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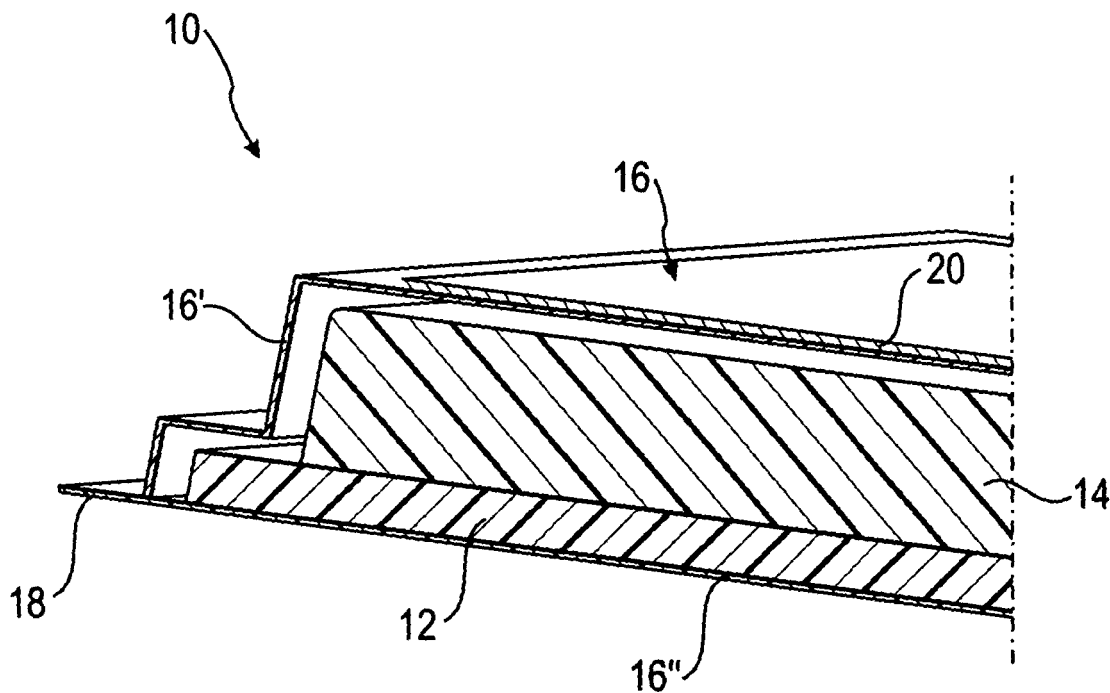
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(54) **A mat having flexible ballistic protection and shock damping**

(57) The invention relates to a mat with flexible, ballistic protection and shock damping. The novel feature of this invention is that in one and same mat a flexible, ballistic protection mat and a shock damping material is

combined. Hereby one obtains an acceleration reduction after blasts, which reduces impact blow on human body parts in contiguity with the coach-work and the body parts of the means of transport.

**FIG. 1**



**Description**

**[0001]** The present invention relates to a mat for use against military threats or threats arising in potentially hostile environments.

**[0002]** The object underlying the present invention is to provide an improved mat which offers better protection against such threats.

**[0003]** In order to satisfy this object there is provided a mat having flexible ballistic protection and shock damping comprising a flexible ballistic protection mat and one or more flexible shock damping materials to reduce impacts on body parts in transport means.

**[0004]** The idea underlying the present invention is thus to create an acceleration damping mat, which reduces impacts on and accelerations of human body parts in direct contiguity with the coachwork and body parts of the means of transport. This is obtained by construction of a flexible, ballistic protection mat of the above mentioned kind which, in one and the same mat, combines the ballistic protection with a flexible shock damping material. The invention thus relates to a mat with an inserted, flexible, ballistic protection mat and flexible shock damping material for use in a means of transport, which might be exposed to acceleration forces during blasts.

**[0005]** Known mats with ballistic protection are not equipped with acceleration damping materials for reducing the impact blow on human body parts in direct contiguity with the coachwork and body parts of the means of transport.

**[0006]** The flexible ballistic protection mat and said flexible shock damping material of the present invention are preferably surrounded by an outer protection cover, for example of PVC. This protects against environmental influences such as humidity, UV-light and abrasive or corrosive materials which could otherwise lead to a deterioration of the physical properties of the mat.

**[0007]** An upper surface of said outer protection cover is preferably covered by a wear protection layer, for example of SBR/ NR (Syrene butadiene rubber/natural rubber). This allows personnel to stand or walk on the mat without this being subject to unnecessary and undesirable wear and tear.

**[0008]** The flexible ballistic protection mat preferably consists in known manner 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 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. Such constructions are known to offer good protection against injury due to projectiles such as bullets or other fragments, for example due to enemy fire or debris or fragments resulting from explosions or land mines or grenades.

**[0009]** The mat preferably utilizes shock damping material comprising a resilient fiber or granulate material bound with a synthetic binder.

**[0010]** One such material which is frequently used in shooting ranges to catch bullets and stop ricochets, comprises rubber, in particular a recycled rubber for example from motor vehicle tyres, and said synthetic binder comprises a polyurethane resin.

**[0011]** The shock damping material can for example comprise Regupol (registered trade mark of BSW GmbH Berleburger Schaumstoffwerk 57301 Bad Berleburg, Germany).

**[0012]** The flexible ballistic protection mat and the shock damping material preferably result in a damping effect factor of at least 10 and preferably of 20 or more, the damping effect factor being measured as explained later herein.

**[0013]** The mat of the present teaching is preferably adapted to be mounted on the coachwork and/or body parts of a means of transport, such as a motor car, a pick-up truck, an all terrain vehicle, a jeep, a truck, a tank or any other form of transportation form, it could also be used in trains, ships or towed trailers. It can generally be used in all forms of transportation, which can be influenced by blast effects. Its use in aeroplanes and helicopters is probably unlikely because of the extra weight. It will generally be in contiguity with said coachwork or body parts, to reduce the acceleration forces acting on personnel carried by said means of transport. It can for example be tailored to the shape of the footwells and footrests of the vehicle concerned or to line critical parts of the doors, tailgate or sidewalls of the vehicle or any other areas of the vehicle considered potentially endangered by the threats or hostilities that are expected.

**[0014]** Each said flexible ballistic mat typically has a thickness selected in the range from 3 to 20 mm and the shock damping material has a thickness selected in the range from 10 to 100 mm, and is preferably 30 to 40 mm in thickness.

**[0015]** The or each flexible ballistic mat is preferably adapted to meet the requirements of a standard such as  $V_{50} > 600$  m/s according to STANAG 2920 and the or each shock damping material is adapted to produce, in combination with said flexible ballistic mat a damping effect factor of at least 10 as herein defined.

**[0016]** The invention also relates to a structure or means of transport provided with a mat in accordance with the present teaching.

**[0017]** Thus, the present invention provides a new technique for ballistic protection in the form of a mat which is novel due to the fact that in one and the same mat a flexible, ballistic protection mat is combined with one or more various flexible shock damping materials. The technical effect is to be seen in the fact that by mounting a mat on the coachwork and body parts of the means of transport the acceleration (in Danish "påvirkninger" = influence, impact or effect) on the

body parts in contiguity with the means of transport are reduced.

**[0018]** The invention will now be explained in more detail by way of example only and with reference to the accompanying drawings in which:

5 Fig. 1 shows an isometric illustration of the mat illustrating its construction,

Fig. 2 illustrates the construction of the flexible ballistic protection mat and shock damping material separately, and

10 Figs. 3a, 3b are two graphs to explain the damping effect factor.

**[0019]** Turning first to Fig. 1 there can be seen a mat 10 comprising a flexible ballistic protection mat 12 and one or more flexible shock damping materials 14 to reduce impacts on human body parts in transport means.

15 **[0020]** The flexible ballistic protection mat 12 and the flexible shock damping material 14 of the present invention, which are typically not bonded together, but could be bonded together, e.g. by a polyurethane resin, are preferably surrounded by an outer protection cover 16, for example of PVC. The cover conveniently comprises upper and lower layers 16' and 16'' which are joined, for example by welding in an overlapped edge region 18. The cover 16 protects against environmental influences such as humidity, UV-light and abrasive or corrosive materials which could otherwise lead to a deterioration of the physical properties of the mat 10.

20 **[0021]** An upper surface of the outer protection cover 16' is preferably covered by a wear protection layer 20, for example of SBR/NR. This allows personnel to stand or walk on the mat 10 without it being subject to unnecessary and undesirable wear and tear.

25 **[0022]** Reference should also be made to Fig. 2 which shows the flexible ballistic protection mat 12 in its own sealed cover 16'', for example of PVC, and the flexible shock damping material 14 as a separate item. The flexible shock damping material of Fig. 2 will typically be placed on top of the sealed cover 16'' and can be held generally in place by an upper cover 16' as in Fig. 1, again with the upper cover 16' (not shown in Fig. 2) being sealingly connected (welded) to the lower cover, 16'' in this example. Again an outer wear protection layer of, for example SBR/ NR, will usually be placed on top of cover 16'.

30 **[0023]** Ballistic protection means in the present context 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:

- 35 - dynamic absorption of the shock wave propagation and shock wave effects,
- protection and isolation of occupants from any form of transportation from shock effects and from the effects of fragments, debris and dust.

40 **[0024]** The flexible ballistic protection mat 12 preferably consists of filaments of glass fiber, preferably E-glass, aramide, polyethylene, preferably PE-UHMW polyethylene or other high strength fibers. The filaments are preferably disposed generally parallel to one another in layers. 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 placed on top of each other to form a mat.

45 **[0025]** In a preferred embodiment the ballistic mat can comprise 16 layers of aramide fiber woven fabric (simple cross weave) with a fabric weight preferably in the range from 100 g/m<sup>2</sup> to 800 g/m<sup>2</sup>, with a filament diameter preferably in the range from 6 to 20 μm, the filaments having a linear density preferably in the range from 400-5000 (different dtex can be used for the warp and for the weft) in both directions of the weave. 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 multi-axial.

50 **[0026]** 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 fiber layers can be stitched together locally or with parallel or crossed seams spaced say 5 cm apart, or in another form in which they are combined to avoid slipping of one layer relative to another while preserving the overall flexibility of the so formed ballistic protection mat which is soft in texture. It should be noted that the side edges and corners of the flexible ballistic protection mat are normally taped with one or more layers of a material such as standard brown plastic packaging tape to prevent fraying. For example, the tape, which can be "Packaging Tape Low Noise 3120" from Scotch/ 3M in rolls 48 mm wide with 66 m length, can be folded along the middle of a strip of tape and stuck to the two outer sides of the mat either lengthways or crossways. The mat with the taped edges is then placed in the PVC cover 16, 16' or 16''.

**[0027]** It should be stressed that the examples given above are only a small selection of possible designs of ballistic mats of which there are many variants.

**[0028]** Ballistic mats of this kind are known per se, and are for example available from Scanfiber Composites A/S in Denmark.

**[0029]** The shock damping material 12 of the mat 10 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.

**[0030]** 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.

**[0031]** 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 shock or blast damping material of the present invention, is able to capture bullets from hand weapons and retain them so that even if they hit an underlying concrete floor or wall the rebounding or ricocheting bullet or fragments thereof or indeed fragments of concrete knocked out of the concrete floor or wall do not re-emerge from the Regupol material and endanger users of the shooting range.

**[0032]** 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 tyres, which is a relatively inexpensive source of such material. The rubber can consist of rubbers of different hardnesses.

**[0033]** Suitable mats 10 in accordance with the present teaching must have or result in a damping effect factor of at least 10. This damping effect factor can be measured in the following way:

**[0034]** 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 80 kg of sand in bags to simulate a standing soldier with full equipment. The boots are typically placed on a thin stiffened steel plate of 1 mm thickness and the plate is weighted down with say two tons of ballast.

**[0035]** An explosion is then detonated beneath the steel plate of a level corresponding to a small land mine with say 200 to 300 gm 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 as shown in Fig. 3a with pronounced positive and negative peaks which decay in size over a period of say 100 ms. The amplitude of the first positive peak is noted. It can for example be around 7,700 g 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 combined with the ballistic mat 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 770 g. 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  $7,700 / 770 = 10$ .

**[0036]** In actual fact significantly better damping effect factors can be achieved. As can be seen from Fig. 3b a material comprising a mat of ballistic protection material of 15 mm thickness and comprising aramide in combination with a 30 mm layer of shock damping material can readily lead to a peak acceleration of 410 g and thus to a damping effect factor of 19 in the example given.

**[0037]** 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.

**[0038]** 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.

**[0039]** The mat of the present teaching is preferably adapted to be mounted on the coachwork and/or body parts of a means of transport, such as a motor car, a pick-up truck, an all terrain vehicle, a jeep, a truck, a tank or any other form of transportation, preferably in contiguity with said coachwork or body parts, to reduce the acceleration forces acting on

personnel carried by said means of transport. It can for example be tailored to the shape of the footwells and footrests of the vehicle concerned or to line critical parts of the doors, tailgate or sidewalls of the vehicle or any other areas of the vehicle considered potentially endangered by the threats or hostilities that are expected.

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## Claims

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1. A mat having flexible ballistic protection and shock damping comprising a flexible ballistic protection mat and one or more flexible shock damping materials to reduce impacts on body parts in transport means.

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2. A mat in accordance with claim 1, wherein said flexible ballistic protection mat and said flexible shock damping material are surrounded by an outer protection cover, for example of PVC.

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3. A mat in accordance with claim 2, wherein an upper surface of said outer protection cover is covered by a wear protection layer, for example of SBR/NR.

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4. A mat in accordance with any one of the preceding claims, wherein said flexible protection mat consists 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 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.

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5. A mat in accordance with any one of the preceding claims, wherein the or each said shock damping material comprises a resilient fiber or granulate material bound with a synthetic binder.

6. A mat in accordance with claim 5 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.

7. A mat in accordance with any one of the preceding claims wherein the or each said shock damping material comprises Regupol (registered trade mark of BSW GmbH Berleburger Schaumstoffwerk 57301 Bad Berleburg, Germany).

8. A mat in accordance with any one of the preceding claims, wherein said mat is selected to have a damping effect factor of at least 10 and preferably of 20 or more.

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9. A mat in accordance with any one of the preceding claims and adapted to be mounted on the coachwork and/or body parts of a means of transport, such as a motor car, a pick-up truck, an all terrain vehicle, a jeep, a truck, a tank or any other transportation form, preferably in contiguity with said coachwork or body parts, to reduce the acceleration acting on personnel carried by said means of transport.

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10. A mat in accordance with any one of the preceding claims, wherein each said flexible ballistic mat has a thickness selected in the range from 3 to 20 mm and the shock damping material has a thickness selected in the range from 10 to 100 mm.

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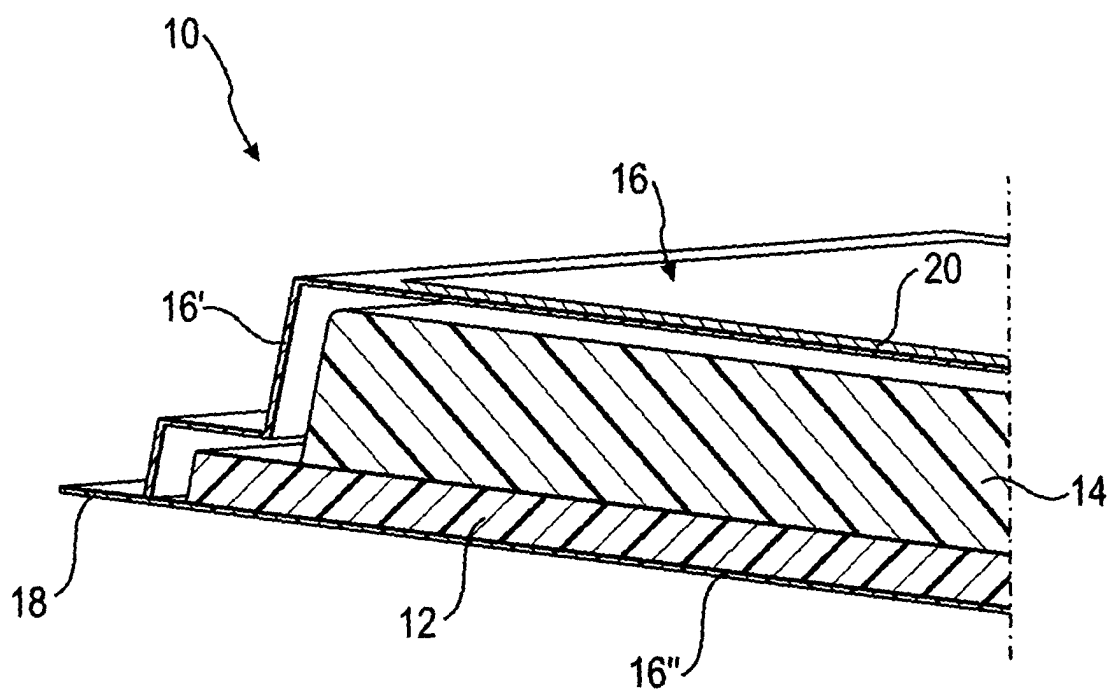
11. A mat in accordance with any one of the preceding claims, wherein each said flexible ballistic mat is adapted to meet the requirements of a standard such as STANAG 2920 and the or each shock damping material is adapted to produce, in combination with said flexible ballistic mat, a damping effect factor of at least 10.

12. A structure or means of transport provided with a mat in accordance with any one of the preceding claims.

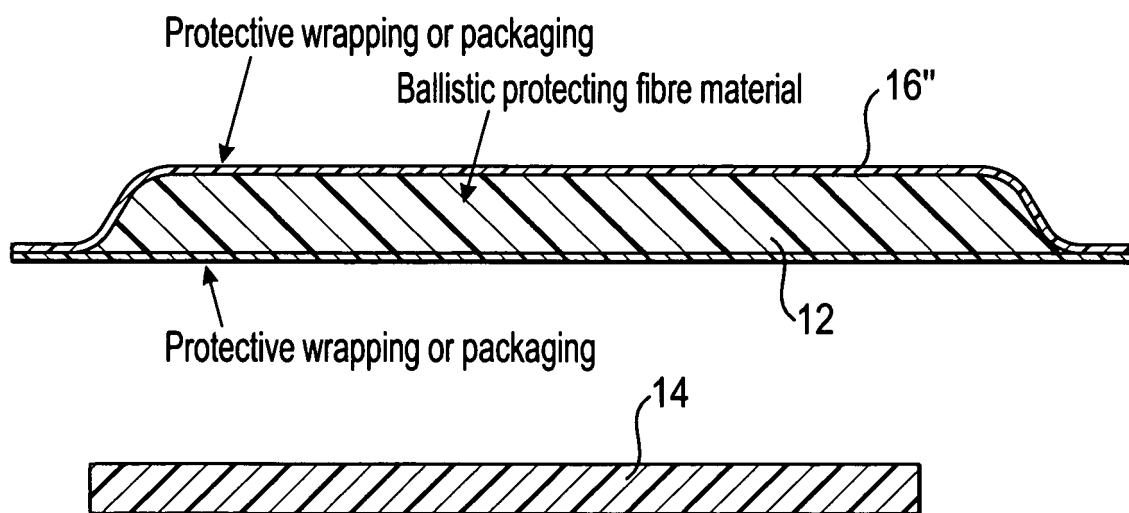
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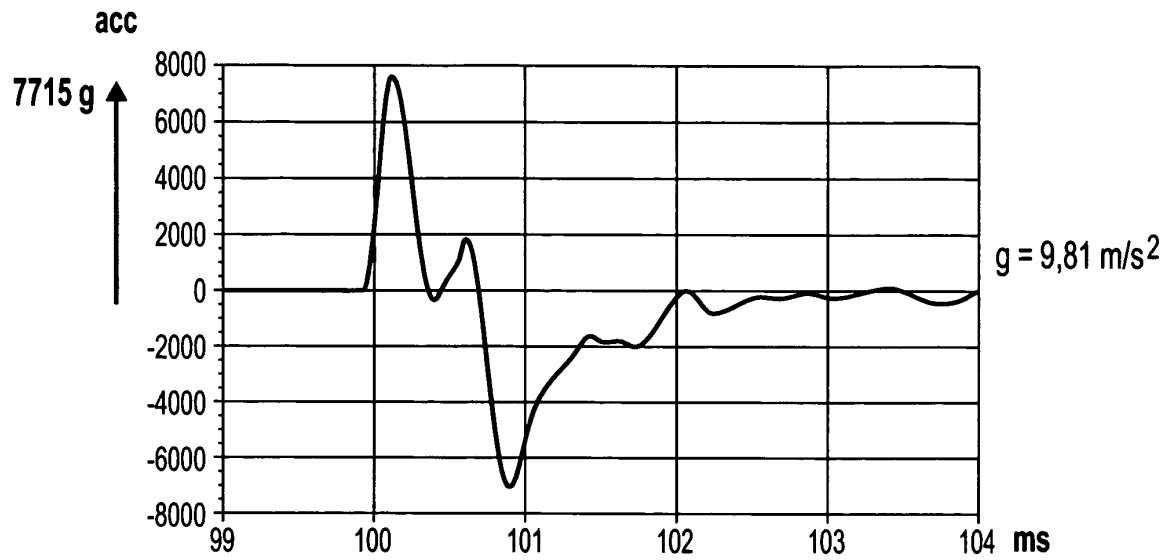
**FIG. 1**



**FIG. 2**



**FIG. 3a**



**FIG. 3b**

