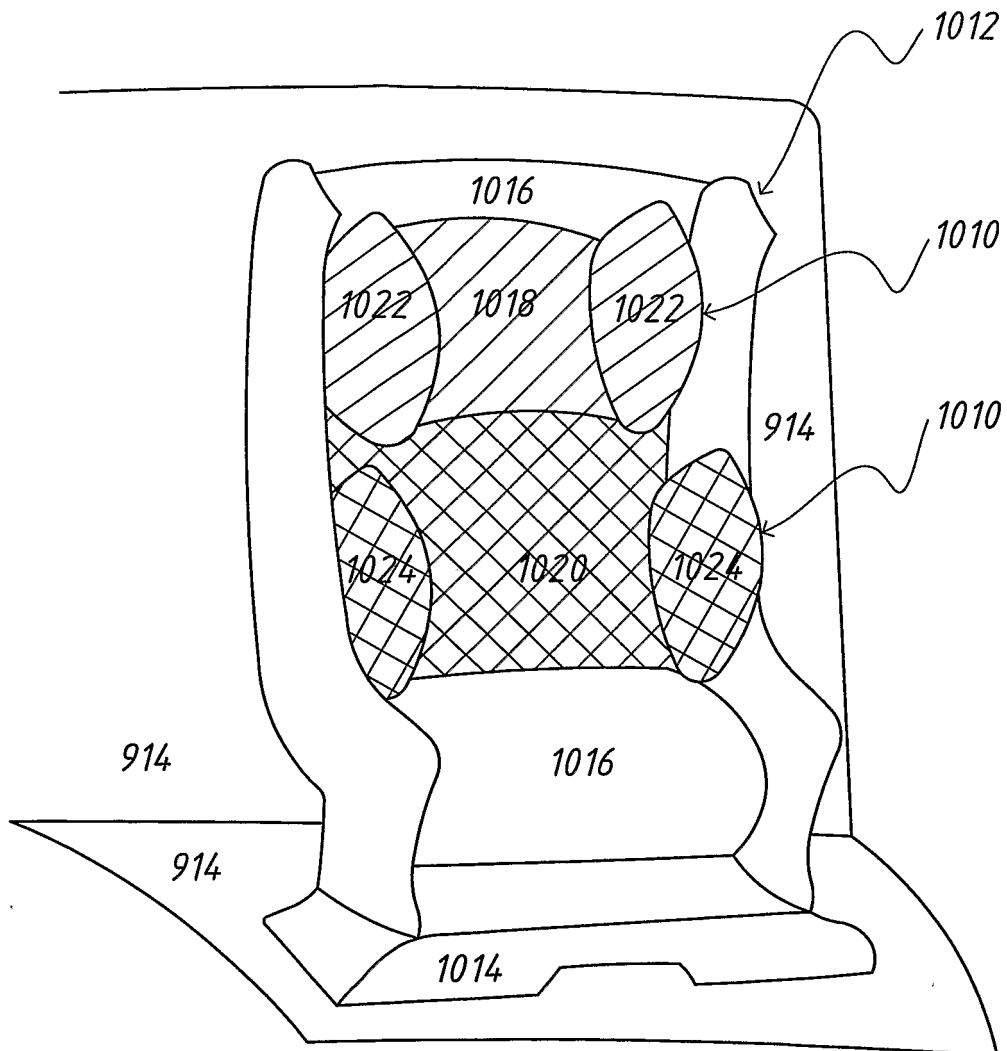


FIG 10/13

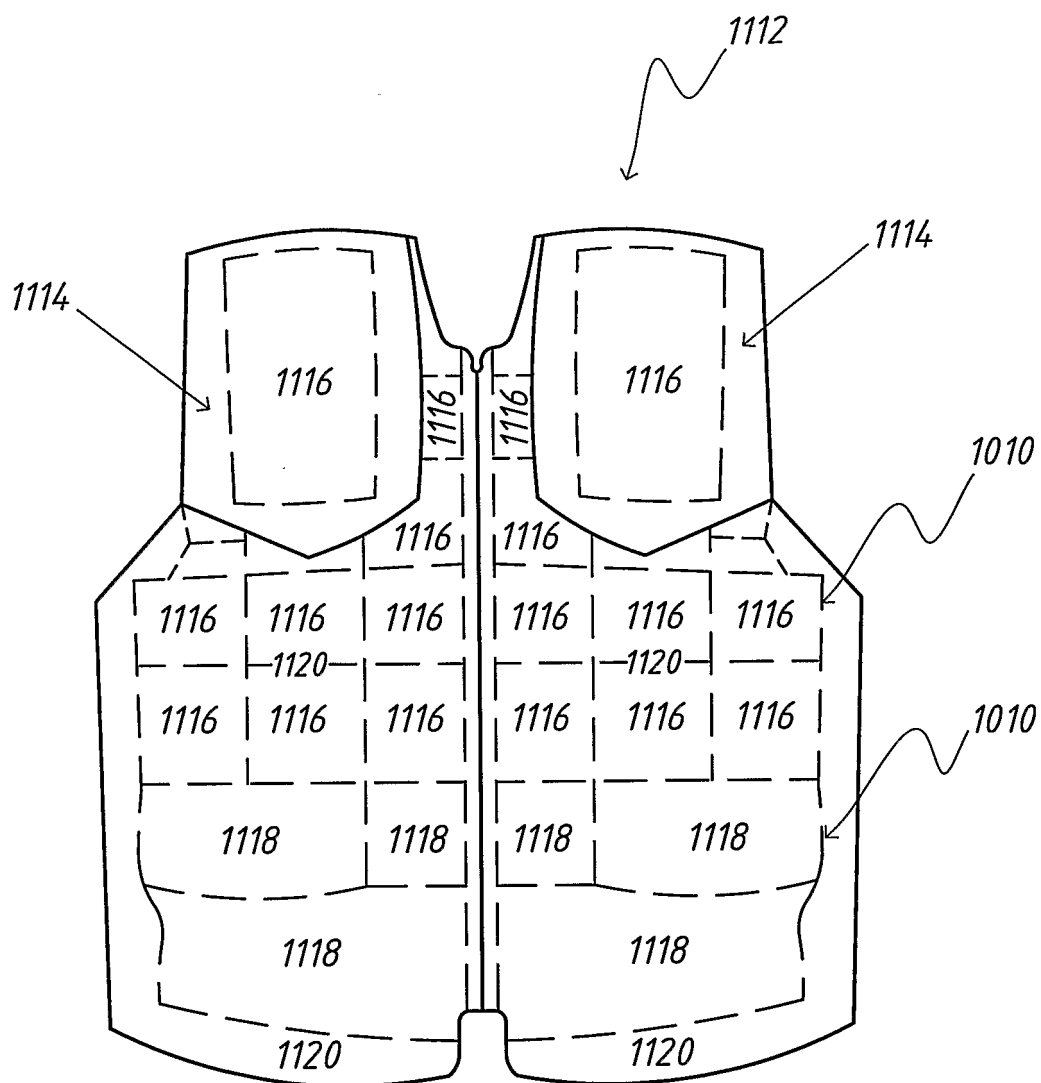


FIG 11/13

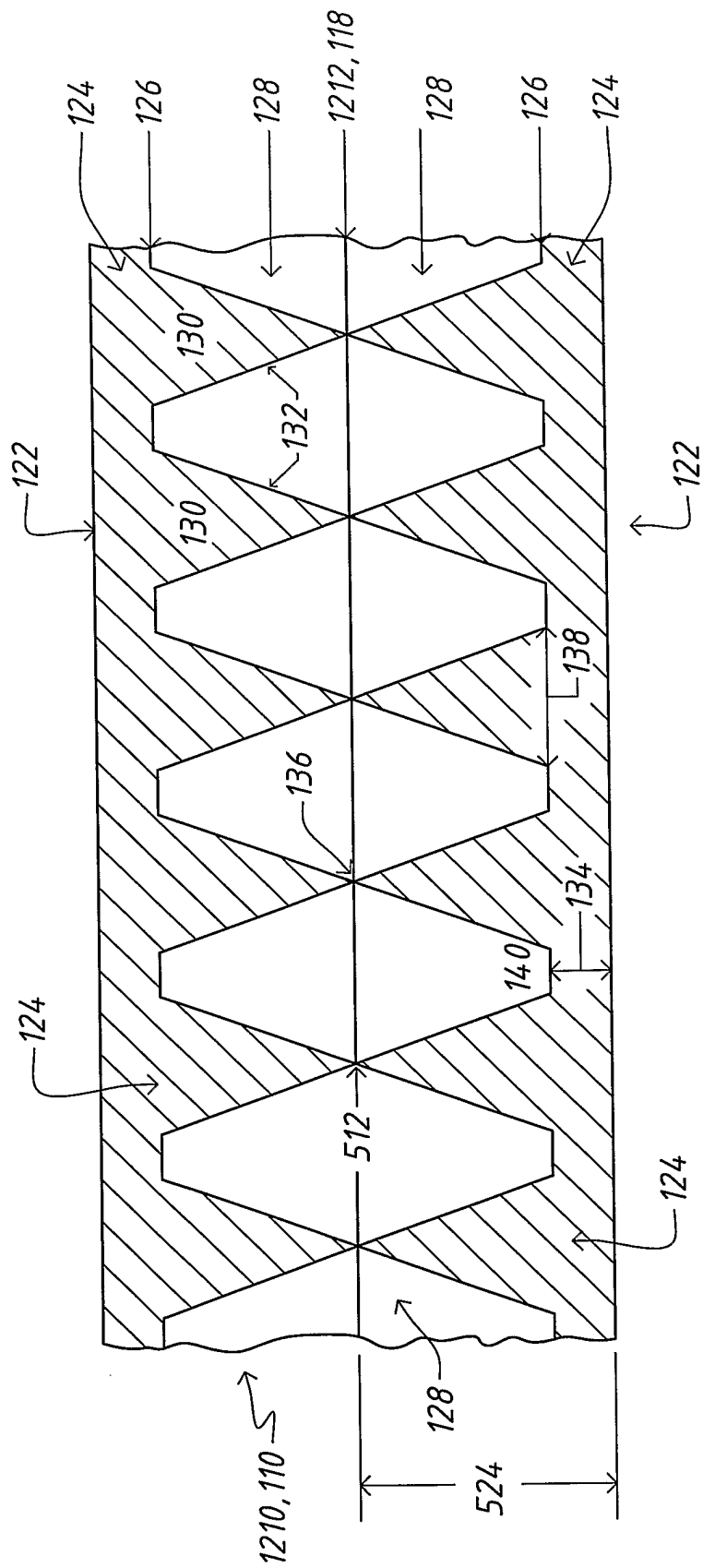


FIG 12/13

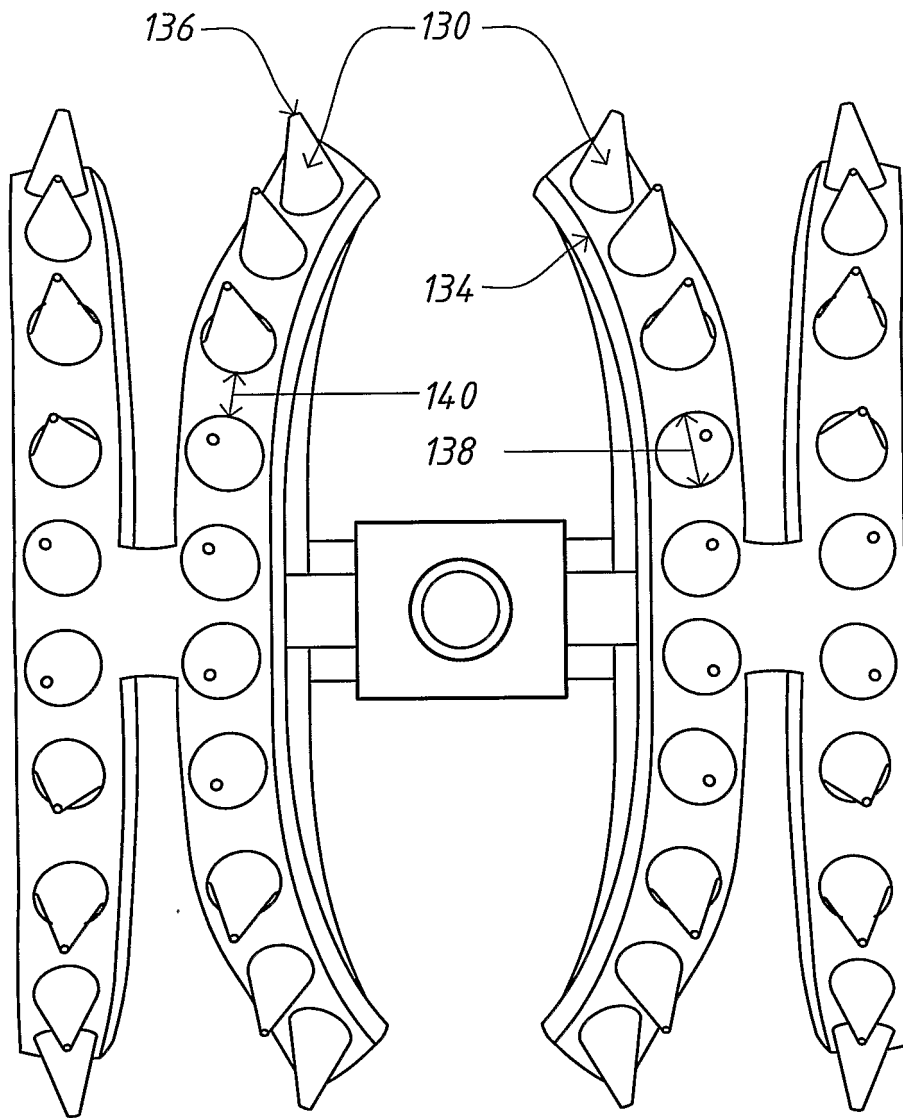


FIG 13/13

REFERENCES CITED IN THE DESCRIPTION

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