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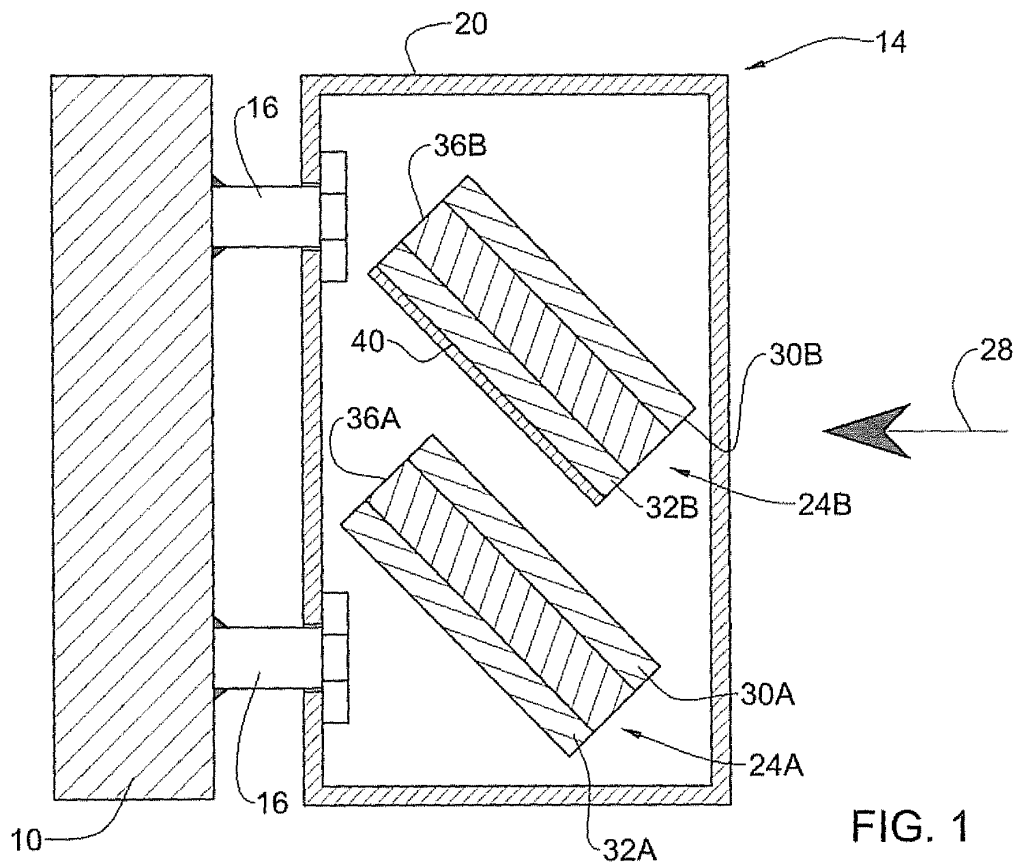
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(54) **Energy dampening system and an element therefore**

(57) A reactive armor cassette (24B) comprising at least a front plate (30B) and at least a back plate (32B) and sandwiching between them at least one layer of ex-

plosive material (36B), and at least one dampening plate (40) adjoining either or both said back plate (32B) and front plate (30B) and wherein the dampening plate (40) is cavitated.



Description

FIELD OF THE INVENTION

[0001] The present invention generally relates to energy absorbing/wasting systems useful for example in armor cassettes fitted for attaching on the outside of a structure or body liable to be exposed to attack by projectiles, e.g. shaped-charged warheads and kinetic energy projectiles. However, the system may be applied in other configuration comprising one or more moving plate members.

[0002] Bodies and structures protectable by armor models in accordance with the present invention are, for example, vehicles such as battle tanks, armored personal carriers, armored fighting vehicles, armored self-propelled guns; helicopters, maritime vessels, static structures such as buildings, above-ground portions of bunkers, containers of various nature, for the storage of fuel, chemicals, ammunitions, etc.

[0003] In particular, the present invention is concerned with an improvement for reactive armor cassettes for increasing kinetic energy absorbing on the one hand and, on the other hand, increasing survivability of neighboring cassettes within an armor module (also referred to as a tile). The invention is also concerned with armor modules holding a plurality of such cassettes and further, with an energy absorbing element for use with such armor modules and cassettes.

[0004] Furthermore the invention offers a system useful for reducing damage to bodies and structures to which said system is applied.

BACKGROUND OF THE INVENTION

[0005] A major consideration in designing armor cassettes and modules and in their manufacture is the problem of so called '*sympathetic detonation*' (also referred to as '*sympathetic initiation*', '*sympathetic activation*' or '*sympathetic energizing*') of neighboring cassettes within a reactive armor module holding a plurality of such cassettes. This may result in a '*domino effect*' where all or most neighboring castes within a reactive armor module are activated, and possibly also of neighboring armor modules. Apart for no longer being fit for offering protection to structure or body, the explosive's energy is transferred to a moving plate which in itself may damage the structure or body, and in some cases may also be hazardous for personnel within or adjacent said structure or body, or expose a significant area leaving the body/structure unprotected at that area.

[0006] Several arrangements have been proposed in the past addressing this issue and offering at least partial solutions. One arrangement is disclosed for example in US Patent No. 5,070,764 which in several of its embodiments discloses an arrangement where a casing holds two pairs of energy and mass consuming units, consisting each of spaced reactive and passive assemblies ar-

ranged in an essentially parallel V-shaped configuration. Whilst this arrangement increases the survivability of neighboring modules, this configuration is substantially wide and increases the 'image print' (silhouette) of the structure or body to be protected. This is a serious deficiency in particular for combat vehicles.

[0007] Other arrangements comprise provision of a plate of homogenous material (e.g. aluminum, Kevlar™) to the cassette (or spaced apart therefrom) to reduce the risk of sympathetic detonation of neighboring cassettes. However, where large quantities of explosive material are provided, the plate may be caused to strike at a neighboring cassette, thus causing its detonation.

[0008] It is a primary object of the invention to provide a mechanism for absorbing kinetic energy. The present invention provides an improved armor wherein likelihood of sympathetic initiation is eliminated or substantially reduced, whilst retaining a substantially low mass. Furthermore, the invention provides dampening of mechanical impact. e.g. of fast moving objects.

[0009] The present invention offers an armor cassette for fitting within a reactive armor module comprising one or more armor cassettes, and also an energy dampening plate for use with such modules and cassettes.

SUMMARY OF THE INVENTION

[0010] According to one aspect of the invention there is provided an energy absorption cavitated plate, for protection of an enclosure, where kinetic energy is wasted over mutual mechanical deformation of the cavitated dampening plate and a moving metal plate of a cassette.

[0011] According to one aspect of the invention there is provided an energy absorption cavitated plate useful in an armor tile, for protection of an enclosure. Energy of an impinging shaped charge or a kinetic head or blast caused by detonation of a sandwiched layer of explosive material in a cassette is wasted over mutual mechanical deformation of a moving metal plate of the cassette and of the associated cavitated dampening plate.

[0012] Such mechanical deformation is in the form of mutual deformation and dimpling/bulging of the metal plate, and further by deformation of the dampening cavitated plate and squashing of the cavities. The term squashing describes applying mechanical energy used to plastically deform the dampening plate.

[0013] According to an aspect of the present invention there is provided a cassette for a reactive armor module, comprising at least a front plate and at least a back plate (e.g. made of metal and known as the 'moving plates') sandwiching between them at least one layer of explosive material; and at least one dampening plate extending at least behind said back plate (though optionally it may extend behind the front plate) and wherein said dampening plate is cavitated. According to modifications of the invention, different sandwiching layers are assemblies to obtain different dampening parameters.

[0014] According to a second aspect of the invention

there is provided an armor module comprising a casing holding at least one reactive armor cassette as defined herein above.

[0015] The invention is further concerned with a method for protecting an enclosure against shaped charge warheads, kinetic energy projectiles and mines, the method comprising fitting the enclosure on an outside thereof with a reactive armor module comprising one or more cassettes of the above referred to type.

[0016] The dampening plate is typically made of low-impedance, homogenous material. Examples of materials suited for this purpose are aluminum, plastics, composite materials, Kevlar™, titanium, magnesium, certain steel alloys, etc. According to some particular embodiments the cavities formed in the dampening plate are circular holes symmetrically distributed over the plate and constituting at least 50% thereof. However, the cavities may be apertures (through going holes formed in the depression plate), or depressions.

[0017] The plastic deformation thus causes boundaries of the cavities to smudge (smear), whereby edges of the cavities deform to adjoin. Further energy is wasted by plastic deformation of the back plate against the dampening plate such that the back plate at least partially assumes the shape of the dampening plate and whereby portions of the back plate at least partially coincide with the cavities of the dampening plate.

[0018] According to some embodiments the dampening plate is spaced apart from the back plate, and according to other embodiments the dampening plate adjoins the back plate, typically parallelly extending.

[0019] According to a particular arrangement the dampening plate is mounted on or adjacent an outside face of an enclosure to be protected by said reactive armor.

[0020] According to another embodiment of the invention, intermediate the back plate and the dampening plate there is provided an auxiliary steel plate, and according to still other embodiments, a dampening plate extends also in front of the front plate.

[0021] According to still an embodiment of the invention, the cavities within the dampening plate are filled with a substance having a lower density, e.g. foamed material, wood, plastic material, aluminum (suited for a steel dampening plate).

[0022] The arrangement is such that the energy/impact imparted to an outside wall of the protected body/structure by the mass of a moving plate of the armor cassette is significantly lower. This may be of significant importance for protection of relatively thin wall structures, e.g. a door of a vehicle (personnel door or service door), where deformation thereof may result in dis-functioning thereof.

[0023] Thus, the system according to the present invention acts in two aspects, namely preventing or minimizing sympathetic initiation and

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] In order to understand the invention and to see how it may be carried out in practice, several embodiments will now be described, by way of non-limiting examples only, with reference to the accompanying drawings, in which:

Fig. 1 is a sectioned side view of an armor module according to an embodiment of the present invention, fitted on an outside surface of an enclosure;

Fig. 2 is a front view of a dampening plate according to an embodiment of the present invention;

Fig. 3A is a sectional side view of the dampening plate and the conjoining metal back plate of a cassette of an armor module, prior to hitting by a charge;

Fig. 3B is a sectional side view of the dampening plate and the conjoining metal back plate of Fig.3A after hitting by a charge;

Figs. 3C and 3D are isometric views of the dampening plate and conjoining back plate, respectively, of an armor module according to the present invention, after hitting by charge;

Fig. 4 is a schematic representation of an armor module according to another embodiment of the invention;

Figs. 5A and 5B are schematic representations of a portion of a troop carrier fitted with a protective module according to an embodiment of the present invention; and

Fig. 5C is a schematic representation of a side portion of a troop carrier fitted with a protective module, according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0025] Turning first to Fig. 1, there is illustrated an external wall **10** of an enclosure, e.g. a combat vehicle, a structure, etc. fitted with an armor module (tile) **14** mounted thereto by bolts **16**. The module **14** comprises a casing **20** accommodating, as an example only, two reactive cassettes **24A** and **24B** extending in a slant with respect to an expected oncoming shaped charge warhead, or kinetic projectile, represented by arrow **28**.

[0026] Each of the reactive cassettes **24A** and **24B** comprises a front plate **30A** and **30B**, respectively, and a rear plate **32A** and **32B**, respectively, made for example of metal, sandwiching between them a layer of explosive material **36A** and **36B**, respectively.

[0027] However, the cassette **24B** differs from cassette **24A** in that it further comprises, adjacent the rear metal plate **32B** a dampening plate **40** which is shown in detail in Fig. 2.

[0028] Turning now to Fig. 2, it is seen that the dampening plate **40** is cavitated by a plurality of circular apertures **44** which in accordance with the particular embodiment illustrated are disposed in a symmetrical manner

and arranged such that each three adjacent such cavities extend at the corners of an equilateral triangle **46A**, **46B**, **46C**, etc. however, it should be appreciated that rather than apertures the cavities may be non-through going cavities formed in the plate. Furthermore, the cavities may assume any other shape and may be disposed over the dampening plate at other configurations.

[0029] The dampening plate **40** is made of a low impedance material of homogenous properties such as aluminum, though other materials are suitable as well setting as examples plastic materials, composite materials, Kevlar™, titanium, magnesium, certain steel alloys, etc.

[0030] It has found to be advantageous that the total area of the cavities be at least 50% of the surface area of the dampening plate **40** with improved performances offered with surface area of the cavities being about 70%.

[0031] The arrangement disclosed hereinabove, and other modifications thereof, have been proven to be suitable for reducing and even eliminating sympathetic initiation of neighboring cassettes, e.g. cassettes **24A** within module **14**, e.g. in the case of a kinetic charge or shaped hollow charge striking cassette **24B**, which in the absence of dampening plate **40** would likely cause rear metal plate **32B** to forcefully displace against cassette **24A** and cause initiation of the explosive material **36A** and optionally, further on of other neighboring modules (not shown). This may cause severe damage to the protected enclosure, to personnel at the vicinity and to neighboring forces/structures.

[0032] The energy absorption mechanism which acts to reduce or eliminate the sympathetic initiation is exemplified in Figs. 3A to 3D. In Figs. 3A and 3C the dampening plate **40** is shown at a position prior to striking by a kinetic projectile or hollow charge **28**, extending parallel to a back plate **32B** whilst Fig. 3B illustrates the situation after striking by a kinetic projectile or a hollow charge, wherein the rear metal plate **32B** deforms under the kinetic energy of the impinging charge or kinetic head and further by the blast caused by the initiation of the sandwiched layer of explosive material, whereby the rear metal plate **32B** plastically deforms against the dampening plate **40**, giving rise to forming dimples/bulges at portions corresponding with cavities of the dampening plate **40** and simultaneously smudging of the cavities **44** (see also Fig. 3D) which in many cases will seal altogether. Furthermore, the plates **32B** and **40** are deformed altogether and in some portions fusion welding between the two plates may occur (see Fig. 3B).

[0033] The mechanical waste of energy thus prevents sympathetic excitement of reactive armor module elements.

[0034] According to an embodiment of the invention (not illustrated in the drawings), the cavities within the dampening plate are filled with a substance having a lower density, e.g. foamed material, wood, plastic material, aluminum (suited for a steel dampening plate).

[0035] Turning now to Fig. 4, there is illustrated a different arrangement of an armor module **62** comprising

two or more reactive cassettes **64A** and **64B** respectively, each comprising a front metal plate **66A** and **66B**, respectively, and a rear metal plate **68A** and **68B**, respectively, sandwiching between them a layer of explosive material **70A** and **70B**, respectively, and further, where each cassette **64A** and **64B** comprises a front dampening plate **74** and **76**, respectively, the latter extending between the rear plate **68A** of cassette **64A** and the front plate **66B** of the cassette **64B**.

[0036] According to other embodiments (not shown) each cassette comprises a front dampening plate and a rear dampening plate, said dampening plates extending in direct contact or spaced apart from the respective front or rear plate.

[0037] Turning now to Figs. 5A to 5C, there are illustrated three different embodiments of protecting an enclosure, a combat personal carrier in the present example. In Fig. 5A, an armored personal carrier **80** is fitted on a front wall portion thereof **82** with an armor module element collectively designated **86** and comprising one or more cassettes **88** which in turn comprises a front metal plate **82** and a rear metal plate **84**, sandwiching between them a layer of explosive material **86** as known *per se*. The reactive armor module **88** is fitted on a second metal plate **90** extending flush with a dampening plate **92** similar to that disclosed in connection with Fig. 2.

[0038] However, it should be appreciated that a second metal plate **90** may be eliminated and further, that there may be provided several couples of a metal plate and an adjoining dampening plate.

[0039] In the embodiment of Fig. 5B, there is illustrated a different arrangement wherein the armored personal carrier **100** is fitted on a front portion thereof **102** with an armor module generally designated **106** comprising a casing **108** fitted with four reactive armor module elements **110A**, **110B**, **110C** and **110D**, each consisting of a front metal plate, a rear metal plate, and an intermediate explosive layer as explained hereinabove. The cassette **106** is mounted on a metal plate **120** extending flush with a dampening plate **124** as explained hereinabove in connection to Fig. 5A.

[0040] The embodiment of Fig. 5C illustrates a side portion of an armed personal carrier **130** where its side wall **132** is fitted with an armor module **136** holding a combination of reactive and passive armor module elements **138A**, **140A**; **138B**, **140B**; **138C**, **140C**; and **138D**, **140D**, respectively, arranged in a V-like pattern and wherein intermediate each active and passive armor module element there is provided a dampening plate **144A-144D**, respectively.

[0041] Whilst some embodiments have been described and illustrated with reference to some drawings, the artisan will appreciate that many variations are possible which do not depart from the general scope of the invention, *mutatis, mutandis*.

Claims

1. A reactive armor cassette comprising at least a front plate and at least a back plate and sandwiching between them at least one layer of explosive material; and at least one dampening plate adjoining either or both said back plate and front plate and wherein said dampening plate is cavitated. 5
2. A reactive armor module element according to claim 1, wherein the dampening plate is made of low-impedance material. 10
3. A reactive armor module element according to claim 1, wherein the dampening plate is made of homogenous material. 15
4. A reactive armor module element according to claim 1, wherein the dampening plate is made of aluminum. 20
5. A reactive armor module element according to claim 1, wherein cavities formed on the dampening plate are symmetrically distributed. 25
6. A reactive armor module element according to claim 1, wherein the cavities formed in the dampening plate are circular. 30
7. A reactive armor module element according to claim 1, wherein at least 50% of the dampening plate is cavitated. 35
8. A reactive armor module element according to claim 1, wherein the dampening plate is spaced apart from the adjoining back or front plate. 40
9. A reactive armor module element according to claim 1, wherein the dampening plate bears flush against the respective back or front plate. 45
10. A reactive armor module element according to claim 1, wherein the dampening plate is parallel to the respective plate. 50
11. A reactive armor module element according to claim 1, wherein a dampening plate extends also in front of the front plate. 55
12. A reactive armor according to claim 1, wherein the cavities are through-going apertures.
13. A reactive armor according to claim 1, wherein the cavities have a tapering cross-section,
14. A reactive armor module element according to claim 1, wherein the dampening plate is mounted on or adjacent an outside face of an enclosure to be protected by said reactive armor.
15. A reactive armor module element according to claim 14, wherein the front plate of the module is an outer face of an armor cassette.
16. A reactive armor module element according to claim 1, wherein intermediate the back plate and the dampening plate there is provided an auxiliary steel plate.
17. A reactive armor comprising a casing holding at least one reactive cassette comprising at least a front plate and at least a back plate and sandwiching between them at least one layer of explosive material; and at least one dampening plate adjoining either or both said back plate and front plate and wherein said dampening plate is cavitated.
18. An energy dampening plate for use with a reactive armor module comprising at least one reactive cassette comprising at least a front plate and at least a back plate and sandwiching between them at least one layer of explosive material, wherein said dampening plate is adapted for positioning adjoining either or both said back plate and front plate and wherein said dampening plate is cavitated.
19. An energy dampening plate according to claim 18, wherein the dampening plate is made of a low-impedance material.
20. An energy dampening plate according to claim 18, wherein the dampening plate is made a homogenous material.
21. An energy dampening plate according to any one of claims 17 to 20, wherein the cavities are through-going apertures.
22. An energy dampening plate according to any one of claims 17 to 20, wherein the cavities are circular.
23. An energy dampening plate according to claim 1, wherein the cavities are filled with a material having a lower density than that of the plate.
24. A method for protecting an enclosure against shaped charge warheads, kinetic energy projectiles and mines, the method comprising fitting the enclosure on an outside thereof with a reactive armor comprising one or more cassettes each comprising at least a front plate and at least a back plate and sandwiching between them at least one layer of explosive material; and at least one dampening plate adjoining either or both said back plate and front plate and wherein said dampening plate is cavitated.
25. A method according to claim 24, wherein the reactive

armor module element and the associated reactive armor module element are received within cassette housing fixable to the enclosure.

- 26.** A method according to claim 24, wherein the dampening plate is made of a low-impedance material. 5
- 27.** A method according to claim 24, wherein the dampening plate is made of a homogenous material. 10
- 28.** An energy dampening plate comprising at least a dampening plate adapted for positioning in front of a wall of an object, wherein said dampening plate is cavitated. 15
- 29.** A energy dampening plate according to claim 28, wherein the dampening plate is made of a homogenous material. 20

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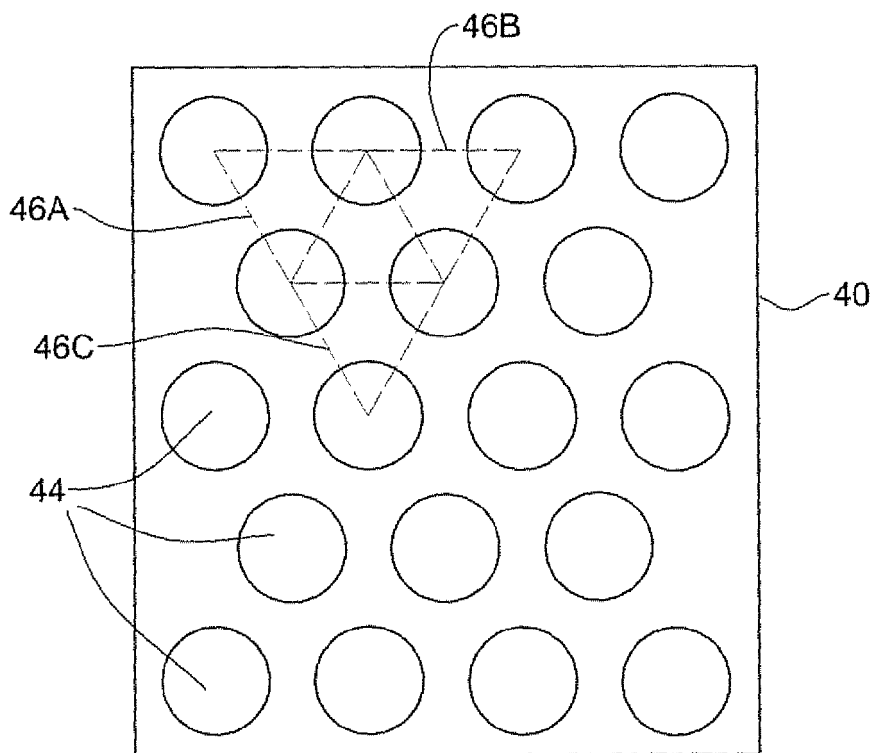
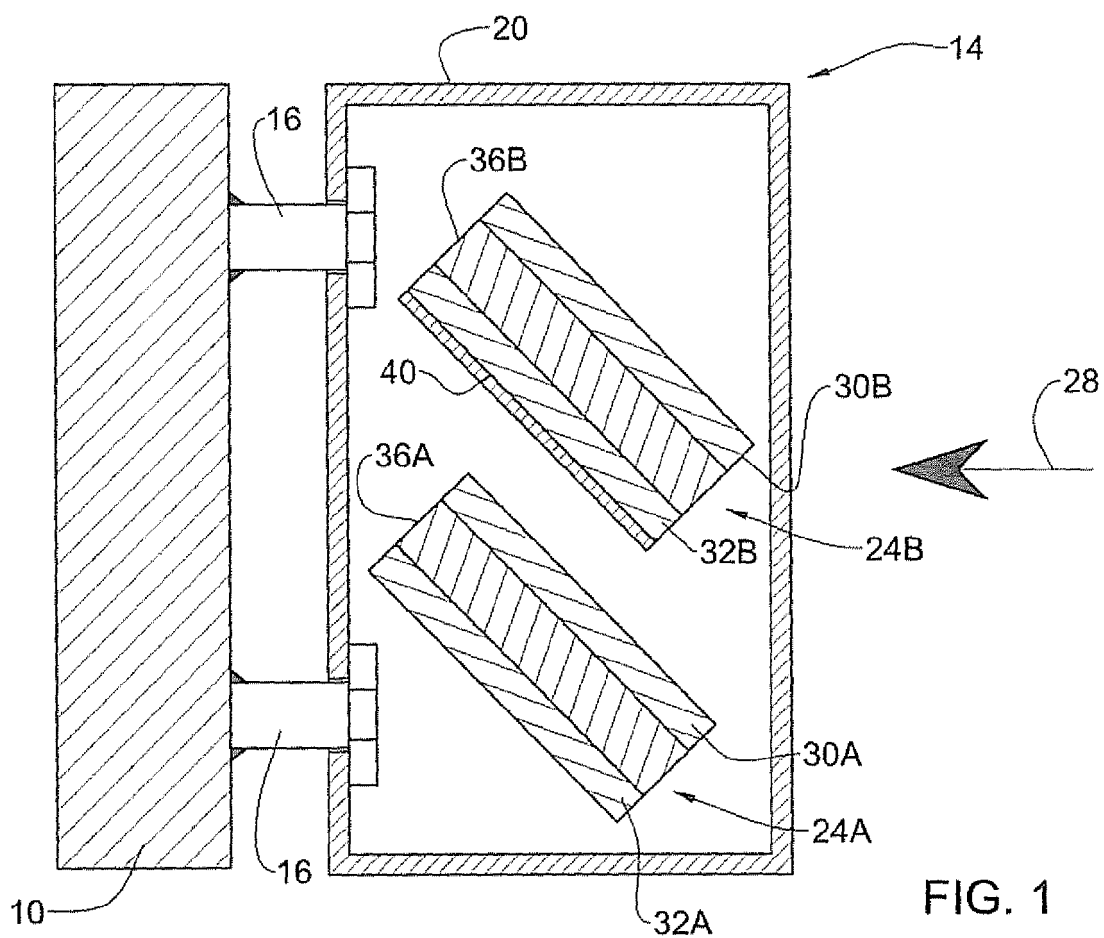
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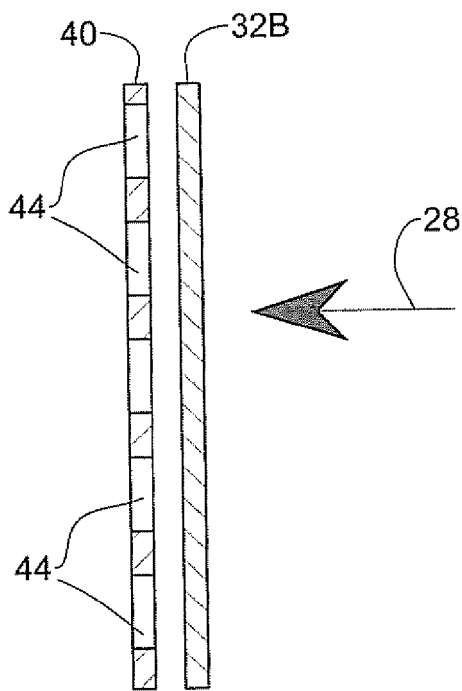


FIG. 3A

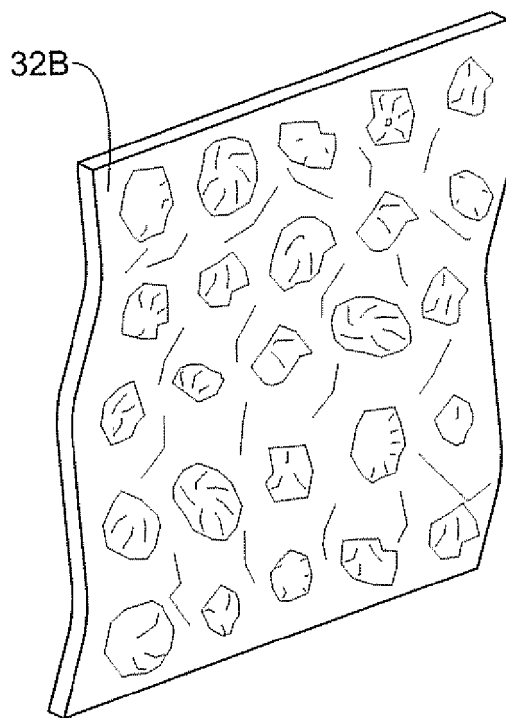


FIG. 3C

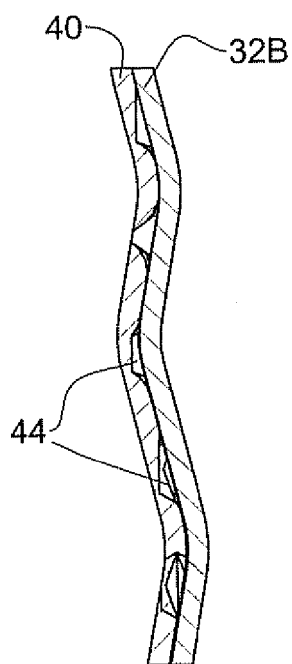


FIG. 3B

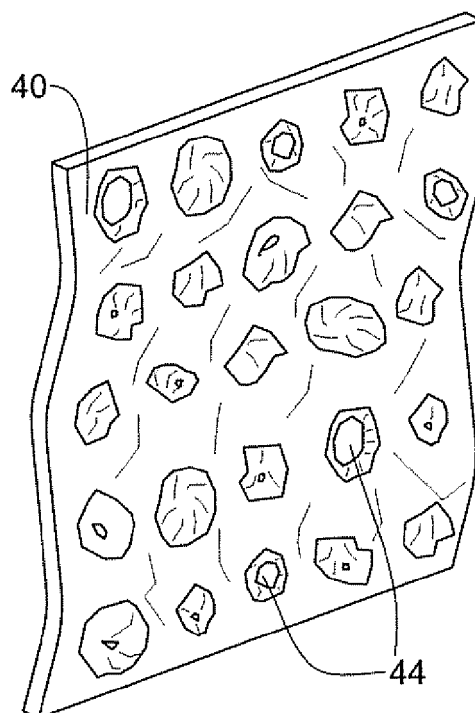


FIG. 3D

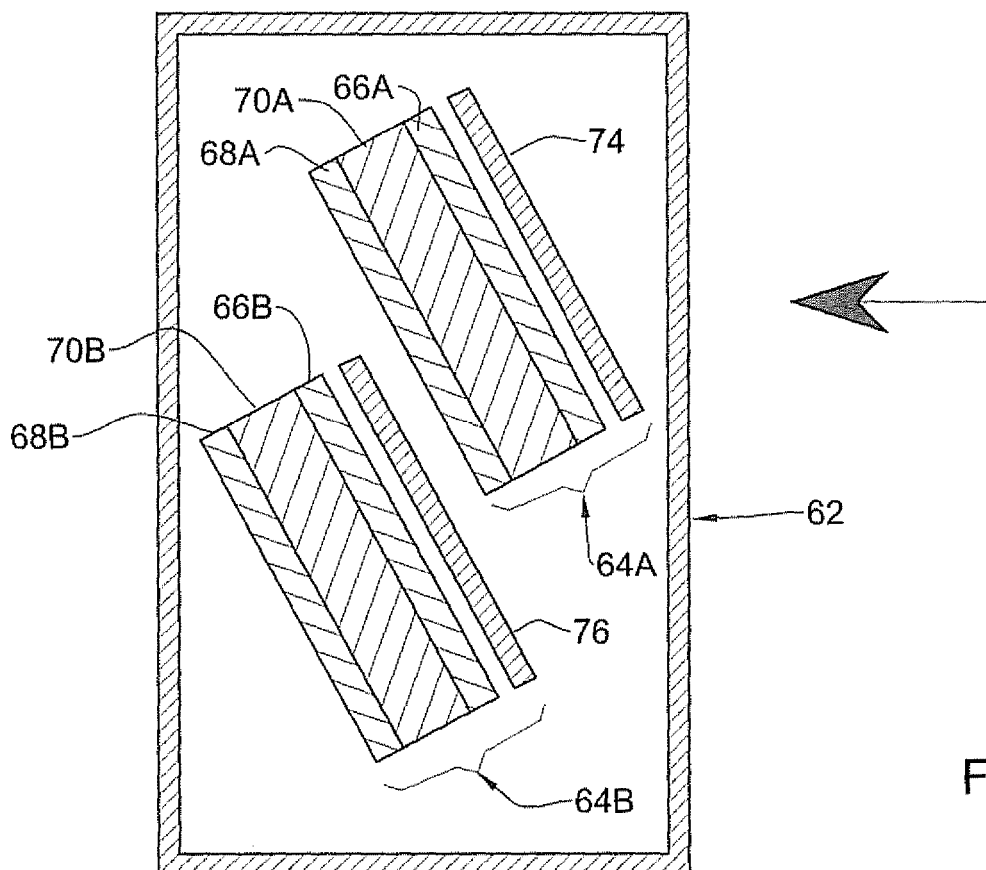


FIG. 4

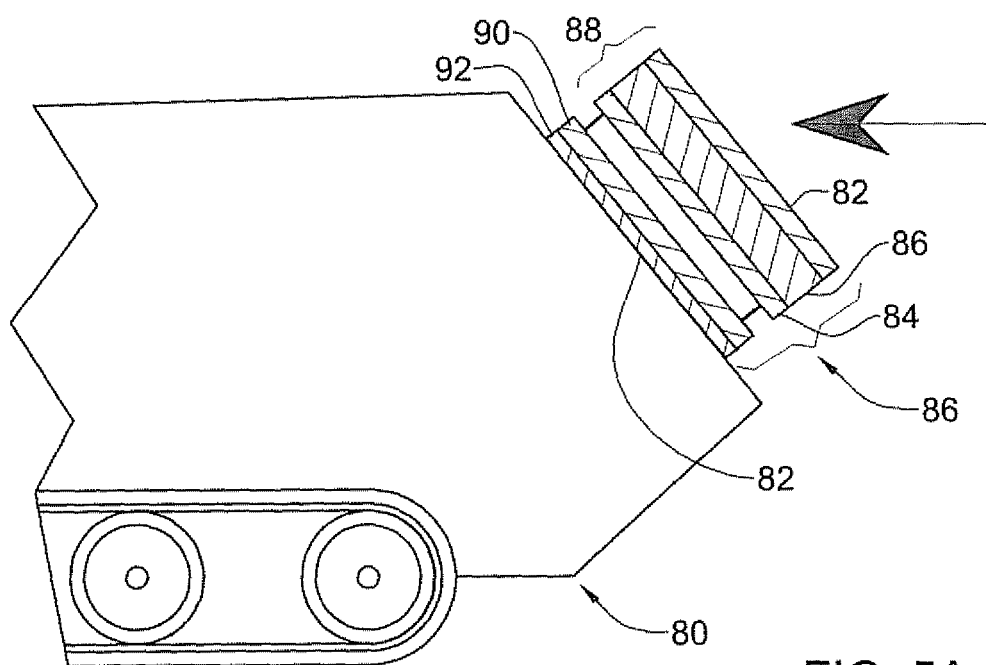


FIG. 5A

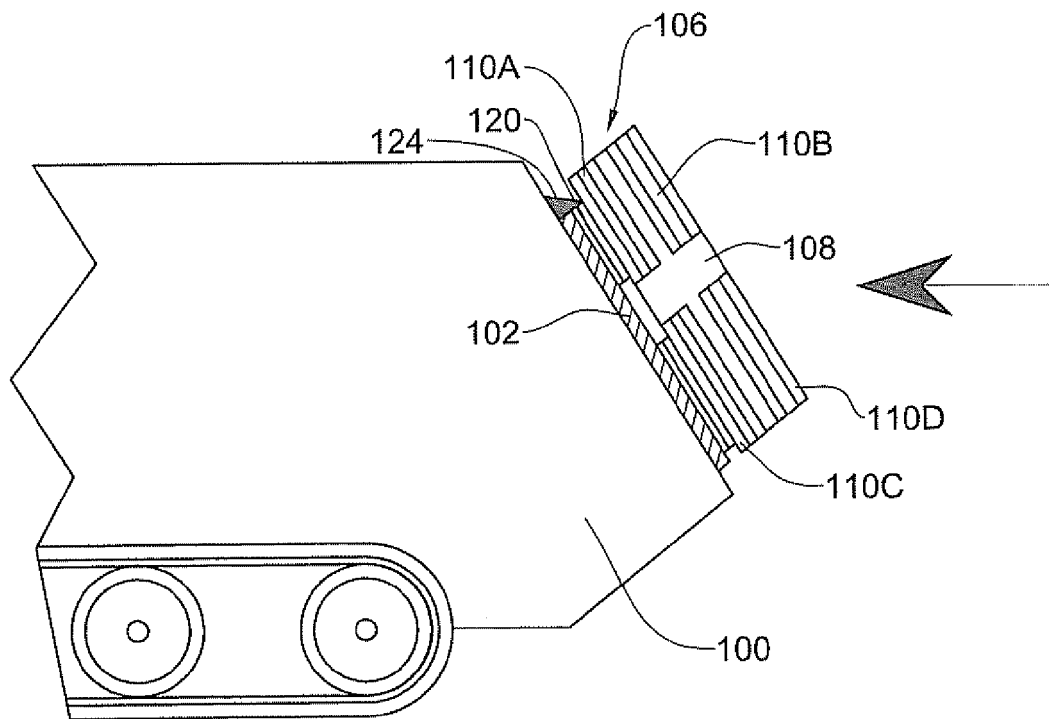


FIG. 5B

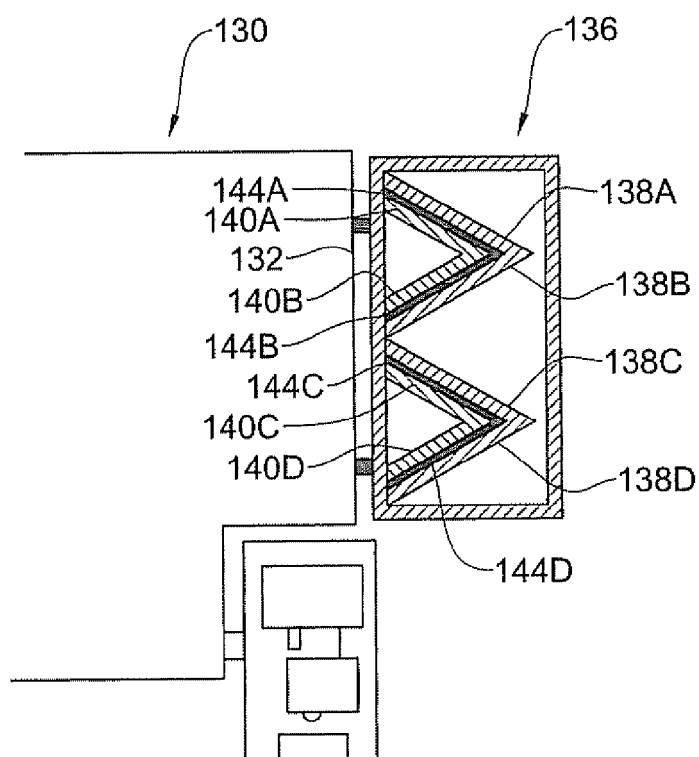


FIG. 5C



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 06 11 5063

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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 13 September 2006	Examiner Menier, Renan
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ----- & : member of the same patent family, corresponding document	

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Place of search The Hague		Date of completion of the search 13 September 2006	Examiner Menier, Renan
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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ON EUROPEAN PATENT APPLICATION NO.**

EP 06 11 5063

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