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(57) A ballistic and/or blast protection material comprises at least first and second ballistic composite panels (12a,12b,12a',12b') and disposed between each pair of adjacent ballistic composite panels a respective core of a blast damping material (14,14'). The ballistic composite panels preferably each consist of filaments of glass fiber, aramide, polyethylene or another high strength fiber said filaments either being disposed generally parallel to one

another in layers in a matrix of a thermoplastic or a thermosetting plastic with the filaments of one layer crossing with the filaments in an adjacent layer, or with the filaments forming a woven fabric and a plurality of layers of said fabric being combined in a matrix of thermoplastic or thermosetting plastic.

Said ballistic panels (12a,12a',12b,12b') can be bolted together by bolts (20,22).

Description

[0001] The present invention relates to a ballistic and/or blast protection material and to a structure protected by such a material.

[0002] There are many situations in the modern world which require special personnel such as embassy staff, military personnel or security staff or specially endangered persons as well as equipment used by any such persons to be protected against ballistic and blast damage.

[0003] Ballistic protection means not just protection against bullets but protection against all high velocity fragments such as fragments of mines, hand grenades, nails or other materials from bombs of diverse kinds and shrapnel generally, as well as dust, gravel or other particles or fragments of wood or glass accelerated by explosions or blasts. Blast protection is understood herein to mean protection against the results of blasts, explosions or detonations through a blast and shock resistant design which involves:

- dynamic absorption of the shock wave propagation and shock wave effects,
- protection and isolation of structure contents from shock effects,
- protection of contents from the effects of fragments (shatterproof design), debris and dust.

[0004] The object of the present invention is to provide a ballistic and/or blast protection material which can be used for a variety of different applications, which is relatively simple to install and can be reused in different applications if required, with the material providing excellent protection against ballistic elements and shock waves and achieving high levels of shock wave damping.

[0005] In order to satisfy this object there is provided a ballistic and/or blast protection material comprising at least first and second ballistic composite panels and disposed between each pair of adjacent ballistic composite panels a respective core of a blast damping material. In other words the present invention provides a sandwich construction which initial tests show should prove particularly successful in protecting personnel and equipment against the effects of bombs and explosions as well as against bullets, projectiles and fragments (shrapnel) resulting from explosions.

[0006] The invention is not restricted to just first and second ballistic panels with a core of blast damping material disposed between them. There could be further ballistic panels, for example third fourth or fifth (or more) ballistic panels with a core of blast damping material being provided between each pair of adjacent panels, for example with three ballistic panels with a first core provided between the first and second ballistic panels and with a second core provided between the second and third ballistic panels.

[0007] The ballistic composite panels each consist of filaments of glass fiber, preferably E-glass, aramide, polyethylene, preferably PE-UHMW polyethylene or other high strength fibers. The filaments are preferably either disposed generally parallel to one another in layers in a matrix of a thermoplastic or a thermosetting plastic, such as polypropylene, epoxy resin, phenolic resin. PUR or polyethylene. The filaments of one layer cross the filaments in an adjacent layer, or form a woven fabric, with a plurality of layers of said fabric being combined in a matrix of thermoplastic or thermosetting plastic to form a panel.

[0008] In a preferred embodiment the ballistic panels can comprise 33 layers of glass fiber woven fabric (simple cross weave) with a fabric weight preferably in the range from 200g/m² to 800g/m², with a filament diameter preferably in the range from 6 to 20 μm, the filaments having a linear density 1200 tex in both directions of the weave. The matrix preferably consists of polypropylene in the form of two layers of Tresphaphan GND (registered trade mark) each of 50 μm thickness between each two layers of E-glass fabric. Other examples of thermoplastics or thermosetting plastics which can be used are, without restriction, epoxy resins, phenolic resins, PUR and polyethylene. The layers of fabric can be arranged at different crossing angles such as a 45 degree angle from one layer to the next, i.e. layers at 0, 45, 90, 135, 180, 225, 270, 315, 360 degrees etc. The crossing angles could also be multiaxial. Examples of suitable filaments and sources of filaments are, without restriction, glass fiber from Saint Gobain or Owens Corning, aramide from Teijin Twaron, Kevlar, Dynema and Spectra. The filaments are preferably present in the matrix in an amount of between 60 and 95% by weight. The laid up materials, i.e. the layers of filaments or fabrics interleaved with layers of matrix material are typically bonded together with heating in a powerful press which causes the matrix material to flow around the filaments and impregnate the spaces between them.

[0009] It should be stressed that the examples given above are only a small selection of possible designs of ballistic panels of which there are many variants.

[0010] Ballistic panels of this kind are known per se, and are for example available from Scanfiber Composites A/S in Denmark.

[0011] The or each said core of a blast damping material preferably comprises a resilient fiber or granulate material bound with a synthetic binder. Fibrous materials are generally to be preferred because they result in better damping properties due to their higher shear strength.

[0012] The resilient fiber or granulate material preferably comprises rubber, in particular a recycled rubber for example

from motor vehicle tyres, and said synthetic binder preferably comprises a polyurethane resin.

[0013] One particular material that has been found useful as a ballistic and/or blast damping material is the material sold under the trade mark Regupol (Regupol is a registered trade mark of BSW GmbH Berleburger Schaumstoffwerk 57301 Bad Berleburg, Germany and Regupol material is available from that source). Regupol material is sold in different qualities one of which is typically used in shooting ranges to protect the users against rebounds and ricochets. That material, which is suitable as the blast damping core of the material of the present invention, is able to capture bullets and retain them so that even if they hit an underlying concrete plate the rebounding or ricocheting bullet or fragments thereof or indeed fragments of concrete knocked out of the concrete plate do not reemerge from the Regupol material and endanger users of the shooting range.

[0014] The suitable Regupol material is preferably in the form of rubber plates or mats made out of "PUR"-bound high quality rubber fibers with a three layer PUR-coating. The rubber is understood to consist of recycled cut up or shredded car tires, which is a relatively inexpensive source of such material. The rubber can consist of rubbers of different hardnesses.

[0015] Suitable blast damping materials must have or result in a damping effect factor of at least 5 preferably of at least 10 when placed between two ballistic composite panels each of 12mm thickness, preferably panels of E-glass in a plastic matrix as described herein. This damping effect factor can be measured in the following way:

[0016] A test is carried out using two artificial legs with military boots on them. The artificial legs carry sensors such as piezo crystals and are weighted down with 80kg of sand in bags to simulate a standing soldier with full equipment. The boots are typically placed on a thin stiffened steel plate of 1mm thickness and the plate is weighted down with say two tons of ballast.

[0017] An explosion is then detonated beneath the steel plate of a level corresponding to a small land mine with say 200 to 300gm of high explosive but without metal fragments. The sensors or data collectors connected to the legs (piezo crystals) are used to measure the acceleration experienced by the foot. This is typically a curve with pronounced positive and negative peaks which decay in size over a period of say 100ms. The amplitude of the first positive peak is noted. It can for example be around 7,700g where $1\text{ g} = 9.81\text{ m/s}^2$. This level of acceleration would normally completely destroy a person's leg, probably killing him at the same time. The test is then repeated with the blast damping material comprising the sandwich of the first and second ballistic panels and the core placed between the boot and the floor. This second test, carried out under the same conditions might, for example, result in a peak acceleration of say 770g. The quotient formed between the peak acceleration for the test without blast damping material and the test with blast damping material yields the damping effect factor, in our example: the blast damping factor is thus $7,700 / 770 = 10$.

[0018] It should be noted that this is a comparative value and this means that the conditions for the test are not terribly critical. Thus the thickness of the steel plate, the size of the explosive charge, the ballast load on the steel plate are largely irrelevant, so long as they have some bearing on reality. Also the sand load and the type of boot and artificial leg are not really critical.

[0019] In the test without blast damping material there is, as stated typically a negative peak following the positive peak and generally of about the same amplitude. In the test with blast damping material the negative peak is almost completely missing and the duration of the positive peak is frequently about the same as the total duration of the positive and negative peaks without blast damping material.

[0020] An alternative test which has proved useful and which yields comparable results is carried out using a steel frame attached to a steel plate, (e.g. Armox 500T-8mm) carrying sensors such as piezo crystals. The steel plate used in this experiment is a square plate with a side length of 1200mm. It is mounted on a sturdy frame of angle iron which is vertically arranged and has two horizontal legs of 1800mm length extending rearwards from the frame. The horizontal legs are bolted to a concrete floor. Two triangulation members extend from the free end of each horizontal leg to the vertical sides of the frame one to the top of the frame and one to the middle thereof. The ballistic and blast damping material covers the full area of the steel plate.

[0021] An explosion is then detonated in front of the steel plate of a level corresponding to, for example, an "improvised explosive device" (IED) with say 2000 to 3000gm of high explosive but without metal fragments. The explosive is positioned at a level corresponding to the middle of the plate at a distance from the plate of 3000mm. The sensors or data collectors connected to the steel plate (piezo crystals) are used to measure the acceleration experienced by the steel plate. This is typically a curve with pronounced positive and negative peaks which decay in size over a period of say 10ms. The amplitude of the first positive peak is noted. It can for example be around 8,700g where $1\text{ g} = 9.81\text{ m/s}^2$. The test is then repeated with the blast damping material comprising the sandwich of the first and second ballistic panels and the core placed between the steel plate and the floor. This second test, carried out under the same conditions might, for example, result in a peak acceleration of say 800g. The quotient formed between the peak acceleration for the test without blast damping material and the test with blast damping material yields the damping effect factor, in our example: the blast damping factor is thus $8,700 / 800 = 10.875$.

[0022] It should be noted that this is a comparative value and this means that the conditions for the test are not terribly

critical. Thus parameters such as the thickness of the steel plate, the size of the explosive charge and its distance from the steel plate are largely irrelevant, so long as they have some bearing on reality.

[0023] Thus the core can comprises material in mat form but also material in tile form, especially in interlocking tile form which can be assembled rather like a jigsaw puzzle, or in building block form. A form resembling the pieces of a jigsaw puzzle like form would result in the advantage that the panels could be clipped together facilitating rapid assembly thereof.

[0024] The core can be adhesively bonded to at least one of said adjacent ballistic panels if desired.

[0025] Although the ballistic and/or blast damping material is preferably preassembled, so that the first and second ballistic panels are joined together in tile-like sandwich form, they could first be assembled to the finished material of the invention on installation in a building or the like. In this case the use of a core material in brick form could be very useful because the bricks could be stacked up behind the first panels before adding the second panels behind the bricks of core material. This can also be of advantage if the individual elements of the material are rather large, because they are then also relatively heavy and assembly on site may be advantageous for this reason.

[0026] The ballistic and/or blast damping material preferably has the form of regular elements, such as (without restriction) rectangular or square tiles, which can be placed together in a regular array, such as a square or rectangular array, to form a wall, floor, roof or ceiling covering.

[0027] The elements can also be round or oval or partly round or oval or have some other shape. This could be useful if the material is to be placed in a specially shaped environment, for example in a window with a rounded top. Such shapes can be achieved efficiently in the materials under discussion by water jet cutting or using another cutting technique.

[0028] The design can be such that, at one side of a said tile, said first panel projects beyond the associated core and the first panel and the associated core both project beyond the second panel whereby, at an opposite side of said tile, said second panel projects beyond the associated core and the second panel and the associated core project beyond the first panel. This arrangement provides a ballistic overlap at said side and at said opposite side, since the danger of a bullet or fragment striking a joint between two first panels and subsequently a joint between two second panels is considerably reduced with such an overlapped arrangement.

[0029] The overlapped arrangement also makes the assembly of the individual tiles into a wall covering easier and facilitates the attachment of a plurality of tiles to a wall or other structural element, since a type of interlock can be provided between the panels. Only some of the tiles then need to be fixed in position for example bolted through the wall or structure or adhesively bonded thereto, to secure the ballistic and /or blast damping covering to the structure.

[0030] It is particularly preferred when the overlapping arrangement is repeated for a rectangular or square tile at a second side of the tile adjacent to the first and forming a right angle therewith.

[0031] To further improve ballistic protection at joints between individual elements of the ballistic and/or blast protection material these joints can be covered at at least one side of the material with a strip of ballistic panel material.

[0032] The sandwich panels of the ballistic and/or blast damping material can be assembled in a variety of ways, for example with a simple mitre joint with a strip of ballistic material covering the mitre joint. Alternatively, they can be assembled in such a way that, in a corner joint between any two elements where the first element mates with a second element at respective sides of the two elements, the first ballistic panel, the associated core and the second ballistic panel are aligned perpendicular to a face of the respective element at a respective side of one of the two said elements, or at an angle to it different from ninety degrees if the corner is not a right angle, thus forming a planar edge face and, at the respective mating side of the second element the first ballistic panel projects beyond the respectively associated core and the second ballistic panel to overlap and cover said planar edge face.

[0033] The respective elements or tiles of the ballistic and/or blast damping material are conveniently secured together by discrete brackets and/or corner reinforcements, e.g. brackets or reinforcements of metal.

[0034] The ballistic and/or blast damping material in accordance with the present invention is preferably such that each said ballistic panel has a thickness selected in the range from 3mm to 20mm, preferably about 12mm, and the or each core has a thickness selected in the range from 10mm to 100mm and preferably of about 30mm. With ballistic panels of E-glass bonded together with a thermoplastic resin to a total thickness of 12mm for each panel (as described above) and a Regupol mat of 30mm thickness one obtains a specific weight of 68kg/m². This means that for a plate size of 1.20 x 2.40 metres a total weight of about 200kg results.

[0035] In the ballistic and/or blast damping material in accordance with the present invention each said ballistic panel is preferably designed to meet the requirements of a standard such as FB4 according to EN 1522 and the or each core is adapted to produce, in combination with said first and second ballistic panels a damping effect factor of at least 5 and preferably of at least 10 as determined by the test set out above.

[0036] It should also be noted that it is generally necessary to coat the materials that are used, at least the first and second ballistic panels if not the entire assembly. This could be done in a variety of ways, for example by using a dip coating of polyurethane or by sealing of the panels or the assembly into a rubber or synthetic bag. The result of the invention is a flexible and mobile system in which tiles can be joined together at different angles and in which ballistic overlap can be achieved. The resulting product is a highly effective blast damping material with good ballistic properties.

[0037] The present invention will now be described in more detail with reference to embodiments and to the accompanying drawings in which:

- 5 Fig. 1 shows two connected ballistic and/or blast damping elements in accordance with the present invention and arranged in the same plane and forming a segment of a protected wall, floor or ceiling,
- Fig. 2 shows a plurality of elements similar to those of Fig. 1 but forming three sides of a protected space, for example within the walls of a building (not shown),
- 10 Fig. 3 shows a construction similar to that of Fig. 2 but seen from the outer side,
- Fig. 4 shows a corner joint between two of the elements of Fig. 3 but seen from the inside,
- 15 Fig. 5 shows an alternative form of right angled corner joint in accordance with the present invention in a perspective view from the inside of the corner,
- Fig. 6 shows the corner joint of Fig. 5 in a perspective view from the outside,
- 20 Fig. 7 shows a tile in accordance with the present invention illustrating the concept of ballistic overlap,
- Fig. 8 shows two full tiles and a part tile in an overlapped assembly resulting from the design illustrated in Fig. 7,
- 25 Fig. 9A shows the result of a ballistic test carried out using the vertically disposed steel plate as described above but without the blast damping material of the present invention,
- Fig. 9B shows a filtered curve derived from the sensor readings of Fig. 9A,
- 30 Figs 10A and 10B show results corresponding to Figs. 9A and 9B of the same test but carried out with the ballistic and or blast damping material of the present invention placed in front of the steel plate and
- Figs. 11A and 11B show the result of superimposing (adding) the curves of Figs. 9A and 10A and 9B and 10B respectively, which is useful for comparison purposes.

35 **[0038]** In the following description the same reference numerals will be used in each figure for the same parts or for parts which have the same function and are supplemented by one or more apostrophies or by a letter a or b when it is sensible to distinguish between individual elements. It will be understood that the description given for a part having a particular reference numeral applies equally to all other parts for which the same reference numeral is used, irrespective of whether apostrophies or letters are used or not, unless something is stated to the contrary.

40 **[0039]** Turning now to Fig. 1 there can be seen two tile like elements 10, 10' of a ballistic and/or blast protection material with each element comprising at least first and second ballistic composite panels 12a, 12b and 12a' and 12b'. Disposed between each pair of adjacent ballistic composite panels 12a, 12b and 12a', 12b' there is a respective core 14, 14' of a blast damping material, preferably Regupol material of 30mm thickness as described above.

45 **[0040]** It can be seen that the joint 16 between the two adjacent first ballistic panels 12a, 12a' is offset relative to the joint 18 between the two second ballistic panels 12b, 12b' and that the two panels are bolted together by bolts 20, 22 (with corresponding nuts not shown) passing through the region 24 of mutual overlap. This concept is explained later in more detail with reference to Figs 7 and 8.

[0041] In the specific embodiment shown the first ballistic panels 12a and 12a' and the second ballistic panels 12b, 12b' consist of woven fabric glass filaments bonded together with polypropylene.

50 **[0042]** The core 14, 14' is preferably adhesively bonded between the respective first and second panels 12a, 12b and 12a', 12b'.

[0043] Fig. 2 shows how any desired number of elements 10, 10', 10'', 10''' and 10'''' of ballistic and/or blast damping material, six in this example, can be bolted together to form a ballistic and blast proof enclosure. The ballistic overlap between the elements 10 and 10', 10'' and 10''' and 10''' and 10'''' is achieved in the same way as described with reference to Fig. 1 whereas it is achieved at the corners 26 and 28 between the elements 10' and 10'' and between the elements 10''' and 10'''' by covering the corners at the outside with an angled strip 30, 32 of ballistic panel material. In addition brackets such as 34 are provided strategically placed inside the corners. Bolts pass through the strips 30, 32 and the brackets such as 34 to hold the structure together. The brackets can be of metal and the corner strips could

also be of metal, optionally lined or covered with ballistic protection panel material.

[0044] Fig. 3 shows an arrangement generally similar to Fig. 2 but this time seen from the outside. It will be appreciated that the description given for Fig. 2 applies equally for Fig. 3 despite the somewhat different shape.

[0045] Fig. 4 shows an enlarged view of one of the inside corners of Fig. 2, namely the corner adjacent the bracket 34. It can be seen that the corner joint is a mitre joint.

[0046] Figs 5 and 6 show two alternative views of a corner joint, here in the form of a right angle, although this is not essential. The corner joint 40 between the two elements 10, 10' of said material is formed in such a way that the first element 10 mates with a second element 10' at respective sides 42, 44 of the two elements at the joint 40. At the respective side 42 of one 10 of the two said elements 10, 10' the first ballistic panel 12a, the associated core 14 and the second ballistic panel 12b are aligned perpendicular to a face 46 of the respective element (or at an angle to it different from ninety degrees if the corner angle is different from ninety degrees) whereby to form an edge face 48 and, at the respective mating side 44 of the second element 10' the first ballistic panel 12a' projects beyond the respectively associated core 14' and the second ballistic panel 12b' to overlap and cover the edge face 48.

[0047] In this embodiment the corner has ballistic overlap and is simply stabilised by external brackets 50 in addition to the internal brackets 34, as can be seen from Fig. 6. Bolts such as 52 extend through the panels 10 and 10' clamping them between the brackets 34 and 50.

[0048] Figs. 7 and 8 explain the concept of ballistic overlap already mentioned in connection with Fig. 1.

[0049] In these Figs. the ballistic and/or blast damping material has the form of regular elements 10, 10', 10'', 10''' such as (without restriction) rectangular or square tiles, which can be placed together in a regular array, such as a square or rectangular array, to form a wall, floor, roof or ceiling covering. At one side of the tile 10 (the left side) the first panel 12a projects beyond the associated core 14 and the first panel 12a and the associated core 14 both project beyond the second panel 12b. At an opposite side of the tile 10 (the right side), the second panel 12b projects beyond the associated core 14 and the second panel 12b and the associated core 14 project beyond the first panel 12a. The situation is the same for the tiles 10' and 10'' (only shown in part in Fig. 8). If the second tile 10' is moved to the left as symbolised by the arrow 54 then it fits neatly against the first panel 10 with the overlap as shown at 58. This overlap forms ballistic protection in the sense that a bullet or fragment striking the joint between the panels 12a and 12a' at an approximate right angle cannot simply pass through the joint between the panels 12b and 12b' which is offset from the joint between the panels 12a and 12a'. This is referred to as ballistic overlap, the bullet or fragment will be slowed down and preferably stopped by the action of the first or second panel and the core material, irrespective of where it strikes in the overlap region.

[0050] The overlapping arrangement is repeated for a rectangular or square tile at a second side of the tile adjacent to the first and forming a right angle therewith. This is shown in Fig. 7 for the tiles so that tile 10''' can be moved in the direction of the arrow 60 to overlap the tile 10 from below. It will be appreciated that the tiles 10 and 10''' can also be shifted laterally relative to one another to build a wall resembling a brick wall with bricks in adjacent rows being offset from one another. Other forms of offset of the panels and cores are possible.

[0051] The ballistic and/or blast damping material in accordance with the present teaching is adapted or intended to be secured to an exterior or internal wall of a permanent or temporary structure such as a portable building, an office, a container (office accommodation, stores, command post, infirmary etc.), a toilet, a command post, an embassy, a section separation wall in a building, a private home or a bedroom or to a wall roof or floor or other part of a motor vehicle. It can also be built up into a self supporting structure within a room or other partly or fully enclosed space. Doors can also be made of or lined with the material.

[0052] The ballistic and/or blast damping material can also be used alone as section separation such as a partition wall or in a self-supporting three-dimensional construction, e.g. as a small command post or snipers hide-out.

[0053] Finally, Figs 9A, 9B, 10A, 10B and 11A and 11B show the results of a test carried out using the vertical steel plate as described above. The ballistic and blast damping material used for this test is the same as used for the test described earlier with respect to the artificial leg test, that is to say it has the following construction:

[0054] A ballistic panel of 33 layers of E-glass fiber fabric in a weave best described as a broken Twill K 1/3 with a fabric weight of 588g/m². The warp and weft strands each have a linear density of 1200tex (600 x 2) and a fiber diameter of 14μm. There are 25 warp strands and 24 weft strands per 100mm in the weft and warp directions respectively.

[0055] Two layers of polypropylene each of 50μm thickness are placed as a matrix material between each two layers of E-glass fabric and the assembly is pressed at 195°C to melt the polypropylene (melting point 160°C and cause it to flow around and embed the E-glass strands. The layers of E-glass fiber fabric are aligned with one another, i.e. with a zero degree crossing angle, and the resulting ballistic panel has a thickness of 12mm.

[0056] Between the above described ballistic panel and a further ballistic panel of the same construction there is a layer of Regupol material of 30mm thickness.

[0057] It can be seen from the Figs. 9A to 11B that a blast damping factor of 10.785 was achieved.

Claims

1. A ballistic and/or blast protection material comprising at least first and second ballistic composite panels and disposed between each pair of adjacent ballistic composite panels a respective core of a blast damping material.
2. A ballistic and/or blast protection material in accordance with claim 1, wherein said ballistic composite panels each consist of filaments of glass fiber, aramide, another high strength fiber or polyethylene, in particular of E-glass or ultra high molecular weight polyethylene said filaments either being disposed generally parallel to one another in layers in a matrix of a thermoplastic or a thermosetting plastic with the filaments of one layer crossing with the filaments in an adjacent layer, or with the filaments forming a woven fabric and a plurality of layers of said fabric being combined in a matrix of thermoplastic or thermosetting plastic.
3. A ballistic and/or blast damping material in accordance with either of claims 1 and 2, wherein the or each said core of a blast damping material comprises a resilient fiber or granulate material bound with a synthetic binder.
4. A ballistic and/or blast damping material in accordance with claim 3, wherein said resilient fiber or granulate material comprises rubber, in particular a recycled rubber for example from motor vehicle tyres, and said synthetic binder comprises a polyurethane resin and/or wherein the or each said core comprises Regupol (registered trade mark of BSW GmbH Berleburger Schaumstoffwerk 57301 Bad Berleburg, Germany)
5. A ballistic and/or blast damping material in accordance with any one of the preceding claims, wherein the or each said core comprises material in mat form, tile form or building block form.
6. A ballistic and/or blast damping material in accordance with any one of the preceding claims wherein the or each said core is adhesively bonded to at least one of said adjacent ballistic panels.
7. A ballistic and/or blast damping material in accordance with any one of the preceding claims wherein said material has the form of regular elements, such as (without restriction) rectangular or square tiles, which can be placed together in a regular array, such as a square or rectangular array, to form a wall, floor, roof or ceiling and wherein, at one side of said tile, said first panel projects beyond the associated core and the first panel and the associated core both project beyond the second panel and wherein, at an opposite side of said tile, said second panel projects beyond the associated core and the second panel and the associated core both project beyond the first panel, whereby to provide ballistic overlap at said side and at said opposite side.
8. A ballistic and/or blast damping material in accordance with claim 7, wherein the overlapping arrangement is repeated for a rectangular or square tile at a second side of the tile adjacent to the first and forming a right angle therewith.
9. A ballistic and/or blast damping material in accordance with any one of the preceding claims, wherein any joint between adjacent elements of said blast damping material is covered at at least one side of the material with a strip of ballistic panel material.
10. A ballistic and/or blast damping material in accordance with any one of the preceding claims, wherein a corner joint between any two elements of said material is formed in such a way that the first element mates with a second element at respective sides of the two elements at a joint, wherein at the respective side of one of the two said elements the first ballistic panel, said associated core and said second ballistic panel are aligned perpendicular to a face of the respective element, or at an angle to it different from ninety degrees, whereby to form an edge face and, at the respective mating side of the second element, the first ballistic panel projects beyond the respectively associated core and the second ballistic panel to overlap and cover said edge face.
11. A ballistic and/or blast damping material in accordance with any one of the preceding claims, wherein respective elements or tiles of said material are secured together by discrete brackets and/or corner reinforcements, e.g. brackets or reinforcements of metal.
12. A ballistic and/or blast damping material in accordance with any one of the preceding claims, wherein it is adapted to be secured to an exterior or internal wall of a permanent or temporary structure such as a portable building, an office, a container, office accommodation, stores, a command post, an infirmary, a toilet, an embassy, a section separation wall in a building, a private home or a bedroom or to a wall, roof or floor or other part of a motor vehicle.

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13. A ballistic and/or blast damping material in accordance with any one of the preceding claims, wherein each said ballistic panel has a thickness selected in the range from 3 to 20mm and the or each core has a thickness selected in the range from 10 to 100mm.

5 **14.** A ballistic and/or blast damping material in accordance with any one of the preceding claims, wherein each said ballistic panel is adapted to meet the requirements of a standard such as FB4 according to EN 1522 and the or each core is adapted to produce, in combination with said first and second ballistic panels a damping effect factor of at least 5 and preferably of at least 10.

10 **15.** A structure provided with a ballistic and/or blast damping material in accordance with any one of the preceding claims.

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FIG. 1

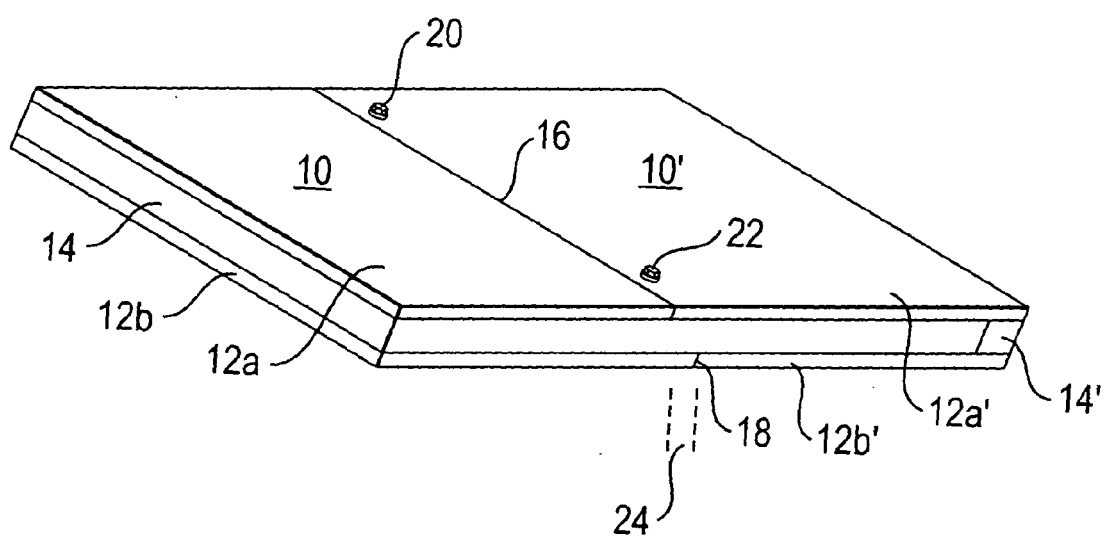


FIG. 2

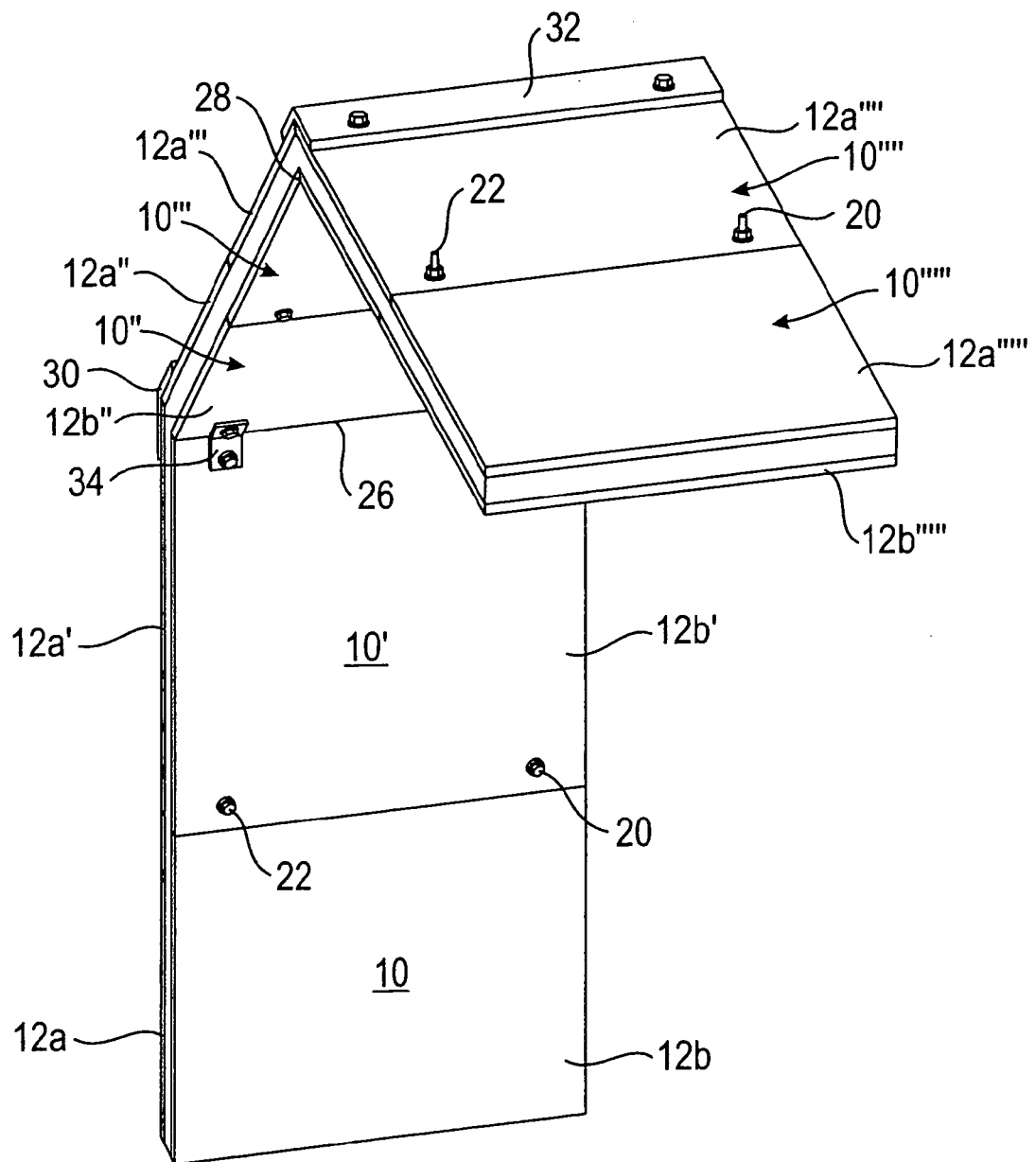


FIG. 3

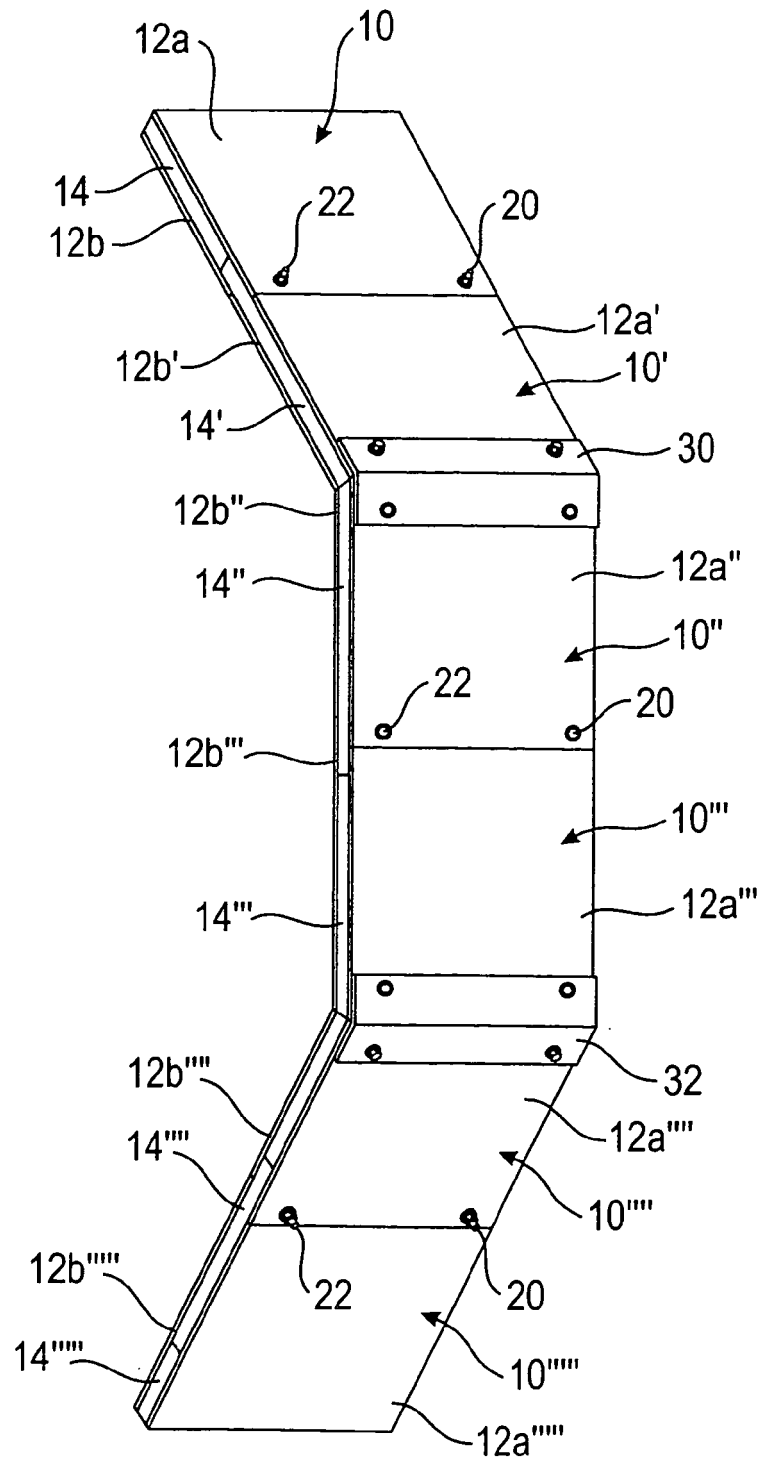


FIG. 4

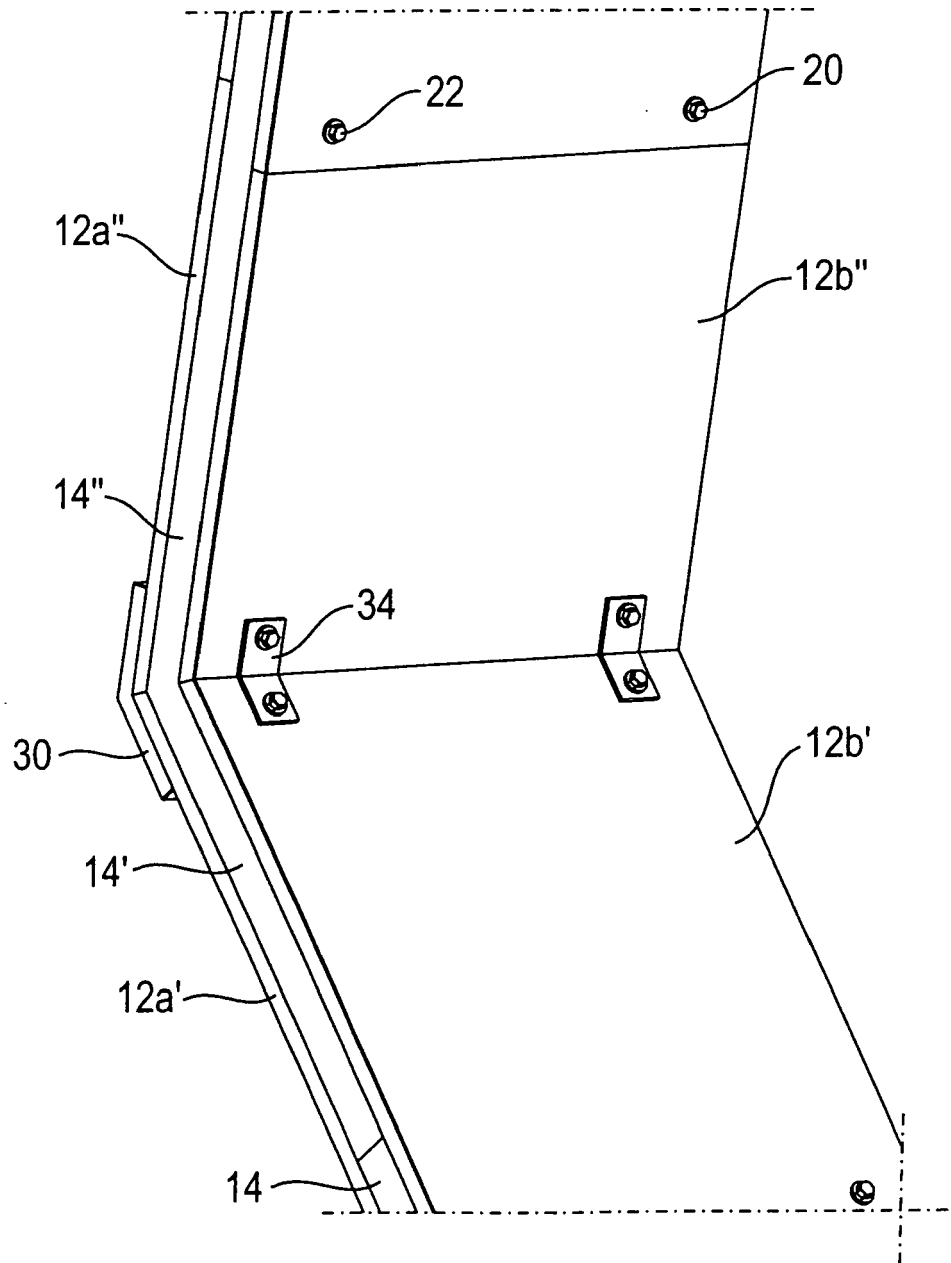


FIG. 5

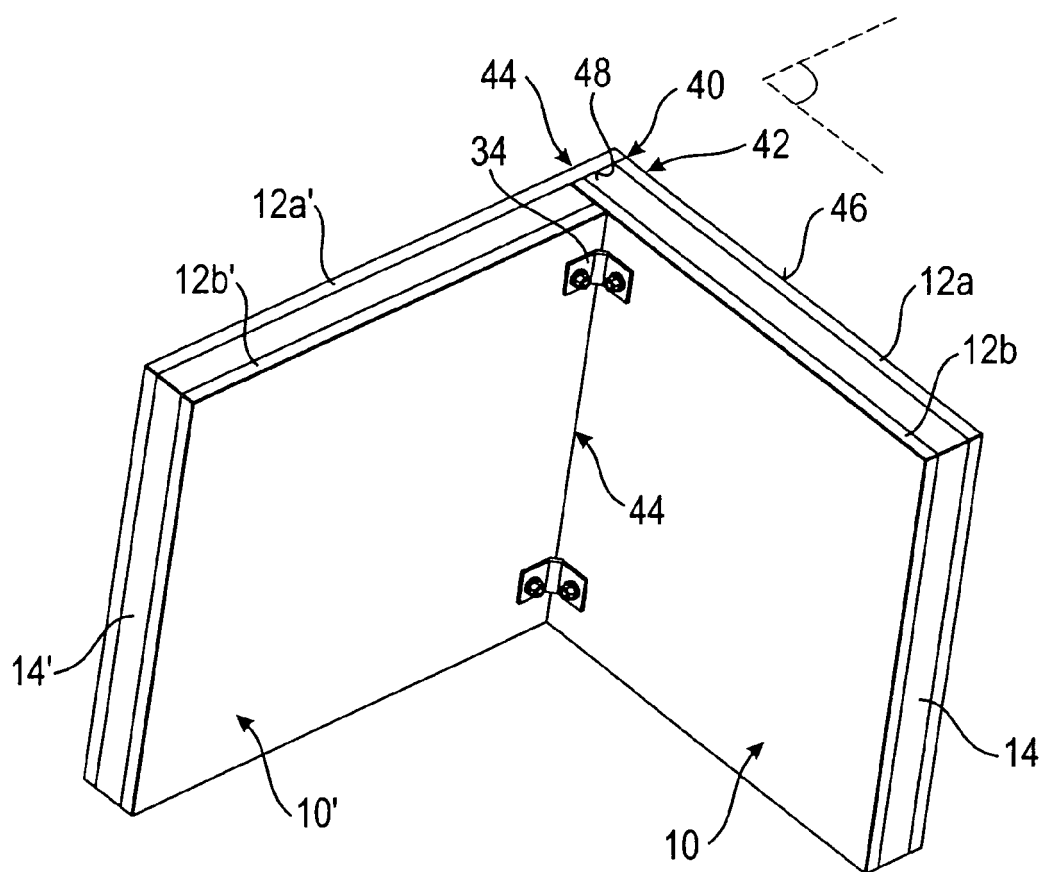
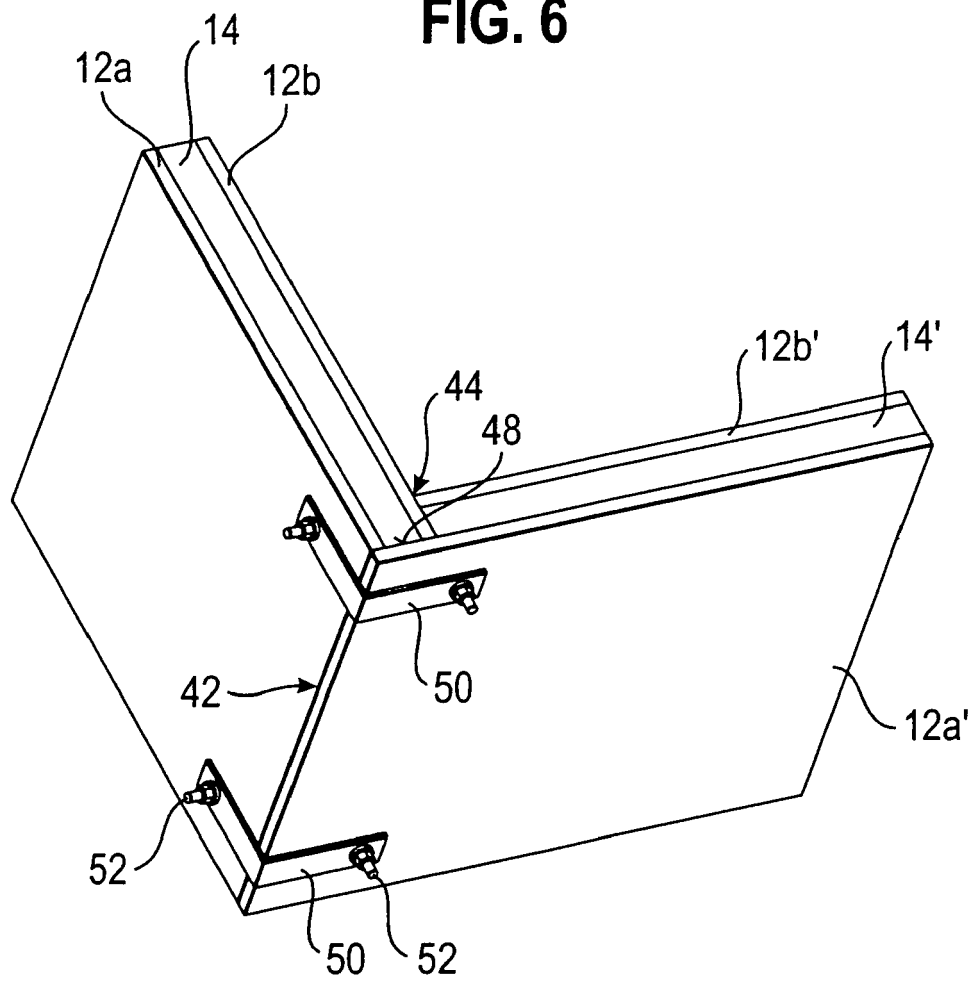


FIG. 6



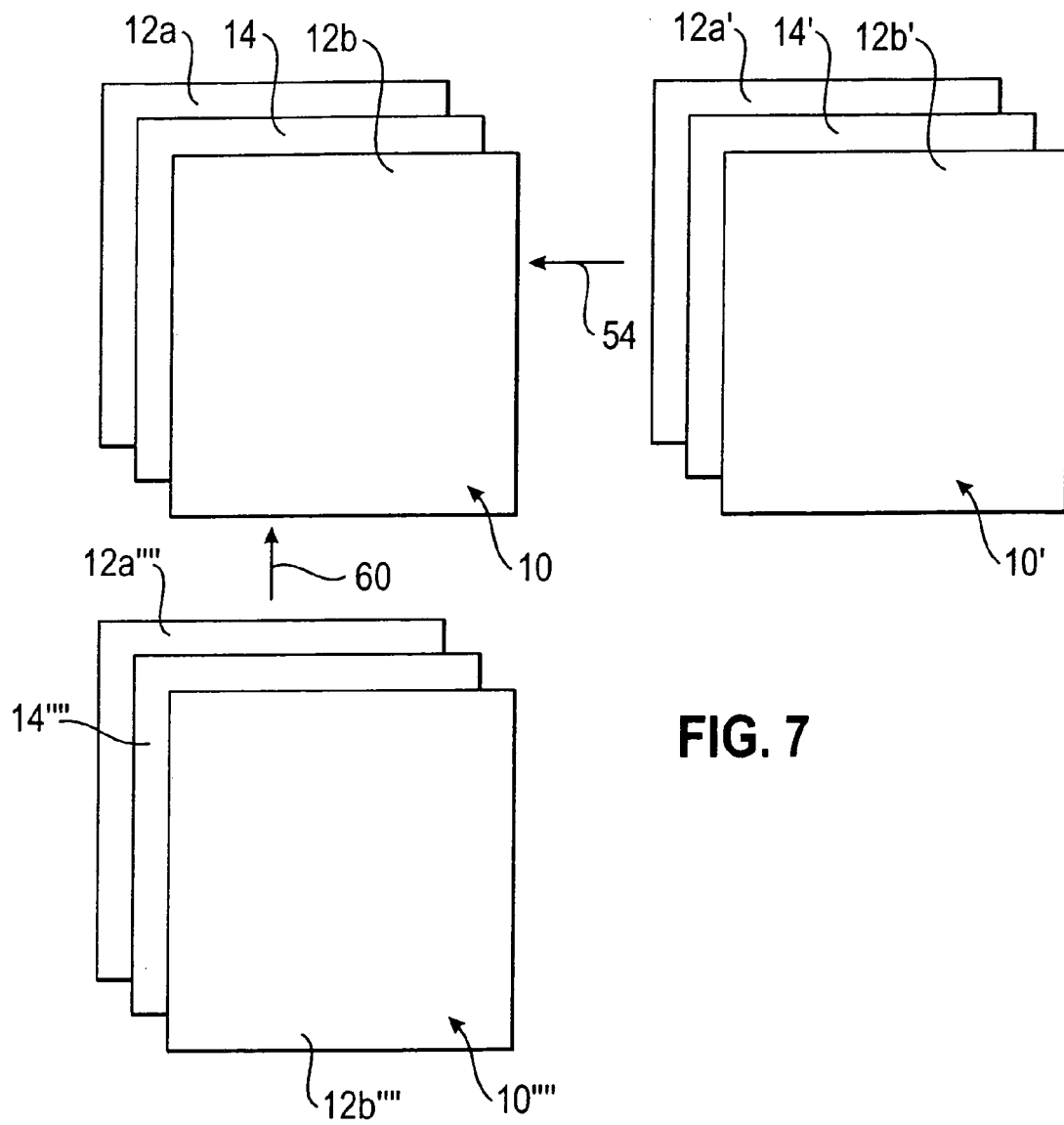


FIG. 7

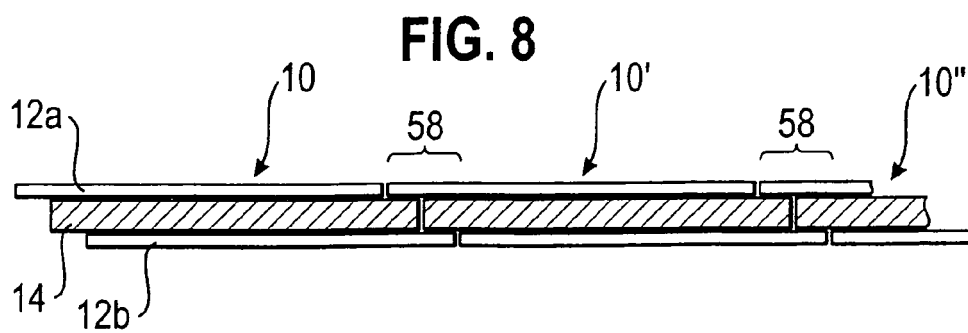


FIG. 8

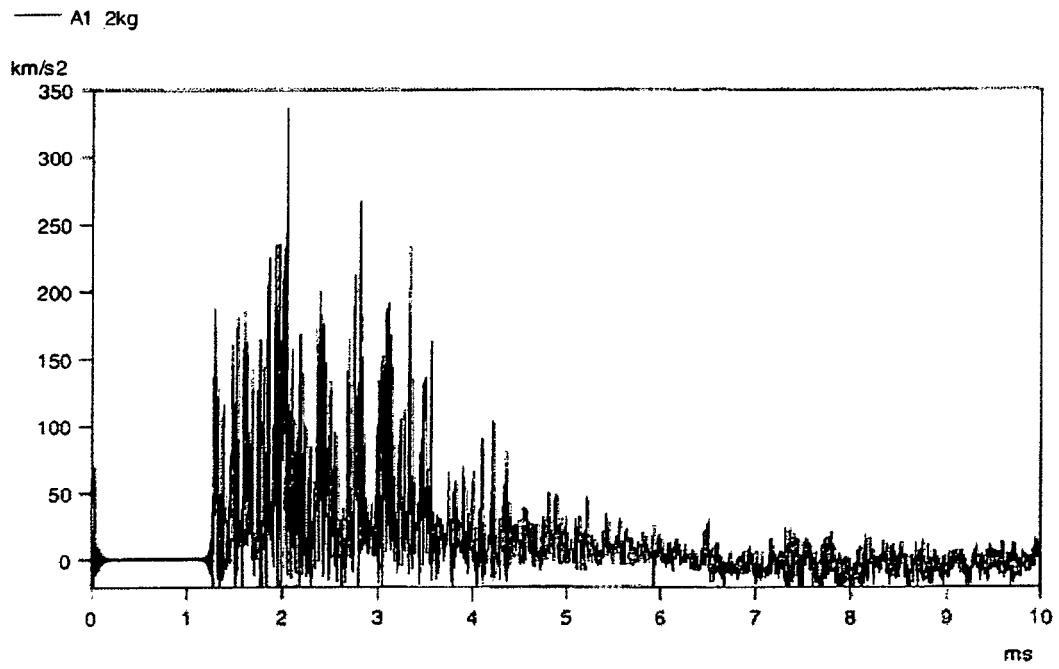


FIG 9A

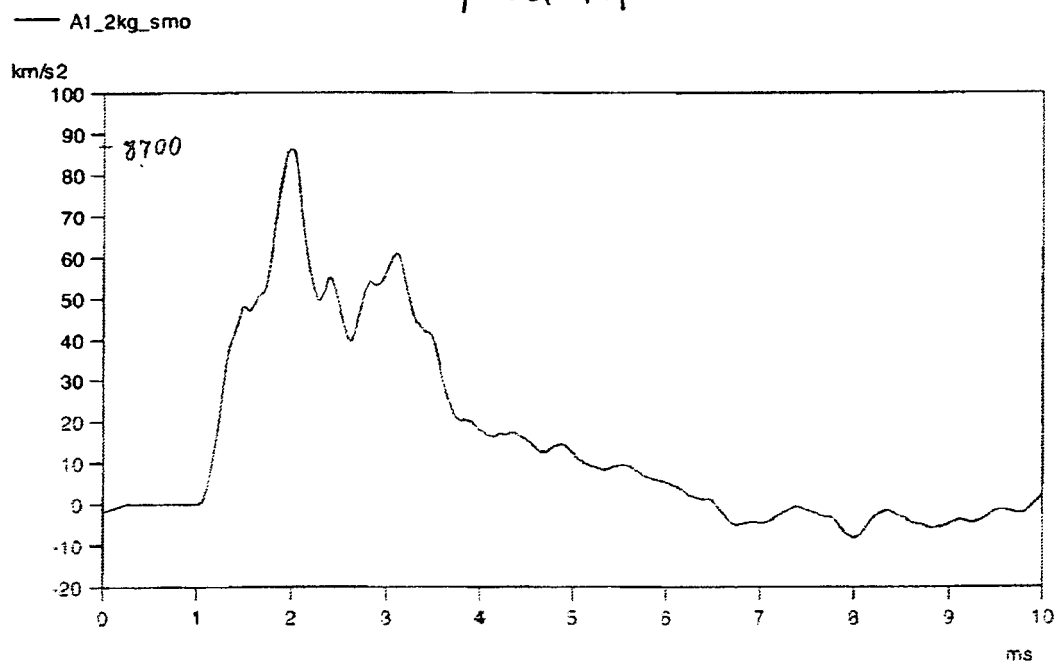


FIG 9B

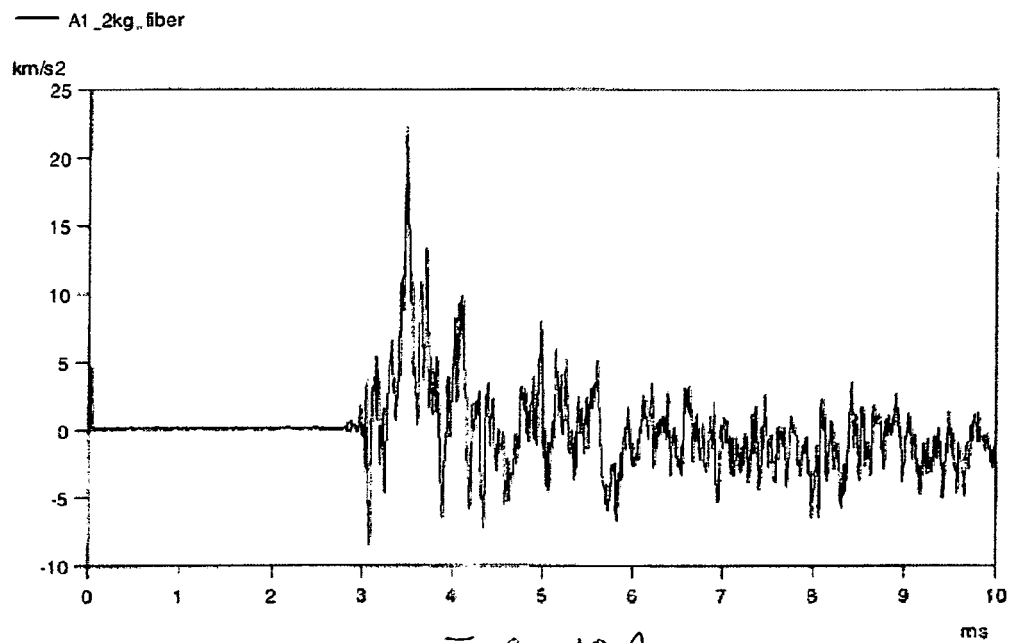


FIG. 10 A

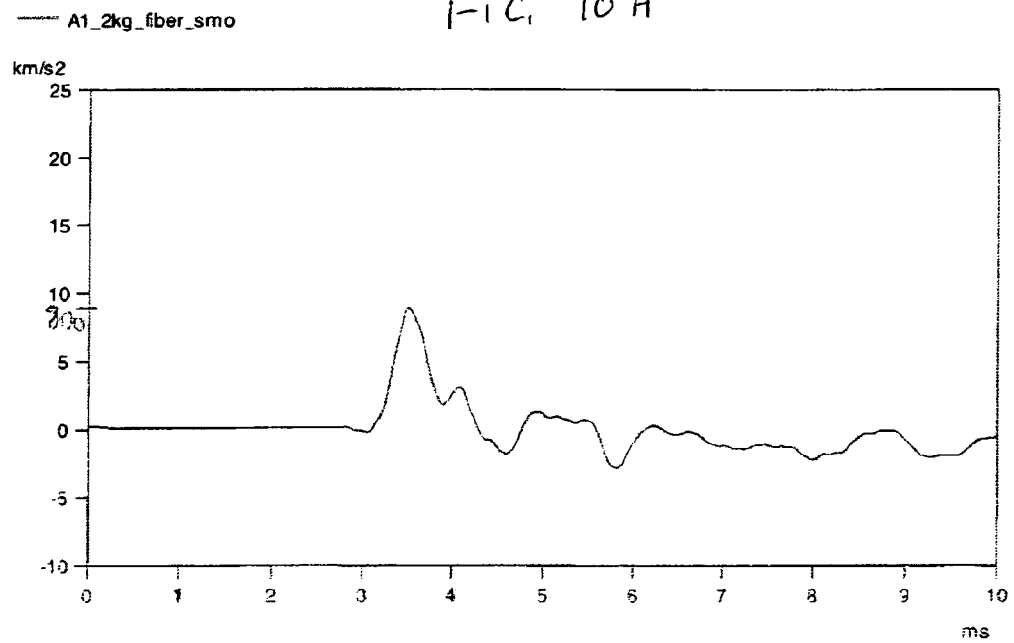


FIG. 10 B

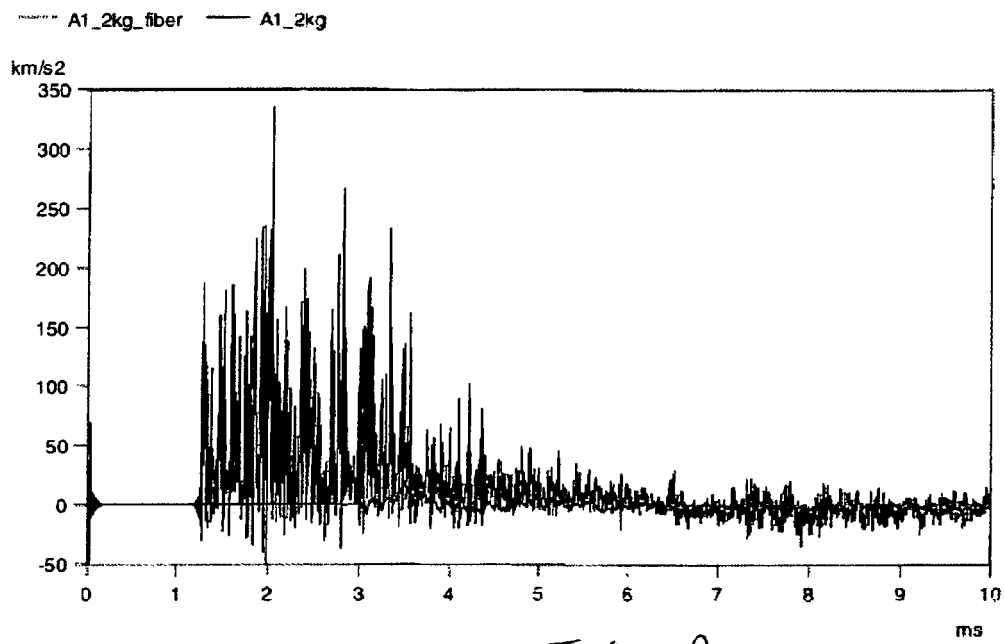


FIG. 11 A

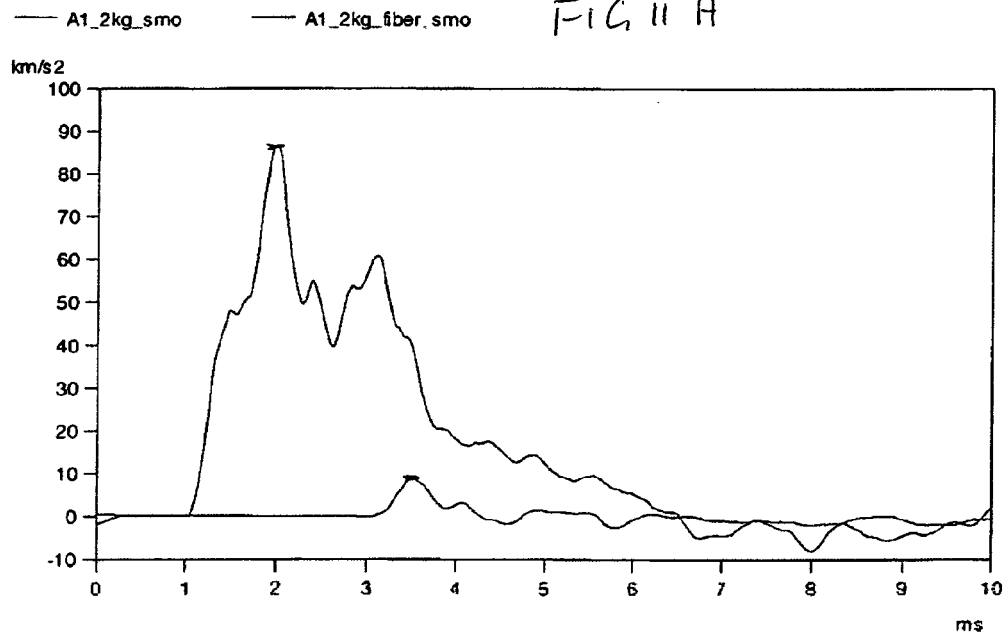


FIG. 11 B