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(54) **BODY PROTECTING DEVICE**

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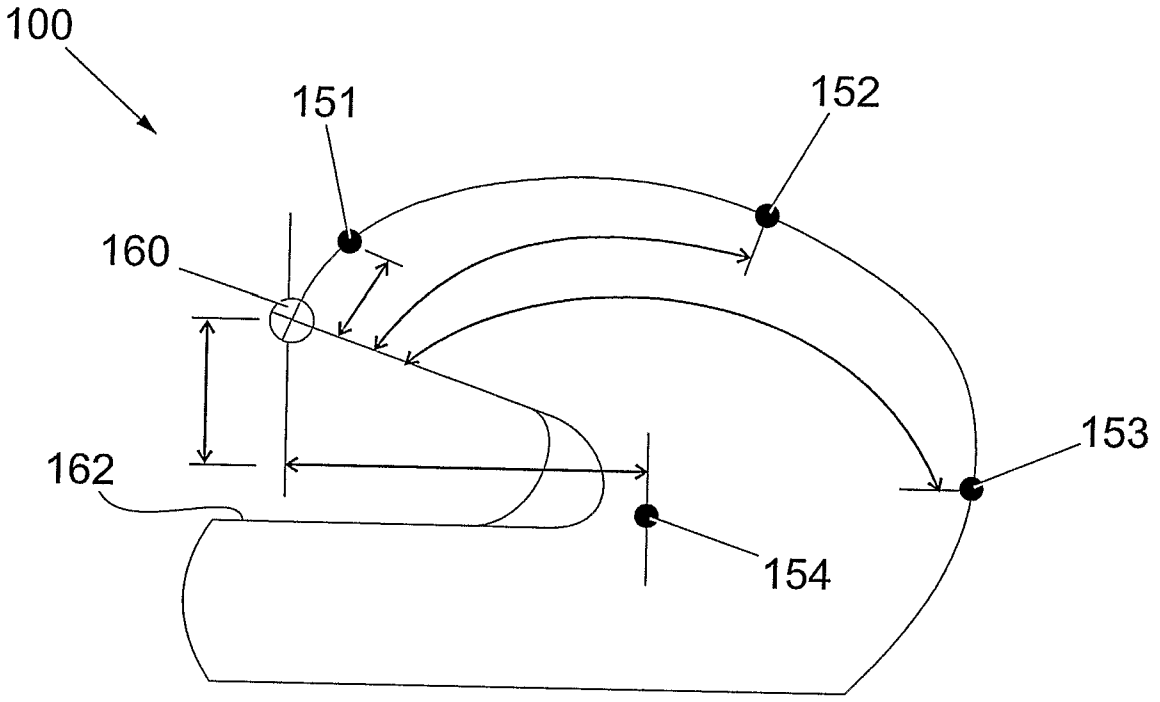
(57) **ABSTRACT**

A body protecting device for wearing by a user comprising: an impact surface; and an array of energy absorbing cells, wherein each of said cells comprises a tube, and wherein the longitudinal axis of the tubes of one or more of said cells is arranged at an oblique angle to the impact surface.



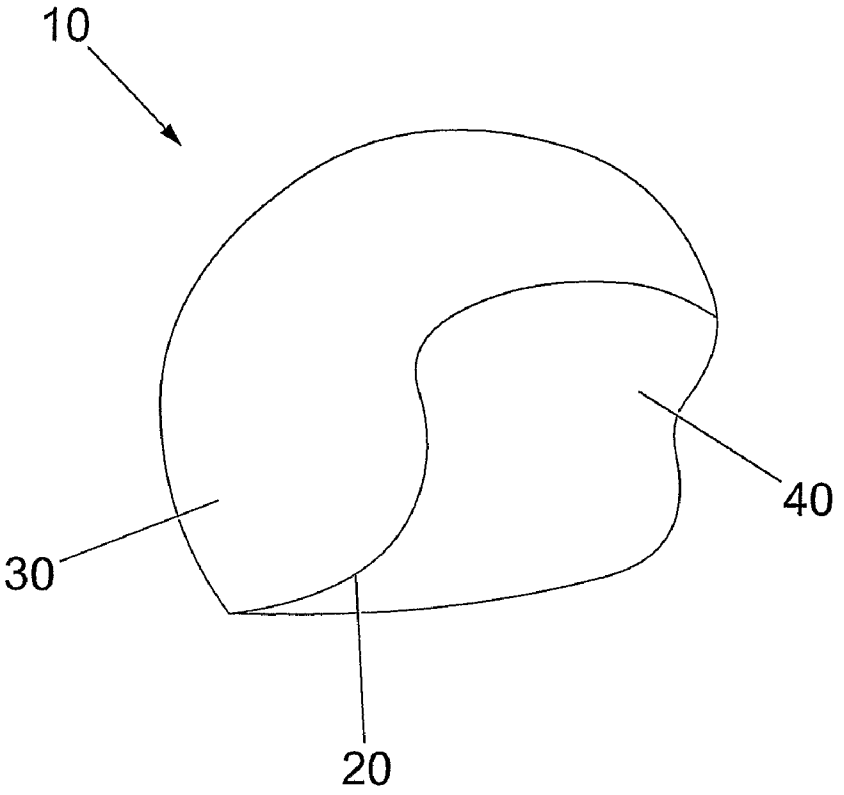


Fig. 1a

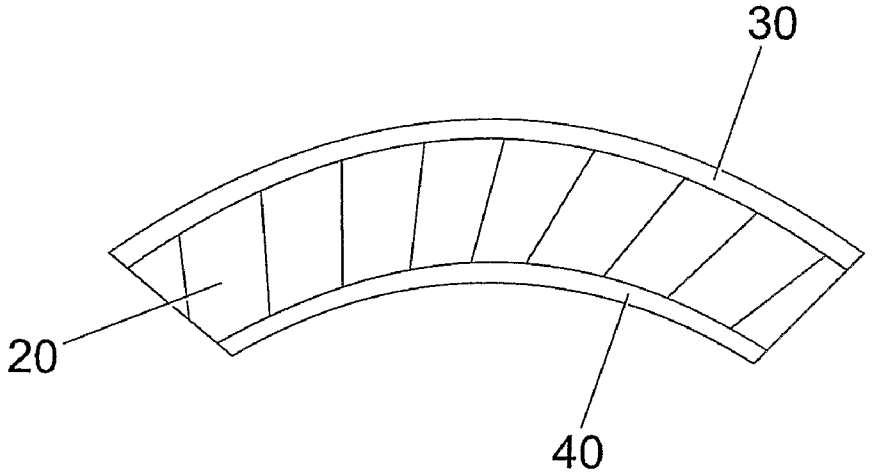


Fig. 1b

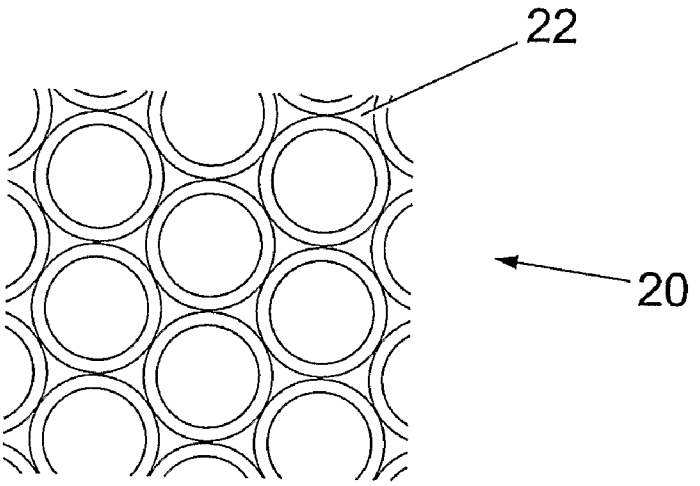


Fig. 2

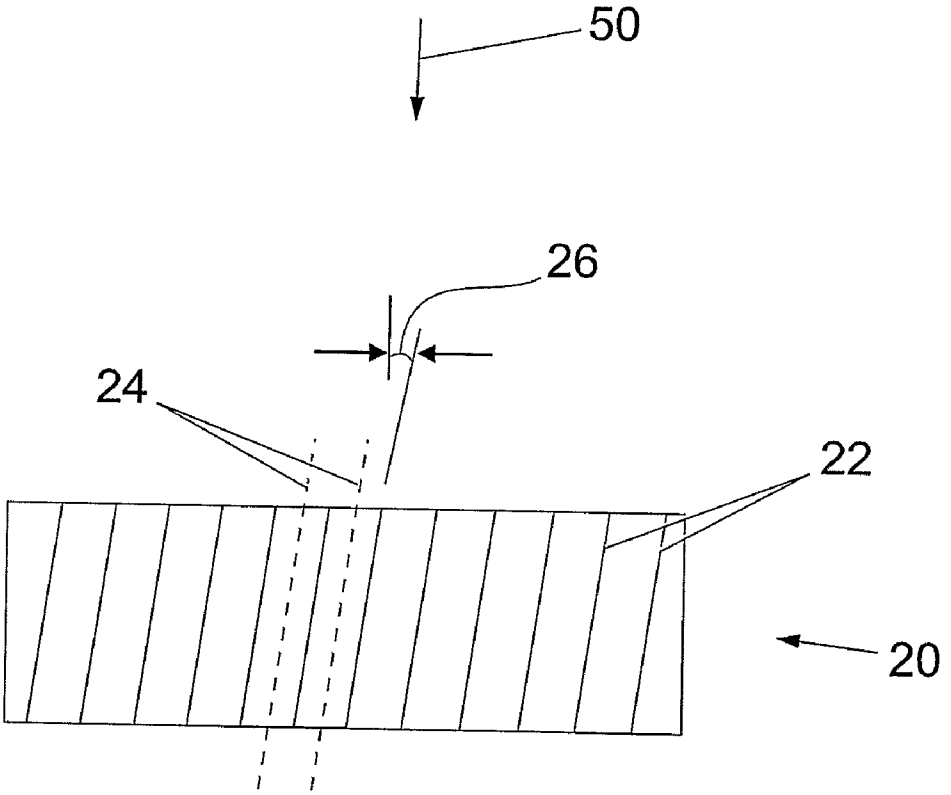


Fig. 3a

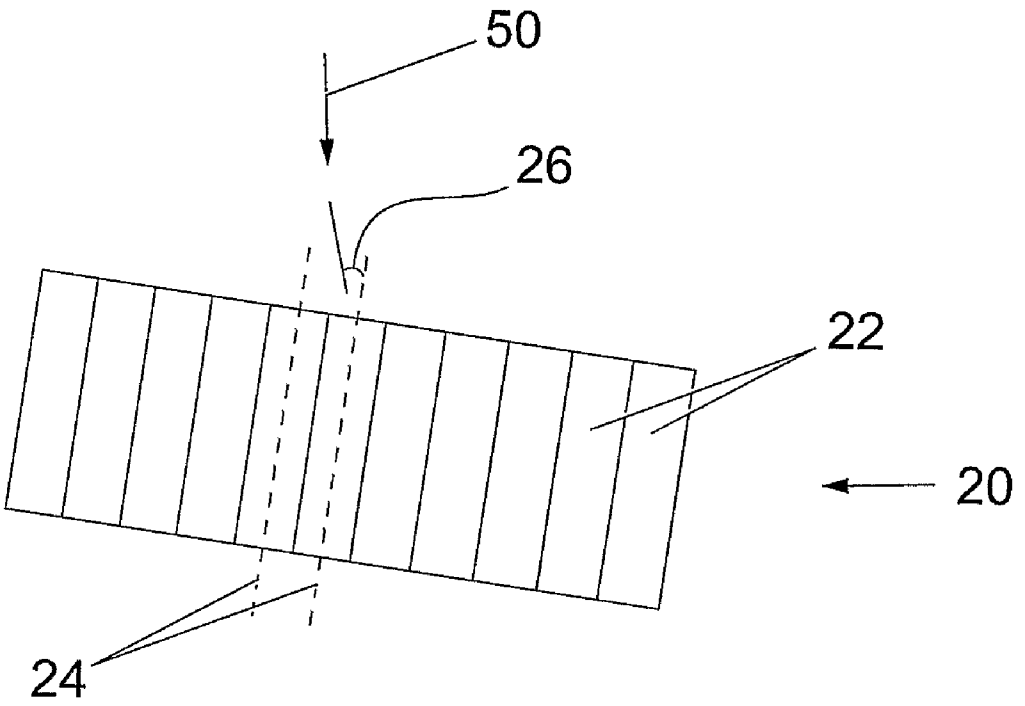


Fig. 3b

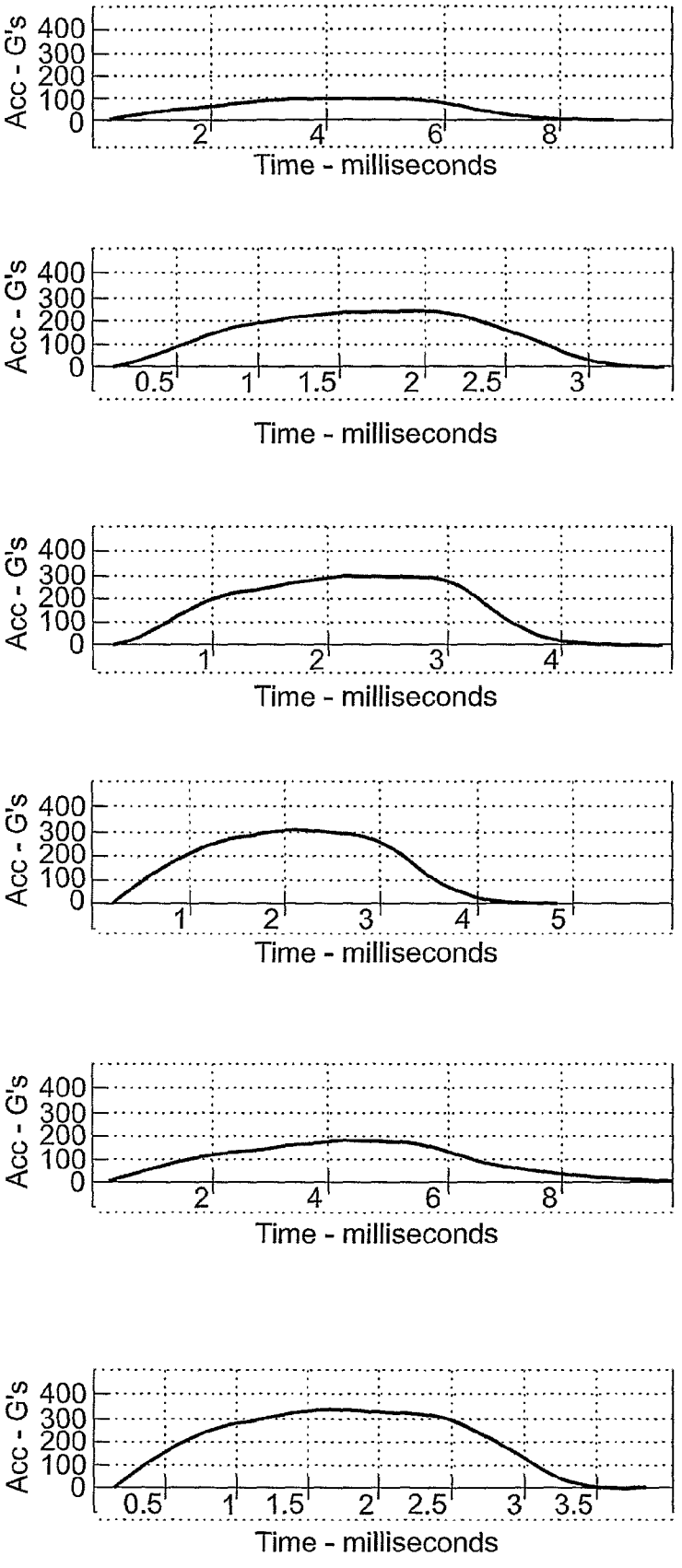

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Fig. 4

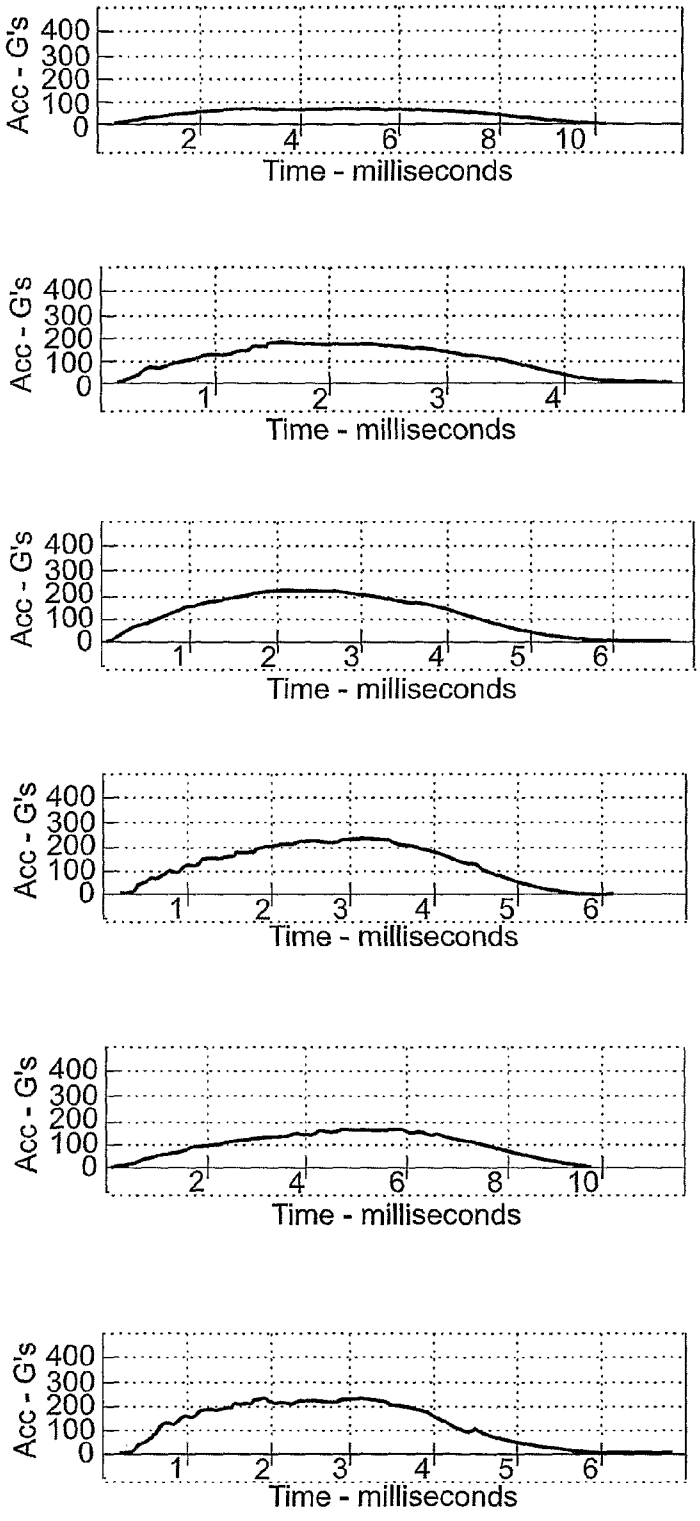
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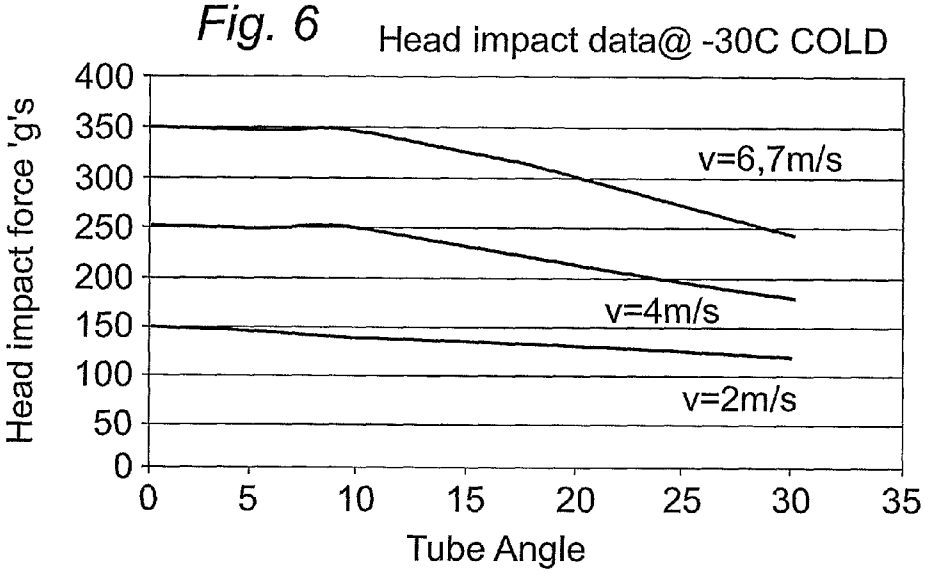
Fig. 5

Fig. 6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5
10
15
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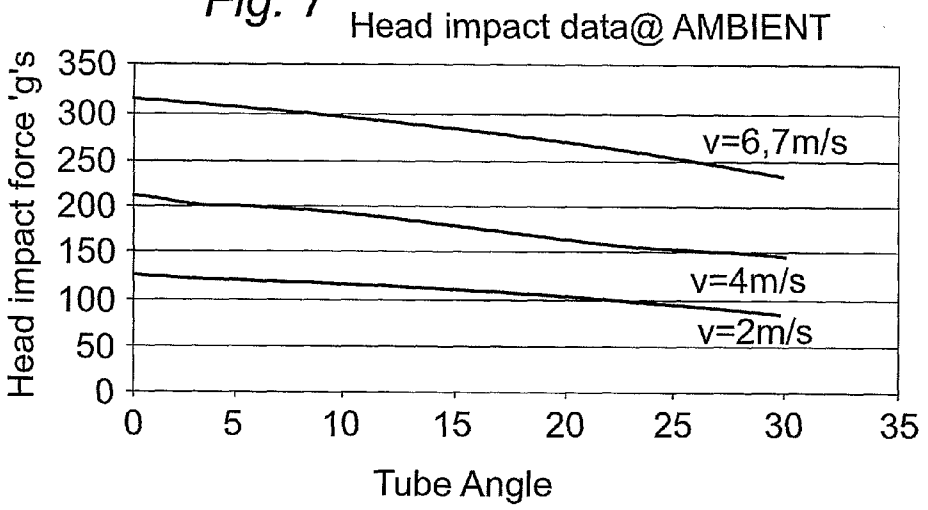
30
35
Tube Angle

Fig. 7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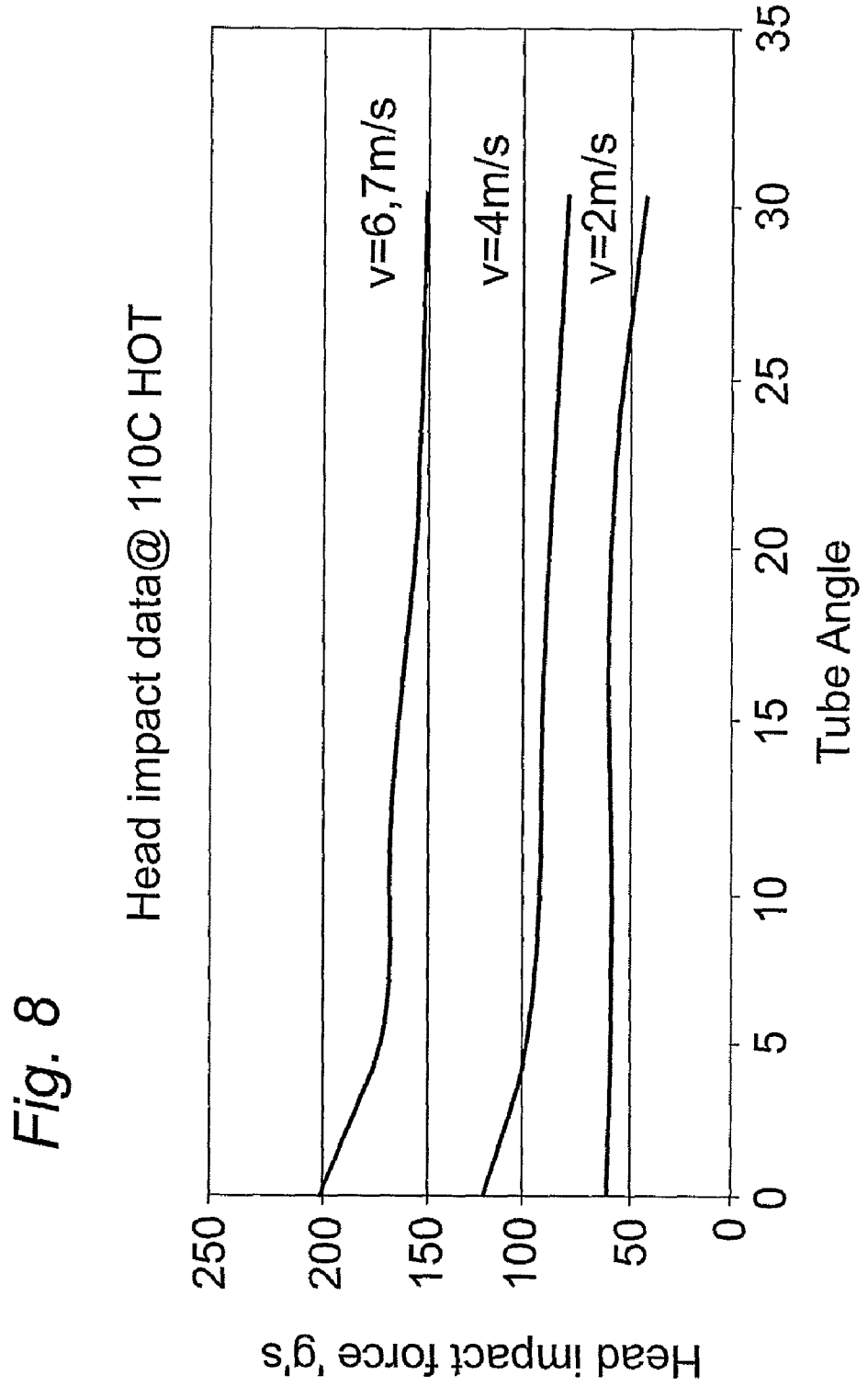
35
Tube Angle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v=2m/s
Head impact force 'g's
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Fig. 8

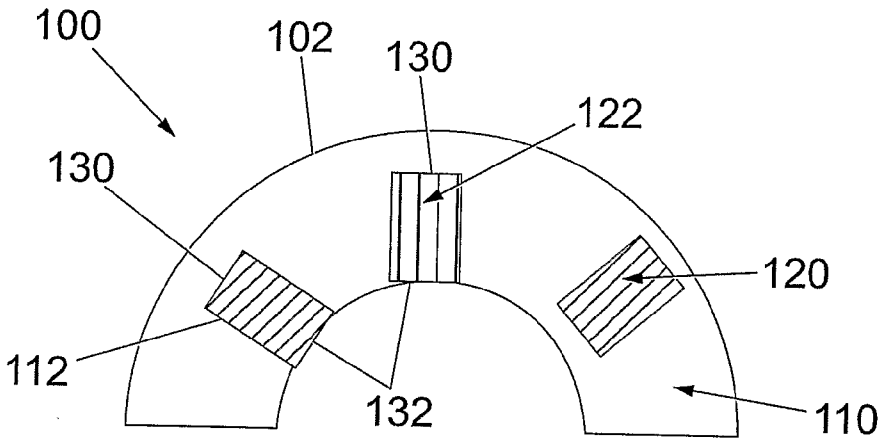
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Fig. 9

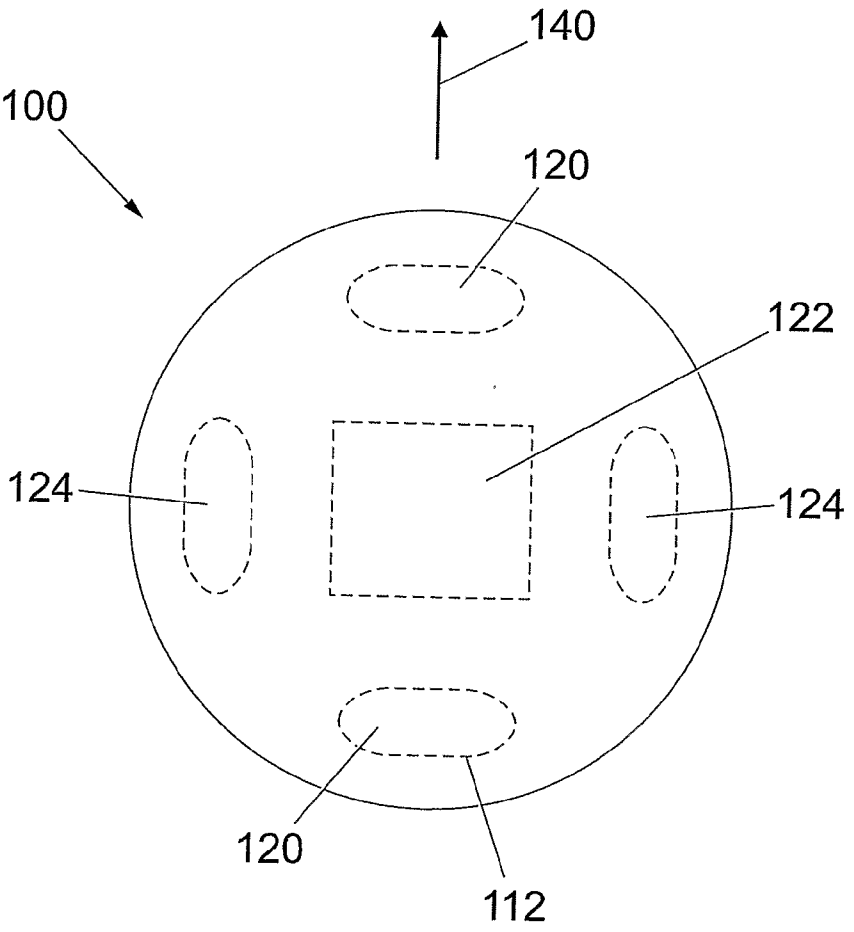
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Fig. 10

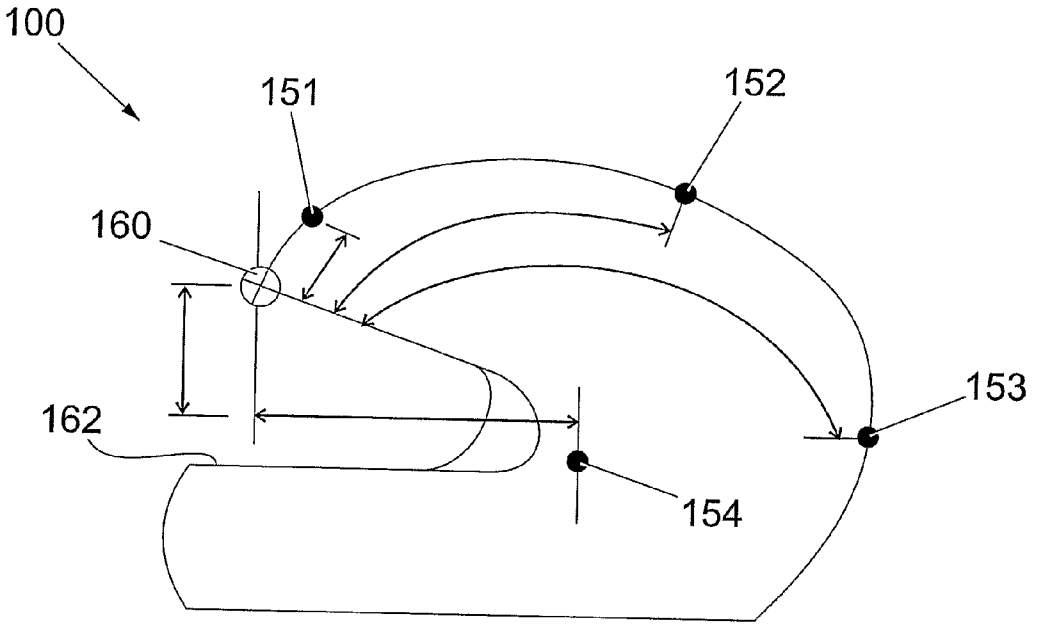

Fig. 11

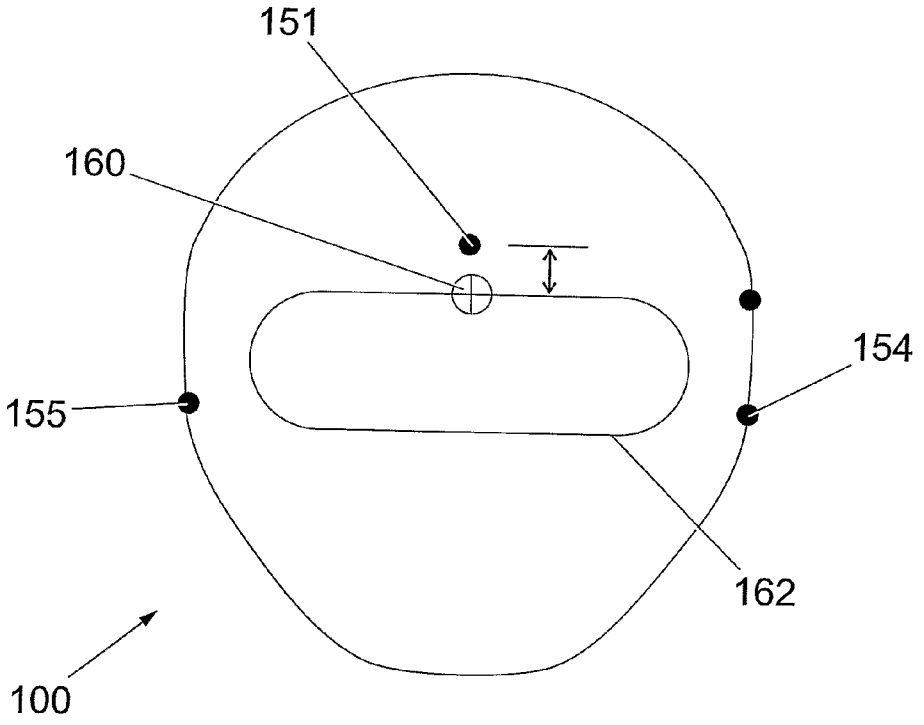

Fig. 12

BODY PROTECTING DEVICE

[0001] The present invention relates to body protecting devices. In particular, but not exclusively, the invention relates to the energy absorbing materials used in devices having a relatively large curvature such as safety helmets, elbow pads, knee pads, shoulder pads and the like.

[0002] Safety helmets conventionally comprise a substantially spheroidal outer skin of tough plastics material and an inner skin of resilient material such as a hard foam. The rigid outer skin acts as an impact surface to transmit an impact load more evenly to the inner skin which absorbs the energy imparted by the impact load.

[0003] The purpose of any body protecting device is firstly to reduce the initial impact load transmitted to the user and secondly to absorb all of the impact energy in a controlled and steady manner. It is often highly desirable that the stiffness or energy absorbing response of the device varies throughout the device. Typically, the liner of a crash helmet can have between two and ten portions of varying density. It is desirable to provide a device, or material for the device, in which the stiffness or energy absorbing response can be easily varied. It is not known to provide a liner which uses different materials or different geometrical arrangements at different locations.

[0004] It is known that body protecting devices, in particular motorcycle safety helmets, are often subject to impacts more frequently at particular areas or locations of the device. Also, some parts of the body of a user are more prone to injury, or the effects of injury are more severe, than others. It is therefore desirable to provide a device which has the highest level of protection at these respective areas. However, a device which provides this high level of protection at all locations is more difficult or costly to produce.

[0005] A body protecting device which includes an array of energy absorbing tubes is disclosed in WO 2005/060778. The tubes are arranged such that in use they are axially loaded. The device outperforms conventional devices using a hard foam material to absorb impact energy.

[0006] Axially loaded columns have been used for some time to improve the structural crashworthiness of vehicles, roadside furniture and the like. The columns of each of these known systems are typically unconnected and function independently.

[0007] It is desirable that metal columns exhibit a multiple local buckling and folding failure mode which is effective in absorbing impact energy. Plastic and composite columns have a number of failure modes which are efficient for absorbing impact energy but all of the modes typically involve progressive crushing of one end of the column.

[0008] The performance and failure mode of plastic and composite columns depends on a complex interaction of a number of different parameters including the material used, the geometry (shape and thickness), fibre alignment in composites, the use of triggers, and the loading conditions. However, a careful selection of these parameters can result in a safety device which outperforms the metal equivalent.

[0009] Regardless of the material used, arrays of independent columns arranged parallel or coaxial to the load have generally been found to provide efficient energy absorbing performance and improve the stability of the safety device. Columns tend to produce a relatively constant level of energy absorption as the column is progressively buckled or crushed.

[0010] It is also known to use one or more cylindrical structural members which are laterally loaded. In other words, the axis of the cylindrical structural member is normal to the loading. Impact energy is absorbed as the circular cross section is progressively crushed flat.

[0011] It is known to use composite materials having directional fibres reinforced within a matrix material. The direction of the fibres relative to the loading can be varied to provide the desired loading response. However, since the matrix material is solid, the composite material is relatively dense. Also, the loading response of a composite material having fibres oriented at an angle is typically dominated by the properties of the matrix material. These properties are often an order of magnitude lower than those of the fibre material. Also, although the material may have fibres arranged at an oblique angle to the load, the structure as a whole is still arranged parallel or normal to the loading.

[0012] According to a first aspect of the present invention there is provided a body protecting device for wearing by a user comprising:

[0013] an impact surface;

[0014] an array of energy absorbing cells, wherein each of said cells comprises a tube, and wherein the longitudinal axis of the tubes of one or more of said cells is arranged at an oblique angle to the impact surface.

[0015] The term "tube" is used to denote a hollow structure having any regular or irregular geometry.

[0016] Preferably the tube has a cylindrical or conical structure, most preferably a circular cylindrical or circular conical structure.

[0017] Preferably the longitudinal axis of the tubes is arranged at an angle of between 5° and 45° to a line normal to the impact surface, most preferably at an angle of between 5° and 30° to a line normal to the impact surface.

[0018] Preferably the oblique arrangement of tubes is adapted to provide deflecting means for causing lateral deflection of the impact of an impacting object at the impacting surface.

[0019] Preferably the impact surface is convex. Alternatively, the impact surface is planar or concave.

[0020] Preferably the body protecting device has an outer layer providing the impact surface. Preferably the body protecting device has an inner surface and the axis of the one or more tubes extend from the impact surface towards the inner surface. Preferably the body protecting device includes an inner layer providing the inner surface. Preferably the body protecting device includes an intermediate layer providing the array of energy absorbing cells.

[0021] Preferably the array is localised at a particular area in the plane of the body protecting device. Preferably a plurality of arrays are provided at discrete locations of the body protecting device. Preferably the intermediate layer comprises a plurality of arrays provided at discrete locations below the impact surface.

[0022] Preferably one or more of the plurality of arrays include tubes which are orientated at a different oblique angle to the tubes of the other of the plurality of arrays. Preferably the device also includes one or more arrays of tubes in which the axis of one or more tubes is arranged at an angle which is normal to the impact surface.

[0023] Preferably each of the plurality of arrays comprises an insert provided at a spacing member. Preferably the spacing member is formed from at least a foam material.

[0024] Preferably the body protecting device comprises a safety helmet. Alternatively, the body protecting device comprises a safety pad or a liner for a garment. The term "body protecting device" is also intended to include a liner for a safety helmet, safety pad or the like.

[0025] Preferably substantially each tube has a side wall which abuts the side wall of at least another tube. Preferably substantially each tube has a side wall which is connected to the side wall of at least another tube.

[0026] Preferably substantially each tube has a side wall which is connected to the side wall of at least another tube by an adhesive. Preferably substantially each tube has a side wall which is connected to the side wall of at least another tube substantially along the length of the tube.

[0027] Alternatively, substantially each tube has a side wall which is welded or fused to the side wall of at least another tube.

[0028] One or more tubes may be formed from an inner core comprising a first material and an outer core comprising a second material. Preferably each of the first and second material is a polymer. Preferably the second material has a lower melting temperature than the first material.

[0029] Preferably substantially each tube is near or adjacent to at least three other tubes. Preferably substantially each tube is near or adjacent to six other tubes.

[0030] Preferably each tube has a diameter of between 2 and 25 mm. Preferably each tube has a diameter of about 8 mm.

[0031] Preferably the thickness of the side wall of each tube is less than 0.5 mm. Preferably the thickness of the side wall of each tube is between 0.1 and 0.3 mm.

[0032] Preferably the length of each tube is between 10 and 50 mm.

[0033] Preferably the array of energy absorbing cells is provided as an integral material. Preferably the density of the material is between 60 and 100 kg/m^3, most preferably around 80 kg/m^3.

[0034] Preferably the integral material comprises polycarbonate, polypropylene, polyethylene, polyetherimide, polyethersulphone, polyphenylsulphone, polyvinyl chloride, polyethylene terephthalate, ethylene vinyl acetate or acrylonitrile butadiene styrene. Preferably the material comprises Tubus Honeycombs™.

[0035] According to a second aspect of the present invention there is provided a body protecting device for wearing by a user comprising:

[0036] an impact surface;

[0037] an array of energy absorbing cells, wherein each cell comprises a tube; and deflecting means adapted to cause lateral deflection of the impact of an impacting object at the impacting surface.

[0038] Preferably the deflecting means is provided by arrangement of the axis of one or more tubes at an oblique angle to the impact surface.

[0039] Preferably the axis of one or more tubes is arranged at an angle of between 5° and 45° to a line normal to the impact surface, most preferably at an angle of between 5° and 30° to a line normal to the impact surface.

[0040] Preferably the array is localised at a particular area in the plane of the device. Preferably a plurality of arrays are provided at different locations of the device. Preferably one or more of the plurality of arrays include tubes which are orientated at a different oblique angle to the tubes of the other of the plurality of arrays. Preferably the liner also includes one or more arrays of tubes in which the axis of one or more tubes is arranged at an angle which is normal to the impact surface.

[0041] It is to be appreciated that the deflecting means may be adapted to cause lateral deflection of the impact of an impacting object in more than one direction depending on the location where the object impacts the device.

[0042] Preferably the body protecting device comprises a safety helmet. Alternatively, the body protecting device comprises a safety pad or a liner for a garment. The term "body protecting device" is also intended to include a liner for a safety helmet, safety pad or the like.

[0043] According to a third aspect of the present invention there is provided a method of absorbing energy imparted by an impact load applied in a first direction comprising:

[0044] providing an array of energy absorbing cells, wherein each of said cells comprises a tube;

[0045] orientating the array such that the longitudinal axis of the tubes of one or more of said cells is at an oblique angle to the first direction.

[0046] According to a fourth aspect of the present invention there is provided a body protecting device for wearing by a user comprising:

[0047] a spacing member formed from a first material and defining one or more receptacles in the plane of the spacing member; and

[0048] one or more inserts formed from a second material, the or each insert located at a receptacle of the spacing member.

[0049] It is to be appreciated that the plane of the spacing member may be flat or arcuate.

[0050] The or each receptacle may be an aperture, recess or cavity.

[0051] Preferably the spacing member defines a plurality of receptacles at selected locations in the plane of the spacing member.

[0052] Preferably the first material comprises a foam. Preferably the first material comprises expanded polystyrene.

[0053] Preferably the or each insert comprises an array of energy absorbing cells, wherein each cell comprises a tube. Preferably the body protecting device has an impact surface and the axis of one or more tubes is arranged at an oblique angle to the impact surface. Alternatively or in addition, the axis of one or more tubes may be arranged at an angle which is normal to the impact surface.

[0054] Preferably the axis of one or more tubes is arranged at an angle of between 5° and 45° to a line normal to the impact surface, most preferably at an angle of between 5° and 30° to a line normal to the impact surface.

[0055] Preferably the oblique arrangement of tubes is adapted to provide deflecting means for causing lateral deflection of an impacting object.

[0056] Preferably the impact surface is convex. Alternatively, the impact surface is planar or concave.

[0057] Preferably the body protecting device has an inner surface and the axis of the one or more tubes extend from the impact surface towards the inner surface.

[0058] Preferably the body protecting device comprises a safety helmet. Alternatively, the body protecting device comprises a safety pad or a liner for a garment. The term "body protecting device" is also intended to include a liner for a safety helmet, safety pad or the like.

[0059] Preferably substantially each tube has a side wall which abuts the side wall of at least another tube. Preferably

substantially each tube has a side wall which is connected to the side wall of at least another tube.

[0060] Preferably substantially each tube has a side wall which is connected to the side wall of at least another tube by an adhesive. Preferably substantially each tube has a side wall which is connected to the side wall of at least another tube substantially along the length of the tube.

[0061] Alternatively, substantially each tube has a side wall which is welded or fused to the side wall of at least another tube.

[0062] Preferably substantially each tube is near or adjacent to at least three other tubes. Preferably substantially each tube is near or adjacent to six other tubes.

[0063] Preferably each tube has a diameter of between 2 and 25 mm. Preferably each tube has a diameter of about 8 mm.

[0064] Preferably the thickness of the side wall of each tube is less than 0.5 mm. Preferably the thickness of the side wall of each tube is between 0.1 and 0.3 mm.

[0065] Preferably the length of each tube is between 10 and 50 mm.

[0066] Preferably the array of energy absorbing cells is provided as an integral material. Preferably the density of the material is between 60 and 100 kg/m^3, most preferably around 80 kg/m^3.

[0067] Preferably the second material comprises polycarbonate, polypropylene, polyethylene, polyetherimide, polyethersulphone, polyphenylsulphone, polyvinyl chloride, polyethylene terephthalate, ethylene vinyl acetate or acrylonitrile butadiene styrene. Preferably the second material comprises Tubus Honeycombs™.

[0068] Preferably the array defines a first and second discontinuous surface. Preferably a sealing material is provided at one or both of the first and second discontinuous surfaces.

[0069] According to a fifth aspect of the present invention there is provided a method of forming a body protecting device for wearing by a user, the method comprising:

[0070] forming a spacing member from a first material, the spacing member defining one or more receptacles in the plane of the spacing member;

[0071] forming one or more inserts from a second material; and

[0072] locating the or each insert at a receptacle of the spacing member.

[0073] It is to be appreciated that the plane of the spacing member may be flat or arcuate.

[0074] Preferably the spacing member defines a plurality of receptacles at selected locations in the plane of the spacing member.

[0075] Preferably the method includes locating the or each insert at the receptacle before or during forming the spacing member.

[0076] Preferably the method includes encapsulating the or each insert within the spacing member.

[0077] Preferably the first material comprises a foam. Preferably the first material comprises expanded polystyrene.

[0078] Preferably the body protecting device comprises a safety helmet. Alternatively, the body protecting device comprises a safety pad or a liner for a garment. The term "body protecting device" is also intended to include a liner for a safety helmet, safety pad or the like.

[0079] Preferably the or each insert comprises an array of energy absorbing cells, wherein each cell comprises a tube.

[0080] Preferably the array of energy absorbing cells is provided as an integral material. Preferably the density of the material is between 60 and 100 kg/m^3, most preferably around 80 kg/m^3.

[0081] Preferably the second material comprises polycarbonate, polypropylene, polyethylene, polyetherimide, polyethersulphone, polyphenylsulphone, polyvinyl chloride, polyethylene terephthalate, ethylene vinyl acetate or acrylonitrile butadiene styrene. Preferably the second material comprises Tubus Honeycombs™.

[0082] Preferably the array defines a first and second discontinuous surface. Preferably the method includes providing a sealing material at one or both of the first and second discontinuous surfaces.

[0083] An embodiment of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

[0084] FIG. **1** (*a*) is a perspective view of a safety helmet in accordance with a first aspect of the present invention;

[0085] FIG. **1** (*b*) is a sectional side view of a portion of the safety helmet of FIG. **1** (*a*);

[0086] FIG. **2** is a plan view of a tubular array of cells used in the safety helmet of FIG. **1** (*a*);

[0087] FIG. **3** is a side view of a tubular array of cells used in the safety helmet of FIG. **1** (*a*);

[0088] FIG. **4** is a selection of graphs of test results for an arrangement of cells at 5° to the loading under various test conditions;

[0089] FIG. **5** is a selection of graphs of test results for an arrangement of cells at 30° to the loading under various test conditions;

[0090] FIG. **6** is graph of a summary of test results for an arrangement of cells at various angles to the loading and at three impact velocities and for a material at a cold temperature;

[0091] FIG. **7** is graph of a summary of test results for an arrangement of cells at various angles to the loading and at three impact velocities and for a material at an ambient temperature;

[0092] FIG. **8** is graph of a summary of test results for an arrangement of cells at various angles to the loading and at three impact velocities and for a material at a hot temperature;

[0093] FIG. **9** is a cross sectional side view of a portion of a safety helmet in accordance with a fourth aspect of the present invention;

[0094] FIG. **10** is a plan view of the portion of the safety helmet of FIG. **9**;

[0095] FIG. **11** is a side view of a safety helmet showing testing locations; and

[0096] FIG. **12** is a front view of the safety helmet of FIG. **11**.

[0097] FIGS. **1** (*a*) and (*b*) shows a first embodiment of a body protecting device in the form of a safety helmet **10**. The helmet **10** comprises a first material or core **20** which is sandwiched between a second material or outer layer **30** and a third material or inner layer **40**. The outer layer **30** provides an impact surface. Each of the outer **30** and inner **50** layer are bonded to the core using an adhesive. In this embodiment, each of the first, second and third materials are continuous throughout the (arcuate) major plane of the helmet **10**.

[0098] The core has a tubular structure which may be a cylindrical arrangement as shown in FIG. **2**. The tubes **22** are arranged in a close packed array such that the gap between adjacent tubes is minimised.

[0099] FIG. **3** (*a*) shows a first arrangement of tubes **22** according to the invention when subject to a load **50**. The load **50** is normal to the plane of the core **20**. Each tube **22** has a longitudinal axis **24** which is at an oblique angle **26** to the direction of the load **50**. The longitudinal axis **24** of each tube **22** is also at a reciprocal oblique angle **26** to the plane of the core.

[0100] FIG. **3** (*b*) shows a second arrangement of tubes **22** according to the invention when subject to a load **50** which is applied in a first direction. In this case, each tube **22** has a longitudinal axis **24** which is normal to the plane of the core **20**. However, the core **20** is arranged such that the plane of the core **20** is at an oblique angle **26** to the first direction. This arrangement represents another method of absorbing the energy imparted by an impact load.

[0101] Although FIGS. **3** (*a*) and (*b*) shows a planar arrangement of tubes **22**, it is to be appreciated that an impact loading to a spherical structure such as a crash helmet or safety pad tends to be in a direction normal to a tangent of the sphere. Therefore, the same oblique arrangement would be present when the tubes are curved to form the core of a crash helmet or safety pad.

[0102] Each tube has a diameter of 8 mm, a thickness of between 0.1 and 0.3 mm, and a length of around 35 mm. This results in a slenderness ratio (the ratio of the length to the diameter) of around 4, and an aspect ratio (the ratio of the diameter to the thickness) of between 25 and 80.

[0103] The use of these geometric values, particularly the low thickness used, results in a stable failure mode of progressive buckling being achieved, even though the tubes are at an angle to the loading. Instability, which could lead to a global buckling failure mode, is avoided since the tubes are connected to, and supported by, adjacent tubes. Being connected to six other tubes which are circumferentially spaced around the tube provides such support in any direction normal to the axis of the tube.

[0104] The tubes may be bonded together using an adhesive. Another suitable method is to form the tubes from an inner core of a first material and an outer core of a second material, the cores being co-extruded. The second material can be selected to have a lower melting temperature than the first material. Typically, a difference of between 15° and 20° Celsius can be used. During forming, the tubes can be heated to a temperature between the melting temperature of the first and second material. This causes the side walls of the tubes to become welded or fused together. This method allows easier forming of shapes and gives better consistency during forming.

[0105] It is to be appreciated that the tubes need not be connected to provide support to each other, or even be abutting, as long as the tubes are in close proximity such that they come into contact following a small amount of deformation.

[0106] It has been found that the present invention can outperform arrangements in which the tubes are parallel or normal to the loading. It is believed that the main reason for this is that the angled arrangement of tubes produces a reaction load which has both a parallel and a normal component relative to the loading. The normal component causes lateral deflection of the impacting object relative to the body protecting device during deformation of the tubes. The overall angled displacement of the head form results in a longer total time period for the impact event. Also, deflection of the impacting object reduces the magnitude of the loading in the parallel direction. Thus, the total impact energy is absorbed at a lower magnitude over a longer time period.

[0107] Another reason for the superior performance of the invention may be the contribution of bending of the tubes without buckling. There is therefore another mode of absorbing energy in addition to the mode of progressive buckling exhibited by both a conventional arrangement and the invention.

[0108] FIGS. **4** and **5** are representative samples of test results for a material according to the invention which is impacted at two different impact velocities: 4 and 6.7 m/s. Also, three different temperatures of the material were used: a relatively cold temperature of −30° C., an ambient temperature of 20° C., and a relatively hot temperature of 110° C. In FIG. **4**, a tube angle of 5° to the loading was used. In FIG. **5**, a tube angle of 30° to the loading was used.

[0109] The test results of FIGS. **4** and **5** measure the acceleration of the impacting object during the impact event. The impact force is directly proportional to the acceleration of the impacting object since the impact force is simply the product of the mass of the impacting object and its acceleration. In each of the tests, the force increases and then decreases in a steady manner. Therefore, the impact energy is absorbed in a controlled and steady manner.

[0110] Various test results are summarised in FIGS. **6** to **8**. It is clear that the impact force that would be transmitted to a wearer of the associated body protecting device tends to decrease as the tube angle is increased. This is particularly the case at ambient or cold temperatures which are more likely to be the environmental conditions during use.

[0111] High speed video playback of an impact event shows the impacting object being deflected laterally as the tubes are deformed.

[0112] In a body protecting device, it is possible to vary the angle of the tubes relative to the impact surface such that the stiffness or energy absorbing response of the material varies throughout the device. Using an integral core material allows moulding of a material which has an array of tubes at any angle up to 45°. This eliminates the need to cut the material at a particular angle which would result in substantial wastage.

[0113] FIG. **9** shows a body protecting device for wearing by a user, again a safety helmet **100**, according to a fourth aspect of the present invention.

[0114] The helmet **100** comprises a spacing member **110** formed from a first material, which is an expanded polystyrene foam. The spacing member **110** defines a number of receptacles or cavities **112** at selected locations in the (arcuate) major plane of the spacing member **110**.

[0115] An insert **120**, **122**, **124** formed from a second material, is encapsulated within each cavity. Alternatively, apertures or recesses can be formed in the spacing member **110**. Methods of providing such formations in foam materials are well known.

[0116] The inserts **120**, **122**, **124** may be positioned during forming of the spacing member **110** or inserted afterwards, such as by forming pockets in the spacing member **110**.

[0117] Each insert **120**, **122**, **124** comprises an array of energy absorbing tubes as described for the first embodiment of the invention. For some of the inserts **122**, **124**, the axis of the tubes are arranged at an oblique angle to an impact surface **102** of the helmet **100**. Also, the specific oblique angle may differ for these inserts **122**, **124**. For the remainder of the inserts **120**, the axis of the tubes are arranged at an angle which is normal to the impact surface **102**.

[0118] FIG. **10** is a plan view of the helmet **100** with the arrow **140** pointing outwards from the front of the helmet **100**.

[0119] At the front and rear of the helmet **100**, which have a smaller radius section, the helmet **100** is more stiff and using an insert **120** with an angle of 90° to the impact surface **102** is beneficial. At the two side portions of the helmet **100**, which have a higher radius section, the helmet **100** is more flexible and using an insert **124** with an angle of 30°, and even up to 45°, to the impact surface **102** is beneficial. The top of the helmet **100** has a section of intermediate radius and using an insert **120** with an angle of 15° to the impact surface **102** is beneficial.

[0120] Helmet stiffness at any particular location can vary depending on the stiffness or thickness of the materials used, as well as the radius of curvature. The tube angle can be varied to meet these requirements and optimise the overall energy absorbing performance of the helmet **100**.

[0121] As previously described, the arrays of the inserts are provided as an integral material. The inserts may be of any geometric shape. Typical dimensions of the inserts are 75 mm^2 for a square insert and a diameter of 90 mm for a circular insert.

[0122] Each array defines a first **130** and second **132** discontinuous surface. A sealing material (not shown) is provided at both of these discontinuous surfaces. This prevents the foam material from entering the open ends of the tubes.

[0123] The inserts **120**, **122** provide a high level of protection from impact loads. The arrays are located at particular predetermined areas where impacts occur more frequently or which are adjacent to parts of the body of a user which are more prone to injury, or the effects of injury are more severe. Moreover, the orientation of the tubes can be arranged to provide the optimum protection for a particular location.

[0124] Helmets tend to be tested at these vulnerable locations to ensure that they meet acceptable levels of safety. Two safety standards are the European standard EC R22-05 and the US standard SNELL 2005, both of which specify similar testing locations. FIGS. **11** and **12** show the testing locations **151-155** for EC R22-05.

[0125] The distance to the testing locations **151-155** is taken from a reference point **160** located at the top and centre of the visor aperture **162**. These distances are given in the standard. Inserts can be provided at each of these locations **151-155**.

[0126] In other areas of the helmet **100**, an acceptable level of protection is still provided by the foam spacing member **110**. Indeed, the level of protection is at least equal to that of conventional helmets which use only a foam core.

[0127] Various modifications and improvements can be made without departing from the scope of the present invention.

1. A body protecting device for wearing by a user comprising:

an impact surface;

an array of energy absorbing cells, wherein each of said cells comprises a tube, and wherein the longitudinal axis of the tubes of one or more of said cells is arranged at an oblique angle to the impact surface.

2. A body protecting device as claimed in claim **1**, wherein the axis of each tube is arranged at an angle of between 5° and 45° to a line normal to the impact surface.

3. A body protecting device as claimed in claim **1**, wherein the axis of each tube is arranged at an angle of between 15° and 30° to a line normal to the impact surface.

4. A body protecting device as claimed in any preceding claim, wherein the oblique arrangement of tubes is adapted to provide deflecting means for causing lateral deflection of the impact of an impacting object at the impacting surface.

5. A body protecting device as claimed in any preceding claim, wherein the impact surface is convex.

6. A body protecting device as claimed in any preceding claim including an inner surface, and wherein the axis of the one or more tubes extends from the impact surface towards the inner surface.

7. A body protecting device as claimed in any preceding claim, wherein the array is localised at a particular area in the plane of the body protecting device.

8. A body protecting device as claimed in any preceding claim, wherein a plurality of arrays are provided at different locations of the body protecting device.

9. A body protecting device as claimed in claim **8**, wherein one or more of the plurality of arrays include tubes which are orientated at a different oblique angle to the tubes of the other of the plurality of arrays.

10. A body protecting device as claimed in claim **8** or **9**, wherein the device also includes one or more arrays of tubes in which the axis of one or more tubes is arranged at an angle which is normal to the impact surface.

11. A body protecting device as claimed in any of claims **8** to **10**, wherein each of the plurality of arrays comprises an insert provided at a spacing member.

12. A body protecting device as claimed in claim **11**, wherein the spacing member is formed from at least a foam material.

13. A body protecting device as claimed in any preceding claim, wherein the body protecting device comprises a safety helmet.

14. A body protecting device as claimed in any preceding claim, wherein substantially each tube has a side wall which abuts the side wall of at least another tube.

15. A body protecting device as claimed in any preceding claim, wherein substantially each tube has a side wall which is connected to the side wall of at least another tube.

16. A body protecting device as claimed in claim **15**, wherein substantially each tube has a side wall which is connected to the side wall of at least another tube by an adhesive.

17. A body protecting device as claimed in claim **15** or **16**, wherein substantially each tube has a side wall which is connected to the side wall of at least another tube substantially along the length of the tube.

18. A body protecting device as claimed in any preceding claim, wherein one or more tubes may be formed from an inner core comprising a first material and an outer core comprising a second material.

19. A body protecting device as claimed in claim **18**, wherein each of the first and second material is a polymer, and wherein the second material has a lower melting temperature than the first material.

20. A body protecting device as claimed in any preceding claim, wherein substantially each tube is near or adjacent to at least three other tubes.

21. A body protecting device as claimed in any preceding claim, wherein substantially each tube is near or adjacent to six other tubes.

22. A body protecting device as claimed in any preceding claim, wherein each tube has a diameter of between 2 and 25 mm.

23. A body protecting device as claimed in any preceding claim, wherein the thickness of the side wall of each tube is less than 0.5 mm.

24. A body protecting device as claimed in any preceding claim, wherein the length of each tube is between 10 and 50 mm.

25. A body protecting device as claimed in any preceding claim, wherein the array of energy absorbing cells is provided as an integral material.

26. A body protecting device as claimed in any preceding claim, wherein the density of the material is between 60 and 100 kg/m^3.

27. A body protecting device as claimed in claim **25**, wherein the integral material comprises one of polycarbonate, polypropylene, polyethylene, polyetherimide, polyethersulphone, polyphenylsulphone, polyvinyl chloride, polyethylene terephthalate, ethylene vinyl acetate or acrylonitrile butadiene styrene.

28. A body protecting device for wearing by a user comprising:

an impact surface;

an array of energy absorbing cells, wherein each cell comprises a tube; and

deflecting means adapted to cause lateral deflection of the impact of an impacting object at the impacting surface.

29. A body protecting device as claimed in claim **28**, wherein the deflecting means is provided by arrangement of the axis of each tube at an oblique angle to the impact surface.

30. A body protecting device as claimed in claim **29**, wherein the axis of each tube is arranged at an angle of between 5° and 45° to a line normal to the impact surface.

31. A body protecting device as claimed in any of claims **28** to **30**, wherein the array is localised at a particular area in the plane of the device.

32. A body protecting device as claimed in any of claims **28** to **30**, wherein a plurality of arrays are provided at different locations of the device.

33. A body protecting device as claimed in claim **32**, wherein one or more of the plurality of arrays include tubes which are orientated at a different oblique angle to the tubes of the other of the plurality of arrays.

34. A method of absorbing energy imparted by an impact load applied in a first direction comprising:

providing an array of energy absorbing cells, wherein each of said cells comprises a tube;

orientating the array such that the longitudinal axis of the tubes of one or more of said cells is at an oblique angle to the first direction.

35. A body protecting device for wearing by a user comprising:

a spacing member formed from at least a first material and defining one or more receptacles in the plane of the spacing member; and

one or more inserts formed from a second material, the or each insert located at a receptacle of the spacing member.

36. A body protecting device as claimed in claim **35**, wherein the or each receptacle is an aperture, recess or cavity.

37. A body protecting device as claimed in claim **35** or **36**, wherein the spacing member defines a plurality of receptacles at selected locations in the plane of the spacing member.

38. A body protecting device as claimed in any of claims **35** to **37**, wherein the first material comprises a foam.

39. A body protecting device as claimed in any of claims **35** to **38**, wherein the or each insert comprises an array of energy absorbing cells, wherein each cell comprises a tube.

40. A body protecting device as claimed in claim **39**, including an impact surface, and wherein the axis of one or more tubes is arranged at an oblique angle to the impact surface.

41. A body protecting device as claimed in claim **40**, wherein the axis of one or more tubes is arranged at an angle of between 5° and 45° to a line normal to the impact surface.

42. A body protecting device as claimed in claim **40** or **41**, wherein the oblique arrangement of tubes is adapted to provide deflecting means for causing lateral deflection of an impacting object.

43. A body protecting device as claimed in any of claims **35** to **42**, including an inner surface, and wherein the axis of the one or more tubes extend from the impact surface towards the inner surface.

44. A body protecting device as claimed in any of claims **35** to **43**, wherein the body protecting device comprises a safety helmet.

45. A body protecting device as claimed in any of claims **39** to **43**, wherein substantially each tube has a side wall which abuts the side wall of at least another tube.

46. A body protecting device as claimed in claim **45**, wherein substantially each tube has a side wall which is connected to the side wall of at least another tube.

47. A body protecting device as claimed in claim **46**, wherein substantially each tube has a side wall which is connected to the side wall of at least another tube substantially along the length of the tube.

48. A body protecting device as claimed in any of claims **39** to **43** or any of claims **45** to **47**, wherein the array of energy absorbing cells is provided as an integral material.

49. A body protecting device as claimed in any of claims **39** to **43** or any of claims **45** to **48**, wherein the array defines a first and second discontinuous surface, and wherein a sealing material is provided at one or both of the first and second discontinuous surfaces.

50. A method of forming a body protecting device for wearing by a user, the method comprising:

forming a spacing member from a first material, the spacing member defining one or more receptacles in the plane of the spacing member;

forming one or more inserts from a second material; and

locating the or each insert at a receptacle of the spacing member.

51. A method as claimed in claim **50**, wherein the spacing member defines a plurality of receptacles at selected locations in the plane of the spacing member.

52. A method as claimed in claim **50** or **51**, including locating the or each insert at the receptacle before or during forming the spacing member.

53. A method as claimed in any of claims **50** to **52**, including encapsulating the or each insert within the spacing member.

54. A method as claimed in any of claims **50** to **53**, wherein the first material comprises a foam.

55. A method as claimed in any of claims **50** to **54**, wherein the or each insert comprises an array of energy absorbing cells, and wherein each cell comprises a tube.

56. A method as claimed in claim **55**, wherein the array defines a first and second discontinuous surface, and the method includes providing a sealing material at one or both of the first and second discontinuous surfaces.

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