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(54) Lightweight armour against firearm projectiles

Leichtpanzerung gegen Feuerwaffengeschosse

Blindage léger pour la défense contre les projectiles d'armes à feu

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(56) References cited:
EP-A- 0 287 918
BE-A- 877 585
DE-A- 4 237 798
GB-A- 1 328 576
US-A- 2 318 301
US-A- 4 633 528
WO-A-92/20520
DE-A- 2 815 582
FR-A- 2 731 512
GB-A- 2 308 401
US-A- 3 380 406

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Description

FIELD OF THE INVENTION

[0001] The present invention is in the field of armor against regular and armor piercing firearm projectiles and their fragments, and aims at providing lightweight armor suitable for a variety of purposes such as, for example, for making protective garments, for fitting enclosures with opaque or transparent armored wall portions and the like.

[0002] More specifically, the present invention is directed to a lightweight armor assembly as defined in the preamble of the appended claim 1.

[0003] Such assemblies are known e.g. from US-A-3 389 406 and US-A-2 318 301, and are based on the observation that if a slanting body is put in the path of a firearm projectile, the latter is subjected to asymmetric forces which cause the projectile to be diverted from its trajectory in the direction of the obtuse angle formed between the trajectory and the body. In addition, the projectile may also be broken up, and all this has the result that the projectile can easily be stopped either by the said body or by rear body.

[0004] The slanting front body of these assemblies is made of high modulus material, such as glass or ceramics in US-A-3 380 406, and metals in US-A-2 318 301.

BACKGROUND OF THE INVENTION

[0005] There is a widespread need for protected enclosures with firearm projectile resistant transparent wall portions, typical examples being shop windows in riot prone areas, armored car windows, fighter plane domes, helicopter windows, domes for a tank commander post, etc. According to the prior art it is customary to use for such purposes laminated glass panels, e. g. 11 to 40 mm thick or even more, which by the effect of their mechanical properties are resistant against the penetration of various types of firearms. However, such panels are very heavy, weighing about 3 to 4 times more than an opaque armor, and also costly and therefore impractical for many purposes. There is thus an ever increasing need for lightweight transparent armor material.

[0006] There is also a widespread need for firearm projectile resistant pliable material, e.g. for making protective garments, bullet resistant tarpaulins and the like.

[0007] There is furthermore a need for hardened lightweight opaque armor against firearms.

[0008] It is the object of the invention to satisfy all these needs.

GENERAL DESCRIPTION THE INVENTION

[0009] Thus, in accordance with the invention there is provided a lightweight armor assembly resistant against the penetration of firearm projectiles, as defined in the appended claim 1.

[0010] The expressions "front body" and "rear body" nerely refer to the relative positions of the two bodies, and do not exclude an additionnal, non-slanted front panel as shown in figure 4.

[0011] If desired, the armor assembly according to the invention may comprise two or more front bodies.

[0012] The low modulus, brittle, lightweight material used in accordance with the present invention may be transparent or opaque and be either soft or hard. Where out of the two complementary angles formed between the trajectory of the firearm projectile and the surface of said at least one front body the upper angle is obtuse and the lower one is acute, the impinging firearm projectile is deflected upward. In contrast, where the lower angle is obtuse and the upper one is acute, an impinging firearm projectile is deflected downward.

[0013] In case of a transparent front body the rear body is preferably also transparent. A transparent front body may be made of PMMA (perspex), various synthetic materials such as polycarbonates, epoxy resins, PVC and the like.

[0014] An opaque front body may be made of a heavy duty cloth material such as of Kevlar™, Spectra™, and various epoxy materials and the like. Such materials may be used in soft pliable form or in composite hardened form, e.g. by being soaked with a suitable polymeric material which hardens upon curing.

[0015] The front body in the lightweight armor assembly according to the invention may be a monoblock, i.e. be made of a single material. Alternatively, it may be laminated and made of two or more layers of the same material or be composite and be made of two or more layers of different materials. In either case adjacent layers are suitably glued or cemented to each other.

[0016] If desired, in a laminated or composite block forming the front body in a lightweight armor assembly according to the invention, the individual layers may be slanted relative to the expected trajectory of an oncoming firearm projectile.

[0017] In operation an oncoming firearm projectile penetrates across the said at least one front body and when it emerges therefrom, either intact or broken up, it is deflected either upwards or downwards depending on the slant of the front body relative to the trajectory, and does not penetrate across the rear body. In case of a thick front body the projectile may be deflected without hitting at all the rear body.

[0018] It is thus seen that in accordance with the invention the required impact resistance of the rear body is much less than in the prior art. For example, where the rear body is a transparent wall or pane, its weight per unit area may be about half of that of a prior art body which has to be resistant to the full impact of an oncoming firearm projectile.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] For better understanding the invention will now be described with reference to the next drawings in which:

Fig. 1 is a schematic illustration showing the manner in which the invention operates in case of one single slanted lightweight material front body;
Fig. 2 is a similar illustration for two successive slanted lightweight material front bodies;
Fig. 3 is a schematic illustration similar to the one of Fig. 1, with the front body being a composite body; and
Fig. 4 is a schematic illustration of another embodiment of the invention.

DESCRIPTION OF SPECIFIC EMBODIMENT

[0020] Turning first to Fig. 1, there is shown schematically an assembly comprising a slanted lightweight front panel **1** and a vertical rear panel **2**. Arrow **3** stands for an oncoming firearm projectile and as can easily be concluded from the figure, the trajectory of the projectile 3 is essentially normal to the vertical rear panel and of the two angles formed at the intersection of the trajectory of projectile **3** with panel **1,** the upper angle is obtuse. In consequence, once the projectile **3** has penetrated across panel **1** it is diverted upwards as shown at **4,** either as a whole or broken up, and it either does not at all hit the vertical rear panel **2,** or else is readily intercepted by it without passing across.
[0021] In the embodiment shown schematically in Fig. 2, in which similar components are marked by similar numerals, there are provided two differently slanted transparent front panels **1** and **5.** In this arrangement the oncoming firearm projectile **3** is deflected by panel **1** in the manner shown at **6** at which it is still in a position to penetrate across the second panel **5** where it is again deflected into the direction shown at **7,** the end result being similar as in Fig 1.
[0022] In the embodiment of the invention schematically shown in Fig. 3, which is essentially similar to that in Fig. 1 with similar components again being marked by the same numerals, panel **1** is sheathed by sheets **8** and **9** of a different lightweight material. Basically this embodiment operates in a similar way as the embodiment of Fig. 1.
[0023] The embodiment shown schematically in Fig. 4 comprises a front panel **10**, a lightweight material block **11** composed of a plurality of slanting plates **12** glued or cemented together, and a vertical rear panel **13.** In its passage across block **11** the firearm projectile **3** is diverted by any of the plates **12** which it hits on its way, and it accordingly does not penetrate the rear panel **13.**
[0024] In any of the above embodiments the lightweight front and rear panels may be transparent or opaque, according to requirements.

Claims

1. A light weight armor assembly resistant against the penetration of firearm projectiles, comprising at least one front body (1;5) extending slanted relative to an expected trajectory of an oncoming firearm projectile (3), and a rear body (2) extending essentially normal to said expected trajectory, **characterized in that** said at least one front body (1;5) is made of a low modulus, brittle, lightweight material such as PMMA, polycarbonates, epoxy resins, PVC and the like.

2. A lightweight armor assembly according to Claim 1, being transparent.

3. An assembly according to Claim 2, wherein said at least one front body is made of a material selected from the group of organic materials.

4. A lightweight armor assembly according to Claim 1, being opaque.

5. An assembly according to Claim 4, wherein the low modulus, brittle, lightweight material is a heavy duty cloth material.

6. A lightweight armor assembly according to any one of Claims 1 to 5, wherein the said at least one front body is a monoblock.

7. An assembly according to Claim 6, wherein the said at least one front body is a composite.

8. An assembly according to Claim 7, wherein the composite front body is made of a plurality of different low modulus, brittle, lightweight transparent materials.

9. An assembly according to claim 8, wherein the composite front body is made of a plurality of different low modulus, brittle, lightweight opaque materials.

10. An assembly according to Claim 7, wherein the composite front body is made of a heavy duty cloth material.

11. An assembly according to Claim 9, wherein said heavy duty cloth is soaked with a suitable polymeric material that hardens upon curing.

12. An assembly according to any one of Claims 1 to 5, wherein said at least one front body is in the form of a multilayer block in which the individual layers are slanted relative to the expected trajectory of an

oncoming firearm projectile and in which adjacent layers are suitably glued or cemented to each other.

Patentansprüche

1. Gegen das Durchdringen von Feuerwaffengeschossen beständige leichte Panzerungsanordnung, welche einen sich im Bezug auf eine erwartete Flugbahn eines ankommenden Feuerwaffengeschosses (3) geneigt erstrecken vorderen Körper (1; 5) und einen sich im wesentlichen senkrecht zu der erwarteten Flugbahn erstrekkenden hinteren Körper (2) umfaßt, **dadurch gekennzeichnet, daß** der wenigstens eine vordere Körper (1; 5) aus einem schwachen, leichten Niedrigmodul-Material, wie z.B. PMMA, Polycarbonaten, Epoxidharzen, PVC und dergleichen besteht.

2. Leichte Panzerungsanordnung nach Anspruch 1, welche durchsichtig ist.

3. Panzerungsanordnung nach Anspruch 2, wobei der wenigstens eine vordere Körper aus einem Material besteht, das aus der Gruppe organischer Materialien ausgewählt wird.

4. Leichte Panzerungsanordnung nach Anspruch 1, welche undurchsichtig ist.

5. Anordnung nach Anspruch 4, wobei das schwache, leichte Niedrigmodul-Material ein hochbelastbares Kleidungsmaterial ist.

6. Leichte Panzerungsanordnung nach einem der Ansprüche 1 bis 5, wobei der wenigstens eine vordere Körper ein Monoblock ist.

7. Anordnung nach Anspruch 6, wobei der wenigstens eine vordere Körper ein Verbundkörper ist.

8. Anordnung nach Anspruch 7, wobei der vordere Verbundkörper aus einer Vielzahl unterschiedlicher schwacher, leichter durchsichtiger Niedrigmodul-Materialien besteht.

9. Anordnung nach Anspruch 8, wobei der vordere Verbundkörper aus einer Vielzahl unterschiedlicher schwacher, leichter undurchsichtiger Niedrigmodul-Materialien besteht.

10. Anordnung nach Anspruch 7, wobei der vordere Verbundkörper aus einem hochbelastbaren Kleidungsmaterial besteht.

11. Anordnung nach Anspruch 9, wobei die hochbelastbare Kleidung mit einem geeigneten polymerischen Material getränkt ist, das nach der Abbindung aushärtet.

12. Anordnung nach einem der Ansprüche 1 bis 5, wobei der wenigstens eine vordere Körper in der Form eines Mehrschichtenblockes vorliegt, in welchem die einzelnen Schichten im Bezug auf die erwartete Flugbahn eines ankommenden Feuerwaffengeschosses geneigt sind und in welchem benachbarte Schichten geeignet miteinander verklebt oder verkittet sind.

Revendications

1. Ensemble d'armure légère résistant contre la pénétration de projectiles tirés par une arme à feu, comprenant au moins un corps avant (1 ; 5) s'étendant incliné par rapport à une trajectoire escomptée d'un projectile provenant d'une arme à feu (3), et un corps arrière (2) s'étendant essentiellement normalement par rapport à ladite trajectoire escomptée ; **caractérisé en ce que** ledit au moins un corps avant (1 ; 5) est réalisé dans une matière légère, cassante, à faible module, comme du PMMA , des polycarbonates, des résines époxy, du PVC et similaires.

2. Ensemble d'armure légère selon la revendication 1, l'ensemble étant transparent.

3. Ensemble selon la revendication 2, dans lequel ledit au moins un corps avant est réalisé dans une matière sélectionnée à partir du groupe des matières organiques.

4. Ensemble d'armure légère selon la revendication 1, l'ensemble étant opaque.

5. Ensemble selon la revendication 4, dans lequel ladite matière légère, cassante, à faible module est une matière en tissu pour usage sévère.

6. Ensemble d'armure légère selon l'une quelconque des revendications 1 à 5, dans lequel ledit au moins un corps avant est un bloc d'un seul tenant.

7. Ensemble selon la revendication 6, dans lequel ledit au moins un corps avant est un corps composite.

8. Ensemble selon la revendication 7, dans lequel le corps avant composite est réalisé dans une pluralité de différentes matières légères, cassantes, transparentes et à faible module.

9. Ensemble selon la revendication 8, dans lequel le corps avant composite est réalisé dans une pluralité de différentes matières légères, cassantes, opaques et à faible module.

10. Ensemble selon la revendication 7, dans lequel le corps avant composite est réalisé dans une matière en tissu pour usage sévère.

11. Ensemble selon la revendication 9, dans lequel ladite matière en tissu pour usage sévère est imprégnée d'une matière polymère appropriée qui durcit lorsqu'elle sèche.

12. Ensemble d'armure légère selon l'une quelconque des revendications 1 à 5, dans lequel ledit au moins un corps avant se présente sous la forme d'un bloc à couches multiples dans lequel les couches individuelles sont inclinées par rapport à la trajectoire escomptée d'un projectile provenant d'une arme à feu, et dans lequel les couches multiples sont collées ou cimentées les unes aux autres, de façon appropriée.

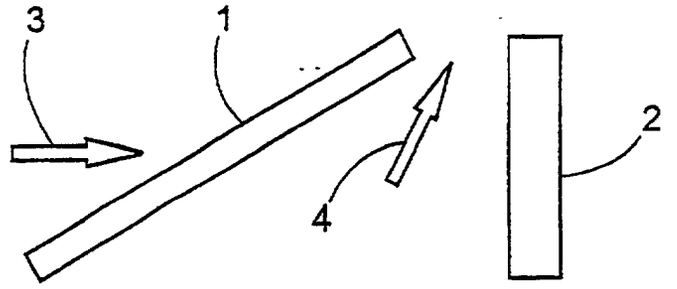

Fig.1

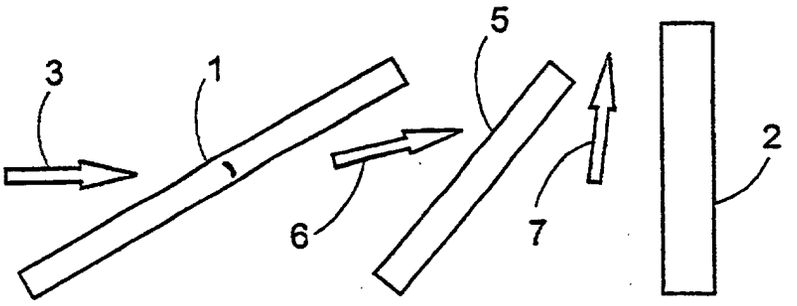

Fig.2

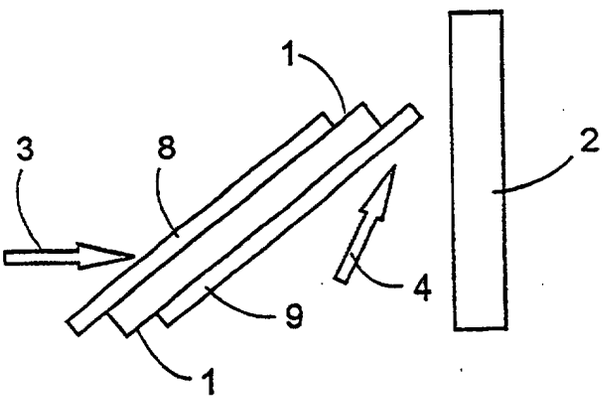

Fig.3

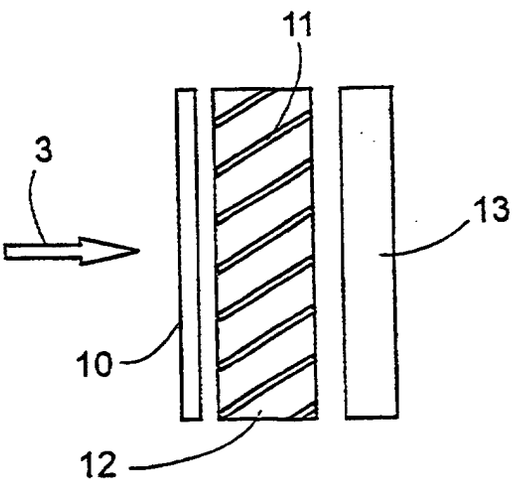

Fig.4